27813254

WBS 14CAE12
81152-609

ALTERNATIVES ANALYSES MISCELLANEOUS MECHANICAL/ ELECTRICAL SUBSYSTEMS

Prepared by
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August 1983

The preparation of this document has been financed in part through a grant from the U.S. Department of Transportation, Urban Mass Transportation Administration, under the Urban Mass Transportation Act of 1964, as amended, the State of California, and the Los Angeles County Transportation Commission.

CONTENTS

EXECUTIVE SUMMARY

Work element WBS 14CAE12 assists the Metro Rail Project staff in selecting preferred design alternatives for the following systems within the Miscellaneous Mechanical/Electrical Subsystems:

- o Gas Detector System
- o Tunnel Car Storage Area Fire Detection System
- o Seismic Detection System
- o Tunnel Sump Pump System

The methodology used in this report compares annual equivalent costs in 1983 dollars of applicable alternatives and evaluates the technical risks as well as avialability of the alternatives. Table A and the paragraphs that follow summarize the results of each analysis.

Table A

ANNUAL EQUIVALENT COST SUMMARY

SUBSYSTEM	ANNUAL EQUIVALENT COSTS (1983 Dollars)	
GAS DETECTION SYSTEM		
Local Sensors	$642,200	
Centralized Analyzer		$934,800
TUNNEL CAR STORAGE AREA		
FIRE DETECTION SYSTEM	No Cost Comparison (see text)	
SEISMIC DETECTION SYSTEM		
Seismic Trigger, per sensor	$ 530	
Accelerograph, per sensor		$ 781
TUNNEL SUMP PUMP SYSTEM		
Submersible Pump, per sump	$ 3,400	
Dry-motor Pump, per sump		$ 4,600

GAS DETECTION SYSTEM

This study compares centralized analyzer-remote probe systems with local sensor systems. The local sensor system is found to be less costly, lower in technical risks, and available from more sources than the centralized system.

TUNNEL CAR STORAGE AREA FIRE DETECTION SYSTEM

This study reviews the types of fire detectors available and recommends flame type detectors for undercar and car compartment fire detection as well as thermistor line-type detectors for detection of other storage area fires and backup for the flame type detectors. The importance of the storage area configuration on the final selection of fire detectors is emphasized.

SEISMIC DETECTION SYSTEM

This study reviews the two types of seismic detectors currently in use on existing rail rapid transit systems. Both types are found to be lacking in performance reliability. Further study of seismic detection systems is recommended.

TUNNEL SUMP PUMP SYSTEM

This study reviews the sump configurations available, compares pumping systems, and discusses level control methods. The wet-pit sump configuration using submersible pumps and displacement type level controls is recommended based on cost and technical risks.

Chapter 1

INTRODUCTION

1.1 BACKGROUND

The Miscellaneous Mechanical/Electrical Subsystems are defined by the SCRTD Metro Rail Subsystem Design Criteria, Volume IV, Section 8, Revision of November 9, 1982, as "...several special equipment subsystems which do not fall conveniently within the parameters of other major subsystems, and which are deployed throughout the Metro Rail System." (See Appendix B.) These systems include the following (modified listing):

- Gas Detection Systems
- Early Warning Fire Detection Systems
- Fire Protection System Monitoring Apparatus
- Siesmic (Earth Movement) Detection Systems
- Pumping Apparatus

By early 1982, the Metro Rail staff began more detailed definitions of the alternatives for these subsystems (see March 10, 1982 memorandum from Donald M. Gardner to M. Burgess via W. Rhine, Appendix C). On January 17, 1983, the Metro Rail staff decided the subsystems listed below should be studied for cost effectiveness (see February 25, 1983, memorandum to W.J. Rhine from P.M. Burgess, Appendix C):

- Gas Detection Systems
- Water Flow Detectors (meters)
- Seismic Detection Systems
- (Tunnel) Sump Pump Systems

During subsequent discussions, the water flow meters were deleted. The fire detection system for the car storage area in the tunnels was added to the study. The remaining subsystems in the Miscellaneous Mechanical/Electrical Subsystems work were determined to be sufficiently straight forward to be effectively selected using standard specification/bid evaluation techniques.

1.2 PURPOSE AND OBJECTIVES

1.2.1 Purpose

The purpose of WBS 14CAE12 is to:

A. Research the various subsystem alternatives

B. Select the alternative types and configurations suitable for the SCRTD Metro Rail System

C. Evaluate the selected alternatives using cost-effectiveness techniques

D. Recommend a subsystem and provide sufficient information for the SCRTD Metro Rail staff to select the most appropriate alternative for the project.

1.2.2 Objectives

The objectives of WBS 14CAE12 are to develop information, locate potential interface points, and identify problem areas for use in establishing design criteria, system descriptions, equipment descriptions, and specifications as well as to provide a basis for additional studies to be completed during WBS 16CAE12 and subsequent work elements.

1.3 SCOPE

1.3.1 Gas Detection System

Chapter 2, "Gas Detection System" reviews two concepts for monitoring methane concentrations which may occur within the tunnels. The two concepts are:

A. Centrally located analyzers with multiple remote probes

B. Local sensors with centrally located monitors.

The study recommends proceeding with the local sensor-type subsystem.

1.3.2 Tunnel Car Storage Area Fire Detection System

Chapter 3, "Tunnel Car Storage Area Fire Detection System" reviews various types of fire detectors available including:

A. Spot-type detectors
B. Line-type detectors
C. Air-sampling-type detectors

The study recommends multiple-type detector subsystems with final selection of detector types withheld until the storage area configuration is finalized.

1.3.3 Siesmic Detection System

Chapter 4, "Siesmic Detection Systems" reviews siesmic detectors used by other rapid transit systems and recommends that further studies be performed on availability and failure causes of detectors before a final selection is made.

1.3.4 Tunnel Sump Pump Systems

Chapter 5, "Tunnel Sump Pump Systems" reviews sump configurations and sump pump equipment with an emphasis on:

A. Dry-pit (sump) vs. wet-pit configuration
B. Dry-motor vs. submersible equipment
C. Level controls.

The study recommends sumps of the wet-pit configuration using certain types of submersible pumps, displacement-type level controls for normal operation, and tilt-type level controls for redundant high-level alarm annunciation.

1.3.5 Design Criteria

Where required, each study presents sufficient information for modification of the November 9, 1982, revision of the "SCRTD Metro Rail Subsystems Design Criteria" and to comply with the subsystem selected by the SCRTD Metro Rail staff.

1.3.6 Interfaces

Each study presents sufficient information for identifying potential interfaces and for assisting with interface clarification during subsequent design work.

1.3.7 Problem Areas

Each study discusses configuration and equipment problems, identifies the problem causes as either subsystem alternate inherent or rapid transit system induced as well as Metro Rail configuration/environment induced. Each study, where possible, also proposes solutions through adaptions or modifications of the subsystem alternatives, or through additional study of the effected subsystem alternatives.

1.4 METHODOLOGY

Each study presents an overview of the area of the Metro Rail System that will be affected and includes an review of the rationales for separate subsystems as well as a discussion of the alternatives available for that subsystem. The alternatives are analyzed by assessing their previous applications, adapting them to the Metro Rail System, applying cost-effectiveness techniques, evaluating technical risks, and confirming availability.

Conclusions are then drawn from the analyses, and are presented along with recommendations.

1.4.1 Criteria and Parameters

Existing SCRTD Metro Rail design criteria operating plans and studies are used as a basis for developing individual study criteria. Parameters, including design assumptions, are based on Metro Rail System characteristics, configurations, and environmental conditions, as perceived at the present time, and on the characteristics and limitations of available equipment.

1.4.2 Alternatives

The various methods of satisfactorily achieving subsystem requirements are based on a review of technical literature, equipment brochures, and previous transit and other industry projects. These methods are supported by interviews with the following groups:

A. Personnel at existing rail rapid transit authorities

B. Engineers and other personnel experienced in rail rapid transit system and other industry design and operation

C. Equipment manufacturers and suppliers.

1.4.3 Cost Effectiveness

The cost-effectiveness analyses consider costs in 1983 dollars for equipment, installation, operation, and maintenance. The application of these cost factors is based on each cost item being significantly different between alternatives.

A. Capital costs of equipment and installation are presented in both total and annualized form. Annualization is based on the equivalent of repaying an installment loan bearing 12% interest in 32 years. (See Appendix D.)

   1. Equipment costs were obtained from suppliers and are supported by quotations where practical.

   2. Installation costs include labor and material, and were obtained from the KE Estimating Department unless otherwise identified.

B. Operation costs include labor, power, and consumable items.

   1. Labor rates are assumed to be the equivalent of $33.75 per hour, with a 1.5 shift differential

factor applied for work required form 5 p.m. to 8 a.m. inclusive.

2. Power costs are assumed to be the equivalent of \$0.07 per kilowatt-hour.

3. Consumable item costs and sources are identified within the individual studies.

C. Maintenance costs include labor and spare parts.

1. Labor rates are assumed to be the equivalent of \$33.75 per hour, with a 1.5 shift differential factor applied for work required from 5 p.m. to 8 a.m. inclusive.

2. Spare parts costs are based on vendor pricing for major items and on allowances applicable to the type of equipment and service.

1.4.4 Supporting Data

Reproducible data concerning costs, calculations, equipment, interviews, and selected references are included in the various appendices.

Data that could not be reproduced is available from KE.

Chapter 2

GAS DETECTION SYSTEM

2.1 INTRODUCTION

The SCRTD Metro Rail Starter Line route passes through or near six major oil fields. The November 1981 "Geotechnical Investigation Report" prepared by General Geotechnical Consultants advised that natural gas from these and other sources may be encountered over half the route. Thus far, only methane has been identified as a constituent of the natural gas that will require extraordinary precautions. Additional geotechnical work presently underway by Engineering-Science, Inc. should either confirm whether or not methane is the only significant hazard among the gas, and identify other constituents such as hydrogen sulfide, which may also require special control and preclusive measures.

Methane (CH_4) is the primary constituent of the natural gas used commercially and domestically, mainly for cooking, comfort heating, water heating, clothes drying, and the like. It is used industrially for various processes requiring a clean burning fuel and, until recently, was used where an economical fuel was required. It is considered an easy-to-handle source of either carbon or hydrogen and has been beneficial in commercial areas such as fertilizer production. In its natural state, methane is colorless, odorless (gas companies add an odorant soon after the gas leaves the well head), tasteless, nontoxic, lighter than air, and highly flammable. This latter characteristic of flammability is the cause for concern among the SCRTD Metro Rail staff.

Methane has an explosive range (also called flammability range) of from 5% to 15% in air, with a minimum oxygen requirement of about 12%. The seriousness with which methane is regarded within the mining industry is reflected in the Code of Federal Regulations (CFR) that classifies noncoal mines as "gassy" when as little as 0.25% methane is detected (see Appendix E). Such a classification requires implementation of procedures that are deemed acceptable to the Mine Safety and Health Administration (MSHA), the organization charged with enforcing the CFR. Such procedures either eliminate the source of methane gas or adapt the mining operation to the stringent restrictions and requirements of the CFR. All coal mines are now classified as "gassy" because of potential methane gases.

The rates at which methane will be liberated along the SCRTD Starter Line will not be known until the tunnels are being constructed. Even then, the initial liberation rates may be much greater than the steady flow rates. This is illustrated by test results at a recent construction project near Wilshire Boulevard. After an excavation encountered a gas source, test measurement found that the initial static pressure was 110 oz/in^2. When gas was flowing from the test well, the residual pressure fell first to 70 oz/in^2 and then to 15.5 oz/in^2. This indicates that flow rate dropped about 50% during the test. The same type of phenomenon occurs in some coal mines, where the initial flow rate may be four cubic feet per minute per square foot of new coal exposed, then gradually it diminishes or even stops. In other mines, however, the flow rate remains relatively steady.

The methane work of the geotechnical specialist is complicated by various factors. For example, natural gas has the tendency to collect under perched water and migrate laterally. Consequently, the gas may appear at a natural entrapment some distance from its source.

Another factor to be considered is the possible effect of earthquakes on gas pockets. An earthquake may cause a movement in a natural barrier, which would permit the gas to migrate. As such, is might travel through the Starter Line alignment or collect in a pocket at or near the alignment.

The study by General Geotechnical Consultants and a subsequent work, "Study of Methane and Other Combustible Gases Effect on Underground Operation of the (SCRTD) Metro Rail Project", March, 1983, by Gage-Babcock & Associates and Kaiser Engineers (California) Corporation (KE) recognized the potential damages involved due to methane and recommended that the following control methods be investigated:

A. Special liners for the tunnel to preclude methane infiltration.

B. Methane drainage (tapping sources with gas wells and routing the gases to disposal or collection points) to reduce the pressure differential between the gas bearing formation and the Starter Line. This would reduce the potential infiltration rate as well as the quantity of gas near the Starter Line.

C. Ventilation systems adequate for the dilution and removal of any infiltrated methane.

In conjunction with these proposed control methods, a methane detection system was recommended by Gage-Babcock &

Associates for use as either alarm and/or control. The alarm function of the detection system would be to provide adequate warning to SCRTD personnel should excessive methane accumulate. The control function would activate the ventilation system to dilute and exhaust any methane detected in the Starter Line. This control function has subsequently been modified so that Central Control personnel would interpret the information from the detection system and activate the ventilation system based on criteria developed during actual start-up and operation of the transit system.

2.2 PURPOSE

The purpose of the gas detection system portion of WBS14CAE12 is to:

A. Research the various methods of detecting the presence of methane gas in the SCRTD Metro Rail tunnel atmosphere

B. Select methods that are suitable

C. Evaluate selected methods using cost effectiveness techniques

D. Provide a recommendation, with sufficient information so that the SCRTD Metro Rail Staff may select a gas detection method appropriate for the SCRTD Metro Rail System.

2.3 DESCRIPTION OF ALTERNATIVES

Methane may be detected by various methods that either measure, observe, or react to its atomic, chemical, or physical characteristics; to changes in those characteristics; or to the effects of changes in those characteristics. These methods range in complexity, safety, and practicality from flame safety lamps (which are still required by mine-related laws in some states), to gas chromatographs which are used only in laboratories.

To assist with the selection of methods to be considered, SCRTD met with Fitz Consultants and KE on January 17, 1983 (see Appendix C). It was decided at that time to limit this study to a comparison of centrally located analyzers with local sensor-type systems. Earlier, it had been decided to deploy the detectors throughout the tunnel system and for primary system monitoring to be conducted at Central Control (see preliminary design criteria, April 7, 1982, Appendix B).

2.3.1 Centrally Located Analyzers

Centrally located analyzers are frequently used in the mines of Europe and South Africa for monitoring methane and other mine air contaminants. The basic system consists of: tubing originating at the point to be monitored; dust filters in the tubing; a vacuum pump for inducing flow through the tubing; valving for directing the flow either into the analyzer or into the atmosphere; connections and valving for periodically purging the tubing of dust and other buildups; and an analyzer. The number of monitoring points served by one analyzer can vary from one point to whatever the practical limits imposed by distance and/or cycling time.

Typically, the analyzer uses optical phenomena as the basis for measuring methane although thermal catalytic detectors may be used. There are two types of optical detectors in use: the nondispersive infrared type and the interferometer, a dispersive type.

The interferometer measures the difference in the velocity of light between a known gas and the gas being sampled. To overcome its specificity limitations, a centralized interferometer system includes carbon dioxide and water vapor scrubbers. Because this complexity decreases their dependability and the specificity limitations decrease their reliability, interferometers are not included in this cost analysis.

The infrared detectors measure the difference between the amount of infrared energy absorbed by a known gas and the gas being sampled. A single-cell type may be used for both gases. In such a system, the known gas (usually nitrogen) is used to purge the unknown gas from the cell. This method, however, increases costs; thus, the two-cell type systems are more frequently employed. The two-cell type has a sealed reference cell and a sample cell. Either type cell can measure from 0% to 100% methane with good specificity and accuracy. The two-cell type is chosen for this cost analysis as it is less complex and less costly to operate than a one-cell system.

The thermal catalytic analyzer operates on the same principle as the thermal catalytic sensor (see Section 2.3.2). The system components are the same or similar to those of optical detectors. The cost of equipment and installation are also similar. The effective range is 0% to 5% methane and the expected life span of the principal element, a thermal catalytic sensor, is about three years. Due to these factors, centralized thermal catalytic analyzers are not included in the cost analysis.

Other types of analyzers have not been adapted to mine and tunnel environments on a consistent basis and therefore are not considered in the cost analysis.

2.3.2 Local Sensors

In the United States, local sensor systems using thermal catalytic sensors are the most common type of methane monitor used. In Europe, several mines have converted from central analyzer systems to thermal catalytic sensor systems to obtain quicker response and to eleviate the problems with leakage in probe tubing and limitations on probe length. The sensors are manufactured under several different names -- heat of combustion; catalytic combustion; catalytic sensors or heads. They have been adapted to centralized analyzers, hand-held combustible gas detectors, and to the local sensor monitoring system considered in this analysis.

The basic local sensor methane monitoring system consists of: a sensor mounted at the point to be monitored; a signal amplifying unit which may be housed in the sensor enclosure; cables for power to and signals from the sensor; and a control unit for local monitoring of individual sensors, sensor calibration; and, if required, conversion of signals for remote monitors.

The following description of thermal catalytic sensors is taken from the United States Department of the Interior, Bureau of Mines, Pittsburgh Research Center, Internal Report 4420[1]:

> The most commonly used principle for methane sensors has been catalytic oxidation (combustion). As used here, the term catalytic sensors includes both filament (platinum, platinum-rhodium, or other alloys of platinum) and catalytic-bead sensors (including pellistors, pellements, or pellement type).

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1 "Applicability and Capabilities of Commercially Available Methane Sensors for Fixed-Point Intrinsically-Safe Underground Coal Mine Monitoring", A.F. Cohen, Physicist, and G.H. Schmakenberg, Jr., Supervisory Research Physicist, April, 1983. Both authors are with the Pittsburgh Research Center, Bureau of Mines. (See Appendix E for the complete report.)

The heat of reaction released by a gas when it burns (oxidizes) on a filament or in the presence of some other heated catalyst can be used to detect combustible gases in air. Sufficient oxygen, greater than 10%, must be present for combustion of methane to be complete. Combustion raises the temperature (and thus the resistance) of the filament, as compared to an inactive reference filament. The reference and active filament forms two arms of a Wheatstone bridge. The amount of imbalance of the bridge gives a measure of the concentration of the combustible gas. To a first approximation, the bridge output voltage is directly proportional to the combustible gas concentration over a small but usable concentration range (0% to 5%). The catalytic combustion principle is useful for detection of methane between approximately 0% to 5% but not much above 5%. Owing to lack of oxygen, the bridge output versus methane concentration relation shows the continuous decrease of output with increasing methane concentrations above 10% to 15% methane in air.

The catalytic element of early combustible gas sensors was a coil of platinum wire, connected to a voltage supply, and electrically heated to approximately 1,000° C (1800°F). A combustible gas in an atmosphere containing oxygen is oxidized at the platinum wire (a catalyst). This oxidation raises the temperature of the platinum wire, resulting in an increase in coil resistance. However, at these elevated temperatures, platinum evaporates. The result of this evaporation is poor zero stability and short platinum coil (catalytic element) life.

The development of catalytic coatings, such as mixtures of palladium and thorium supported on a substrate surrounding a small platinum coil results in a catalytic bead with the ends of the coil connected as before to a voltage supply to provide the necessary temperature for the oxidation (combustion) of the gas. With such catalytic coatings, methane can be oxidized at approximately 550 to 700°C (1,000 to 1,300°F). Zero drift of such catalytic bead elements due to evaporation is much less than for unbeaded platinum wire coils. An inactive catalytic bead element is similar to the active one, except that it is poisoned or made inactive and acts as a reference element to compensate for changes of humidity, temperature, and pressure.

These lower operating temperature gas-sensing elements (catalytic bead types such as pellistors or pellements, etc.) can lose sensitivity in the presence of atmospheres containing silicone vapors from silicone containing compounds. Silicone vapor is a poison to the catalytic bead. Other catalyst poisons are sulfur compounds, such as hydrogen sulfide and phosphate esters used as corrosion inhibitors in oils. Pure platinum coil filaments operating at much higher temperatures than the bead type are not poisoned by silicones.

The lower operating temperature, catalytic bead-type, thermal catalytic sensors were chosen for this analysis for two reasons:

1. These sensors have a longer life

2. There has been no indication of significant amounts or use of catalytic poisons in the SCRTD Starter Line.

A newer type local sensor using semiconductors that react to methane by changes in electrical conductivity was not included in the analysis because only insufficient and unsatisfactory operating experience is available. At present, these sensors are reported to lack the specificity required for reliable methane detection in the SCRTD Starter Line.

2.4 APPLICATION HISTORY

The Port Authority of Allegheny County's light rail transit system in Pittsburgh purportedly will be the first rapid transit system to use methane detectors in a tunnel.

The detection systems analyzed in this report, however, have satisfactorily served the mining, refining, and other industries for decades. Considerable effort was expended to obtain information from the coal mining industry and related industries because of their vast experience with methane detection and monitoring systems. Both of the detection systems analyzed are used in coal mines where methane is prevalent and the operating conditions are harsh.

2.5 METHODOLOGY

In addition to methodology parameters discussed in Chapter 1, the following parameters were applied to the methane detection system analysis:

2.5.1 Design Criteria

A. Applicable portions of the SCRTD Metro Rail Subsystem Design Criteria, Volume IV, Section 8 - Miscellaneous Mechanical/Electrical Subsystems including:

1. "A Central Control facility. . .will contain the necessary displays, control consoles, communication apparatus, and operating personnel for the overall safety and security passengers and for the daily operations. . . ."

2. "Automatic gas sensors shall be installed in tunnels and stations, and shall be capable of detecting concentrations of any gas which may become dangerous due to toxicity or explosion hazard. Sensing shall detect trends in concentration while still in a safe range, to ensure that adequate warning is given so that mitigating measure can take effect before a dangerous situation can arise. Since this is a vital area of safety, redundant apparatus, including sensors, circuits and control elements, shall be employed, as necessary.

   The sensors shall be of thermal conductivity or infrared analyzer type, capable of continuous automatic measurement and monitoring (chemical reagents shall not be accepted). The sensors shall also be easy to install and require minimum maintenance."

B. Modifications to sections of the design criteria and the reasons for the changes:

1. Section IV - 8.5.1: Toxic gas detection capabilities were not included in the systems because, to date, only insignificant traces of

one toxic gas, hydrogen sulfide, have been identified. These traces do not necessitate extraordinary precautions such as detectors. If, in the future, toxic gases in significant quantities are identified, detection and monitoring systems similar to the methane detection systems analyzed will be added to the SCRTD Starter Line.

2. Section IV - 8.5.1: The term "thermal conductivity sensors" was taken to mean thermal catalytic detectors, because sensors that measure the thermal conductivity of methane are not commonly used for monitoring methane in mines and tunnels.

3. Section IV - 8.5.2: Central Control display panels and other equipment were not included. This equipment will be included with other communications equipment by the communication system designers. (The Communication System interfaces at the remote signal and standby power terminals on the control units of the local sensor system and in the passenger stations at the signal cable leads from the central analyzers.)

2.5.2 Parameters

Design assumptions include:

A. Methane monitoring will be done at 500-foot intervals throughout both tunnels.

B. The DTS will multiplex signals from the gas detection system, including 390 methane concentration related signals, and trouble signals.

C. The time for DTS multiplexing of data and sample probe cycling will not detract from system reliability.

D. Calibration gas cylinders can be stored, in limited quantities, at the passenger stations.

E. Primary power is available at 110 V, single phase, 60 Hz. Redundancy of primary power will be done at the substations.

F. Standby power is available at 24V dc from the Uninterruptible Power System (UPS).

G. Signal power is available from the Communication System.

H. Tunnel overall length is 97,650 feet.

I. Central analyzers can be installed in crossover passages connecting the two tunnels and in stations, as required.

J. Control units for local sensors can be located in the stations.

K. Proper auxiliary vehicles are available for local sensor replacement and central analyzer probe repairs.

L. Proper auxiliary vehicles are available for local sensor replacement and central analyzer probe repairs.

M. Sensors and probes are installed at the highest part of the tunnel. Except for the analyzer rooms of the central system, no attempt is made to include auxiliary room monitoring. This will be done during detail design and may require additional analyzers or control units.

N. Sensor and analyzer/control unit redundancy is obtained through spacing intervals rather than through duplex installation.

O. Silicones will not be used near sensors hydrogen sulfide gas quantities are insignificant; other materials that poison catalytic bead thermal catalytic sensors are nonexistent or exist in insignificant quantities in the tunnel atmosphere.

2.6 RESULTS

2.6.1 Capital Costs

Methane monitoring systems are available directly from manufacturers or may be purchased as part of other monitoring packages from various system designers, such as fire and intrusion detection system specialists. The relationship among the system specialists is through the similarity of detector output signals and functions of the monitors. Initial contacts were made with system specialists, including:

A. Langford Control Systems, Danville, CA
B. Alison Control Inc., Fairfield, NJ
C. Rel-Tek Corporation, Pittsburgh, PA.

Simultaneously, contacts were made with manufacturers, including:

A. United Technologies Bacharach, Pittsburgh, PA
B. National Mine Service Company, Oakdale, PA
C. Mine Safety Appliance Co., Pittsburgh, PA.

Contacts with detection system specialists were halted after a review of the SCRTD Fire/Life Safety Criteria revealed that gas monitoring is not a part of the station EMP and discussions with the communication system designers indicated that the DTS already has included multiplexing capabilities and Central Control equipment for the gas detection system. (The quotations, pricing information, and system information, where reproducible, are provided in Appendix F. Information not reproducible is available for review from KE.)

A review of the data received from equipment manufacturers showed that the Mine Safety Appliances Company (MSA) has both the infrared analyzer systems and the catalytic bead thermal catalytic sensor systems as well as catalytic bead thermal catalytic analyzer systems. MSA is one of the oldest manufacturers of mine safety equipment and has a good reputation within the industry. Because of these factors, and the fact that their initial pricing information was comparable to that of other vendors, MSA was used as the sole basic equipment pricing source.

The pricing information received for the centralized analyzer system is based on the manufacturer's "best estimate" for an analyzer complex with additional material and installation labor costs from KE's Estimating Department (see minutes of meeting, June 22, 1983 and telecom reports, June 10, 1983 and March 4, 1983, Appendix C).

Pricing information for the local sensor system is from MSA's Quote 8705, March 1, 1983. It was modified by discussions with MSA and additional material and installation labor costs from KE's Estimating Department (see Appendixes F and C). Backup calculations for this comparison are in Appendix C. Table 2-1 summarizes the capital costs for systems with 390 sensing points. A brief discussion of each item follows.

Table 2-1

SUMMARY OF CAPITAL COSTS

Item	Central System	Local System
Analyzers or Control Units	$ 981,500	$ 430,000
Air Compressor	400	Not Required
Calibration Gas Cylinders:		
Prime	2,200	1,800
Spare	2,600	900
Tubing for Probes or Calibration	590,600	72,800
Cable:		
Signal	238,500	744,100
Power	133,600	Included
Initial Spare Parts	53,000	39,100
TOTAL	$2,002,400	$1,289,100
Annualized Cost	$ 246,900	$ 158,900

A. Analyzer Cost: The analyzer cost is based on using MSA Lira (TM) Model 3000, nondispersive infrared analyzers complete with filters, pumps, timers, valving, and enclosures (see Appendices C and F).

A total of 65 analyzers are required due to the practical limit of analyzer-to-probe distance being approximately 700 feet. This, in turn, limits to six the number of probes spaced 500 feet apart, i.e., three in each tunnel, and one in the analyzer room.

Using a duplex pump set, with one as standby, and time-operated 3-way valves in the probe lines, it will take about 30 seconds for a fresh sample of gas from the farthest probes to reach the analyzer, and about 2 seconds for a fresh sample from the nearest probes. Allowing another 5 seconds for the sample tube to be purged results in a 2.5- to 3-minute total cycle time. As confidence and experience with the system grows, the cycle time may be reduced. Even so, the practical limit is approximately 15 to 30 seconds.

B. Control Unit Cost: The control unit cost for local systems is based on MSA Model 516-N monitors and includes MSA Model 512 catalytic bead-type thermal catalytic sensors with calibration attachment. Each monitor can handle up to 16 sensors, and the sensors can be located up to approximately 5,000 feet from the monitor without special signal amplifiers.

Assuming the monitors can be located in the passenger stations, 25 monitors will be required, one of which will have only six sensors. Each of the other monitors will control eight sensors spaced 500 feet apart in each tunnel.

Because each sensor sends a continuous signal back to the monitor and DTS, the cycle time for each sensor will depend upon the speed of the multiplexing unit in the DTS.

C. Probe Tubing: The probe tubing of the central system must be cleaned periodically. This will be done with low pressure compressed air. Sears & Roebuck has portable units for about $400 each.

D. Analyzers and Sensors: The analyzers of the central system and the sensors of the local system must be calibrated frequently. Initially, both will be calibrated once a week. This may or may not be reduced as experience with the system is gained. For this study, costs are based on once-a-week calibration.

E. Cylinders: The central system will require four cylinders, containing 240 cubic-foot of calibration gas, each week. In order to assure an adequate gas supply, an additional six cylinders will be needed as part of the initial purchase.

The local system will require two 240-cubic-foot cylinders every two weeks, one for each tunnel. In order to assure an adequate gas supply, an additional four cylinders will be needed as part of the initial purchase.

Costs for the cylinders were obtained from MSA. Cart cost is estimated. It is recommended that SCRTD investigate the advantages and disadvantages of owning versus renting cylinders.

F. Tubing: Tubing costs for the central analyzer probes and for the sensors, to permit sensor calibration from the tunnel walkway level, are based on 3/8-inch 316 stainless steel. Material costs and installation labor time requirements were obtained from KE's Estimating Department. The labor rate is assumed to be the same as construction electrician rates for Los Angeles, $33.75/hour.

G. Signal Cable: The central analyzer system will require 12 conductor signal cables for individual probe location, alarm, warning, and trouble signals. The cable is assumed to be 14 gauge and laid in the cable trough along the tunnels with junction boxes at analyzer locations, conduit fastened to the tunnel ceiling from the cable trough to the analyzers, and conduit to the DTS in the stations. Material and labor costs and installation time requirements, except connections to the DTS and analyzer, were obtained from KE's Estimating Department.The costs for connecting to the DTS and analyzers are allowances based on other estimates for similar work.

Power cable to the analyzers are assumed to originate at the passenger stations, with any required power source redundancy at the point of origin. The cable would be installed in a similar manner as the signal cable. Material costs and installation time requirements are adapted from cost estimates of similar work.

H. Conductor Cable: The local system requires four conductor cable from the monitors to each sensor. Two conductors are for low voltage, 12V or 24V, dc power and two are for signals. Average cable size is assumed to be 18 gauge. The cable is run in conduit from the monitor, to the tunnel trough, through the trough to individual sensor locations, junction box, and conduit to the ceiling mounted sensor. Cable cost is adapted from MSA Quote 8705. Conduit and installation unit costs are assumed to be same as for the central analyzer.

Power cable to the monitors is assumed to be negligible for this study's purposes because of the proximity of the monitors to the sources.

I. Spare Parts: The initial spare parts costs were developed after discussions with MSA and KE engineers experienced in estimating spare parts requirements.

It is recognized that not all accounting systems will permit items such as calibration cylinders and initial spare parts to be classified as capital costs. It should be noted that in this study, capital costs include those items because they are required, or may be required, during the startup and first year of operation.

The total and individual costs should not be construed to be a true system installed cost estimate, nor should the equipment pricing be construed as binding on the vendor. The level of effort applied to the estimates was commensurate with the requirements of this study. Firm equipment pricing can only be obtained after specifications are developed. An installed cost estimate can only be made after detail design of the system has progressed further.

2.6.2 Annual Costs

Annual costs considered include calibration gas, spare parts, labor, and power. These are summarized in Table 2-2 and discussed below.

Table 2-2

ANNUAL COSTS

Item	Central System	Local System
Calibration Gas	$ 12,600	$ 2,100
Spare Parts	43,900	22,600
Labor	596,700	494,700
Power	34,700	3,900
TOTAL	$687,900	$523,300

A. Calibration Gas: The quantity of calibration gas required is based on information from MSA, with an allowance made for the local system's sensors having calibration tubing to tunnel walkway level.

Calibration gas costs were obtained from Airco Industrial Gas Company for 2% methane in air and include gas analysis costs (see Capital Costs 2.6.1).

B. Spare Parts Costs: See Capital Costs, 2.6.1

C. Labor Costs: Labor costs are based on time requirements for calibration, plus allowances for other maintenance costs. A 1.5 multiplier was applied to the costs for calibration and other work in the tunnels since this work must be done when trains are not operating. A labor rate of $33.75 per hour was used.

D. Power Costs: Power costs are based on $0.07/KWH and each system operating continuously. Power requirements for the central system are estimated to be 870 watts per analyzer and, for the local system, 254 watts per monitor.

2.6.3 Annual Equivalent Cost

The annual equivalent cost is shown in Table 2-3. This is the sum of the capital costs on an annualized basis and the annual costs.

Table 2-3

ANNUAL EQUIVALENT COSTS

Item	Central System	Local System
Annualized Capital Cost	$246,900	$158,900
Annual cost	687,900	523,300
TOTAL	$934,800	$682,200

2.6.4 Technical Risks

Either the central system or the local system can be successfully adapted from their current applications in mines, refineries, and heavy industries to the SCRTD Starter Line. The record of satisfactory operations, particularly in the coal mining industry, indicate such an adaptation will be a low risk application.

2.6.5 Availability

Due to the stringent CFRs for coal mines and "gassy" noncoal mines, the relatively new, proven, cost effectiveness of methane monitoring as applied to mining process control, and the number of industries using the same or similar equipment for combustible gas monitoring, there is no foreseeable shortage of either type of methane monitoring equipment or replacement parts for the equipment.

2.7 CONCLUSIONS AND RECOMMENDATIONS

2.7.1 Conclusions

Overall, the local sensor system is more cost effective for the SCRTD Starter Line than is the central analyzer system.

A. Other favorable factors of the local sensor system include:

   1. Initial costs are less than those for a central system.

   2. Power, spare parts, and consumable items are less costly than for central systems.

   3. The equipment is available from more manufacturers than is the central system equipment.

4. In general, the local system is more adaptable to changes and modifications than the central system. This is due to the distance from monitors that the sensors can be located and to the difference in cable conduit installation versus stainless steel tubing.

5. The local system will respond quicker to changes in methane concentrations due to differences in sensor versus probe cycle time.

6. The loss of a module in a monitor results in the loss of one sensor length of one tunnel, affecting 500 feet. The loss of an analyzer, pump set, or timer will result in the loss of seven probes, with both tunnels affected for 1,500 feet.

7. The monitors are fully utilized in the local system, whereas the analyzer is under utilized due to probe distance limitations and the need for only 0% to 5% methane detection rather than 0% to 100%.

8. The local system is less mechanically complicated and makes greater use of state-of-the-art, solid-state technology than the central system.

9. The local system may be more reliable than the central system. This is indicated by changeovers in European mines, the higher frequency of use in U.S. mines, and the greater use of state-of-the-art technology, as well as less frequently scheduled maintenance.

10. Modules within the monitors are similar to other modules with the SCRTD equipment, whereas the infrared analyzers are unique.

11. Considerable effort is being expended by manufacturers and government research centers on improving catalytic bead thermal catalytic sensors and developing direct replacement sensors that are more efficient than current models.

12. Individual sensors of the thermal catalytic type are presently in use in heavy rail rapid transit systems for gasoline vapor detection. There have been no installations of infrared detectors reported in such transit systems.

B. Disadvantages of the local system include:

1. Sensor life is short, averaging three years or less, due to the primary element being consumed during operation.

2. Sensor replacement, as currently envisioned, may tie up the section of track in the replacement area.

2.7.2 Recommendations

Kaiser Engineers recommends that SCRTD authorize the system designers to proceed with designing and specifying a local sensor-type methane detection system.

This recommendation is based on an evaluation of the conclusions. Factors other than cost that influence this recommendation are:

A. Local sensor systems appear to be more reliable than central systems.

B. Local sensor systems are preferred by U.S. mining companies.

C. Considerable research and development effort is being expended to extend sensor life by new or improved elements which are interchangeable with existing sensors.

D. The loss of one module of a monitor results in the loss of one sensor. The loss of an analyzer, pump set, or timer results in the loss of seven probes.

Chapter 3

TUNNEL CAR STORAGE AREA FIRE DETECTION SYSTEM

3.1 INTRODUCTION

Conventional spot-type fire detector systems will be installed throughout all station ancillary areas where automatic sprinkler protection is not required and in traction power substations, gap-tie stations, unit substations, pump and valve rooms, and ventilation systems. The tunnel car storage area, located north of the North Hollywood Station, however, presents situations and requirements which may be beyond the capabilities of conventional detector systems.

The primary source of fire on transit cars is the equipment under the car passenger area floor (see Appendix E). This is an area about three feet, eight inches above the top of the rail and essentially as long as the car, which is about 75 feet. The car body and air currents or ventilation will alter the normal flow of the heat and combustion products from these fires.

Secondary fire sources are within the occupant areas of the cars from arson and the heating, air conditioning and ventilation system. These are enclosed areas in which the products of combustion may accumulate for some time before finding their way out of the car, and the car insulation may retain the heat generated.

Another potential fire source will be from materials temporarily placed or stored near the cars, for example, oily rags used by maintenance personnel.

Factors other than the variety of possible fire sources which detract from using conventional fire detection systems include:

A. The physical and environmental conditions which will contribute to false alarms with conventional detection systems.

B. The need for fire department and emergency personnel to have accurate location identification. This is an increased priority item due to the possible disruption of passenger service by either the fire itself or water damage to cars not on fire. Accurate location identification will also minimize fire department and emergency personnel on-site time requirements.

C. The unusual air currents caused by natural drafts, forced ventilation, and train movements in either the tunnels, station or storage area.

D. The types of possible fires.

E. The possible final storage area layout and arrangement which may include walls and platforms proximate to the stored cars.

F. The variable length and location of stored trains; i.e., from one- to six-car trains parked anywhere along the storage tracks.

G. The use of high pressure water to clean the area.

3.2 PURPOSE

The purpose of the tunnel car storage area fire detection system portion of WBS 14CAE12 is to:

A. Research the various fire detection methods available.

B. Select the methods which are suitable for the tunnel car storage area.

C. Evaluate the selected methods.

D. Make a recommendation with sufficient information concerning the recommended method and the other evaluated methods for the SCRTD Metro Rail Staff to decide which method is best suited for the SCRTD Metro Rail System.

3.3 DESCRIPTION OF ALTERNATIVES

3.3.1 General

Initially, the parameters limited alternatives to spot detectors compared with thermistor-type continuous detectors (see February 25, 1983 Memorandum to W.J. Rhine from P.M. Burgess in Appendix C). As the review of fire detectors progressed, however, KE decided to add other types of detectors. This decision was influenced by the possible storage area configurations presented as well as by the possible suitability of other types of detector systems. The types and classifications of detectors available are defined in NFPA 72E-1982, "Standard on Automatic Fire Detectors" (see Appendix E) as follows:

A. Detector Types

1. Spot-Type Detector. A device whose detecting element is concentrated at a particular location. Typical examples are bi-metallic detectors, fusible-alloy detectors, certain pneumatic rate-of-rise detectors, certain smoke detectors and thermoelectric detectors.

2. Line-Type Detector. A device in which detection is continuous along a path. Typical examples are rate-of-rise pneumatic tubing detectors, projected beam smoke detectors, and heat-sensitive cable.

3. Air Sampling-Type Detector. A sampling-type detector consists of piping or tubing distribution from the detector unit to the area(s) to be protected. An air pump draws air from the protected area back the the detector through the air sampling ports and piping or tubing. At the detector, the air is analyzed for fire products.

B. Detector Classifications

1. Heat Detector. A device which detects abnormally high temperature or rate-of-temperature rise.

2. Smoke Detector. A device which detects the visible or invisible particles of combustion.

3. Flame Detector. A device which detects the infrared, or ultraviolet, or visible radiation produced by a fire.

4. Fire-Gas Detector. A device which detects gases produced by a fire.

5. Other Fire Detectors. Devices which detect a phenomenon other than heat, smoke, flame, or gases produced by a fire.

3.3.2 Spot-Type Heat Detectors

Spot-type detectors may operate with either restorable or nonrestorable elements and may use either or both fixed temperature or rate-of-(temperature)rise operating principles. the detectors range in cost from about $15 to $75, or more, each.

A. Restorable elements are usually either bi-metallic or fluid, commonly air, devices although thermoelectric principles are sometimes applied.

1. The bi-metallic types may be either the reed type contact or snap-action disk type. The reed type may be either fixed temperature or a combination of fixed temperature and rate-of-rise devices, and some can be field adjusted through a temperature range. The reed types are subject to false alarms due to vibrations especially at elevated temperatures. The disk types are fixed temperature and are usually mounted on a surface directly heated by the fire.

2. Pneumatic elements typically are combination fixed temperature and rate-of-temperature rise devices. The elements are available in a variety of configurations including types which vent to and/or draw from the atmosphere and double-ended diaphrams. Both FM 5-48 (see Appendix E) and NFPA 72E-1982 recommend that detectors with pneumatic elements be tested semiannually, at least, for leaks and proper operation.

3. Thermoelectric elements include fixed temperature electric resistance devices and thermocouple or thermopile units which may be either or both fixed temperature or rate-of-rise devices. FM 5-48 cautions that these units are subject to lowering of sensitivity by corrosion.

B. Nonrestorable element detectors use spring (or equivalent) loaded contacts held apart by metal alloy links (fusible links) which melt quickly at the rated temperature. The links must be replaced after activation; therefore, the detector operation can not be tested periodically as with restorable element detectors. NFPA 72E-1982 does recommend, however, that at least two out of every 100 detectors, or fraction thereof, be removed every fifteenth year and tested by a testing laboratory.

3.3.3 Line-Type Detectors

Four types of line-type detectors were considered as potentially applicable.

A. Thermistor Type

These are restorable detectors that utilize the thermal-electric phenomenon of certain ceramic materials, which changes electrical resistance dramatically from a near insulator to a conductor near rated temperatures to detect fires. The control and monitoring circuitry associated with these detectors has been developed to provide warning annunciation when temperatures along the element approach the rated temperature, location of the fire (rated temperature or more) or over temperature, and average temperature as well as alarming fires (fixed temperature or rate-of-rise), and providing detector circuitry monitoring. These detectors cost about $8/foot not including controls.

B. Heat Sensitive Cable

These are nonrestorable, fixed-temperature devices which are activated when two wires make electrical contact after their heat-sensitive insulation softens at the rated temperature. The control and monitoring circuitry associated with these detectors can be modified to provide location of the fire and alarming fires (fixed temperature) and provide detector circuit monitoring. These detectors cost about $5/foot not including controls.

C. Pneumatic Tubing

These are restorable detectors which use the thermal expansion characteristics of air to cause contacts to be closed when rated temperature is reached and/or when the rated rate-of-rise is exceeded. The associated control systems are not readily adapted to fire location identification or malfunction monitoring. Small fires may not be detected and coincident temperature drops along other parts of the tubing may preclude fire detection.

D. Series Type

These are small fixed-temperature detectors installed in a series along a cable. Although the associated control systems reportedly are able to provide fire location identification, no manufacturer of this type of detector responded to inquires by KE.

3.3.4 Fire-Gas Detectors

Fire-gas detectors may be either local spot (sensor) type or centralized-analyzer type (air-sampling type detector as defined by NFPA 72E-1982) with system configurations very similar to those of the gas detections systems described in Chapter 2 of this study. For fire detection purposes, these detectors typically monitor carbon dioxide, but may also monitor oxygen. Based on the information received for the gas detection systems, the local spot-type detectors cost around $400 to $1,00 each and related monitors cost about $5,000. Centralized systems may cost around $15,000 each.

3.3.5 Other Fire Detectors

Other fire detectors, as defined by NFPA 72E-1982, may have either spot-type detector or air-sampling type detector configurations. Such detectors tend to be for esoteric situations and were not considered in this study.

3.3.6 Flame Detectors

Flame detectors provide very fast response, one second or less, to fires that occur within their cone of vision. These detectors range in price from about $300 to $2,000 each. The following descriptions and comments are from FM 5-48:

A. The infrared detector contains a sensing element that is responsive to radiant energy at wavelengths below the range of human vision. This is usually above approximately 7700 Angstroms.

B. The ultraviolet detector contains a sensing element that is responsive to radiant energy above the range of human vision. This is usually below approximately 4000 Angstroms.

C. The photoelectric flame detector contains a sensing element comprised of a photocell which either changes its electrical conductivity or produces an electrical potential when exposed to radiant energy.

D. A flame flicker detector consists of a photoelectric flame detector including a means to prevent response to visible light unless the observed light is modulated at a frequency characteristic of the flicker of a flame (4-30 Hz).

E. Flame detectors should be arranged or shielded so that they are not actuated by radiant energy sources that could produce false alarms. Infrared lamps, matches, cigarette lighters, and sunlight may result in an unwanted alarm from an infrared detector. False alarms from ultraviolet detectors may be produced by germicidal lamps, X-ray machines, welding arcs, and arcing from electrical motors.

F. Flame radiation detectors are also adversely affected by slight accumulations of dust or other coatings on the lens or sensitive element. Again, the frequency of cleaning depends upon the operating environment.

3.3.7 Smoke Detectors

In keeping with the design criteria, smoke detectors were not considered.

3.3.8 Control Systems

A. All fire detection systems considered can be designed to conform to the CAC and SCRTD requirements and NFPA standards cited in the Fire/Life Safety Criteria.

B. Spot-type detector and flame detector systems can provide fire location identification by having control modules operate in a nonmatrix mode so that each actuated detector causes its respective alarm light to be illuminated at the local Fire and Security, EMP, and, through the Communication System, Central Control. Neither type detector system can provide either warning signals for prefire overtemperature conditions or detector zone average temperature signals, except spot detectors utilizing thermoelectric elements.

C. Thermistor line-type detector systems are commonly furnished with fire location identification and warning signals for prefire overtemperature conditions, and can readily be modified to provide average detector temperature signals.

D. Heat-sensitive cable systems can be modified to provide fire location identification, but not overtemperature warnings or average detector temperature.

E. Fire-gas type detector systems do not furnish temperature related signals. The location of the alarming detector or probe can be identified and warning signals based on the monitored constituent concentration levels can be provided.

3.4 APPLICATION HISTORY

3.4.1 Transit Systems

A pursual of heavy rail rapid transit systems yielded no reports of fire detection systems in operation in situations similar to the SCRTD tunnel car storage area. Both the BART and NYCTA systems are reportedly considering reto-fitting fire detection systems in certain tunnel sections. The fire detection system being considered by BART uses thermistor line type sensors and will be installed on a trial basis, see April 15, 1983 Minutes of Meeting in Appendix C.

3.4.2 Industry and Other

All detectors considered are currently in use in heavy, light, and mining industries, and most are in use in utilities, commercial establishments and other applications.

A. Industries tend to use a combination of detector types depending upon the fire sources and physical and environmental conditions.

B. The mining industry tends to use fire-gas, line- and spot-type detectors in mines and shafts; however, problems with the sensitivity of heat-sensing detectors in some areas have led to their replacement with fire-gas type detector systems.

3.5 METHODOLOGY

The usual procedures for evaluating alternatives was deviated from with this fire detection system. No cost analysis was made because of the impact the final storage area arrangement will have on the fire detection system configuration and detector types used. Additionally, the system size indicates that the total equipment cost will be less than $75,000 to $100,000.

3.5.1 Design Criteria

A. Paragraph 8.6, "Early Warning Fire Detection Apparatus," of the November 9, 1982, revision to the SCRTD Metro Rail Subsystem Design Criteria, Volume IV, Section 8, "Miscellaneous Mechanical/Electrical Subsystems" is to be modified in two places, i.e.:

   (1) Fire detectors will be required in the tunnel car storage area only, rather than in all tunnels.

   (2) If accepted by the SCRTD Metro Rail Staff, the type of detector(s) in the tunnel car storage area will be as recommended by this study, rather than "combination of fixed and rate-of-rise temperature sensing."

B. Other applicable parts of the above-mentioned design criteria were applied, including the exclusion of smoke detectors from the tunnel area.

3.5.2 Assumptions

Assumptions applied to individual detector types are identified in the comments under Section 3.6, "Results."

3.6 RESULTS

3.6.1 General

No one type detector is suitable for detecting all types of fires, and the type detector most suitable for one area arrangement may not be suitable at all for another area arrangement even though the fire source remains the same.

3.6.2 Detector Features and Limitations

Detectors have general features and limitations to be considered including:

A. Heat sensing detectors should be close to the fire source to provide an early alarm, even then selectivity and sensitivity may be lacking.

B. Spot-type detectors will require additional wiring and nonmatrix annunciation to provide fire location identification, and will require closer than normally required spacing in order to provide fire location identification comparable to the line-type detectors considered.

C. Nonrestorable elements must be replaced after activation, even if the detector is not damaged.

D. Flame detectors provide fast response, but must be located so that the fire sources are within their cone of vision which may require additional detectors viewing the same fire source area from different angles. Space requirements may be greater than for other detector types in order for the fire sources to be within their cone of vision. Lenses must be kept clean, which increases maintenance costs. Electrical arcs may cause false alarms. Smoke may interfere with operation. Reflections may cause false alarms.

E. Line-type detectors must be protected from physical damage, especially heat sensitive cable and pneumatic tube types.

F. Detectors sensitive to water will be unacceptable because of the tunnel cleaning procedures.

G. Detectors sensitive to pressure transients will be unacceptable because of the piston effect of moving trains.

H. Detectors with mechanical contacts will require additional maintenance to asssure that electrical connections are properly made. Vibrations may cause false alarms.

I. Temperature averaging thermocouples may lack selectivity when unusual ambient temperatures occur.

3.6.3 <u>Undercar Equipment Fires</u>

A. Undercar equipment arrangement, potential fire sources, and possible fire consequences indicate flame type detectors should be used if possible.

1. These detectors will have to be arranged in a "look back" type configuration due to blockages of the cone of vision by the equipment being protected, and will have to be located on both sides of each storage track to provide complete protection.

2. Because of potential cone-of-vision blockages by temporary obstructions, heat-sensing or fire-gas type detectors should be provided as backup for the flame type detectors.

3. Flame detectors should include internal circuitry for checking lense clarity and for adjusting sensitivity so that normal operational and maintenance related electrical arcs and other activities, including reflections from car bodies and equipment housings do not cause (or, at least, minimize) false alarms.

B. If space limitations on either or both sides of the storage tracks preclude the use of flame type detectors, heat-sensing detectors located as near the undercar equipment as practical should be used.

1. Thermistor line type detectors with combination fixed temperature and rate-of-rise features should be used where possible. These operate without mechanical contacts which may be tripped by vibration, require less maintenance than other rate-of-rise detectors, are less susceptible to physical damage than other line-type detectors, and provide more information than most other detector systems.

2. Where line-type detectors can not be used, vibration/shock mounted, waterproofed combination fixed temperature/rate-of-rise type spot detectors may be applicable.

3. Detector redundancy may be provided by fire-gas type detectors or ceiling-mounted, heat-sensing detectors.

3.6.4 Car Compartment Fires

Flame type detectors are the only detector considered that can see through the car windows into the operator and passenger compartments for early detection of fires. Either heat-sensing or fire-gas type detectors will be needed for redundancy, and can be the same system providing redundancy for the undercar equipment primary fire detection systems.

3.6.5 Storage Area Fires

Ceiling-mounted, heat-sensing detectors will detect fires in the storage area. These detectors may well be the redundant system for the undercar equipment and car compartment primary fire detection systems.

3.6.6 Other Considerations

A. Fire-gas type detectors for monitoring oxygen and carbon monoxide may provide quicker response than heat-sensing detectors because of the normal air movements within the storage area.

B. Heat-sensing scanners as used for kiln shell temperature monitoring in the portland cement and other industries, or other heat sensitive scanners used for detecting hot spots and heat leakage perhaps could be adapted to provide overtemperature surveillance of the trains on the storage tracks from a central location. These devices were not considered in this study because the scanners are not generally used for fire detection systems.

3.7 CONCLUSIONS AND RECOMMENDATIONS

3.7.1 Conclusions

The three most probable sources of fire, i.e., under equipment, car compartment arson and equipment, and miscellaneous items in the storage area, and the resulting types of fires and their consequences (for example, see the National Transportation Safety Board, Report No. NTSB-SEE-81-1, "Safety Effectiveness Evaluation of Rail Rapid Transit Safety," January 22, 1981, available through the National Technical Information Service), indicate a multiple detector type system will be required. The types of detectors most suitable can only be determined when the tunnel car storage area configuration is established.

3.7.2 Recommendations

A. Flame type detectors should be used as the primary fire detection system for the undercar equipment and car compartments.

B. Ceiling-mounted, heat-sensing type detectors with combination fixed temperature and rate-of-rise capabilities should be used as the primary fire detection system for the storage area and as backup for the primary fire detection system.

C. If air movements are relatively high, fire-gas type detectors monitoring oxygen and carbon dioxide should be provided as a redundancy to both primary fire detection systems.

D. Wall or platform mounted heat-sensing type detectors with combination fixed temperature and rate-of-rise capabilities should be used for undercar equipment only if space limitations preclude the use of flame-type detectors.

E. Thermistor line type detectors are the most suitable heat-sensing type detector for the storage area.

F. Consideration should be given to TV monitoring of the storage area.

Chapter 4

SEISMIC DETECTION SYSTEM

4.1 INTRODUCTION

The proposed Metro Rail System alignment crosses at least 12 geologic faults. The Geotechnical Investigation Report, Volume 1, lists these in the following sequence from downtown Los Angeles to North Hollywood:

- MacArthur Park Fault
- 6th Street Fault
- 3rd Street Fault
- San Vicente Fault
- Santa Monica Fault (zone)
- Hollywood Fault
- Hollywood Bowl Fault
- Unnamed Fault (north of Boring CE9 32)
- Unnamed Fault (north of Boring CE9 32A)
- Benedict Canyon Fault
- Unnamed Fault (north of Boring CE9 36)
- Unnamed Fault (north of Boring (CE9 38)

The Metro Rail System will be designed to withstand earthquake activity; however, effective monitoring of ground movements is considered critical for safe operation and maintenance of the railway system. In the tunnel, earth movement monitors will be deployed and indicate to Central Control any significant earth tremors.

4.2 DESCRIPTION OF ALTERNATIVES

Basically, there are two types of seismic detection systems: the Strong Motion Accelerograph and the Seismic Trigger. (See Appendix E.)

4.2.1 Strong Motion Accelerograph

The strong motion accelerograph is an earthquake recorder specifically designed to measure and provide a permanent detailed record of acceleration from local earthquakes.

The level of sensitivity for these devices ranges from 0.005g to 1g. Triaxial recording on magnetic tape is provided when the accelerograph is triggered by significant local earthquakes and aftershocks.

4.2.2 Seismic Trigger

The seismic trigger is a triaxial acceleration switch; when the applied acceleration reaches a preset level, a switch is closed, and stays closed for a period of time. The switch closure is used to signal the occurrence of the earthquake to Central Control, where appropriate safety action will be initiated.

The trigger is comprised of three sensor-relay modules (1 vertical, and 2 horizontal), a 12-volt battery, and a cast aluminum housing. In turn, each sensor-relay module contains a sensing mechanism, an amplifier, and a relay-switch. The sensor is a damped spring-mass system which produces a voltage output by means of a coil moving in a magnetic field. The voltage produced by the sensor is amplified and the amplified voltage closes a relay which actuates an annunciator at Central Control, via the DTS. The level of sensitivity of these devices ranges from 0.005 to 1g, but the setting should be such that it is not affected by vibrations induced by the trains and other sources. These sensors are frequency selective to minimize unwanted triggering.

4.3 APPLICATION HISTORY

Earthquake monitoring equipment has been used in BART and in transportation systems in Venezuela. The BART earthquake monitoring system uses Kinemetrics Seismic Triggers and has been in operation for five years. The Metro System in Venezuela uses the Kinemetrics SMA-3 Strong Motion Accelerographs, and has been in operation for over a year. In the transportation industry the seismic detection system has not performed with any consistent degree of reliability. This is based on recent experience with BART system where the seismic detectors have not responded during several earthquake episodes.

4.4 METHODOLOGY

In addition to the critical evaluating factors discussed in Chapter 1, the following factors are applicable:

4.4.1 Design Assumptions

- o The earthquake monitoring system will be connected to the emergency power system.
- o The system will be designed to operate every day of the year, 24 hours a day. The components chosen will be of heavy-duty application with a proven history of reliable operation.

- The system will be designed for automatic operation in remote areas with minimum maintenance.
- While the seismic control system for elevators and escalators is not included in this study, it is recommended that it be looked into as a part of the elevator/escalator emergency stopping system.
- The seismic detection systems for the station structures are also not included in this study.

4.5 RESULTS

4.5.1 Capital Costs

The capital costs for the two different types of monitors are shown in Table 3-1. The costs have been obtained from the manufacturers and include only that of basic equipment. A breakdown of the Table shows the unit cost per sensor to be $2,300 for Alternate 1, and $3,500 for Alternate 2.

Table 4-1

COMPARATIVE UNIT CAPITAL COSTS

	ALTERNATE 1	ALTERNATE 2
	* Seismic Trigger	** Strong Motion Accelerograph
No. of sensors	1	3
Cost of basic equipment	1800	10,000
Cost of Calibrators	500	500
TOTAL CAPITAL COST	$2300	$10,500
Total Capital Cost per Sensor	$2300	$ 3,500

* Used in BART System

** Used in Venezuela Metro System

A. Costs associated with installation of equipment and procurement and installation of cables are considered equivalent to both the alternatives and have not been included in this analysis.

B. This assumes distribution of sensors essentially along the full length of the tunnel system.

4.5.2 Operating Costs

Spare parts are assumed to be 10% of the initial capital costs. This includes the cost of calibration system.

	ALT 1	ALT 2
Spare parts/probe/year	$230	$350

4.5.3 Maintenance Cost

The maintenance labor and power costs for both the alternatives are considered identical and would not have any impact on the final selection, thus they have not been included in this analysis.

4.5.4 Annual Equivalent Cost

A further breakdown of the cost per sensor is itemized in the following Table 4-2.

Table 4-2

	ALT 1	ALT 2
Annualized Capital Cost (per sensor)	283	431
Annualized Operating Cost (per sensor)	230	350
ANNUAL EQUIVALENT COST (per sensor)	$530	$781

4.5.5 Technical Risks

Industrial use of seismic detection is only about a decade old; seismic detection systems have been in use in nuclear power plants since 1972. A partial list of places where these devices are is in Appendix E. Although the reliability and accuracy of seismic detectors has improved with more widespread use, they are still considered to be a develcping technology--hence high risk items.

4.5.6 Availability

Kinemetrics manufactures an extensive line of seismic detection equipment. While the simpler models, such as Alternative 1, are more readily available than the more sophisticated models, such as Alternative 2, replacement electronic components for both alternatives are readily available.

4.6 CONCLUSIONS AND RECOMMENDATIONS

The seismic trigger system will, at modest cost per location, provide instant information to Central Control as to the occurrence and location of an earthquake. This is the system chosen by BART. It is recommended that a trigger sensor be provided at each identifiable location of a geologic fault along the tunnels.

It is also recommended that permanent accelerometer recordings be provided along the system. These would improve the level of engineering information available for future corrective actions, if required. The recommendation is that three strong-motion recording accelerometers be installed, one in the Union Station zone, one in the Santa Monica Mountains zone, and one in the Valley Basin zone. Each such unit would have three remote accelerometer sensors, one close to each of the seismic areas judged to be the most active along the route. In the event of an earthquake, the trigger will activate the alarm indicating the location where acceleration exceeds the preset limit. Simultaneously, the accelerograph will record the intensity in that zone and can be recalled for postearthquake investigation relating to structural damage, etc.

The capital cost estimates are shown for unit cost per probe. The total cost figures will be developed after the actual number of sensors are ascertained in WBS 16CAE1211 work.

Based on preliminary discussions with the BART staff and the apparent failure of their seismic detection triggers to respond during several earthquake episodes, it is recommended that an indepth study be undertaken of seismic detection system operation history and reasons for failures to respond to seismic events.

Chapter 5

TUNNEL SUMP PUMP SYSTEM

5.1 INTRODUCTION

Water may enter the tunnels of the SCRTD Starter Line from any of several sources, including:

A. Seepage from groundwater: The tunnel lining is to be designed and constructed to restrict this inflow to a maximum of 0.03 gallons per day per square foot of liner surface, which converts to about six gallons per minute per mile of tunnel.

B. Tunnel washing: This periodic operation will use an estimated 100 gallons per minute.

C. Fire fighting: Each hose may spray up to 500 gallons per minute.

D. Rain through vent shafts and portals: This varies with the opening design and the weather.

E. Leaks in fire standpipes and other water lines: These are usually detected and repaired before significant flow rates occur for substantial periods of time.

This water will drain by gravity along sloping surfaces to a trough along the centerline of each track. The troughs lead to small drain pits at the low points in the track grade. A drainage pipe in the pit will direct the water to sumps located between the tunnels and adjacent to tunnel crosspassages. Periodically, the water will be pumped from the sumps to the nearest storm sewer or other approved disposal point.

Although the collection and disposal of drainage water predates mankind, and mechanical pumps have been in use for thousands of years, the selection of the most economical method for a given situation requires careful consideration. For example, the Manual for Highway Storm Water Pumping Stations, Volume I, U.S. Department of Transportation, lists 22 different criteria to be determined and includes a selection matrix based on 72 different general design features. Only one of the criteria and six of the design features in that manual are not applicable to the system being considered after it has been adjusted for the SCRTD Starter Line.

5.2 PURPOSE

The purpose of the tunnel sump pump system portion of WBS 14CAE12 is to:

A. Identify the types of pump systems available for sump service

B. Select the pump systems which are suitable for tunnel service

C. Evaluate the selected pump systems

D. Make a recommendation, with sufficient information concerning the recommended pump system and the other selected systems, for the SCRTD Metro Rail staff to decide which system is best for the SCRTD Starter Line.

5.3 DESCRIPTION OF ALTERNATIVES

There are three basic methods of disposing of the collected water:

A. Use no sump, but rather pump water out as fast as it comes in

B. Use a dry-pit type sump system

C. Use a wet-put type sump system.

The no-sump method is impractical because of the highly variable inflow rates. On January 17, 1983, SCRTD, Fitz Consultants, and Kaiser Engineers (California) Corporation (KE) agreed this study would evaluate dry-pit and wet-pit sump systems only (see Appendix C). General descriptions of each type of sump systems are as follows:

5.3.1 Dry-Pit Sump

Dry-pit sumps, also called dry-well sumps, are constructed in a horizontal configuration. For systems of the size being considered there are two separate rooms, each with about the same floor elevation. One room is the water collection sump and in the other, the pump room, are controls, motors, pumps, and piping. The pump suction line extends horizontally through the sump wall and terminates at an appropriate level in the sump. Water-level actuated automatic controls start and stop the pumps. Water leaked from pump seals or the suction line sleeve, etc., is returned to the sump by a separate small pump. (An example of a dry-pit sump in a rapid transit system is depicted in Appendix E.) Pumps used in dry-put sump systems include:

A. Horizontal centrifugal: The most commonly used type

B. In-line centrifugal: Usually used where space is limited

C. Vertical angle flow: Usually used where space is limited

D. Screw: Used for low head (35 feet or less), free discharge applications; this is not suitable for the SCRTD Starter Line.

Automatic level controls are applicable to both the dry-pit and wet-pit sump systems.

5.3.2 Wet-Pit Sump

Wet-pit sumps are constructed in a vertical configuration, with the equivalent of the dry-pit pump room located on the "roof" of the water collection sump. (An example of a wet-pit sump in a rapid transit system is depicted in Appendix E.)

Pumps that are used with wet-pit sump systems include:

A. Vertical angle flow, dry motor: Motor is in the pump room; impeller assembly in the sump; this is a commonly used type.

B. Vertical angle flow, submersed motor: Both motor and pumps are in the sump; this type is also commonly used.

C. Horizontal centrifugal: Both motor and pump in the pump room; this type requires special priming features; it is not unusual, but it is not commonly used.

D. Axial flow and mixed flow: Usually vertical dry motor for sump applications, but can be either horizontal or vertical submersed motor; used for very large flow rates and water wells; these are not applicable to system being considered.

5.4 APPLICATION HISTORY

The dry-pit and wet-pit sump systems being considered are presently providing satisfactory service for rapid transit systems (see drawings, Appendix E). The basic configurations have been adapted by industries, utilities, municipalities, and others needing to collect water from one or more sources for transfer to another area.

5.5 METHODOLOGY

In addition to the methodology parameters discussed in Chapter 1, the following parameters were applied to the tunnel sump pump system analysis:

5.5.1 Design Criteria

A. Applicable portions of the SCRTD Metro Rail Subsystem Design Criteria, Volume IV, Section 8 - Miscellaneous Mechanical/Electrical Subsystems including:

1. A Central Control facility. . .will contain the necessary displays, control consoles, communication apparatus, and operating personnel for the overall safety and security passengers and for the daily operations. . . .

2. Sump pumps shall be located at low points in tunnels and shall be sized to handle water resulting from infiltration, weather, fire fighting operations, and other sources.

3. Two pumps shall be utilized at each installation; each pump shall handle full anticipated load. Controls shall be such that, under normal conditions, one pump is operating and one is at standby. In order to equalize usage of each pump, control circuits shall be designed so that pumps operate alternately.

4. Sump pumps...shall be designed to accommodate solids of up to two inches in diameter.

5. Operating voltage for the electric motors shall be rated at 460 volts, 60 hertz, 3-phase.

6. Electric control apparatus shall be convenient to disconnect for maintenance purposes. Also, where automatic operation is involved, local controls shall facilitate manual override of the automatic controls to assist in performing maintenance.

7. Pumps shall be activated by float switches. A high-water indicator shall be included to start up the standby pump when the water level continues to rise with one pump in operation. An alarm indication shall be received at Central Control if the water level continues to rise after the second pump has been activated.

8. Sump pumps shall be equipped with hour meters to assist in scheduling preventive maintenance and

for indicating erratic operation of the control element.

9. The pumps shall be installed in a pit. Dimensions of the pit shall be such that all parts of the pumps requiring periodic maintenance shall be easily accessible.

10. Maintenance, installation, removal, and other repair operations shall be capable of being performed without interruption of revenue service. Mechanical lifting devices, such as fixed rings, hooks, etc., shall be installed in pit structures where appropriate, to aid in handling the sump pumps.

B. Modifications to Section IV-8.10.1 of the abovementioned Design Criteria were made for the following reasons:

1. Permanent or automatic lubrication: Most suitable submersible pumps require periodic changes of the oil used to seal the motor from the pump and, in some, to cool the motor. (Other comments will be offered during the course of WBS 16CAE1211 work.)

(2) Pumps shall be activated by float switches. The term "float switches" is generally interpreted to include the hollow ball on a rod-type switching device which does not have the history of reliability required for this service.

C. Design assumptions include:

(1) Neither Central Control nor local passenger station equipment (EMP, etc) will control the operation of the pumps.

(2) Primary power redundancy capabilities are not included.

(3) Pump capacity will be 500 gpm.

(4) Sumps will be installed in openings off of tunnel crosspassages.

(5) Sump piping, equipment, hatch covers, and the like will not intrude into the emergency walkway portion of the crosspassage, i.e., no trip hazards.

(6) Submersible pumps should include quick make/break discharge connection and guide rods for positioning.

5.6 RESULTS

5.6.1 Capital Costs

As a general rule, for a given water collection sump capacity, dry-pit sump systems require more horizontal space and less vertical space than wet-pit sump systems. Within the crosspassages, however, the vertical space requirement is essentially the same because of the access requirements. With both sump configurations, personnel will enter both the pump room and the water collection sump from the crosspassage. Therefore, the additional horizontal requirements of the dry-pit sump system will increase construction costs.

The Ways and Structures designers advise that the construction cost of each crosspassage ranges from $150,000 to $170,000. (See minutes meeting, June 6, 1983, Appendix C.) This converts to a unit cost of about $50 per cubic foot of excavation. When applied to the dry-pit pump room, each room with its above-floor access will cost about $114,000 more than the wet-pit pump room and water collection sump combined. For this reason, dry-pit sump systems are not included in the complete cost analysis.

The wet-pit sump system analysis includes the dry motor and the submersible angle flow pumps. Initially, consideration was extended to horizontal centrifugal pumps as well. These were eliminated when reliability criteria was applied.

Horizontal centrifugal pumps require special features to maintain their prime when used in wet-pit sump applications. The features may be designed into the pump or exterior to the pump. In either case, they depend upon air-tight sealing of the pump suction line; this seal can be broken by a leaking gasket, flange bolts that vibrate loose, and other incidents that occur during normal operation. Exterior features can also become blocked, plugged, or otherwise fouled from particles in the water, deposits, and the like. The vibrations from trains, water quality, and probably long periods of inactivity for the pumps combine to increase the likelihood of the loss of prime for these pumps.

The criterion requiring pumps to be capable of passing two-inch solids eliminated other types of pumps from being considered and restricted the types of angle pumps to those with solids handling abilities. In order to obtain representative pricing, two well-established, reputable manufacturers were contacted. These were:

A. For dry motor, vertical angle pumps:
   Goulds Pumps, Inc.
   Seneca Falls, NY

B. For submersible angle pumps:
Flygt Corporation
Norwalk, CT

In order to equalize the equipment pricing, a pump capacity of 500 gallons per minute at 100 feet total dynamic head is used. In the case of the submersible pump, this ran afoul of the manufacturer's standard models. To illustrate this affect, which may occur with any pump manufacturer, the costs for a 500 gallon per minute at 80 feet total dynamic head submersible pump are included in the analysis.

Items common to both systems are not included in the analysis. These include:

A. Basic sump construction: The water collection sump is assumed to be 8 ft x 8 ft x 12 ft deep. The depth is dictated, in part, by the drainage pipe from the tracks.

B. Discharge piping and valving above the sump cover

C. Motor starters and pump controls

D. Power and signal cable and materials.

Table 5-1 summarizes the divergent capital costs on a per sump pump station basis (see Appendix D for backup calculations).

Table 5-1

SUMMARY OF DIVERGENT CAPITAL COSTS

Item	Dry Motor 100 ft TDH	Submersible 100 ft TDH	Submersible 80 ft TDH
Equipment	$15,000	$19,000	$10,600
Installation	3,400	3,200	1,800
Sump Modification	2,000	N/A	N/A
Extra Piping	N/A	900	400
TOTAL	$20,400	$23,100	$12,800
ANNUALIZED COST	$ 2,500	$ 2,800	$ 1,600

Comments concerning capital costs are as follows:

A. Equipment:

(1) Dry motor - Morris Vertical Hydro-Solids Model 4 VHS 12. Weight: 2,000 lbs

(2) Submersible, 100 ft TDH - Flygt Model CP 3201. Weight: 1,265 lbs

(3) Submersible, 80 ft TDH - Flygt Model CP 3152. Weight: 640 lbs

B. Installation: Based on pump weight

C. Sump modifications: For solids-handling dry motor angle pumps, the impeller drive shaft lengths is limited, in this case, to six feet. In order to immerse the impeller, the sump cover must be lowered about four feet.

D. Extra piping: Submersible pump equipment pricing does not include piping from pump discharge assembly to the sump cover. The dry motor pump includes this pipe because it is used for structural/mechanical rigidity.

5.6.2 Annual Costs

Annual costs considered were limited to spare parts and labor, and are summarized in Table 5-2. Power costs were not included because they will be essentially equal, differing only by the difference, if any, in pump efficiencies for the same quantity of water pumped.

Table 5-2

ANNUAL DIVERGENT COSTS

Item	Dry Motor 100 ft TDH	Submersible 100 ft TDH	Submersible 80 ft TDH
Spare Parts	$ 300	$ 400	$ 200
Labor	1,800	200	200
TOTAL	$2,100	$ 600	$ 400

Comments concerning capital costs are as follows:

A. Spare parts: An allowance of 2% of pump cost was used. This was based on an expected 15% allowance for normal 2,000 hour per year duty, factored by the anticipated operating hours.

B. Labor:

(1) Dry motor: The entire pump must be pulled to replace the lower bushing. An allowance was made for this occurring every seven years.

(2) Submersible: The pumps should be pulled annually to check the oil in the seal, and an allowance for replacing the mechanical seal every ten years was also included.

5.6.3 Annual Equivalent Costs

The annual equivalent costs are shown in Table 5-3. These are the sum of the capital costs on an annualized basis and the annual costs.

Table 5-3

ANNUAL EQUIVALENT COSTS

Item	Dry Motor 100 ft TDH	Submersible 100 ft TDH	Submersible 80 ft TDH
Capital Costs	$2,500	$2,800	$1,600
Annual Costs	2,100	600	400
TOTAL	$4,600	$3,400	$2,000

5.6.4 Technical Risks

The technical risks associated with either the dry-motor or the submersible angle pump are considered low. These types of pumps are in use in various industrial and municipal systems where pumping demands and hours of operation exceed those anticipated for the SCRTD Metro Rail Starter Line.

Rather than the pumps, the types of controls and particularly the level controls could be the cause of operation outages. There are at least 25 different types of level detectors on the market, some of which are specialized in nature (see Appendix E). Even discounting the specialized detectors, the variety of applicable detectors indicates the users are not entirely satisfied with the older versions. Rather than attempt an evaluation as was done for the pumps, the heavy Industry Design Section of KE was asked for their opinion. When the application was explained, their response was to use either of the following for normal operation:

A. Displacement-type liquid level controls similar to that shown in Magnetrol Bulletin: 45-115 (see Appendix F.)

B. Conductive-type, equivalent to B/W Controls' electrode type (see Appendix F). It should be noted that this type may not be suitable because of potential methane gas infiltration.

A less expensive float or tilt-type level switch should be satisfactory for the redundant high level alarm.

Further investigation of the controls will be done under WBS 16CAE1211 work.

5.6.5 Availability

The sump systems considered are generally available for delivery within 18 weeks.

5.7 CONCLUSIONS AND RECOMMENDATIONS

5.7.1 Conclusions

The wet-pit sump system using submersible vertical angle pumps with the quick make/break discharge connection and guide rod assembly is the most cost effective system.

A. The dry motor vertical angle pumps require additional construction considerations; are more difficult to remove and replace for repairs; are more susceptible to bearing and shaft damage due to their long drive shafts; and the motors are air-cooled which may require special ventilation of the pump room.

B. The Dry-pit sump system requires excessive construction costs.

5.7.2 Recommendations

Kaiser Engineers recommends that SCRTD authorize the Systems designers and Ways and Structures designers to proceed with the wet-pit sump system, using submersible vertical angle pumps with the quick make/break discharge connection and guide rod assembly, and with displacement type level controls for normal operation as well as float or tilt-type level controls for redundant high level alarm.

APPENDIX A
BIBLIOGRAPHY

APPENDIX A
BIBLIOGRAPHY FOR CHAPTER 2, GAS DETECTION

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APPENDIX B
SCRTD DESIGN CRITERIA

Revd: 1/18/83

SCRTD METRO RAIL SUBSYSTEMS DESIGN CRITERIA
VOLUME IV, SECTION 8 - MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

CONTENTS

SECTION 8
MISCELLANEOUS MECHANICAL/ELECTRICAL SUBSYSTEMS

IV-8.1 DESCRIPTION

The purpose of these criteria is to describe several special equipment subsystems which do not fall conveniently within the parameters of other major subsystems, and which are deployed throughout the Metro Rail System.

The initial stage of the Metro Rail System (Starter Line) will comprise 18.8 miles running west and north from the Central Business District (CBD) to North Hollywood. The southeastern end of the route terminates at Union Station. The Metro Rail System (eventual system) will be a rapid transit network consisting of approximately 100 miles of grade-separated, double-track mainline with associated stations, electrically powered rail passenger vehicles, yard and shop facilities, auxiliary vehicles and related anciliary facilities.

The main storage yard and the shop facility will be located in the vicinity of the southeastern terminus. A smaller storage facility with limited service and inspection capabilities will be located near the North Hollywood terminal. Crossover tracks, storage tracks, and pocket tracks will be situated at suitable locations to enable trains to turn back at both ends of the corridor and at selected midline locations. These tracks will also provide temporary storage for malfunctioning trains, storage of trains at the northern end of the route, and reverse running during emergency situations.

A Central Control facility is planned in a proposed new SCRTD headquarters building in the downtown area near Union Station. The facility will contain the necessary displays, control consoles, communications apparatus, and operating personnel responsible for the overall safety and security of passengers and for the daily operations of the trains, stations, and all supporting wayside apparatus, which include the miscellaneous mechanical/electrical subsystems covered by these criteria.

The miscellaneous mechanical/electrical subsystems covered by these criteria, will include the following:

A. Gas detection apparatus
B. Early warning fire detection apparatus
~~C~~. Early warning smoke detection apparatus

D. Manual fire alarm stations
E. Fire protection system monitoring apparatus
F. Earth Movement Detection Apparatus
G. Pumping apparatus

The criteria will define the following parameters, where applicable:

A. Functions
B. Description of equipment
C. Sensing/detecting features
D. Location
E. Power requirements
F. Output signals
G. Controls
H. Warning/alarm features

IV-8.2 APPLICABLE DOCUMENTS

The codes of Los Angeles City and County and the State of California will prevail, where applicable. Where no City, County or State codes exist, the following regulatory and advisory agencies' standards will be followed:

A. California Public Utilities Comission (PUC)
B. Institute of Electrical and Electronics Engineers (IEEE)
C. American National Standards Institute (ANSI)
D. Electronic Industries Association (EIA)
E. National Electrical Manufacturers Association (NEMA)
F. Association of American Railroads (AAR)
G. Federal Communications Commission (FCC)
H. U.S. Department of Transportation (DOT/UMTA)
I. American Society of Mechanical Engineers (ASME)
J. Federal Railroad Administration (FRA)
K. 1978 National Electrical Code (NEC)
L. State of California Electrical Safety Orders
M. Occupational Safety and Health Administration (OSHA) (Federal and State)
N. Underwriters Laboratories, Inc. (UL)
O. National Fire Protection Association (NFPA)
P. American Society for Testing and Materials (ASTM)
Q. American Society of Civil Engineers (ASCI)
R. Insulated Cable Engineers Association (ICEA)

IV-8.3 FUNCTIONAL REQUIREMENTS

The following general requirements shall apply to all mechanical/electrical subsystems:

A. They shall be compatible with existing auxiliary power supply sources.

B. They shall be easily serviceable and maintainable.

C. They shall have testing features such that they can be checked out without triggering the alarms at Central Control.

D. They shall have built-in redundancy to ensure that they remain operational under all contemplated conditions.

Functional requirements particular to each mechanical/electrical subsystem are included in the description of each individual subsystem.

IV-8.4 SUBSYSTEM INTERFACES

The miscellaneous mechanical/electrical subsystems shall interface with the following subsystems:

A. Communications
B. Auxiliary Power
C. Ways and Structures
D. Stations

IV-8.4.1 INTERFACE PARAMETERS AND REQUIREMENTS

Interface requirements with the abovementioned subsystems are summarized in Table IV-8-1.

TABLE IV-8-1

SUBSYSTEM INTERFACES

Mechanical/ Electrical Subsystems	Interface			
	Communi-cations	Auxiliary Power	Ways & Structures	Stations
Gas Sensors	- Signal transmis-sion & conditioning - Adjacent emergency telephones - Central Control	-Power require-ments -Wiring	-Location -Conduits	--
Fire ~~& Smoke~~ detectors	- Signal transmis-sion & conditioning - Adjacent emergency telephones - Central Control	-Power require-ments -Wiring	-Location -Conduits	-Location -Conduits -
Manual fire alarm stations	- Signal transmis-sion & conditioning - Adjacent emergency telephones - Central Control	-Power require-ments -Wiring	-Location -Conduits	-Location -Conduits
Earth Movement Monitors	- Signal transmis-sion & conditioning - Adjacent emergency telephones - Central Control	-Power require-ments -Wiring	-Location -Conduits	-Location -Conduits

TABLE IV-8-1 (Cont'd)

Sump Pumps	- Alarm signal transmission -Central Control	-Power requirements -Wiring	-Location -Discharge piping -Pits -Service shafts -Lifting beams -Conduits	--
Scavenger Pumps	--	-Power requirements -Wiring	-Location	--

IV-8.5. GAS DETECTION APPARATUS

IV-8.5.1 GAS SENSORS

Automatic gas sensors shall be installed in tunnels and stations, and shall be capable of detecting concentrations of any gas which may become dangerous due to toxicity or explosion hazard. Sensing shall detect trends in concentration while still in a safe range, to ensure that adequate warning is given so that mitigating measures can take effect before a dangerous situation can arise. Since this is a vital area of safety, redundant apparatus, including sensors, circuits and control elements, shall be employed, as necessary.

The sensors shall be of thermal conductivity or infrared analyzer type, capable of continuous automatic measurement and monitoring (chemical reagents shall not be accepted). The sensors shall also be easy to install and require minimum maintenance.

IV-8.5.2 ANNUNCIATING EQUIPMENT

Continuous monitoring shall be provided at Central Control, including immediate indication of any sensing apparatus malfunction. Hazardous gas concentration shall be indicated for each detector.

High gas concentration shall be annunciated on a display panel at Central Control. Detection of high gas concentration of a sensor shall trigger an audible alarm and activate an indicator that pinpoints the area of the emergency. The visual indicator shall be capable of displaying emergency messages from a minimum of four location simultaneously or sequencially. The audible alarm shall have a manual override, but the visual annunciator shall remain activated until the emergency condition has subsided.

Central Control will take appropriate measures to initiate corrective action.

IV-8.6 EARLY WARNING FIRE DETECTION APPARATUS

IV-8.6.1 FIRE AND SMOKE DETECTORS

Automatic fire detectors and smoke detectors shall be installed in all station concession areas, storage areas, ancillary rooms, and in other places where concentration of apparatus warrants early fire and smoke detector location.

Smoke detectors shall serve the function of redundant equipment for fire detectors in these areas. Fire detectors only shall be installed along all tunnels.

Fire and smoke detectors shall not be required in areas where automatic sprinklers are installed and provided with waterflow alarm signals which fulfill the functions of automatic fire detection as well as their primary function of fire extinguishing.

Smoke detectors shall be dual ionization chamber type, with adjustable sensitivity, functional test switch, and self--check against false alarms.

Fire detectors shall be of a type having a combination of fixed and rate-of-rise temperature sensing.

Operating voltage for fire and smoke detectors shall be 120 volts, 60 hertz a-c.

IV-8.6.2 ANNUNCIATING EQUIPMENT

Fire and smoke detectors shall be connected to respective control panels at Central Control. Dectection of fire and/or smoke shall trigger an audible alarm and activate an indicator that pinpoints the area of the emergency on the respective control panels. The visual indicators shall be capable of displaying emergency messages from a minimum of four locations simultaneously or sequencially. The audible alarms shall have a manual override, but the visual annunciators shall remain activated until the respective sensors are reset, or the emergency condition has subsided. Central Control will take appropriate action to handle fire emergencies.

IV-8.7 MANUAL FIRE ALARM PULL STATIONS

Manual fire alarm pull stations shall be installed in all passenger stations at the following locations:

A. Platforms
B. Mezzanines
C. Concourses

They shall be mounted flush in walls or columns, in locations of easy access to the public and conspicuously marked "Fire Alarm."

The pull stations shall be break-glass-pull-handle type, and shall be connected to Central Control, where a control board shall indicate when a pull station has been activated. Annunciation shall consist of an audible alarm and a visual display that indicates which pull station has been activated. The audible alarm shall have a manual override, but the visual disply shall remain activated until the respective pull station is reset.

Central Control will clear all fire alarms and will have the sole responsibility of notifying the Fire Department and other agencies as required, and coordinating all activities required to cope with fire emergencies.

IV-8.8 FIRE PROTECTION SYSTEM MONITORING APPARATUS

IV-8.8.1 WATER FLOW DETECTION APPARATUS

Water flow sensors shall be installed immediately down-stream of the shut-off valve in each fire branch. The water flow sensors shall alert Central Control when water is flowing into a fire line.

Activation of the flow sensors shall trigger an audible and visual alarm at Central Control. The audible indicator shall have a manual override, but the visual indicators shall remain activated until water flow stops.

IV-8.8.2 POST INDICATOR VALVE APPARATUS

A post indicator valve (PIV) switch shall be installed on each shut-off valve at each fire branch. The PIV switch shall alert Central Control when the shut-off valve is opened or closed. Opening or closing of the valve shall activate an audible and visual alarm at Central Control. The audible indicator shall have a manual override, but the visual indicators shall remain activated until the valve is restored to its original position.

IV-8.9 EARTH-MOVEMENT DETECTION APPARATUS

Earth-movement monitors shall be deployed throughout the tunnels, indicating to Central Control any significant earth tremors. The earth movement sensors shall be installed at intervals and specific locations dictated by the system configuration and the type of sensing equipment used.

The sensing equipment shall be capable of filtering out routine vibrations caused by trains, and shall not be affected by electromagnetic interference from all sources in the tunnels.

Earth movement indication at Central Control shall consist of a chart and brush recorder that shall indicate the intensity of the earth tremor. The chart shall be normally static, activated only if an earth tremor of a certain predetermined intensity occurs. An audible alarm shall sound whenever the chart is activated.

(The earth-movement detection criteria will be further updated, and the recommendations defined during subsequent design tasks, including incorporation of seismic design requirements.)

IV-8.10 PUMPING APPARATUS

IV-8.10.1 SUMP PUMPS

Sump pumps shall be located at low points in tunnels and shall be sized to handle water resulting from infiltration, weather, fire fighting operations, and other sources. Two pumps shall be utilized at each installation; each pump shall handle full anticipated load. Controls shall be such that, under normal conditions, one pump is operating and one is at standby. In order to equalize usage of each pump, control circuits shall be designed so that pumps operate alternately.

Sump pumps shall have permanent or automatic lubrication, and shall be designed to accomodate solids of up to two inches in diameter. Operating voltage for the electric motors shall be rated at 460 volts, 60 hertz, 3-phase.

Electric control apparatus shall be convenient to disconnect for maintenance purposes. Also, where automatic operation is involved, local controls shall facilitate manual override of the automatic controls to assist in performing maintenance.

Pumps shall be activated by float switches. A high-water indicator shall be included to start up the stand-by pump when the water level continues to rise with one pump in operation. An alarm indication shall be received at Central Control if water level continues to rise after the second pump has been activated.

Sump pumps shall be equipped with hour meters to assist in scheduling preventive maintenance and for indicating erratic operation of the control element.

The pumps shall be installed in a pit. Dimensions of the pit shall be such that all parts of the pumps requiring periodic maintenance shall be easily accessible.

Wherever feasible, access to the pumps shall be possible without having to travel through the tunnels, by means of stairways or shafts opening to street level. Maintenance, installation, removal and other repair operations shall be capable of being performed without interruption of revenue service. Mechanical lifting devices, such as fixed rings, hooks, etc., shall be installed in pit structures where appropriate, to aid in handling the sump pumps.

IV-8.10.2 AUXILIARY PORTABLE PUMPS

Self-priming portable pumps shall be transported on an auxiliary vehicle to emergency locations that experience high-water level due to fire fighting, flooding, or other situations where the two sump pumps are insufficient to prevent water build-up.

The auxiliary portable pumps are included in these criteria as a reference only, and are described under the Auxiliary Vehicles Design Criteria.

IV-8.10.3 SCAVENGER PUMPS

Hydraulic pumping units with reservoirs of more than 20 gallons capacity shall be installed in pits with floor drains. A scavenger pump shall be fitted to the floor drain to collect hydraulic fluid leakage and return it to the reservoir, serving the dual function of avoiding spillage and recycling hydraulic fluid. The scavenger pump sending line shall have a particle filter and a water separator. Scavenger pumps shall be powered by 460 volts, 60 hertz, 3-phase electric motors.

SCRTD METRO RAIL PROJECT

MEMO

cy for VK
to CMC
to Jim A.

To: M. Burgess Date: April 7, 1982

From: W. Rhine W. Rhine WBS 13CAE12

Subject: Design Criteria Miscellaneous Mechanical-Electrical Systems

Attached are preliminary design criteria for miscellaneous mechanical/electrical systems, please review and comment per WBS task 13CAE12.

cc: D. Gardner (w/o attach.)

RECEIVED

APR 08 1982

[illegible] ENGINEERS
LOS ANGELES

RTD

Southern California Rapid Transit District

SECTION 8

MISCELLANEOUS MECHANICAL-ELECTRICAL SYSTEMS

8.1 GENERAL

8.1.1 PURPOSE OF CRITERIA

The purpose of these criteria is to describe several special equipment systems which do not fall conveniently within the parameters of other major systems, and which are generally deployed throughout the transit system.

Such special electro-mechanical equipment includes:

- o Gas sensors
- o Fire detectors (early warning)
- o Smoke detectors (early warning)
- o Earth movement sensors
- o Sump pumps and motors

8.1.2 CRITERIA INTERFACES

These five items will interface with the DTS and alarm facilities of the Communications Criteria. Sump pumps and motors will also interface with Auxiliary Power Criteria and the Ways and Structures Criteria for sumps.

8.2 SCOPE

The automatic function of each type system will be described. Each unit will serve as a particular alarm and control element, except for the sump pumps, which will function to pump according to sump level and initiate appropriate alarm signals for high water and flooding conditions.

8.3 APPLICABLE CODES, STANDARDS AND REGULATIONS

List Los Angeles City and County Codes which are the governing documents.

8.4. SPECIAL MECHANICAL-ELECTRICAL SYSTEMS

8.4.1 GAS SENSORS

A system of gas sensors must be deployed throughout the tunnel system, capable of detecting concentrations of any gas which may become dangerous. Sensing must detect trends in concentration while still in a safe range to insure that adequate warnings is given and mitigating measures can take effect before any dangerous situation arises. Since this is vital area of safety, redundant apparatus is dictated, including sensors, circuits and control elements. Continuous monitoring shall be provided at Central Control, including immediate indication of any sensing equipment malfunction.

Each detector shall indicate its location at Central Control, showing gas concentration.

8.4.2 FIRE DETECTORS

Early warning fire detectors shall be deployed throughout the tunnel system, indicating presence of fire or flame at each individual sensor location. Monitoring of the system shall be coordinated with the fire protection system on a continuous basis.

8.4.3 SMOKE DETECTORS

Early warning smoke detectors shall be deployed throughout the tunnel system, indicating presence of smoke at each individual sensor location, similar to fire sensor above. However, smoke detectors often can detect a fire before flames erupt and are therefore a priority vital element and should be installed as redundant systems. Continuous monitoring at Central Controls is essential.

8.4.4 EARTH MOVEMENT MONITORS

Earth movement monitors shall be deployed throughout the tunnel system, indicating to Central Control any significant earth tremors. These shall indicate magnitude and location so that Central Control personnel can govern systems operations appropriately.

8.4.5 SUMP PUMPS AND MOTORS

Sump pump locations and sumps will be identified by the Ways and Structures Section. All pumps shall be installed in duplicate, and each pump shall be capable of maintaining the designed sump level independently. Pump motors shall be designed for the particular duty and location with regard to the motor type and protection from moisture. Motor controls designed for the service shall call for operation of alternate pumps each time pumping is called for, and arranged so that under excessive sump levels, both pumps shall operate. Indications at Central Control shall indicate when any pump is operating and a special alarm shall indicate any situation when conditions call for both pumps to operate.

Each sump pump motor shall be fed from a circuit dedicated exclusively for each pump motor, coordinated with the design criteria for Auxiliary Power Systems.

It is recommended that provisions be included for use of a mobile pump brought to a problem location, by rail, when required. Coordination with the design criteria for Auxiliary Vehicles is required.

APPENDIX C
MEMORANDUMS, MINUTES OF MEETINGS, AND TELEPHONE CONVERSATION REPORTS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DO NOT INCLUDE MORE THAN ONE SUBJECT IN THIS COMMUNICATION

DATE: October 15, 1982

TO: DISTRIBUTION

WBS: 12AAM

Via: William Rhine William Rhine

FROM: Roger Wooden

SUBJECT: Working Paper: Seismic Criteria Input Data

for ref only
recd 1/20/80
(from PBQD)

The following presents information pertaining to the above subject. It identifies:

- Failure Definition(s)
- Seismic Event Categorization
- Listings of Failure/Event Categories for various Metro Rail system elements.

1. Failure Definitions

Catastrophic Failure - a failure that would result in loss of life, and/or system loss.

Critical Failure - a failure that would result in severe injuries, severe occupational illness and/or major system damage.

Marginal Failure - a failure that would result in minor injury, minor occupational illness and/or minor system damage.

Negligible Failure - a failure that would not result in injury, occupational illness and/or system damage.

NOTE: "SYSTEM LOSS" is defined as a seismic event of significance that would render the system and/or its elements inoperative when they must be operational both, during and after a seismic event, for reasons of safety.

"MAJOR SYSTEM DAMAGE" is defined as a seismic event that would induce substantial system damage, but not cause loss of life.

"MINOR SYSTEM DAMAGE" is defined as a seismic event that would not significantly effect system operations, or not induce injury.

2. Seismic Event Categorization

Category I - structures, components and systems which perform a vital safety-related function.

Category II - structures, components and systems (not in I) which are required to maintain safety system operation.

Category III - structures, components and systems (not in I or II) which are required for normal system operation.

3. Listing of Failure/Event Categories for Various Metro Rail System Elements

The attached sheets represent a listing, provided by the working group, for review by Metro Rail staff. Upon completion of staff review, these listings will become an integral part of the submittal to Lindvall, Richter & Associates for their use in seismic analysis.

These listings were prepared as follows:

- Identify the failure condition (a statement of the condition or problem)
- Identify its severity category, both to the system and human life
- Categorize it by seismic event

EXAMPLE

Failure Description	CATEGORY System	CATEGORY Life
I. Tunnel		
1. Offset of tunnel while train close approaching or passing	Crit/I	Cat/I
Severity Category		Seismic Event

Upon completion of the above, and attached listings, it is anticipated that all of this information would become an integral part of our submittal to Lindvall, Richter & Associates.

A meeting is scheduled for Tuesday, October 19,1982 at 1:30PM in the 6th Floor Conference Room (A). At this time it is anticipated that the attached will be delivered, in final form, to Lindvall-Richter & Associates.

DISTRIBUTION:	R. Gallagher	SCRTD/Metro Rail Project
	J. Crawley	SCRTD/Ways & Structures
	D. Low	SCRTD/Stations Design
	R. Beuermann	SCRTD/Systems Design
	D. Gardner	SCRTD/Systems Design
	M. Becher	SCRTD/Systems Design
	R. Wood	SCRTD/System Safety & Assurance
	J. Moss	DMJM/PBQD
	A. Ny	DMJM/PBQD
	C. Costa	Kaiser Engineers
	F. Purdy	Kaiser Engineers
	J. Rippa	Harry Weese & Associates

FAILURE DESCRIPTION	CATEGORY SYSTEM	CATEGORY LIFE
I. TUNNELS:		
1. LINE TUNNELS -		
A. Lighting Fixtures Fall and Tunnels Left Unlit	MARG./III	CRIT./III
B. Collapse of Tunnel Liner Permitting Soil To Block Tunnel Denying Passenger Emergency Egress	CAT./I	CAT./I
C. Instability of Tunnel Liner Causing Distortion Such that Trains Cannot Pass Through	CRIT./ I	CRIT./I
D. Breakdown of Liner Waterproofing Causing Wayside Train Control Equipment Malfunction	MARG./III	MARG./III
E. Loss of Sump Pump(s)	MARG./II	MARG./II
F. Minor Leaks in Tunnel Liner not Causing Damage to Trackside Equipment	NEG./I	NEG./I
G. Loss of Fire Suppression Water Main	CRIT./I	MARG./I
2. VENT SHAFTS/EMERGENCY EVACUATION STAIRWAYS -		
A. Lighting Fixtures Fall and Stairways Left Unlit	MARG./III	CRIT./III
B. Fracture of Fire Main so that Fires cannot be Mitigated (Loss of Water)	CRIT./II	CRIT./II
C. Fracture of Pumping Mains so that Line Sumps Cannot be Emptied	MARG./II	MARG./II
D. Collapse of Vent Shaft Structure Denying Passenger Egress (Exit Blocked)	CRIT./I	CAT./I
E. Collapse of Vent Shaft Structure; Emergency Exiting Maintained	CRIT./I	CRIT./I
F. Total Loss of Watertightness of Vent Shaft Structure	MARG./I	MARG./I
G. Minor Breakdown of Watertightness of Vent Shaft	NEG./I	NEG./I

FAILURE DESCRIPTION	CATEGORY	
	SYSTEM	LIFE
I. TUNNELS: (Cont'd.)		
3. CROSSOVERS/POCKET TRACKS		
A. Lighting Fixtures Fall Resulting In Unlit Tunnel	MARG./III	CRIT./III
B. Fracture of Fire Main so that Fires cannot be Suppressed with Water	CRIT./II	CRIT./II
C. Fracture/Displacement of Tracks, Train Control Cables or Contact Rail	MARG./II	MARG./II
D. Collapse of structure; soil enters blocking Tunnel which denies passenger emergency egress	CRIT./I	CAT./I
E. Breakdown in Watertightness of the Structure Causing Loss of Trackside Train Control (Flooding)	MARG./III	MARG./III
F. Minor Breakdown in Watertightness of the Structure	NEG./I	NEG./I
G. Loss of Fire Suppression Water Main	CRIT./II	MARG./II
4. CROSSPASSAGES -		
A. Collapse of the Structure; soil enters blocking tunnel crosspassage such the passenger cannot egress in an emergency	MARG./I	CAT./I
B. Collapse of the structure; Line Tunnel Evacuation is Possible	CRIT./I	MARG./I
C. Lighting Fixture Falls; Tunnel Crosspassage Unlit	MARG./III	CRIT./III
D. Total Breakdown of Watertightness of the Structure	MARG./I	MARG./I
E. Minor Breakdown of Watertightness of the Structure	NEG./I	NEG./I
F. Loss of Fire Suppression Water Main	CRIT./II	MARG./II

FAILURE DESCRIPTION	CATEGORY	
	SYSTEM	LIFE
II. STATIONS* *Assumes worst case; structural collapse causing major damage and/or equipment loss		
1. UNDERGROUND (SUBWAY STATION) -		
A. Trainroom/Platform	CAT./I	CAT./I
B. Public Mezzanine Structure	CAT./I	CAT./I
C. Ancillary Equipment Mezzanine Structure,	CAT./I	CAT./I
D. Communication	CRIT./II	CRIT./II
E. Lighting	CRIT./II	CRIT./II
F. Auxiliary Power	CRIT./II	CRIT./II
G. Surface Concourse Pavilion	CRIT./I	CRIT./I
H. Entry/Exit Portal & Shaft	CRIT./I	CRIT./I
I. Traction Power	CRIT./I	CRIT./I
J. Train Control	CRIT./I	CRIT./I
K. Fire Equipment	CRIT./I	CRIT./I
L. Emergency Power	CRIT./I	CRIT./I
M. Elevator/Escalator	MARG./II	MARG./II
N. Fare Collection	MARG./II	MARG./II
O. Gap Breaker	MARG./II	MARG./II
P. Valves	MARG./II	MARG./II
Q. Bus Terminal	MARG./II	MARG./II
R. Train Room-A/C	MARG./II	CRIT./II
S. Toilet Rooms/Plumbing	MARG./II	MARG./II
T. Blast Shafts	MARG./I	MARG./I
U. Battery Power	MARG./I	CRIT./I
V. Entry Walkways	MARG./I	MARG./I

FAILURE DESCRIPTION	CATEGORY	
	SYSTEM	LIFE
II. STATIONS (Cont'd)*		
1. UNDERGROUND (SUBWAY STATION) Cont'd -		
W. Security	MARG./I	MARG./I
X. Mezzanine Guards	MARG./I	MARG./I
Y. Sump Pumps	MARG./I	MARG./I
Z. Ejector Pumps	MARG./I	MARG./I
AA. Ventilation Shafts	MARG./I	MARG./I
AB. Concessions	NEG./III	NEG./III
AC. Staff Room	NEG./III	NEG./III
AD. Kiss and Ride	NEG./III	NEG./III
AE. Custodial	NEG./II	NEG./II
AF. Telephone	NEG./II	NEG./II
AG. Storage Room	NEG./II	NEG./II
AH. Stairways	CRIT./I	CRIT./I
2. SURFACE STATION -		
A. Platform	CAT./I	CAT./I
B. Retaining Walls	CAT./I	CAT./I
C. Overhead Structures	CAT./I	CAT./I
D. (Parking Garages Buildings)	CAT./I	CAT./I
E. Traction Power	CRIT./I	CRIT./I
F. Communications	CRIT./II	CRIT./II
G. Emergency Power	CRIT./I	CRIT./I
H. Public Concourse	CRIT./I	CRIT./I
I. Platform Canopy	CRIT./I	CRIT./I
J. Stairways	CRIT./I	CRIT./I

FAILURE DESCRIPTION	CATEGORY	
	SYSTEM	LIFE
2. SURFACE STATIONS (Cont'd)*		
K. Public Entry/Exit	CRIT./I	CRIT./I
L. Bridges	CRIT./I	CRIT./I
M. Train Control	CRIT./I	CRIT./I
N. Fire Equipment	CRIT./I	CRIT./I
O. Battery Power	MARG./II	CRIT./III
P. Gap Breaker	MARG./II	MARG./II
Q. Valves	MARG./II	MARG./II
R. Fare Collection	MARG./II	MARG./II
S. Security	MARG./II	MARG./II
T. Bus Terminal	MARG./II	MARG./II
U. Lighting	MARG./II	MARG./II
V. Communications	CRIT./II	CRIT./II
W. Emergency Exits	MARG./I	CRIT./I
X. Entry Walkways	MARG./I	MARG./I
Y. Auxiliary Power	MARG./II	MARG./II
Z. Elevator/Escalator	MARG./III	MARG./III
AA. Sump Pumps	MARG./III	MARG./III
AB. Ejector Pumps	MARG./III	MARG./III
AC. Custodial	NEG./II	NEG./II
AD. Toilet Rooms/Plumbing	NEG./II	NEG./II
AE. Telephone	NEG./II	NEG./II
AF. Storage	NEG./II	NEG./II
AG. Concessions	NEG./III	NEG./III

FAILURE DESCRIPTION	CATEGORY SYSTEM	LIFE
I. STATIONS (Cont'd)		
SURFACE STATIONS (Con'td)		
AH. Kiss and ride	NEG./III	NEG./III
AI. Staff Room	NEG./III	NEG./III
AJ. Trash	NEG./III	NEG./III
AK. Concourse A/C	NEG./III	NEG./III
3. AERIAL STATION -		
A. Elevated platform and Guideway Structural Systems	CAT./I	CAT./I
B. Adjacent parking Structures	CAT./I	CAT./I
C. Mezzanine Floors	CAT./I	CAT./I
D. Communications	CRIT./II	CRIT./II
E. Emergency Power	CRIT./II	CRIT./II
F. On Surface Public Concourse	CRIT./II	CRIT./II
G. Platform Canopy	CRIT./I	CRIT./I
H. Stairways	CRIT./I	CRIT./I
I. Public Entry/Exit	CRIT./I	CRIT./I
J. Traction Power	CRIT./I	CRIT./I
K. Train Control	CRIT./I	CRIT./I
L. Fire Equipment	CRIT./I	CRIT/I
M. Elevator/Escalator	MARG./III	MARG./III
N. Battery Power	MARG./II	CRIT./II
O. Fare Collection	MARG./II	MARG./II
P. Security	MARG./II	MARG./II

FAILURE DESCRIPTION	CATEGORY SYSTEM	LIFE
II. STATIONS (Cont'd)*		
3. AERIAL STATIONS (Cont'd		
Q. Gap Breaker	MARG./II	MARG./II
R. Bus Terminal	MARG./II	MARG./II
S. Custodial	NEG./II	NEG./II
T. Toilet Rooms/Plumbing	NEG./II	NEG./II
U. Telephone	NEG./II	NEG./II
V. Storage Room	NEG./II	NEG./II
W. Lighting	MARG./I	MARG./I
X. Communications	MARG./II	MARG./II
Y. Valves	MARG./I	MARG./I
Z. Auxiliary Power	MARG./I	MARG./I
AA. Emergency Exits	MARG./I	MARG./I
AB. Entry Walkways	MARG./I	MARG./I
AC. Concessions	NEG./III	NEG./III
AD. Staff Room	NEG./III	NEG./III
AE. Trash	NEG./III	NEG./III
AF. Kiss and Ride	NEG./III	NEG./III
AG. Concourse - A/C	NEG./III	NEG./III
III. MECHANICAL/ELECTRICAL APPARATUS: (Other Than Traction Power)		
1. ELEVATORS -		
A. Elevator Crushed Due to Shaft Collapse	NEG./III	CAT./III
B. Elevator Stopped Due to Power Failure	NEG./III	CRIT./II
C. Elevator Wedged Due to Shaft Deformation	NEG./III	CRIT./III

FAILURE DESCRIPTION	CATEGORY	
	SYSTEM	LIFE
III. MECHANICAL/ELECTRICAL APPARATUS (Cont'd)		
1. ELEVATORS (Cont'd) -		
D. Elevator Plunges Due to Total Failure	NEG./III	CAT./II
E. Electrical Shock Due to Exposed Wires	MARG./II	CAT./II
F. Fire Due to Shorted Wires	CRIT./II	CAT./II
2. ESCALATORS		
A. Escalator Collapse Due to Structural Failure	MARG./III	CAT./III
B. Sudden Stop, Passengers Tumble	NEG./III	CRIT./III
C. Stop Due to Power Failure	NEG./III	MARG./III
D. Electrical Shock Due to Exposed Wires	MARG./III	CAT./III
E. Fire Due to Shorted Wires	CRIT./III	CRIT./III
3. FARE COLLECTION		
A. Structural Damage to Gates	MARG./III	MARG./III
B. Gates Malfunction Due to Power Failure	NEG./III	NEG./III
C. Electrical Shock Due to Exposed Wires	NEG./III	CAT./III
D. Passenger Evacuation Hampered Due to Fail-safe System Malfunction	MARG./III	CRIT./III
E. Fire Due to Shorted Wires	NEG./III	CRIT./III
4. AUXILIARY POWER		
A. UPS Breakage, Acid Spill	CRIT./II	MARG./II
B. panelboards Collapse, Exposed Wires	MARG./II	MARG./II
C. Power Failure, Lights Out	CRIT./II	CRIT./II
D. Fire Due to Shorted Wired or Buses	CRIT./I	CRIT./I
E. Structural Damage to Buses	MARG./II	MARG./II
F. Structural Damage to Panelboards	MARG./II	NEG./II

FAILURE DESCRIPTION	CATEGORY SYSTEM	CATEGORY LIFE
III. MECHANICAL/ELECTRICAL APPARATUS: (Cont'd)		
5. VENTILATION EQUIPMENT		
A. Stops	CRIT./I	CRIT./I
B. Fire Due to Shorted Wires	CRIT./I	CRIT./I
C. Controls Failure, Dampers Locked	CRIT./I	CRIT./I
D. Controls Failure, Fans Inverted	CRIT./I	CRIT./I
IV. TRAINWAY:		
1. TRACKS		
A. Severed	MARG./I	CAT./I
2. TRACK SWITCHES		
A. Damaged Switch Causing Vehicle Derailment	MARG./I	CAT./I
V. TRACTION POWER:		
1. MAIN ELECTRICAL POWER FEEDER		
A. Train(s) Stalled Due to Seismic Event Which Disrupts Power to the 3rd Rail (Assumes Emergency Lights, Communications Working)	MARG./III	NEG./III
2. POWER SUBSTATION		
A. Loss of Power From Substation to 3rd Rail - Train Stalled	MARG./III	NEG./III
B. Loss of Power From Substation to Communications. Emergency Lighting, Ventilation Fans, etc. (Assumes Doublefeed)	MARG./III	MARG./III
3. CONTACT (3RD) RAIL		
A. Damaged	CRIT./III	CAT./III

FAILURE DESCRIPTION	CATEGORY SYSTEM	CATEGORY LIFE
VI. TRAIN CONTROL		
1. <u>AUTOMATIC TRAIN CONTROL</u>		
A. Train Control Automatic Train Protection or Automatic Train Operation Failure	MARG./I	NEG./I
B. Misalignment of Track such that Switch shows "Lined and Locked" When Switch is Actually Misaligned, Causing Derailment.	CRIT./I	CAT./I
C. Seismic Event Which Causes Loss of Wayside Automatic Train protection; Loss at Central Control of Interlockings	MARG./III	MARG./III
D. Loss of Wayside ATP (Circuit)	NEG./III	NEG./III
VII. VEHICLES/TRAINS :		
1. <u>VEHICLES/TRAINS IN REVENUE SERVICE</u>		
A. Train Collison/Jam Due to Seismic Offset of Tunnel While Train is Closely Approaching or Passing	CRIT./I	CAT./I
B. Train(s) Derailed at Speed Due to Seismic Forces; Track Intact	CRIT./I	CAT./I
C. Train(s) Derailed at Speed Due to Tracks buckling/breaking in Earthquake Area	CRIT./I	CAT./I
D. Train(s) Stalled Due to Seismic Event Inducing Wide Spread Power Outage; No Disruption of Emergency Lights, Communications	NEG./II	NEG./II
E. Train(s) Stalled Due to Seismic Event Which Induces Power Outage and Major Failure of Emergency Lighting or Ventilation, or Communications, (Assumes Panic)	NEG./I	CRIT./I
F. Train(s) Short Out 3rd Rail Due to Seismic Event Which Buckles/Breaks Tracks	MARG./I	MARG./I
G. Train(s) Tipped Onto Side by Seismic Event While In Double-track Station (Assumes Spaced to Tip)	MARG./I	CAT./I

FAILURE DESCRIPTION	CATEGORY SYSTEM	CATEGORY LIFE
VII. VEHICLES/TRAIN (Cont'd)		
2. <u>VEHICLES IN STORAGE</u>		
A. Seismic Event Which Causes Major Upset/ Damage to Vehicle Fleet	CRIT./I	NEG./I
VIII. COMMUNICATIONS		
1. LOSS OF:		
A. Base Radio Antenna	NEG./II	NEG./II
B. Emergency Telephone	NEG./II	NEG./II
C. Central Control Computers	CRIT./II	NEG./II
2. LOSS OF:		
A. PABX Telephone	NEG./II	NEG./II
B. Maintenance Radio Base	NEG./II	NEG./II
C. Maintenance Telephone	NEG./II	NEG./II
D. Yard Radio Base	NEG./II	NEG./II
E. Closed Circuit TV(s)	NEG./II	NEG./II
3. LOSS OF:		
A. Intercom	NEG./III	NEG./III
B. Shop Communications	NEG./III	NEG./III
C. Test Track Radio Base	NEG./III	NEG./III

Cm

Kaiser Engineers California

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Job #: 81152-407
WBS #: 14 CAE12 (.7)
Chrono

November 18, 1982

MEMO TO: W. J. Rhine

FROM: P. M. Burgess PMBurgess

SUBJECT: ALTERNATIVES FOR MECHANICAL/ELECTRICAL EQUIPMENT

The alternative that is available to KE on the above subject is the fire detection system. This alternative is continuous wire fire detection versus point of contact (sensor) fire detection system (similar to smoke detectors).

The remaining portions of the above subject, such as sump pumps, sewage ejectors, gas sensors and earth moving sensors, are a matter of pricing of one manufacture versus the other, thus the technology differences are the same and do not need to be compared.

KE recommends selection between continuous versus point detection during final design, rather than during the alternatives analysis. If you differ in this recommendation please advise us promptly.

PMB:pl

cc: K. Rummel

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JOB #: 81152
WBS #: 14CAE12

SUBJECT: SEISMIC DETECTION SYSTEM

From: K. Fitz
MINUTES OF THE MEETING
20 January 1983

ATTENDEES:

K. Fitz - Fitz Consultants
R. Beuermann - SCRTD
R. Dielman - Kinemetrics, Inc.

KINEMETRICS manufacturers several types of seismic instruments; each designed for specific application. Following are highlights of the discussion.

- Strong motion accelerograph (SMA-1) is designed to measure vertical and horizontal movement, time and magnitude (½ hour of data at set-points) on photographic papers. This instrument is required by the L. A. Building Code on highrise buildings to record structural response from earthquakes. Price is $2,775.00.

- Strong motion acceleration system (SMA-3 with SMP-1 playback) is a multi-channel centralized recording magnetic tape system designed to detect and record, strong local earthquakes. The magnetic tape playback system provides immediate visual playback capability of recorded data. System cost is $18,000. This system was provided for Venezuela's Metro System.

- Seismic Trigger TS-3 (or 3A with internal battery) is a triaxial version of Vertical Seismic trigger and is offered for $1,800.00.

  These orthogonal transducers are individually adjustable and are mounted in a rugged watertight housing. As a seismic trigger, it can be applied for centrally located accelerographs or as a seismic switch for remote alarm indicators. This instrument was supplied for the seismic system on the BART Project.

- Elevator Seismic Trigger (EST-2) is to provide an immediate shut-down of elevator in the event of a potentially damaging earthquake, eliminating the damage caused by continued elevator operation after an earthquake has occurred. This triffer should be specified for the elevators and furnished by the elevator supplier. Price is listed at $500.00.

Kinemetrics offers a wide variety of services, such as to engineer and design any built-up modules to suit customer's needs as well as training program for testing and maintenance. They also provide field support for on-site installation and propose contract maintenance and calibration services.

RECOMMENDATIONS for System Bases by R. Beuermann:

1. Assume three (3) recording devices for the different seismic zones, like the Valley-Basin, the Santa Monica fault and the Union Station.

2. Provide TS-3 (or 3A) seismic triggers for the rest of the areas as required.

3. Display, control and command in Central Control only (indicators for stations are not required).

COMMENTS by K. Fitz (not discussed):

1. C & I System Engineer to develop and recommend the most optimum system and then components could be selected.

2. Special consideration should be given to the system design, which is a "SAFETY SYSTE". (Liability in the case of catastrophic event; legal questions, etc.)

3. Close coordination with all safety systems is essential (design of common RTV might be feasible).

4. Design Criteria to be defined for:
   - sensing, recording and alarming
   - sensing, local alarming and signaling
   - sensing and signaling only
   - extent of detector - locations in the tunnels (access and maintainability of most importance)

5. System design shall be coordinated with Life-Safety System Engineering as well.

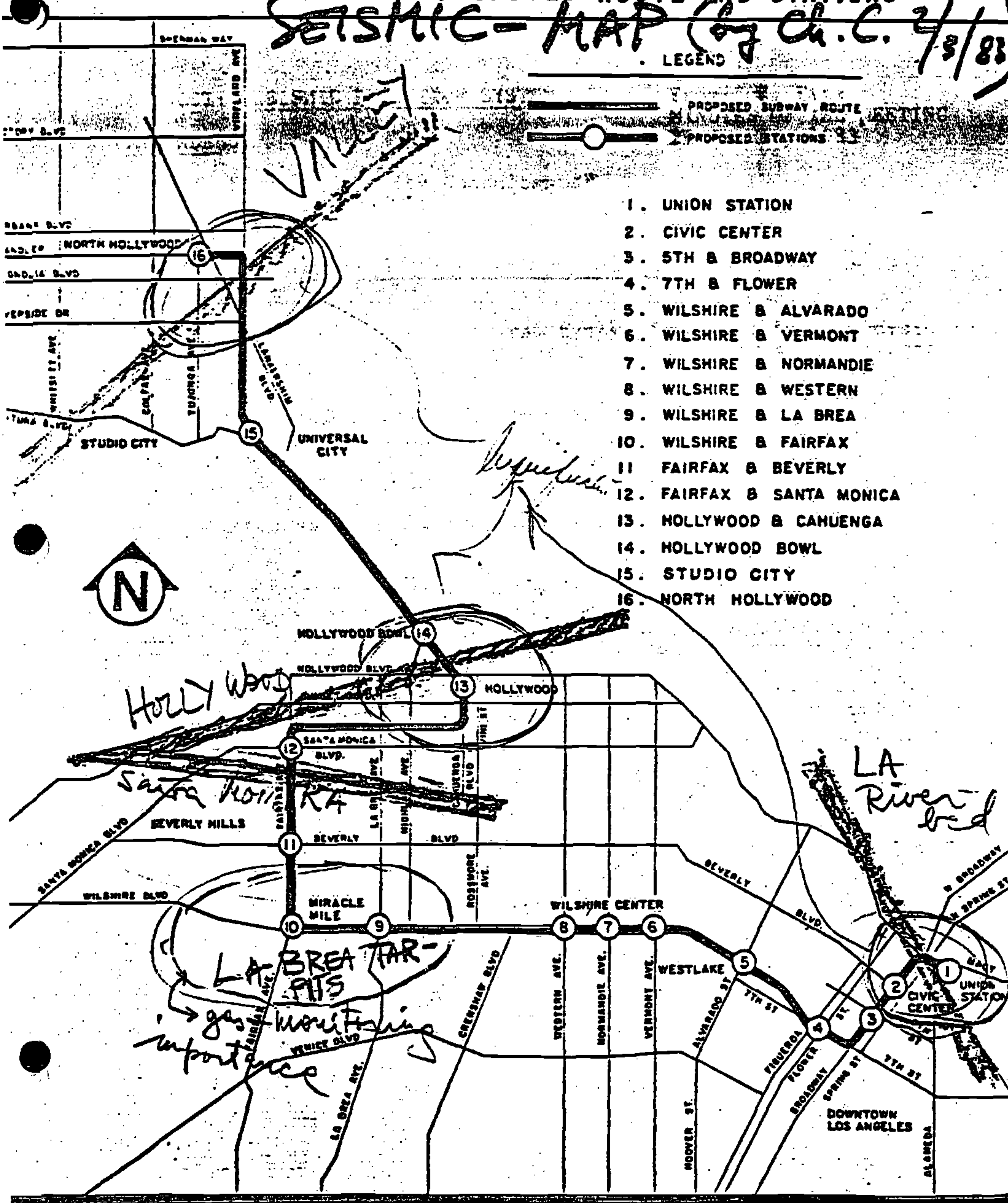
KF/1m

cc: P. M. Burgess - KE/Los Angel
K. Rummel - KE/Los Angeles
C. Costa - KE/Los Angeles
D. Schuler - KE/Los Angeles
D. P. Mohapatra - KE/Oakland
K. Fitz - Fitz Consultants

FIGURE II-1

SCRTD Metro Rail Project

PROPOSED ROUTE AND STATIONS



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JOB #: 81152
WBS #: 14CAE12

SUBJECT: GAS MONITORING SYSTEM

From: K. Fitz
MINUTES OF THE MEETIN
1 February 1983

ATTENDEES:

C. Costa - Kaiser Engineers
R. Beuermann - SCRTD
K. Fitz - Fitz Consultants
N. Bacile - ALISON CONTROLS

Nick Bacile discussed the system's capabilities for the ALISON CONTINUOUS GAS DETECTION SYSTEM. Alison uses a control system designed around the Bacharach thermal conductivity type gas sensor. The following points were discussed.

Alison does not have any in-house information on the spacing of the methane probes. Generally, special consideration will be given to:

- low points in the tunnel
- gas stratification during off-hours

Additional factors that will be taken into consideration for the gas monitoring system include:

- the recommendations in the methane report
- location and capacity of the exhaust fans

Alison was advised to consider 36 miles of train tunnel with gas detection probes at 500' intervals.

Nick stated that the Bacharach Catalytic type of probe, depending on the environment, may require monthly calibration and replacement of the detection module once every three to 36 months.

Nick stated that with better system definitions, the gas detection system can be streamlined to include:

- one controller at each station
- controller at station followed by smaller area panels

The general concensus was that better definition of the system will permit optimized choice of components.

For comparative cost of the central system hardware; Nick suggested that we contact Ervin Ackkamen of Coral Electronics or Gerry Kujn of Grinnel. Alison is interested in total system supply and would guarantee all components even though they're from multiple sources.

Nick recommends that the purchase order should be awarded two years ahead of the required delivery date of the system.

The following data and guidelines were furnished to Nick for his use to develop preliminary cost figures:

- Assume 2,000 sensor points
- A set of the station drawings and a drawing set of station profiles

It's expected that Nick will send a response to Kaiser Engineers in three weeks.

# # #

cc: P. M. Burgess - KE/Los Angeles
K. Rummel - KE/Los Angeles
C. Costa - KE/Los Angeles
D. Schuler - KE/Los Angeles
D. P. Mohapatra - KE/Oakland
K. Fitz - Fitz Consultants

Kaiser Engineers California

Kaiser Engineers (California) Corporation
A Subsidiary of Raymond Kaiser Engineers Inc.
425 South Main Street, 6th Floor
Los Angeles, California 90013
(213) 972-6033

JOB #: 81152
WBS #: 14CAE12

SUBJECT: METHANE DETECTION SYSTEM

From: D. P. Mohapatra DM
MINUTES OF THE MEETING
9 February 1983

ATTENDEES:

D. P. Mohapatra - Kaiser Engineers
R. Beuermann - SCRTD
W. Yates - Bacharach Instruments

Wayne Yates from BACHARACH INSTRUMENTS visited this office to demonstrate the Bacharach Methane Detection System. It is based on a catalytic type of sensor.

SYSTEM DESCRIPTION:

The Bacharach system consists of the sensor assembly, amplifier and callibrator housing and the controller. The controller has a provision for remote signal monitoring and alarming for no more than four probes. The controller flashes a yellow light at 20% L.E.L. methane level and alarms at 40% L.E.L. level. Since SCRTD is going to have a DTS system, maybe the controller can be eliminated by incorporating the amplified signal into the DTS system.

COST:

- A preliminary cost for 370 sensors, 370 amplifiers and 95 controllers is $276,595. This is based on 36 miles of tunnel and probes at 500 ft. intervals.
- Inclusion of a long distance amplifier, along with a D.C. converter and step-down transformer will raise the total cost of $400,249.
- Deletion of the Controller will reduce the total cost to $241,690.
- None of the above cost figures include the cost of data multiplexing and connection to the Central Control Room.

MAINTENANCE:

Calibration of the probes and replacements of the sensor filament module is the only maintenance that will be needed. The calibration will probably be needed every three months and, depending on the environment, replacement of filament module may be necessary every two years.

Following are some of the miscellaneous costs of the components:

Filament module	$ 66.00
Filament module housing	66.00
Amplifier	305.00
Power supply transformer	216.00
Controller	1630.00
Calibration kit	110.00
Sample cylinder	20.00

The sample cylinder will have enough gas for calibration of four to five probes.

HISTORY OF APPLICATION:

The Bacharach probes have been used in coal mines in Vancouver, Canada and long distance installations in oil fields in Saudi Arabia. Wayne is going to provide a detailed list of users.

# # #

DPM/lm

cc: P. M. Burgess - KE/Los Angeles
K. Rummel - KE/Los Angeles
C. Costa - KE/Los Angeles
D. Schuler - KE/Los Angeles
K. Fitz - Fitz Consultants
D. P. Mohapatra - KE/Oakland

14CAE12

KAISER
ENGINEERS

INTEROFFICE MEMORANDUM

TO: PLEASE SEE DISTRIBUTION

DATE: 25 FEBRUARY 1983

FROM: [redacted]

AT:

COPIES TO

AT: LOS ANGELES

WBS #: 14CAE12

JOB NO. 81152-407

SUBJECT: SUMP PUMP STATIC HEAD

I went through the alignment drawings with John Moss of DMJM, and following are static heads for the low spots in the tunnel:

ALIGNMENT LOCATION	STATIC HEAD
120 + 00	55 FT.
187 + 00	75 FT.
220 + 00	90 FT.
297 + 00	70 FT.
337 + 00	75 FT.
383 + 00	50 FT.
435 + 00	50 FT.
526 + 00	60 FT.
713 + 00	55 FT.
970 ~~952~~ + 00	80 FT.

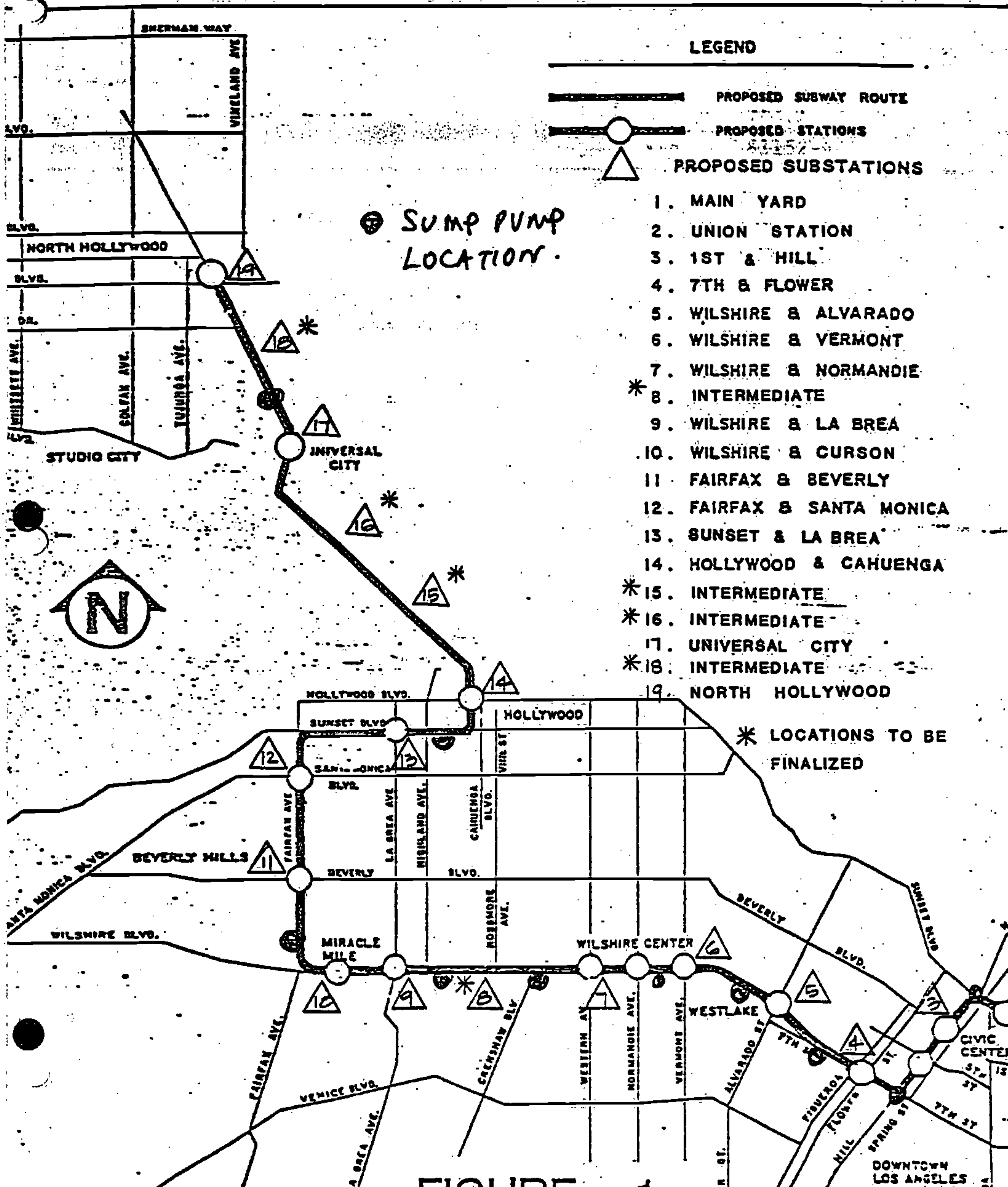
For the alternative study, the total dynamic head of all the pumps will be assumed to be 100 Ft. at 500 gpm capacity.

DPM/lm

DISTRIBUTION: P. M. Burgess - KE/Los Angeles
K. Rummel - KE/Los Angeles
C. Costa - KE/Los Angeles
G. Trnka - KE/Oakland
J. Moss - DMJM/PBQD
D. Schuler - KE/Los Angeles

SCRTD Metro Rail Project

PROPOSED ROUTE AND STATIONS



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Los Angeles, California 90013
(213) 972-6033

WBS #: 14CAE12
JOB #: 811-2-407

25 FEBRUARY 1983

MEMORANDUM TO: W. J. Rhine

FROM: P. M. Burgess

SUBJECT: WBS 14CAE12 - MECHANICAL/ELECTRICAL ALTERNATIVES ANALYSIS

At a meeting on January 17, 1983, with C. Costa of our staff, K. Fitz of Fitz Consultants and R. Beuermann of your staff, the following mechanical/electrical subsystems were selected for analysis:

1) Gas Sensors: Analyzer vs. sniffer

2) Water Flow Detectors: Magflow vs. rotometer vs. orifice meter

3) Seismic Sensors: Readout-type vs. recording-type

4) Pump System: Dry pit centrifugal pumps vs. wet pit submersible pumps.

The Design Criteria states that continual fire detection in tunnels should be provided. However, since this is not required by the Fire/Life Safety Criteria, nor is it installed in any U.S. transit systems, we would like to suggest that the Design Criteria be revised to agree with the Fire/Life Safety Criteria. If an anlysis is still required, however, we suggest analyzing a series of spot detectors versus thermister continuous detectors.

Since the Fire/Life Safety Criteria allows the manual fire alarm function to be performed by the emergency phones, it is also recommended that the Design Criteria be changed to reflect the fire/life safety approach.

Please let us know by March 1, 1983 if any of the above listed alternatives should be modified.

PMB/DS/lm

cc: M. C. Becher - SCRTD
R. Beuermann - SCRTD
K. Fitz - Fitz Consultants
[redacted]
C. Costa - KE/Los Angeles

telecon report

Raymond Kaiser Engineers

date: 3/3/83 job no: 81152

call to: D.P. Mohapatra

call from: Bob Murphy

routing:
P. M. Burgess
C. COSTA, Kirk Rummel
D. Schuer
File WBS-14 CAE

subject:- SEISMIC DETECTORS ALONG BART

Bob talked to Bill Snyder of BART telephone no (415)-465-4100. Bill said that ~~the~~ BART has seismic triggers made by Kinemetrics at selected locations (8) along the route. Bay area has experienced several earthquakes during the last 10 years, however the seismic detectors have not gone off on any occasion.

action required:- During ~~a~~ the final design the Bart seismic ~~design~~ system history should be analyzed and SCRTD seismic detection system should be developed with

telecon report

Raymond Kaiser Engineers

date: 3/4/83 job no: 81152

call to: Rich Briar of MSA
Phone 412-273-5000

call from: [redacted]

routing:
P. M. Burgess
K. Rummel
C. Costa
C. Fisher
D. Schuder
File WBS-14CA

subject:– For comparision purpose the following prices were confirmed over the phone by Rich for the infrared sensors.

No of Sensors	300
Type of "	INFRARED
Control room equip	50,000
Cable	150,000
Amplifiers	100,000
Sensors	900,000
Total	1,200,000

action required:

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Los Angeles, California 90013
(213) 972-6033

METRO RAIL PROJECT
KE JOB NO. 81152

[XXX] Minutes of Meeting

[ ] Confirmation of Telephone Conversation

[ ] Trip Report

DATE & PLACE: TUESDAY, MARCH 8, 1983
KAISER ENGINEERS CALIFORNIA
(Los Angeles Office)

PREPARED BY: D. P. MOHAPATRA

SUBJECT: MINETICS

TIME: AM

DATE: 10 MARCH 1983

FROM: D. P. MOHAPATRA DM

AT:

FILE NOS. 14CAE12

CALL FROM: ______ : CALL TO: ______ (If applicable)

PARTICIPANTS: (Minutes of Meeting only)

C. M. Costa - KE/Los Angeles
D. P. Mohapatra - KE/Los Angeles
N. H. Parker - N.H. Parker Associates

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	Norm Parker now represents the Minetics gas detection and monitoring system and came down to familiarize himself with the SCRTD project requirements. Al Ketler from Minetics has provided us data from their Pittsburgh office and from now on, Norm would like to interface for any information we need on Minetics. Norm has promised to provide operation history of the Minetics within the next few weeks. cc: P. M. Burgess - KE/Los Angeles K. G. Rummel - KE/Los Angeles		

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METRO RAIL PROJECT
KE JOB NO. 81152

[XXX] Minutes of Meeting

[ ] Confirmation of Telephone Conversation

[ ] Trip Report

DATE & PLACE: WEDS., MARCH 9, 1983
KAISER ENGINEERS CALIFORNIA
(Los Angeles Office)

DATE: 10 MARCH 1983

FROM: D. P. MOHAPATRA DM

PREPARED BY: D. P. MOHAPATRA

AT:

SUBJECT: METHANE DETECTION & MONITORING SYSTEM

FILE NOS. 14CAE12

TIME: 4:00PM

CALL FROM: ______ : CALL TO: ______ (If applicable)

PARTICIPANTS: (Minutes of Meeting only)

R. Wood - SCRTD
C. M. Costa - KE/Los Angeles
D. P. Mohapatra - KE/Los Angeles
J. Moss - DMJM/PBQD (Los Angeles)
W. Metsch - DMJM/PBQD (New York)
M. E. Nosanov - E-S Energy
G. Magnuson - E-S Energy

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	E-S Engineering Science has been retained by PBQD to provide consulting service on methane detection and monitoring during: Pre-construction phase Construction phase System operation phase The attached proposal describes the first phase of their work and is estimated to be completed within two months at an estimated cost of $100,000. PBQD will be responsible for coordination of the efforts between E-S Engineering and the participants in the meeting. E-S Engineering will produce a monthly progress report for circulation among the interfacing entities. cc: P. M. Burgess - KE/Los Angeles K. G. Rummel - KE/Los Angeles		

ENGINEERING-SCIENCE

125 WEST HUNTINGTON DRIVE • P. O. BOX 538 • ARCADIA, CALIFORNIA 91006 • 213/445-7560

CABLE ADDRESS: ENGINSCI
TELEX: 67-5428

28 February 1983

5529.211

Mr. Wehner Metsch
c/o Parsons Brinckerhoff Quade Douglas
Penn Plaza
250 W 34th Street
New York, NY 10119

Subject: Southern California Rapid Transit District
Wilshire Corridor Transportation Facility

Dear Mr. Metsch:

Thank you for your telephone call of 24 February 1983. This letter contains a brief summary of the work that we propose to perform in the initial phase of our work with your project team. This phase is described in our letter of 15 February 1983 to Mr. Wood as "A field investigation to detect, identify, and measure combustible gases, concentrations, and pressures along the route." Based on your description of the project status we also recommend that we also address criteria development during this phase as stated in the Work Plan.

You also indicated that we should prepare an estimate of the cost of the proposed work. The estimate is now being prepared, for the scope of work shown in the "Work Plan Outline and Comments" (Attachment A). The "Work Plan Outline and Comments" is brief but virtually complete except for final details. It is based on our present level of information but provides for an increase thereof.

In response to your question about the scope of our solid waste services I submit one copy of the supplemental brochure "Solid Waste Management and Resource Recovery" With respect to our mutual concern referent to air quality I submit one copy of the supplemental brochure "Air Quality Modeling Services."

We appreciate the opportunity to be part of this project and would be happy to provide further information and discuss this work plan with you. Please contact me or Gordon S. Magnuson, Division Vice President, at our toll free number (800)423-4991.

Very truly yours,

M. E. Nosanov

M. E. Nosanov

Attachment A

WORK PLAN OUTLINE AND COMMENTS

Task

1. Review existing data including following:

GER vol 1
- Geology reports
- Substructure investigation report
- Waste gas investigation to date
- Underground utilities locations
- Design criteria for following:
  - Underground rail structure
  - Underground stations
  - Substructures for utilities and other purposes

Determine data deficiencies and acquire (if any)

2.
- Prepare preliminary probe location plan
- Verify substructures location by surface survey
- Revise probe location plan
- Perform preliminary excavation at probe (boring) location
- Bore, place probes, gravel, backfill, and probe set cover boxes; at grade
- Identify locations for as-built probe plan

3.
- Perform field sampling in each probe for both qualitative (detection) and quantitative (concentrations) for following characteristics:
  - Methane
  - Carbon dioxide

- Oxygen
- Temperature
- Pressure
- Hydrogen sulfide (equivalents)

Water

b. Acquire samples in laboratory flasks for analysis by independent laboratory (either "Truesdail Labs" or "Associated Labs") for following:

- Higher hydrocarbons
- Methane
- Carbon dioxide
- Oxygen
- Nitrogen
- Carbon monoxide
- Hydrogen
- Opinion as to source

A week (Field sampling will be performed not less than 3 times)

(Acquisition of samples will be least once at selected locations)

Probes are initially proposed to be set in public right of way between the following limits:

- Wilshire Boulevard from Western Ave on the East and Fairfax Ave to the West
- Fairfax Ave from Wilshire Boulevard on the South to Beverly Boulevard on the North

The approximate footage has been scaled, from a large scale map, to be 35,000 feet. Based on analysis of the initial investigation results, the linear boundary of the field will be estimated. If either the existing or acquired data indicate that the boundaries should be extended this would be recommended. The average probe set spacing would be 500 feet. If exactly 500 feet a total of 71 probe sets would be installed; the deepest at either 40 feet or within a few feet above ground or perched water, whichever is closest to ground surface.

4. As early as possible, after initiation of the field investigation, criteria will be proposed, for discussion, to the client and client's consultants for compatibility with their safety, planning, and engineering concepts.

5. Prepare an estimate of fees for subsequent phases of work currently considered to be as follows:

   - Assistance with development of engineering, design and construction drawings, specifications, site work safety conditions, and cost estimates compatible with the basic rapid transit engineering of the prime engineering consultants.

   - Technical observation and resident engineering to assure compliance with the drawings, specifications, and site work safety conditions.

   - Post-construction monitoring to assure continued efficacy of the gas migration control system.

6. Prepare and submit a draft final report for review and comment. Prepare a final report. The final report will contain a description of the services performed, the field data, an analysis of the field data, recommended action, criteria for design, and an estimate of costs for both recommended design features and related future professional services.

OUTSIDE SERVICES

Outside services to be performed include hand excavation at drilling locations, drilling (boring), provision and placement of gravel for probe locations, backfilling, placement of probe cover boxes, hauling away surplus excavated materials, independent laboratory services, and Underground Service Alert.

SERVICES NOT INCLUDED

Engineering-Science does not propose to provide architectural service, land surveying, construction staking, structural engineering, electrical engineering, or civil engineering. The provision of materials shall be limited to those necessary for the field investigation and shall not include materials to be used during construction or operations of the transit system or its apparatus.

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SCRTD METRO RAIL PROJECT

[XX] MINUTES OF MEETING
[ ] CONFIRMATION OF TELEPHONE CONVERSATI
[ ] TRIP REPORT

DATE & PLACE: 15 APRIL 1983
SCRTD CONFERENCE ROOM "B"

DATE: 20 APRIL 1983

FROM: K. G. RUMMEL

AT :

PREPARED BY : K. G. RUMMEL

SUBJECT : DESIGN CRITERIA REQUIREMENTS

FILE: WBS #16CAD12
#14CAE12

TIME : 3:00PM

CALL FROM : N/A
(If applicable)

CALL TO: N/A

'ARTICIPANTS: (Minutes of Meeting only)

M. C. BECHER - SCRTD
J. SANDBERG - SCRTD
R. WOOD - SCRTD
J. CHANG - HWA
H. A. KIVETT - HWA
P. M. BURGESS - KE
K. G. RUMMEL - KE
D. P. MOHAPATRA - KE
I. SHAFIR - KE

'O.	DESCRIPTION	ACTION	RESPONSIBLE
	The purpose of the meeting was to resolve five issues that the architectural staff had raised relating to design decisions affecting on-going station designs. A sixth subject was a briefing by D.Mohapatra on his recent trip to BART and the resolution of related items in the WBS "14" alternative analysis for mechanical/electrical alternatives.		
1	Station Space Requirements	X	KE /SCRTD
	The first issue raised by the architects was the nature and extent of the incoming feeders from the various utility companies and the related space requirements in the station area. Their concern was related to the need to reduce ancillary space requirements in the station box and development of directive drawings for conduits. The current status of the incoming service was reiterated to HWA by M. Becher and I. Shafir which consisted of:		

	DESCRIPTION	ACTION	RESPONSIBLE
	A) We need to retain the 40 x 40 space for the outdoor type switchgear until our negotiations with the D.W.P. permit otherwise, i.e., a smaller space for metalclad switchgear. B) We must assume, for the present time, that we will get the degree of reliability/independency from the utility companies and, therefore, on-site generation provisions need not be acknowledged. C) The issue of overhead or underground feeders cannot be resolved at this time. HWA was assured that SCRTD and KE are working agressively to resolve these issues. HWA acknowledged that the problem of space reduction was not as great now as it had been since we had moved the substations to an at-grade location in many of the stations and in many of the remaining stations, the substation location over the crossover area is not as critical. However, any reduction in room sizes <u>will</u> result in cost savings.		
2	<u>Train Arrival Warning System</u> The matter of train arrival warning system was discussed. HWA wanted the opinions of the group on proceeding with a design involving platform edge lights similar in concept to WMATA. They stated they believed they could avoid the high maintenance and electrical costs of the WMATA System and still achieve the high degree of safety that design provides. HWA would like to have a system where the array of lights would sequentially activate as the train progressed into the station. They were informed that train control block design does not permit such discrimination with a response from HWA that perhaps photo-electrical sensors (or a similar system) which is self-contained could be utilized. HWA was reminded that the Safety Criteria does not specifically require such a system and, therefore, its benefits in safety or station appearance would have to justify whatever costs arise out of the design effort.	X	HWA to submit design.

	DESCRIPTION	ACTION	RESPONSIBLE
3	Station Attendant's Booth The matter of station attendants' booth functions and equipment requirements were reviewed. A previous meeting had established a baseline design for Board approval which did not involve station attendant's booths and, therefore, this subject was inappropriate for further discussion. Subsequent meetings have been schedule to resolve detailed issues of the facilities required in the station for station agents.	X	KE for meeting minute
4	Escalators The matter of escalator truss equipment housing was deferred to a later meeting.	X	KE to coordinate wi HWA.
5	Fare Collection Equipment On the quantities of fare collection gates and vendors, J. Sandberg reported that BAH would soon be recalculating these values based on the latest patronage data -- due the week of 4/18/83.	X	BAH
	Briefing - D. Mohapatra on Recent BART Visit Kaiser Engineers took the opportunity at this meeting for a brief trip report by D.Mohapatra on his recent visit to BART. The purpose of the trip was to review BART's seismic, gas and fire detection equipment. Observations on the seismic and gas detection equipment were discussed as they relate to the WBS "14" alternatives work currently underway. The status of BART's examination of a continuous tunnel fire detection system was reviewed in terms of the proposed trial installation of an Alison heat sensor and in terms of BART's engineering concerns as to its potential application and/or problems. The matter of the scope of the WBS "14" alternatives analysis was discussed and it was agreed that KE should examine this continuous sensor system vs. spot detectors in a 1000' tunnel section. This would be equivalent to a storage track length. Deba stated that the ongoing WBS "16" work can proceed for the current time without more specific direction on the extent of application of seismic gas and fire detection requirements but that in the near future these requirements will have to be solidified. KGR/llm # # #		

DMJM/PBQD/KE/HWA

A Joint Venture
METRO RAIL TRANSIT CONSULTANTS
3250 Wilshire Boulevard, Los Angeles, California 90010 Telephone: 213/381-3663

WBS #: 16CAE12

9 JUNE 1983

MEMORANDUM TO: H. J. Chaliff

FROM: P. M. Burgess

SUBJECT: SUMP PUMPS

There will be sump pumps located at low spots in the Metro Rail Transit tunnels, to pump out drainage in the sumps. Normally, these pumps would operate infrequently and will discharge the water at a predetermined point. The drawings prepared by the DMJM/PBQD staff, DRW #AC-16AAA-C-103, show that the discharge pipes penetrate the tunnel straight throught the roof.

We have met with John Moss (minutes attached) and discussed this at some length, and agree that this would be the best solution. However, we would like to point out possible problems associated with this configuration:

- The discharge pipe might come out at a point where adequate street drainage handling does not exist.

- These straight penetrations may come against the ground floor slab of existing buildings.

For these reasons, we recommend that each of the sump pump locations be analyzed carefully. We are proceeding with the assumption that these discharge pipes will go straight up. Should your analysis prove otherwise and require a discharge line in the tunnels, the arrangement of equipment in the tunnel will have to be addressed in order to accommodate this discharge line.

Let us know if any further discussion is required on this subject.

PMB/DPM/lm
attachment

cc: J. Moss - DMJM/PBQD
S. Khaled - KE
T. K. McCranie - KE
R. S. Rodda - KE
O. Headley - DMJM

Kaiser Engineers California

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425 South Main Street, 6th Floor
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(213) 972-6033

RE

[XX] MINUTES OF MEETING

[ ] CONFIRMATION OF TELEPHONE CONVERSATION

[ ] TRIP REPORT

SCRTD METRO RAIL PROJECT

DATE & PLACE: 6 JUNE 1983
DMJM/Wilshire Blvd.

DATE: 7 JUNE 1983

FROM: TKMcCranie

PREPARED BY : T. K. McCRANIE

AT : LOS ANGELES

SUBJECT : SUMP PUMPS

FILE: WBS 16CAE1211

TIME : 1:30PM

CALL FROM : N/A
(If applicable)

CALL TO:

RTICIPANTS: (Minutes of Meeting only)

J. Moss - DMJM/PBQD
S. Khaled - KE
T. K. McCranie - KE
R. S. Rodda - KE

cc: P. M. Burgess - KE
C. R. Fisher - KE
I. Shafir - KE

DESCRIPTION	ACTION	RESPONSIBLE
AC-16AAA-C-103, "Tunnel Standard, Low Point Sumps in Cross Passage Between Tunnels, Reinforced Concrete" (NOTE: Two drawings with same number). Discussed arrangement and agreed:		
A) KE to recommend one sump between tunnels, three submersible sump pumps per sump, redundant level controls, ventilation system for venting heavy hydrocarbons from sumps, and portable gas monitors for maintenance personnel.	KE	S. RODDA/ T. K. McCRANIE
B) Access to sump to be relocated out of emergency walkway, and handrail type barrier to be added to keep passengers from wandering into sump area.	DMJM/ PBQD	J. MOSS
C) DMJM/PBQD needs KE's comments on the review print submitted earlier.	KE	M. BURGESS, S. RODDA, et al.

NO.	DESCRIPTION	ACTION	RESPONSIBLE
2	AC-16AAA-C-103, "Metro Rail Starter Line, Tunnel Cross Passages-Location" (NOTE: Two drawings with same number.)	NONE	
	John Moss pointed out that the location of sump pumps could easily be adjusted to correspond with the cross passages, the cross passages in soil cost $150,000 each and in rock $170,000 each, separate rooms for sump pumps would cost similar amounts, and the cross passages can be enlarged somewhat to include the sump pumps, but there is a limit -- which is being approached with the arrangement shown on drawing AC-16AAA-C-103 of Item 1 above.		
3	AC-16AAA-C-103, "Tunnel Standard, Subway Facilities in Tunnel, Tangent Track".		
	General discussion of arrangement.	NONE	
	John Moss pointed out DMJM/PBQD needs KE's comments on this drawing.	KE	M. BURGESS C. FISHER I. SHAFIR
		KE	S. RODDA T. McCRANIE

telecon report

Raymond Kaiser Engineers

date: 10 June 1983 **job no:** 81152

routing:

R.S.Rodda

~~WBS - 14 CAF12~~

call to: Mine Safety Appliances Co. (MSA)
600 Penn Center Blvd
Pittsburgh, Pa. 15235
412.273-5000

call from: T. K. McCranie Tom
213/381-3663 ext. 631

subject: LA Metro- Rail Project, Alternative Analysis Gas Detection System

1. Discussed infrared analyzer system with R. Briar:

   A. Telcon quote of 3/4/83 to D. Mohapatra for Model 3000 sensors in a single point type system; i.e., one analyzer per sensor. Will, also, need filters, pumps, etc., add $1000 per sensing point

      Not a realistic system for the Metro Rail.

   B. Multi-point system with maximum of 24 sensing points better for Metro Rail, but still expensive compared with, say, thermal catalytic sensor type system.

      - Tubing to sensing points; aluminium, Teflon (TM), or new coated Teflon (TM) may be o.k., instead of stainless. No cost figures available.
      - Maximum run 600 - 700 ft.; therefore, only 5 or 6 sensing points per analyzer when spacing is 500 ft.
      - SPDT contacts for warning and alarm
      - Use $ 13 to $14,000 per analyzer for 5 or 6 point systems, complete with filters, pumps, etc., without tubing and without installation.
      - Maintenance items: pumps, calibration, filters (2 types, $5 to $6 each).
      - Amplifiers not needed if we use the DTS.

action required: T. M_ McCranie: Complete alternatives analysis report.

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	o Delivery: 120 days		
	o Calibrate once per week initially; then set program.		
	Discussed thermal catalytic system with Mr. W.R. Freeman:		
2.	A. Sensing heads guaranteed one year, average replacement, say three years. Guarantee valid for all atmospheres encountered so far; will be valid for Metro Rail as well. Replacement heads $115; New heads $200 each.		
	o Use same heads on coal mining machines with auto power cutout if methane detected. False alarm rate is negligible.		
	o Console modules are shock mounted in many mines where vibration may be a problem, add $100 per module.		
	o Add $50 per head for remote calibration feature. Calibrate once per month, allow four minutes per head for calibration if using platform and remote calibration feature.		
	o Calibration kits $236. Calibration gas either in 24 liter cylinders at $24 each, or 200 cu. ft. cylinders at $750 each with regulator, $425 each without regulator. Use about 0.5 liter per calibration.		
	B. Quotation No. 8705 of March 1, 1983.		
	o Model 516-N portion includes relay housing in the 467446 monitor housing.		
	o Proposing similar system for Pittsburgh Subwqy system, with hydrogen sulfide sensors, also.		
	o Can work with Catalyst Research Corp. (CRC), wholly owned subsidary of MSA, to develop other arrangements such as direct to either RTD's computer or a MSA dedicated computer at CC. Have done coal mine systems up to three miles from sensor to control.		
	o Liability for equipment will not be affected by arrangement, that is, whatever MSA furnishes will be covered by performance and material warranties.		
	o Not sure if MSA has ever furnished a sensor only type system, but for size ~~at~~ of Metro Rail would consider.		

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	o If hydrogen sulfide sensing needed, double quotation 8705 price and add $200 per head (heads cost $400 each vs $200 for methane) for explosion-proof.		
	o Hydrogen sulfide heads are electro-chemical type with limited shelf life, would stock in MSA LA warehouse.		
	o Have hydrogen sulfide sensors in Penn Turnpike tunnels, coal mines, oil shale mines, salt mines, etc.		
	o Do not do installation, furnish only with service engineer for installation and start up assistance.		
	o Recommended spares per year: 5 - control modules @ $460 ea. 5 - relay boards @ $117 ea. 5 - methane heads @ $115 each		
3.	Other		
	A. Local rep; Don Hughes or Steve Hernandaz at 213/ 875-2905. Both on road often, call in daily.		
	B. Toll free number: 1-800-MSA-INST.		

telecon report

Raymond Kaiser Engineers

date: 13 June 1983 job no: 81152

routing:

R. S. Rodda

WBS 14CAE12

call to: Mr. Tieman
Klien-Tieman Associates
213/655-7178

call from: T.K. McCranie

subject: LA Metro Rail Project
Mechanical Electrical Subsystems
Alternative Analysis, Sump Pumps

Budget pricing for triplex pump system with alternating starting feature:

? Flyt Model CP 3201 pumps, 29 brake hp, 1755 rpm, either 6 in. or 8 in. pump, high head impellar, can handle 2 inc. solids.

Use $35,000 per set.
Delivery within 4 to 18 weeks after approval.

action required: T. K. McCranie - complete alternative analysis

telecon report

Raymond Kaiser Engineers

date: 14 June 1983 **job no:** 81152

routing:

R. S. Rodda

WBS 14CAE

call to: Don Kriens - RKE Oakland
415/271/4622

call from: T. K. McCranie
213/381-3663, ext. 631

subject: L. A. Metro Rail Project, Mechanical/Electrical Subsystems Alternative Analysis, Gas Detection

In response to my request, Don gave the following prices from the Orange County Project:

Ford diesel engine pickup	
with high rail assembly	$49,000
with cherry picker	$56,000
Option for hydraulic platform add -	$ 5,000

Don also, advised that a technician must be accompanied when working in the tunnel.

action required: T. K. McCranie: complete the alternatives analysis.

telecon report

Raymond Kaiser Engineers

date: 16 June 1983 **job no:**

routing:

R. S. Rodda

WBS 14CAE12

call to: Joe Matoney/David Olsen
RKE - Oakland
415/271-4193 - 4857

call from: T.M. McCranie

subject: L.A. Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Gas Detection

I called Joe Matoney, VP-Coal, to discuss methane detection systems used in coal mines. Joe referred me to David Olsen who suggested I talk directly with safety personnel with various coal mining companies, starting with Mr. Bill Perves, Director of Safety - Consolidated Coal, 412/831-4053.

action required: T. M. McCranie - complete alternative Analysis

telecon report

Raymond Kaiser Engineers

date: 16 June 1983 **job no:** 81152

routing:

R. S. Rodda

WBS 14CAE12

call to: Mr. Nick Bacile
Alison Control Inc.
1556 Halford Avenue, Suite 145
Santa Clara, Calif. 95051
408/984-4818

call from: T. K. McCranie

subject: LA Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Tunnel Fire Protection

I called Alison Controls for revised pricing on their "ACI Proposal No. 216" dated October 29, 1982. The revision is for 2000 ft. of car storage track.

A. Thermistor System
Two zones of 1,000 ft. each
1 - NEMA 12 panel
2 x 1000 ft. - Model 9090 Sensor
2 - Junction box
500 - Sensor mounting clamps
2 - Hot spot indicators, panel mtd.
1 set - Local alarm, panel mtd.
1 set - Contacts for remote annuciation, panel mtd.

TOTAL - $25,000
Option: Add $2,600 for average sensor temperature indicator.

Owner furnishes:

Installation:

Wire - to sensors, 2 conductors, 16 g.a., per zone.
- from sensors, 1 conductor, 16 ga., per zone
Conduit
Power - 120 V, single phase, with 24 V dc backup.

action required:

B. Ultraviolet System

Based on one panel with Model 11700 detectors.
Use $2,000 per detector.
Add $500 for chart recorder used during startup testing

Owner Furnishes:

Installation
Wire - 3 conductor, 12 to 14 ga.
Conduit for explosion-proof installation.

Figure double coverage (look back type system), 150 ft. spacing, on each side of cars.

Clean lense once a month.

telecon report

Raymond Kaiser Engineers

date: 17 June 1983 **job no:** 81152

routing:

R. S. Rodda

WBS 14CAE12

call to: Mr. Jerry Schaffer
Director of Safety
Consolidated Coal
412/831-4053

call from: T. K. McCranie

subject: LA Metro Rail Project
Mechanical/Elecyrical Subsystems
Alternative Analysis - Gas Detection

As suggested by David Olsen yesterday, I called the Director of Safety, Consolidated Coal. Mr. Perves has retired, Mr. Jerry Schaffer is now Director of Safety. Mr. Schaffer advised they use the wheatstone bridge type sensor (catalytic oxidation) exclusively on their mines and on their coal handling equipment. If maintained properly, e.g., calibrated monthly and diffuser inlet cleaned, the sensors function satisfactorily and without appreciable or any, false alarms. Monitors are required in the mines by law, and must alarm if 2% methane is detected. Many companies set the alarm/power shutoff at 0.5% methane. On coal handling equipment, the detectors systems are often arranged to shut off power if the methane level rises to the set point (0.5%, etc.). Mr. Schaffer was not familar with infrared analyzer systems. Mr. Schaffer suggested I contact Mr. Bill Miller, Safety and Technical Supervisor, Cardinal River Mines, Hinton, Alberta, Canada, 403/692-3763.

action required: T. K. McCranie - complete the alternative analysis.

telecon report

Raymond Kaiser Engineers

date: 17 June 1983 **job no:** 81152

routing:

R. S. Rodda

WBS 14CAE12

call to: Dr. James Stanko
Safety and Industrial Relations
U. S. Steel - Coal Mining Division
412/533-6798

call from: T. K. McCranie

subject: L. A. Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Gas Detection

Dr. Stanko advised they use the wheatstone bridge type detector exclusively in their mines and are satisfied with the operation. Other type equipment, which may be the infrared type, is used only in their laboratories. He suggested I talk with:

Mr. Bernard Roy, Director of Safety
Amax
Greenwich, Conn.
203/622-2970

Mr. John Murphy, Research Director
U. S. Bureau of Mines
412/675-6601, or 6400, or 621-4500

action required: T. K. McCranie - complete the alternative analysis.

telecon report

Raymond Kaiser Engineers

date: 17 June 1983 **job no:** 81152

routing:

R. S. Rodda

WBS 14CAF12

call to: Mr. S. Hernandaz
Mine Safety Appliances Co.
800-672-2222

call from: T. K. McCranie

subject: LA Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Gas Detection

Mr. Hernandaz will develop a users list for ultraviolet analyzers, mostly used in process industries, have been used in parking garages. Mines use thermal catalytic systems most often. Other methods used are thermal conduitivity type and a solid state type. The thermal conduitivity type are more expensive, MSA's Model 3 costs about $1,000 per head. The solid state type are sensitive to humidity, carbon dioxide, carbon monoxide, hydrogen sulfide and some others which affect accuracy and reliability.

Set up meeting with Mr. Hernandaz for 2 PM June 20, 1983 at 425 So. Main Street Office.

action required: T. K. McCranie - complete alternative analysis

telecon report

Raymond Kaiser Engineers

date: 20 JUNE 1983 job no: 81152

routing:

R. S. RODDA

WBS 14CAE12

call to: MR. JOHN MURPHY, Director of Research
U.S. BUREAU OF MINES
Pittsburgh, PA, 415/675-6601

call from: [redacted] Tom

subject: MECHANICAL/ELECTRICAL SUBSYSTEMS - LOS ANGELES METRO RAIL ALTERNATIVE ANALYSIS - GAS DETECTION

Mr. Murphy advised:

- Catalytic type sensors are used in U.S. coal mines primarily, European mines have used central analyzer type systems extensively. Some changeover in Europe to catalytic sensors to get quicker response (long probe run) and eliminate the possibility of probe leakage.
- Pump maintenance probably the primary maintenance item on central syste
- "Poisoning" by silicons potential problem with catalytic sensors. Confirm atmosphere before selecting. Make sure silicon products are not used for cleaning of tunnels or sensors.
- If approved for use in mines, detectors are intrinsically safe. Knows of no approved detectors with a history of causing fires or explosions.
- Check with catalytic sensor suppliers for remote calibration attachment
- May be able to increase sensor/probe spacing by measuring air flow.
- Will discuss the Metro Rail System with his staff and advise of their comments.

action required: T. K. McCRANIE -- COMPLETE ALTERNATIVE ANALYSIS.

/llm
06/21/83

Kaiser Engineers California

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A Subsidiary of Raymond Kaiser Engineers Inc.
425 South Main Street, 6th Floor
Los Angeles, California 90013
(213) 972-6033

[X] MINUTES OF MEETING

[ ] CONFIRMATION OF TELEPHONE CONVERSATION

[ ] TRIP REPORT

SCRTD METRO RAIL PROJECT

DATE & PLACE: 21 June 1983
KEC Office
425 So. Main
Los Angeles, CA

PREPARED BY : T.K. McCranie

SUBJECT : Mech./Elect. Subsystems

TIME : 4 PM

CALL FROM : N/A
(If applicable)

DATE: 21 June 1983

FROM: T.K. McCranie Tom

AT : LA (So. Main)

FILE: WBS 14CAE12

CALL TO: N/A

PARTICIPANTS: (Minutes of Meeting only)

W.C. (Bill) Tieman, Klein-Tieman Associates
T.K. McCranie, KEC

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	Discussed the features of Flygt submersible pumps, (Flygt Corporation, a subsidiary of ITT). Flygt is the originator and world's largest manufacturer of heavy duty submersible pumps. Features of Flygt submersible pumps include: o Inlet screen not recommended, pumps can generally handle particles up to discharge I.D. size. o Machined discharge flange, cantilevered support and guide system designed so that pump/motor can be lifted without unbolting. Need to attach hoist line only. o Pump to motor seal tungsten carbide in oil bath. o Routine maintenance is to check oil annually, depending on service. o If motor rotation reversed, pump/motor not damaged. Pump capacity affected.		

Minutes of Meeting

Confirmation of Telephone Conversation

Trip Report

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	o Can run dry without adverse effects. o Motor has circulated water cooling jacket. o Stator press fitted which will increase rewind costs. o Bearings "lubed for life" type, adequate L_{10} Life (not sure of figure). o Motor air filled type - fewer losses than oil filled type. o Feeder sealed. Feeder terminals sealed and separated from motor. Mr. Tieman left various pieces of literature about Flygt pumps and sumps. He will furnish budget pricing for triplex pump sets in the near future. TK:dm		

telecon report

Raymond Kaiser Engineers

date: 21 June 1983 job no: 81152

routing:

R.S. Rodda

WBS 14CAE12

call to: Reliance Electric Co,
714-527-0105

call from: [redacted] Tom

subject: LA Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Sump Pumps

Requested budget pricing for 25 Hp, 1800 rpm, 480V, 3ph, 6.0 Hz motors from Mr. Tom Meyers who advised:

- TEFC $630.
- Explosion proof $840.
- Do not make vertical; hollow shaft motors.

action required: T.K. McCranie - Complete alternative analysis.

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[XX] MINUTES OF MEETING
[ ] CONFIRMATION OF TELEPHONE CONVERSATION
[ ] TRIP REPORT

SCRTD METRO RAIL PROJECT

[illegible]

DATE & PLACE: 22 JUNE 1983
KE OFFICE - LOS ANGELES

DATE: 23 JUNE 1983

FROM: T. K. McCRANIE Tom

AT : LOS ANGELES

FILE: 14CAE12

PREPARED BY : T. K. McCRANIE

SUBJECT : MECHANICAL/ELECTRICAL SUBSYSTEM GAS DETECTION

TIME : 10:00AM

CALL FROM : N/A
(If applicable)

CALL TO:

PARTICIPANTS: (Minutes of Meeting only)

S. Hernandaz, Mine Safety Appliances Co.
T. K. McCranie - KE

cc: R. S. Rodda

NO.	DESCRIPTION	ACTION	RESPONSIBLE
1	<u>INFRARED SYSTEMS</u> ° Model 202X, explosion proof. Cost $5100.00 each, add about $10,000 for filter, pumps, cabinets and valves. ° Figure 15fps gas velocity using 3/8" stainless steel tubing. ° Use stainless steel tubing because Teflon will harden, aluminum and copper will oxidize. ° Figure 2 to 3 ft.^{3}/min, of calibration gas for 3 to 4 minutes for calibration. ° Calibrate once per week. ° Need 3-way valve for purging line and cleaning probe inlet filter.		

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	o Power requirements analyzer 500 watts, 1/3 hp pump and 3/8" solenoid.		
	o <u>Maintenance</u>: Line filters, change once per month, use $12/month. Leak check every six months. Replace pump diaphrams every six months, $10/set.		
	o <u>Disadvantages</u>: Time lag for gas to travel to analyzer. If analyzer is out of order, related probes are, also, out. Installation cost and interface, both electrians and pipe filters required. Probe purge requirements, need portable air compressor. Calibration gas requirements..		
2	<u>MODEL 516 SYSTEM</u>		
	o A present, not Class I, Division I, Group D housing but Mr. Hernandez will discuss with home office.		
	o Can permanently mount sensing head adapter to sensor inlet; then run tube to convenient location for calibration. Remote calibration assembly not required if two technicians are available. Sensing head adapter will, also, help with air flow into the sensor by dampening the disturbances caused by the trains. Can use nylon or teflon tubing for calibration gas even though life is about five years, because of short run and no couplings required.		
3	<u>SERIES 512 SYSTEM</u>		
	o Explosion proof control unit monitors one catalytic oxidation type sensor, cost with sensor $2,253 per set.		
	o Requires power (110 Vac, 12Vdc, see brochure) and three 2-wire signal cables (one each for trouble, warning and alarm contacts) to control unit, and four wire cable to sensor.		
	o Sensor same as Model 516 System.		
	o May reduce wiring and conduit costs.		
	o Explosion proof design already part of MSA's products.		
	o Power consumption, about 100 milliwatts per unit.		

No.	DESCRIPTION	ACTION	RESPONSIBLE
4	OTHER o Calibration gas available from local distributors. Use $200 for empty 25 ft.^{3} portable bottle, and $85 for gas costs. o Thermal Conductivity Analyzer System. Cost $5,170/unit, system arrangement and cost similar to infrared system (need pumps, etc.) slower response than infrared, not normally used for methane detection (see brochure). # # # TKM/llm		

telecon report

Raymond Kaiser Engineers

date: 22 June 1983 job no: 81152

routing:

R.S. Rodda

WBS 14CAE12

call to: McKenna Engineering & Equipment Co. Inc,
Mr. Gerry Allen
213-775-2613

call from: [redacted]

subject: SCRTD Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Sump Pumps

Mr. Allen advised:

Alternation control for triplex pump set, 25 hp motors, with 3-hand/off/auto switches, pilot lights, magnetic circuits, clock operated alternation, NEMA 12 housing: Estimated cost $4,800 each. Dimensions about 3'W X 5'H X 1'D.

Mercury bulb type level switches, about $70 each.

action required: T.K. McCranie - Complete alternative analysis.

telecon report

Raymond Kaiser Engineers

date: 23 June 1983 job no: 81152

call to: John E. Thompson
Fire Protection and Safety Inspector
WMATA
202-637-1563

call from: [redacted] Tom

routing:

R.S. Rodda

John Moss

WBS 14CAE12

subject: SCRTD Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Sump Pumps

Mr. Thompson advised that the tunnel flooding WMATA experienced was due to a blockage of the drain from the track area to the sump; and not due to sump pump failure as had previously been thought.

(The flood level reached the third rail causing short circuits and extensive damage to eight miles of track.)

action required: T.K. McCranie - Complete alternative analysis.

telecon report

Raymond Kaiser Engineers

date: 23 June 1983   job no: 81152

call to: John Moss
DMJM/PBQD - T & TC
213/381-3663 Ext 434

call from: T.K. McCranie
Tom

routing:
R.S. Rodda
John Moss
WBS 14CAE12
WBS 16CAE12

subject: SCRTD Metro Rail Project
Mechanical/Electrical Subsystems
Alternative Analysis - Sump Pumps and Gas Detection

Mr. Moss advised that (1) consideration was being given to specifying a leakage rate of 0.3 gpd/100 ft^2 of linear area, however this was barely in the discussion stage; and (2) either Bud MaDuke or Frank Fortunato should be contacted about the E-S Engineering Science contract.

I advised Mr. Moss that contrary to our previous discussion (see Minutes of Meeting, 6 June 1983), KEC may not be recommending triplex sump pumps because the WMATA failure was due to a blockage of the line to the sump, and not a sump pump failure (see Telcon Report, John E. Thompson - T.K. McCranie, 23 June 1983).

action required: T.K. McCranie - Complete alternative analysis

Kaiser Engineers California

KE

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SCRTD METRO RAIL PROJECT

[XX] MINUTES OF MEETING

[ ] CONFIRMATION OF TELEPHONE CONVERSATION

[ ] TRIP REPORT

DATE & PLACE: 30 JUNE 1983
OFFICE OF R. S. RODDA (KE)

DATE: 5 JULY 1983

FROM: T. K. McCRANIE Tom

PREPARED BY : T. K. McCRANIE

AT : LOS ANGELES

SUBJECT : MECH/ELECT SUBSYSTEMS
Alternative Analysis - Fire Detection

FILE: WBS 14CAE12

TIME : 9:30AM

CALL FROM : N/A
(If applicable)

CALL TO:

PARTICIPANTS: (Minutes of Meeting only)

KEITH KUSHNER, Sales Rep., GRINNEL FIRE PROTECTION SYSTEMS CO., INC.
[redacted]

NO.	DESCRIPTION	ACTION	RESPONSIBLE
	GRINNEL FIRE PROTECTION SYSTEMS COMPANY, INC. 564 Mateo Street Los Angeles, CA 90013 213/687-9990		
	GRINNEL DESIGNS SYSTEMS FOR, AND REPRESENTS OTHER, MANUFACTURERS BESIDES BEING A MANUFACTURER THEMSELVES. PRODUCTION INFORMATION RECEIVED AND PRODUCTS DISCUSSED WERE:		
1	Thermotech heat compensated, fixed point fire detectors manufacturered by Fire Device Company. Cost $50 to $60 each. Requires two conductor signal wire for contact closure signal. Explosion proof model available. Other manufacturers have similar products as well as uncompensated type fixed point fire detectors. Heat compensation helps prevent temperature overrun problems experienced with uncompensated type, e.g., set point at 135F, but uncompensated type have been known not to respond until 400F because of the heat rise rate.		

Minutes of Meeting

Confirmation of Telephone Conversation

Trip Report

NO.	DESCRIPTION	ACTION	RESPONSIBLE
2	Notifier fixed temperature only, and combination fixed temperature and rate-of-rise heat detectors by Notifier Company, Emhart Electrical/Electronic Group. Cost $15 to $16 each. Requires two (2) conductor signal cable for contact closure type signal. Uses fusible link for fixed temperature detection and air filled, flexible metal bellows for rate-of-rise detection. Entire unit must be replaced if fusible link melts. Not temperature compensated. Other manufacturers have similar products with heat compensation.		
3	Pyrotector infrared fire detector by Pyrotector, Inc., subsidiary of Grinnel Fire Protection Systems Co., Inc. Cost about $600 each. Requires two conductor signal cable for contact closure type signal, two conductor power cable for 18 to 30 Vdc power, and two conductor test cable for 18 to 30 Vdc power (six conductors total). Faster response than most other types, must see fire, includes compensation for welding arcs, sunlight and other causes of false alarms in other infrared and ultraviolet detectors, has integral test light for checking lense condition, explosion proof, unusually small lense for this type detector. Other manufacturers have similar products without compensation costing about $200 each and up.		
4	Linear thermal detector cable manufacturer either Pyrotector Inc., to be confirmed. Literature to be sent later. Cost about $15/meter plus $4000 for control. Continuous line type detector, adjustable annunciating temperature setting, senses heat and causes alarm if one meter or more at cable exceeds set point, open and short circuit circuit supervision, about 0.011" O.D., circuits up to 10 kilometers long. Not as sophisticated as thermistor system by Alison.		
	Mr. Kushner advised that he is aware of, but has handled neither any pneumatic tube type systems nor fusible thermal wire type systems. Grinnel is presently working with Alison Control on a thermistor system for an ANG plant.		
	Mr. Kushner will send literature on new systems from Europe.		
	# # #		
	TKM/llm		

APPENDIX D
CALCULATIONS

APPENDIX D

CALCULATIONS

PARAMETERS OF ECONOMIC ANALYSES

In the tables, all costs are based on 1983 dollars.

Annual Equivalent Cost = ACC + AOC + AMC

ACC = Annual Capital Cost

$$ACC = \frac{(1 + i)^{n} \times i}{(1 + i)^{n} - 1} \times CC$$

CC = initial capital cost

i = 12% interest rate

n = 32-year life

$$ACC = \frac{(1 + 0.12)^{32} \times 0.12}{(1 + 0.12)^{32} - 1} \times CC = 0.12328 \times CC$$

AOC = Annual Operating Cost

Based on an average cost of electricity at $0.07/kwh.

AMC = Annual Maintenance Cost

Alternative Analysis, Gas Detection

I Sensing points Required.
Spacing: 500 ft between sensing points per
1 Feb 83 Minutes of Meeting.

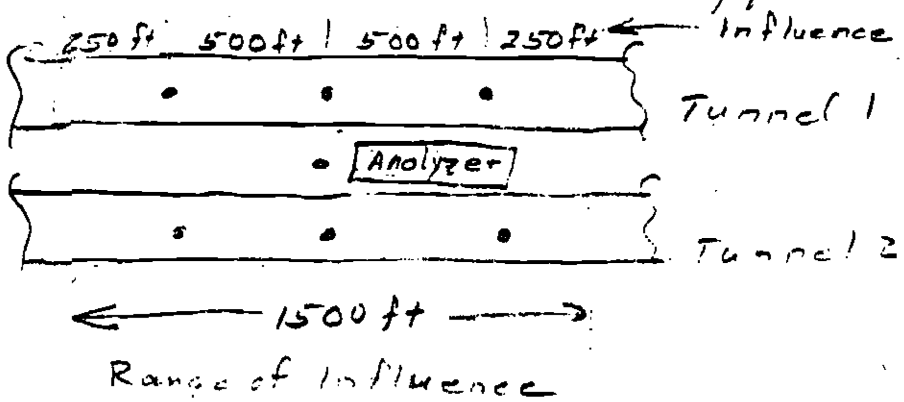
Tunnel length per Milestone 10

End	106150
Portal	8500
	97,650 ft

$$\frac{(97{,}650\ \text{ft/tunnel})(2\ \text{tunnels})}{500\ \text{ft/point}} = 390\ \text{points}$$

II MULTI-POINT INFRARED ANALYZER SYSTEM.

A. Spacing of Analyzers
Maximum of 700 ft from sensing point to analyzer.



Continuation, Alternative Analysis, Gas Detection
II Continued
B. Analyzers Required

$$\frac{390 \text{ points in tunnel}}{6 \text{ points in tunnel/analyzer}} = 65 \text{ analyzers}$$

C. Analyzer Cost

65 analyzers w/accessories installed @ \$15,100/each = \$981,500
Reference 22 June 1983 Minutes of Meeting
and 10 June 1983 telcon report

D. Portable Air Compressor for purging senior tubing

Per Sears Catalog \$400.00

E. Calibration Gas
1) Gas Requirement
$(3\ ft^3/min)(4\ min/week\text{-}analyzer) = 12\ ft^3/wk\text{-}analyz$
2) Cylinder choices: (Airco Industrial Gas)

Cylinder No.	ft^3	Gas Cost \$/ft^3	Gas Cost \$	Cylinder Wt.	Cylinder O.D. X Ht
30	30	\$1.91	\$57.30	27#	6" X 24"
80	80	0.76	60.80	68	8 X 31
200	210	0.32	67.20	130	9 X 56
300	240	0.31	74.40	140	10 X 61

Continuation, Alternative Analysis, Gas Detection

II Continued

E. 2) Continued

Cylinder Cost, per MSA, $200 for 25 ft^3 (assume 30 ft^3)

$425 for 200 ft^3 (assume 240 ft^3)

$325 for regulator assembly

$24 for 24 liter with gas.

Compare 240 ft^3 cylinder with 30 ft^3 cylinder

3) 240 ft^3 Cylinder

Number of analyzers serviced:

$$\left(\frac{240\ ft^3}{cyl.}\right)\left(\frac{anal}{12\ ft^3}\right) = 20\ anal.$$

Will need $\left(\frac{65}{20}\right)$ = say 4 cylinders/wk if we have sufficient time to connect-calibrate-disconnect.

Allow 6 minutes per analyzer.

$$(65\ anal)(6\ min/anal)(1h/60\ min) = 6.5\ h/wk$$

Travel time walking at 2 mph starting at one analyzer

$$\left(\frac{1500\ ft}{anal}\right)(64\ anal)\left(\frac{mile}{5,280\ ft}\right)\left(\frac{h}{2\ mile}\right) = 9.1\ h/wk$$

Total time = 6.5 + 9.1 = 15.6 h/wk

Continuation, Alternative Analysers, Gas Detection

II Continued

E.3) Continued.

Can calibrate all analyzers in one week.

Need cylinders and cart.

cylinders	1 @ $750	=	750
	3 @ 425	=	1275
cart, allow			~150
		say	$2200

Labor, use $33.75/h, electrician rate from Estimating Dept

$$(2\text{ techs})(15.6\ h/w)(\$33.75/h)(52\ w/y) = \$54,800$$

Gas Cost

$$\left(\frac{12\ ft^3}{\text{anal-wk}}\right)\left(\frac{\$0.31}{ft^3}\right)\left(65\ \text{anal}\right)\left(\frac{52\ wk}{y}\right) = \$12,600/y$$

Spare Cylinders

Need four/wk for calibration, so need four spares plus contingency, say six spares

$$(6\ cyl)(\$425/cyl) = \$2,600$$

4) 30 ft^3 Cylinders

Analyzers serviced:

$$\left(\frac{30\ ft^3}{\ }\right)\left(\frac{\text{anal}}{12\ ft^3}\right) = 2.5\ \text{anal/cyl.}$$

Continuation, Alternative Analysis, Gas Detection

II Continued

E. 4) Continued.

Assume cylinders are kept at stations and are portable.

Number of cylinders needed:

$$\left(\frac{65 \text{ anal}}{\text{wk}}\right)\left(\frac{\text{cyl}}{2.5 \text{ anal}}\right) = 26 \text{ cyl/wk.}$$

cylinders:	1 @ \$525	525
	25 @ \$200	5000
	say	\$5,500

Calibration time and travel time same as for 240 ft³; therefore, labor cost the same.

Gas Cost

$$(12\ ft^3/\text{anal-wk})(\$1.91/ft^3)(65\ \text{anal})(52\ \text{wk/y}) = \$77,500/\text{yr}$$

Spare Cylinders

Need 26 cyl/wk plus contingency, say 30 cyl.

$(30\ \text{cyl})(\$200) = \$6,000$

Continuation, Alternative Analysis, Gas Detection

II Continued.

E.5) Summary - Cylinder Comparison.

Capital & Initial Cost Item	240 ft^3	30 ft^3
Primary cylinders	$ 2,200	$ 5,500
Spare cylinders	2,600	6,000
Total	$ 4,800	$ 11,500
Annualized (0.12328)	$ 600	$ 1,400

Annual Costs		
Capital	$ 600	$ 1,400
Labor	54,800	54,800
Gas	12,600	77,500
TOTAL	$ 68,000	$ 133,700

Use 240 ft^3 cylinders.

Continuation, Alternative Analysis, Gas Detection

II. Continued

F. Tubing for Sensing Probes: 3/8" 316 Stainless Steel.

Refer to sketch on page 1,

In tunnels: (2 tunnels)(500 ft to #1 + 500 ft to #3) =	2,000 ft
Tunnel to analyzer, say (30 ft)(6 lines) =	180
Sensor in analyzer room, say	20
Tubing per analyzer	2,200 ft

Material including clamps, fittings and valves:

(2200 ft)($4/ft)(65 anal) =	$572,000
Labor (2,200 ft)(0.25h/ft)($33.75/h) =	18,600
	$590,600

G. Signal Cable to DTS at Stations

Need 12 conductor cable for individual probe location, methane level and trouble signals. Assume 14 gauge. Length of cable in raceway equals length of tunnel less 1000 ft. Material cost, labor cost, and installation time from Estimating, except connections to analyzers

Raceway:	Cable Cost: (96,560 ft)($1,136/1000 ft) =	$109,700
	Installation (96,560 ft)(20 hr/1000 ft)($33.75/h) =	65,200
To Analyzer	Cable: (100 ft)($1,136/1000 ft)(65 anal) =	7,400
and DTS	Conduit: (100 ft)($1.65/ft)(65 anal) =	10,700
(Allow 50 ft each)	Installation (100 ft)(0.15 hr/ft)($33.75/hr)(65 anal) =	32,900
	Ringout etc (12 cond)(0.2 h/cond)($33.75/hr)(65 anal) =	5,300
	Subtotal:	$231,200

Continuation, Alternative Analysis, Gas Detection

II Continued

G. Continued

	Subtotal from page 6		$231,200
Connections	Material: ($10/anal)(65 anal)	=	700
to DTS and	Labor: (3h/anal)(65 anal)($33.75/h)	=	6,600
analyzers	Total - Signal Cable		$238,500

H. Power Cable

Two conductor, 110V, 1-ph, 60Hz, length equals length of tunnel less 1000 ft.

Raceway:	Cable: (96,560ft)($0.25/ft) =		$24,100
	Installation: (96,560ft)(20h/1000ft)($33.75/h) =		65,200
To Analyzer	Cable: (100 ft)($0.25/ft)(65 anal)	=	1,600
and Power	Conduit: (100 ft)($1.50/ft)(65 anal)	=	9,800
supply:	Installation: (100 ft)(0.15h/ft)($33.75/h)(65 anal)	=	32,900
	Connections: Included with signal cable		
	Total - Power Cable		$133,600

I. Spare Parts Allowance

	Initial	Annual
Spare analyzers, 2 @ $5,100 each =	$10,200	5,100
Parts for analyzers, 2% of $5,100 x 65 =	6,600	6,600
Spare pumps, 5 @ $1,000 each =	5,000	1,000
Line filters: ($5/probe-mn)(390 probes)(12 m/y) =	23,400	23,400
Pump diaphrams: ($10/anal-6mn)(65 anal)(2/yr) =	1,300	1,300
Other pump parts: 10% of $1,000 x 65 =	6,500	6,500
Total - Spare Parts	$53,000	$43,900

Continuation, Alternative Analysis, Gas Detection

II Continued

J. Calibration and Maintenance Personnel

1) Calibrate every week. Allow 10 minutes/analyzer

$$\left(\frac{10\,min}{anal-wk}\right)\left(65\,anal\right)\left(\frac{h}{60\,min}\right) = 10.8\ h/wk$$

Travel time between analyzers, walking at 2 mph starting at one analyzer.

$$\left(\frac{1500\,ft}{anal}\right)\left(64\,anal\right)\left(\frac{mile}{5{,}280\,ft}\right)\left(\frac{h}{2\,mile}\right) = 9\ h$$

Calibration 10.8 h + travel 9 h = 19.8 h/wk

2) Pump - Replace diaphragm every 6 months
Allow 1 h/anal, 65 anal. gives 65 h/y, say 1.3 h/w

3) Other in tunnel maintenance, allow 1 h/w - analy = 65 h/w

4) - Calibration and travel 19.8 h/w
Pump 1.3 h/w
Other 65
86.1 h/w

Continuation, Alternative Analysis, Gas Detectors

II Continued

J. Continued

Available non-revenue hours: 4 h/d

$$\frac{86.1\ h/w}{4\ h/d} = 21.5\ d/w$$

Available time per week per technician team: 5 d/w-team

$$\frac{21.5\ d/w}{5\ d/w\text{-team}} = 4.3 \text{ teams, say 4 teams}$$

Technicians per team: 2, gives 8 technicians

Allow one technician in shop, day shift, also, for vacation relief, sick leave, etc.

Allow 1.5 shift differential for non-revenue hours

Assume one team does related work and three teams do other work for balance of Midnight to 8AM shift.

$(2\ \text{techs})(40\ h/w)(52\ w/y)(\$33.75/h)(1.5) = \$210,600$

$(6\ \text{techs})(4\ h/d)(5\ d/w)(52\ w/y)(\$33.75/h)(1.5) = 315,900$

$(1\ \text{tech})(40\ h/w)(52\ w/y)(\$33.75/h) = 70,200$

$\$596,700/y$

K. Power

Analyzer = 500 watts

Pump $(1/3\ hp)(746\ w/hp)\left(\frac{1}{0.75}\right)$ = 330

Solenoids $(7)(6\ \text{watts})$ = 40

Continuation, Alternative Analysis, Gas Detection

II Continued

K. Continued

$$\left(\frac{870\ \text{watts}}{\text{anal}}\right)\left(\frac{\text{Kw}}{1000\ \text{w}}\right)\left(\frac{\$0.07}{\text{Kw}}\right)\left(\frac{24\ \text{h}}{\text{d}}\right)\left(\frac{365\ \text{d}}{\text{y}}\right)\left(650\ \text{anal}\right) = \underline{\underline{\$34,700/\text{y}}}$$

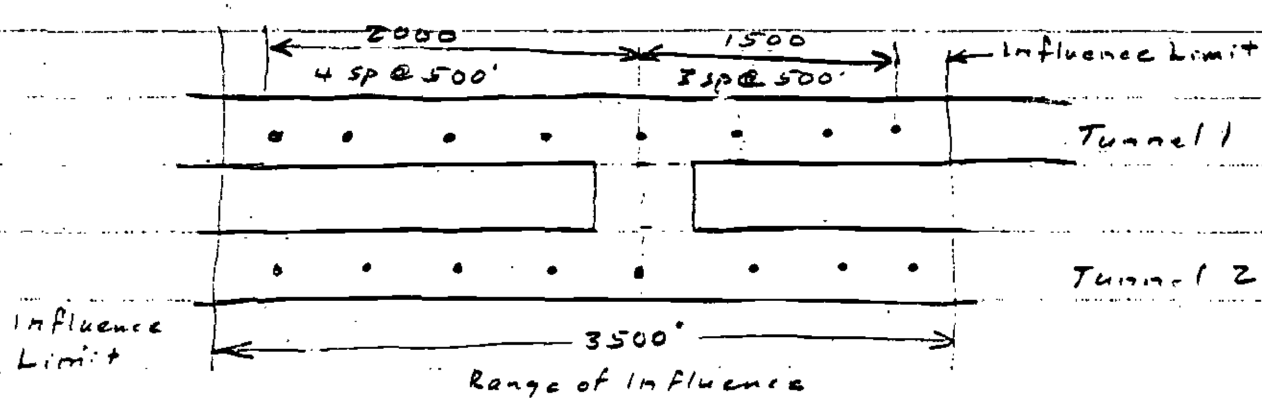
III CATALYTIC OXIDATION SYSTEM

A. Spacing of Monitors - Using MSA Quote 8705 as modified by 6/10/85 telcon.

One monitor controls up to 16 sensors, Maximum distance between sensors and monitors 5000 ft. without amplifiers.

Assume monitors located in stations.

Average spacing:



Continuation, Alternative Analysis, Gas Detection

III Continued

B. Monitors Required

$$\frac{390 \text{ points}}{16 \text{ points/monitor}} = 24.4\text{, use 25 monitors}$$

C. Monitor and Sensor Cost

Use MSA Model 516-N pricing

Monitor sets, 25 @ 16,517 each =	\$412,900
Calibration Assembly, 390 @ \$50 each =	19,500
Deduct for sensors not installed	
[(25 monitor sets X 16 sensors/set) - (390)] \$200 =	(2,000)
	\$430,400

D. Calibration Gas

1) Gas Requirement

Allow 0.5 l per 6/10/85 telcon plus five times volume needed to fill tubing required for calibration at walkway level. Allow 20 ft of 3/8 in tubing per sensor.

Internal diameter 7/8" tubing 0.5"

$$\text{Volume} = 3.14\left(\frac{0.5^2}{4}\right)\left(\frac{ft^2}{144\ in^2}\right)(20\ ft) = 0.03\ ft^3$$

$$\text{Gas Required}: (0.5\ l)(0.035\ ft^3/l) + (5)(0.03\ ft^3) = 0.2\ ft^3/\text{sensor}$$

$$(16\ \text{sensors/monitor-week})(0.2\ ft^3/\text{sensor}) = 3\ ft^3/\text{monitor-week}$$

Compare 240 ft^3 cylinders with 50 ft^3 cylinders

Continuation, Alternative Analysis, Gas Detection

III Continued

D. Continued

2) 240 ft^3 Cylinder

Number of monitor sets serviced:

$$\left(\frac{240 ft^3}{cyl}\right)\left(\frac{monitor}{8 ft^3}\right) = 30 \text{ say 25 with contingency}$$

Need one cylinder per week if we have sufficient time:
Allow 6 minutes per sensor to connect-calibrate-disconnect.
(Per 6/10/83 telecon, 4 minutes to calibrate, simple attachment)

$$(390 \text{ sensors})(6 \text{ min/sensor})(1h/60min) = 39 h/wk$$

Travel time walking at 2 mph starting at one sensor

$$\left(\frac{500 ft}{sensor}\right)\left(387 \text{ sensors}\right)\left(\frac{mile}{5,280 ft}\right)\left(\frac{h}{2 mile}\right) = 19 \quad h$$

Total time required: 39 + 19 = 58 h/wk
Can be done with two crews, one for each tunnel,
Will require two cylinders with carts

Cylinders with regulators	$750 x 2 =	1500
Cart, allow	150 x 2 =	300
		$1800

Need to replace cylinders every two weeks

Continuation, Alternative Analysis, Gas Detection

III Continued

D.2) Continued

Labor for calibration and travel:

Two crews of two technicians, i.e., four technicians

$$\left(4 \text{ techs}\right)\left(\frac{\$33.75}{h}\right)\left(\frac{1}{2}\text{ system}\right)\left(\frac{58\ h}{wk\text{-system}}\right)\left(\frac{52\ wk}{yr}\right) = \$203{,}600/yr$$

Gas Cost

$$\left(\frac{8\ ft^3}{mon\text{-}wk}\right)\left(\frac{\$0.31}{ft^3}\right)\left(16 \text{ monitor}\right)\left(\frac{52\ wk}{yr}\right) = \$2{,}100/yr$$

Spare cylinder Cost

Need to change cylinders every two weeks, will need two spare cylinders plus contingency of say two.

$$(4\ cyl)(\$425/cyl) \approx \$900$$

3) 30 ft^3 Cylinders

Number of monitor sets serviced:

$$\left(\frac{30\ ft^3}{cyl}\right)\left(\frac{mon}{8\ ft^3}\right) = 3.75 \quad \text{say 3 with contingency}$$

Assume cylinders are kept at stations and at 29 lbs each are portable (without cart).

Continuation, Alternative Analysis, Gas Detection

III Continued

D. 3) Continued.

Number of cylinders required.

$$\left(\frac{16 \text{ mon}}{\text{wk.}}\right)\left(\frac{\text{cyl}}{3 \text{ mon}}\right) \approx 5 \text{ cyl/wk}$$

(5 cyl with regulators)(\$525 each) = \$2,600

Calibration time and travel time same as for 240 ft^3 cylinders; therefore, labor cost the same.

Gas Cost

$$\left(16 \text{ mon}\right)\left(\frac{8 \text{ ft}^3}{\text{mon-wk}}\right)\left(\frac{\$1.91}{\text{ft}^3}\right)\left(\frac{52 \text{ wk}}{\text{yr}}\right) = \$12,700/\text{yr}$$

Spare cylinders

Need five cylinders per week plus contingency, say ten cylinders total

(10 cyl)(\$200/cyl) = \$2,000.

Continuation, Alternative Analysis, Gas Detection

III Continued

D, 4) Summary — Cylinder comparison

Capital Cost Item	$240 ft^3$	$30 ft^3$
Primary Cylinders	1,800	2,600
Spare cylinders	900	2,000
Total	2,700	4,600
Annualized (0.12328)	300	600

Annual Cost Item		
Capital Cost	300	600
Labor	203,600	203,600
Gas	2,100	12,700
TOTAL	\$206,000	\$216,900

Use $240 ft^3$ cylinders

E. Cable to Sensors

Need four conductor cable to each sensor, two power conductors and two signal conductors, assume averge is 18 gauge. Refer to sketch on page 9.

Continuation, Alternative Analysis, Gas Detection

III Continued

E. Continued.

Cable in raceway.

Distance	Tunnel 1	Tunnel 2	Total Cables	Feet of Cable
2,000 ft	1	1	2	4,000
1,500	2	2	4	6,000
1,000	2	2	4	4,000
500	2	2	4	2,000

Total cable length in raceway per monitor 16,000 ft/monitor

Cable and conduit from sensor to raceway

Tunnel 17.5 ft I.D., about 1/3 of circumference from sensor to raceway,

$$(1/3)(3.14)(17.5\,ft) = 18.3\,ft, \text{ per sensor}$$

Per monitor: (16 sensors)(18.3 ft) ≈ 290 ft /monitor

Raceway to Station, Allow 50 ft to monitor location

Tunnel 1 (51 ft - 9 ft) + 50 ft = 92 ft

Tunnel 2 9 ft + 50 ft = 59 ft

Cable per sensor, conduit per monitor: 151 ft

Cable cost, \$1.10/ft per MSA, use 0.75 discount factor,

1.10 × 0.75 = \$0.825/ft, use \$0.80/ft.

Conduit: use figure for infrared sensors.

Installation: adapt infrared sensor figures.

Continuation, Alternative Analysis, Gas Detection

III Continued

E. Continued

Cable in raceway:

Material: (16,000 ft)(25 monitors)($0.80/ft) = $320,000

Installation: (16,000 ft)(25 mon)(20h/1000ft)($33.75/h) = 270,000

Sensor to raceway:

Cable: (290 ft)(25 mon)($0.80/ft) = 5,800

Conduit: (290 ft)(25 mon)($1.65/ft) = 12,000

Installation: (290 ft)(25 mon)(0.15 h/ft)($33.75/h) = 36,700

Raceway to station

Cable: (151 ft)(390 sensors)($0.80/ft) = 47,100

Conduit: (151 ft)(25 mon)($301.33/100 ft) = 11,400

Installation: (151 ft)(25 mon)($21.65 h/100 ft)($33.75/h) = 27,600

Subtotal $730,600

Ring out, etc. (4 cond/sensor)(0.2h/cond)($33.75/h)(390 sensors) = 10,500

Installation: Monitors - (3.5h/mon)(25 mon)($33.75/h) = 3,000

Sensors - included with conduit

Subtotal $744,100

F. Calibration Tubing for walkway level calibration.

Allow 15 ft per sensor, 3/8" 316 Stainless Steel tubing

Material: (390 sensors)(15 ft/sensor)($4/ft) = $23,400

Labor: (390 sen)(15 ft/sen)(0.25h/ft)($33.75/h) = 49,400

$72,800

Continuation, Alternative Analysis, Gas Detection

III Continued

G. Spare Parts Allowance

	Initial	Annual
Monitors, 1 set @ $16,517 each	$16,500	[illegible]
Monitor modules, 5 @ $460 each	2,300	$2,300
Sensors, Replace every three years		
$(\frac{1}{3})$(390 sensors)($115 ea)	15,000	15,000
Other, allow 2% module and sensor costs		
(0.02)($460/mod.)(16 mod/mon)(25 mon)	3,700	3,700
(0.02)($200/sensor)(390 sensors)	1,600	1,600
Total - Spare Parts	$39,100	$22,600

Continuation, Alternative Analysis, Gas Detection

III Continued

H. Calibration and Maintenance Personnel

1) Calibration and travel time 58 h/wk from page 13, Item D.2)

Available non revenue hours: 4 h/d

$$\frac{58\ h/w}{4\ h/d} = 14.5\ d/w$$

Available time per week per team 5 days

$$\frac{14.5\ d/w}{5\ d/w\text{-team}} = 2.9 \text{ teams, say } 3 \text{ teams}$$

Will need 3 teams of 2 technicians each for calibration (6 technicians)

Allow one technician in shop, day shift (also for vacation relief, sick leave, etc.)

Assume 1.5 shift differential for calibration team

Assume one team does related work and two teams do other work for balance of Midnight to 8AM shift.

$$(2\ techs)(40\ h/w)(52\ w/y)(\$33.75/h)(1.5) = \$210,600$$
$$(4\ techs)(4\ h/d)(5\ d/w)(52\ w/y)(\$33.75/h)(1.5) = 210,600$$
$$(1\ tech)(40\ h/w)(52\ w/y)(\$33.75/h) = \underline{70,200}$$
$$\$491,400/yr$$

2) Time to change sensors,

Average life 3 years, must be done during

Continuation, Alternative Analysis, Gas Detection

III Continued

H. Continued

Allow ½ h per sensor including calibration, assume equipment needed is already available.

$$\left(\tfrac{1}{3}\right)(390\,\text{sensors})(0.5\,\text{h/sensor})(\$33.75/\text{h})(1.5\,\text{premium}) = \$3{,}300/\text{y}$$

Summary of Calibration and Maintenance Personnel

Calibration and routine maintenance	$491,400 /y
Replace sensors	3,300
	$494,700/y

I. Power

230 w/monitor plus 24 w for sensors = 254 w/monitor set,

$$\left(25\,\text{mon}\right)\left(\frac{254\,\text{w}}{\text{mon}}\right)\left(\frac{\text{kw}}{1000\,\text{w}}\right)\left(\frac{\$.07}{\text{kw}}\right)\left(\frac{24\,\text{h}}{\text{d}}\right)\left(\frac{365\,\text{d}}{\text{y}}\right) = \$3{,}900/\text{y}$$

Continuation, Alternative Analysis, Gas Detection

IV Summary

Capital & Initial Cost Item	Infra Red	Catalytic
Analyzers/Monitors	981,500	430,400
Air Compressor	400	Not Required
Calibration Gas Cylinders - Prime	2,200	1,800
- Spare	2,600	900
Tubing - Probes & Calibration	590,600	72,800
Cable - Signal	238,500	744,100
- Power	133,600	Incl.
Initial Spare Parts	53,000	39,100
Total - Initial Costs	$2,002,400	$1,289,100
Annualized	$246,900	$158,900

Annual Costs.		
Capital & Initial	$246,900	$158,900
Calibration Gas	12,600	2,100
Spare Parts	43,900	22,600
Labor	596,700	494,700
Power	34,700	3,900
TOTAL	$934,800	$682,200
Difference	$252,600	

Alternative Analysis - Sump Pumps

I. Vertical Sump Pumps, 500 GPM, 100 FT TDH.

1. Morris Model VHS Vertical Hydro-Solids Pump, 4VHS12, for 12 feet sump. 49% efficiency, 30-40 hp motor 2000 lbs., 4 inch outlet, will pass 4 inch solids, can run dry, can be reversed for short periods, Impeller at -6 ft.
$7,500 for pump and motor
Per Gary Patton of Goulds Pump, Walnut Creek, CA.

2. Installation per Estimating Department
2 pumps @ $1,700 each = $3,400

3. Piping to sump cover, included with pump.

4. Duplex control - same as for submersible pump.

5. Power and signal cable - same as for submersible pump.

6. Sump cover at -4 feet, Allow $2,000.

Continuation, Alternative Analysis, Sump Pumps

I Continued

6. Summary of Divergent - Capital Costs

2-pumps & motors @ \$7,500 ea =	\$15,000
Installation	3,400
Sump Modification	2,000
Total	\$20,400

Annualized \$2,500

7. Spare Parts

Allow 2% of Cost.

$0.02(15{,}000) = \$300/yr$

8. Labor

Installation estimate 45 hours

Average shaft bushing life, say 7 years

Rebuild time 8 hours

Total hours $45 + 8 + 45 = 98$ h, 2 men

$(2)(2)(98h/7yrs)(\$33.48/h) = \$1{,}800/yr$

Travel time to and from shop the same as submersible.

9. Power - same as submersible

Continuation, Alternative Analysis, Sump Pumps

I Continued

10. Summary of Comparable Annual Costs

Spare Parts	$300
Labor	1800
	$2100

11. Annualized Equivalent Costs

Capital Costs	$2,500
Annual Costs	2,100
	$4,600

Continuation, Alternative Analysis, Sump Pumps

II Submersible Pumps

1. Flygt Model 3201, 100 TDH, 29 bHp
   6 inch outlet, can pass 6 inch solids
   can run dry, can be reversed for short period
   \$9,500 each, 1,265 lbs; 460 lbs for outlet.

2. Installation, adapted from Estimating Dept.
   (2 pumps)(25 h/p)(1.28 factor)(\$33.48)(1.12 equip) = \$2,400
   (2 outlets)(8 h/o)(1.28)(\$33.48)(1.12) = 800
   \$3,200

3. Piping, 2-6 inch discharge pipes, 11 ft. long.
   Adapted from Estimating Dept.
   Material: (2)(11 ft)(\$19.18/ft)(0.6 factor)(1.12) = \$300
   Labor: (2)(6 h)(1.28)(\$33.48)(1.12) = 600
   \$900

Continuation, Alternative Analysis, Sump Pumps

II Continued

4. Summary of Divergent Capital Costs

2-pumps & motors @ $9,500 each =	$19,000
Installation	3,200
Piping	900
	$23,100

Annualized $2,800

5. Spare Parts

Allow 2% of cost

0.02 (19,000) = $400/yr

6. Labor

Hoist and lower, allow 0.25 hour

Average seal life, say 10 years

Rebuild time 4 hours

Total hours: 0.25 + 4 + 0.25 = 4.5

Allow 1h/y for lube check, Two men

$[2 \times 2][1 + (4.5/10)][\$33.43/h] = \$200$

Continuation, Alternative Analysis, Sump Pumps

II Continued

7. Summary of Comparable Annual Costs

Spare Parts	$400
Labor	200
	$600

8. Annualized Equivalent Costs

Capital Costs	2,800
Annual Costs	600
	$3,400

Continuation, Alternative Analysis

III Submersible Pump

1. Elygt Model 3152, 80 Ft TDH, 20 Hp
   4 inch outlet, can pass 4 inch solid
   can run dry can be reversed for short periods
   $5,300 each, 640 lbs outlet 225 lbs.

2. Installation
   (2 pumps)(10 h/p)(1.28)($33.48)(1.12) = $1000
   (2 outlets)(8 h/o)(1.28)(33.48)(1.12) = 800
   $1,800

3. Piping, 2 - 4 inch lines 11 ft long
   Material: (2)(11 ft)($11.05/ft)(0.6)(1.12) = 200
   Labor: (2)(11 ft)(0.16 h/ft)(1.28)(33.48)(1.12) = 200
   $400

4. Summary of Divergent Capital Cost

2 pumps & motors @ 5,300 each =	$10,600
Installation	1,800
Piping	400
	$12,800

Annualized $1,600

Continuation, Alternative Analysis

III Continued

5. Spare Parts

Allow 2% of cost

$(0.02)(\$14,600) = \$200$

6. Labor

same $\$200$

7. Summary of Divergent Annual Costs

Spare Parts	$200
Labor	200
	$400

8. Annualized Equivalent Cost

Capital Costs	1,600
Annual Costs	400
	$2,000

Continuation, Alternative Analysis, Sump Pumps

IV Summary – Per Sump Station

1. Capital Costs

Item	Vertical	Submersible #1	Submersible #2
Equipment	$15,000	$19,000	$10,600
Installation	3,400	3,200	1,800
Sump/Piping	12,000	900	400
TOTAL	$20,400	$23,100	$12,800
Annualized	$2,500	$2,800	1,600

2. Annual Cost

Item	Vertical	Submersible #1	Submersible #2
Spare Parts	$300	$400	200
Labor	1,800	200	200
Power	No Difference		
TOTAL	$2,100	$600	400

3. Annualized Equivalent Cost

Item	Vertical	Submersible #1	Submersible #2
Capital Costs	$2,500	$2,800	$1,600
Annual Costs	2,100	600	400
TOTAL	$4,600	$3,400	$2,000

Continuation, Alternative Analysis

II Operating Hours

Tunnel seepage rate 0.03 gpd / ft^2-liner

17.5 ft ID

$c = \pi(17.5) = 54.96$ ft

Say 1 mile between sumps

sump inflow = (0.03 gpd/ft^2)(54.96 ft)(5,280 ft)
= 8700 gpd

Use safety factor of 5

5(8700) = 43,500 gpd

Pump operating time = $\frac{43500 \text{ gpd}}{500 \text{ gpm}}$ = 87 m/d (1.45 h/d)

With alternator, pumps average 1.45 h every other day.

Annual operating hours = (1.45 h/d)($\frac{1}{2}$)(365) = 265 h/y

Standard operating hours are 2,000 h/y

% of standard = $\frac{265}{2000} \times 100 = 13\%$

If usual spare parts are 15%, use 15 × 0.13 = 2%.

Continuation, Alternative Analysis, Sump Pump

VI Sump Sizing, 12 ft deep, minimum useful depth 6 ft.

1. Duplex Vertical

Indicated minimum sump size (to be confirmed)

Pump plate size	40" x 30" + 30" =	40" x 60"
Cover allowance		8" 8"
Total		48" x 68"
	or	4' x 5.7'

Rectangular sump

$4 \times 5.7 \times 12 = 273.6\ ft^3$

useful capacity, ½ 136.8 ft^3 x 7.48 = 1,000 gal.

Approximate cost

$(273.6\ ft^3)(\$50/ft^3) = \$13,700$

2. Duplex Submersible - 100 ft TDH

Indicated minimum sump size (to be confirmed)

Plate size plus discharge	56.5 + 8.25	X 2(44.5)
	= 64.75	x 89
Clearance	5.25	Incl
	70"	x 89
	5.8	x 7.4

Approximate cost

$(5.8)(7.4)(12)(\$50) = (515\ ft^3)(\$50) = \$25,800$

Useful Volume = ½(515) = 258 ft^3 = 1900 gal.

Continuation, Alternative Analysis

3. Duplex Submersible - 80 ft TDH

Indicated minimum sump size (to be confirmed)

with allowances 59" x 56.5"

say 5' x 4.7'

Approximate Cost

$(5)(4.7)(12)(\$50) = 280\ ft^3(\$50) = \$14,100$

Useful volume $= \frac{1}{2}(280) = 140\ ft^3 = 1000$ gal.

4. Full Size Sump

8 ft x 8 ft

Approximate Cost

$(8)(8)(12)(\$50) = 768\ ft^3(\$50) = \$38,400$

Useful volume $- \frac{1}{2}(768) - 384\ ft^3 = 2800$ gal.

5. Time to fill at 500 gpm inflow

$T = \frac{\text{Useful Volume}}{500}$

Sump	V_s	T
1	1000	2 min.
2	1900	3.8
3	1000	2
4	2800	5.6

KAISER ENGINEERS

PROJECT TITLE METRO RAIL PROJECT
CLIENT SOUTHERN CAL. RAPID TRANSIT DISTR. LOCATION LOS ANGELES, CAL.
SUMP PUMP PIPING

JOB NO. 81152-609
DATE JUNE 8-83 BY BCK
SHEET 1 OF 1
CHECKED BY

ACCT REF	DESCRIPTION	QUANTITY	UNIT MH	UNIT EU	UNIT M	UNIT SC	MANHOUR	LABOR RATES 33.48	LABOR & BURDEN	EQUIPMENT USAGE 12%	MATERIAL	SUB-CONTRACT		EQUIPMENT	TOTAL $
	RTD ALTERNATE														
1	SUMP PUMP PIPING	37 LF					150		5000	600	2600				8200
	RKE ALTERNATE														
2	SUMP PUMP PIPING	39 LF					90				2500				
3							75				200				
	TOTAL	39 LF					165		5500	700	2700				8900
	VERTICAL SUMP PUMPS														
4	PUMP, 500 GPM, 2001 LBS	1 EA					45		1500	200					1700
4	PUMP, 30 GPM	1 EA					15		500	100					600

EXCLUSIONS
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PUMP PRICES
INSTRUMENTATION
ELECTRICAL WORK
STRUCTURAL WORK

FOR REFERENCE ONLY

KAISER ENGINEERS

RTD ALTERNATE

PIPE/HVAC – QUANTITY AND PRICING SHEET

BY BCK CHK'D [illegible] DATE MAY 8, 83
DRG REF AC-16AAA-C REV 03

JOB NAME METRO RAIL PROJECT
LOCATION TUNNEL
SYSTEM SUMP PUMP PIPING
SPEC

JOB NO. 81152 - 609
ACC'T NO.
SHEET 1 OF
T.O. SHEET

DESCRIPTION	SIZE	RATING	SPECS	PIPE LENGTH	FTGS NO. PCS	VALVES NO. PCS	INSUL LENGTH	HGR & SUP QUANTITY	OTHER QUANTITY	*	UNIT M	UNIT L	TOTAL MAT & SUBS	TOTAL LABOR HOURS
SUBMERSIBLE PUMP, 500 GPM, 1200 LBS									2		—	25.0	—	50
PIPE, GALV, T&C	8"	S.40		21'						.60	29.35	.32	35	1
	6"			35'						.60	19.18	.24	403	8
FLG'D TEE, GALV	6"	125			1					.50	216.05	2.57	108	3
RED. TEE	8×6×6				1					.50	478.40	3.07	239	3
FLANGE, COMP, GALV	6"	125			6					.80	45.55	.39	219	2
	8"				2					.80	67.95	.52	109	1
GATE VALVE	6"	125	C465			3				.75	335.–	1.80	754	5
CHECK VALVE	6"	125	C373			2				.75	300.–	1.80	450	4
QUICK COUPLER, FLG'D	6"				1						149.30	.80	149	1
B&G	6"	150							12		10.42	1.60	125	19
	8"								2		11.32	1.60	23	3
JOINT, SCR'D	6"								6		—	1.80	—	11
	8"								2		—	2.40	—	5

QUANTITY TOTAL	AVG SIZE 6	37 LF	SF	LBS	FIXT
TRENCHING TOTAL	CY	MAT	LAB HRS	EQPT USAGE
USE				2614 / 116
SUBCONTRACT	EQUIPMENT	MATERIAL X FACTOR		
USE	USE	LABOR X FACTOR 1.28		— / 148
			USE	2600.– / 150

FOR REFERENCE ONLY

9–80

* MATERIAL UPDATING FACTOR

KAISER ENGINEERS

RKB ALTERNATE

PIPE/HVAC – QUANTITY AND PRICING SHEET

BY BCK CHK'D [illegible] DATE July 8-83
ORG REF SK-4-9683 REV A

JOB NAME METRO RAIL PROJECT
LOCATION TUNNEL
SYSTEM SUMP PUMP PIPING
SPEC

JOB NO. 8152-609
ACC'T NO.
SHEET 2 OF
T.O. SHEET

DESCRIPTION	SIZE	RATING	SPECS	PIPE LENGTH	FTOS NO. PCS	VALVES NO. PCS	INSUL LENGTH	HGR & SUP QUANTITY	OTHER QUANTITY	*	UNIT M	UNIT L	TOTAL MAT & SUBS	TOTAL LABOR HOURS
SUBMERSIBLE PUMP, 500 GPM, 1200 LBS									1		—	25.0	—	25
" " , 30 GPM, 600 LBS									1		—	10.0	—	10
PIPE, GALV, TOE	4"	S40	120B	14'						.60	11.05	.16	93	2
	6"			25'						.60	19.18	.24	288	6
FLG'D 90° GALV	4"	125			1					.50	97.70	1.37	49	1
	6"				3						157.20	1.63	236	5
TEE	6"				1						216.05	2.57	108	3
RED. TEE	6x6x4				1						279.20	2.57	140	3
FLANGE, COMP, GALV	4"	125			4					.80	28.40	.27	91	1
	6"				10					.80	45.55	.39	364	4
FLG'D QUICK COUPLER	6"				1						149.30	.80	149	1
GATE VALVE	4"	125	C465			1				.75	209.-	1.20	157	1
	6"					2					335.-	1.80	503	4
CHECK VALVE	4"		C373			1					173.10	1.20	130	1
	6"					1					300.-	1.80	225	2

QUANTITY TOTAL	AVG SIZE 5 / 39 LF / SF / LBS / FIXT	—	—
TRENCHING TOTAL	CY / MAT / LAB HRS / EQPT USAGE	—	—
USE		2533	69
SUBCONTRACT / EQUIPMENT	MATERIAL X FACTOR		—
USE / USE	LABOR X FACTOR 1.28	—	88
	USE	2500.-	90

FOR REFERENCE ONLY

9-80

* MATERIAL UPDATING FACTOR

KAISER ENGINEERS

RKE ALTERNATE

PIPE/HVAC – QUANTITY AND PRICING SHEET

BY BCK CHK'D [illegible] DATE JULY 8, -83
ORG REF SK-C-7683 REV A

JOB NAME METRO RAIL PROJECT
LOCATION TUNNEL
SYSTEM SUMP PUMP PIPING
SPEC

JOB NO. 81152-609
ACC'T NO.
SHEET 3 OF
T. O. SHEET

DESCRIPTION	SIZE	RATING	SPECS	PIPE LENGTH	FTGS NO. PCS	VALVES NO. PCS	INSUL LENGTH	HGR & SUP QUANTITY	OTHER QUANTITY	*	UNIT M	UNIT L	TOTAL MAT & SUBS	TOTAL LABOR HOURS
Bol	4"	150							6		6.75	1.60	41	10
	6"								15		10.42	1.60	156	24
JOINT	4"								4		—	1.20	—	5
	6"								10		—	1.80	—	18
QUANTITY TOTAL	AVG SIZE			LF		SF			LBS			FIXT	—	—
TRENCHING TOTAL	CY		MAT			LAB HRS			EQPT USAGE				—	—
USE													197	57
SUBCONTRACT			EQUIPMENT				MATERIAL X FACTOR							—
USE			USE				LABOR X FACTOR				1.28		—	73
												USE	200	75

FOR REFERENCE ONLY

9-80

* MATERIAL UPDATING FACTOR

KAISER ENGINEERS

PIPE/HVAC – QUANTITY AND PRICING SHEET

BY BCK CHK'D JJ DATE July 8, 83
ORG REF ______ REV ______

JOB NAME Metro Rail Project
LOCATION Tunnel
SYSTEM Vertical Sump Pump
SPEC ______

JOB NO. 81152-609
ACC'T NO. ______
SHEET 4 OF ______
T.O. SHEET ______

DESCRIPTION	SIZE	RATING	SPECS	PIPE LENGTH	FTGS NO. PCS	VALVES NO. PCS	INSUL LENGTH	HGR & SUP QUANTITY	OTHER QUANTITY	*	UNIT M	UNIT L	TOTAL MAT & SUBS	TOTAL LABOR HOURS
PUMP 500GPM. 2400 LBS									1		—	35.0	—	35
LAB. ADJ. FACT.	1.28													~45
PUMP 30 GPM									1		—	10.0		10
LAB. ADJ. FACT. 1.28														~15

FOR REFERENCE ONLY

QUANTITY TOTAL	AVG SIZE	LF	SF	LBS	FIXT
TRENCHING TOTAL	CY	MAT	LAB HRS	EQPT USAGE	
USE					
SUBCONTRACT	EQUIPMENT	MATERIAL X FACTOR			
USE	USE	LABOR X FACTOR			

-80 * MATERIAL UPDATING FACTOR USE

KAISER ENGINEERS

JOB NO. ______
SHEET 1 OF

SCRTD METRO RAIL
SUMP PUMPS

DESIGNED BY FAP DATE 4-8-83
CHECKED BY DATE

DISCHARGE PIPE SIZES per Walworth Chart

8" PIPE 500 GPM $\Delta p = 4.5^{ft}/1000^{ft}$ $v = 3$ fps
$v^2/2g = 0.15$ ft

90° ELL equiv to 14 ft

6" PIPE 500 GPM $\Delta p = 15^{ft}/1000^{ft}$ $v = 6$ fps
$v^2/2g = 0.6$ ft

90° ELL EQUIV to 11 ft

For runs 1300 – 3600 ft 8" PIPE ABOUT RIGHT

If 2 pumps run flow won't increase greatly but that is OK Pumps rated TDH ≈ 100 ft
Lifts up to 80 ft

PUMP 500 GPM 100 ft TDH

$$\frac{500 \text{ GPM} \times 8.3 \text{ \#/gal} \times 100^{ft} \text{ lift}}{33000 \times 0.7 \text{ efficiency}} = 17.9 \text{ HP}$$

20 HP motor

ELECTRICAL FEEDER SIZES 480V 3φ 60Hz NOM

Code Says Short run One 20 HP motor #8 wire ~~[illegible]~~
40 HP ≈ 2 @ 20 HP needs #6 wire

20 HP MOTOR 480V NOMINAL FL AMPS = 27 AMPS
2 motors × 27 = 54 amps

SCRTD METRO RAIL
Sump Pumps

DESIGNED BY FAP DATE 4-8-83
CHECKED BY DATE

TYPICAL SHORT FEEDER 1400 ft ± FROM STATION

For 4% voltage drop w/ 2 motors on } conservative

$0.04 \times 480 = 18.4\ V$ $E = IR$ $R = \frac{E}{I}$

Allow $R = \frac{18.4\ V}{54\ \text{Amps}} = 0.34\ \Omega$

$\frac{0.34\ \Omega}{2 \times 1400'} \times 1000 = 0.12\ \Omega/1000\ ft$ allowable

(#8 = 0.6 Ω/1000 ft)

Need Copper Wire Size #0 0.10 Ω/1000 ft

3 conductors #0 in $1\frac{1}{2}$" ϕ conduit ←
THW insulation

Grounding conductor? Neglect - basis is conservative

#0 wire copper 319#/1000 ft

Copper Base price \$0.75/lb

FAP guess net \$3/lb + \$3/ft $1\frac{1}{2}$"ϕ conduit

$\left(1400' \times 3 \times \frac{319}{1000} \times \$3/lb\right) + \left(1400' \times \$3/ft\right) = \underline{\$8000. + labor}$

MEDIUM RUNS 2000 ft ± FROM STATION

Allow $R = 0.34\ \Omega$ TOTAL

$\frac{0.34}{2 \times 2000} \times 1000 = 0.085\ \Omega/1000\ ft$

Need Cu Wire Size #00 in $1\frac{1}{2}$" ϕ Conduit ←

Copper 403#/1000 ft neglects any grounding wire

FAP guess @ \$3/lb Cu + \$3/ft conduit

$\left(2000' \times 3 \times \frac{403}{1000} \times \$3/lb\right) + \left(2000' \times \$3/ft\right) = \underline{\$13000 + labor}$

KAISER ENGINEERS

JOB NO.

SHEET 3 OF

SCRTD METRO RAIL
SUMP PUMPS

DESIGNED BY FAP DATE 4-8-83

CHECKED BY DATE

LONGEST RUNS (2) 3600 ft $\pm$ FROM STATION

ALLOW R= 0.34 Ω TOTAL

$\frac{0.34}{2 \times 3600} \times 1000 = 0.047\ \Omega/1000'$ allowable

needs conductor 250 mcm Copper 0.043 Ω/1000'

0.58" ϕ stranded 772#/1000'

@ \$3/lb Copper & \$5/ft conduit

FAP guess

$\left(3600' \times 3 \times \frac{772}{1000} \times \$3/lb\right) + (\$5 \times 3600) = \$43000.$

+ labor

=

CALCULATIONS KE Form No. E-6 Rev. 10-71

Raymond
Kaiser Engineers

Job No. 81152-609
SHEET OF

SCRTD
Sump Pumps for Tunnel

DESIGNED BY S. Tsui DATE 7/5/83
CHECKED BY DATE

James Merrit : Shape Inc. 651-9890

on Flygt Pumps.

1. 5 H.P. Submersible Wastewater Pump.
Cast Iron Construction
CP-3101 F.O.B. Job Site $2000.-

2. 20 H.P. CP-3152 : 80' @ 500 gpm
640# $8.28/# F.O.B. Job Site $5300.-

3. 35 H.P. CP-3102 : 130' @ 500 gpm.
1,265# $7.51/# F.O.B. Job Site $9500.-

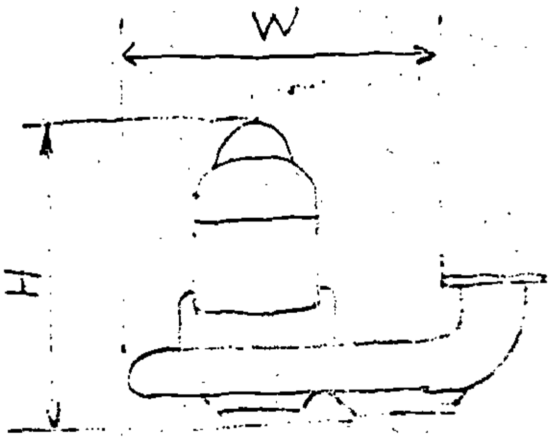
4. Control Panel and Accessories
For Duplex $2500.00 To $3600.00

CALCULATIONS KE Form No. E-6 Rev. 10-71

Raymond Kaiser Engineers

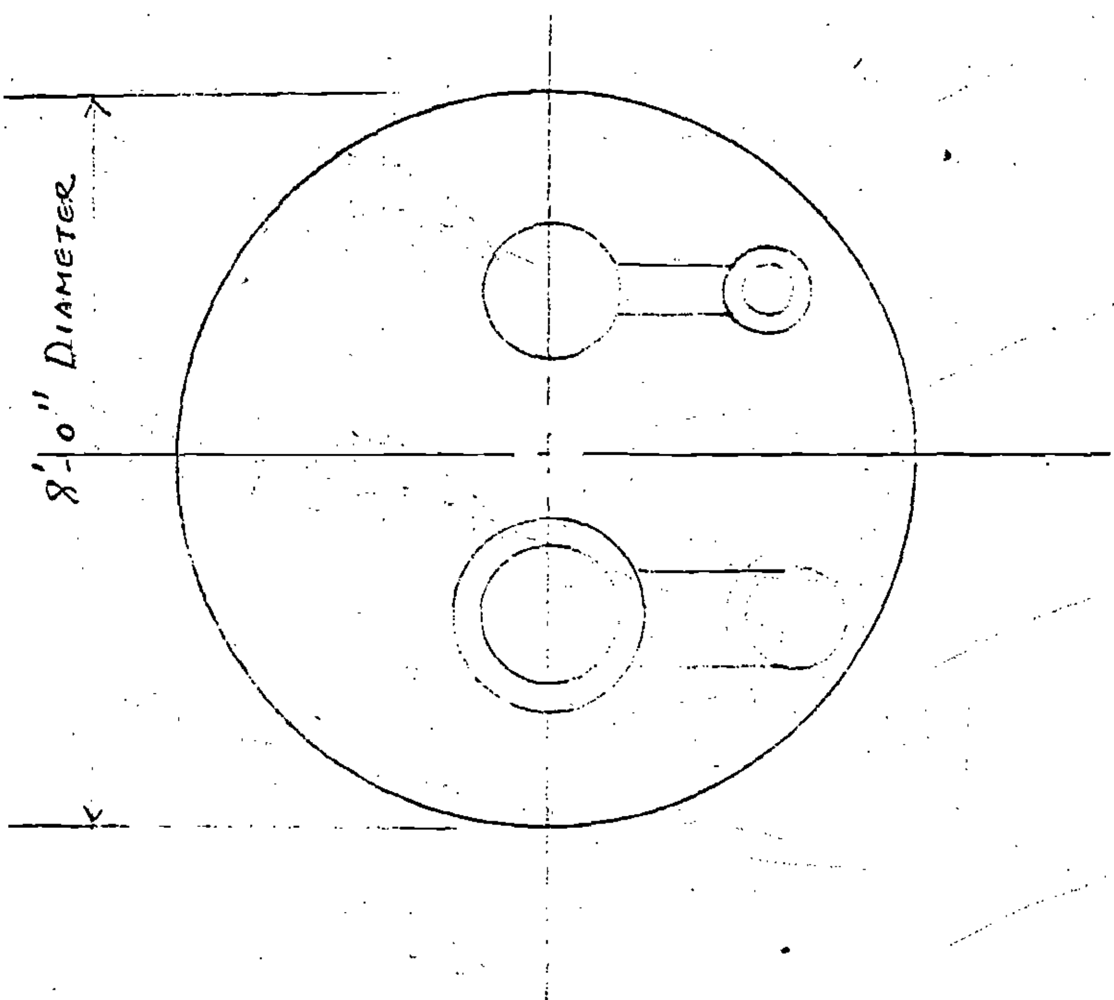
Job No. 8152-609	Sheet of
Designed by S. Tsui	Date 7/5/83
Checked by	Date

CASE 1 : ONE CP-3101 & ONE CP-3152



CP-3101
W : 27"
H : 34¼"

CP-3152
W : 33½"
H : 49¼"



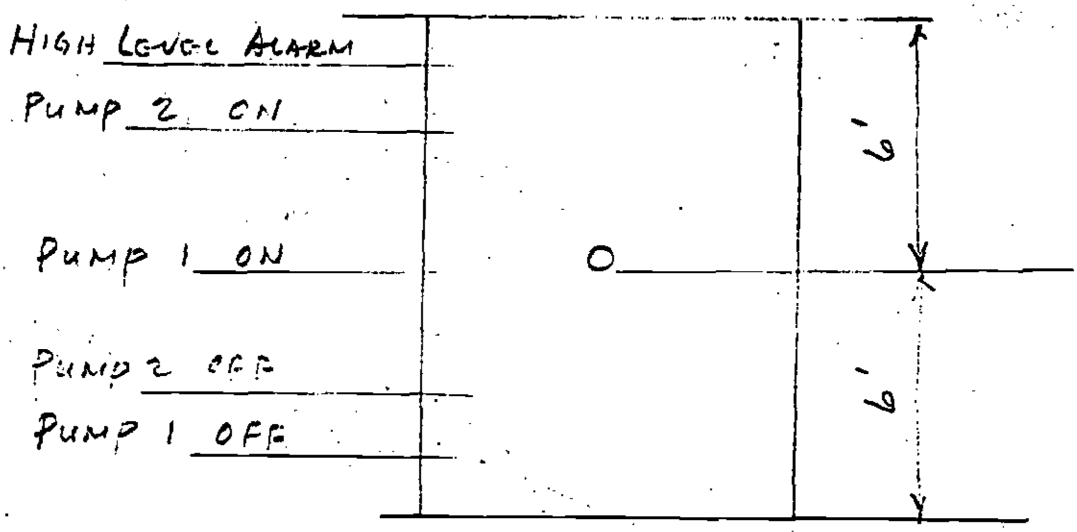
FOR 10 gpm INFLOW

$$t = \frac{1875}{10} = 187.5 \text{ MIN.} \quad \text{SAY 3 HRS.}$$

Raymond
Kaiser Engineers

Job No. 81152-609
Sheet of

DESIGNED BY S. TSUI DATE 7/6/83
CHECKED BY DATE



SUMP VOL : 8'-0" ϕ

$V = 50.24$ CF/FT

$= 375$ GAL/FT

FOR $H = 5$ VOL = 1875 GAL.

FOR 30 GPM rate $t = 62.5$ MIN.

FOR 500 GPM rate $t = 3.75$ MIN.

APPENDIX E
REFERENCED REPORTS AND DRAWINGS

APPENDIX E

PROBABILITY OF GAS CONDITIONS,
ADAPTED FROM p. 684.18, TITLE 8,
CALIFORNIA ADMINISTRATIVE CODE

NONGASSY

Applied to intervals where there is little likelihood of encountering gas during the construction of the tunnel.

POTENTIALLY GASSY

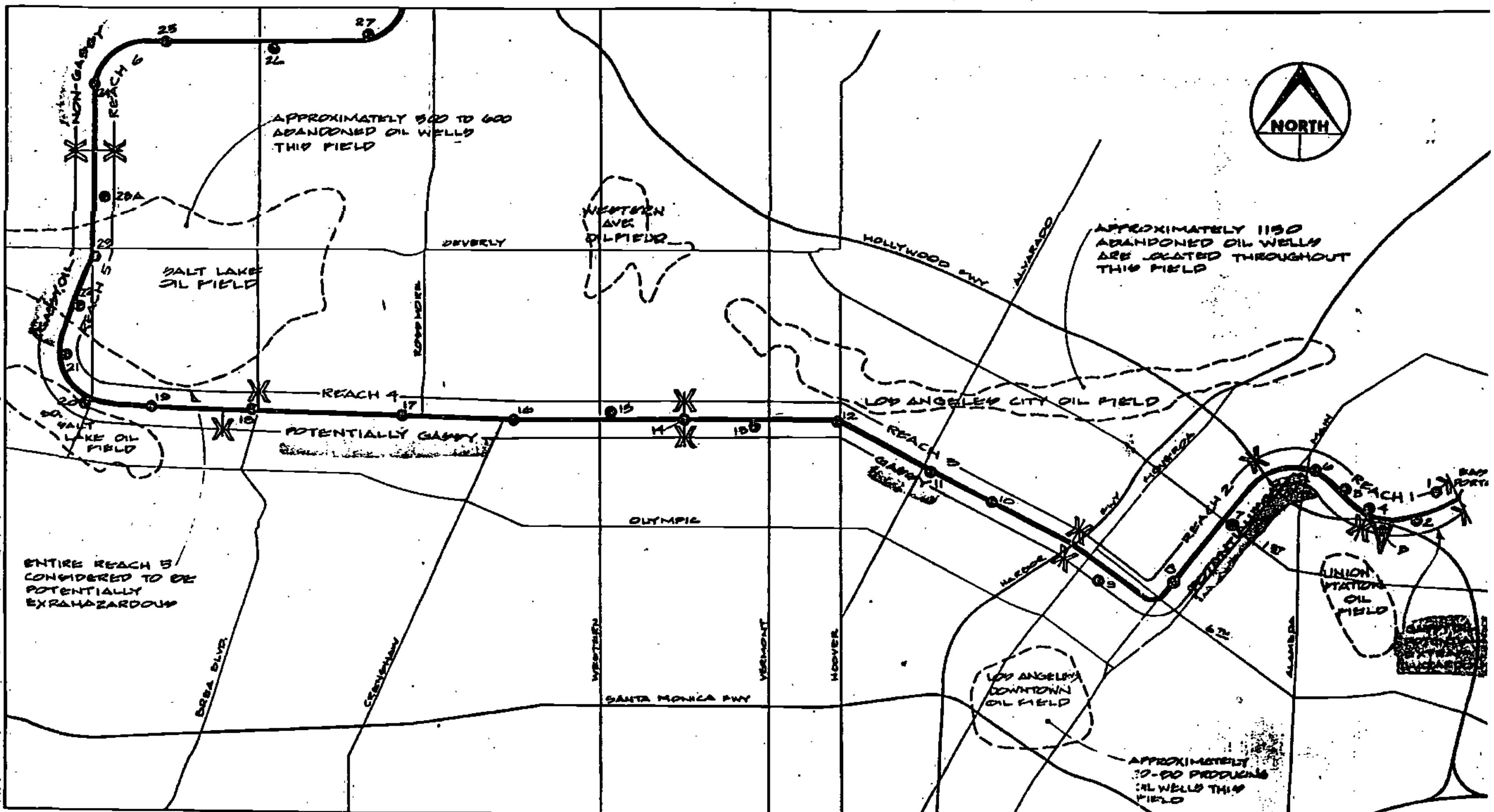
Applied to intervals where there is a possibility of encountering flammable gas or hydrocarbons.

GASSY

Applied to intervals where it is likely that gas will be encountered.

EXTRAHAZARDOUS

Applied to intervals with serious danger to the safety of employees.



• CWDD/EGA/GRC BORING (1981)

REFERENCES:

CWDD/EGA/GRC – GEOTECHNICAL CONSULTANTS
GEOTECHNICAL INVESTIGATION REPORT, VOL 1 & 2, NOV. 1981

CALIFORNIA DIVISION OF OIL & GAS
ONSHORE OIL & GAS SEEPS IN CALIFORNIA, 1980-81

DRAWN BY: BJ
CHECKED BY: WED
DATE: 10/21/82
SCALE: 0 1 MI. 2 MI.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJEC

GBA
GAGE-BABCOCK & ASSOCIATES, IN
FOR
KAISER ENGINEERS

PITTSBURGH RESEARCH CENTER

Internal Report No. 4420

APPLICABILITY AND CAPABILITIES OF COMMERCIALLY AVAILABLE METHANE SENSORS FOR FIXED-POINT INTRINSICALLY-SAFE UNDERGROUND COAL MINE MONITORING

By A. F. Cohen
G. H. Schnakenberg, Jr.

U.S. Department of the Interior
Bureau of Mines
Pittsburgh, PA 15236
April 1983

APPLICABILITY AND CAPABILITIES OF COMMERCIALLY AVAILABLE METHANE SENSORS FOR FIXED-POINT INTRINSICALLY-SAFE UNDERGROUND COAL MINE MONITORING

by A. F. Cohen[1] and G. H. Schnakenberg, Jr.[2]

ABSTRACT

Optimal values for methane sensor characteristics required by the Bureau of Mines intrinsically safe mine monitoring system are presented.

A list presenting the input current and voltage requirements for commercially available catalytic sensors for methane detection has been compiled.

The lowest current methane sensor available requires 60 mA, twice that required by the intrinsically safe mine monitoring system, but satisfies interim sensor requirements for this system.

The stability of the low-current sensor, especially of a newer model, meets requirements, assuming a monthly calibration schedule. Other characteristics of this sensor, yet to be investigated, are expected to meet the intrinsically safe mine monitoring system methane sensor requirements.

INTRODUCTION

At present, Title 30 Code of Federal Regulations, Part 75, (30 CFR 75), Mandatory Safety Standards, Underground Coal Mines, requires intermittent pre-shift and on-shift examinations and once a week examinations of potential mine hazards. These include methane (CH_4) measurements in idle workings, in the return of each air split, and in the main return. Except for machine-mounted methane monitors (30 CFR 75.301) and thermal fire detectors, no automatic remote monitoring is required by Title 30, CFR.

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[1]Physicist
[2]Supervisory Research Physicist
Both authors are with the Pittsburgh Research Center, Bureau of Mines, Pittsburgh, PA.

Automatic remote environmental mine monitoring improves both safety and production (6)[3]. For instance, methane transducer modules[4] appropriately located within the mine could be used to accurately measure methane concentrations throughout the mine and transmit the data to a central control system aboveground. This input, along with continuous ventilation data (air quantity and air velocity), determined with appropriate air velocity transducer modules, would provide continuous information about the safety of the mine with regard to methane explosions. Early detection of a trend toward buildup of the methane concentration, in conjunction with the associated ventilation data, could result in early warning and prompt correction of conditions conducive to an explosion. Computers could be used for rapid recording and analyzing of data.

THE BOM FIXED-POINT ISMMS

Fisher and Uhler (5) have proposed a multipurpose ISMMS for underground mines. Power to the monitoring system is supplied aboveground from a commercial power system, independent of mine power. In event of commercial power failure, backup is provided by a battery supply capable of operating for 4 hrs, after which a motor generator set would be used to operate the system indefinitely. System components are modular, for ease of expansion and maintenance. A microprocessor controller, used in conjunction with an intrinsically safe power supply under development, supplies power to and bidirectional communication with remotely located sensors (up to 10,000 ft from the entry) via 4 trunk drivers over a 4-conductor cable of special design. Each trunk power supply provides 18 Vdc at up to 800 mA. To maintain intrinsic safety, current is limited to 800 mA by a fast-acting electronic switch which cuts system power when current exceeds the 800 mA limit. Since the system is intrinsically safe and powered from the surface,

---

[3]Underlined numbers in parentheses refer to the items in the list of references at the end of this report.

[4]A transducer module is defined here as that standardized and interchangeable functional component of a fixed point remote monitoring system which is located at the point of measurement and connected directly to the system from which it obtains its power, and to which it delivers standardized output signals unambiguously related to the level of the variable being measured. Transducer modules usually consist of a sensor element and signal-and power-conditioning circuits in an appropriate enclosure. For the Bureau's intrinsically safe mine monitoring system (ISMMS), the transducer module also contains the Conspec Controls Ltd. Accessor[5] circuitry used by that system to identify the particular module. The Accessor also converts the internal analog signal to an appropriate digital format and outputs that signal upon request.

[5]Use of company of trade names is for identification only and does not imply endorsement by the Bureau of Mines.

monitoring would be continuous in the event of mine power failure or shutdown. A prototype of the monitoring system is being installed at the Bruceton Safety Research Coal Mine of the Pittsburgh Research Center.

Because the trunk current (equal to the sum of the current required by the transducer modules connected to that trunk) is limited to 800 mA, the current requirements of the individual modules determine the maximum number that can be connected to a given trunk. The current required by the methane transducer modules available today is determined by the current required by the methane sensor itself. In July 1980, the lowest current of a commercially available transducer module was 375 mA. With this level of current, only two methane transducers could be accommodated by one trunk.

In consequence, the Bureau has embarked on research and development to provide methane transducer modules requiring a considerably lower operating current. Specifically, the present goal is to enable a trunk to accommodate 20 methane transducers. This means 40 mA per module, assuming that no other transducer modules (airflow, carbon monoxide) are to be accommodated. The first step was to conduct a search for commercially available methane sensors having a low input current and satisfying other characteristics required by the ISMMS. The applicability and capabilities of commercially available methane sensors for the ISMMS is the subject of this report.

METHANE SENSOR CHARACTERISTICS FOR FIXED-POINT MINE MONITORING

The most important sensor requirement for the ISMMS is low current. A current of 40 mA per module would be the upper limit, but current is also required for the sensor and electronics voltage regulator (approximately 7 mA), for the electronics used to amplify the sensor signal to the required level (approximately 4 mA), and for the Accessor to convert the analog output to a digital signal (approximately 4 mA). Assuming that some current reduction could be made in the voltage regulator, accessor, and amplifier, the sensor current remaining to operate the sensor is approximately 25 to 30 mA.

The list of sensor characteristics and the quantitative and/or qualitative requirements associated with the sensor characteristics for the ISMMS are listed in Table 1.

METHANE SENSORS

Sensitivity of methane sensors to concentrations of methane below 5 pct is defined as the change in output signal, usually mV per 1 pct CH_4 concentration change. Some manufacturers claim a sensitivity of 30 mV per pct CH_4. Generally, any concentration-dependent property of methane gas can be the basis for principle of sensor operation. Thus, instruments based on thermal conductivity, sonic velocity, infrared transmission, refractive index, density (of gas), pressure change, and catalytic combustion have been constructed. In addition to these principles, the historic Davy lamp which uses the gas height and color

TABLE 1. - Methane sensor for intrinsically safe mine monitoring system (0-5 pct CH4)[1]

Sensor characteristic	Value required by ISMMS
Power	
(1) Input current................	20-30 mA
(2) Input voltage................	~5-6 Vdc (ISMMS can accept 8-18 Vdc)
Output signal	
(3) Sensitivity..................	>15 mV/1 pct CH_4
(4) Sensor output signal........	Proportional to pct CH_4 in air in range of detection
(5) Total drift..................	Zero drift/month and span drift/month together must be less than ±0.20 pct CH_4/month at 1.0 pct CH_4; less than ±0.20 pct CH_4/month at 2.0 pct CH_4; less than ±0.15 pct CH_4/month at 0.25 pct CH_4.
(6) Accuracy in mine............	Allowable variations (CFR 30, Part 22.7)

Methane in mixtures, pct	Minimum indication, pct	Maximum indication, pct
0.25	0.10	0.40
.50	.35	.65
1.00	.80	1.20
2.00	1.80	2.20
3.00	2.70	3.30
4.00	3.70	4.30

Sensor characteristic	Value required by ISMMS
	Accuracy must be maintained when exposed to range of air velocities found in U.S. coal mines (0-1700 fpm).
(7) Speed of response..........	Less than 60 sec to reach 90 pct of final reading (for a step change in concentration).
(8) Specificity..................	If affected by presence of other combustible gases, output signal should be in fail-safe direction; sensor output should not be largely affected by CO, CO_2, or water vapor.

[1]The most important detection and measurement range for early methane detection and explosion prevention is 0-5 pct CH_4. To date, methane detection is most often based on catalytic-oxidation principles. For post-disaster and methane drainage applications, 5-100 pct methane detection is often based on the thermal conductivity principle.

TABLE 1. - Methane sensor for intrinsically safe mine monitoring system (0-5 pct CH_4)[1] - continued.

Sensor characteristic	Value required by ISMMS
(9) Poisoning..........................	Sensors must be protected against gases and vapors that may be found in the mine and which temporarily or permanently affect sensor response characteristics (zero and sensitivity); silicone vapors are known to poison catalytic CH_4 sensors.
(10) Exposure to high methane concentrations.	Momentary exposures of 5 pct CH_4 or continuous exposures of 1.5 pct CH_4 must not permanently affect sensor response characteristics (zero and sensitivity).
(11) Air velocity.................	Sensor must be operational between 0-1700 fpm and accuracy requirement must be met over this range.
(12) Calibration:	
(a) Procedure.................	A standard procedure should be specified by the manufacturer.
(b) Calibration kit..........	A calibration kit shall be available from manufacturer.
(c) Ease of calibration......	Calibration requires less than 15 min by a qualified person.
(13) Minimum maintenance:	
(a) Inspection...............	Performance inspection no more frequent than once per week unless sensor is clearly inoperative (fault condition).
	Performance inspection: Check accuracy at zero gas and at 2.5 pct CH_4. If response is out of specification, recalibrate. Labor and material for inspection less than 1 pct of unit transducer module cost.
(b) Ease of replacing sensor.	Less than 1/2 hr by qualified maintenance personnel.

TABLE 1. - Methane sensor for intrinsically safe mine monitoring system (0-5% CH_4)[1] - continued.

Sensor characteristic	Value required by ISMMS
Environment of operation [(16)-(21)]:	
(14) Range of detection	0-5 pct CH_4 in air.
(15) Intrinsic safety	Must meet MSHA approval requirements for intrinsic safety.
(16) Ambient temperatures	Must be operational between -20° C and +40° C within the accuracy requirements; must survive storage temperatures between -40° C and +50° C.
(17) Relative humidity	Operational at 30 pct to 100 pct RH. [Ref. (2)].
(18) Atmospheric pressure	Calibratable and operational between 9.7 and 19.7 psi. [Ref. (2)]. (Low pressure equivalent to 10,000 ft above sea level; high pressure equivalent to 10,000 below sea level)
(19) Corrosive environment	Functional after acidified salt spray test 5 pct salt concentration pH of 3.1 to 3.3 [Ref. (2)].
(20) Shock	Survive drop test at maximum height 36 in. (for machine-mounted equipment); sawtooth impulse shock of 40 g for 11 msec duration [Ref. (2)].
(21) Sand and dust	Must be operational at dust concentration 10 mg/m^3, up to velocity 1750 fpm (ac fine dust classed from Arizona Road Dust). [Ref. (2)].
(22) Sensor life	>1 year.
(23) Sensor cost	Dollar cost <$100 (1982).
(24) Size, shape, and weight	Minimum weight and size consistent with sufficient ruggedness to endure mine environment.

above the flame as an indicator of gas concentration has been used. The most commonly used principle for methane sensors has been catalytic oxidation (combustion). As used here, the term catalytic sensors includes both filament (platinum, platinum-rhodium, or other alloys of platinum) and catalytic-bead sensors (including pellistors, pellements, or pellement type).

THE BASIC PRINCIPLE

CATALYTIC METHANE SENSORS

The heat of reaction released by a gas when it burns (oxidizes) on a filament or in the presence of some other heated catalyst can be used to detect combustible gases in air. Sufficient oxygen (>10 pct) must be present for combustion of methane to be complete (see fig. 1).

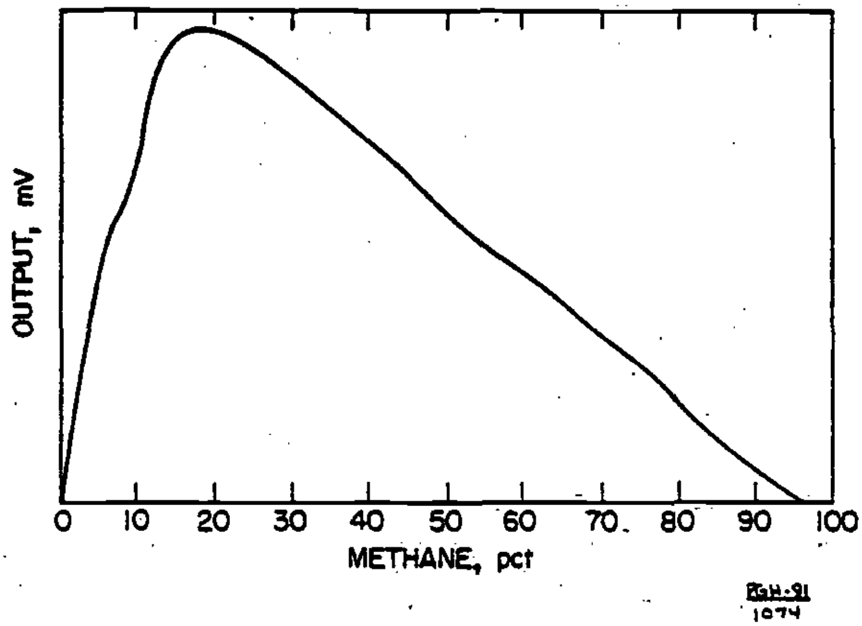

FIGURE 1. - Example of response of catalytic filament sensor for methane (catalytic bead type).

Combustion raises the temperature (and thus the resistance) of the filament, as compared to an inactive reference filament. The reference and active filament forms two arms of a Wheatstone bridge. The amount of unbalance of the bridge gives a measure of the concentration of the combustible gas. To a first approximation, the bridge output voltage is directly proportional to the combustible gas concentration (3) over a small but usable concentration range (0-5 pct). The catalytic combustion principle is useful for detection of CH_4 between approximately 0 to 5 pct but not much above 5 pct. Owing to lack of oxygen, the bridge output versus methane concentration relation (see fig. 1) (8) shows the continuous decrease of output with increasing methane concentrations above 10 to 15 pct CH_4 in air.

THE EFFECTS OF COMBUSTIBLE GASES OTHER THAN METHANE ON CATALYTIC SENSORS

In coal mine explosion prevention there is an advantage if, in addition to methane, the sensor responds to combustible gases such as hydrogen and ethane. In such cases, the sensor output voltage is larger than for methane alone, and provides a conservative measure of the combustible gas level. The presence of other flammable gases, called interferents because their presence interferes with the accuracy of measuring the methane concentration, are given (1) to within ±25 pct by:

$$S = \frac{H}{700\sqrt{M}};$$

where

S = sensitivity on open circuit (V per pct gas concentration by volume)

H = heat of oxidation of the gas (kJ/mole);

M = molecular weight of the gas, for M not more than approximately 100.

According to Baker (1), readings given by an instrument calibrated in percent methane would be 1.0 in 1 pct of ethane or hydrogen but would be 0.3 in 1 pct of CO.

SENSOR CATALYST POISONS

The catalytic element of early combustible gas sensors was a coil of platinum wire, connected to a voltage supply, and electrically heated to approximately 1000° C. A combustible gas, in an atmosphere containing oxygen, is oxidized at the platinum wire (a catalyst). This oxidation raises the temperature of the platinum wire, resulting in an increase in coil resistance. However, at these elevated temperatures, platinum evaporates. The result of this evaporation is poor zero stability and short platinum coil (catalytic element) life.

The development of catalytic coatings, such as mixtures of palladiu m and thorium supported on a substrate surrounding a small platinum coil (4), results in a catalytic bead with the ends of the coil connected as before to a voltage supply to provide the necessary temperature for the oxidation (combustion) of the gas. With such catalytic coatings, methane can be oxidized at approximately 550-700° C. Zero drift of such catalytic bead elements due to evaporation is much less than for unbeaded platinum wire coils. An inactive catalytic bead element is similar to the active one, except that it is poisoned or made inactive and acts as a reference element to compensate for changes of humidity, temperature, and pressure.

These lower operating temperature gas sensing elements (catalytic bead types such as pellistors or pellements, etc.) can lose sensitivity in the presence of atmospheres containing silicone vapors from silicone containing compounds. Silicone vapor is a poison to the catalytic bead (7). Other catalyst poisons are sulfur compounds, such as H_2S and phosphate esters used as corrosion inhibitors in oils. Pure platinum coil filaments, operating at much higher temperatures than the bead type, are not poisoned by silicones.

COMMERCIALLY AVAILABLE CATALYTIC SENSORS FOR METHANE DETECTION

Considerable experience in coal mines has been logged with catalytic-type sensors. For the present study, this general sensor type will be the only one considered for 0 to 5 pct methane detection. For detection of methane in the 5 to 100 pct range (methane drainage applications or postdisaster needs), catalytic sensors are inappropriate, and the thermal conductivity of gases is often the operating principle used. Such 5 to 100 pct CH_4 concentration range transducer modules are not now a part of the ISMMS.

Table 2 lists the operating current and voltage for catalytic combustion-type methane sensors and the manufacturers contacted. It represents the best information obtainable, but its accuracy or completeness is not guaranteed. The sensor with the lowest operating current is manufactured by Scott Aviation and requires 60 mA at 5.5 V. Although these Scott sensors have not been subjected to in-mine use, they have been widely used in the chemical and oil industries. The Bureau has performed zero and span stability tests on one of these sensors (Scott Aviation 40008560).

Fig. 2 shows a Scott Aviation sensor and detector assembly. Concurrent with laboratory testing of the sensor, J-Tec Associates, Inc. redesigned its methane transducer module to incorporate the Scott Aviation sensor for possible use in the first iteration of the ISMMS.

PRELIMINARY LABORATORY TESTS ON SCOTT AVIATION METHANE SENSOR FOR USE IN THE ISMMS

One Scott Aviation methane sensor and associated bridge circuitry was tested over a period of 5 months at the Bureau. With the exception of about 16 hours, power was applied to the sensor continuously for the 5-month test period.

Table 2. - Operating current and voltage for methane sensors (catalytic combustion principle)

Sensor manufacturer	Sensor current (mA)	Sensor voltage (V)
Appalachian Electronic Instruments..........	250	6.0
	100	5.0
Bacharach Instruments Co. (Subsidiary of United Technologies).........	195-260	6.0
	352-400	2.7
	170-200	4.0
Bendix Corporation (Environmental and Process Instruments Div.).	280	2.2
Control Instruments Corp....................	1050	1.2
CSE Mine Service #102......................	400	2.4
#140......................	350	2.4
Delphian Corp. (sold with system)...........	170	6.0
English Electric Valve		
VQ1, VQ4, VQ11, ...	~375	2.0 ±1
VQ2, VQ9, VQ10,............................	~180	2.0 ±1
VQ8, VQ3,..................................	~400	2.5
VQ16.......................................	~350	2.5
ERDCO Engineering Corp......................	1400	2.5-3.0
Gas Tech, Inc.		
#610101....................................	250	6.0
#620106....................................	400	2.2
Gastronics, Inc.............................	200	3.0
Can make..............	~100	~6.0
General Monitors, Inc.(sold with system)....	300	5.0

Table 2. - Operating current and voltage for methane sensors (catalytic combustion principle) - continued

Sensor manufacturer	Sensor current mA	Sensor voltage V
International Gas Detectors (IGD).......	360	2.6
	200[1]	2.0 ±.1
Mine Safety Appliances Co..............	765	~2.0
	~375	2.6
	400	1.88
National Mine Service Co...............	360	2.4
	300	2.0
	115	2.0
Rexnord Gas Detection Products (formerly Dictaphone).	340 ± 10	3.0
	300	2.5
Rexnord Safety Products (formerly Biomarine).	400	2.0
Scott Aviation Corp. (Davis Instruments Division).	60	5.5
Teledyne Analytical Instrument Co.......	300	6.0
Universal Sensors & Devices, Inc........	270	1.0
CERCHAR (Spelna, Inc.)..................	500	2.5
J & S Sieger, Ltd. (Type 770 sensor)....	200	5.8
Lab Model under development..........	80-90	1.0

NOTE: Each entry under same manufacturer is a different sensor model
[1]not yet available

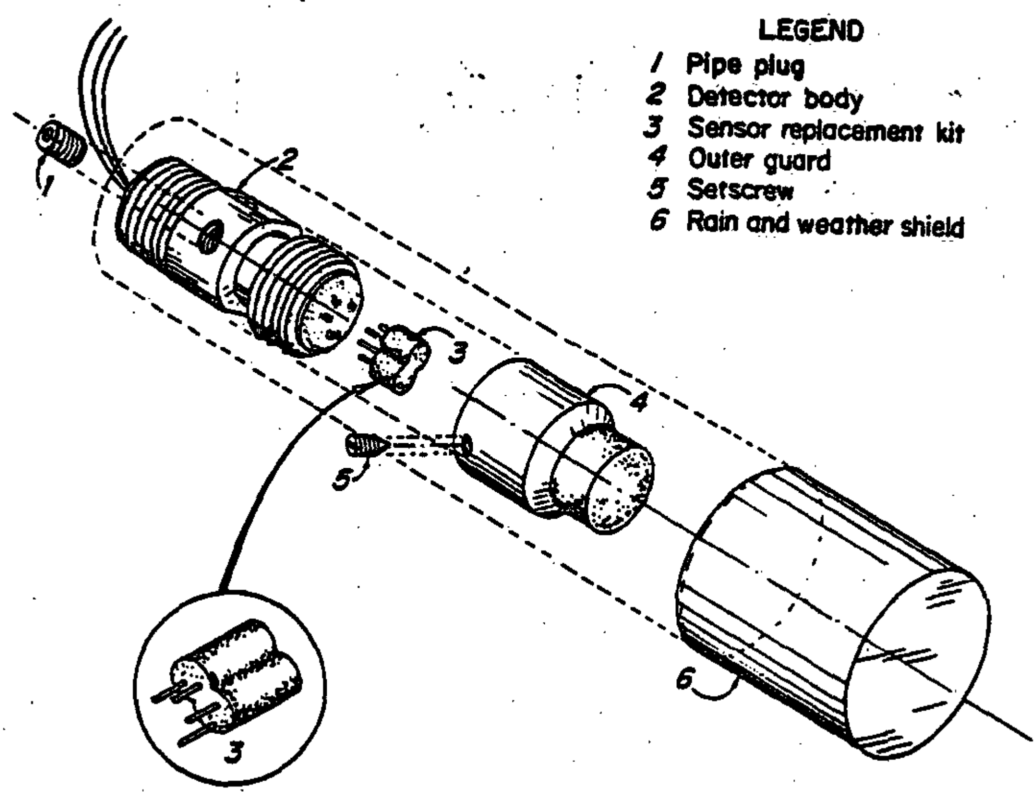

FIGURE 2. - Scott Aviation detector assembly: Gas inlet (side pipe) replaces screw (5) when determining gas flow dependence of sensor output.

Results from these tests on the Scott sensor showed:

(a) An appreciable initial sensitivity decrease (total drift equivalent to 0.25 pct CH_4) occurred during the first continuous (30 hr) exposure of the sensor to 2.44 pct CH_4 after running in air for approximately 10 days (on each of these days, the sensor was exposed for 7-8 minutes to 2.44 pct CH_4 in air).

(b) Subsequent to (a), continuous exposure of the sensor for 4 days to 2.44 pct CH_4 appears to change the zero. The effect, though small, will be studied further at the Bureau.

(c) After (b), continuous exposures of the sensor to 1.5 pct, 2.0 pct, and 2.44 pct CH_4 for periods of from 3 to 6 hours resulted in negligible sensitivity decrease.

(d) With gas flowing into the side pipe of the detector assembly (gas inlet replaces part 5 (screw of fig. 2) to the sensor in accordance with the manufacturer's suggested calibration method, the sensor output for a given methane concentration in air is slightly gas-flow dependent, increasing with flow rate and reaching a plateau at 500 to 1000 cc/min. A similar, though not identical, effect is observed with gas introduced from the bottom end of the sensor via an opening into a snug-fitting holder (shown in fig. 3).

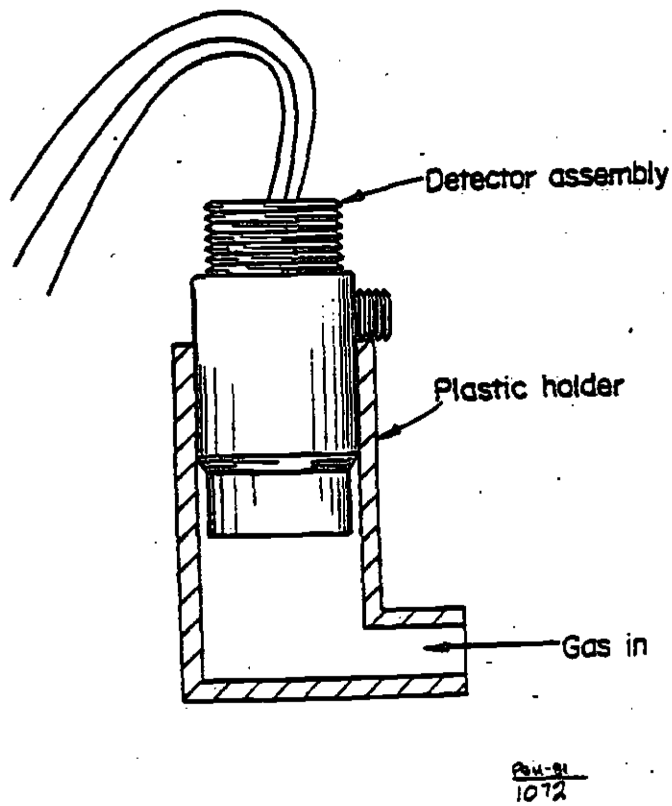

FIGURE 3. - Schematic drawing of test arrangement in which gas is introduced through a port at "bottom" of sensor.

(e) The average zero drift (increase in zero) of the sensor in the first month was less than 0.10 pct CH_4; it was less than 0.05 pct CH_4 equivalent per month in the 4th and 5th month during which the sensor was not exposed to methane.

Recently, an improved version of the Scott Aviation sensor, a prototype with increased diffusion path, has been tested by the manufacturer. It is identical to the standard Scott low-current sensor with regard to current and voltage requirements, but has approximately 2/3 the sensitivity of the standard Scott sensor. The manufacturer found the total drift (zero drift + span drift) at 2.5 pct CH_4 in air over a 6-month test period (1 hr CH_4 exposure per week) to be f0.55 pct CH_4, approximately half that of the standard sensor when similarly tested by the manufacturer. Methane transducers with the standard Scott sensors will be used in early field testing of the ISMMS. Meanwhile, the prototype sensors will be extensively tested in the laboratory.

SUMMARY AND CONCLUSIONS

A list of sensor characteristics and requirements for use in the fixed-point ISMMS were developed.

A compilation of commercially available catalytic combustion sensors for methane detection was assembled, and the input current and voltage requirements were obtained. The methane sensor with the lowest current requires 60 mA, which is at least twice the value required for the ISMMS but can be used satisfactorily in the interim. At this sensor current level, ten J-Tec methane transducer modules can be placed on a single trunk line. The stability (total drift) of the sensor, especially of a newer model looks very good, assuming a monthly calibration schedule. Additional testing in the laboratory, for linearity and sensor-to-sensor uniformity and stability, is in progress. In-mine stability tests will also be performed. The search for methane sensors requiring <60 mA current is continuing. The next step is to investigate technical approaches to methane sensors that will enable the 25-mA goal to be achieved.

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

GEOTECHNICAL INVESTIGATION REPORT VOLUME I

PREPARED BY

Converse Ward Davis Dixon
Earth Sciences Associates
Geo/Resource Consultants
General Geotechnical Consultant

November, 1981

RTD

4.4.1.3 Hollywood Syncline

The axis of the Hollywood syncline (downfold) trends east-west and roughly parallels the alignment from the intersection of Fairfax and Fountain avenues to the intersection of Sunset and Cahuenga boulevards (Drawing 1). The syncline defines the Hollywood ground water basin.

4.4.1.4 Santa Monica Mountain Anticline

The Santa Monica Mountains are structurally an anticline with an east-west axis plunging to the west. Throughout late Pleistocene to recent time, this rapidly rising anticline has produced large amounts of debris which have pushed the Pacific Ocean shoreline west and south and formed interfingering marine and nonmarine deposits.

4.4.1.5 San Fernando Valley Basin

The San Fernando Valley is an asymmetric synclinorium (basin) developed chiefly in Miocene and younger rocks that have been deformed by late Quaternary folding and faulting, especially at the northern margin, and by thrusting along the Santa Susana and Sierra Madre faults.

4.4.2 Faults

The proposed Metro Rail alignment crosses several faults (Drawing 1). These faults are listed below in the sequence they occur along the alignment from downtown Los Angeles to North Hollywood.

- MacArthur Park fault
- 6th Street fault
- 3rd Street fault
- San Vicente fault
- Santa Monica fault (zone)
- Hollywood fault
- Hollywood Bowl fault
- Unnamed fault (north of Boring CEG 32)
- Unnamed fault (north of Boring CEG 32A)
- Benedict Canyon fault
- Unnamed fault (north of Boring CEG 36)
- Unnamed fault (north of Boring CEG 38).

4.4.2.1 MacArthur Park Fault

The MacArthur Park fault, east side down (Drawing 2) relative to the [illegible] side (near-vertical fault), is inferred in the Puente Formation (Lamar, 197[illegible] This fault is not known to be active or potentially active. Neither the [illegible] ical condition nor the width of the fault is known. Since the fault [illegible] crosses the alignment at right angles, it would not follow any excava[illegible] (Drawing 1). Artesian flow from Boring CEG 11 may indicate the fault [illegible] barrier to ground water, as well as a trap for gas and oil. The highly [illegible] water contains 19,670 total dissolved solids (sea water is about 35,000 [illegible] suggesting an origin deep in an oil-bearing formation.

4.4.2.2 6th Street Fault

This fault is near-vertical with north side up relative to the south side and is in the Fernando Formation (Drawing 2). The fault location (Drawing 1) is based on Salt Lake Oil Field data (Crowder, 1961). It is not known to be active or potentially active, but it is probably a trap for gas and oil migration. During our seismic profiling, two anomalies commonly associated with faulting were observed in the area underlying Lines S-38 and S-39 (see Appendix C, Volume II: Figure C-25 for location, and Figures C-6 and C-7 for results). These anomalies probably represent the 6th Street fault from 60 to 80 feet below the ground surface. The fault is crossed twice by the alignment, but if the track grade is no more than about 80 feet deep, the fault should not be penetrated. The fault is judged not to penetrate the San Pedro sand or Old Alluvium overlying the Fernando Formation (Drawing 2). The physical properties in and adjoining the fault are not known.

4.4.2.3 3rd Street Fault

Displacement on this fault is north side up relative to the south side and is in the Fernando Formation (Drawing 2). This fault is also located based on Salt Lake Oil Field data (Crowder, 1961) and is not known to be active or potentially active. Neither the physical condition nor the width of the fault is known, but the fault is likely a trap for gas and oil. The fault trace crosses the alignment at nearly right angles by Boring CEG 22, thus would not follow any excavation for more than a few tens of feet (Drawing 1). The fault should not be encountered if track grade is less than about 140 feet deep.

4.4.2.4 San Vicente Fault

This fault is also north side up relative to the south side (Drawing 2). The fault location is based on Salt Lake Oil Field data (Crowder, 1961) and is in the Fernando Formation (Drawing 1). This fault is not known to be active or potentially active. Neither the physical condition nor the width of the fault is known, but the fault is likely a trap for gas and oil. The fault trace crosses the alignment at about a 45° angle near Boring CEG 23 (Drawing 1). The fault should not be encountered if track grade is less than about 200 feet below the ground surface.

4.4.2.5 Santa Monica Fault (zone)

The near-surface location of the Santa Monica fault zone is not well defined. The location shown on Drawing 1 is based on oil well and water well data, CEG borings, seismic profiles, gravity data and ground water information. Interpretation of gravity survey (Figure D-3, Appendix D, Volume II) suggests a location at Fairfax High School near Boring CEG 23A but could not conclusively confirm location of this fault. However, Gravity Profile 4 (Figure D-4, Appendix D, Volume II) near Boring CEG 27 appears to have located the Santa Monica fault in the Hollywood area; i.e., about 150 feet of vertical offset along a 50° north-dipping reverse fault (north side up) with bedrock thrust over Old Alluvium. The fault is judged to be potentially active, and the inference is "it hasn't moved in" (11,000 ybP). Dont assume will move in next or 200 years. i.e. spend no $ money.

fault trace crosses the proposed alignment at an angle of about 35° near the intersection of Melrose and Fairfax avenues (Drawing 1). Based on our interpretation, the Santa Monica fault displaces Old Alluvium (A_4), as illustrated on Drawing 2. A summary of information and opinions reported by other investigators not associated with the Metro Rail Project is as follows:

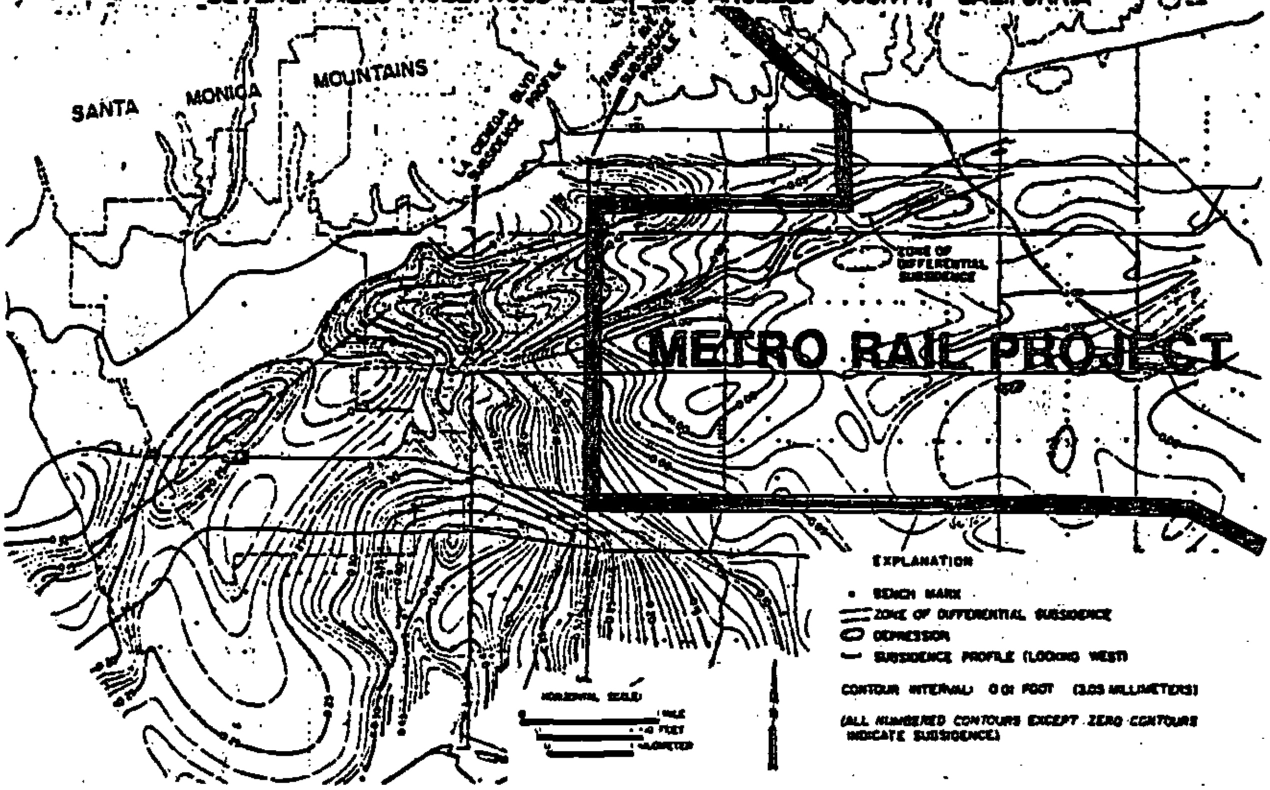
- The near-surface location of the Santa Monica fault in the Beverly Hills-Hollywood area is defined by a zone of differential subsidence (Figure 4-9), coincident with a ground water barrier in the Pleistocene sediments (Figure 4-10). This interpretation implies that movement along the Santa Monica fault extended into part of the Pleistocene. Holocene movement [11,000 ybp (years before present)] cannot be precluded on the basis of current knowledge, and based on micro-earthquake activity, the Santa Monica fault appears to be actively undergoing strain accumulation and release (Hill, 1979, pp. A-3, B-4 and B-11).
- The Santa Monica fault is a distinctly separate structural feature from the Hollywood fault; i.e., the Hollywood fault lies at the base of the Santa Monica Mountains and is separated from the Santa Monica fault by the Hollywood syncline (Drawing 1). The Santa Monica fault is also distinctly separate from the Raymond fault, although it is on the same trend (Converse, 1972).
- The basement surface is upthrown on the north more than 7,500 feet. The base of the upper Miocene is upthrown about 6,500 feet. The base of the lower Pliocene is upthrown about 3,000 feet. Left-lateral offset is also suggested (Yerkes, 1965, p. A51).

4.4.2.6 Hollywood Fault

The Hollywood fault is located at the base of the Santa Monica Mountains (Drawings 1 and 2). The proposed alignment will penetrate this zone, which apparently has two branches in the Cahuenga Pass: the Hollywood fault between Borings CEG 28 and 28A and Gravity Profile, Figure D-5, Appendix D, Volume II; and the Hollywood Bowl fault at Borings CEG 30 and 31 and Gravity Profile Figure D-6, Appendix D, Volume II (see Hollywood Bowl fault description in subsection 4.4.2.7). The Hollywood fault is judged to be active based on interpretation of Borings CEG 28 and 28A (Drawings 1 and 2), Seismic Refraction Survey Area 4 (Drawing 3) and micro-gravity profile 5 (Figure D-5, Appendix D, Volume II), the principal reason being the apparent 270 feet of vertical displacement (north side up) of Young and Old Alluvium (Drawing 2). The fault and/or fault zone should have minor influence relative to broken rock and/or ground water inflows on the anticipated mixed-face tunneling conditions. Opinions by other investigators, not associated with the Metro Rail Project, are:

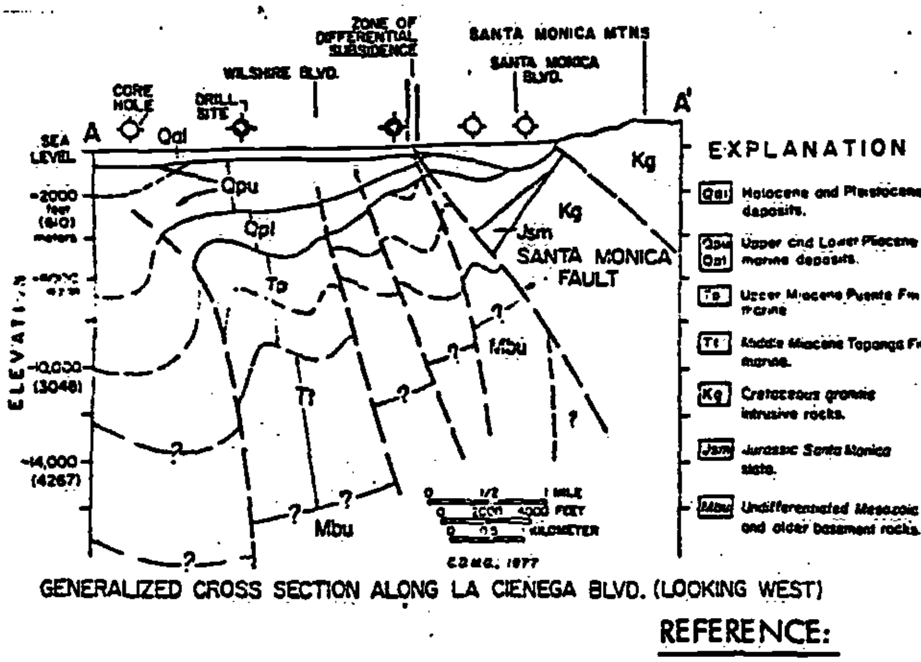
- Based on geomorphic evidence, a fault is present along the south edge of the Santa Monica Mountains and caused post-Pleistocene uplift of the Santa Monica Mountains causing tilting of the Santa Monica Plain (Hoots, 1930).

TOTAL ELEVATION CHANGE (IN FEET) BETWEEN 1955 AND 1970 LEVELING SURVEYS
BEVERLY HILLS-HOLLYWOOD AREA, LOS ANGELES COUNTY, CALIFORNIA



REFERENCE:

Hill and others, 1979, p. B-25



GENERALIZED CROSS SECTION ALONG LA CIENEGA BLVD. (LOOKING WEST)

REFERENCE:

Hill and others, 1979, p. B-32

PLAN AND SECTION OF ZONE OF DIFFERENTIAL SUBSIDENCE ALONG SANTA MONICA FAULT

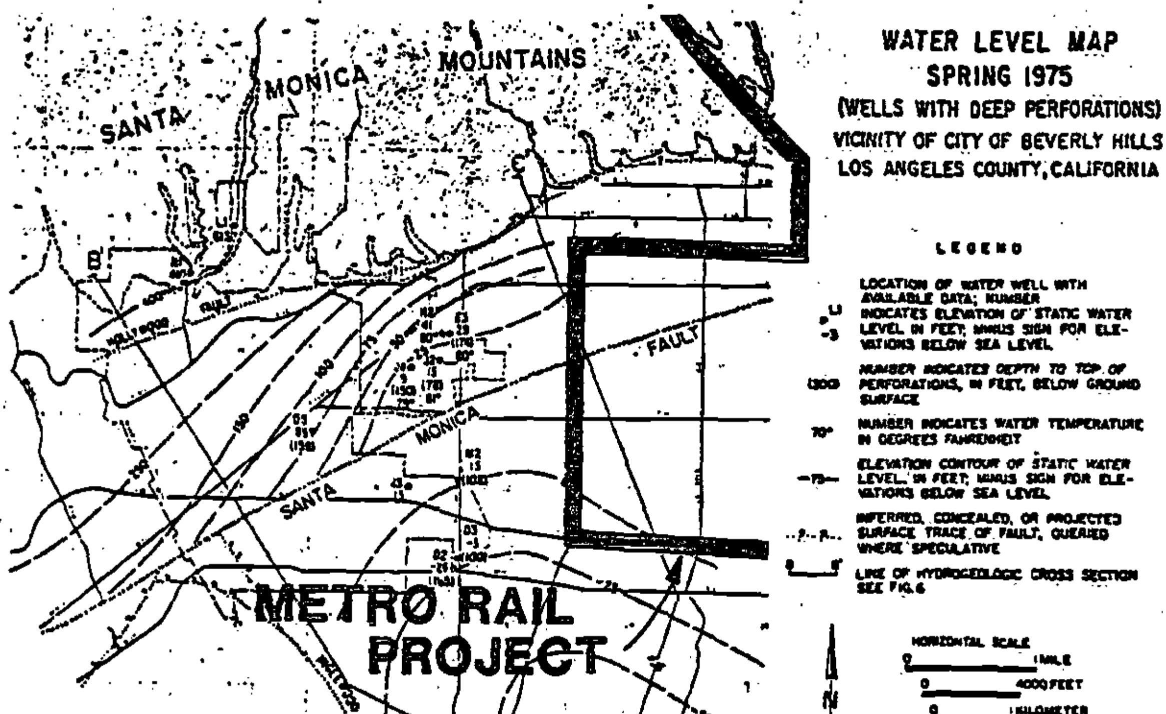
Southern California Rapid Transit District

METRO RAIL PROJECT

Project No. 80-1280

CWDD/ESA/GRC Geotechnical Consultants

Figure No. 4-9



REFERENCE:
Hill and others, 1979, p. B-22

SANTA MONICA FAULT AS A GROUND WATER BARRIER

Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 80-1280

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Figure No. 4-10

- Based on offset alluvial sediments and other geologic evidence, the Hollywood fault is judged to have been active during very late Quaternary (including Holocene) time (Weber, 1980, p. A-3).
- East of the Los Angeles River, in the Atwater area of Los Angeles, a series of gentle south-facing breaks in slope 2 to 3 m in height apparently represent scarps along the principal, most recently active trace of the zone. The Hollywood fault zone is primarily expressed at the ground surface by scarp-like features in older and younger alluvial deposits. These sediments, lying at a depth of about 35 meters on the north (upthrown) side, are displaced downward about 35 meters on the south side (Weber, and others, 1980, p. B-58).
- There is no subsurface evidence that the Hollywood fault crosses the Los Angeles River alluvium in the Atwater area, judging from a 1-mile diameter, continuous undisplaced clay layer located about 100 feet below the ground surface (defined by 60 borings). The clay layer is believed to be ±30,000 years old, according to paleoclimatic age-dating of redwood tree remnants obtained in the clay layer (Converse Davis Associates, 1972).
- The Hollywood fault is classified as potentially active (no recognized historic activity, but may move again in the near future). (Yerkes, and others, 1977, p. 7).
- Data from wells drilled north of Beverly Hills indicate the existence of a number of a north-dipping fault zones with a minimum of 1,500 feet of vertical separation at the base of the Modelo Formation (Lamar, 1970, p. 38).
- The Hollywood fault extends along the southern edge of the Santa Monica Mountains and at depth serves as the northerly edge of the Hollywood Basin, one of the ground water basins included in the Coastal Plain. The Hollywood fault truncates the northern flank of the Hollywood syncline and is a complete barrier to ground water movement to the north and east (California Department of Water Resources Bulletin 104, 1961, p. 88 and 95).

4.4.2.7 Hollywood Bowl Fault

The Hollywood Bowl fault was encountered in Borings CEG 31 and 32 and is interpreted to be present in Gravity Profile 6 (Figure D-6, Appendix D, Volume II) and seismic line S-51 (Appendix C, Volume II: Figure C-16 for interpretation and Figure C-28 for location). This fault does not appear to have offset alluvial deposits and is steeply dipping (±80°), with the north side displaced upward relative to the south side (see Drawing 1 for location and Drawing 2 for interpretation). The amount of displacement and the age of last displacement is unknown. However, the fault is not known to be an active or potentially active fault. The fault is judged to represent a zone of discontinuities several hundreds of feet wide and be a likely source of ground water inflow to any tunnel construction.

4.4.2.8 Unnamed Fault North of Boring CEG 32

An unnamed fault occurs at the contact of Topanga Formation sandstone and basalt at the location shown on Drawing 1. This fault, mapped by Hoots (1930), is nearly vertical, with the north side down relative to the south side (Drawing 2). The fault is not known to be active or potentially active. The fault trace crosses the alignment at nearly right angles and should not follow any excavation for more than a few tens of feet, but it is likely to be encountered. MWD's 1940 Hollywood Tunnel (Section 6.4), encountered a moderately blocky and seamy area about 80 feet wide and a two-day inflow of 600 gpm at this fault location.

4.4.2.9 Unnamed Fault North of Boring CEG 32A

An unnamed fault in the near-vertical dipping Topanga sandstone and conglomerate is inferred from interpretation of aerial photographs, faulting encountered in the Los Angeles City Sewer Tunnel (Section 6.3), Hoots' 1930 Geologic Map, and surface geomorphic expression (Drawing 1). This fault may be encountered in the alignment. The Los Angeles City Sewer Tunnel, during construction, encountered a maximum inflow of about 200 gallons per minute (for a few days) from this fault contact area. "Heavy" ground pressures were reported in the Los Angeles City Sewer Tunnel in this area. The fault is not known to be active or potentially active. The fault trace crosses the alignment at nearly right angles and should not follow the project line for more than a few tens of feet. The north side is down relative to the south side in this near-vertical fault (Drawing 2).

4.4.2.10 Benedict Canyon Fault

The proposed alignment could penetrate the Benedict Canyon fault if track grade is deeper than 40 feet below the ground surface (Drawing 2). The fault is not known to be active or potentially active. The location of the fault is based on topographic expression on the north flank of the Santa Monica Mountains and confirmed by our seismic profiling (Appendix C, Volume II: Figure C-18, seismic line 28 for interpretation, and Figure C-29 for location). The Benedict Canyon fault location, as mapped by Hoots (1930), cuts diagonally across the Santa Monica Mountains northwest of Beverly Hills. However, according to Hoots, the fault terminates west of the proposed alignment. The fault has been projected northeastward across the alignment (Drawing 1), based on works of others (Los Angeles City Geologic Map Sheet No. 94, 1970; Hill, 1979; and Weber, 1980). Tertiary movement along this fault zone appears to have resulted in a horizontal offset of several stratigraphic units for a distance of approximately 1.5 miles (Hoots, 1930). The fault shows nearly 2.5 km of left-lateral slip separation at the contact between upper Cretaceous rocks and Paleocene rocks (Weber, 1980). Gravity gradients suggest a zone of steep north-facing gradients that possibly express two faults, the more southerly being the Benedict Canyon (Weber, 1980), p. B-52). Gravity data indicates that rocks along both faults are down relatively on the north, which is compatible with geologic evidence to the west in the mountains (Weber, 1980, p. B-52). If projected eastward near the abrupt bend from east to south of the Los Angeles River, water-well data suggests that the bottom of the alluvial basin is displaced downward 170 meters on the north side (California Water Rights Board, 1960 Cross-section M-M' on Plate 5E, and p. 111-7 to 111-8).

4.4.2.11 Unnamed Fault North of Boring CEG 36

The location (Drawing 1) of this postulated fault is based on surveyed elevation change data along the south edge of the San Fernando Valley, as interpreted by J.H. Bennett (Weber, 1980, p. B-99, and Plate I), suggesting an east-trending fault in the vicinity of the Ventura Freeway. The fault is not known to be active or potentially active, nor act as a ground water barrier. This postulated fault is expected to have little or no effect on the Metro Rail Project.

4.4.2.12 Unnamed Fault North of Boring CEG 38

The location (Drawing 1) of this postulated fault is based on an apparent east-northeast trending, south-facing, linear break in topography discernible on USGS quadrangle maps published in 1901 and 1926, suggesting a possible fault. In addition, elevation change data, by J.H. Bennett (Weber, 1980, p. B-99, and Plate I) suggest a zone of subsidence to the south. These relationships suggest that youthful deposits of Tujunga Wash may be offset downward relatively to the south in recent time (Weber, 1980). The fault is not known to be active or potentially active, nor to act as a ground water barrier. This postulated fault is expected to have little or no effect on the Metro Rail Project.

4.5 GROUND WATER BASINS

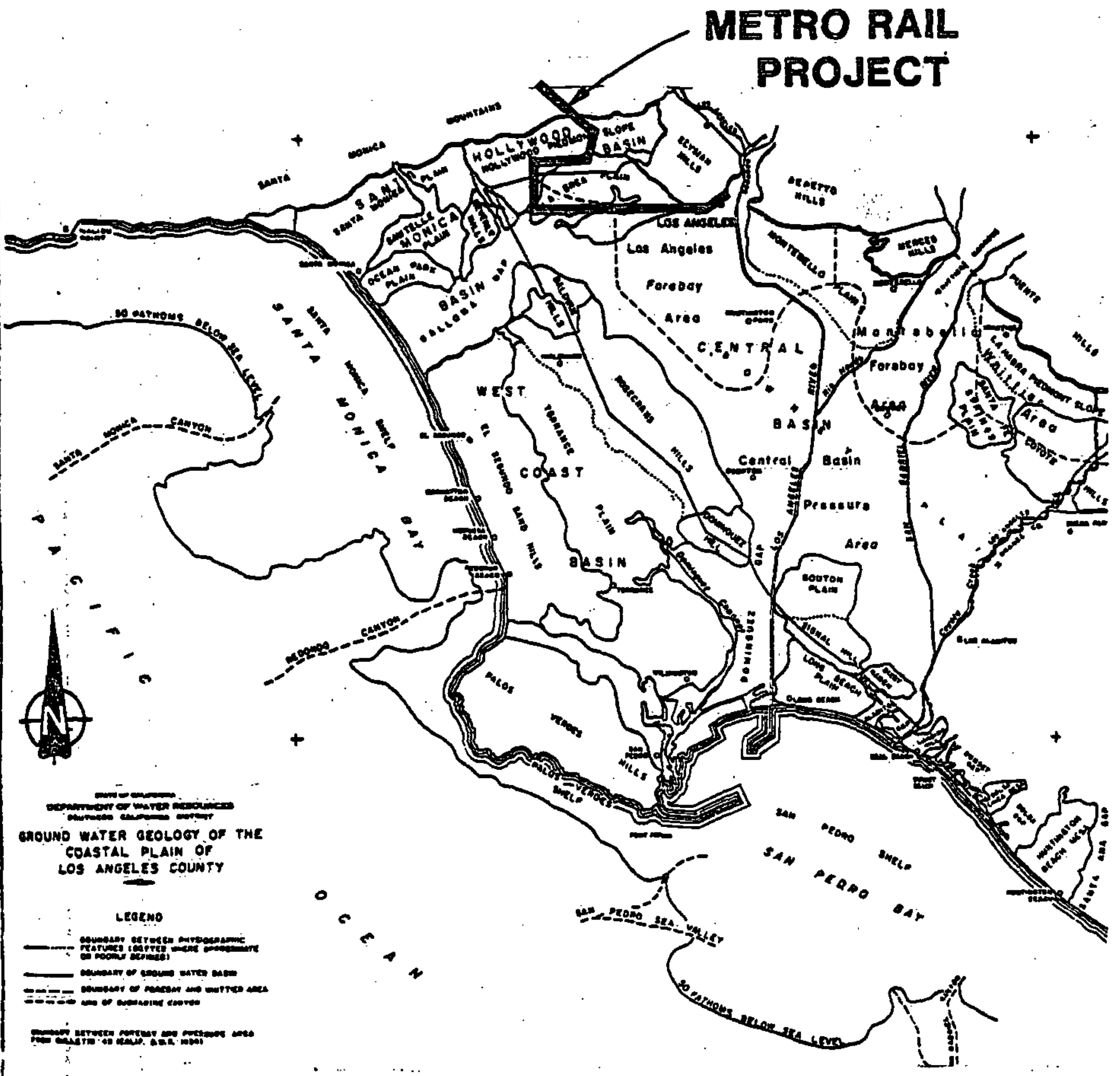
4.5.1 General

The proposed alignment will traverse four hydrologic units, each having distinct characteristics with respect to storage and transmission of ground water. Three of these units are considered ground water basins. The fourth is the Santa Monica Mountain mass (Figure 4-11). These units, starting from downtown Los Angeles to North Hollywood, are:

- Los Angeles Forebay Area (Central Basin)
- Hollywood Basin
- Santa Monica Mountains
- San Fernando Valley Basin (Drawing 1).

4.5.2 Los Angeles Forebay Area

The Los Angeles Forebay area is in the Central Ground Water Basin, extending southerly and westerly in an irregular semi-circular fashion from the mouth of the Los Angeles Narrows near downtown Los Angeles (Figure 4-11). The Forebay area includes the area traversed by the proposed alignment from downtown Los Angeles to the Hollywood Basin. The term "forebay" refers to an intake area where substantial infiltration of surface water into the basin can occur. This concept is a gross simplification. Several aquicludes of sufficiently low transmissivity occur locally, permitting perched ground water conditions similar to those shown on Drawing 2 along the alignment. Where the aquiclude



REFERENCE:

California Department of Water Resources, 1961, Plate 2

MAP OF COASTAL GROUND WATER BASINS

Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 80-1280

CWDD/ESA/GRC Geotechnical Consultants

Figure No. 4-11

is missing, the aquifers are in direct hydraulic continuity with the surface. Ground water occurs in Young Alluvium and Old Alluvium and other underlying pervious Pleistocene sediments. The known water-bearing sediments extend to depths of 1,600 feet below the ground surface in the southern parts of the Forebay. The Tertiary sedimentary rocks beneath the basin are essentially nonwater-bearing. Coastal Plain ground water contours for shallow aquifers, November 1973, are shown on Figure 4-12.

4.5.3 Hollywood Basin

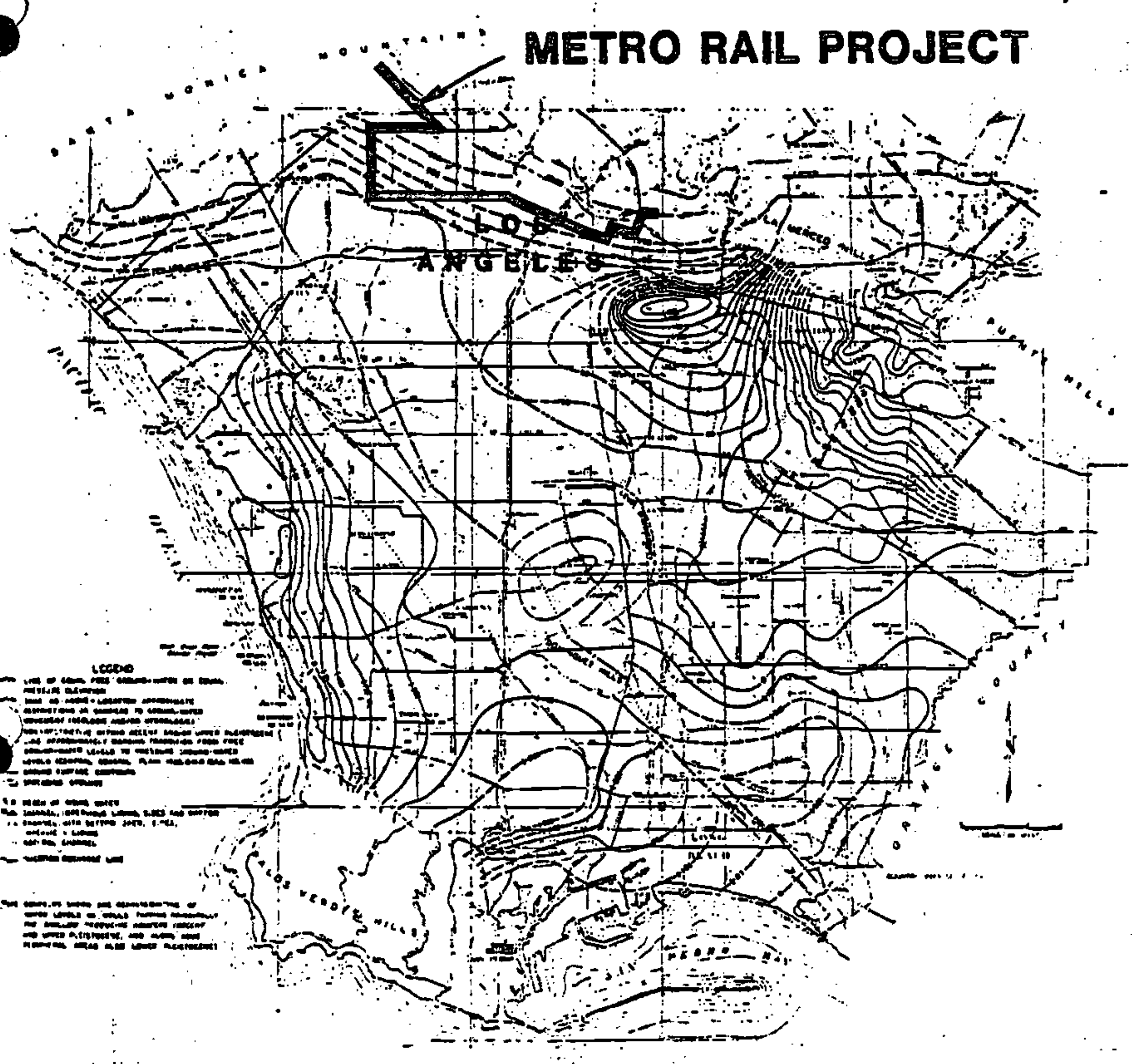
This basin extends from the southern margin of the Santa Monica Mountains southerly to the Santa Monica fault (Figure 4-10). Many water wells were present in the Hollywood Basin around the turn of the century, but most of these have since been destroyed as land use has changed. Most of the water wells were located in the deeper portions of the basin corresponding to the Hollywood synclinal axis near the Santa Monica Mountains (Drawing 1). Sediments containing known aquifers extend to a maximum depth of 650 feet and include alluvium and Pleistocene sediments. In general, aquifers in the Hollywood Basin possess relatively low transmissivity rates. A zone of differential subsidence, coincident with the Santa Monica fault, on the south side of the Basin (Figure 4-9) is attributed, in large part, to ground water withdrawals. This subsidence is judged not to impact the Metro Rail Project, provided there is no more heavy pumping and attendant water level declines. Coastal Plain ground water contours, November 1973, are illustrated on Figure 4-12.

4.5.4 Santa Monica Mountains

This mountain range does not constitute a ground water basin, but rather a mass of Tertiary sedimentary (Tt) and volcanic (Tb) rocks (Drawing 1) and other older crystalline rocks with a limited capacity for transmission of water. The term "nonwater-bearing" has been used by others but is meant to imply that these materials yield relatively limited quantities of water to wells, not that the materials contain no water. Wells that intersect extensive joint and fracture systems can produce ground water in fairly sizable quantities for short periods of time. Such joint and fracture systems are significant in tunneling. A case in point occurred, during construction of MWD's Hollywood Tunnel in 1941 (Section 6.4). At that time, flash flows of up to approximately 600 gpm were encountered, lasting for a few hours (MWD, 1942). Water pressure tests in Borings CEG 30 and 31 indicated that the bedrock in these locations is highly permeable. Pressure tests completed in borings that encountered geologic Unit C show the bedrock to be relatively impermeable (see Table A-4, Appendix A, Volume II).

4.5.5 San Fernando Valley Basin

This basin lies on the north side of the Santa Monica Mountains. In this basin, ground water occurs chiefly in the Young and Old Alluvium that, in places, reach depths of 1,000 feet. In this area the water-bearing sediments



REFERENCE:

Los Angeles County Flood Control District
1973-74 HYDROLOGIC REPORT, 1975, p. 275

COASTAL PLAIN GROUND WATER CONTOURS - SHALLOW AQUIFERS - NOVEMBER 1973

Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 80-1280

CWDD/ESA/GRC Geotechnical Consultants

Figure No. 4-12

are about 600 feet thick. These sediments are permeable and freely yield water to wells. In general, water levels in the San Fernando Basin have declined markedly, in some cases 100 feet or more, since the mid-forties in response to heavy pumping. Efforts by both the City of Los Angeles and the Los Angeles County Flood Control District to replenish the basin with imported water seem to have arrested this decline. San Fernando Valley ground water contours, April 1974, are presented on Figure 4-13 (LACFCD, 1975). As shown on Figure 4-13, there is a relatively deep 150-foot ground water depression about 4 1/2 miles east of the Metro Rail Project near the "bend" in the Los Angeles River. A rapid rise in water levels at this depression, due to wet winters or supplementary recharge, is judged to be capable of raising water levels at the project area several tens of feet in a year or two.

4.6 GROUND WATER QUALITY

With very few exceptions, water quality along the alignment is poor (Table G-1, Appendix A, Volume II); i.e., exceeds 500 parts per million (ppm) total dissolved solids (TDS), which is the U.S. Environmental Protection Agency drinking water standard (Todd, 1980). Chloride, sulfate and total dissolved solids contents are very high, as is conductivity. The TDS of the artesian water from Boring CEG 11 is extremely high, i.e. 19,670 ppm, as were waters from Borings CEG 6 (20,230 ppm) and 19 (15,425 ppm). Mineral springs were common in the Hollywood area at the turn of the century. Above-normal concentrations of certain ions are to be expected where ground water is associated with oil and gas. However, high total dissolved solids (TDS) were also encountered in the sulfate-type water in the San Fernando Valley, ranging from a low of 732 ppm in Boring CEG 36 to a high of 2605 ppm in Boring CEG 35; averaging about 1,000 ppm from seven boring samples. More specific discussion and results of ground water quality analyses are presented in Sections 5.1.6 and 10.6, and Appendix G, Volume II.

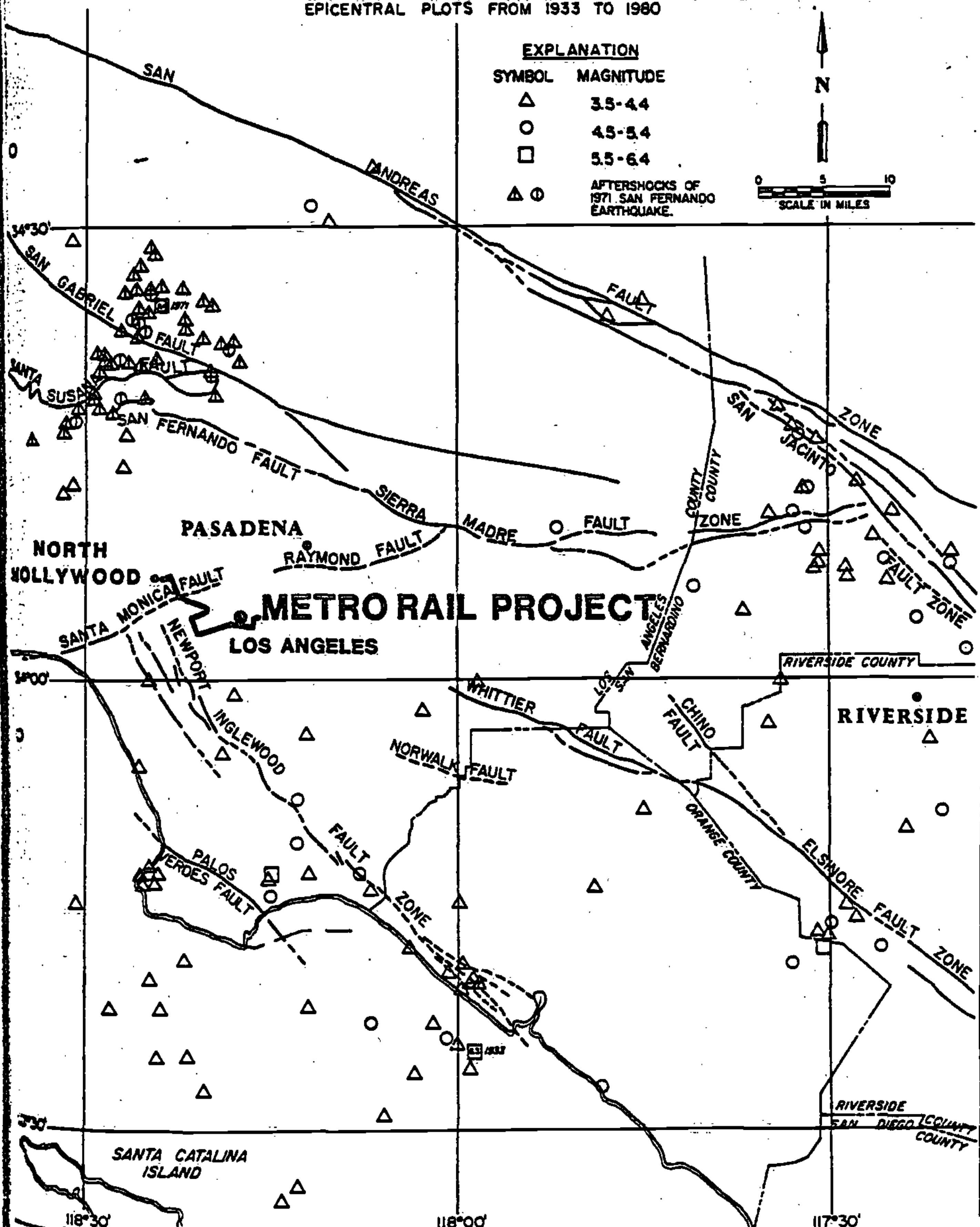
4.7 OIL AND GAS

4.7.1 General

Oil was first discovered in the Los Angeles Basin in 1880, and the Los Angeles City Oil Field was discovered in 1892, based on oil seeps at the surface. Oil is produced chiefly from thick deposits of lower Pliocene and upper Miocene strata. About 58% of recovered oil has come from the lower Pliocene rocks and about 42% from upper Miocene rocks. In relation to area, the Los Angeles Basin is the most prolific of California's oil producing districts and is one of the most prolific in the world. A unique combination of factors and timing of events accounts for the productivity of this basin. The petroliferous sediment accumulated rapidly in stagnant cool water more than 1,600 feet deep during the advancing and maximum phases of the last marine transgression. The initially high organic content of the sediment was preserved because of poor

EARTHQUAKE EPICENTER AND FAULT MAP

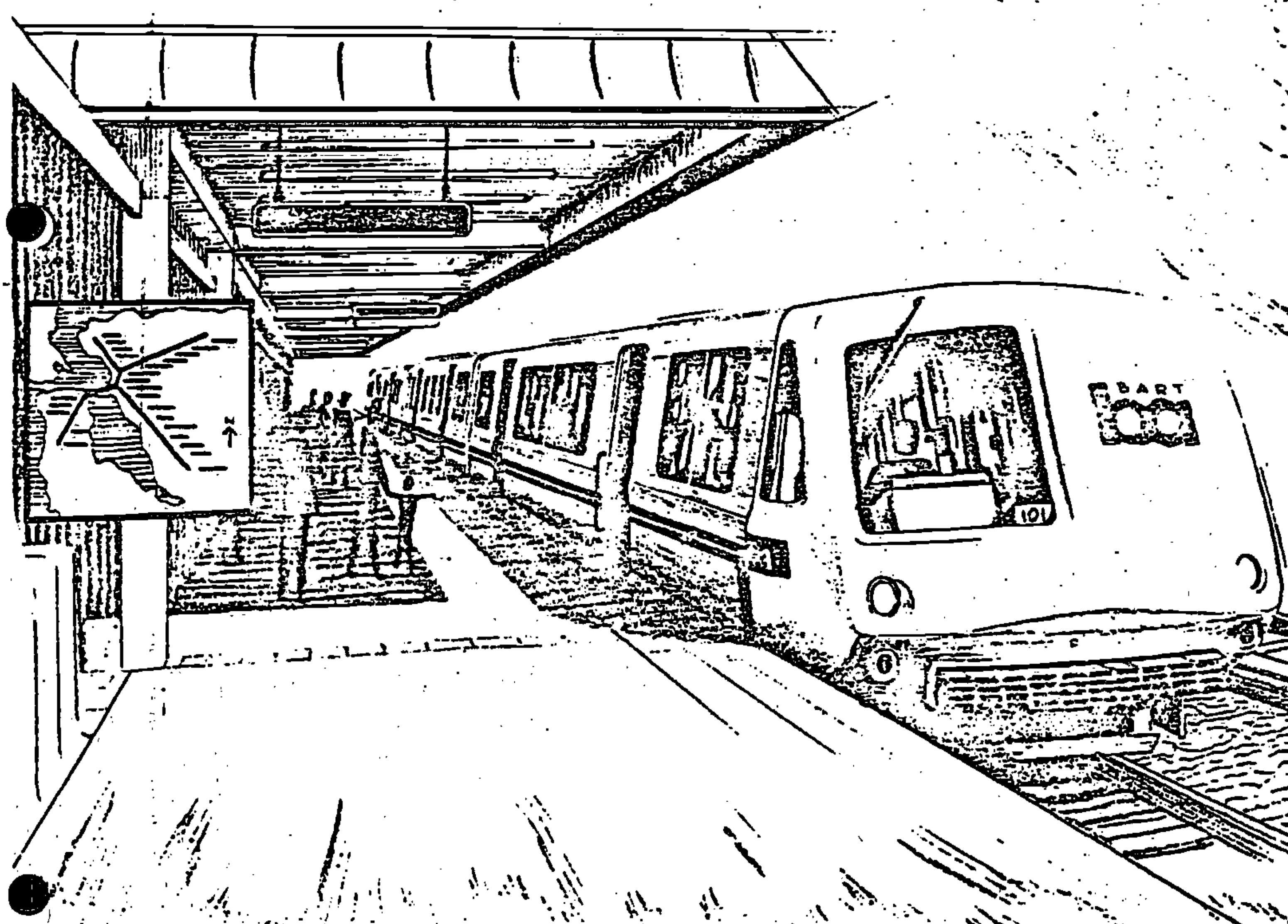
EPICENTRAL PLOTS FROM 1933 TO 1980



seismic

bart impact program

IMPACTS OF BART ON THE NATURAL ENVIRONMENT INTERIM SERVICE FINDINGS



Pilings

Pilings were used for all elevated structures to minimize problems with differential settlement. The depth of piles and the number used were designed for local soil conditions (Moore).

Granular Base Material

A granular base material was used for the Transbay Tube to spread the Tube structure weight evenly over the soft Bay bottom mud. The use of this material minimized the effects from differential settlement (Moore).

IMPACT FROM ACCELERATED WEATHERING

4.7 - The exposure of Orinda formation soils along the northern side of Route 24 accelerated the weathering process, thereby weakening the existing unstable structure of these soils and increasing the potential for additional landslides and erosion.

Accelerated weathering occurs when soil or bedrock is exposed directly to the effects from air, wind, and water. In the case of cut slopes along Highway 24, the very unstable Orinda soils were exposed to these elements. This exposure produces chemical reactions that weaken the soils and increase their propensity to slide and erode. Such slides, if they are severe enough, could damage Highway 24 and the included BART facilities (Heyes). However, because of the complex interrelationships between weathering, soil structure, groundwater, and other factors in determining the occurrence and severity of landslides it has not been possible, within the scope of this study, to determine the extent of the danger from major slides on Highway 24 that can be directly related to accelerated weathering of Orinda formation soils.

IMPACT FROM SEISMIC ACTIVITY

4.8 - Since there is a widely acknowledged potential for major seismic activity in the Bay Area, BART design included several unique features to minimize adverse effects from shear movement along faults, ground shaking, and liquefaction.

The BART system crosses the Hayward fault in the Berkeley Hills and along the rest of its length the system will be affected by ground movement from earthquakes. It was of great concern, therefore, on the part of BART engineers, to minimize the effects from seismic activity on BART facilities. The three characteristics of seismic movement requiring specialized design solutions included shear zone movement along faults, ground shaking and liquefaction:

Shear Zone Movement Along Faults

BART intersects the Hayward fault at the western entrance to the Berkeley Hills tunnel. This is the only location within the BART system where a major active fault zone is crossed. The following measures were used to minimize the effects of shear zone movements (Moses):

Tunnel Section Tying

At the entrance to the Berkeley Hills tunnel the Hayward fault is actually a 1,000 foot zone of pulverized bedrock. Through this section the BART tunnel was constructed from concrete ring sections 2-1/2 feet wide. If movement should occur along the fault in any direction, these sections can easily be replaced during one three hour work shift so that normal operations will not be disrupted. Many smaller non-active fault systems were also discovered during construction of the Berkeley Hills tunnel and in each case similar ring sections were installed. In all areas in which the ring sections were installed, the tunnel diameter is wider than normal to allow greater flexibility in adjusting tunnel sections and track should fault movement occur (Moses).

Tunnel Separation

100

The Berkeley Hills tunnel is actually composed of two separate tunnels spread apart by as much as 1,000 feet in the center. The purpose of this separation is to minimize damage to both tunnels should movement along the fault occur. At the portals to each tunnel where they come together, crossover tracks have been installed so if one tunnel is damaged trains from both directions can use the other tunnel (Moses).

Cross Tunnels

THREE

The two main trackway tunnels are interconnected by passageways every 1,000 feet along the four mile route. These passageways will allow maintenance personnel access to both tunnels from any location and serve as alternate exitways should a BART train be located in one tunnel when earthquake damage occurs (Moses).

Fault Deflection Meters

A fault deflection meter has been installed to detect the slightest movement along the Hayward fault. The meter is senstive to any movements along the fault, including those which would not be visible (Moses). 0.1g

Ground Shaking

Ground shaking will affect all parts of the BART system should major seismic activity occur in the Bay Area. To counter this effect all BART structures were designed with a simple span construction to allow maximum flexibility during any such episodes.

With simple span construction the span beams are not integrally tied to the pier, but are connected to the pier cap by a six inch diameter pin. The span beams are not continuous over the pier, and therefore will not be adversely affected within limits by lateral or vertical displacement (Moore).

Liquefaction

Liquefaction is a phenomenon which occurs in some very fine soils during seismic activity. During liquefaction soils which are normally firm become "liquid" causing structures to shift out of plumb. The only areas within the BART system with soils subject to liquefaction are the Oakland portal and bed of the Transbay Tube. A granular material was used as a base for the Transbay Tube to mitigate possible effects from liquefaction (Moore).

CONCLUSIONS

BART construction removed soils and geologic resources where BART and related freeway construction traversed steep terrain, particularly on the north side of Route 24 between Orinda and Walnut Creek. However, the effects of grading, landslides, and erosion resulting from this excavation were primarily visual and did not directly affect BART operations or surrounding residences.

The extensive excavations required to expand Route 24 from six to eight lanes altered existing landforms, caused landslides and erosion in areas with unstable soils. While some visual impacts were created by these landslides, the excavating did not have significant effects on BART operations, freeway capacity, or residents in surrounding communities.

The one major impact, a massive landslide which occurred during early stages of construction on Route 24 in 1965, was mitigated by alterations in freeway design and excavation of loose material. Since 1965 no major landslide has directly affected the freeway or BART operations.

Where BART traversed relatively flat terrain there were no significant impacts on soils or geologic resources.

BART had little effect on soils or geologic resources in areas of flat terrain because of the extensive use of aerial structures and the limited requirements for grading. Since most of the system is located in existing urban corridors with little elevation change, no special geologic features, and limited areas where slope stability is a potential problem, there were negligible impacts on soils and geologic resources.

Design features were incorporated into the BART system to minimize impacts to BART from ground subsidence, consolidation, accelerated weathering of cut slopes, and seismic activity.

Standard engineering practices were employed to ensure BART facilities can absorb limited amounts of ground movement. To date these measures have been effective. However seismic activity or other ground movement which exceeds these built-in limits will cause severe damage and disruption to the BART system.

IMPLICATIONS

BART's impacts on soils and geologic resources were not significant because special geologic features did not exist along the selected right-of-way and appropriate engineering practices were employed to maintain stable slopes and system flexibility during ground movement.

The primary effects of a major engineering project like BART on soils and geologic features are visual changes resulting from massive excavation and grading. These impacts are experienced as changes to the natural shape of the hillsides, but the effects are softened over time by the growth of ground cover and other plant material.

Other effects include BART-related changes to landforms which may be potentially damaging to surrounding land uses. Adverse effects from these conditions, for example landslides, ground consolidation, subsidence, etc., can be minimized through appropriate engineering practices. To date the practices adopted by BART planners have prevented significant impacts both to soils and geologic resources from BART construction and from soils and geologic conditions to the BART system.

In other cities where mass transit systems will be planned, the geologic conditions may be different from those in the Bay Area. In these cases, other engineering practices will be required to minimize impacts from soils and geologic resources.

Form No. 0061

BAY AREA RAPID TRANSIT

Routing Slip

J. Burns — From

4/5/83 — Date Initiated

To	Person	Initials
1	P. Todd	
2		
3		
4		
5		
6		

Use Routing Sequence Numbers to Designate Person Concerned

___ Referred for appropriate action

___ For concurrence

___ For comment

___ For information

___ For approval

___ Please discuss with me

___ Read and retain

___ Return before filing

___ Note & send to central files

Comments:

This copy is for
Deba Mohatatra of Kaiser
to be here (OUB) 4/11/83 @ 11:00A
(per Simerton)
Since this was written,
the Bay area has had
10 earthquakes with a
magnitude between
2.9 and 5.8 Richter Scale.
BART has experienced no damage
and there have been no
trips of our system which is
(over)

set for the threshold of damage or .1g @ 10sec

$\cancel{64}$ $\cancel{32}$ $\cancel{16}$ $\cancel{8}$ 2 x 10

$\cancel{160}$ $\cancel{40}$ 5

$\cancel{80}$ $\cancel{10}$

Tom McGrane

SEISMIC SENSING AND ALARM AT BART

By

J.S. BURNS
Manager, Electrical/Mechanical
Design Engineering

BAY AREA RAPID TRANSIT DISTRICT

BA-ENG-78-E2

APTA
June, 1978

Rapid Transit Conference
Chicago, Illinois

SEISMIC SENSING AND ALARM AT BART

A B S T R A C T

Several recognized critical earthquake faults cross or are in close proximity to the San Francisco Bay Area Rapid Transit System. Seismic sensing and alarm devices have recently been installed in eight key stations to give an early indication of the severity and location of seismic disturbances. Alarms are sent to the local station agent and Central. At Central the information is recorded via a teleprinter. Central Control evaluates the information and train operation is adjusted accordingly.

I N T R O D U C T I O N

Earthquakes have long been associated with California, but in addition to San Francisco and Los Angeles, there are several other major cities in North America that are susceptible to seismic damage. Atlanta, Boston, Cleveland, Montreal, Toronto and Mexico City are located in, or in close proximity to risk zones where seismic disturbances may cause moderate to major damage.

The San Francisco Bay Area is seismically active and has experienced severe earthquakes in the past. The Bay Area Rapid Transit District (BARTD) was designed to operate within this environment. However, in addition to the provision provided in the structures to minimize the effects of seismic shock, it has been considered prudent to have an earthquake identification and reaction program.

Initially, BARTD relied only upon a telephone communication from the University of California's Seismic Station. BARTD is advised of earthquakes in the Bay Area having magnitudes greater than 4.0. Because the length of time to be notified is at least 15 minutes (hours in some cases), it was decided that this approach alone was not adequate for a quick response in seismic emergencies. To satisfy a criteria of determining with a degree of certainty and speed the location and severity of a seismic disturbance, BARTD has installed its own Seismic Sensing and Alarm System.

D I S C U S S I O N

Earthquake Terminology

The following is a brief review of certain terminology associated with earthquakes:

Seismic is an adjective pertaining to earthquakes. The epicenter of an earthquake is the point on the surface of the earth directly over the earthquake source or focus. The seismic disturbance travels away from the epicenter in shock waves. The primary "P" wave is a compressional body wave, the speed of which depends upon the material. (1). (0.3 to 2.5 km/sec. - unconsolidated sediments; 3.0 to 7.5 km/sec. rock.) A secondary "S" wave follows at about 1/2 speed of the "P" wave, and is a shear wave. Long "L" waves travel along the earth's surface. Inertial instruments known as seismographs can be used to record the seismic waves.

The magnitude of an earthquake is a measure of the energy at its source, independent of the places of observation, and is taken from the largest amplitude on a seismograph. (2). Magnitude is measured on the Richter Scale, which is logarithmic. Each increase of one whole number is a 10 fold increase in the value and a 31 times increase in energy. Therefore, as an example, an 8 Richter magnitude earthquake has a size 10,000 times as great as a 4 Richter magnitude earthquake. The energy release of an 8 magnitude is about one million times greater than that of a 4 magnitude.

Intensity is a partly subjective measure of the severity of ground motions observed and the damage effects at any point influenced by the earthquake. The most widely used measure is the Modified Mercalli (1956) and varies from I to XII. After an earthquake, information is solicited from persons in the affected areas, and from this data, isoseismal lines can be plotted on a map through points of equal intensity. The modified Mercalli scale makes it possible to estimate the intensity of earthquakes that occurred in history where there were no instruments, but where eyewitness accounts have been noted. Intensity diminishes generally with the distance from the source, but topography and geological conditions cause wide anomalies in this attenuation rule.

Ground motions of earthquakes occur as a series of non-periodic acceleration pulses. The amplitude of the pulse, or the maximum acceleration is often used to indicate the severity of the ground motion or intensity. The duration of the pulses is roughly correlative to the magnitude, or energy release, at the focus.

Figure No. 1 shows a rough relationship between magnitude, intensity, acceleration and damage.

San Francisco Bay Area - Earthquake Activity

The San Francisco Bay Area is located in Number 4 seismic risk zone which is defined in the Uniform Building Code (3) as an area which may experience major damage as a result of its proximity to a major earthquake fault.

Over the last 150 years, the Bay Area has experienced numerous earthquakes that today would be viewed as severe. Between 1836 and 1954, seventeen (17) earthquakes causing moderate to major damage were noted or recorded within 150 miles of San Francisco. (4) Earthquakes in the Bay Area tend to be shallow focus (near surface to 10 miles deep), with a few in the 8.5 magnitude range. The most historic, of course, was the 1906 earthquake, which, with the resulting fire, caused the loss of hundreds of lives, and did hundreds of millions of dollars worth of damage.

Based upon this history, future earthquakes can be expected. Figure No. 2 is a map of the San Francisco Bay Area and shows the BARTD System, the bay, key cities and earthquake fault systems in area. The San Andreas fault is the largest and best known and at its closest point, is situated in the Pacific ocean, about three miles from the Daly City Station. The Hayward fault runs the length of the East Bay and crosses BARTD in the Berkeley Hills tunnel. The Calaveras fault runs through Contra Costa County and crosses BARTD close to Walnut Creek at the #680 Highway overcrossing. In addition, the Concord fault crosses the BARTD line just north of the Concord Yard. Most of the major earthquakes in the Bay Area are associated with sudden movement along these faults.

BARTD History

The BART District was formed in 1962. Design started in 1963, under the guidance of Parsons-Brinckerhoff-Tudor-Bechtel (PB-T-B) who were retained as general consultants. A design criteria was prepared for use during the detailed design phases. Special sections addressed seismic considerations for aerial and subway structures and specific criteria were developed for design of these structures. Standards and Codes such as the Uniform Building Code were used for less critical areas. Special designs were also engineered to handle several unique situations. As an example, special joints were designed to allow differential movement between the transbay tube and adjacent ventilation structures. At the point where the Hayward fault crosses the Berkeley Hills Tunnel, an enlarged tunnel cross section and 1/4 length timber ties under each rail will allow special realignment of the track to compensate for the gradual creep along this fault. The rate of this movement is about 0.2 inch per year.

Most of BARTD was constructed between 1964 and 1973. Revenue Service started in September 1972, and was completed with the opening of transbay service two years later. During the construction period, two seismic sensing schemes were considered by the District and its consultants. The first provided for an alarm only concept, and the second provided for an initial alarm at low seismic levels and train stoppage at higher seismic levels.

The necessity, methods and merits of an actual link with the system's train control was a controversial issue, especially in light of other critical train control problems being resolved at that time. Therefore, a phased program was decided upon.

PHASE I - Operational response without benefit of proprietary seismic sensing and alarms.

PHASE II - Operational response, based upon proprietary seismic sensing and alarms.

PHASE III - Depending upon the experience of Phase II, a possible automatic link between seismic sensing and the control of trains.

Seismic Sensing - Installation

The total cost to implement Phase II has been approximately $70,000. This includes the cost for equipment, the services of a consultant, BARTD personnel and a contractor.

Woodward-Clyde Consultants were retained to make recommendations on equipment selection and installation locations. The essential elements of their recommendations have been followed.

BARTD's staff performed the design and developed a contract for competitive bidding. After the contract was awarded, BARTD's staff provided the construction management. BARTD's maintenance forces provided the hardware interface connection between the Seismic Sensing System and the existing active equipment. Finally, BARTD's engineering department performed the necessary software changes, final checkout and testing.

Howell Electric was the successful low bidder on the contract. Equipment was furnished and installation was complete in the fall of 1977.

Seismic Sensing - Equipment Location

The Seismic Sensing and Alarm System employs seismic strong-motion accelerometer type triggers located in eight selected stations, audio alarms in the stations for the local agents; a transmission system to Central and visual and teleprinter alarms at Central.

The eight stations, (Daly City, Embarcadero, El Cerrito Del Norte, Rockridge, Bay Fair, Fremont, Walnut Creek, Concord), were selected because of their proximity to the major faults (Figure No. 2), and they represent reasonable system coverage. The seismic triggers are mounted in the train control rooms (except for Embarcadero) to provide controlled personnel access, controlled environment, close proximity to interface equipment, essential power and monitoring of key train control equipment. At Embarcadero, the only subway station monitored, the seismic trigger is located in a room at the lower platform level to be as close as possible to the bottom invert foundation. At other stations, the seismic triggers are bolted to the concrete floor of the train control room. (Figure No. 3.) The seismic triggers are protected by locked security enclosures about foot locker size. (Figures Nos. 4 & 5.)

Seismic Sensing - Equipment Description

Each strong-motion accelerometer sensor contains three trigge oriented to sense in vertical and in longitudinal and transverse horizontal directions. The operation of each trigger is based upon the output of a coil mass supported by a spring moving in a magnetic field. The trigger signal is amplified and operates a relay. The relays are designed to "trigger" or "trip" when the signal from the spring-mass system exceeds a certain threshold value. The triaxial triggers have a field adjustable range of 0.025 g to 0.25 g. The triaxial trigger output is a timed relay contact which is field adjustable from 6 to 20 seconds. The seismic triaxial triggers are Kinemetrics Model TS-3A. (Figure No. 6.) These triggers are used on structures such as dams and atomic generating plants worldwide, and have an excellent reputation for reliability. Usually they are operated with a self-contained 12 VDC battery supply and recording seismograph. BARTD's installation has its own vital power supply and does not use the recording device.

A test button is mounted in a separate box adjacent to the seismic triaxial trigger within the security enclosure. This test button simulates a seismic action. (Figure No. 7.)

The seismic triggers are adjustable by a Field Calibrator purchased from Kinemetrics. The triggers are set to trip at 0.10 g which is the point just below the damage threshold for specially designed structures. (Figure No. 1.)

Seismic Sensing - System Description

Figure No. 8 is the block diagram representing this system.

The seismic triaxial triggers are powered from the vital 12 Volt DC power supply of the train control equipment. A Wabco vital relay provides the interface signal for alarming Central and the local station. Normally closed contacts are used so that a seismic disturbance de-energizes the Wabco relay. This relay is located in the train control cabinet with the other vital relays. Wiring from the seismic switches to the vital relay and beyond was placed in conduit and/or existing cable tray within the train control room.

De-energization of the vital relay sends two signals through separate contacts. The first activates the station code call chime system. A code of six chimes is sounded over the station public address system, so that the alarm will be received wherever the agent is working.

The second vital relay contact controls an input to the digital transmission system (DTS) and is forwarded to Central. The DTS was the existing communication link for the train control system and there was sufficient spare capacity for the Seismic Alarm System.

At Central an alarm passes through the computer and initiates the following action:

1. The Support Facilities Console annunciator panel flashes "Seismic Disturbance". (Figures Nos. 9 & 10.)

2. An Amber "T" for the appropriate station flashes on the Support Facilities Display Board. (Figure No. 9.)

3. The message "Alarm - Seismic Disturbance - Station Number" prints on the Support Facilities Teleprinter. (Figures Nos. 10 & 11.)

4. Depression of the Support Facilities Console's acknowledge button causes the console and display board signals to change to steady lights.

5. When the seismic alarm signal stops, the message "Clear-Seismic Disturbance - Station Number" prints on the teleprinter. (Figure No. 11.)

It is to be noted that the system has a degree of redundancy. Each seismic sensor has three triggers and a major disturbance is expected to trip more than one sensor. Finally, the agents at each instrumented station are alerted and are expected to advise Central over the regular communication channels.

Alarm Response

The reaction to the alarms will depend upon the number of stations reporting, the order received and the speed at which they are recorded and cleared. This information, calls from station agents and/or train operators and the perception of the earthquake by Central personnel, will allow assessment of the severity. As an example, a single alarm from Daly City would probably mean a mild seismic disturbance on the San Andreas fault. However, alarms from numerous stations eminating in sequence from Daly City would probably mean a severe seismic disturbance on the San Andreas fault. The same logic and schemes would apply to the other faults.

Upon determination of a seismic disturbance, Central implements an earthquake response procedure. All trains are stopped, except trains in tunnels or the transbay tube are moved to the next station. Maintenance, BARTD Police and Public Information are alerted. If, during the hold period (five minutes) there is no reported damage or abnormal conditions, Central, at its discretion, may initiate an inspection conducted from the revenue vehicles in the slowest automatic mode with passengers aboard. Any report of abnormal conditions would result in inspections in a manual mode without passengers. During non-revenue hours, Central would oversee the inspection by maintenance forces.

C O N C L U S I O N S

*To date, none of the strong-motion seismic sensors have tripped for cause. However, when the Bay Area experiences its next earthquake of consequence, BARTD's alarm system will give objective information so that the BARTD operational response may be fast and accurate. Information from human observation, of course, is invaluable and necessary, especially during response implementation; but during the first critical minutes, correlation of such verbal input is a major task in itself. The teleprinter readout of information should avoid much of the confusion which might be expected in a major earthquake.

After experience has been gained with this alarm system, the Phase III decision will be made on whether to tie the seismic sensing into the train control system. Also, experience will help determine the adequacy of the sensing levels and if there are sufficient seismic triggers.

* Still so as of 4/5/82. Area has experienced about 10 earthquakes from 2.9 to 5.8 Richter
JSK

R E F E R E N C E S

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A C K N O W L E D G M E N T S

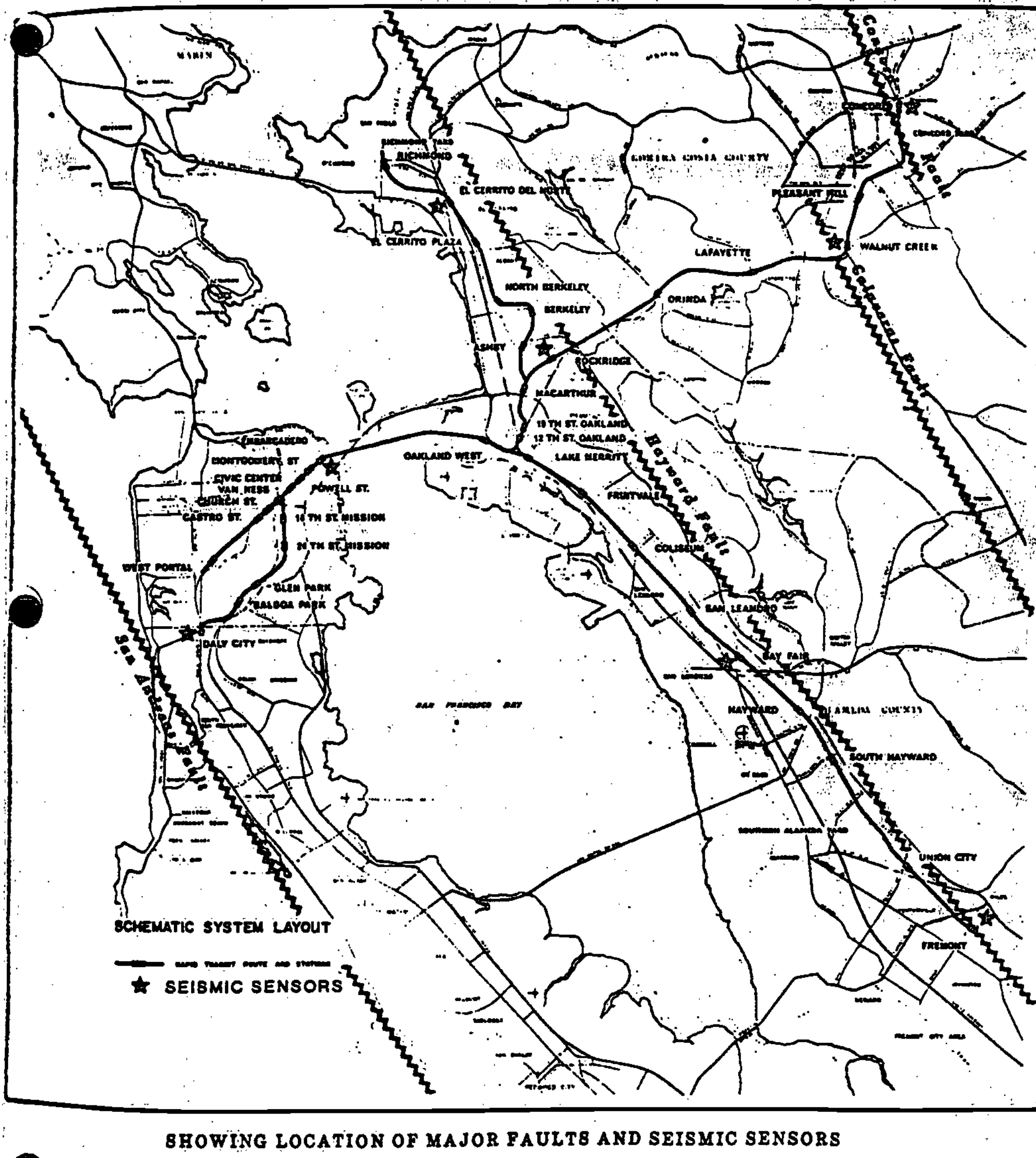
A special thanks is extended to W.R. McCutchen and W.G. Snyder of BART's Design and Construction Department for their assistance.

EARTHQUAKE MEASURES

COMPARISON

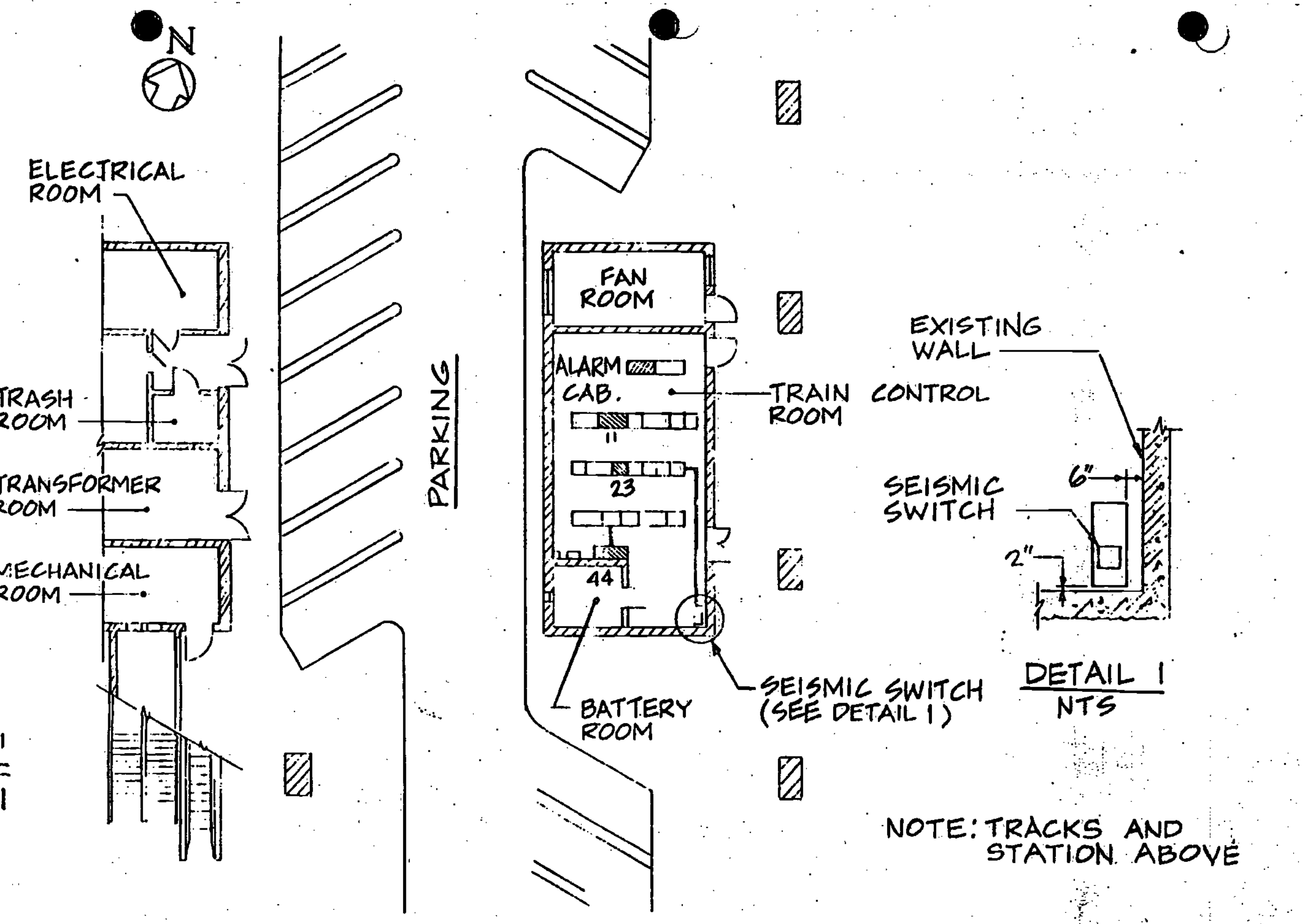
Magnitude (4)	Intensity (4)	Acceleration (5)	Damage & Remarks (4)
Richter Scale	Modified Mercalli Maximum at Epicenter	G	
2	I - II		Usually detected only by instruments
3	III		Felt indoors - similar t light truck passing
4	IV - V	.02	Felt by most - similar t heavy truck passing. Damage: Unstable objects overturn
5	VI - VII	.04 - .125	Felt by all - Structure damage: Specially design Negligible; Ordinary Substantial - Minor to Moderate
6	VII - VIII	.125 - .250	Structure Damage: Specially designed-Sligh Ordinary Substantial - Moderate; Poorly Built - Major
7	IX - X	.50	Structure damage: Specially designed - Ma
8 +	X - XII		Structure damage: Major Total

FIGURE NO. 1.



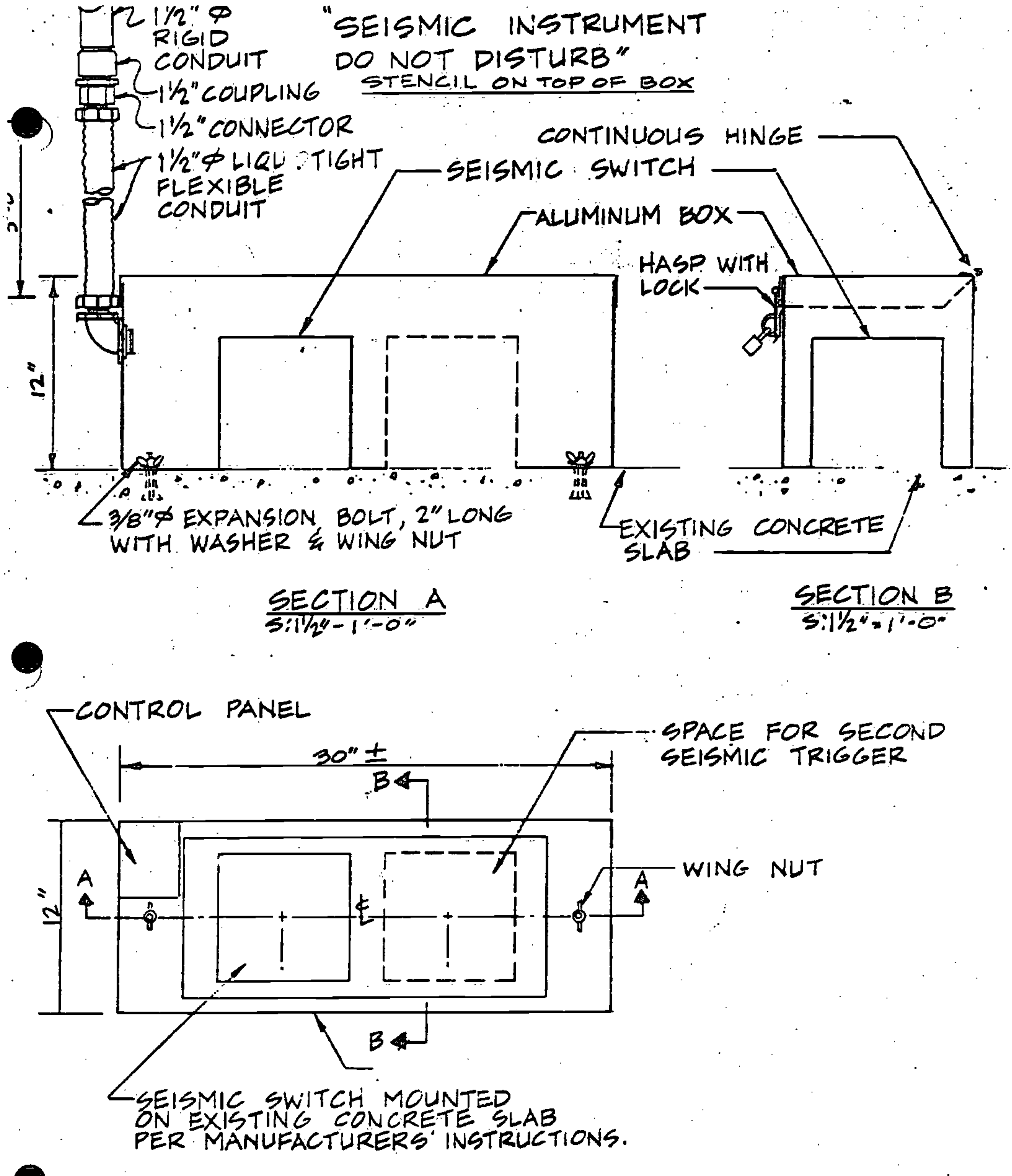
SHOWING LOCATION OF MAJOR FAULTS AND SEISMIC SENSORS

FIG. NO. 2



PART PLAN - ROCKRIDGE STATION (STREET LEVEL)

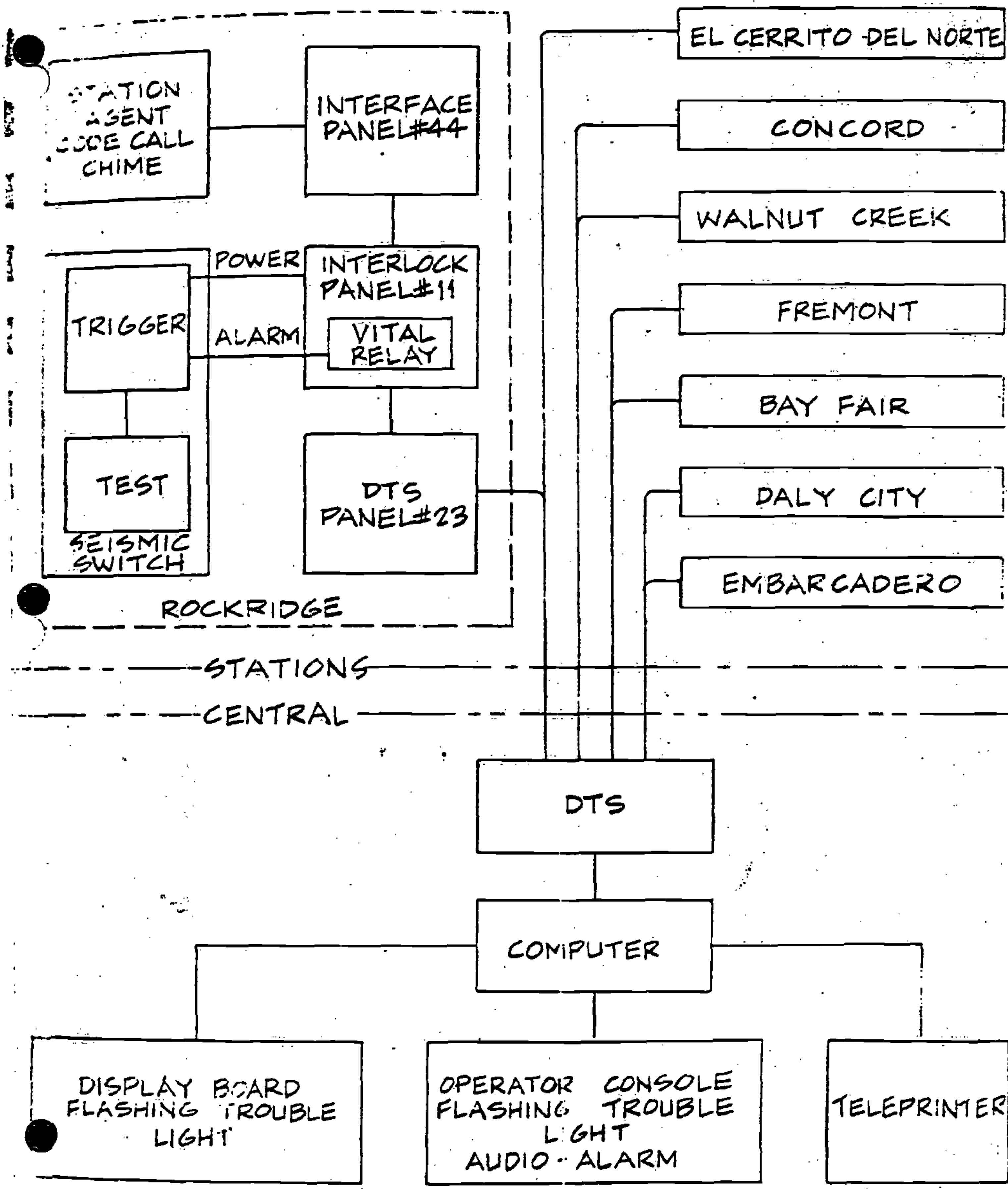
NTS



PLAN SEISMIC SWITCH & ENCLOSURE
S:1½"=1'-0"

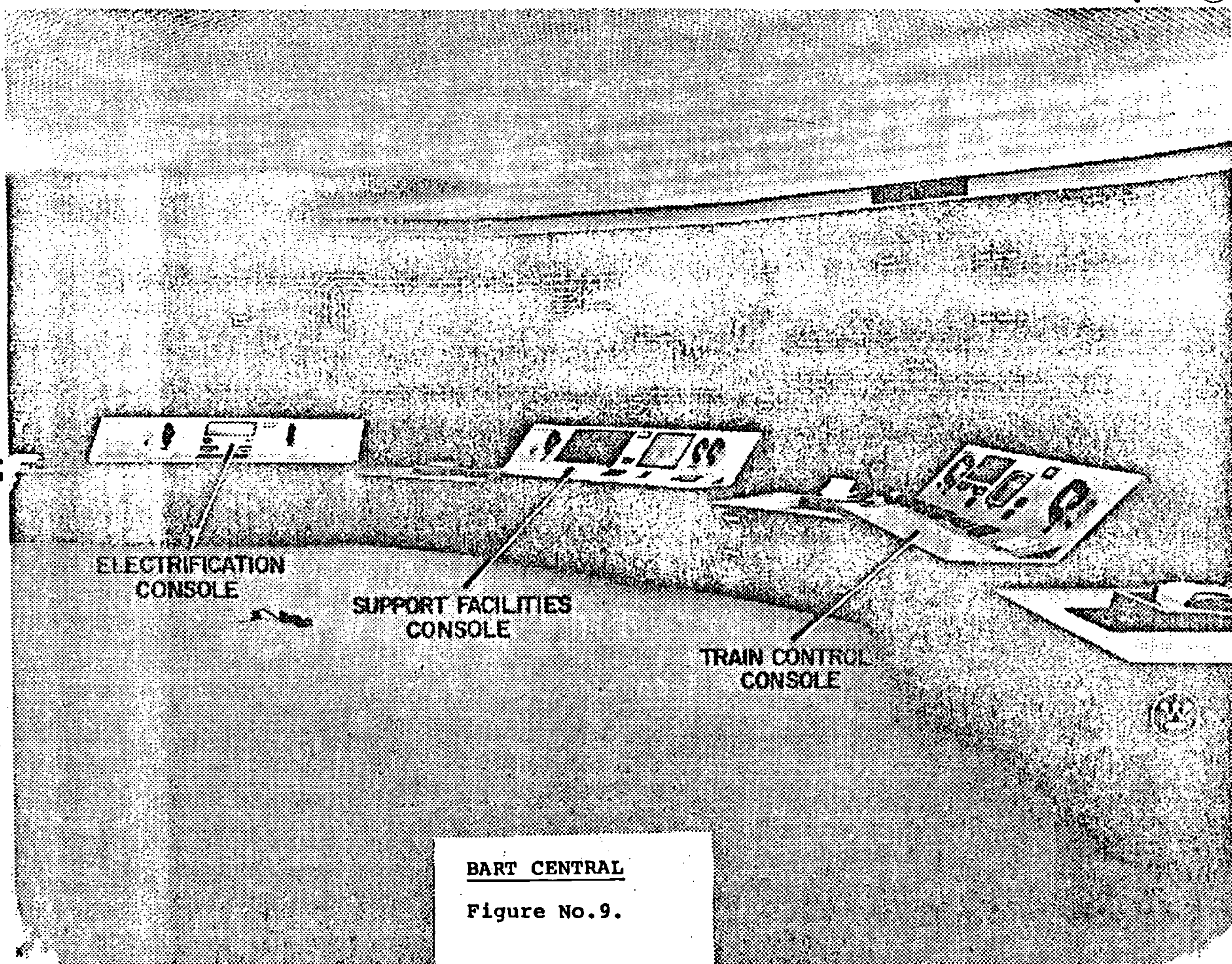
FIGURE NO. 4

BLOCK DIAGRAM



SUPPORT FACILITIES

FIGURE NO. 8



BART CENTRAL

Figure No.9.

```
3/15  8:12:39  ALARM KOWD02 1000 V DC BREAKER TRIP
3/15  8:12:43  CLEAR KOWD02 1000 V DC BREAKER TRIP           O
3/15 08:31:17  M-LINE  FAN    V19 EXHST
3/15 08:31:26  M-LINE  FAN    V20 EXHST    W
3/15 08:39:02  M-LINE  FAN    V19 OFF
3/15 08:39:08  M-LINE  FAN    V20 OFF      O
3/15  8:43:03  ALARM AZD    LOCAL STATION CONTROLS ENABLED   W
3/15  9:07:00  ALARM A10    TROUBLE PABX                     O
3/15  9:25:38  ALARM MXP    LOCAL STATION CONTROLS ENABLED
3/15  9:25:49  ALARM MXP    CONTROL POWER TROUBLE
3/15  9:26:48  ALARM M10    TROUBLE ESSENTIAL POWER
3/15  9:26:57  CLEAR M10    TROUBLE ESSENTIAL POWER          ?
3/15 10:13:55  ALARM M16    SEISMIC DISTURBANCE              O
3/15 10:15:04  CLEAR M16    SEISMIC DISTURBANCE
3/15 10:16:31  ALARM R50    SEISMIC DISTURBANCE              O
3/15 10:17:02  CLEAR R50    SEISMIC DISTURBANCE              >
3/15 10:17:31  ALARM C40    SEISMIC DISTURBANCE
3/15 10:18:02  CLEAR C40    SEISMIC DISTURBANCE              O
3/15 10:20:54  ALARM C10    SEISMIC DISTURBANCE
3/15 10:21:04  CLEAR C10    SEISMIC DISTURBANCE              O
3/15 10:22:27  CLEAR AZD    LOCAL STATION CONTROLS ENABLED   W
3/15 10:23:42  ALARM C10    SEISMIC DISTURBANCE
3/15 10:23:54  CLEAR C10    SEISMIC DISTURBANCE              ←
3/15 10:24:23  ALARM C10    SEISMIC DISTURBANCE              W
3/15 10:24:36  CLEAR C10    SEISMIC DISTURBANCE              ←
3/15 10:26:13  ALARM A50    SEISMIC DISTURBANCE
3/15 10:26:24  CLEAR A50    SEISMIC DISTURBANCE
3/15 10:28:17  CLEAR MXP    LOCAL STATION CONTROLS ENABLED
3/15 10:28:42  CLEAR MXP    CONTROL POWER TROUBLE            O
3/15 10:30:07  BRKR COMMAND: MXP-D01 CLOSE
3/15 10:30:23  BRKR COMMAND: MXP-D01 TRIP
3/15 10:30:35  BRKR COMMAND: MXP-D02 CLOSE    W
3/15 10:30:51  BRKR COMMAND: MXP-D02 TRIP
3/15 10:39:37  ALARM C60    SEISMIC DISTURBANCE
3/15 10:39:53  CLEAR C60    SEISMIC DISTURBANCE
3/15 10:46:03  ALARM M90    SEISMIC DISTURBANCE              [
3/15 10:46:20  ALARM C20 01 SOR COMPUTER 1 FAILURE
3/15 10:46:21  ALARM C20 02 SOR COMPUTER 2 FAILURE
3/15 10:46:22  ALARM C20    SOR SPEED RESTRICTION
3/15 10:46:34  CLEAR C20 01 SOR COMPUTER 1 FAILURE
3/15 10:45:34  CLEAR C20 02 SOR COMPUTER 2 FAILURE
3/15 10:46:53  CLEAR M90    SEISMIC DISTURBANCE
```

TELEPRINTER PRINTOUT

Figure No. 11

FIGURE A-5

IGNITION SOURCES FOR RAIL RAPID TRANSIT FIRES

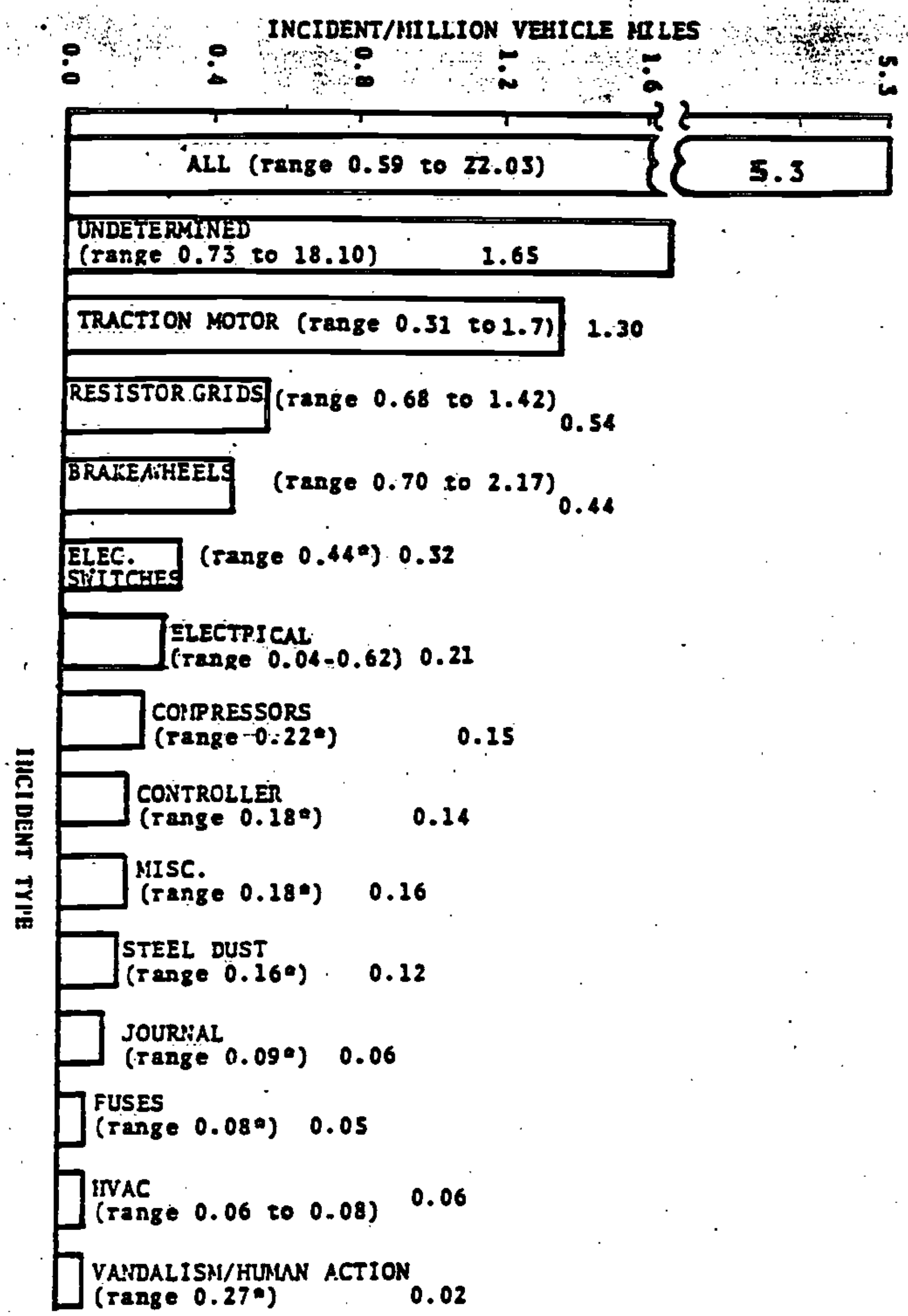
Ignition Source	Incidents/Million Vehicle Miles	% of All Incidents
(UNDERCAR FIRES)		
traction motor	1.3	24.5
resistor grid	0.54	10.2
defective brake control handbrake not fully released	0.44	8.3
switch failure	0.32	6.0
battery cable short metallic object lodged under car	0.29*	5.5
compressor	0.15	2.8
controller	0.14	2.6
journal	0.06	1.1
fuse	0.05	0.9
(OCCUPANT COMPARTMENT FIRES)		
arson cigarette arson	0.02	0.4
HVAC	0.06	1.1
defective lighting unit	-	-
(WAYSIDE IGNITION FIRES)		
steel dust	0.12	4.3
		67.7
Undetermined and miscellaneous*		32.3
		100.0

*Vandals Drop Objects on Track, Equipment Cover on Track.

Source: Identification of the Fire Threat in Urban Transit Vehicles, U.S. Department of Transportation, 1980.

FIGURE A-4

RAIL RAPID TRANSIT FIRE/SMOKE INCIDENT RATE (1978 DATA)



Source: Identification of the Fire Threat in Urban Transit Vehicles, U.S. Department of Transportation, 1980.

Standard on
Automatic Fire Detectors

NFPA 72E-1982

1982 Edition of NFPA 72E

This edition of NFPA 72E, *Standard on Automatic Fire Detectors*, was prepared by the Technical Committee on Detection Devices, released by the Correlating Committee on Signaling Systems, and acted on by the National Fire Protection Association Inc. on May 18, 1982 at its Annual Meeting in San Francisco, California. It was issued by the Standards Council on June 8, 1982, with an effective date of June 28, 1982, and supersedes all previous editions.

The 1978 edition of this standard was approved by the American National Standards Institute as an American National Standard. This edition has also been submitted for similar approval.

This edition contains contains some revisions for clarification and a new Table 3-5.1.2, which addresses spacing of heat detectors on high ceilings.

Changes other than editorial are indicated by a vertical rule in the margin of the page on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 72E

This standard was written to assist in the proper use of automatic fire detectors. Technology has produced a large number of devices which respond to some phenomenon of fire. To operate effectively these devices must be located properly within the protected space. There are various types of fires — fast or slow, flaming or smoldering — but each is a specific product of the type and form of fuel it feeds on and the physical size and shape of the space in which it starts. An automatic fire detector should be selected after identification of both the type and size of fire to be detected and the response required. These detectors should be located in that space so that they are properly responsive to these fires.

The committee recognizes the need for additional fire research. The Fire Detection Institute is expected to perform these needed tasks. The current edition of this standard is based on the best information known to date. The standard will be refined as results and additional information are received and studied.

The first edition of this standard was submitted and adopted as a tentative standard in May 1972. The standard was adopted as an official standard in 1974. The 1978 edition contained a complete revision of Chapter 4, Smoke Sensing Fire Detectors, a new Chapter 6, Gas Sensing Fire Detectors, and other revisions.

Correlating Committee on Signaling Systems

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US Department of Energy

Charles E. Zimmerman, *Secretary*
National Fire Protection Assn.
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Samuel S. Levinrad, US Veterans Administration
Dewey W. Lewis, Lewis Fire Equipment Inc.
Rep. Nat. Assn. for Fire Equipment Distribution
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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Contents

Standard on
Automatic Fire Detectors

NFPA 72E-1982

NOTICE: An asterisk(*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Appendix C.

Chapter 1 Introduction

1-1 Purpose.

1-1.1 The purpose of this standard is to provide basic minimum requirements for performance of automatic fire detectors to ensure timely warning for the purposes of life safety and property protection.

1-1.2 This standard is intended for use by persons knowledgeable in the application of fire detection as part of fire protection systems.

1-2 Scope.

1-2.1 This standard covers minimum performance, location, mounting, testing, and maintenance requirements of automatic fire detectors for protection of the occupant, building, space, structure, area, or object to be protected in accordance with the stated purpose.

1-2.2 This standard is intended to be used with other NFPA standards that deal specifically with fire alarm, extinguishment or control. Automatic fire detectors add to fire protection by initiating emergency action but only when used in conjunction with other equipment.

1-2.3 The interconnection of detectors, the control configurations, the power supply or the output systems responding to automatic fire detector actuation are detailed in NFPA 71, *Central Station Signaling Systems*; NFPA 72A, *Local Protective Signaling Systems*; NFPA

72B, *Auxiliary Protective Signaling Systems*; NFPA 72C, *Remote Station Protective Signaling Systems*; NFPA 72D, *Proprietory Protective Signaling Systems*; NFPA 74, *Household Fire Warning Equipment*; and others.

1-2.4 Nothing in this standard is intended to prevent the use of new methods or devices providing sufficient technical data are submitted to the authority having jurisdiction to demonstrate that the new method or device is equivalent in quality, effectiveness, durability and safety to that prescribed by this standard.

Chapter 2 General

Fire is a phenomenon which occurs when a substance upon reaching a critical temperature reacts chemically, as for example, with oxygen, to produce heat, flame, light, smoke, water vapor, carbon monoxide, carbon dioxide, or other products and effects.

An automatic fire detector is a device designed to detect the presence of fire and initiate action.

2-1 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

Ceiling. The upper surface of a space, regardless of height. Areas with a suspended ceiling would have two ceilings, one visible from the floor and one above the suspended ceiling.

Ceiling Height. The height from the continuous floor of the room to the continuous ceiling of a room or space.

Combination Detector. A device that either (a) responds to more than one of the fire phenomena calssified in 2-2.1.1 through 2-2.1.5 or (b) employs more than one operating principle to sense one of these phenomena. Typical examples are (a) a combination of a heat detector with a smoke detector, or (b) a combination rate-of-rise and fixed temperature heat detector.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority baving jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority baving jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Spacing. A horizontally measured dimension relating to the allowable coverage of fire detectors.

2-2 Classification of Fire Detectors.

2-2.1 For tbe purpose of this standard, automatic fire detectors are classified as listed below:

2-2.1.1 Heat Detector. A device which detects abnormally high temperature or rate-of-temperature rise.

2-2.1.2 Smoke Detector. A device which detects the visible or invisible particles of combustion.

2-2.1.3 Flame Detector. A device which detects the infrared, or ultraviolet, or visible radiation produced by a fire.

2-2.1.4 Fire-Gas Detector. A device which detects gases produced by a fire.

2-2.1.5 Other Fire Detectors. Devices which detect a phenomenon other than heat, smoke, flame, or gases produced by a fire.

2-2.2 Types of Detectors.

2-2.2.1 Line-type Detector. A device in which detection is continuous along a path. Typical examples are rate-of-rise pneumatic tubing detectors, projected beam smoke detectors, and heat-sensitive cable.

2-2.2.2 Spot-type Detector. A device whose detecting element is concentrated at a particular location. Typical examples are bimetallic detectors, fusible alloy detectors, certain pneumatic rate-of-rise detectors, certain smoke detectors and thermoelectric detectors.

2-2.2.3 Air Sampling-type Detector. A sampling-type detector consists of piping or tubing distribution from the detector unit to the area(s) to be protected. An air pump draws air from the protected area back to the detector through tbe air sampling ports and piping or tubing. At the detector, the air is analyzed for fire products.

2-2.3 Operating Modes.

2-2.3.1 Nonrestorable Detector. A device whose sensing element is designed to be destroyed by the process of detecting a fire.

2-2.3.2 Restorable Detector. A device whose sensing element is not ordinarily destroyed by the process of detecting a fire. Restoration may be manual or automatic.

2-3 Shapes of Ceilings.

2-3.1 The shapes of ceilings are classified as follows:

2-3.1.1 Level Ceilings. Those that are actually level or have a slope of 1½ in. (40 mm) or less per ft (0.3 m).

2-3.1.2 Sloping Ceilings. Those having a slope of more than 1½ in. (40 mm) per ft (0.3 m). Sloping ceilings are further classified as follows:

(a) *Sloping-Peaked Type.* Those in which the ceiling slopes in two directions from the highest point. Curved or domed ceilings may be considered peaked with the slope figured as the slope of the chord from highest to lowest point. (*See Figure A-3-5.4.1 in Appendix A.*)

(b) *Sloping-Shed Type.* Those in which the high point is at one side with the slope extending toward the opposite side. (*See Figure A-3-5.4.2 in Appendix A.*)

2-4 Ceiling Surfaces.

2-4.1 Ceiling surfaces referred to in conjunction with the locations of fire detectors are:

2-4.1.1 Beam Construction. Ceilings having solid structural or solid nonstructural members projecting down from the ceiling surface more than 4 in. (100 mm) and spaced more than 3 ft (0.9 m) center to center.

2-4.1.2 Girders. Girders support beams or joists, and run at right angles to the beams or joists. When girders are within 4 in. (100 mm) of the ceiling, they are a factor in determining the number of detectors and are to be considered as beams. When the top of the girder is more than 4 in. (100 mm) from the ceiling, it is not a factor in detector location.

2-4.1.3 Solid Joist Construction. Ceilings having solid structural or solid nonstructural members projecting down from the ceiling surface a distance of more than 4 in. (100 mm) and spaced at intervals 3 ft (0.9 m) or less, center to center.

2-4.1.4 Smooth Ceiling. A surface uninterrupted by continuous projections, such as solid joists, beams, or ducts, extending more than 4 in. (100 mm) below the ceiling surface.

NOTE: Open truss constructions are not considered to impede the flow of fire products unless the upper member in continuous contact with the ceiling projects below the ceiling more than 4 in. (100 mm).

2-5 Common Requirements.

2-5.1 Approval.

2-5.1.1 All fire detection devices shall be listed or approved for the purpose for which they are intended, and shall be installed in conformity with this standard.

2-5.1.2 When required by the authority having jurisdiction, complete information regarding the fire detectors, including specifications and floor plans showing the location of the detectors, shall be submitted for approval prior to installation of the detectors.

2-5.1.3 Before requesting final approval of the installation by the authority having jurisdiction, the installing contractor shall furnish a written statement to the effect that the detectors have been installed in accordance with approved plans and tested in accordance with the manufacturer's specifications.

2-5.2 Acceptance Test. Upon completion of the installation, a satisfactory test of the fire detectors in accordance with Chapter 8 of this standard shall be made in the presence of a representative of the authority having jurisdiction.

2-6 Installation.

2-6.1 Where subject to mechanical damage, detectors shall be protected.

2-6.2 Detectors shall be supported, in all cases, independently of their attachment to the circuit conductors.

2-6.3 Detectors shall not be recessed in any way into the mounting surface unless they have been tested and listed for such recessed mounting.

2-6.4 Detectors shall be installed in all areas where required by the appropriate NFPA standard or the authority having jurisdiction. Where total coverage is required this shall include all rooms, halls, storage areas, basements, attics, lofts, spaces above suspended ceilings, and other subdivisions and accessible spaces, and inside all closets, elevator shafts, enclosed stairways, dumbwaiter shafts and chutes. Inaccessible areas which contain combustible material shall be made accessible and protected by detector(s).

Exception No. 1: Detectors may be omitted from combustible blind spaces when any of the following conditions prevail:

(a) When the ceiling is attached directly to the underside of the supporting beams of a combustible roof or floor deck.

(b) When the concealed space is entirely filled with a noncombustible insulation. In solid-joisted construction the insulation need fill only the space from the ceiling to the bottom edge of the joist of the roof or floor deck.

(c) When there are small concealed spaces over rooms provided any space in question does not exceed 50 sq ft (4.6 m²) in area.

(d) In spaces formed by sets of facing studs or solid joists in walls, floors or ceilings where the distance between the facing studs or solid joists is less than 6 in. (150 mm).

Exception No. 2: Detectors may be omitted from below open grid ceilings when all of the following conditions prevail:

(a) The openings of the grid are ¼ in. (6.4 mm) or larger in the least dimension.

(b) The thickness of the material does not exceed the least dimension.

(c) The openings constitute at least 70 percent of the area of the ceiling material.

2-6.5* Detectors shall also be required underneath open loading docks or platforms and their covers, and for accessible underfloor spaces of buildings without basements.

Exception: By permission of the authority having jurisdiction, detectors may be omitted when all of the following conditions prevail:

(a) The space is not accessible for storage purposes or entrance of unauthorized persons and is protected against accumulation of wind-borne debris.

(b) The space contains no equipment such as steam pipes, electric wiring, shafting, or conveyors.

(c) The floor over the space is tight.

(d) No flammable liquids are processed, handled or stored on the floor above.

2-6.6 Where codes, standards, laws, or authorities having jurisdiction require the protection of selected areas only, the specified areas shall be protected in accordance with this standard.

Chapter 3 Heat Sensing Fire Detectors

Heat is added energy that causes substances to rise in temperature and, also, the energy produced by a burning substance.

3-1 General.

3-1.1 The purpose and scope of this chapter is to provide standards for location and spacing of fire detectors which sense heat produced by burning substances. The detectors are usually referred to as heat detectors.

3-1.2 Heat detectors shall be installed in all areas where required either by the appropriate NFPA standard or the authority having jurisdiction.

3-2 Operating Principles.

3-2.1 Fixed Temperature Detector.

3-2.1.1 A fixed temperature detector is a device which will respond when its operating element becomes heated to a predetermined level.

3-2.1.2 Thermal Lag. When a fixed temperature device operates, the temperature of the surrounding air will always be higher than the operating temperature of the device itself. This difference between the operating temperature of the device and the actual air temperature is commonly spoken of as "thermal lag," and is proportional to the rate at which the temperature is rising.

3-2.1.3 Typical examples of fixed temperature sensing elements are:

(a) *Bimetallic.* A sensing element comprised of two metals having different coefficients of thermal expansion arranged so that the effect will be deflection in one direction when heated and in the opposite direction when cooled.

(b) *Electrical Conductivity.* A line-type or spot-type sensing element whose resistance varies as a function of temperature.

(c) *Fusible Alloy.* A sensing element of a special composition (eutectic) metal which melts rapidly at the rated temperature.

(d) *Heat-Sensitive Cable.* A line-type device whose sensing element comprises, in one type, two current-carrying wires held separated by a heat-sensitive insulation which softens at the rated temperature, thus allowing the wires to make electrical contact. In another type a single wire is centered in a metallic tube and the intervening space filled with a substance which, at a critical temperature, becomes conductive, thus establishing electrical contact between the tube and the wire.

(e) *Liquid Expansion.* A sensing element comprising a liquid capable of marked expansion in volume in response to temperature increase.

3-2.2 Rate Compensation Detector.

3-2.2.1 A rate compensation detector is a device which will respond when the temperature of the air surrounding the device reaches a predetermined level, regardless of the rate of temperature rise.

3-2.2.2 A typical example is a spot-type detector with a tubular casing of a metal that tends to expand lengthwise as it is heated, and an associated contact mechanism that will close at a certain point in the elongation. A second metallic element inside the tube exerts an opposing force on the contacts, tending to hold them open. The forces are balanced in such a way that on a slow rate of temperature rise, there is more time for heat to penetrate to the inner element, which therefore inhibits contact closure until the total device has been heated to its rated temperature level. However, on a fast rate of temperature rise, there is not as much time for heat to penetrate to the inner element, which therefore exerts less of an inhibiting effect, so that contact closure is obtained when the total device has been heated to a lower level. This, in effect, compensates for thermal lag.

3-2.3 Rate-of-Rise Detector.

3-2.3.1 A rate-of-rise detector is a device which will respond when the temperature rises at a rate exceeding a predetermined amount.

3-2.3.2 Typical examples are:

(a) *Pneumatic Rate-of-Rise Tubing.* A line-type detector comprising small diameter tubing, usually copper, which is installed on the ceiling or high on the walls throughout the detected area. The tubing is terminated in a detector unit containing diaphragms and associated contacts set to actuate at a predetermined pressure. The system is sealed except for calibrated vents which compensate for normal changes in temperature.

(b) *Spot-type Pneumatic Rate-of-Rise Detector.* A device consisting of an air chamber, diaphragm, contacts, and compensating vent in a single enclosure. The principle of operation is the same as that described in 3-2.3.2(a).

(c) *Thermoelectric Effect Detector.* A device whose sensing element comprises a thermocouple or thermopile unit which produces an increase in electric potential in response to an increase in temperature. This potential is monitored by associated control equipment, and an alarm is initiated when the potential increases at an abnormal rate.

3-3 Temperature Classification.

3-3.1 Heat detectors of the fixed-temperature or rate-compensated spot-pattern type shall be classified as to the temperature of operation and marked with the appropriate color code. (*See Table 3-3.1.*)

Table 3-3.1

Temperature Classification	Temp. Rating Range °F	Max. Ceiling Temp. °F	Color Code
Ordinary	135 to 174	100	Uncolored
Intermediate	175 to 249	150	White
High	250 to 324	225	Blue
Extra High	325 to 399	300	Red
Very Extra High	400 to 499	375	Green
Ultra High	500 to 575	475	Orange

For SI Units: °C = 5/9 (°F −32).

3-3.1.1 Where the overall color of a detector is the same as the color code marking required for that detector, either one of the following arrangements, applied in a contrasting color and visible after installation, shall be employed:

(a) A ring on the surface of the detector.

(b) The temperature rating in numerals at least 3/8 in. (9.5 mm) high.

3-4 Location.

3-4.1* Spot-type heat detectors shall be located upon the ceiling not less than 4 in. (100 mm) from the side wall or on the side walls between 4 in. (100 mm) and 12 in. (300 mm) from the ceiling. (*See Figure A-3-4.1 in Appendix A.*)

Exception No. 1: In the case of solid joist construction, detectors shall be mounted at the bottom of the joists.

Exception No. 2: In the case of beam construction where beams are less than 12 in. (300 mm) in depth and less than 8 ft (2.4 m) on center, detectors may be installed on the bottom of beams.

3-4.2 Line-type heat detectors shall be located upon the ceiling or on the side walls not more than 20 in. (500 mm) from the ceiling.

3-4.3 High Temperature Areas. Detectors having fixed temperature or rate compensated elements shall be selected in accordance with Table 3-3.1 for the maximum ceiling temperature that can be expected.

3-5 Spacing.

3-5.1* Smooth Ceiling Spacing. One of the following rules shall apply:

(a) The distance between detectors shall not exceed their listed spacing and there shall be detectors within a distance of one-half the listed spacing, measured at a right angle, from all walls or partitions extending to within 18 in. (460 mm) of the ceiling; or

(b) All points on the ceiling shall have a detector within a distance equal to 0.7 times the listed spacing. This will be useful in calculating locations in corridors or irregular areas.

3-5.1.1* Irregular Areas. For irregular shaped areas the spacing between detectors may be greater than the listed spacing, provided the maximum spacing from a detector to the furthest point of a side wall or corner within its zone of protection is not greater than 0.7 times the listed spacing (0.7S). (*See Figure A-3-5.1.1 in Appendix A.*)

3-5.1.2* High Ceilings. On ceilings 10 ft (3 m) to 30 ft (9.1 m) high, heat detector spacing shall be reduced in accordance with Table 3-5.1.2.

Table 3-5.1.2

Ceiling Height (ft) Above	Up To	Percent of Listed Spacing
0	10	100
10	12	91
12	14	84
14	16	77
16	18	71
18	20	64
20	22	58
22	24	52
24	26	46
26	28	40
28	30	34

For SI Units: 1 ft = 0.305 m.

Exception: Table 3-5.1.2 does not apply to the following detectors which rely on the integration effect:

(a) Line-type electrical conductivity detectors. [See 3-2.1.3(b).]

(b) Pneumatic rate-of-rise tubing. [See 3-2.3.2(a).]

(c) Series connected thermoelectric effect detectors. [See 3-2.3.2(c).]

In these cases, the manufacturer's recommendations shall be followed for appropriate alarm point and spacing.

3-5.2* Solid Joist Construction. The spacing of heat detectors, when measured at right angles to the solid joists, shall not exceed 50 percent of the smooth ceiling spacing allowable under 3-5.1 and 3-5.1.1. (*See Figure A-3-5.2 in Appendix A.*)

3-5.3 Beam Construction. It shall be treated as a smooth ceiling if the beams project no more than 4 in. (100 mm) below the ceiling. If the beams project more than 4 in. (100 mm) below the ceiling, the spacing of spot-type heat detectors at right angles to the direction of beam travel shall be not more than two-thirds the smooth ceiling spacing allowable under 3-5.1 and 3-5.1.1. If the beams project more than 18 in. (460 mm) below the ceiling, and are more than 8 ft (2.4 m) on centers, each bay formed by the beams shall be treated as a separate area.

3-5.4 Sloped Ceilings.

3-5.4.1* Peaked. A row of detectors shall first be spaced and located at or within 3 ft (0.9 m) of the peak of the ceiling, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling in accordance with the type of ceiling construction. (*See Figure A-3-5.4.2 in Appendix A.*)

3-5.4.2* Shed. The shed shall have a row of detectors located on the ceiling within 3 ft (0.9 m) of the high side of the ceiling measured horizontally, spaced in accordance with the type of construction. Remaining detectors, if any, shall then be located in the remaining area on the basis of the horizontal projection of the ceiling. (*See Figure A-3-5.4.2 in Appendix A.*)

Chapter 4 Smoke Sensing Fire Detectors

Smoke is the totality of the airborne visible or invisible particles of combustion.

4-1 General.

4-1.1 The purpose and scope of this chapter is to provide standards for location and spacing of fire detectors which sense smoke produced by burning substances. These detectors are usually referred to as smoke detectors.

4-1.2* Smoke detectors shall be installed in all areas where required either by the appropriate NFPA standard, or by the authority having jurisdiction.

4-2 Operating Principles.

4-2.1 Ionization Smoke Detection Principle. Smoke detectors utilizing the ionization principle are usually of the spot type. An ionization smoke detector has a small amount of radioactive material which ionizes the air in the sensing chamber, thus rendering it conductive and permitting a current flow through the air between two charged electrodes. This gives the sensing chamber an effective electrical conductance. When smoke particles enter the ionization area, they decrease the conductance of the air by attaching themselves to the ions, causing a reduction in mobility. When the conductance is less than a predetermined level, the detector responds.

4-2.2 Photoelectric Light Obscuration Smoke Detection Principle. Smoke detectors utilizing the photoelectric light obscuration principle consist of a light source which is projected onto a photosensitive device. Smoke particles between the light source and the photosensitive device reduce the light reaching the device, causing the detector to respond.

4-2.2.1 Projected Beam Smoke Detector. This is a line-type obscuration smoke detector, where the light beam is projected across the area to be protected.

4-2.3 Photoelectric Light Scattering Smoke Detection Principle. Smoke detectors utilizing the photoelectric light scattering principle are usually of the spot type. They contain a light source and a photosensitive device so arranged that the light rays do not normally fall onto the photosensitive device. When smoke particles enter the light path, light strikes the particles and is scattered onto the photosensitive device, causing the detector to respond.

4-2.4 Resistance Bridge Smoke Detection Principle. A smoke detector utilizing the resistance bridge principle is usually of the spot type. It responds to a combination of smoke particles and moisture which falls onto an electrical bridge grid. As conductive substances fall on the grid, they increase the conductance of the grid and cause the detector to respond.

4-2.5 Cloud Chamber Smoke Detection Principle. A smoke detector utilizing the cloud chamber principle is usually of the sampling type. An air pump draws a sample of air from the protected areas into a high humidity chamber within the detector. After the air is in the humidity chamber, the pressure is lowered slightly. If smoke particles are present, the moisture in the air condenses on them forming a cloud in the chamber. The density of this cloud is then measured by a photoelectric principle. When the density is greater than a predetermined level, the detector responds.

4-3 Location and Spacing.

4-3.1* General. The location and spacing of smoke detectors shall result from an evaluation based on engineering judgment supplemented by the guidelines detailed in this standard. Ceiling shape and surfaces, ceiling height, configuration of contents, burning characteristics of combustible material present, and ventilation are some of the conditions that shall be considered.

4-3.1.1 Where the intent is to protect from a specific hazard, the detector(s) may be installed closer to the hazard in a position where the detector will readily intercept the smoke.

4-3.1.2* Stratification. The possible effect of smoke stratification at levels below the ceiling shall also be considered.

4-3.2 Spot-type smoke detectors shall be located on the ceiling not less than 4 in. (100 mm) from a sidewall to the near edge, or if on a sidewall, between 4 in. and 12 in. (100 mm and 300 mm) down from the ceiling to the top of the detector. (*See Figure A-3-4.1 in Appendix A.*)

Exception No. 1: See 4-3.1.2.

Exception No. 2: In the case of solid joist construction, detectors shall be mounted at the bottom of the joists.

Exception No. 3: In the case of beam construction where beams are less than 12 in. (300 mm) in depth and less than 8 ft (2.4 m) on center, detectors may be installed on the bottom of beams.

4-3.3 Projected beam-type smoke detectors shall be located with their projected beams parallel to the ceiling, and not more than 20 in. (500 mm) below the ceiling.

Exception No 1: See 4-3.1.2.

Exception No.2: Beams may be installed vertically, or at any angle needed to afford protection of the hazard involved. (Example: vertical beams through the open shaft area of a stair well where there is a clear vertical space inside the handrails.)

4-3.3.1 The beam length shall not exceed the maximum permitted by the equipment listing.

4-3.3.1.1* Where mirrors are used with projected beams, the total listed length of the beams shall be progressively reduced by 33⅓ percent for each mirror used. (*See Figure A-4-3.1.1 in Appendix A.*)

4-3.3.1.2 Beams shall be adjustable for total light cutoff values ranging from 5 percent on up to at least 40 percent. Settings of ½ percent per ft (0.3 m), or less (more sensitive), shall be used wherever conditions permit.

Not more than 60 ft (18.3 m) of beam length shall be considered in determining percent cutoff per ft. While the cutoff is not linear since each increment of beam length affects the next increment, linear calculations may be used for purposes of this standard.

4-3.4 Each sampling port of a sampling-type smoke detector shall be treated as a spot-type detector for the purpose of location and spacing.

4-3.5 Smooth Ceiling Spacing.

4-3.5.1 Spot-type Detectors. On smooth ceilings, spacing of 30 ft (9.1 m) may be used as a guide. In all cases, the manufacturer's recommendations shall be followed. Other spacing may be used depending on ceiling height, different conditions or response requirements.

4-3.5.2* Projected Beam-type Detectors. For location and spacing of projected beam-type detectors, the manufacturer's installation instructions shall be followed. (*See Figure A-4-3.5.2 in Appendix A.*)

4-3.6* Solid Joist Construction.

4-3.6.1 Ceiling construction where joists are 8 in. (200 mm) or less in depth shall be considered equivalent to a smooth ceiling.

4-3.6.2 If joists exceed 8 in. (200 mm) in depth, the spacing of spot-type detectors in the direction perpendicular to the joists shall be reduced. If the projected light beams of line-type detectors run perpendicular to the joists, no spacing reduction is necessary; however, if the projected light beams are parallel to the joists, the spacing between light beams shall be reduced.

4-3.7 Beam Construction.

4-3.7.1 Ceiling construction where beams are 8 in. (200 mm) or less in depth shall be considered equivalent to a smooth ceiling.

4-3.7.2 If beams are over 8 in. (200 mm) in depth, the spacing of spot-type detectors in the direction perpendicular to the beams shall be reduced. The spacing of line-type detectors run perpendicularly to the beams need not be reduced; however, if the line-type detectors are run parallel to the beams the spacing shall be reduced.

4-3.7.3 If the beams exceed 18 in. (460 mm) in depth and are more than 8 ft (2.4 m) on centers, each bay shall be treated as a separate area requiring at least one spot-type or line-type detector.

4-3.8 Sloped Ceilings.

4-3.8.1 Peaked. Detectors shall first be spaced and located within 3 ft (0.9 m) of the peak, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-3-5.4.1 in Appendix A.*)

4-3.8.2 Shed. Detectors shall first be spaced and located within 3 ft (0.9 m) of the high side of the ceiling, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-3-5.4.2 in Appendix A.*)

4-3.9 Suspended Ceilings. (*See 2-6.4.*)

4-3.10 Partitions. Where partitions extend upward to within 18 in. (460 mm) of the ceiling, they will not influence the spacing. Where the partition extends to within less than 18 in. (460 mm) of the ceiling, the effect of smoke travel shall be considered in reduction of spacing.

4-4 Heating, Ventilating and Air Conditioning (HVAC).

4-4.1 In rooms, buildings, etc. where forced ventilation is present, detectors shall not be located where air from supply diffusers could dilute smoke before it reaches the detector. Detectors shall be located to favor the air flow toward return openings. This may require additional detectors, since placing detectors only near return air openings may leave the balance of the area with inadequate protection when the air handling system is shut down. The detector manufacturer shall be consulted before installation of detectors.

4-4.2 In above-ceiling areas which are designed as common returns for HVAC systems, the air circulating through them is usually at a higher velocity than would be prevalent in the room below. For this reason, detector spacing shall be reduced. (*See 4-3.5.1.*)

4-4.2.1 Detectors placed in the areas used to handle environmental air shall not be used as a substitute for open area protection because:

(a) Smoke may not be drawn into the area when the ventilating system is shut down.

(b) The detector will be less responsive to a fire condition in room of fire origin due to dilution by clean air.

4-5 Special Considerations.

4-5.1 General. The selection and installation of smoke detectors shall take into consideration both the design characteristics of the detector and the areas into which the detectors will be installed so as to prevent false operation or nonoperation after installation. Some of the considerations are as follows:

4-5.1.1 Projected beam-type detectors and mirrors shall be firmly mounted on stable surfaces, so as to prevent false or erratic operation due to movement. The beam shall be so designed that small angular movements of the light source or receiver do not prevent operation due to smoke and do not cause false alarms. Ordinarily, movement of ¼ degree shall be tolerated (½ degree circular included angle).

4-5.1.2 Since the projected beam-type unit will not operate for alarm (but will give a trouble signal) when the light-path to the receiver is interrupted or obscured, the light-path shall be kept clear of opaque obstacles at all times.

4-5.1.3 Smoke detectors having a fixed temperature element as part of the unit shall be selected in accordance with Table 3-3.1 for the maximum ceiling temperature that can be expected in service.

4-5.1.4 Smoke detectors shall not be installed in areas where the normal ambient temperature is likely to exceed 100°F (38°C) or fall below 32°F (0°C), unless they have been specifically listed for installation at higher or lower temperatures.

4-5.1.5 The installation shall take into consideration any normal sources, such as manufacturing processes, which may produce smoke, so as to avoid possible false alarms.

4-5.1.6* High Rack Storage. [*See Figures A-4-5.1.6(a) and A-4-5.1.6(b) in Appendix A.*] Detection systems are often installed in addition to suppression systems. Where smoke detectors are installed for early warning in high rack storage areas it shall be necessary to consider installing detectors at several levels in the racks to ensure quicker response to smoke. Where detectors are installed to actuate a suppression system, see NFPA 231C, *Standard for Rack Storage of Materials*.

Chapter 5 Flame Sensing Fire Detectors

Flame is the column of gases, made luminous by heat, emanating from a burning substance. Flame from some substances (e.g., hydrogen) may not be visible to the unaided human eye.

5-1 General.

5-1.1 The purpose and scope of this chapter is to provide standards for location and spacing of fire detectors which sense flame produced by burning substances. These detectors are usually referred to as flame detectors.

5-1.2 Flame detectors shall be installed in all areas where they are required either by the appropriate NFPA standard, or by the authority having jurisiction.

5-2 Operating Principles.

5-2.1 **Flame Detector.** A device which responds to the appearance of radiant energy visible to the human eye (approximately 4000 to 7700 Angstroms) or to radiant energy outside the range of human vision.

5-2.1.1 **Flame Flicker Detector.** A photoelectric flame detector including means to prevent response to visible light unless the observed light is modulated at a frequency characteristic of the flicker of a flame.

5-2.1.2 **Infrared Detector.** A device whose sensing element is responsive to radiant energy outside the range of human vision (above approximately 7700 Angstroms).

5-2.1.3 **Photoelectric Flame Detector.** A device whose sensing element is a photocell which either changes its electrical conductivity or produces an electrical potential when exposed to radiant energy.

5-2.1.4 **Ultraviolet Detector.** A device whose sensing element is responsive to radiant energy outside the range of human vision (below approximately 4000 Angstroms).

5-3 Fire Characteristics.

5-3.1 Flame detectors are sensitive to glowing embers, coals, or actual flames, which radiate to the detectors energy of sufficient intensity and spectral quality to initiate action.

5-3.2 The detector(s) shall respond to the radiation from the area of fire that is to be detected. This usually involves expert application engineering. The time in which a fire must be detected and the area or intensity thereof may have to be related to the capabilities of associated extinguishing media and equipment.

5-4 Spacing Considerations.

5-4.1 Except as otherwise permitted herein, flame detectors shall not be spaced beyond their listed or approved maximums. Closer spacing shall be utilized where the structural and other characteristics of the protected hazard would otherwise impair the effectiveness of the detection.

5-4.2 Flame detectors shall be so designed and installed that their field of vision will be sufficient to assure detection of a specified area of fire.

5-4.3 Where conveyance of materials on chutes or belts, or in ducts or tubes, or otherwise, to or past a detector is involved, spacing considerations will not govern, but strategic placement of detectors is required to assure adequate detection.

5-5 Field of View Considerations.

5-5.1 Since flame detectors are essentially line-of-sight devices, special care shall be taken in applying them to assure that their ability to respond to the required area of fire in the zone which is to be protected will not be unduly compromised by the presence of intervening structural members or other opaque objects or materials.

5-5.2 The overall situation shall be reviewed frequently to assure hat changes in structural or usage conditions that could interfere with fire detection capabilities are remedied promptly.

5-6 Other Considerations.

5-6.1 Flame detectors shall have such spectral and optical response capabilities that they will initiate action from the specific spectral emission which occurs when the particular fuel(s) of the protected hazard is afire.

5-6.2 Detectors shall be designed, protected, or serviced so that interference with reception of radiation will not occur so as to prevent operation.

5-6.3 Where necessary, detectors shall be shielded or otherwise arranged to prevent action from unwanted radiant energy.

5-6.4 When used in outdoor applications, detectors shall be shielded in a fashion to prevent diminishing sensitivity by rain, snow, etc., and yet allow a clear field of vision of the hazard area.

Chapter 6 Gas Sensing Fire Detectors

Gases, which are molecules without cohesion, are produced by a burning substance and may be oxidizable or reducible.

6-1 General.

6-1.1* The purpose and scope of this chapter is to provide standards for location and spacing of fire detectors which sense gases produced by burning substances. These detectors are hereafter referred to simply as fire-gas detectors.

6-1.2 Fire-gas detectors shall be installed in all areas where required either by the appropriate NFPA standards or by the authority having jurisdiction.

6-1.3 Fire-gas detectors shall respond to one or more of the gases produced by a fire.

6-1.4 Although some fire-gas detectors are capable of detecting combustible gases or vapors prior to ignition, such applications are not within the scope of this standard.

6-2 Operating Principles.

6-2.1 Semiconductor. Fire-gas detectors of the semiconductor type respond to either oxidizing or reducing gases by creating electrical changes in the semiconductor. The subsequent conductivity change of the semiconductor causes actuation.

6-2.2 Catalytic Element. Fire-gas detectors of the catalytic element type contain a material which in itself remains unchanged but accelerates the oxidation of combustible gases. The resulting temperature rise of the element causes actuation.

6-3 Location and Spacing.

6-3.1* General. The location and spacing of fire-gas detectors shall result from an evaluation based on engineering judgment supplemented by the guidelines detailed in this standard. Ceiling shape and surfaces, ceiling height, configuration of contents, burning characteristics of combustible material present, and ventilation are some of the conditions that shall be considered.

6-3.1.1 Where the intent is to protect from a specific hazard, the detector(s) may be installed closer to the hazard in a position where the detector will readily intercept the fire gases.

6-3.1.2 **Stratification.** The possible effect of gas stratification at levels below the ceiling shall also be considered. (*See A-4-3.1.2 in Appendix A.*)

6-3.2 Spot-type fire-gas detectors shall be located on the ceiling not less than 4 in. (100 mm) from a sidewall to the near edge, or if on a sidewall, between 4 in. and 12 in. (100 mm and 300 mm) down from the ceiling to the top of the detector. (*See Figure A-3-4.1 in Appendix A.*)

Exception No. 1: See 6-3.1.2.

Exception No. 2: In the case of solid joist construction, detectors shall be mounted at the bottom of the joists.

Exception No. 3: In the case of beam construction where beams are less than 12 in. (300 mm) in depth and less than 8 ft (2.4 m) on center, detectors may be installed on the bottom of beams.

6-3.3* Each sampling port of a sampling-type fire-gas detector shall be treated as a spot-type detector for the purpose of location and spacing.

6-3.4 Smooth Ceiling Spacing.

6-3.4.1 Spot-type Detectors. On smooth ceilings, spacing of 30 ft (9.1 m) may be used as a guide. In all cases, the manufacturer's recommendations shall be followed. Other spacing may be used depending on ceiling height, different conditions or response requirements.

6-3.5 Solid Joist Construction. (*See A-4-3.6 in Appendix A.*)

6-3.5.1 Ceiling construction where joists are 8 in. (200 mm) or less in depth shall be considered equivalent to a smooth ceiling.

6-3.5.2 If joists exceed 8 in. (200 mm) in depth, the spacing of spot-type detectors in the direction perpendicular to the joists shall be reduced.

6-3.6 Beam Construction.

6-3.6.1 Ceiling construction where beams are 8 in. (200 mm) or less in depth shall be considered equivalent to a smooth ceiling.

6-3.6.2 If beams are over 8 in. (200 mm) in depth, the spacing of spot-type detectors in the direction perpendicular to the beams shall be reduced.

6-3.6.3 If the beams exceed 18 in. (460 mm) in depth and are more than 8 ft (2.4 m) on centers, each bay shall be treated as a separate area requiring at least one spot-type detector.

6-3.7 Sloped Ceilings.

6-3.7.1 Peaked. Detectors shall first be spaced and located within 3 ft (0.9 m) of the peak, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-3-5.4.1 in Appendix A.*)

6-3.7.2 Shed. Detectors shall first be spaced and located within 3 ft (0.9 m) of the high side of the ceiling, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-3-5.4.2 in Appendix A.*)

6-3.8 Suspended Ceilings. (*See 2-6.4.*)

6-3.9 Partitions. Where partitions extend upward to within 18 in. (460 mm) of the ceiling, they will not influence the spacing. Where the partition extends to within less than 18 in. (460 mm) of the ceiling the effect on gas travel shall be considered in reduction of spacing.

6-4 Heating, Ventilating, and Air Conditioning (HVAC).

6-4.1 In rooms, buildings, etc. where forced ventilation is present, detectors shall not be located where air from supply diffusers could dilute the fire gases before they reach the detector. Detectors shall be located to favor the air flow toward return openings. This may require additional detectors, since placing detectors only near return air openings may leave the balance of the area with inadequate protection when the air handling system is shut down. The detector manufacturer shall be consulted before installation of detectors.

6-4.2 Detectors placed in areas used to handle environmental air shall not be used as a substitute for open area protection because:

(a) Gases may not be drawn into the area when the ventilating system is shut down.

(b) The detector will be less responsive to a fire condition in the room of fire origin due to dilution by clean air.

6-5 Special Considerations.

6-5.1 The selection and installation of fire-gas detectors shall take into consideration both the design characteristics of the detector and the areas into which the detectors will be installed so as to prevent false operation or nonoperation after installation. Some of the considerations are as follows:

6-5.1.1 Fire-gas detectors may alarm in nonfire situations due to certain human activities. The use of some aerosol sprays, and hydrocarbon solvents are examples. Accordingly, considerable care shall be employed when installing fire-gas detectors. They shall not be installed where, under normal conditions, concentrations of detectable gases may be present. A garage is not a place to use fire-gas detectors for fire alarm purposes because the concentration of carbon monoxide may be high enough to trigger an alarm.

6-5.1.2 Fire-gas detectors having a fixed temperature element as part of the unit shall be selected in accordance with Table 3-3.1 for the maximum ceiling temperature that can be expected in service.

6-5.1.3 Fire-gas detectors shall not be installed in areas where the normal ambient temperature is likely to exceed 100°F (38°C) or fall below 32°F (0°C) unless they have been specifically listed for installation at higher or lower temperatures.

Chapter 7 Other Fire Detectors

Detectors in the classification of "Other Fire Detectors" are those which operate on principles differing from those described in Chapters 3, 4, 5 and 6.

7-1 General.

7-1.1 Detectors in the classification of "Other Fire Detectors" shall be installed in all areas where they are required either by the appropriate NFPA standard, or by the authority having jurisdiction.

7-1.2 Facilities for testing or metering or instrumentation to assure adequate initial sensitivity and adequate retention thereof, relative to the protected hazard, shall be provided. These facilities shall be employed at regular intervals.

7-2 Fire Characteristics.

7-2.1 These detectors shall operate when subjected to the abnormal concentration of combustion effects that occur during a fire, such as water vapor, ionized molecules, or other phenomena for which they are designed. Detection is dependent upon the size and intensity of fire to provide the necessary amount of required products and related thermal lift, circulatinn, or diffnsion for adequate operation.

7-2.2 Room sizes and contours, air-flow patterns, obstructions, and other characteristics of the protected hazard shall be taken into account.

7-3 Location and Spacing.

7-3.1 The location and spacing of detectors shall be based upon the principle of operation and an engineering survey of the conditions anticipated in service. The manufacturer's technical bulletin shall be consulted for recommended detector uses and locations.

7-3.2 Detectors shall not be spaced beyond their listed or approved maximums. Closer spacing shall be utilized where the structural or other characteristics of the protected hazard warrant.

7-3.3 Consideration shall be given to all factors which bear upon the location and sensitivity of the detectors. This includes reckoning with structural features such as sizes and shapes of rooms and bays, their occupancies and uses, ceiling heights, ceiling and other obstructions, air-flow patterns, stock piles, files, and fire hazard locations.

7-3.4 The overall situation shall be reviewed frequently to assure that changes in structural or usage conditions that could interfere with fire detection are remedied.

7-4 Special Considerations. Conditions which could foster false operation or nonoperation of detectors shall be considered when installation of detectors in this group is being planned.

Chapter 8 Maintenance and Testing

8-1 General.

8-1.1 Each automatic detector shall be maintained in reliable operating condition. Periodic inspections and tests shall be made to assure proper maintenance as specified herein.

8-1.1.1 Maintenance and testing shall be in accordance with this standard supplemented by the manufacturer's instructions and those of the authority having jurisdiction.

8-1.2 Detectors shall be under the supervision of a responsible person who shall cause proper tests to be made at specified intervals and have general charge of all alterations and additions.

8-1.3 In any tests, all persons who would automatically receive an alarm shall be notified, so that an unnecessary response shall not take place.

8-1.4 After installation, a visual inspection of all detectors shall be made to be sure that they are properly located.

8-1.5 After installation, each detector shall be checked to ensure that it is properly connected and powered in accordance with the manufacturer's recommendations.

8-1.6 Any method or device used for testing in a hazardous atmosphere or process shall be suitable for use within the hazardous atmosphere or process.

8-1.7 A permanent record of all test results shall be kept on the premises for at least five years for review by the authority having jurisdiction.

8-2 Initial Installation Tests.

8-2.1 Heat Detectors.

8-2.1.1 A restorable heat detector shall be tested with a heat source, such as a hair dryer or shielded heat lamp, until it responds. After each heat test, the detector shall reset. Precaution shall be taken to avoid damage to the nonrestorable fixed temperature element of a combination rate-of-rise/fixed temperature detector.

Exception: A pneumatic tube line-type detector shall be tested either with a heat source (if a test chamber is in the circuit) or tested *pneumatically with a pressure pump. The manufacturer's instructions shall be followed.*

8-2.1.2 Line- or spot-type nonrestorable fixed temperatore heat detectors shall not be beat tested, but shall be tested mechanically or electrically for fire alarm function. Line-type detectors shall have their loop resistance measured to see if it is within acceptable limits for the equipment being used. The loop resistance shall be recorded for future reference. The record shall be maintained on the premises. Other tests shall be performed as required by the manufacturers.

8-2.1.3 Detectors with a replaceable fusible alloy element shall be tested by:

(a) removing the fusible element to determine that the detector contacts operate properly, and then

(b) reinstalling the fusible element.

8-2.2 Smoke Detectors.

8-2.2.1 To assure that each smoke detector is operative, it shall be tested, in place, in accordance with the manufacturer's instructions.

8-2.2.2 Detector sensitivity shall be determined using either:

(a) A calibrated test method, or

(b) The manufacturer's calibrated sensitivity test instrument, or

(c) Other calibrated sensitivity test method acceptable to the authority having jurisdiction.

Detectors fouod to be outside the approved range of sensitivity shall be replaced.

Exception: If the detector is listed as field adjustable, it may be either adjusted to bring it within an approved range or replaced.

8-2.3 Flame Detectors, Fire-Gas Detectors and Other Fire Detectors. Flame detectors, fire-gas detectors and other fire detectors shall be tested for operation in accordance with instructions supplied by the manufacturer or other test methods acceptable to the authority having jurisdiction.

8-3 Periodic Tests.

8-3.1* Detectors shall be tested as described in the following paragraphs. The method of test shall be as outlined in Section 8-2. The authority having jurisdiction may accept testing at a greater or lesser frequency.

8-3.2 Heat Detectors.

8-3.2.1 For nonrestorable spot-type detectors, after the fifteenth year at least two detectors out of every hundred, or fraction thereof, shall be removed every five years and sent to a testing laboratory for tests. The detectors that have been removed shall be replaced with new detectors. If a failure occurs on any of the detectors removed, additional detectors shall be removed and tested as a further check on the installation until there is proven to exist either a general problem involving faulty detectors or a localized problem involving only one or two defective detectors.

8-3.2.2 For restorable heat detectors (except pneumatic line-type), one or more detectors on each signal-initiating circuit shall be tested at least semiannually and different detectors shall be selected for each test. Within five years, each detector shall have been tested.

8-3.2.3 All pneumatic line-type detectors shall be tested for leaks and proper operation at least semiannually.

8-3.2.4 Nonrestorable line-type fixed temperature detectors shall be tested for alarm function at least semiannually. The loop resistance shall be measured, recorded and compared with that previously recorded. Any change in loop resistance shall be investigated.

8-3.3 Smoke Detectors. All smoke detectors shall be tested at least semiannually.

8-3.4 Flame Detectors, Fire-Gas Detectors and Other Fire Detectors. All flame detectors, fire-gas detectors and other fire detectors shall be tested at least semiannually as prescribed by the manufacturer and more often if found to be necessary for the application.

8-4 Cleaning and Maintenance. Detectors require periodic cleaning to remove dust or dirt which has accumulated. The frequency of cleaning will depend upon the type of detector and the local ambient conditions. For each detector, the cleaning, checking, operation, and sensitivity adjustment shall be attempted only after consulting the manufacturer's instructions.

8-5 Tests Following an Alarm. All detectors shall be restored to service as promptly as possible after each test or alarm, and shall be kept in normal condition for operation. Detectors requiring resetting or replacement shall be reset or replaced as promptly as possible after each test or alarm. All detectors exposed to a fire shall be tested.

8-6 Inspection Forms.

8-6.1 An inspection form shall be provided and include the following information on initial tests:

(a) Date.

(b) Name of property.

(c) Address.

(d) Installer/maintenance company name, address and representative.

(e) Approving agency(ies) name, address, and representative.

(f) Number and type of detectors per zone for each zone.

(g) Functional test of detectors. (*See Section 8-2.*) (*Warning: See also 8-1.3.*)

(h) Check of all smoke detectors. (*See 8-2.2.1.*)

(i) Loop resistance for all fixed temperature line-type detectors. (*See 8-2.1.2.*)

(j) Other tests as required by equipment manufacturers.

(k) Signature of tester and approval authority representative.

8-6.2 An inspection form shall be provided and include the following information for periodic tests:

(a) Date.

(b) Test frequency.

(c) Name of property.

(d) Address.

(e) Maintenance company name, address and representative.

(f) Approving agency(ies) name, address, and representative.

(g) Designation of the detector(s) tested (tests performed in accordance with Section 8-3).

(h) Functional test of detectors. (*See Section 8-2.*) (*Warning: See also 8-1.3.*)

(i) Check of all smoke detectors. (*See 8-2.2.1.*)

(j) Loop resistance for all fixed temperature line-type heat detectors. (*See 8-2.1.2.*)

(k) Other tests as required by equipment manufacturers.

(l) Signatures of tester and approval authority representative.

Chapter 9 Special Applications

9-1 Duct Detectors.

9-1.1 General.

9-1.1.1 The function of air duct smoke detectors is to detect smoke for the primary purpose of controlling air movement by air conditioning and ventilating systems in an attempt to prevent possible panic and damage from distribution of smoke and gaseous products.

9-1.1.2 An air duct smoke detector installation shall not be used as a substitute for open area protection because:

(a) Smoke may not be drawn from open areas when air conditioning systems or ventilating systems are shut down.

(b) Dilution by smoke-laden air from other parts of the building, or dilution by fresh air intakes, may allow high densities of smoke in a single room with no appreciable smoke in the duct at the detector location.

9-1.1.3 Detectors shall be within the duct, or protruding into the duct, or mounted in a housing with sampling tubes protruding into or traversing the duct.

9-1.1.4 Air duct smoke detectors, including housing and sampling tubes where used, shall be listed or approved for the range of air velocities which may exist in service.

9-1.1.5 Air duct smoke detectors shall be suitable for the maximum temperature which may exist in service.

9-1.2 Application of Duct Detectors.

9-1.2.1 Air duct smoke detectors shall be provided as required by NFPA 90A, *Standard on Air Conditioning and Ventilating Systems.*

9-1.2.2 Air duct smoke detectors used only to initiate control of air movement and not connected to a fire protective signaling system shall be listed or approved as suitable for releasing device service.

9-1.2.3 Air duct smoke detectors connected in the signal-actuating circuit of a fire protective signaling system shall be listed or approved for this application.

9-1.3 Testing and Maintenance of Duct Detectors.

9-1.3.1 Due to the quantity of smoke that may be required, an inservice test of an air duct smoke detector installation is not practical. Reference shall be made to Chapter 8 for the "Initial" and "Periodic" tests which may be conducted.

9-1.3.2 Cleaning frequency of air duct smoke detectors will depend on local ambient conditions. Following placemeot in service, installations shall be inspected as necessary to establish a cleaning schedule. Refer to Section 8-4 for further details on cleaning.

9-2 Detectors for Smoke Damper Release Service.

9-2.1 Where control of smoke dampers is not initiated by a fire alarm system which includes automatic smoke detection devices in the area served by the related ducts, the control shall be initiated by either of the following methods:

9-2.1.1* Preferably by open area-type smoke detectors listed or approved for releasing service located for protection of the area(s) served by the related ducts.

9-2.1.2 By listed or approved duct-type smoke detectors located in the related ducts.

9-3 High Air Movement Areas.

9-3.1 General. The purpose and scope of this section is to provide location and spacing from smoke detectors in high air movement areas.

9-3.2 Acceptance Criteria. Detector response shall be determined by the authority having jurisdiction who may utilize the detector manufacturer's recommendations.

9-3.3 Location. Smoke detectors shall not be located near air supply registers.

9-3.4* Spacing. Smoke detector spacing depends upon the movement of air within the room (including both supplied and recirculated air) which can be designated as minutes per air change or air changes per hour. Except where otherwise accepted by the authority having jurisdiction, spacing shall be in accordance with Figures A-9-3.4 (a) and (b).

9-4 Smoke Detectors for Door Release Service.

9-4.1 Smoke door release not initiated by a fire alarm system which includes smoke detectors protecting the areas on both sides of the door affected shall be accomplished by smoke detectors applied as specified in this section.

9-4.2 Smoke detectors listed or approved exclusively for door release service shall not be used for open area protection. (*See 1-2.3.*)

A smoke detector used concurrently for door release service and open area protection shall be acceptable if listed or approved for open area protection and installed in accordance with Chapter 4 of this standard.

9-4.3 Smoke detectors may be of the photoelectric or ionization type or other approved type.

9-4.4 Number of Detectors Required.

9-4.4.1 Where doors are to be closed in response to smoke flowing in either direction the following rules apply:

9-4.4.1.1* Where the depth of wall section above the door is 24 in. (610 mm) or less, one ceiling-mounted detector shall be required on one side of the doorway only. (*See Figures A-9-4.4.1.1 B and C in Appendix A.*)

9-4.4.1.2 Where the depth of wall section above the door is greater than 24 in. (610 mm), two ceiling-mounted detectors shall be required, one on each side of the doorway. (*See Figure A-9-4.4.1.1 E in Appendix A.*)

9-4.4.1.3 Where the depth of wall section above the door is 60 in. (1520 mm) or greater, additional detectors may be required as indicated by an engineering evaluation.

9-4.4.1.4 Where a detector is specifically listed for door frame mounting, or where a listed combination or integral-detector-door closer assembly is used, only one detector is required when installed in the manner recommended by the manufacturer.

9-4.4.2 Where door release is intended to prevent smoke transmission from one space to another in one direction only, one detector located in the space to which smoke is to be confined shall suffice regardless of the depth of wall section above the door. Alternatively, a smoke detector conforming with 9-4.4.1.4 shall be used.

9-4.4.3 Where there are multiple doorways, additional ceiling-mounted detectors shall be required as follows:

9-4.4.3.1* Where the separation between doorways exceeds 24 in. (610 mm), each doorway must be treated separately. (*See Figure A-9-4.4.3.1 E in Appendix A.*)

9-4.4.3.2* Each group of three doorway openings must be treated separately. (*See Figure A-9-4.4.3.2 A in Appendix A.*)

9-4.4.3.3* Each group of doorway openings which exceeds 20 ft (6 m) in width measured at its overall extremes must be treated separately. (*See Figure A-9-4.4.3.3 of Appendix A.*)

9-4.4.4 Where there are multiple doorways and listed door frame-mounted detectors or where listed combination or integral- detector door closer assemblies are used, there shall be one detector for each single or double doorway.

9-4.4.4.1 A double doorway is a single opening that has no intervening wall space or door trim separating the two doors. (*See Figure A-9-4.4.3.1 C in Appendix A.*)

9-4.5 Location.

9-4.5.1 Where ceiling-mounted smoke detectors are to be installed on a smooth ceiling for a single or double doorway, they shall be located as follows (*see Figures A-9-4.4.3.1 A, B, and C in Appendix A*):

(a) On the centerline of the doorway, and

(b) No more than 5 ft (1.5 m) measured perpendicularly on the ceiling from the wall section above the door (*see Figure A-9-4.4.1.1*), and

(c) No closer than shown in Figures A-9-4.4.1.1 B, D, and F.

9-4.5.2 Where ceiling-mounted detectors are to be installed in conditions other than those outlined in 9-4.5.1, engineering judgment is required.

Appendix A

This Appendix is not a part of the requirements of this NFPA document... but is included for information purposes only.

A-2-6.5 Detectors may be required under large benches, shelves or tables and inside cupboards or other enclosures.

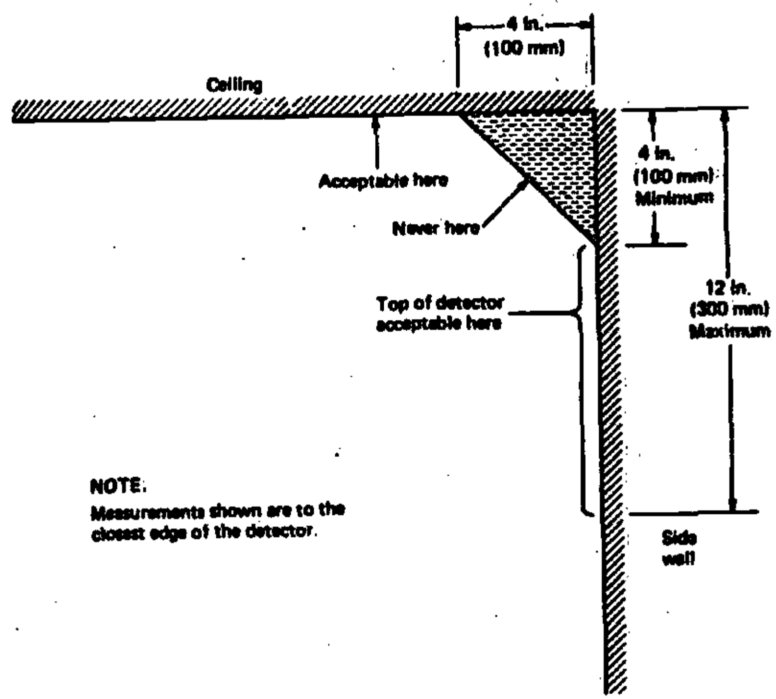


Figure A-3-4.1 Spot-type detectors.

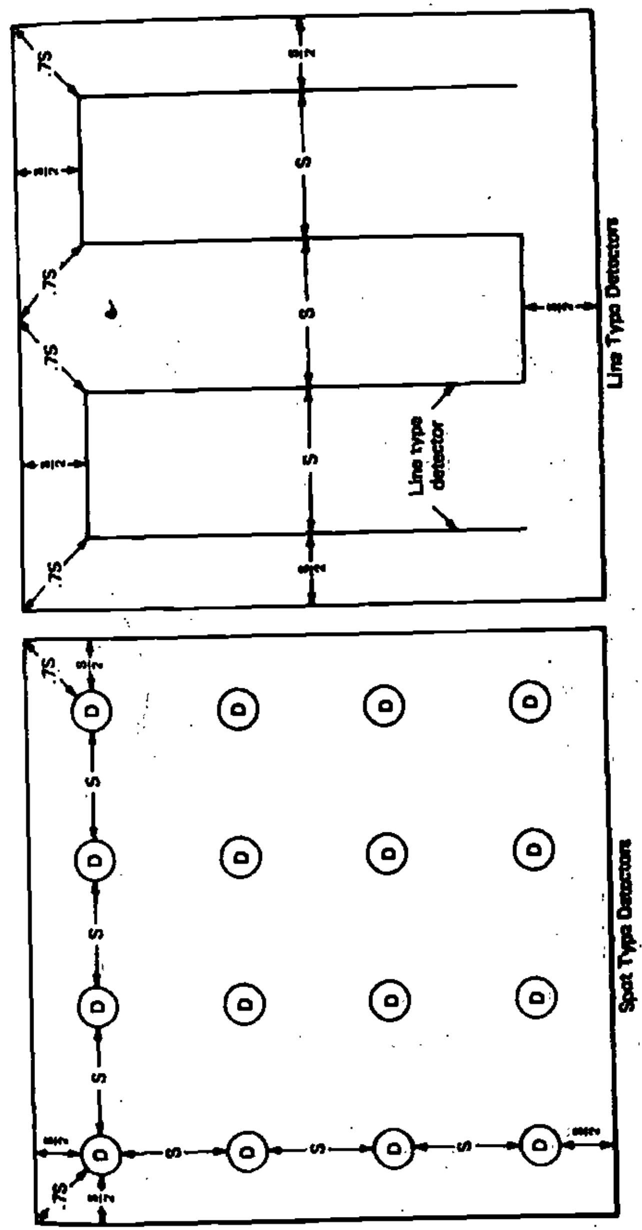
A-3-5.1 Maximum linear spacings on smooth ceilings for spot-type heat detectors are determined by full-scale fire tests. These tests assume that the detectors are to be installed in a pattern of one or more squares, each side of which equals the maximum spacing as determined in the test. This is illustrated in Figure A-3-5.1(a). The detectors to be tested are placed at one corner of the square, which is the furthest distance it can be from the fire and still be within the square. Thus the distance from the detector "D" to the fire "F" is always the test spacing multiplied by 0.7, and can be set up in the following tables:

Test Spacing	Maximum Test Distance from Fire to Detector (.7 × D)
50 × 50 ft	35 ft
40 × 40 ft	28 ft
30 × 30 ft	21 ft
25 × 25 ft	17.5 ft
20 × 20 ft	14 ft
15 × 15 ft	10.5 ft

For SI Units: 1 ft = 0.305 m.

Once the correct maximum test distance has been determined, then it is valid to interchange the positions of the fire "F" and the detector "D." The detector is now in the middle of the square, and what the listing actually says is that the detector is adequate to detect a fire that occurs anywhere within that square — even out to the furthest corner.

In laying out detector installations, designers talk in terms of rectangles, because building areas are generally rectangular in shape. The pattern of heat spread from a fire source, however, is not rectangular in shape. On a smooth ceiling, heat will spread out in all directions, in an ever-expanding circle. Thus the coverage of a detector is not in fact a square, but rather a circle whose radius is the linear spacing multiplied by 0.7.

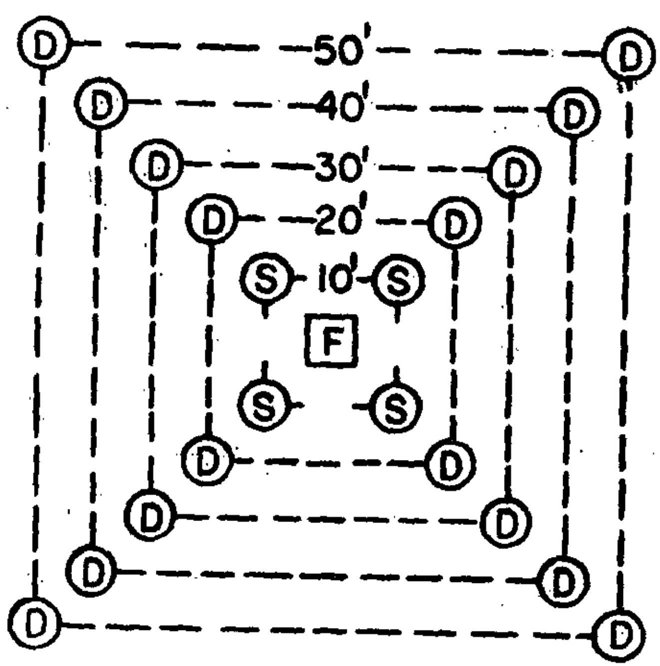


HEAT DETECTORS — SPACING LAYOUTS — SMOOTH CEILING

Figure A-3-5.1

S – Listed spacing
D – Detector

Fire-Test Layout



For SI Units: 1 ft = 0.305 m.

Figure A-3-5.1(a)

Legend

F — Test fire, denatured alcohol, 190-proof. Pan located approximately 3 ft (0.9 m) above floor.

S — Indicates normal sprinkler spacings on 10-ft (3-m) schedules.

D — Indicates normal detector spacing on various spacing schedules.

This is graphically illustrated in Figure A-3-5.1(b). With the detector as the center, by rotating the square an infinite number of squares can be laid out, the corners of which will plot a circle whose radius is 0.7 times the listed spacing. The detector will cover any of these squares, and consequently any point within the confines of the circle.

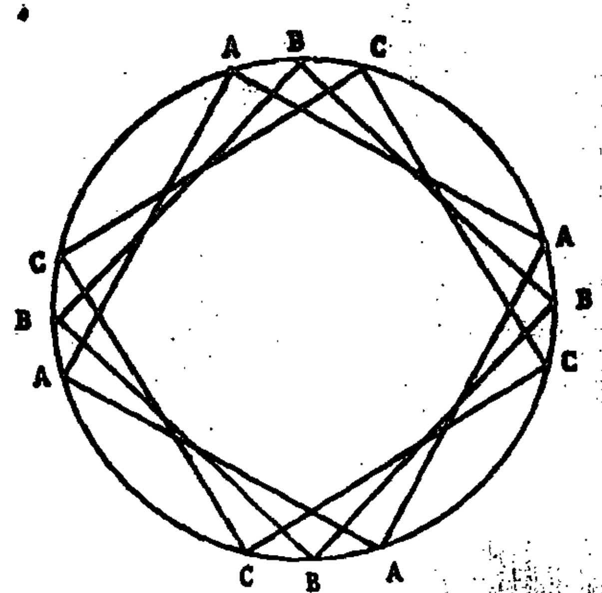
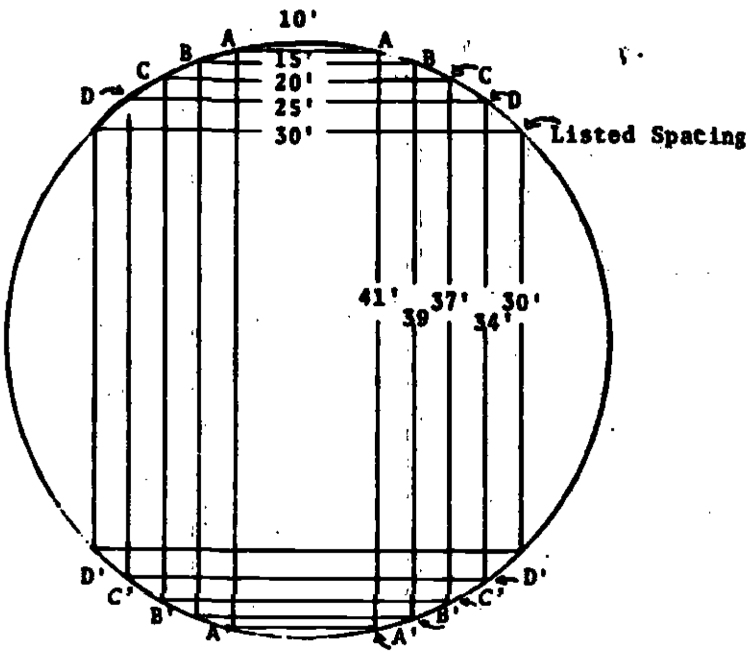


Figure A-3-5.1(b)

So far this explanation has considered squares and circles. In practical applications, very few areas turn out to be exactly square, and circular areas are rare indeed. Designers deal generally with rectangles of odd dimensions, and corners of rooms or areas formed by wall intercepts, where spacing to one wall is less than one-half the listed spacing. To simplify the rest of this explanation, consider the use of a detector with a listed spacing of 30 ft by 30 ft (9.1 m by 9.1 m). The principles derived will be equally applicable to other types

Rectangle A = 10′ x 41′ = 410 sq. ft.
B = 15′ x 39′ = 585 sq. ft.
C = 20′ x 37′ = 740 sq. ft.
D = 25′ x 34′ = 850 sq. ft.
Listed Spacing = 30′ x 30′ = 900 sq. ft.



For SI Units: 1 ft = 0.305 m.

Figure A-3-5.1(c)

Figure A-3-5.1(c) illustrates the derivation of this concept. A detector is placed in the center of a circle with a radius of 21 ft (0.7 × 30 ft) [6.4 m (0.7 × 9.1 m)]. A series of rectangles with one dimension less than the permissible maximum of 30 ft (9.1 m) is constructed within the circle. The following conclusions can be drawn:

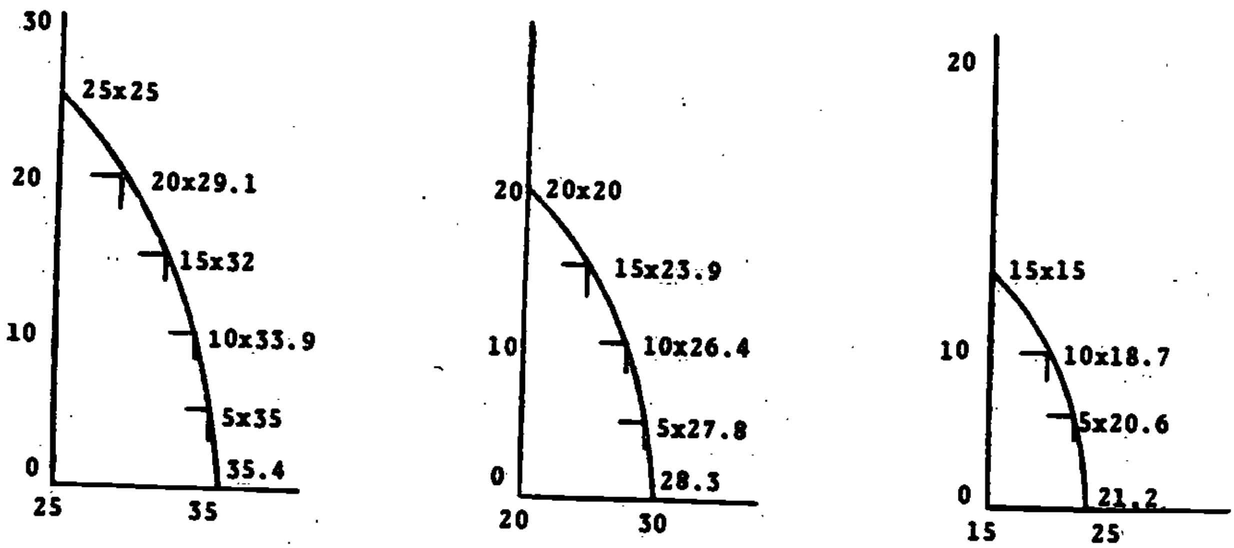
1. As the smaller dimension decreases, the longer dimension can be increased beyond the linear maximum spacing of the detector, with no loss in detection efficiency.

2. A single detector will cover any area that will fit within the circle. For a rectangle, a single properly located detector will suffice if the diagonal of the rectangle does not exceed the diameter of the circle.

3. Relative detector efficiency will actually be increased, because the area coverage in sq ft is always less than the 900 sq ft (83.6 m^2) permissible if the full 30 ft by 30 ft (9.1 m × 9.1 m) square were to be utilized. The principle illustrated here allows equal linear spacing between the detector and the fire, with no recognition for the effect of reflection from walls or partitions, which in narrow rooms or corridors will be of additional benefit. For detectors that are not centered, the longer dimension should always be used in laying out the radius of coverage.

Areas so large that they exceed the rectangular dimensions given in Figure A-3-5.1(c) require *additional detectors*. *Often proper* placement of detectors can be facilitated by breaking down the area into multiple rectangles of the dimensions that fit most appropriately. [*See Figure A-3-5.1(d).*] For example, see Figure A-3-5.1(c). A corridor 10 ft (3 m) wide and up to 82 ft (25 m) long can be covered with two 30-ft (9.1-m) detectors. An area 40 ft (12.2 m) wide and up to 74 ft (22.6 m) long can be covered with four detectors. Irregular areas will take more careful planning to make sure that no spot on the ceiling is more than 21 ft (6.4 m) away from a detector. These points can be determined by striking arcs from the remote corner. Where any part of the area lies beyond the circle with a radius of 0.7 times the listed spacings, additional detectors are required.

Figure A-3-5.1(d)

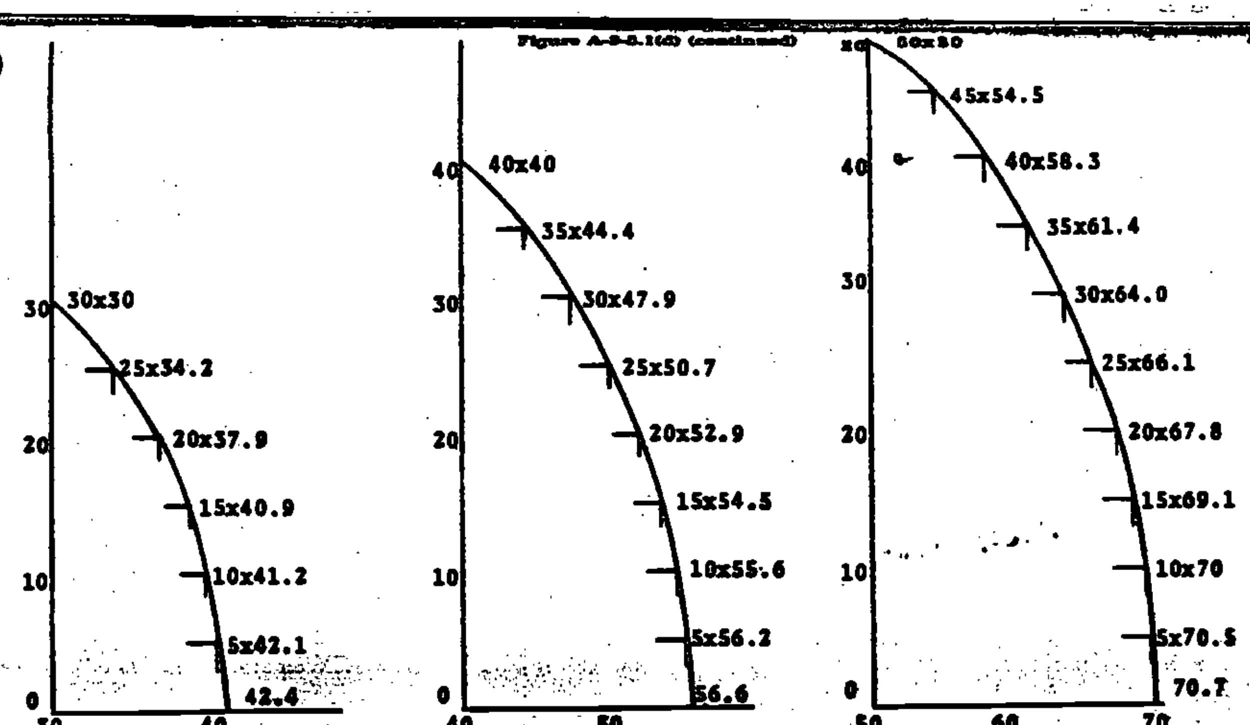


25' Detector Curve
Typical Rectangles.
5 x 35
10 x 33.9
15 x 32
20 x 29.1
For SI Units: 1 ft = 0.305 m.

20' Detector Curve
Typical Rectangles.
5 x 27.8
10 x 26.4
15 x 23.9

15' Detector Curve
Typical Rectangles.
5 x 20.6
10 x 18.7

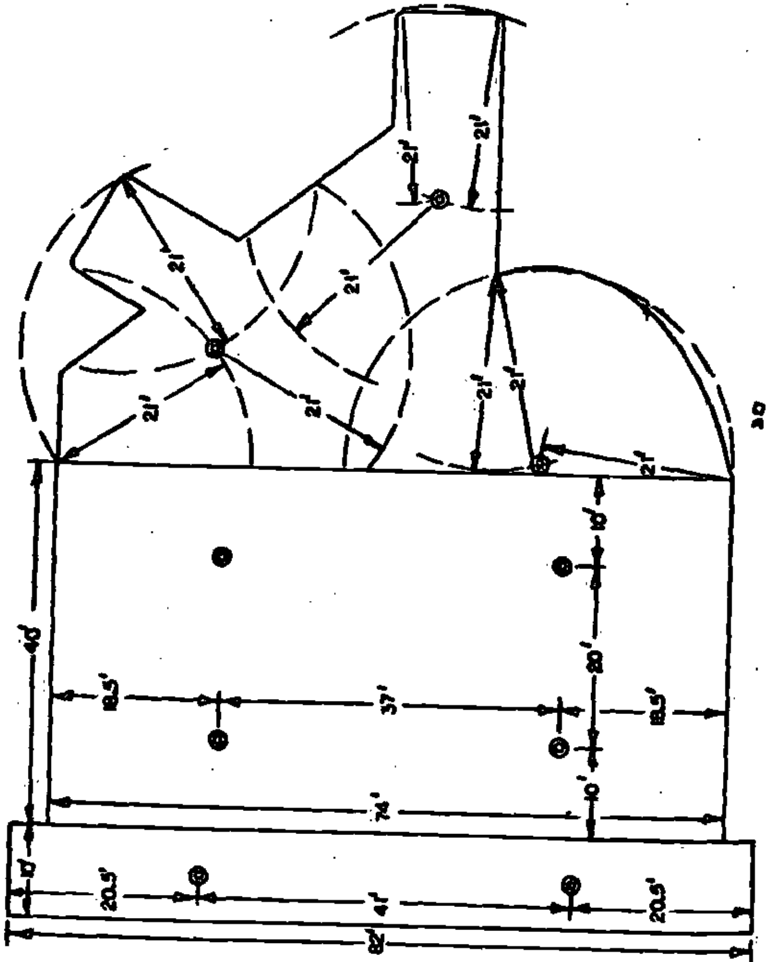
Figure A-3-5.1(d) (continued)



30' Detector Curve
Typical Rectangles.
10 x 41.2 15 x 40.9 25 x 34.2
5 x 42.1 20 x 37.9
For SI Units: 1 ft = 0.305 m.

40' Detector Curve
Typical Rectangles.
5 x 56.2 15 x 54.5 25 x 50.7
10 x 55.6 20 x 52.9 30 x 47.9
35 x 44.4

50' Detector Curve
Typical Rectangles.
5 x 70.5 20 x 67.8 35 x 61.4
10 x 70 25 x 66.1 40 x 58.3
15 x 69.1 30 x 64 45 x 54.5

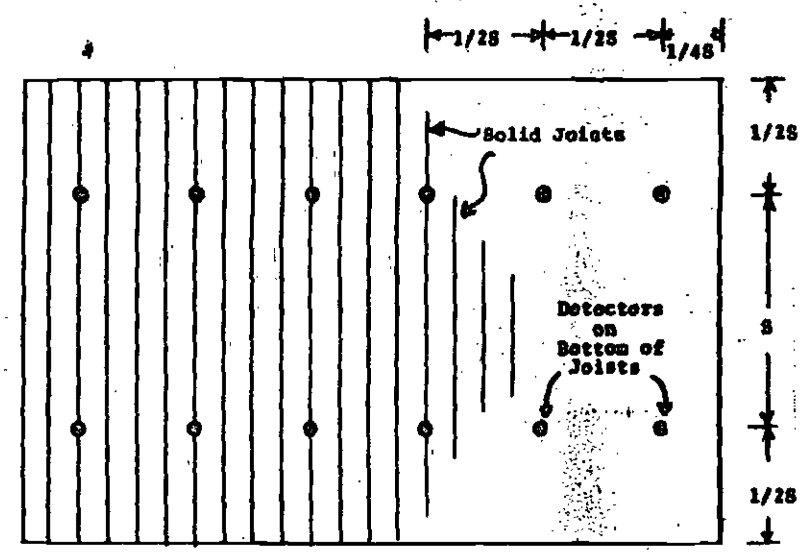


For SI Units: 1 ft = 0.305 m.

Figure A-3-5.1.1

A-3-5.1.2 Both paragraph and Table 3-5.1.2 are constructed to provide essentially the equivalent detector performance on higher ceilings [to 30 ft (9.1 m) high] to that which would exist with detectors on a 10-ft (3-m) high ceiling. (*See Appendix B.*)

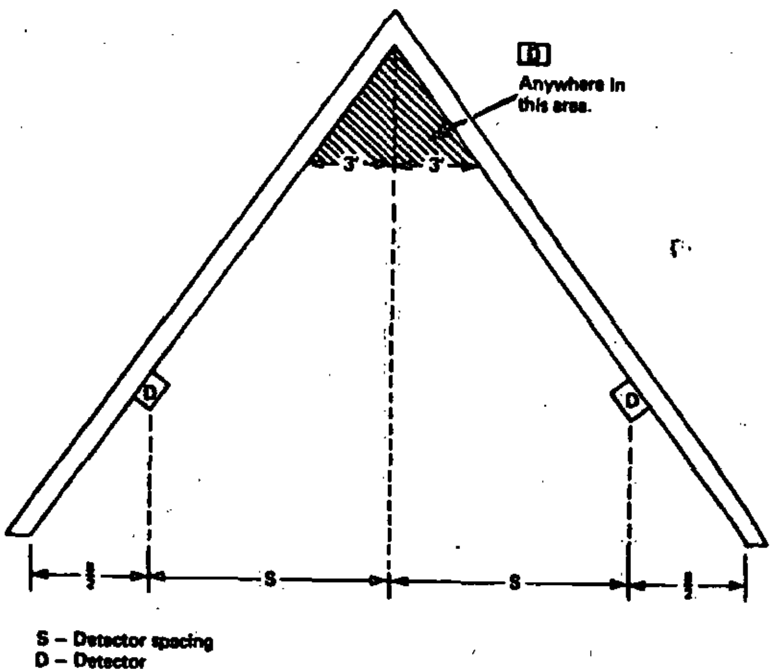
The Fire Detection Institute Fire Test Report (see C-2.1), used as a basis for Table 3-5.1.2, does not include data on integration-type detectors. Pending development of such data, the manufacturer's recommendations provide guidance.



S = Listed Spacing

Heat Detector — Spacings Layout
Joisted Ceiling

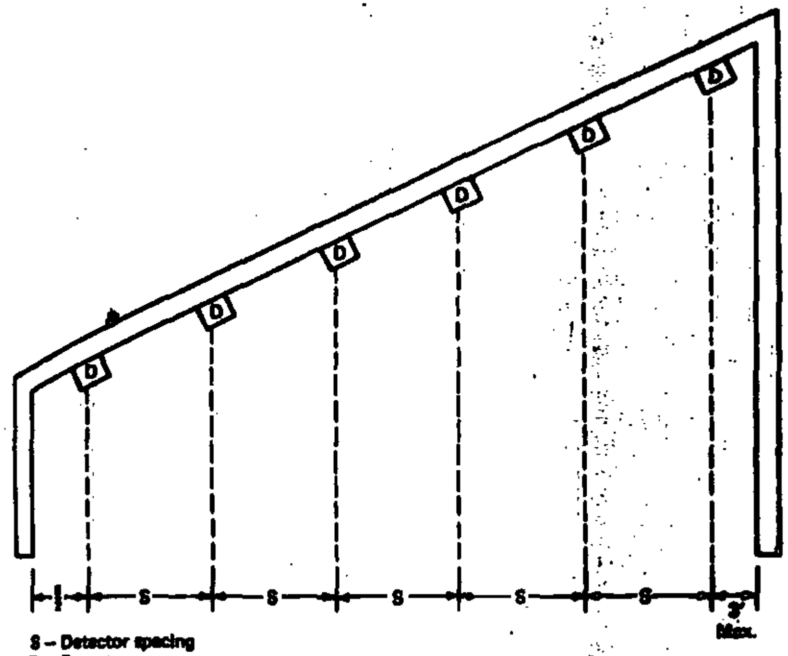
Figure A-3-5.2



Detector – spacing layout – sloped ceilings (peaked type)

For SI Units: 1 ft = 0.305 m.

Figure A-3-5.4.1



Detector – spacing layout – sloped ceilings (shed type)

For SI Units: 1 ft = 0.305 m.

Figure A-3-5.4.2

A-4-1.2 The person designing an installation should keep in mind that in order for a smoke detector to respond, the smoke must travel from the point of origin to the detector. In evaluating any particular building or location, likely fire locations should first be determined. From each of these points of origin, paths of smoke travel should be determined. Wherever practical, actual field tests should be conducted. The most desired location for smoke detectors would be the common points of intersection of smoke travel from fire locations throughout the building.

NOTE: This is one of the reasons that specific spacing is not assigned by the testing laboratories to smoke detectors.

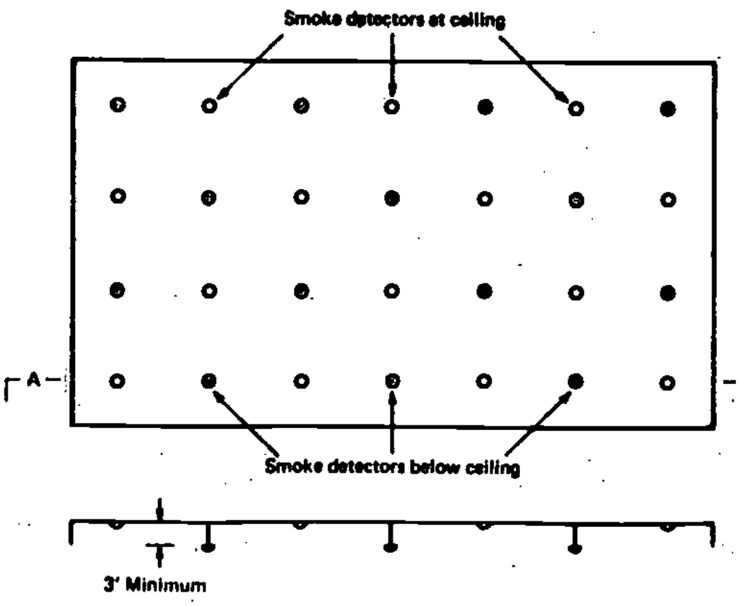
A-4-3.1 All types of smoke detectors depend for operation upon smoke entering the sensing chamber or light beam. When sufficient concentration is present, operation is obtained. Since the detectors are usually mounted on the ceiling, response time depends upon the nature of the fire. A hot fire will drive the smoke up to the ceiling rapidly. A smoldering fire, such as in a sofa, produces little heat; and therefore the time for smoke to reach the detector will be increased.

A-4-3.1.2 Stratification. Stratification of air in a room may hinder air containing smoke particles or gaseous combustion products from reaching ceiling-mounted smoke or fire-gas detectors.

Stratification occurs when air containing smoke particles or gaseous combustion products is heated by smoldering or burning material and, becoming less dense than surrounding cooler air, rises until it reaches a level at which there is no longer a difference in temperature between it and the surrounding air.

In installations where detection of smoldering or small fires is desired and where the possibility of stratification exists, consideration should be given to mounting alternate detectors below the ceiling. (*See Figure A-4-3.1.2.*) Specific designs for such an alternate detection system should be based upon an engineering survey.

The effect of stratification is to delay detection of smoke or gaseous combustion products by ceiling mounted detectors.



For SI Units: 1 ft = 0.305 m.

Figure A-4-3.1.2

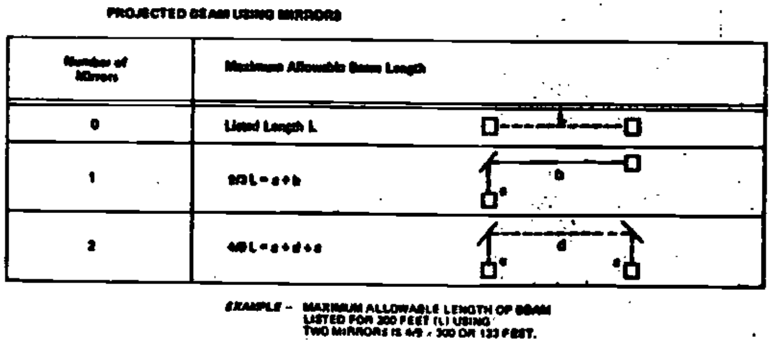
Air heated by smoldering or small fires may have insufficient thermal lift to overcome the stratification effect. As fire size increases, the rising column of contaminated air will be at higher temperature and will overcome stratification. Detection should then take place.

Three conditions are known to accentuate stratification:

(1) When a layer of hot air exists under a poorly insulated roof heated by the sun, air of lower temperature will stratify below the hot air layer at the ceiling.

(2) When a layer of cold air exists under a poorly insulated roof cooled from the outside by cold air, the heated air is cooled as it reaches this cold air layer.

(3) When an HVAC system creates artificial hot or cold layers in a room, one of conditions (1) or (2) above may occur.

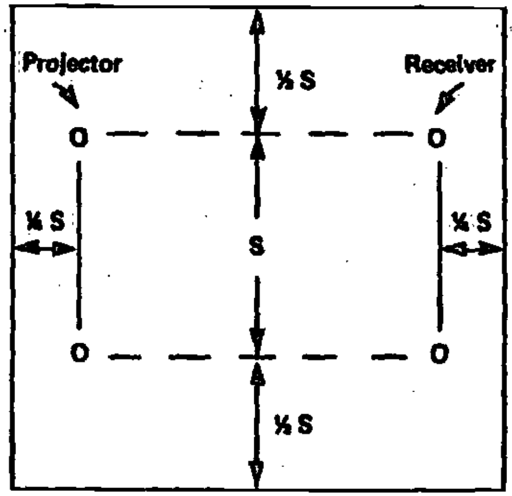


For SI Units: 1 ft = 0.305 m.

Figure A-4-3.5.1.1

A-4-3.5.2 On smooth ceilings, a spacing of not more than 60 ft (18.3 m) between projected beams, and not more than one-half that spacing between a projected beam and a sidewall (wall parallel to the beam travel) may be used as a guide. Other spacing may be determined depending on ceiling height, air flow characteristics, and response requirements.

In some cases, the light beam projector will be mounted on one end wall, with the light beam receiver mounted on the opposite wall. However, it is also permissible to suspend the projector and receiver from the ceiling at a distance from the end walls not exceeding one-quarter the selected spacing. For an illustration of this, see Figure A-4-3.5.2.



Maximum distance that ceiling-suspended light projector and receiver may be positioned from end wall is ¼ selected spacing "S."

Figure A-4-3.5.2

A-4.3.6 Detectors are placed at reduced spacings at right angles to joists or beams in an attempt to ensure that detection time is equivalent to that which would be experienced on a flat ceiling. It takes longer for the combustion products (smoke or heat) to travel at right angles to beams or joists, because of the phenomenon wherein a plume from a relatively hot fire with significant thermal lift tends to fill the pocket between each beam or joist before moving to the next one.

Though it is true that this phenomenon may not be significant in a small smoldering fire, where there is only enough thermal lift to cause stratification at the bottom of the joists, reduced spacing is still recommended to assure that detection time is equivalent to that which would exist on a flat ceiling, even in the hotter type of fire.

A-4-5.1.6 High Rack Storage. For most effective detection of fire in high rack storage areas, detectors should be located on the ceiling above each aisle and at intermediate levels in the racks. This is necessary to detect smoke, which may be trapped in the racks at an early stage of fire development, when insufficient thermal energy is released to carry the smoke tn the ceiling. Earliest detection of smoke is achieved by locating the intermediate level detectors adjacent to alternate pallet sections as shown in Figures A-4-5.1.6(a) and (b). Detector manufacturer's recommendations and engineering judgment should be followed for specific installations.

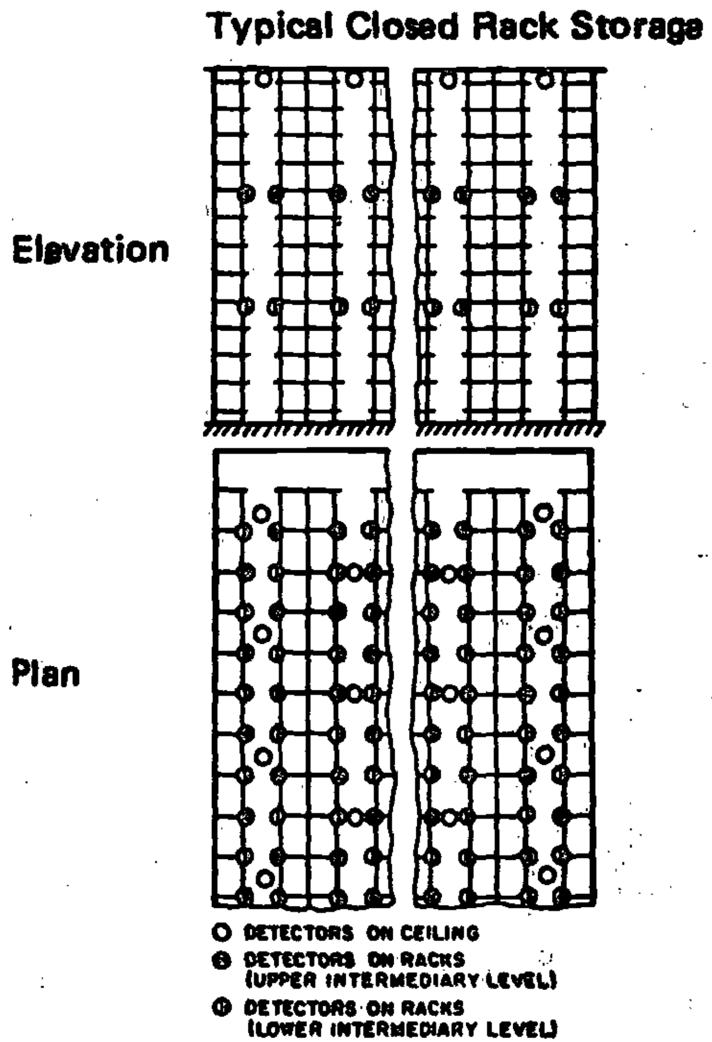


Figure A-4-5.1.6(a) For solid storage in which transverse and longitudinal flue spaces are irregular or nonexistent, as for slatted or solid shelved storage.

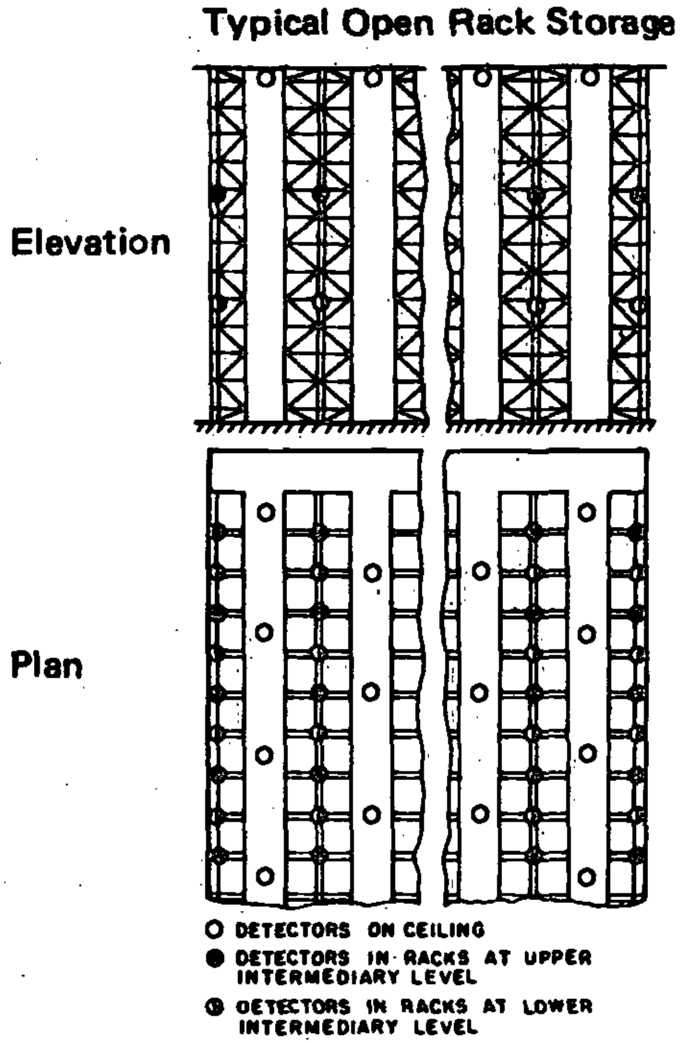


Figure A-4-5.1.6(b) For palletized storage or no shelved storage in which regular transverse and longitudinal flue spaces are maintained.

A-6-1.1 Many gases may be produced by a fire. Fire-gas detectors are instruments which are triggered into alarm by one or more fire gases. Fire-gas detectors need not be able to differentiate among the various fire gases. Depending upon the material being burned and the available oxygen supply, the quantity and composition of gases given off can vary greatly. If ordinary cellulosic material such as wood or paper is burned with an abundance of oxygen, the gases given off are primarily carbon dioxide and water vapor. If, however, the same material is burned or smolders with a limited supply of oxygen, a host of additional gases will be evolved.

A-6-3.1 Fire-gas detectors depend upon fire gases reaching the sensing element. When sufficient concentration is present, operation is obtained. Since the detectors are usually mounted on or near the ceiling, response time depends upon the nature of the fire. A hot fire will drive fire gases up to the ceiling more rapidly. A smoldering fire produces little heat and therefore the detection time will be increased.

A-6-3.3 Gas transport to the sensor of a fire-gas detector may occur by diffusion where migration results from concentration gradients or by sampling if pumps, fans or aspirators are employed.

A-8-3.1 Regardless of the type of detectors in use, the following detectors should either be replaced or representative samples sent to a testing laboratory or the manufacturer for testing:

(a) Detectors on systems that are being restored to service after a period of disuse.

(b) Detectors that are perceptibly corroded.

(c) Detectors that have been painted in the field, unless they are of a type found by the testing laboratory to be unaffected by painting.

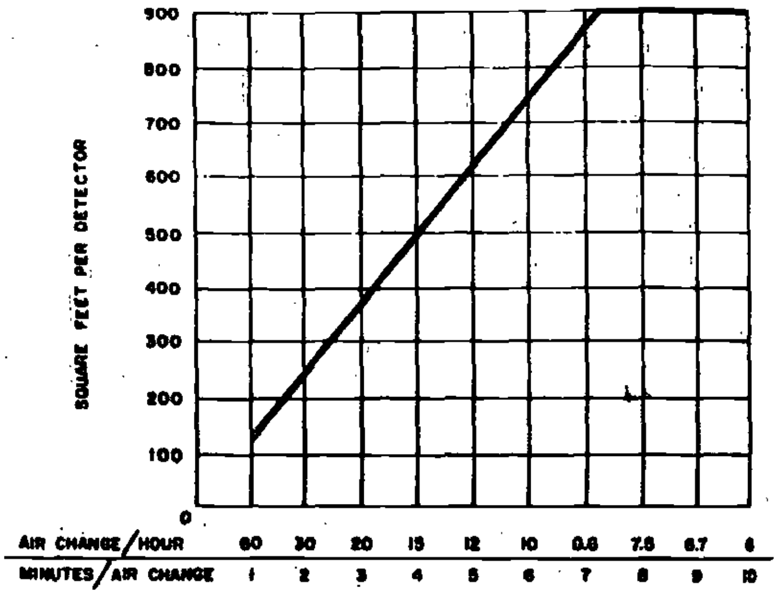
(d) Detectors that have been cleaned of paint.

(e) Detectors that have been subjected to mechanical injury or similar abuse.

(f) Detectors on circuits that have been subjected to surges by over-voltages or lightning damage.

(g) Detectors that are subjected to other conditions that may permanently affect their operation, such as grease or other deposits or corrosive atmospheres.

A-9-2.1.1 Smoke detectors located in the open area(s) are preferred to duct-type detectors because of the dilution effect in air ducts.



For SI Units: 1 sq ft = 0.0929 m².

$$\text{(a) Minutes per air change} = \frac{\text{volume of protected space}}{\text{cu ft per minute (cfm) of air supplied to the protected space}}$$

$$\text{(b) Air changes per hour} = \frac{60 \times \text{cu ft per minute (cfm) of air supplied to the protected space}}{\text{volume of protected space}}$$

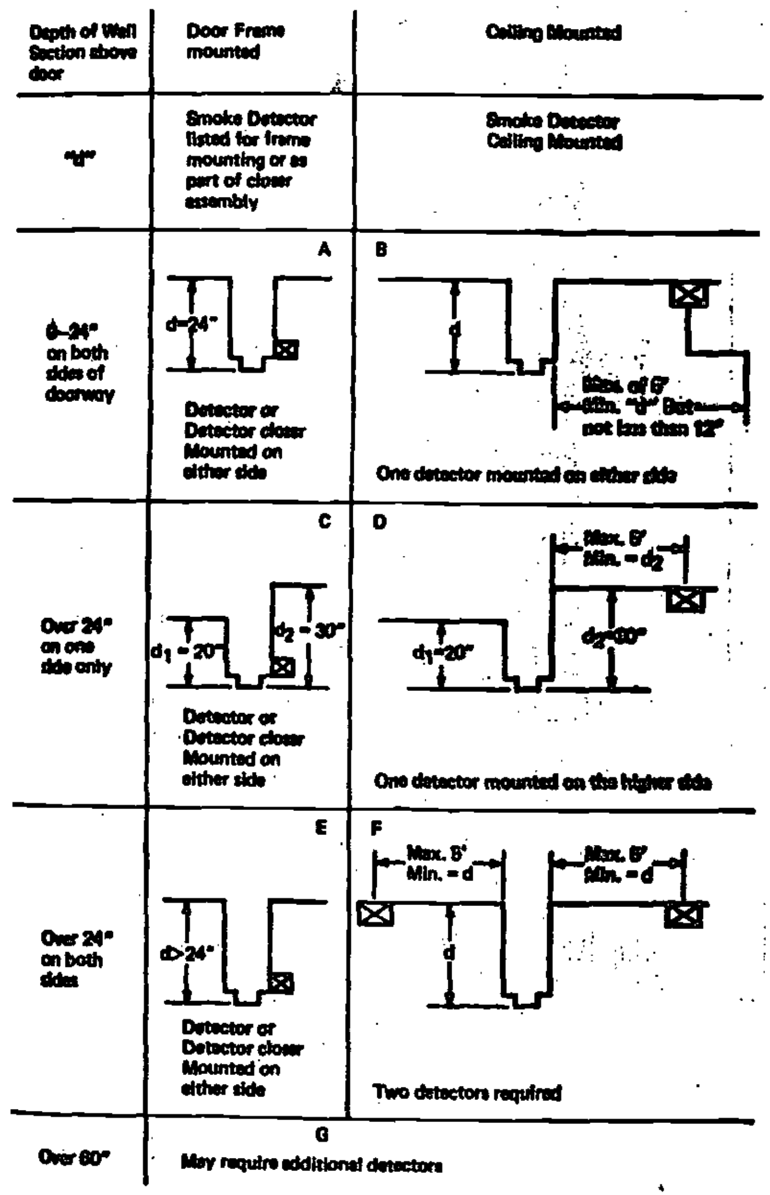
NOTE: If a constant air volume system is not used, the maximum available cfm shall be used to determine the number of air changes.

Figure A-9-3.4(a) High Air Movement Areas (not to be used for under floor or above ceiling spaces).

Minutes/Air Change	Air Changes/Hour	Sq Ft/Detector
1	60	125
2	30	250
3	20	375
4	15	500
5	12	625
6	10	750
7	8.6	875
8	7.5	900
9	6.7	900
10	6	900

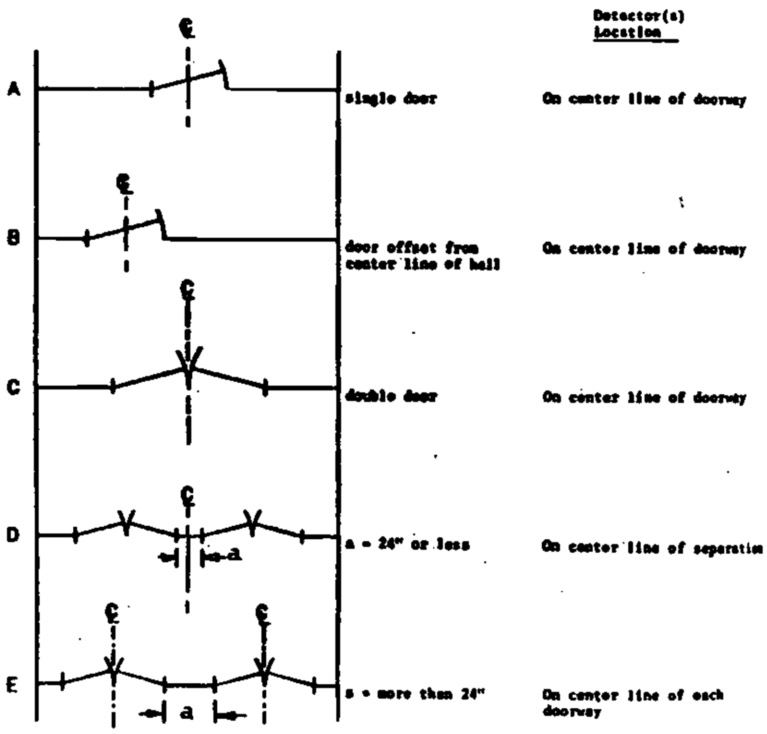
For SI Units: 1 sq ft = 0.0929 m²

Figure A-9-3.4(b)



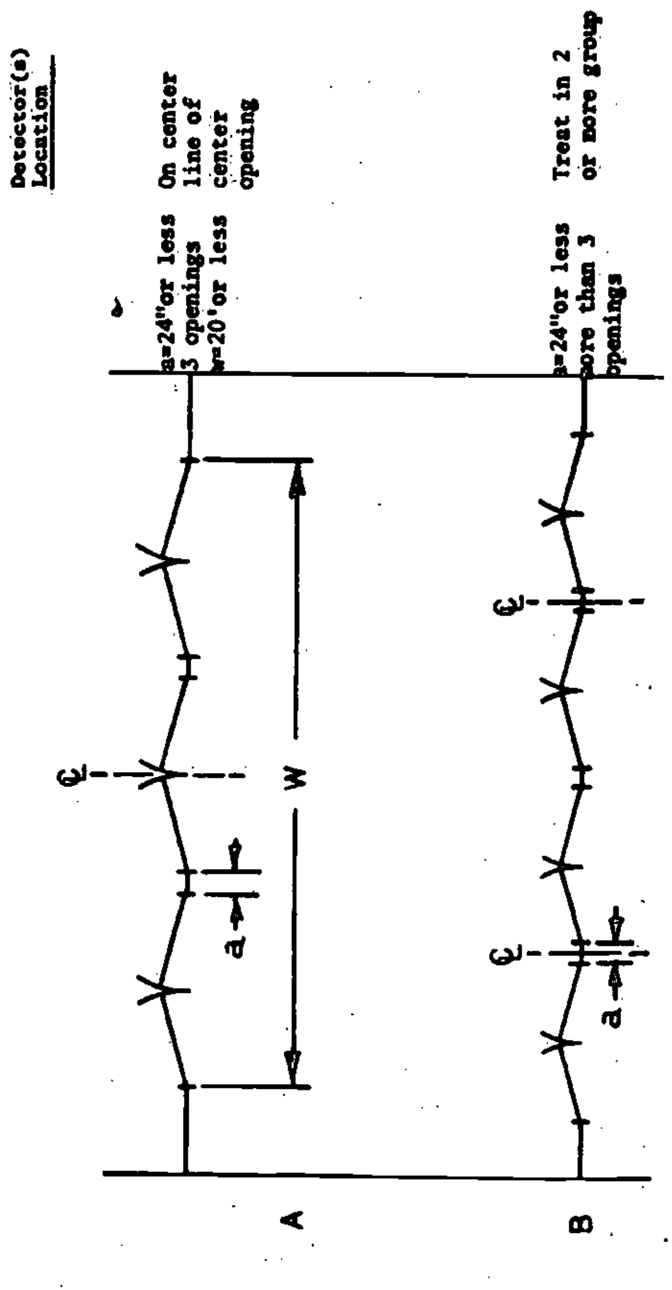
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.305 m

Figure A-9-4.4.1.1



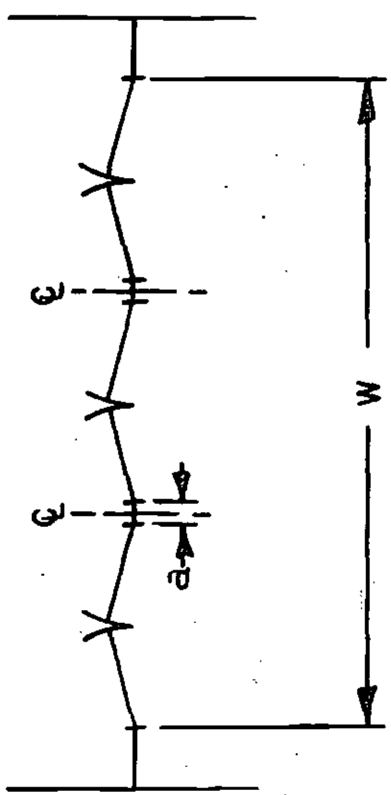
For SI Units: 1 in. = 25.4 mm

Figure A-9-4.4.3.1



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.305m

Figure A-9-4.4.3.2



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.305m

Figure A-9-4.4.3.5

Appendix B
Spacing and Sensitivity

This Appendix is not a part of the requirements of this NFPA document. . .but is included for information purposes only.

B-1 General.

B-1.1 A detector will ordinarily operate sooner in detecting the fire if it is nearer the fire.

B-1.2 Generally, height is the most important single dimension where ceiling heights exceed 16 ft (4.9 m).

B-1.3 As smoke and heat rise from a fire, they tend to spread in the general form of an inverted cone. Therefore, the concentration within the cone varies inversely as a variable exponential function of the distance from the source. This effect is very significant in the early stages of a fire as the angle of the cone is wide. As a fire progresses in intensity, the angle of the cone narrows and the significance of the effect of height is lessened.

B-1.4 High Ceilings. As the ceiling height increases, a larger size fire is required to actuate the same detector in the same time. In view of this, it is mandatory that the designer of a fire detection system calling for heat detectors consider the size of the fire and rate of heat release which may be permitted to develop before detection is ultimately obtained.

B-1.5 The most sensitive detectors should be employed which are suitable for the maximum ambient temperature at heights above 30 ft (9.1 m).

B-1.6 'Spacing" recommended by testing laboratories for the location of detectors is an indication of their relative sensitivity. This applies with each detection principle; however, detectors operating on various physical principles have different inherent sensitivities to different types of fires and fuels.

B-1.7 Reduction of listed spacing may be required for any of the following purposes:

(a) Faster response of the device to a fire.

(b) Response of the device to a smaller fire.

(c) Accommodation to room geometry.

(d) Other special considerations, such as air movement, or ceiling or other obstructions.

Appendix C Referenced Publications

C-1 This portion of the Appendix lists publications referenced within this NFPA document, and thus is considered part of the requirements of the document.

C-1.1 NFPA Publications. The following publications are available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 71-1982, *Standard for Central Station Signaling Systems*

NFPA 72A-1979, *Standard for Local Protective Signaling Systems*

NFPA 72B-1979, *Standard for Auxiliary Protective Signaling Systems*

NFPA 72C-1981, *Standard for Remote Station Protective Signaling Systems*

NFPA 72D-1979, *Standard for Proprietary Protective Signaling Systems*

NFPA 74-1980, *Standard for Household Fire Warning Equipment.*

NFPA 90A-1981, *Standard for the Installation of Air Conditioning and Ventilating Systems*

NFPA 231C-1980, *Standard for Rack Storage of Materials*

C-2 This portion of the Appendix lists publications which are included in this NFPA document for information purposes only, and thus is not considered part of the requirements of the document.

C-2.1 Other Publication. The following publication is available from the US Government Printing Office, Washington, DC 20002.

Heskestad, G. and Delichatsios, M. A., "Environments of Fire Detectors — Phase I: Effect of Fire Size, Ceiling Height and Material," *The Fire Detection Institute Fire Test Report*, Volume II — "Analysis" (NBS-GCR 77-95).

June 1980
Supersedes Data Sheet 5-3

AUTOMATIC FIRE DETECTORS

TABLE OF CONTENTS

SCOPE

This data sheet describes the basic types of automatic fire detectors and presents general guidelines for spacing and testing. These detectors are the signal initiating devices in the alarm and signaling systems described in other loss prevention data sheets.

GENERAL

New 3/80

An important factor in the reduction of loss from fire is reliable and prompt detection. Automatic fire detectors can provide early detection and warning of fire or smoke. They may be used to activate extinguishing systems or to initiate an alarm, or both. Automatic fire detectors have many applications in commercial, institutional, and industrial properties and for residential use. Although fire detectors can be a valuable part of a property's fire protection system, they are not considered a substitute for automatic sprinklers or other automatic extinguishing systems.

Revised 3/80

An automatic fire detector is a device which senses or detectors the presence of fire and initiates action. The four principal classes of automatic fire detectors are heat detectors, smoke detectors, flame detectors, and fire-gas detectors. The three principle types are spot detectors, line-type detectors, and air sampling detectors. A spot-type detector is one in which the detecting element is concentrated at a particular spot or location. A line-type detector is one in which detection is continuous along a path. An air sampling type detector consists of piping or tubing distribution from the detector to the protected area. An air pump draws air from the protected area to the detector where it is analyzed for fire products.

The Factory Mutual *Approval Guide* lists the automatic fire detectors approved by Factory Mutual. Information and specific recommendations for unusual or hazardous occupancies are given in the appropriate Factory Mutual loss prevention data sheets covering the particular occupancy or equipment involved. Fire detectors should be connected to protective signaling circuits in accordance with the applicable signaling system data sheet.

The dimensions used to indicate the allowable coverage of the detector are called the spacing. The spacing may be stated as the horizontal distance between detectors, expressed in feet (meters), for heat detectors, and as the maximum coverage, expressed in square feet (square meters), for smoke detectors. The spacing figure mentioned by recognized testing laboratories for detectors is an indication of their relative sensitivity. However, detectors operating on various physical principles have different sensitivities to different types of fires and fuels. Fires may be fast or slow burning, flaming or smoldering. The rapidly developing fire is more likely to be encountered in industry, while most residential fires start as the slow-burning type. In most cases, the selection of detectors should be based on the type and size of fire to be detected and the response required.

HEAT DETECTORS

A heat detector senses abnormally high temperature or rate of temperature rise. Heat detectors can be classified according to their operating principle as fixed-temperature detectors, rate-compensation detectors, and rate-of-rise detectors.

The **fixed-temperature detector** is designed to operate when the temperature of its operating element reaches a predetermined value. Since there is a thermal lag, the temperature of the surrounding air is higher than the operating temperature of the detector itself. The fixed-temperature sensing element for a detector may consist of two metals having different coefficients of thermal expansion (bimetallic), an electrical resistor whose resistance varies as a function of temperature (electric conductivity), a special composition metal which melts quickly at the rated temperature (fusible alloy), two current-carrying wires separated by heat sensitive insulation which softens at the rated temperature so that the wires make electrical contact (heat sensitive cable), or a liquid capable of expansion in response to the increase in temperature (liquid expansion).

The **rate-compensation detector** is designed to operate when the temperature of the air surrounding the detector reaches a predetermined value, regardless of the rate of temperature rise. This device is intended to reduce the effect of thermal lag that is present in a fixed-temperature detector.

A typical rate-compensation device has a tubular casing of a metal that tends to expand lengthwise as it is heated and an associated contact mechanism that will close at a certain point in the elongation. A second metallic element inside the tube exerts an opposing force on the contacts, tending to hold them open. The forces are balanced in such a way that on a slow rate of temperature rise, there is more time for heat to penetrate to the inner element, which restrains contact closure until the total device has been heated to its rated temperature level. On a fast rate of temperature rise, there is not as much time for heat to penetrate to the inner element, so that contact closure is obtained when the total device has been heated to a lower level. This condition, in effect, tends to compensate for thermal lag.

The rate-of-rise detector is designed to operate when the temperature of its operating element rises at a rate exceeding a predetermined amount, regardless of the temperature level. Usually the rate rate is 15° to 25°F (8.3° to 13.9°C) per minute. A rate-of-rise detector may consist of small diameter pneumatic tubing which is terminated in a detector unit having calibrated vents, diaphragms, and contacts arranged to actuate at a predetermined pressure. The detection system is sealed except for the calibrated vents which compensate for normal changes in temperature. A rate-of-rise detector can also consist of a spot type unit with an air chamber, diaphragm, contacts, and vent contained in a single enclosure. A third type of rate-of-rise detector is the thermoelectric effect type. In this type the sensing element consists of a thermocouple or thermopile unit which produces an increase in electric potential in response to an increase in temperature. An alarm is initiated when the potential increases at an abnormal rate. This is subject to a lowering of sensitivity by corrosion.

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Heat detectors may employ more than one operating principle. Such a unit could be a combination fixed-temperature and rate-of-rise heat detector. The fixed-temperature device in this combination detector operates in case the temperature rises too slowly to operate the rate-of-rise device.

A nonrestorable heat detector has a sensing element that is destroyed when a fire is detected. The sensing element in a restorable detector is not ordinarily destroyed when a fire is detected. Some detectors are automatically self-restoring as the sensing element returns to normal.

An approved heat detector will operate at least as quickly as an approved, comparably degree-rated automatic sprinkler on 10 by 10 ft (3.05 by 3.05 m) spacing under the same conditions of heat exposure. An approved detector is also designed to operate within 3% of its intended fixed temperature in °F or, if of the rate-of-rise type, to operate at an ambient temperature increase of between 15° and 25°F (8.3° and 13.9°C) per minute.

Fixed-temperature and rate-compensation spot type heat detectors are rated to operate at temperatures ranging from about 135° to 575°F (57.2° to 301.7°C). Table 1 gives the temperature ratings of detectors than can be used for various maximum expected ceiling temperatures.

Table 1. Selection of detector temperature rating.

Temperature Rating Range of Detector °F	°C	Maximum Expected Ceiling Temperature °F	(°C)	Color Code
135 to 174	(57.2 to 78.9)	100	(37.8)	None
175 to 249	(79.4 to 120.6)	150	(65.6)	White
250 to 324	(121.1 to 162.2)	225	(107.2)	Blue
325 to 399	(162.8 to 203.9)	300	(148.9)	Red
400 to 499	(204.4 to 259.5)	375	(190.6)	Green
500 to 575	(260.0 to 301.7)	475	(246.1)	Orange

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Heat detectors should be properly installed or protected so that they are not subject to mechanical damage. They should be supported or mounted independent of their attachment to the circuit wiring. Heat detectors of the spot type are generally located on the ceiling and not less than 4 in. (102 mm) from the side wall. A less desirable location would be on the side wall between 4 and 12 in. (102 and 305 mm) from the ceiling. (See Fig. 1.) Line type heat detectors are generally located on the ceiling. A less desirable location would be on the side wall not more than 20 in. (508 mm) from the ceiling. For joisted construction the detectors are generally located on the bottom of the joists.

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The spacing guide for Factory Mutual approved heat detectors on smooth ceilings varies from 10 by 10 ft (3.05 by 3.05 m) maximum to 30 by 30 ft (9.14 by 9.14 m) maximum. The recommended spacing of heat detectors depends on the sensitivity of the specific detector, the ceiling construction, the normal room temperature, and the occupancy.

The distance from a detector to the nearest wall or partition should be one-half the distance between detectors (Fig. 2). For irregularly shaped areas with smooth ceilings, the distance between detectors may be greater than the listed spacing, as long as the maximum distance from any point on the ceiling to a detector is not greater than 70% of the listed spacing. For joisted ceilings, the spacing of spot-type heat detectors, as measured at right angles to the joists, should not exceed 50% of the detector's smooth ceiling spacing (Fig. 3). Closer spacing may be necessary in many cases because of the particular type of construction of the of the protected area (Fig. 4), possible drafts, heating systems, and other factors, such as the occupancy and monetary values.

Closer spacing should also be considered when faster

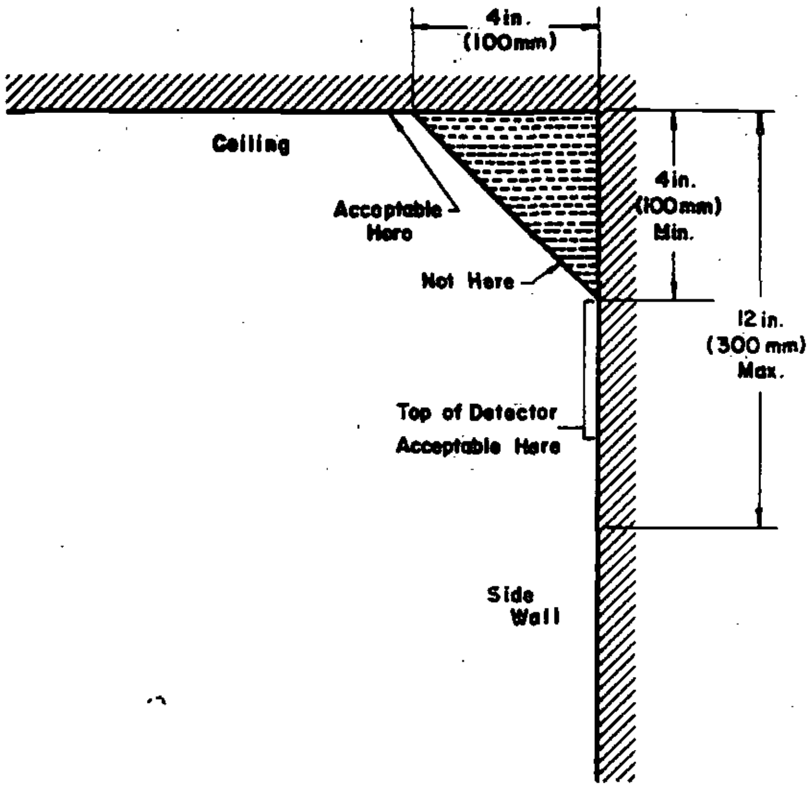

Fig. 1. Recommended location of spot-type heat detectors. Measurements shown are to the closest edge of the detector.

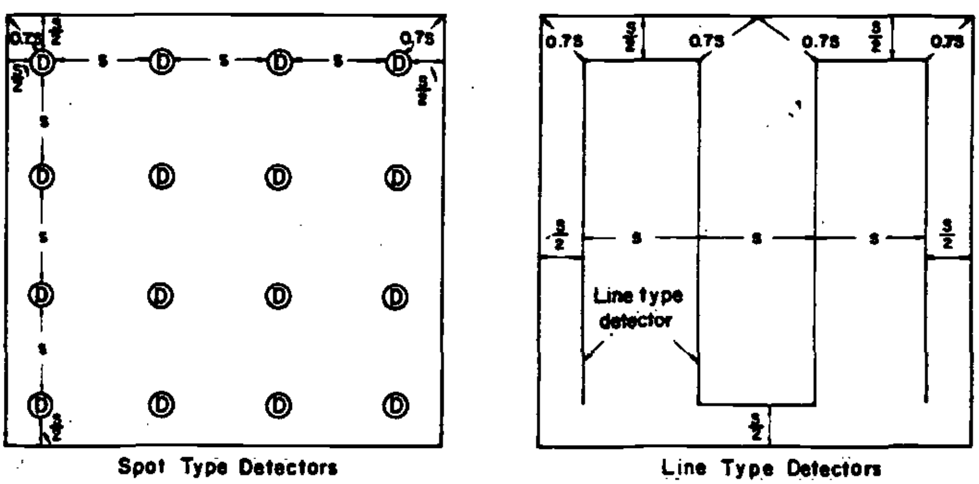

Fig. 2. Maximum suggested spacing of heat detectors on a smooth ceiling.

response is desired. Rate-of-rise devices may give a quicker alarm than fixed-temperature detectors, particularly in highly combustible occupanices, in unheated buildings in the winter, and in cold storage areas. An alarm may also occur when temporary heaters or an interruption of refrigeration occurs. Fixed-temperature devices may be more reliable in detecting slowly developing fires, and they usually require less attention to prevent false alarms.

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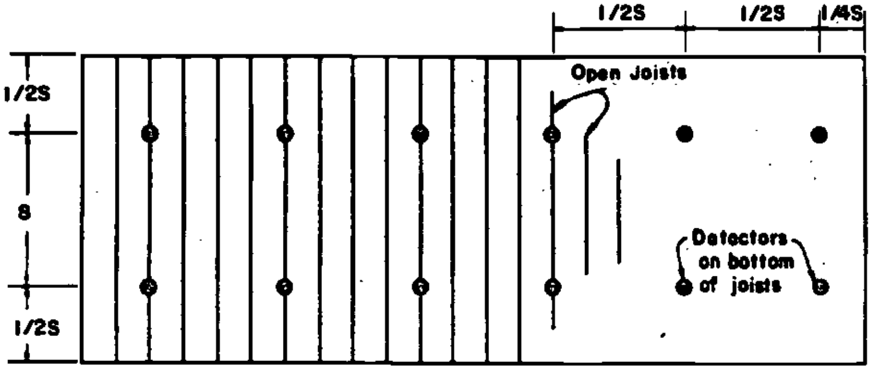

Fig. 3. Spacing of spot-type heat detectors under a joisted ceiling.

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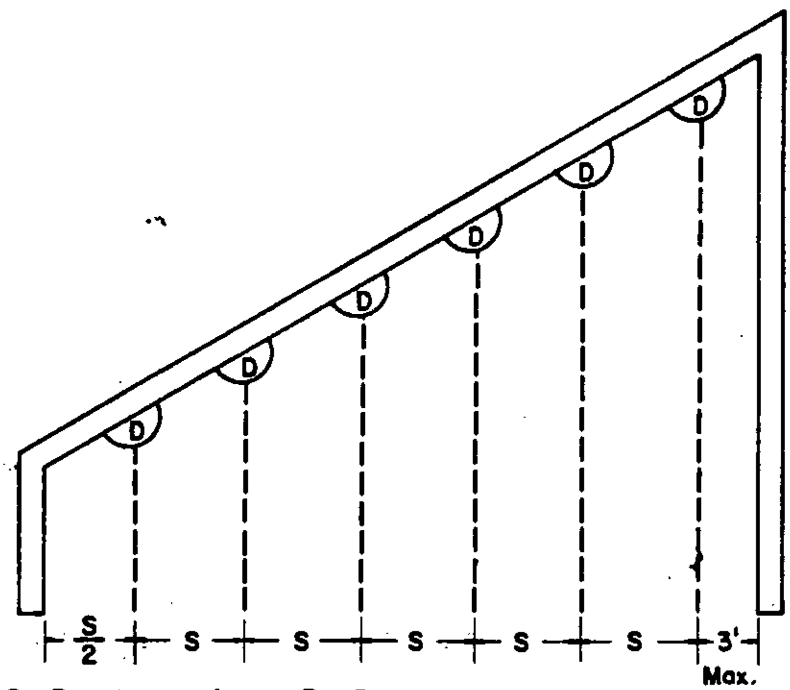

Fig. 4. Spacing of spot-type heat detectors under sloped ceilings (shed type). Note: 1 ft = 0.305 m.

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SMOKE DETECTORS

A smoke detector senses visible or invisible particles of combustion. Smoke detectors can be classified according to their operating principle as ionization detectors, photoelectric detectors, and air sampling detectors.

The ionization smoke detector contains a small amount of radioactive material which ionizes the air in special chambers in the detector. This makes the air conductive. When particles of combustion enter the sensing chamber in the detector, the normal ionization current is changed and a signal is initiated. Usually, ionization detectors are the spot type and mounted on the ceiling of the protected area, although they may be specially designed for installation in air ducts.

The photoelectric smoke detector may be a beam type or a spot-type device. In the beam-type photoelectric detector, a light source is projected across the protected area into a photoelectric (photosensing) cell. Sufficient obscuration of the light beam by smoke reduces the light intensity reaching the cell and a signal is initiated. The spot-type detector incorporates the light source and photoelectric cell in the same unit. A signal is initiated when the smoke, which has entered the unit, causes reflected light to strike the photoelectric cell.

Combination smoke detectors have been recently introduced. These detectors combine the principles of ionization detection and photoelectric detection in a single unit. Since each unit will respond to either the products of combustion or the light obscuration of smoke, smoldering fires as well as fires producing very little smoke could be readily detected. Units are also available which will require both inputs before initiating a signal.

The cloud chamber smoke detector is usually the air sampling type. An air pump draws a sample of air into a high humidity chamber. Moisture in the chamber condenses on the smoke particles, forming a cloud. The density of the cloud is then measured by the photoelectric principle.

Some fire detectors respond to both smoke and heat. They are usually selected for various application according to the rating of their fixed temperature element for the ceiling temperatures than can be expected. These combination detectors are often used where either a flash fire or a smoldering fire could occur and where rapid detection is desirable.

Approved smoke detectors are designed to respond to specified sources of smoke before the light obscuration exceeds 4% per ft (13.2% per m).

Smoke detectors of the spot type are generally located on the ceiling and not less than 4 in. (102 mm) from the side wall, while detectors of the line type (beam type) are generally located on the ceiling. A heat barrier may form under a high ceiling which could prevent smoke from reaching the ceiling. In buildings with high ceilings, the devices are usually located at the ceiling level and also at least 3 ft (0.92 m) below the ceiling (Fig. 5).

Smoke detectors should be properly installed or protected so that they are not subject to mechanical damage. They should be supported or mounted independent of their attachment to the circuit wiring. The light beams to photoelectric detectors should be located, enclosed, or arranged so that the movement of any objects will not cause a false alarm.

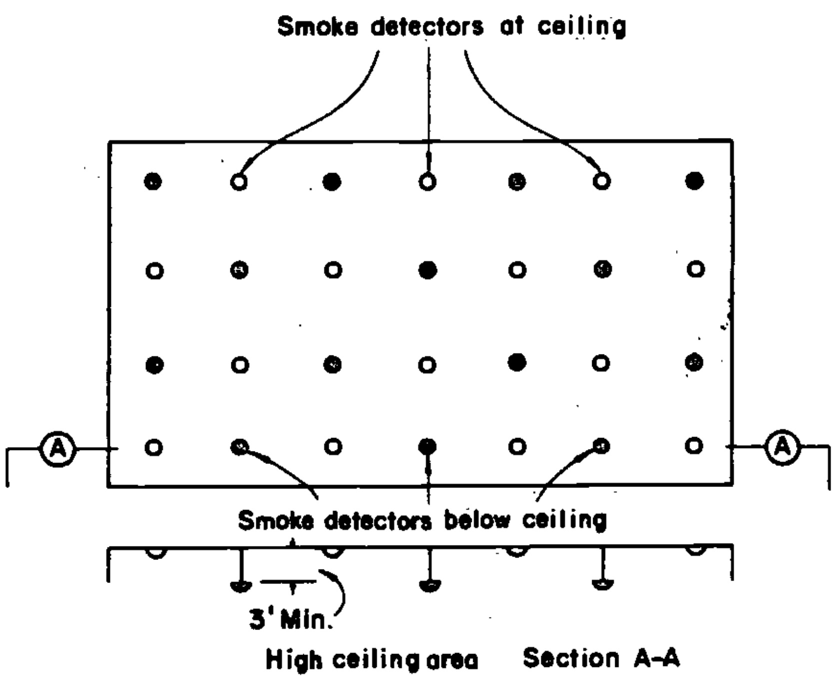

Fig. 5. Location of smoke detectors in high ceiling areas to minimize the effects of gas stratification. Note: 1 ft = 0.305 m.

To obtain a signal from a smoke detector, the smoke must enter the detector unit itself, or the smoke must interrupt or obscure the light beam. Although the protected area may appear to be filled with smoke, smoke is sometimes prevented from getting to the detector because of stratification, or because air currents carry smoke particles away from the detector. Other factors that influence the ability of the smoke to get to the detector in sufficient quantity to activate it are the location of ventilation inlet and exhaust openings in the protected area, rate of air change, room furnishings, and structural beams or other obstructions.

The response speed of the detector to a given fire is also dependent upon the nature of the products of

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combustion and the extent of thermal lift that may be produced, in addition to the speed at which the smoke builds up. Some products of combustion are much lighter than others and, because of thermal lift, these lighter particles rise more rapidly. Other larger, heavier particles may rise more slowly, drift horizontally, and tend to stratify, particularly if there is little thermal lift or other air currents. For example, tests have shown that the products of combustion of polyvinyl chloride insulation for electrical wiring rise slowly and the detector response is apparently slower than when other lighter gases or aerosols are involved.

The sensitivity of a smoke detector can also be affected by the color of smoke. Some spot-type photoelectric detectors are more responsive to light-colored smoke than to dark-colored smoke.

The ceiling height, shape of ceiling, arrangement of contents, burning characteristics of the stored combustibles, and ventilation are some of the variables that should be considered in determining the spacing for smoke detectors in various applications. An engineering evaluation of the particular installation supplemented, if feasible, by field smoke tests is often necessary. However, some spacing figures, which may be used as a guide, are given in the following paragraph. These spacings are subject to modification depending upon the actual conditions.

For spot-type smoke detectors on smooth ceilings with no forced air flow in the room, a maximum coverage of 900 ft^2 (83.6 m^2) per detector or a spacing of 30 ft (9.15 m) between detectors may be used as a guide. A maximum coverage of 200 ft^2 (18.6 m^2) per detector may be necessary where the room air is changing at a rate of 20 air changes per hour or 100 ft/min (0.5 m/sec). For beam-type photoelectric detectors on smooth ceilings with no forced air flow in the room, acceptable detection can usually be obtained with the light beams installed 30 ft (9.15 m) or less apart with one-half or less that spacing to side walls. Faster response can result with closer spacing of the detectors.

Approved smoke detectors are valuable for detecting fires in occupancies highly susceptible to smoke and water damage, and especially those occupancies subject to slowly developing fires where a rapid alarm is desirable before the operation of sprinklers. Such occupanices would include fur storage vaults, baled hops storage, computer installations, and electronic equipment life test facilities. Approved smoke detectors for room or area protection can be expected to operate more quickly than an approved heat sensitive device exposed to a slowly developing fire.

Smoke detectors are also used to monitor air conditioning and ventilating systems, and to supervise and control fans and fire dampers, especially in areas where positive control of smoke is essential. Air duct smoke detectors are specially designed and approved for this purpose, but should not be used as a substitute for open area protection.

In order to avoid false tripping of a Halon 1301, carbon dioxide, or pre-action sprinkler system for a computer room, smoke detectors should be cross-zoned or otherwise connected in a matrix. With this arrangement, alternate or adjacent detectors in an area are on separate circuits and only an alarm is obtained by the operation of a single detector. Discharge of the agent does not occur until an adjacent detector or one on a different circuit also operates. Cross-zoning or matrixing is desirable in order to minimize false operation of the extinguishing system and the resulting waste of the extinguishing agent. This arrangement is also advisable wherever the environmental conditions may be expected to cause an occasional false operation of the detector. New 3/80

FLAME DETECTORS

A flame detector is sensitive to infrared, visible, or ultraviolet radiation produced by a fire, or to specific ranges of radiation that are modulated at characteristic flame flicker frequencies.

Flame detectors are essentially line-of-sight devices and are usually designed to respond to a fire within the detector's cone of vision in approximately one second or less. However, a signal from the detector may be delayed up to 60 seconds, depending on local conditions. Revised 3/80

The infrared detector contains a sensing element that is responsive to radiant energy at wavelengths below the range of human vision. This is usually above approximately 7700 Angstroms. A very high speed infrared detector which senses a portion of the infrared energy of flame is available. This device responds in less than 5 milliseconds to produce a voltage sufficient to release an extinguishing agent and sound an alarm. Normally, the device is used to actuate an external explosive-operated release to discharge water or other extinguishing agent through associated equipment. The overall system provides specialized protection for hazards such as rocket fuel manufacture, where extremely fast fire detection and application of water is needed.

The ultraviolet detector contains a sensing element that is responsive to radiant energy above the range of human vision. This is usually below approximately 4000 Angstroms.

The photoelectric flame detector contains a sensing New 3/80 comprised of a photocell which either changes its electrical conductivity or produces an electrical potential when exposed to radiant energy.

A **flame flicker detector** consists of a photoelectric flame detector including a means to prevent response to visible light unless the observed light is modulated at a frequency characteristic of the flicker of a flame (4-30 Hz).

The specific locations and spacing for flame detectors should be based on an engineering survey of the anticipated conditions in the area to be protected. The detectors should be installed so that their field or vision will be adequate to assure detection of a specified area of the fire. Test flames are sometimes necessary in order to determine the proper detector locations. The protection of an area can be improved by the overlapping of areas of cone coverage from the detectors. Flame detectors should be arranged or shielded so that they are not actuated by radiant energy sources that could produce false alarms. Infrared lamps, matches, cigarette lighters, and sunlight may result in an unwanted alarm from an infrared detector. False alarms from ultraviolet detectors may be produced by germicidal lamps, X-ray machines, welding arcs, and arcing from electrical motors.

Flame detectors may be used in a variety of fire detection applications. Applications include surveillance of conveyor housings, yard storage, and chemical plant yards; auxiliary to smoke detectors in cross zone systems; and automatic tripping of monitor nozzles used in large scale flammable liquid storage applications.

Infrared or ultraviolet flame detectors are often used for actuating extinguishing systems for protection against fuel spill fires beneath the fuselage and wings of aircraft in hangars.

GAS-SENSING FIRE DETECTORS

Gas-sensing fire detectors, also known as fire-gas detectors, sense and respond to one or more of the gases produced by burning substances.

The semiconductor type fire-gas detector responds to either oxidizing or reducing gases by creating electrical changes in the semiconductor used for actuation.

The catalytic element type contains a material which accelerates oxidation of combustible gases. Actuation is caused by the resultant temperature rise of the element.

As with other types of detectors, the location and spacing of fire-gas detectors should be based upon engineering judgment and consideration of the ceiling shape and surfaces, ceiling height, arrangement of contents in the area, burning characteristics of the combustible materials, ventilation, and so forth.

Spot-type detectors should be located preferably on the ceiling no less than 4 in. (102 mm) from the sidewall, or if on the sidewall, between 4 and 12 in. (102 and 305 mm) below the ceiling. On small ceilings, in general, a 30 ft (9.15 m) spacing may be used as a guide but other spacings may be needed depending upon ceiling height, different conditions, and response requirements.

Where forced ventilation is present, do not locate detectors where the fire gases could be diluted before reaching the detector.

To prevent false operation, selection of fire-gas detectors should take into consideration the design of the detector and the normal environment of the area to be protected. They should not be installed where, under normal conditions, concentrations of detectable gases are present. For instance, some aerosol sprays and hydrocarbon solvents may result in false detector operation.

TESTING OF FIRE DETECTORS

Periodic inspections and tests should be made of automatic fire detectors in order to insure that they are in reliable operating condition. Persons normally receiving an alarm should be notified in advance of the tests.

Heat Detectors

For restorable spot-type heat detectors, at least one detector on each signal-initiating circuit should be tested semiannually. Different detectors should be chosen for each test. The detector can be tested with a heat source, such as a hair dryer or shielded heat lamp until it responds. The detector should reset after each test.

Nonrestorable spot-type heat detectors do not need to be periodically heat tested because the sensing element would be destroyed by the test. The alarm circuit should be tested semiannually for electrical continuity.

Pneumatic rate-of-rise line-type heat detectors should be tested for proper operation and leaks semiannually. The detector can be tested with a heat source if a test chamber is available in the signal circuit, or pneumatically with a pressure pump in accordance with the manufacturer's instructions.

Fixed-temperature line-type heat detectors should have their loop resistance measured semiannually.

Smoke Detectors, Flame Detectors, and Fire-Gas Detectors

The various types of smoke detectors, flame detectors, and fire-gas detectors should be tested semiannully in accordance with the manufacture's instructions.

New 3/80

Ionization and photoelectric smoke detectors may require periodic cleaning to remove accumulated dust and dirt. The frequency required dependa upon the operating environment.

Flame radiation detectors are also adversely affected by slight accumulations of dust or other coatings on the lena or sensitive element. Again, the frequency of cleaning depends upon the operating environment.

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the magazine of power generation and plant energy systems

Power

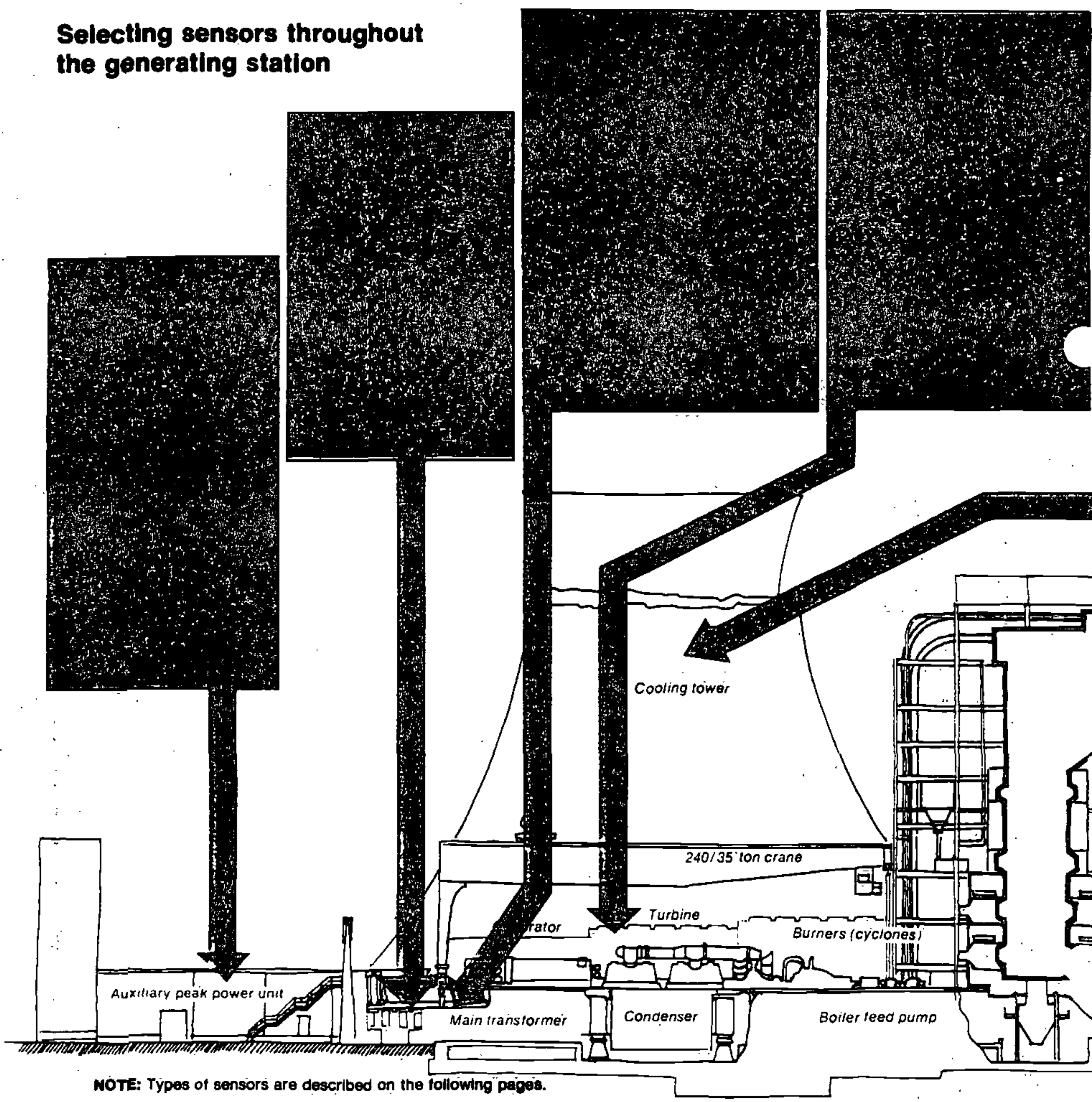
Integrated fire protection for the modern generating station

Integrated fire protection for the modern generating station

Fire hazards in generating stations grow haphazardly unless you're alert to them. Here's a summary of the best in modern hazard-sensing techniques

By **Charles Doak**, Alison Control Inc

Selecting sensors throughout the generating station

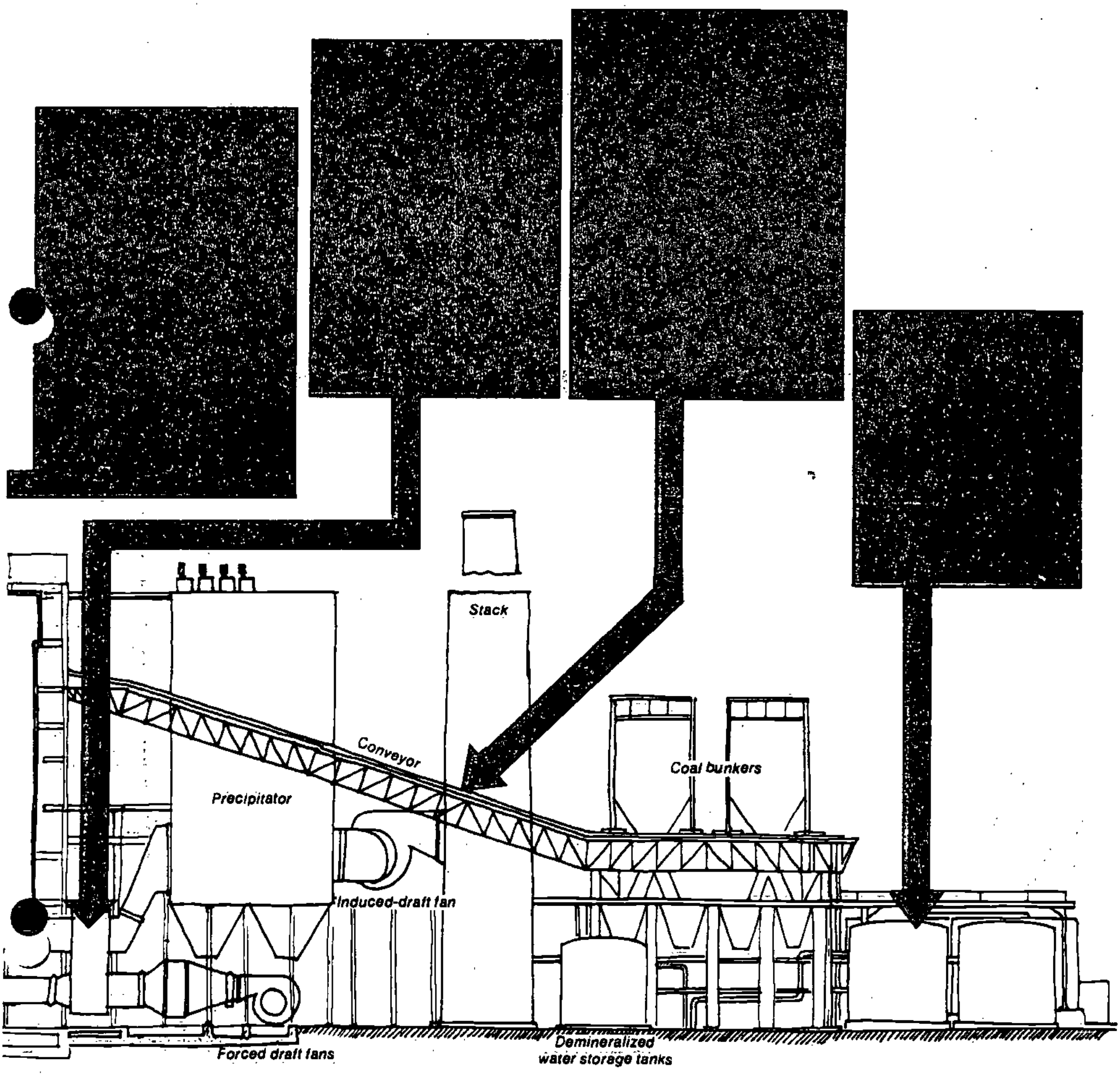


NOTE: Types of sensors are described on the following pages.

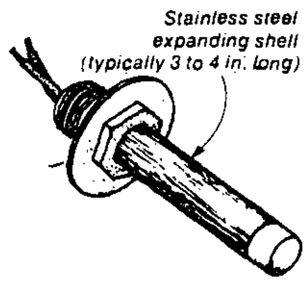
A great many US electric generating plants, both utility and privately owned, are smack up against a problem that is steadily growing more serious. Except for nuclear generating plants, where adequate fire-detection systems are mandated by the Nuclear Regulatory Commission, most generating plants are woefully underequipped to sense and promptly extinguish certain types of fires. Yet at the same time, reserve power capacity has become so slim for many utility systems during much of the year, and individual stations so large and/or so critical, that a few major fires could place a significant part of a state or several states in a near-crisis position on electric power. And in the case of privately owned plants, any significant fire in the steam or power generating station puts the entire plant out of production until repairs can be made.

For a variety of reasons many of the fire-hazard sources within generating plants have increased. For example, many plants are now forced to burn coal that is more dusty, more abrasive, and more prone to combustion than the coal for which the plant was designed. The result: More problems with conveyor bearings overheating, plus fire hazards throughout the handling system.

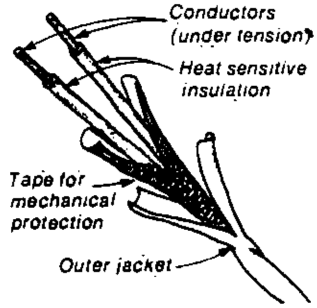
How has the industry arrived at this undesirable position? Anyone in the field can cite several reasons, but I think the underlying cause is the fragmentation of responsibility that has been inevitable in the design of the modern power plant. The mechanical-engineering staff has been primarily concerned with optimizing the fire-detection and -extinguishing means in the fuel-handling, boiler, and stack areas. The electrical engineers have been concerned with doing the best possible job of protecting the generator, buswork, main and auxiliary transformers, and critical motors. But, except for a few unusual utilities, no one has been



Continuous thermal sensor



Spot sensor



Fusible thermal wire

Optical sensor

responsible for integrating the entire fire-detection system, or of making sure that every possible combination of events that might result in a hazardous condition registers a warning or alarm condition at the point where effective action can be taken.

Some manufacturers of fire-detection equipment have been trying to bring about a change in this pattern, both via papers at technical conferences and by offering to take the responsibility for selecting the optimum sensing devices and locations, and integrating all fire and overtemperature detection into a single system, monitored from the main station control room. Central monitoring is generally recommended, even though it may be advantageous to have local monitoring as well at special or isolated areas.

The essence of a good system is to use the right sensors in the right places and to have a staff trained to take the right corrective measures promptly. This article describes, without any attempt to be exhaustive, some examples of good modern practice.

Seven types of sensors

A thorough discussion of all the varieties of thermal sensors available would just about fill a book. In fact, the National Fire Protection Assn. does publish such a book. But the severe duty and types of hazards involved in generating-station protection are well covered by the following seven basic types of detectors:

■ **CTS (continuous thermal sensor).** A continuous linear thermistor, consisting of a thin, flexible, usually heat- and corrosion-resistant outer tubing, with a *concentric inner* conductor, insulated from the shell by a variable-resistance, tightly compressed ceramic powder (similar in construction to mineral-insulated cable). Resistance of the ceramic changes from that of a near-insulator to that of a conductor at the critical threshold temperature.

Many options are available. Temperature sensitivities (and metallurgical withstand capabilities) can vary from below-zero temperatures to 2000F or above. The type shown in the photo with control box/transmitter, is able to measure temperature at any point along the length of the thermistor. The CTS end-cap can be removed and the thermistor extended. Some are approved for use in hazardous atmospheres. The central monitor can be set to alarm at different and adjustable temperatures along a single length of CTS.

■ **FTSS (fixed-temperature spot sensor).** Essentially an on-off thermostat, usually nonadjustable, designed for severe duty, with the contacts protected from the environment. Pipe-thread mounting is common practice. Units can be shielded from adjacent normal heat sources if desired. Bimetallic strip-type thermostats may give false alarms near the critical-temperature point under severe vibration: snap-action disc types (usually for surface mounting) are less susceptible to false alarming. This type

Points to remember in planning fire-detection and fire-protection systems

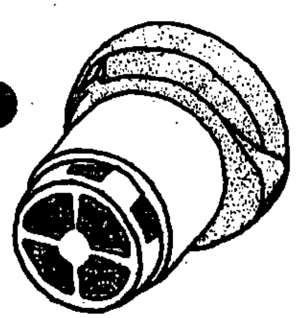
[illegible] In choosing an extinguishing agent (and in limiting its use), be sure to factor in the cost of cleanup following a fire. For instance, a low-cost water deluge could be exorbitantly expensive compared to other agents [illegible] exposed area in below-freezing weather.

[illegible] can be as important to know exactly where a fire is, and the level of its severity, as it is to know that a fire exists. Some fires or overtemperature conditions do not necessarily demand immediate attention. Whether the fire-protection system relies on human or preprogrammed decision-making, the system's *response to the overtemperature condition ought to be* matched to the risks it poses to overall plant security.

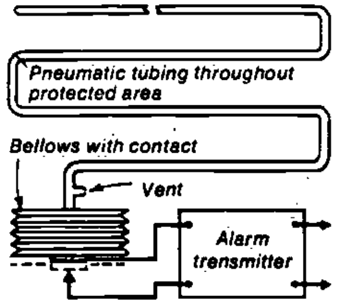
[illegible] complications when you add pushbuttons so [illegible] the fire-extinguishing system for their own [illegible]. Such action should not interrupt the [illegible] process. Controls for returning the system [illegible] should be placed at points where someone respon[illegible] the area is cleared.

[illegible] your detection-monitoring system, you should consider built-in event-simulation at the central monitor. It's seldom feasible or even advisable to try to provide preprogrammed action to take care of every fire-caused eventuality. Many important decisions on equipment shutdowns, etc are best made on the spot by properly trained operators. Only rarely does a crisis allow the duty operator time to look up proper procedures in a manual, or even read from a projected slide. His reaction should be automatic and absolutely correct. However, because the cost of a mistake by an operator can be so serious, and because the time between fire events may be months or years, even the best operators need retraining. The capability of simulating fire conditions—and of allowing the operator to simulate proper corrective measures—is easily built into the monitoring panel at the time of manufacture.

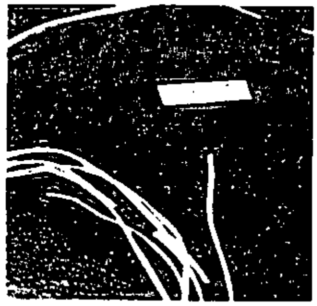
7. Remember that proper protection or defensive action for support or auxiliary equipment can be as important as *protecting the main plant components. One power plant failed* to provide automatic energization and direction to the crane in



Products-of-combustion unit



Rate-of-rise system



Series thermal detector

provides economical, durable protection for areas where hazard sources are definitely known. It can be wired back to monitor individually, in parallel, or multiplexed when numbers are large and runs are long.

■ **FTW (fusible thermal wire).** This sensing device (also known as thermostatic cable) is a fixed-temperature detection means in which twisted steel wires (illustration) are held in tension, while insulated from each other by a heat-sensitive plastic coating with a specific melting point. The cable is typically ⅛ in. in diameter. After contact (alarming), the section of the cable in which the insulation has melted must be replaced. This type is economical for coverage of widespread areas with multiplicity of hazard spots. It is not adaptable for temperature indications or multiple adjustable alarm levels—only overtemperature alarming. It is difficult to shield against mechanical abuse without reducing sensitivity.

■ **OS (optical sensors).** These units are primarily optically aimed ultraviolet sensors, which screen out heat sources other than the UV output of flames. They are not adaptable for overtemperature-warning applications. Extremely fast sensing, they can be programmed to discriminate against most localized UV sources, such as arc welding, high-intensity lighting, etc. The area of coverage for each sensor is limited optically, so they are useless when obstructions occur, but are free from some limitations of other heat-sensing methods. Long-distance sensing capability is feasible, but can be susceptible to false alarming, particularly in outdoor locations.

■ **POC (products of combustion).** These sensors are used where smoke or other particulate emissions can be expected before the actual outbreak of a fire. They are modest in cost, and require little attention except for testing at recommended intervals. They require power (either battery or line energization) for operation, and, to be effective, must be located in the smoke (or ionized-gas) flow path. While capable of warning long before an overtemperature condition breaks into a fire, they may cause false alarms because of the presence of nearby exhaust or other irrelevant sources of particulate emission.

■ **PRRS (pneumatic rate-of-rise system).** This type of sensor is made in several widely different configurations, one of which is illustrated. Sealed, flexible tubing is mounted wherever overtemperatures are expected. A tiny vent bleeds off slow changes in internal pressure, characteristic of ambient-temperature shifts, but fast rises due to overtemperature anywhere along the tubing will cause the diaphragm to expand and alarm contacts to close. This system can fail to alarm if a hot spot is very small, or if heat is offset by a coincident widespread drop in temperature in other parts of the tubing. Other types of rate-of-rise detectors include double-ended diaphragm types, large single-bulb devices, and dual-thermocouple units with one element exposed to ambient changes and the other used as a reference.

■ **STD (series thermal detectors).** Small fixed-temperature detectors (each of which can be matched to the hazard temperature involved) can be mounted at any desired spacing along a thin, easy-to-mount cable. Operating temperatures are typically 100F to 300F. Monitor circuits can report which sensor is in alarm condition. These units are economical and easy to mount, but limited in application. The cable must be mechanically protected in harsh environments.

Edited by G C Quinn

the generating area. A fire in the turbogenerator damaged the crane, leaving the plant almost helpless to begin repairs to the generator. Linear-type overtemperature sensors properly placed on the crane and tied into the crane-control circuit could have energized the crane drive automatically to get it out of the fire's heat.

8. Don't count on equipment manufacturers to do the hazard analysis that really is the plant designer's responsibility. Although their literature may indicate otherwise, many manufacturers are quite casual about providing thorough overtemperature sensing. On one job, for instance, the compressor maker protected the bearings by sensing lube-oil reservoir temperature. But the reservoir had so much capacity that, under some conditions, a bearing could overheat to failure before temperature rise in the reservoir caused an alarm.

9. Remember that there is no all-purpose sensor. A well-designed system often needs a wide array of sensors for optimum protection. A products-of-combustion sensor may seem ideal for detecting smoldering fires inside a wooden structure (e.g., a cooling tower or a process unit), but these units are typically so sensitive that they will respond to exhaust smoke from nearby trucks or tugboats. Or it is possible that the sensing elements can become contaminated from the buildup of pollutants passing through the structure, with eventual loss of sensitivity.

10. In the majority of systems, breaks in the interconnecting cable are a far greater likelihood than are short circuits. Thus, such systems need a "system-not-functioning" alarm on an open rather than a short-circuit condition.

11. Beware the built-in handicaps of temperature-averaging thermocouple sensor systems. An interesting parallel to what can happen using such systems: If you put your feet in the refrigerator and your head in the oven, your average body temperature might be exactly normal. In one case, the manufacturer of a big gas turbine had installed thermocouples around the combustion-chamber periphery and connected them so the operator's panel read out average temperature (a fairly common practice). During an unusual combination of troubles, the temperature reached approximately 2600F at one combustor, while at another it was only 1400F (instead of the normal 1800F). The overtemperature caused the turbine to explode, almost totally destroying it.

12. It may take a decade, but many noncombustible structural materials around a power plant will become coated with a film of combustible material—coal dust, soot, oil deposits, etc. If such a possibility exists, you should consider protecting the components just as if the structure itself was combustible.

13. When locating ultraviolet or other optical-type sensors, remember that any reflective metallic surface could be the source of a false indication. If that possibility exists, it may be essential to use a combination of UV and thermal sensors.

14. Always plan for growth and change when laying out a system. Because both are inevitable, it makes sense to install systems that can be readily changed, extended, or expanded.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-IP-82-17		

4. Title and Subtitle	5. Report Date
Design Manual for Highway Storm Water Pumping Stations (2 Volumes) PARTIAL FROM VOLUME I	October 1982
	6. Performing Organization Code
7. Author(s) William F. Lever	8. Performing Organization Report No.
9. Performing Organization Name and Address William F. Lever Consulting Engineers Long Beach, California	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-FH-11-9282
12. Sponsoring Agency Name and Address Federal Highway Administration Office of Research and Development Implementation Division Washington, D.C. 20590	13. Type of Report and Period Covered June 1977 - January 1982
	14. Sponsoring Agency Code

15. Supplementary Notes

CO-Contract Managers: Robert Baumgardner HNG-31
Dan O'Connor HBR-06
Robert Wood HOV-21

16. Abstract

The purpose of this manual is to provide a comprehensive source of design information on storm water pumping stations for highway facilities. However, users are cautioned to use proper engineering judgment and must themselves be entirely responsible for any interpretations and applications of the data and opinions set forth herein.

An initial field survey was conducted to determine the present practices and experiences in several States, which proved to be extremely varied, with some basic differences in design concepts. All States were invited to submit information on their installations and most did so. Some of the data presented have been taken from these submittals, and some from relevant literature. Some have been drawn from manufacturers' catalogs. Examples from actual pumping stations have been incorporated whenever possible, by reproducing photographs or construction drawings in simplified form.

Various types of pumping stations are discussed in the early chapters, with guidance as to which might be expected to be most suitable for various conditions.

Later chapters deal with station machinery and features, including electrical systems. A number of appendices cover specifications, construction costs, energy economics, and maintenance.

17. Key Words	18. Distribution Statement
Pumping Stations, Collection Systems, Discharge Systems, Machinery, Specifications, Costs, Maintenance	This document is available to the public through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	404	

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~~2-G. Wet-Pit Example: Circular Pit with (1) Two, or (2) Three, Vertical Pumps with Engines (LPG).~~

~~2-H. Wet-Pit Example: Structure, with (1) Two or (2) Three Screw-type Pumps, with Electric Motors.~~

~~2-J. Wet-Pit Examples: (1) Two, or (2) Multiple Submersible Pumps, in Circular Caisson or Rectangular Pit.~~

<u>5-C.</u> <u>STATION CRITERIA</u>

It is difficult to concisely and uniformly express diverse station design features in the form of criteria, but the following is a listing of features to be considered. The listing should be of assistance in making comparisons and selections.

The three categories, (a), (b) or (c) are intended to convey a high, medium or low condition respectively, and apply to all features except 22, which is a gathering of generally unrelated special features which must not be overlooked, even if none is found to be applicable.

1.	<u>Station Design Capacity</u>	(a) Maximum exceeding 300 cfs (b) Maximum between 100 and 300 cfs (c) Maximum less than 100 cfs
2.	<u>Station Design Head</u>	(a) Over 35 feet TDH (b) Between 15 and 35 feet TDH (c) Less than 15 feet TDH
3.	<u>Storage Upstream of Pumps</u>	(a) For velocity reduction, settlement of solids, minimizing equipment (b) Utilized if available (c) Not required or available
4.	<u>Quality of Water to be Pumped</u>	(a) Turbid and sand-laden inflow (b) Moderate contamination (c) Minimal contamination
5.	<u>Inflow Rate</u>	(a) Rapid increase (b) Normal hydrograph (c) Slow increase
6.	<u>Weather Conditions</u>	(a) Extreme cold in winter (b) Moderate winters (c) Mild winters, no freezing

7.	Discharge Conditions	(a) Long rising outfall from each pump (b) Short free outfall from each pump (c) Limitation of discharge rate
8.	Sump Dewatering	(a) Sump pump required (b) Vacuum truck preferred (c) No provision
9.	Electric Power Reliability	(a) Completely dependable - dual service (b) Very dependable - single service (c) Undependable - frequent outages
10.	Natural Gas/LPG Desired as Fuel	(a) Completely dependable - dual service (b) Very dependable - good storage (c) Not readily available - supply unreliable
11.	Station Siting	(a) Good access from frontage road or similar (b) Good access from highway (c) Poor access, alongside highway
12.	Soil Conditions	(a) Rock (b) Hard, steep unshored cuts (c) Clay or soft soil
13.	Foundation Conditions	(a) Acceptable bearing strata (b) Piling required for bearing (c) Extensive dewatering with piling required because of uplift
14.	Above-Ground Structure	(a) Large acceptable (b) Modest preferred (c) Smallest possible desired
15.	Structure Visibility	(a) Large structure acceptable (b) Modest structure desired (c) Minimum only acceptable
16.	Initial Cost	(a) High capital cost acceptable (b) Moderate cost acceptable (c) Lowest cost mandatory
17.	Maintenance Capability	(a) Excellent with complex machinery (b) Reasonably good (c) Mediocre

18. <u>Operating Cost</u>
    (a) High cost acceptable
    (b) Moderate budget desired
    (c) Lowest budget desired

19. <u>Equipment Handling Devices-Built-in</u>
    (a) Elaborate type considered essential
    (b) Simple type acceptable
    (c) Minimum or none required

20. <u>Equipment Handling Devices-Mobile</u>
    (a) Use preferred for all requirements
    (b) Used to supplement built-in
    (c) Not required due to elaborate built-in

21. <u>Trash Handling Devices</u>
    (a) Elaborate built-ins preferred
    (b) Simple built-ins found adequate
    (c) Vacuum trucks preferred

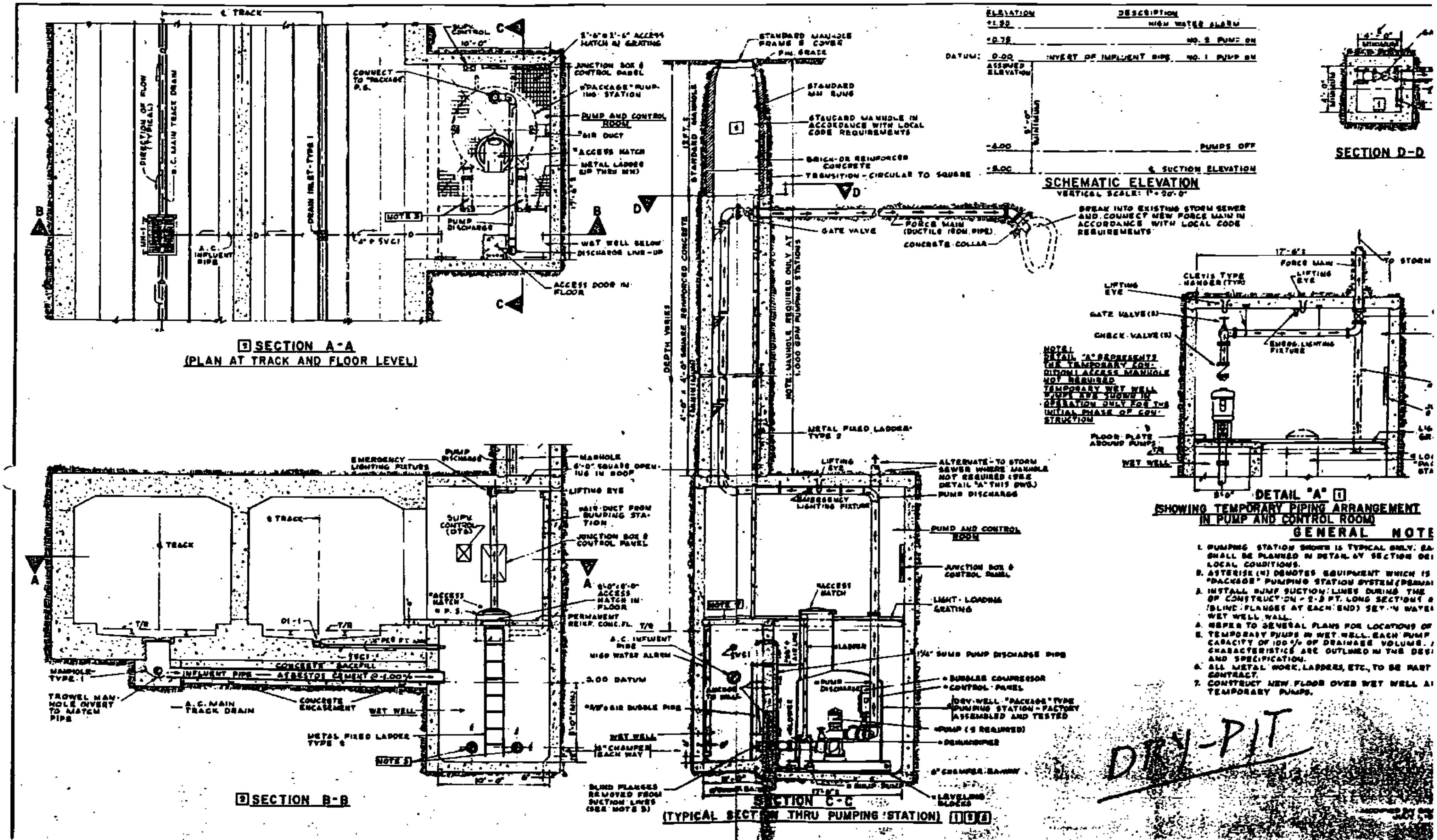
22. <u>Special Features</u>
    (a) Pre-screening of debris from inflow
    (b) Vulnerability to hazardous spills
    (c) Epoxy coating and lining of pumps
    (d) Grease lubrication for pumps
    (e) Galvanizing of steelwork
    (f) Manifold to pressure discharge
    (g) Sediment and hydrocarbon removal from discharge
    (h) Emergency generator
    (i) Supervisory control (telemetering)

5-D. SELECTION PROCEDURE

In the selection of type of station and equipment, the designer will experience a number of inputs from various sources in developing the criteria.

First are the site constraints, in other words, the items over which the designer has little or no control. These would mainly be the items listed in 5-C under:

1. Station Design Capacity
2. Station Design Head
4. Quality of Water to be Pumped
5. Inflow Rate
6. Weather Conditions
7. Discharge Conditions
11. Station Siting
12. Soil Conditions
13. Foundation Conditions



Designed	C. H. BISHOP	6-1-67
Drawn	R. E. EASLEY	4-18-67
Checked	C. H. BISHOP	4-17-67
Approved		

REFERENCE DRAWINGS

NUMBER	DESCRIPTION
ST-M-12	STAIRS, LADDERS, AND HANDRAILS SHT. 1
ST-M-1	DRAINAGE DETAILS AND AND CASTINGS
ST-M-11	TYPICAL SERVICE CONNECTIONS AND SLEEVES
ST-M-6	SERVICE DETAILS

REVISIONS

DATE	BY	DESCRIPTION	
10-11-68	E.C.	GENERAL REVISIONS	1
9-26-69		CHANGED X.E.C.I. PIPE TO SVCI PIPE	2
		CHANGED "NOTE 7" TO "NOTE 6"	3

NATIONAL CAPITAL TRANSPORTATION AGENCY

DE LEUW, CATHER & COMPANY
GENERAL ENGINEERING CONSULTANTS

N. C. T. A.

MECHANICAL DIRECTIVE
TYPICAL DRAINAGE PUMPING
CUT AND COVER CONSTRU

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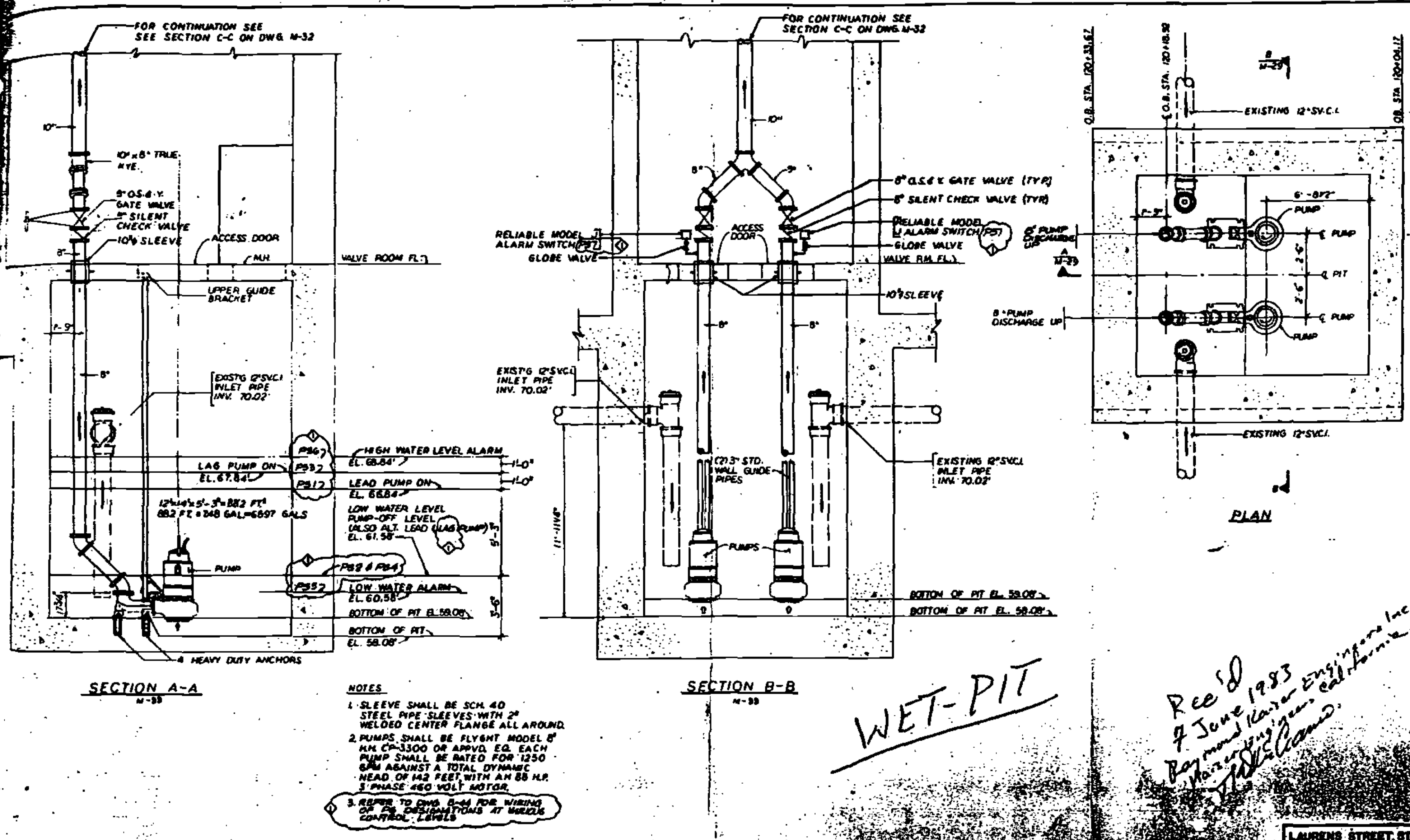

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STATE OF MARYLAND DEPARTMENT OF TRANSPORTATION
MASS TRANSIT ADMINISTRATION
BALTIMORE REGION RAPID TRANSIT SYSTEM
PHASE 1

DANIEL, MANN, JOHNSON, & MENDENHALL / KAISER ENGINEERS
GENERAL CONSULTANT
TIPPETTS-ABBETT-McCARTHY-STRATTON

NORTHWEST LINE
DRAINAGE PUMPING STATION-UNIT NW 1201
PLAN AND SECTIONS

GUIDE TO LEVEL DETECTORS

JOSEPH POWERS
Senior Associate Editor

SHARON BAKOS
Editorial Assistant

Presented here in tabular form is a wide variety of level detecting instruments designed to operate in the many applications in the chemical processing industries. Since there are so many applications, the job of selecting the appropriate instrument for the job primarily becomes one of fitting the detector to the particular requirement in mind.

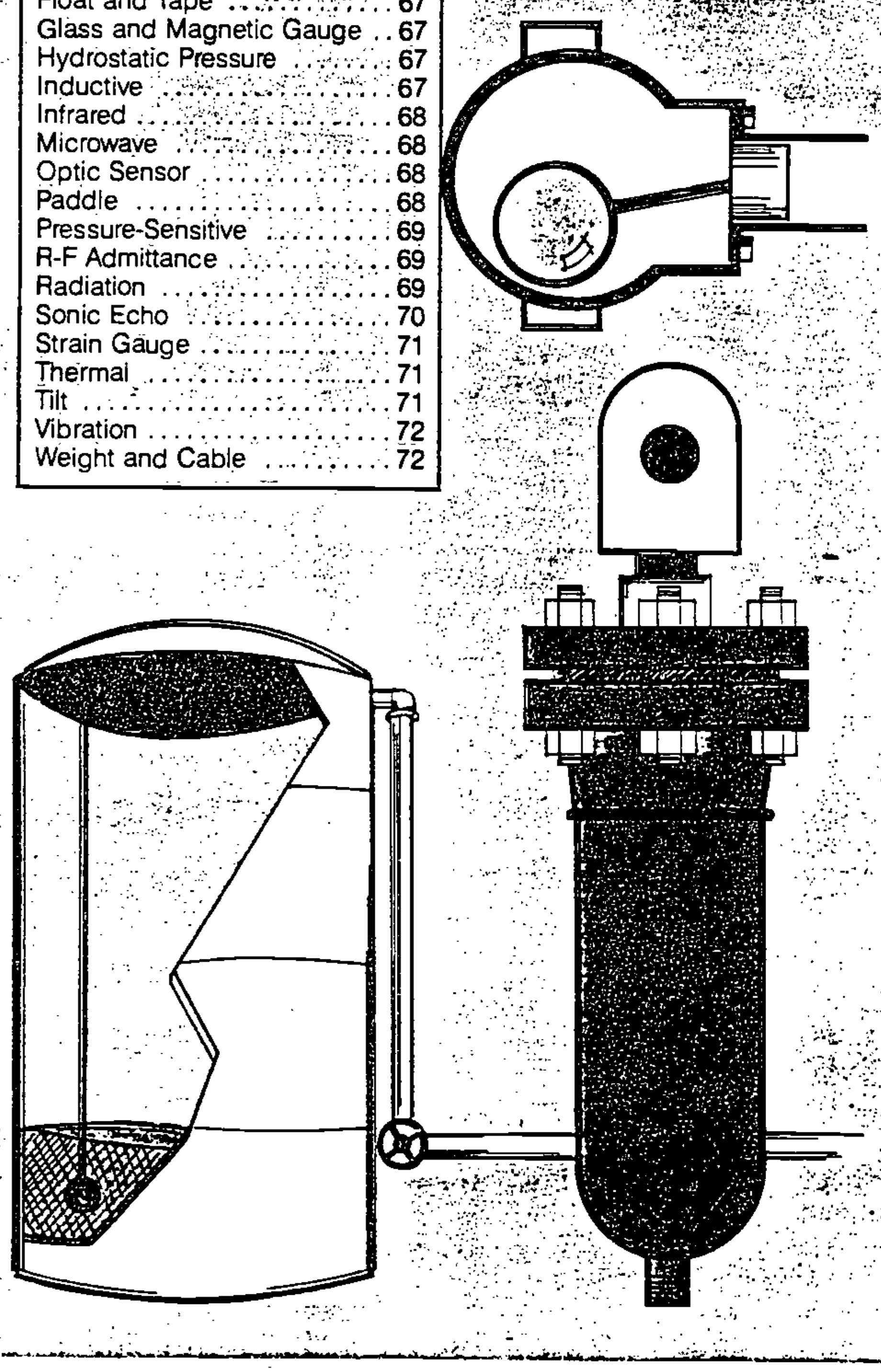
There are additional factors, of course, and these are also covered in the guide. These factors include type, advantages, temperature and pressure range, accuracy, installation, and features.

Every effort has been made to make the guide as complete as possible. Where there are blank spaces, the lack of data signifies that either it is not applicable, available, or it is not meaningful without providing much more information that is beyond the scope of this guide.

Additional information is provided in the review of manufacturers' literature that immediately follows this guide. The reader can obtain a copy of any brochure listed by circling the appropriate reader service number on the card adjacent to the inside back cover of this magazine. The numbers in the review section coincide with those in the guide itself.

For a reprint of this guide, circle number 339 on the card opposite last page.

INDEX TO GUIDE



Beam Breaker

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Autotron, Inc. BLF303 control	201	Bul 1277	Dry material	No moving parts	−40 to 130°F	Standard	1¾"	Any way	Unaffected by pressure
Veeder-Root Co. Series 7192 sensor	202	Bul 8726	Limited-space industrial sensing	Needs no external amplifier	−40 to 70°C	Not designed for pressure use	±.0005"	Any way	Extremely small size, all solid-state, watertight case
Skan-A-Matic Corp. Sight Glass Skanner S19100 Series	203	Skanner bul	Measures liquid levels inside sight glass	Detects virtually any liquid			±.003"	Vertical	Can be easily repositioned by means of thumbscrews

Bubbler

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Type 450 transmitter	204	Type 450 lit	Open tanks, pits, & sumps	Economical, simple	−100 to 500°F	0-20" to 0-2000" H_2O	½% of FS	Vertical	4-20 MADC isolated output
King Engineering Corp. Purge Control, Mdls 760, 761, 762	205	Cat 1000	Tank liquid level gauging, indicating systems	High accuracy signal	Depends on distance from tank	Not to exceed 130 psig	±¼" of total tank depth	Vertical	Integral coalescing filter, differential regulator provide low-volume flow of air to downpipe to minimize pressure drop
Liquiseal Purge Control, Mdls 735, 736, 737	206	Bul 1300-1-735	Tank liquid level gauging, indicating systems	Isolating diaphragm allows for tube near tank bottom	Depends on distance from tank	Not to exceed 130 psig	±¼" of total tank depth	Vertical	Pneumatic operation allows for use in explosive areas
Mid-West Instrument Mon-O-Con Mdl 400	207	Bul 40061	Atmospheric tanks, wet wells	Indicating pressure switch with from 1-16 set-points	30-130°F	Vacuum to 10,000 psig	±2% FS	Vertical	Photoelectric switching 10-amp DPDT output
Cutler Controls, Inc. Non-contact Air Jet	208	Air-Jet lit	Level detection of slurries, liquids, powders, coal pieces	Sees through foam to accurate liquid level	−25 to 300°F, PVC tube, −45 to 1300°F ss		±0.050"	Any way	Low energy, low pressure flow is economic. True off-on detector
Uehling Instrument Co. Tank-O-Meter	336	Bul 945R79	Any liquid that can be pumped	No moving or wearing parts					

Capacitance

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
C-E Invalco, Combustion Engineering Electr-O-Probe, Mdls B-07, B-11-A	209	IVC-845-A1	Liquids, granular solids	No moving parts, easily installed	−20°F to 160°F	To 600 psi	±3/16"	Any way	Compact, solid-state design; local or remote mounting

Controlotron Corp. Liquilite Series 205	210	Bul 1002	Point-level sensing	Senses most materials without contact	−65 to 235°F std.	2000 psi std.	To 1/100"	Any way	No moving parts, fail-safe for low or high levels
Custom Controls Co., Inc. Level Lance™ Series 5000	211	Level Lance bul	Liquid, granular	No moving parts, easy installation	To 1000°F	To 10,000 psi	± 1/2% FS	Any way	Two-wire transmission, no calibration adjustments at transmitter
Delavan Electronics, Inc. Type "C" transmitters	212	Type "C" lit	Liquids and solids	No moving parts, top-mount installation	To 2000°F	2500 psig	Greater than 0.25%	Vertical	Contact and non-contact sensors available
Delta Controls Corp. Series 100 probe	213	Series 100 lit	General-purpose transmission and alarm of liquid levels	Ultra stable	−100 to 1000°F	−15 to 10,000 psig	1/4% FS	Any way	No coax required on remote electronic models
Endress + Hauser FMC 1320	214	FMC 1320 lit	Liquid level	No moving parts or tubes to foul	Up to 1000°F		+1%	Any way	Immunity to build-up on probe, no special cables needed between probe and electronics
Magnetrol International, Inc. Series 82 transmitters	293	Bul 50-145	Liquids, dry bulk materials	Signal directly proportional to level changes	−40 to 160°F			Any way	Analog or digital display, probes to 150' long, probe-mounted or remote electronics
Monitor Manufacturing Model E	294	Model E lit	Liquid level sensing	Two-wire installation	−20 to 170°F	To 10 BAR	Point level	Any way	Remote-mounted PC card with connection to head, housing all cast aluminum
Pope Scientific, Inc. Lab Monitor III	295	Bul 55-49	Liquid level, temperature, vacuum or pressure, flow	Selections on probe, built-in alarm	Normal lab, industrial	Normal lab, industrial	0.1°C on mercury thermometer	Any way	Alarm switch, power receptacle with indicator lights
Robbins & Myers Monitor II	296	Bul 137A	Flow detection	Prevents pumps from running dry	210°F			Vertical	"No panic" button, electronic calibration
Robertshaw Controls Co. Level-Tel MDL 167	297	Product Spec Mdl 167	Sticky, viscous products	"Reads" through probe coatings	−40 to 160°F	30" VAC to 2000 psi	±2%	Vertical, slant	Directly mounted on sensing probe
Accru-Tel Mdl 161	298	Product Spec Mdl 161	Sticky, viscous products	True readings even with probe coating	−40 to 160°F	30" VAC to 2000 psi	±2%	Vertical, slant	Remote mounting up to 150' from vessel
Level-Tek Mdl 304A	299	Product Spec Mdl 304A	General purpose	Simple calibration			±3%	Any way	Standard adjustable differential and time delay
Level-Tek Mdl 310	300	Product Spec Mdl 310	General purpose	Remounts mounting up to 150'	−40 to 160°F	30" VAC to 2000 psi	±3%	Any way	Standard adjustable differential and time delay
Level-Tek Mdl 162	330	Product Spec Mdl 162	Where liquid make-up varies	Automatic recalibration as product varies	−40 to 160°F	30" VAC to 2000 psi	±2%	Vertical	Digital display, microprocessor based
Level-Tek Mdl 314B	331	Product Spec Mdl 314B	Two independent set-points for dual use	Reads through probe coatings	−40 to 160°F	30" VAC to 2000 psi	±3%	Vertical, slant	Wide adjustment range, adjustable differential on each set-point

Capacitance

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Model 166	332	Product Spec 166	Submergence flow correction in Parshall flumes	Microprocessor-based for great accuracy	−40 to 120°F		±.5%		All flow tables in memory section
Amprodux, Inc. Lev-Trol system	333	Lev-Trol lit	Storage and processing tank level alarm/control	Intrinsically-safe	−40 to 350°F	To 300 psi	To 1/64"	Any way	No floats to stick, no moving parts in vessel
Princo Instruments, Inc. Mdl L1510	339	L1510 lit	Point (on/off) control for liquids, powders, granulars	Easy installation	−40 to +170°F	1000 psi	± 1/2%	Horizontal, vertical or slant	Temperature stable

Diaphragm

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Series 460	221	Bul 460	Open storage tanks	No cavities to plug up	−50 to 250°F	0/20" to 0/2000" H_2O	1/2% of FS	Any way	Strain gauge bridge, extended diaphragm available
King Engineering Corp. TeleSensor	222	Bul 1100-20V	Tank liquid level gauging	External flange mounting	0-250°F	To 130 psig	± 1/4" of tank depth	Any way	Pneumatic operation, high-sensitivity diaphragm available
Monitor Manufacturing Binstrol Mdl G/GX/GX-SS	223	Bul 123	Open bin level detection		−40 to 400°F	Atmospheric	Point level	Any way	External sensitivity adjustment, diaphragm replaceable without removing main frame
Moore Products Co. Mdls 25, 27 ball float level controller	224	Bul 2504	Process vessel level control	Simplicity, no packing glands	0-300°F	ANSI Class 150, 300, 600, 900 flange rating	Good	Horizontal	Electric, pneumatic, high or low temperature versions available
Cosa Corporation Holledge PB	225	Holledge PB lit	Industrial level and pressure measurement	Overload protection	−40 to 150°C	To 250 psig	Repeatability better than 0.04%	Any way	Vessel contents isolated from instrument air, small wetted parts
Fisher Controls Series 115 transmitters	334	Bul 31.2: 115	Highly corrosive or heavy viscous liquids	Useful in slurries	To 400°F	Up to 320 psig, depending on model	±2.5% @ 400 psig		Downward diaphragm mounting minimizes solids collection in diaphragm recess

Conductive

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Autotron, Inc. A744C control	215	Bul A744C	Liquid level in tanks	Accurate	115°F max.	2500 psig max.	± 1/4"	Any way	

C-E Invalco, Combustion Engineering, Inc. Leveltronic Mdls 9402-A, 7402	216	Leveltronic lit	Conductive liquid point level control	Economical, dependable, many probe styles	To 660°F	To 500 psig	± 1/8"	Any way	High or low level "failsafe" design, solid-state
Delta Controls Corp. Type 513 switch	217	Bul 513	Water-based compounds	Low probe voltage, 6 megohm sensitivity	−50 to 750°F	−15 to 10,000 psi	1% of range	Any way	Adjustable pull-in point, adjustable time delay, hermetically sealed relays
ITT McDonnell & Miller PCH, PCL control	218	Bul SL-PCH	Liquids to indicate levels, start/stop pumps, alarm	Uses liquid conductivity to sense levels	406°F	250 psig	1/8"	Vertical	PCH: sensitivity to 4K ohms; PCL: to 250K ohms
Zi-Tech Division, Alkenwood Corp. A180/A190	219	Bul 0973	Conductive liquids	Self-contained, no moving parts	To 230°F	To 400 psi	Point	Vertical	Easily installed, sealed, precise
Amprodux, Inc. Conductivity control unit	220	Conductivity unit lit	Level alarm/control of conductive liquids	System made to user requirements	To 500°F	To 2000 psi	To 1/64"	Any way	Modest cost, probes can be made-to-order for most corrosives, difficult operations
Charles F. Warrick Co. Subsidiary of Armstrong International Series 2 Control	337	Series 2 lit	On/off level, high or low alarms	No moving parts in liquid	0 @ 500°F to 400 psig @ 150°F		± 1/16"	Vertical recommended	Wide range of rod material (electrode)

Differential Pressure

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Action Instruments Co., Inc. AP4051, ASP-400, AP1000	226	Bro 721-0014C	Tank liquid level measurement	High accuracy, linear output	32-140°F	Any	Better than 0.5%	Any way	AC line operation, plug-in instrumentation
Fischer & Porter Co. Type 50DPL100	227	Spec 50 DPL100	Tank level	Small size, light weight	248°F	To flange rating 150 or 300 psi	±0.5% of span	Horizontal	Easy maintenance, rugged construction
Type 50LL	228	Spec sheet 50LL3000	Tank level	Process fluid isolation	350°F	150 psi	±0.5%	Horizontal	All-welded body construction, vernier span adjustment
Mid-West Instrument Mdls 105, 109	229	Bul LLC 80	Pressurized tanks	Full over-range protection	−40 to 160°F	Vacuum to 6000 psig	+1 or 1/2% FS	Vertical	Indicator with one or two fully adjustable LED/LST
Moore Products Co. Mdl 13F D/P cells	230	Bul GC-13	Closed tank liquid levels	Tank-mounted flange	−40 to 375°F	ANSI Class 150 or 300	± 1/2%	Horizontal	Standard 3-15 psig transmission signal
Robinson-Halpern Co. Mdls 140, 150	231	Short form cat	Liquid tank level and bubbler systems	Excellent accuracy, stability	−40 to 176°F	0-2" H_2O to 0-5000 psid	±0.15% to ±0.75%	Any way	AC or DC input power options; DC or 4-20 mA output signal options
Sensotec Inc. LL Series	232	Mdl LL bul	Clean fluids	No capillary tubes, great stability	−65 to 475°F	10" H_2O to 10,000 psi	0.2%	Any way	Active part of sensing diaphragm can be placed in contact with fluid
Yarway Liquid level indicating system	233	Level system bro	In high-pressure vessels	Remote reading, continuous indication	700°F	3000 psi	±2%	Vertical	Density compensation, complete system, foolproof

Differential Pressure

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Dieterich Standard Corp. Eagle Eye	301	Bro DS-2000	Water level detection	Simple to use, low cost	40 to 180°F	75 to 225 psi	±2% FS	Any way	Electronic on-off control option, portable or permanent mount
Fisher Controls Type 1151LL transmitter	302	Type 1151LL bul	General liquid level monitoring	Low installation cost, minimum shock and vibration effects	−20 to 200°F	Up to 720 psig	±0.25% of calibrated span	Vertical or horizontal	Externally accessible span and zero adjustments, CSA or FM approval for safety use
The Foxboro Company Mdls 13A (pneumatic), 823DP (electronic) dp cell transmitters	303	Bro A-31A 3/81	Clean, non-viscous fluids, open or closed vessels	Wide range of temperatures and pressure	−40 to 250°F	Vacuum to 2000 psi (13A); to 3000 psi (823DP)	±0.5% (13A) ±0.2% (823DP)	Pipe-mounted	Wide material selection, long-term stability
13DMP, E13DMP transmitters	303	Bro A-31A 3/81	Pressurized or evacuated vessels	Eliminates wet and dry legs and need for purge systems	−35 to 550°F	0.25 psia to Class 600 ANSI flange	±0.5%	Flush flange mounting	Low temp errors for filled system, minimum of wetted parts
13F (pneumatic), E17DM (electronic) transmitters	303	Bro A-31A 3/81	Corrosive, viscous liquids and slurries	Wide range of process materials and temp and pressures	−40 to 600°F	Vacuum to flange rating up to Class 600 ANSI	±0.5%	Flush mounting to vessel with flange	Wide material selection for corrosive applications
Honeywell Inc. Class 41 transmitter	304	Reference S414-1a	Vented or pressurized tanks	Stability, wide range of adjustment	−40 to 350°F	150 to 3000	0.2% to 0.6%		Pipe-connected, flange-mounted or remote diaphragm seal models
Taylor Instrument Co. Mdls 3410T (electronic), 310T/360T pneumatic transmitters	305	Bro 98226	Tank level measurement	Good accuracy, wide application	−40 to 300°F	To 650" H_2O	±0.25%	Universal	Easy to calibrate, wide variety of materials, open or closed tank forms
Cutler Controls, Inc. CCS21A, CCS21H detectors	306	CCS21A, H lit	Portable, outdoor isolated uses	No loss of air	−45 to 1300°F ss	0 to 50" W.C. input, 10-130 psi output	±0.050"	Vertical, slant	Works on conductive, non-conductive media
Rosemount Inc. Mdl 1151 LLT	307	Bul 2262	Precision tank level and specific gravity measurement	Wide choice of materials, modular construction	−40 to 300°F	0-25" H_2O min., 0-100 psid max.	±0.25% calibrated span	Any way	Flush or extended diaphragms, external span and zero adjustments
Leeds & Northrup Co. Flange DP transmitter	342	Cat 473	Liquid level measurement in tanks	Uses flange; eliminates belts and pulleys	−30 to 250°F	Differential pressure is 12" water column to 1250" WC	±.25% of span	Vertical, typically	Has 4 to 20 mA output to remote receivers

For additional information on any of the detectors described above, please circle the appropriate Reader Service number on the card in the back of the magazine. A free reprint of the entire Guide to Level Detectors is available by circling 339 on the Reader Service Card.

Displacer

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
C-E Invalco, Combustion Engineering, Inc. Flex Tube® Model CTM level control	234	Bro IVC-802	High or low pressure separators	Rugged design, reliable operation	275°F	1500 psi	± ¼"	Horizontal, vertical	Choice of mounting connections, snap or throttling action
ITT McDonnell & Miller DFC and DFS	235	Bul DFC	Liquids, to indicate levels in corrosives	Wide level differentials	150°F	175 psig	± ¼"	Vertical	Mercury or snap switches, simple direct operation, isolated switches from liquid
Jo-Bell Products, Inc. Model "FT"	236	Mdl FL bro	Liquids with min. spec. gr. of 0.6	Field adjustable	−385 to 250°F	Vacuum to flange rating allowable	± ⅛"	Vertical	Porcelain displacer, SPDT or DPDT switching available, precision snap-action switch
Moore Products Co. Mdls 20, 21 transmitter	237	Bul GC-20	Pressurized tank measurement of liquid	Reliability	−40 to 450°F	ANSI Class 150 or 300 flange rating	± ½%	Horizontal	Standard 3-15 psig transmission signal
Enraf-Nonius Mdl 812 level gauge	238	Bro 812	Liquid bulk tanks, continuous level monitoring	High reliability, accuracy	−40 to 160°F	Atmos-560 psi	± (0.002 + 0.0014L)" L = liquid height in feet	Vertical	More than 30,000 units in use, complete safety approvals, computer compatible
Fisher Controls Series 2500-249 transmitters and controllers	308	Bul 34.2: 2500	Any CPI application	Easy adjustment, simple construction	−400 to 1100°F	Varies widely	Varies by model	Vertical	Sensitivity to small changes, easy reversibility
Type 2340-249 transmitter	309	Bul 11.2: 2340-249	Varied liquid level monitoring	Easy to calibrate, explosion proof	−40 to 160°F	ANSI pressure rating varies	± 0.5% of span	Variable	Several transmitter/displacer combinations to choose among, internal or external displacers
Type 2100 switch	310	Bul 32.2: 2100	Safety shutdown systems, oil and gas production	Reliability, cleaning ease	−20 to 400°F	Up to 1440 psig	N/A	Vertical	Corrosion-resistant materials, magnetic operation, compact design
Brooks Instrument Division, Emerson Electric Company Omnitrol 600, 700 series	311	Bul B-610	Level switching	Constant engaged magnetic switch field	−300 to 750°F	To 5500 psi	± ⅛"	Horizontal, vertical	U/L, CSA-approved switch housings

Float

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Series 700 switches	239	Series 700 lit	Liquid level alarm	High reliability	−300 to 1000°F	−15 to 2250 psi	½" H_2O	Horizontal or vertical	Available in exotic materials, any piping arrangement
Harwil Corp. Mdls L-30, L-30CR, L-20, L-20VCR	240	Level switch lit	Depends on model	Easily accessible side mount	To 200°F	To 200 psig		Horizontal	Can be simply threaded into 1½ NPT hole or fitting

Float

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
ITT McDonnell & Miller PFC control	241	Bul SL-PFC	Liquids to indicate level	Pneumatic operation	406°F	250 psig	1/16"	Vertical	For hazardous use since no electrical service needed; direct or reverse-acting models
VFC and VFS	242	Bul L-174	Liquids to indicate level	Up to 3 switches for 6 functions	406°F	250 psig	1/16"	Vertical	Can be top- or side-mounted using chamber; accurate control
Jo-Bell Products, Inc. Model "A" control (Seven others described in catalog)	243	Cat L2	Liquids to minimum spec. gr. of 0.5	Compact, ease of mounting	−385 to 400°F	Vacuum to 500 psi	±1/8"	Horizontal	Adjustable differential, explosion-proof, flange mounting available
Krohne-America Inc. BM-26 meter	244	BM-26 lit	Liquid levels	Temperature-independent			0.5% of FS	Vertical	High level/low level/fail alarm
Switch Systems, Inc. Mercury Monitor FW, FG series	245	Mercury Monitor bro	Tank surveillance and control	Easy to install	To 150°F		±5%	Horizontal	ABS shell, Neoprene cord
Transamerica Delaval Inc., Gems Sensors Div. Liquid Level switches	312	Bro HS3-681J	Monitor/control water, oil, chemicals	Reliability, accuracy	−32 to 400°F	3000 psig	±1/16"		One moving part, hermetically sealed reed switch
Vanton Pump & Equipment Corp. Levl sensors	313	Cat 30.0	Pump and system protection	High reliability, all-plastic construction	To 250°F	250 psig		Vertical	Self-cleaning floats, fast action, electrical components sealed
Zi-Tech Division, Alkenwood Corp. Karl 24	314	Karl bul	Any large container, tank, reservoir	Multiple, adjustable switching levels	0 to 140°F	To 280 psi	n/a	Vertical	Operates in almost any liquid, needs no maintenance
Fisher Controls Series 220 sensors	315	Bul 61.7:220	Liquid level detection in all types of vessels		To 660°F	To 700 psig	N/A		Used with firm's Type 772B on/off controller or Type 779K proportional controller
Stevens International, Inc. Checkerbob Mdl 4100	316	Mdl 4100 lit	Intermittent or continuous level measurement	Easy to install, low maintenance					Self-actuating timer, multiple switch, and special cones for low-density material
Masoneilan Division, McGraw Edison Co. Mdl 12120 level transmitter	317	Bul BU 5000E	Inventory and valve control	Unaffected by reasonable build-up or dielectric constant or specific gravity changes	−350 to 850°F	To 2500 lb	±1.00%	Horizontal, vertical	Two-wire transmitter, simple calibration procedure, reliable control capability
Industrial Control Co. Type 1119A/1120A	335	Type 1119A/1120A lit	Lube oil monitor	Synchro output	Ambient	Atmospheric		Vertical	
Hersey Products, Inc. Mdl 5000 series	340	Series 5000 lit	Continuous monitoring of multi-tank applications	Variety of upgrading accessories available					Intrinsically safe for Class 1, Division 1, Group C and D hazardous locations

Float and Tape

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Type 803 level transmitter	246	Type 803 lit	Large storage tanks	Long life	0 to 180°F	0 to 5 psi	¼% FS	Vertical	Isolated output, infinite resolution
F.I.C. Industries, Inc. Mdl 1121 gauge	247	1121 lit	Chemical and petroleum storage tanks	High accuracy	−20 to 150°F	0 to 150 psi	.010" in 100'	Vertical	Also detects by conductivity or capacitance, dual measurements with one sensor transmitter
Leupold & Stevens, Inc. Type A-71 recorder	248	Bul 12	Stream gauging, ground water studies	Long-term unattended operation	0 to 50°C/30 to 110°F/0 to 45°C	N/A	±.02' of head	Horizontal	Easy in-field change of chart speed and recording ratio; months of unattended operation
NMC Controls Inc. Mdl 2100 tank gauging system	249	Bro 2100	Reporting levels of storage tanks	2-wire communications line	Optional	Optional	±1°F, ±1/16", ±1mm	Any way	In-house software capabilities allows microprocessor to be configured many ways

Glass and Magnetic Gauge

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Penberthy Houdaille Direct-reading liquid level gauge	250	Bul 2100	Refinery and chemical processing		−300 to 600°F	To 5000 psig	Vision	Vertical	Units available for wide range of temperatures and pressures
Daniel Industries, Inc. Flow Products Division Reflex gauge	341	Bro DFP-364-5M	Rapid visual indication of liquid level	All liquids appear black in high contrast to mirror-like surface	750°F max.	400 psig			Tempered borosilicate glass used

Hydrostatic pressure

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Moore Products Co. Mdls 19L1, 19K1	251	Bul GC-19A	Open tank liquid level measurement	Inexpensive, non-fouling type sensor	−40 to 350°F	0-50 psig	¼% to ½%		Submersible installation, simple construction, 1:1 pressure transmission

Inductive

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Veeder-Root Co. Series 7785 switches	252	Bro 6284	To detect without contact	Self-contained variety of sizes	−25 to 70°C	Not for pressure use	±.0005"	Any way	Long life, solid-state, available in AC or DC models

Infra-red

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Enraf-Nonius Mdl 1748.911 level alarm	253	Bul 1748.911	High-level liquid alarm	Self-checking	−58 to 175°F	To 580 psi		Horizontal or vertical	Intrinsically safe
Genelco, Inc. Levelite 303, 510, 520, 603, 810, 820	254	Levelite lit	Corrosive liquids, high-purity liquids, non-conductive liquids	No moving parts, compact, simple	−20 to 250°F	500 psi max.	Better than 1/64"	Any way	Solid-state control circuitry, corrosion-resistent, low power consumption
Zi-Tech Division, Alkanwood Corp. Z10/Z20 controls	255	Bul 0979/510	Any liquid container	Reliable, no moving parts	−29 to 70°C	To 280 psi		Any way	Sensitivity adjustment, dual probes
Series 3000	256	Bul 0777/3000	Non-contacting applications	All solid-state	−50 to 70°C	N/A		Vertical	No moving parts, easy level adjustment

Microwave

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Delavan Electronics, Inc. Microwave Type 1	257	Bro 1680A −679	Hot, corrosive process materials	Non-contact, no user license needed	Unaffected		± 1/4"	Horizontal	No moving parts, self-proving feedback loop for high reliability

Optic Sensor

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Dover Corporation/ OPW Division Optic liquid level monitor	265	NP-OLLS	Storage and transport of petroleum-based products	Solid-state, lack of electrical energy in storage compartment	−40 to 158°F	Atmospheric to low pressure	Response time is 1/2 sec.	Vertical recommended for probe	No moving machine parts, completely self-checking, CSA and FM-certified and approved as intrinsically safe

Paddle

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Gould R.B. Denison Mdl C5880	258	Spec sheet C5880	To control feeding of hoppers, surge bins, drums, and silos	Prevents overfilling, under filling, or material waste	0 to 185°F	Needs only 5"-ounce operating force	± 2°	Vertical	Curved paddle arm attachment, 10-amp continuous NEMA A600 switch
Monitor Manufacturing Bin-O-Matic	259	Bul 129	Point level detection of solids in storage	Low cost, easy maintenance	−57 to 300°F	Vacuum to 30 psi	Point level	Any way	Adjustable sensitivity, floating motor mount, stainless steel wetted parts

Pressure/resistive

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Metritape, Inc. Type L/T-AFC sensor	260	Bul L/T-AFC	Chemical and petroleum tanks	No moving parts, accessible from tank top	−20 to 225°F		±10mm	Vertical	One penetration measurement, all-Teflon outer surfaces, intrinsically safe
Ametek Controls Division Mdl 570 Series	261	Bul IC-4 81	Water level management	Inexpensive, simple, and accurate	33 to 150°F	5 to 300 psi	±3%		Eliminates need for bubbler systems

Radiation

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Texas Nuclear, A Subsidiary of Ramsey Engineering Mdl 6400 system	262	Bro 6400	Fly ash	Monitor up to 64 detection points on one microprocessor panel	−20 to 200°F		±0.25		Combines digital-signal and pulse counting techniques, has self-diagnostic features
CNH continuous level gauge	263	CNH Series bul	Continuous level uses	Unrestricted process temperatures	−20 to 140°F	Not affected	±1% of span	Any way	Full line of system configurations available
PND Series	264	PND Series bul	Point level detection in the process industries	Not affected by temperature, pressure, or corrosives	−40 to 170°F	Not affected	±1/8"		100% digital signal and data handling circuitry

R-F Admittance

Company & Product:	Circle No.	Litera-ture	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Instal-lation:	Features:
Drexelbrook Engineering Co: Z-Tron™ point level switch	266	Bul 502-LA	Controlling levels of liquids, wet or dry granulars, slurries, interfaces	No moving parts, maintenance-free	−40 to 145°F	200 psi	1/64" or less level error		Ignores coating and build-up, foolproof operation, simple installation
True Level™	267	Bul 507-1000-LA	Liquids, slurries of changing composition	Dual-purpose sensing element constantly adjusts calibration	−40 to 600°F	To 5000 psi			Circuitry ignores coating build-up on sensing element
UniversaLevel™ transmitter	268	Bul 508-6200-LA	Liquids, slurries, granulars, interfaces	Intrinsic safety, low cost, low maintenance	−40 to 160°F	2mm absolute to 20,000 psi		Vertical	No moving parts

Sonic Echo

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Controlotron Corp. Sonic Liquilite	271	Bul 285	High or low liquid level	Fail safe (Hi or Lo level)	−400 to 260°F	2000 psi	To 1/100"	Any angle	Simple installation, no moving parts, corrosion-resistant
Delavan Electronics Sonac® system	272	Sonac bul	Dry bulk bin level, plugged chute indication	No moving parts	−65 to 400°F	To 50 psi	± 1/4"	Horizontal	No probes project into bin or chute, high reliability
Delta Controls Corp. Series 850	273	Series 850 lit	Liquids where non-contact is required	Built-in temperature compensation	−30 to 180°F	0-50 psi	1/2% of FS		Factory-aligned, built-in troubleshooting and performance lamps
Endress + Hauser Echo Systems FMU	274	Echo Systems lit	Continuous level detection of liquids or solids	Non-contact	0 to 140°F	Up to 15 psi	± 1% span	Vertical, top	Various frequencies and power levels to fit different applications
Fischer & Porter Co. Type 50US	275	Spec 50US 1000	Any use up to 72" where head can sit above liquid	Minimum maintenance	150°F	Not applicable	± 0.5% to ± 1.0%	Vertical	Easy to install, field adjustable, multiple outputs
Inventron Industries, Inc. EC 100, PC 15	276	Bro 1277	Industrial level controls, wastewater, pump stations	Non-contacting, no moving parts	−200 to 350°F	1000 psi	0.2%	Vertical	Temperature compensation, automatic calibration (optional), alarm set-points
Magnetrol International Inc. "Echotel" 83-7001	277	Bul 50-150.2	Various liquids	Easy installation	−40 to 250°F	To 1500 psi	± 1/8"	Any way	Fail safe, explosion-proof
Manning Corp. Mdls UL, UTL recorders	318	Bro UX-978	Industrial waste monitoring, tank levels, plant influent and effluent	Non-contact, wide-span capability	−40 to 176°F	N/A	± 1% FS	Vertical to flow	Analog output signal, solid-state design, automatic temperature compensation
Milltronics, Inc. MidRanger	319	Bul 573	Solids, liquids, and slurry materials	Little maintenance, easy to install	−40 to 92°C	40 to 50 psi	Better than 1% of span	Vertical	Non-contacting sensor, solid-state circuitry, two independent set-points, true current output
Level Genie	320	Bul 551	Solids, liquids, and slurry materials	Little maintenance, easy to install	−40 to 200°F	40 to 50 psi	Better than 1% of span	Vertical	Non-contacting sensor, solid-state circuitry, two independent set-points, true current output
National Sonics Sensall Mdl 501	321	Bul 105E	Tank level control	Low cost, reliability	−22 to 158°F	600 psi	1/2%	Any way	No adjustment or recalibration once unit is installed, no coating problems
Sensall 100 series	322	Bul B-1100	Dry materials, powders	Unaffected by dust, vibration, ambient light	−40 to 212°F	50 psi	1/2%	Horizontal	No moving parts, solid-state electronics, variable time delays
Sensall Mdl 880	323	Bro B-8800	Tank, bin liquid levels	Non-contacting, microprocessor-based	−22 to 158°F	To 50 psig	1/2% of FS	Vertical	Dual points, near-zone and far-zone indication, switchable modes
Marine Moisture Control Co., Inc. Gauging tape	324	Gauging tape lit	Readings of tank liquid levels	Fast, accurate			To ± 1/8"		Factory Mutual approved. Determines ullage level or levels of interface between dissimilar liquids.

Ohmart Corp. Level Art 1000	325	Bul SDBL 3780	Hot, abrasive, corrosive material level detection	Non-contact	Not affected	Not affected	±1% of FS	Vertical	Alarms, 4 to 20 mA output
Robertshaw Controls Co. Mdl 165 system	326	Spec Mdl 165	Flumes and weirs	Non-contact	−20 to 160°F		±3%	Vertical	Internal signal characterization, simple installation, highly directional beam pattern
Sonic Control, Inc. HT Series	327	Bro 1081A	Tank level measurement and pump controllers	Non-contact, maintenance-free, flexible and expandable	350°F	150 psi	±0.5% digital, ±1% analog	Vertical	Automatic tracking, integral calibration, custom-designed
WESMAR Industrial Systems Division DLM12 monitor	328	Bul LM2774-979	Liquid or solid level detection and control	Non-contact operation eliminates fouling	−8 to 65°C	0 to 50 psi	Better than ±1%	Any way	Useful in any corrosive or hostile environment
Lumenite Electronic Co. Mdl Lups-100	329	Lups-100 flt	Non-constant point sensing of any liquid	Designed for liquids that coat probes	−30 to 150°F	500 psi	Within ½%	Normally vertical	Can be field-adjusted to operate at any point over total distance range (1.5 to 15' for liquids)

Strain Gauge

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Kistler-Morse Corp. Microcell sensor	278	Bul KM 20-010	Bulk solids monitoring	Low cost, easy to install	−30 to 150°F		±5%	Vertical	Bolt-on sensor, LED display scaled 0-100% in 10% increments

Thermal

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Type 840 switch	279	Bul 840	General-purpose liquid level	Built-in time delay reduces chattering output	0-400°F	0-5000 psi	1°	Any way	All exotic materials available

Tilt

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Monitor Manufacturing TC-1, TC-1X, TC-3X	280	Bul 134R	High-level detection of large bulky material	Two-wire installation, one moving part	−40 to 300°F	N/A	Point level	Vertical	Can be operated with flashlight batteries if necessary
Ramsey Engineering Co. Tilt Switch	281	Cat 20,000	Heavy bulk materials, point level open applications	Abrasion-resistant, simple, explosion-proof	−60 to 400°F	N/A	Point level		Simple installation, solid-state control unit, adjustable time delay to 10 seconds

Vibration

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Bin Level Co. Mdl PK21WP Level Wand	282	Level Wand bro	Solid material, plastic, powder, pellets and granules	Dependable, long life	−30 to 150°F	2000 psi	± 1/10'	Any way	Explosion-proof, 1" mounting connection, 6" probe, all 316 SS wetted parts
Delavan Electronics, Inc. Sonac® system	283	Sonac lit	Liquids	No moving parts, senses virtually any liquid	−425 to 400°F	To 4000 psig	± 0.005"	Horizontal, vertical	No readjustment for different liquids or process pressure or temperature changes
Endress + Hauser Vibratrol FTM 1630	284	Vibratrol lit	Point level in solids	No adjustments or calibration	−45 to 200°F	150 psi maximum	N/A	Horizontal	Not affected by electrical qualities of material sensitive to low bulk
Monitor Manufacturing Model IF indicator	285	Model IF lit	Point level sensing, dry solid materials	Two-wire installation, field-adaptable shaft extension	−40 to 57°F	Up to 10 BAR	Point level	Any way	Cast-aluminum or alternate 316 stainless steel housing
Zi-Tech Division, Alkenwood Corp. Nohken Bin-Leveler	286	Nohken lit	Bulk materials	Simple, reliable construction	To 80°C	N/A	N/A	Any way	Various models are offered for different applications and materials

Weight and Cable

Company & Product:	Circle No.	Literature	Chief application:	Advantages:	Temp range:	Pressure range:	Accuracy	Installation:	Features:
Delta Controls Corp. Type 850	287	Type 850 lit	Inventory of solids or liquids in large tanks	Torque limiting design	−20 to 180°F	−10 to 10 psi	1/100'	Vertical	Computer interface allows direct operation and reading by a computer
Endress + Hauser Silopilot FMM 760	288	Silopilot lit	Inventory of solids storage	Accuracy	−4 to 140°F	5 psi max.	± 1/16 of one foot	Vertical, top mounting	Up to 190 lb of lifting power
Manning Corporation L-2000, L-3000 level recorder	289	Bro DIP-578	Industrial wastes monitoring, effluent monitoring	Non-fouling probe, ease of installation	32 to 122°F	N/A	± 2% of FS		Portable, impact-resistant case
Monitor Manufacturing Model CM3A/CM4	290	Bul 136	Inventory control of material in silos, both liquid and solid	Top mount, retracted except with sensing	−57 to 300°F	To 50 psi	± 2mm	Vertical plumb only	Measures silos up to 75 meters in height
Monitrol Mfg. Co., Inc. Mdl MSU III	291	MSU III lit	Proportionate level of all solids and liquids	Straight-forward indication	−1150 to −30°F	Vacuum to 50 lb/sq in	1/10th of 1% overall depth	Vertical	Explosion-proof, heavy-duty, simple design
Ramsey Engineering Co. Mdl 20-60	292	Cat 30.130	Heavy bulk material levels in bins and silos	Rugged, not affected by dust	−20 to 130°F		1%	Vertical	Continuous level measurement up to 50' vertical spans

APPENDIX F
QUOTATIONS AND MANUFACTURERS' INFORMATION

National Mine
Service Company

INDUSTRIAL SAFETY DIVISION
355N Old Steubenville Pike • Oakdale, PA 15071 • Phone 412-788-4353 • TWX 510-697-4065

February 10, 1983

RECEIVED
FEB 14 1983
... ENGINEERS
... ANGELES

D. P. Mohapatra
Metro Rail Project
425 S. Main
6th Floor, Annex B
Los Angeles, CA 90013

Dear Mr. Mohapatra:

Thank you for your interest in National Mine Service Company and our products.

Enclosed is a product bulletin covering the R5000 Fixed Point Monitor. The R5000 is a unique approach to monitoring systems. Its ability to accept signals from 4 to 20 milliamp or 10 to 50 milliamp transducers significantly broadens the application for this unit. Now you can monitor combustible gases, oxygen concentrations, pressure, temperature, etc. with the same instrument. This approach decreases spare part inventories, simplifies training of technicians, and allows your safety department to justify systems needs based on the R5000's many uses.

The R5000 has three completely independent control and signaling relays for each channel. They are standard! This extra capability allows a tremendous flexibility in alarms and control design applications of the system.

"One-man" system calibration is another important feature of the R5000 System. The Systems Test and Calibration (STAC) Unit simplifies system calibration and lowers routine maintenance cost by allowing one person to calibrate a system.

Good hope. System
Mike Formica.

Dave Jones.

Information is also included on the 200 Series Portable Instruments manufactured by National Mine Service Company. If additional information is needed, please contact your local National Mine Service Company distributor or National Mine Service Company at the above address.

Sincerely,

Larry J. Lycett

Larry J. Lycett
Sales Representative
INDUSTRIAL SAFETY DIVISION

/dh

National Mine Service Company

INDUSTRIAL SAFETY DIVISION
355N Old Steubenville Pike, Oakdale, PA Phone 412-788-4353 TWX 510-697-4065

INSTRUMENTS

		SUGGESTED LIST PRICE
1810-0008	CD210 Digital Methanometer	$ 288.00
1810-0016	LD220 Digital LEL	288.00
1810-0024	OX230 Oxygen Monitor	392.00
1810-0198	MX240 Combination Methane/Oxygen Monitor	696.00
1810-0230	MX241 Combination Combustible/Oxygen Monitor	696.00

CHARGERS

1810-0115	Five Unit Instrument Charger, 115V	206.00
1810-0123	Single Unit Instrument Charger, 115V	94.00
1810-0297	12VDC Instrument Charger	94.00
1810-0305	Single Unit Instrument Charger, 230V	98.00
1810-0362	Five Unit Instrument Charger, 230V	206.00
1810-0412	Economy Charger	47.00

ACCESSORIES

1810-0131	Leather Carrying Case, 200 Series	28.00
1810-0180	SP200 Sampling Pump	198.00
1810-0354	Leather Carrying Case, SP200	35.00
1701-3145	SP200 In-Line External Filter	8.50
1810-0248	AD200 Audio Driver	74.00
1810-0313	AD200 Audio Driver w/Earphone	96.00
1700-6933	Calibration Cup, 200 Series	2.55

REPLACEMENT SENSORS

1700-3740	CD210 Detector Block Assembly	71.70
1700-3757	LD220 Detector Block Assembly	78.00
1701-2451	LEL Detector Block Assembly, Remote	98.00
1701-0810	MX LEL Detector Block Assembly	84.00
1701-9282	Oxygen Sensor Assembly, Electrochemical, MX	108.00
1700-4698	Oxygen Cell w/Load, OX230	127.00

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

CALIBRATION KITS		SUGGESTED LIST PRICE
1810-0149	Calibration Kit w/o Gas, w/Regulator	$ 78.00
1810-0156	Calibration Kit containing non-returnable cylinders of propane at 25 & 50% LEL and a pressure regulator	117.00
1810-0222	Calibration Kit containing non-returnable cylinders of 1 and 2.5% methane and a pressure regulator	117.00

CYLINDERS, CALIBRATION GASES

1810-0164	Cylinder, Cal. Gas, 25% LEL Propane	24.00
1810-0172	Cylinder, Cal. Gas, 50% LEL Propane	24.00
1810-0206	Cylinder, Cal. Gas, 1% Methane	24.00
1810-0214	Cylinder, Cal. Gas, 2.5% Methane	24.00
1810-0289	Cylinder, Cal. Gas, 19.0% Oxygen	24.00
1810-0271	Cylinder, Cal. Gas, 20.9% Oxygen	24.00
1810-0453	Cylinder, Cal. Gas, 25% Hydrogen	24.00
1810-0461	Cylinder, Cal. Gas, 50% Hydrogen	24.00
1810-0479	Pressure Regulator, Calibration Kit	39.00

FIXED SYSTEMS

1810-0040	R5000 Central Control Station	2,585.00
1810-0057	R5000 Central Control Station, Wall Mounted	2,850.00
1810-0065	Remote LEL Sensor Module	282.00
1810-0073	Remote Methane Sensor Module	282.00
1810-0081	Remote Oxygen Sensor Module	324.00
1810-0099	Remote Power Supply, Intrinsically Safe	124.00
1810-0107	Systems Test & Calibration Module, STAC I	318.00
1810-0495	Remote Visual Alarm Module	128.00
1810-0503	Junction Box, 3 Hub, w/Terminal Block	42.50

GASBADGE

1890-0092	Organic Vapor Monitor Kit	1-9	83.50
		10+	71.00
1890-0076	Analysis/Collection Kit	1-9	42.00
		10-49	37.00
		50+	33.60
1890-0068	Replacement Elements/Box of 10	1-49	24.60
		50+	22.00
1890-0498	Replacement Elements, Dust Shields and Labels Package of 200		350.00

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

BACHARACH

CD 850/CD 860

Four Channel Gas Detection and Monitoring System

UNITED TECHNOLOGIES BACHARACH

Bacharach Instruments
301 Alpha Drive
Pittsburgh, PA 15238
(412) 782-3500

WARRANTY POLICY

Bacharach Instrument Company, Division of AMBAC industries, Inc. warrants that this product will perform properly in the application for which it is intended, and that it is free of defects in material and workmanship. This warranty is applicable for one year from the date of purchase by the original user. We will repair or replace the product, when returned to us with transportation paid and, upon examination, it proves to be defective and not abused, misused,altered or damaged.

This warranty does not apply to products or parts which are expendable in normal use or have a limited shelf life, as indicated in the related Operating Instructions. This warranty expresses the full extent of our intended liability, and may not be construed as covering removal or replacement costs, or contingent expenses of any other nature.

Filters, lamps, fuses, etc., being expendable items, are excluded from the terms of this warranty.

SECTION 1

DESCRIPTION

CD850 FOUR-CHANNEL GAS DETECTION AND MONITORING SYSTEM

The Bacharach CD850 Four-channel Gas Detection and Monitoring System consists of four combustible gas detectors and a four-channel control unit. Detectors can be located in four separate areas in which combustible gases or vapors may be a hazard. The control unit, common to all four of the detectors, may be located in a remote safe area, where it operates to process gas analog signals from the detectors. The control unit responds to gas signals with percent Lower Explosive Limit (L.E.L.) meter gas concentration readings, and with front panel warning and alarm lights to signal the presence of dangerous concentrations of gas. If detector or detector circuitry failures render a channel temporarily inoperative, this also is signaled for each channel by a front panel failure indicator light. Internal relays activated by warning, alarm, and failure signals may be used to switch external annunciators and to control gas and fire control devices such as blowers, valves, and deluge systems.

The four-channel gas detection and monitoring system may be operated in either of two modes—an auto mode in which the percent L.E.L. meter and recorder respond to the individual detector that has the strongest signal; or a manual channel selection mode in which meter and recorder monitor the area selected by means of a manual control switch.

DETECTOR AND DETECTOR AMPLIFIER ASSEMBLY (Figure 1-1)

Each of the four detectors of the CD850 system contains a matched pair of resistor filaments; one coated with a catalyst that oxidizes combustible gases, and the other uncoated, upon which no oxidation of combustible gases occurs. The two resistor filaments, coated ("active") and uncoated ("reference"), are connected in series across a 6-volt power supply. So connected, the coated and uncoated resistor filaments divide the applied voltage equally in proportion to the equal resistance values. A third lead connected between the two resistors carries the voltage at this point (3 volts if no combustible gas is at the detector) to an amplifier circuit, which is housed in a junction box to which the detector is attached. A second input

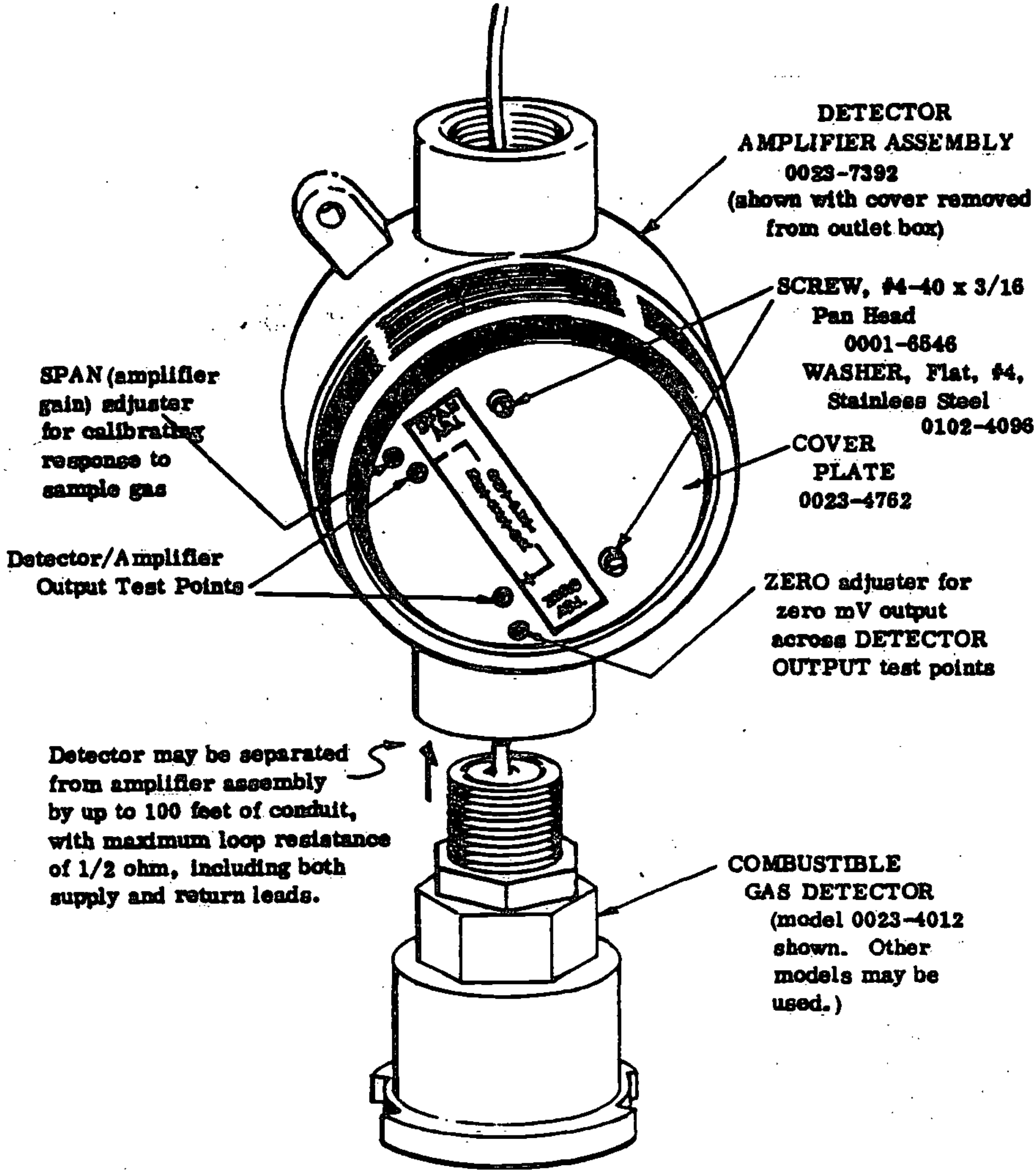


Figure 1-1. CD850 Detector and Amplifier

to the amplifier from a voltage divider on the amplifier printed circuit board provides a standard 3-volt reference voltage with which to compare the signal voltage from the detector. In the absence of combustible gas at the detector, the 3-volt detector signal voltage equals the 3-volt voltage divider reference voltage at the operational amplifier inputs, so that the amplifier produces no output signal.

When combustible gases or vapors appear at the detector, the electrical signals from the detector change in proportion to the concentration of gas or vapor. Combustible gas is oxidized on the catalytic coating of the detector "active" filament to heat and consequently increase the resistance of this filament. Now the constant 6-volt power supply voltage applied across the series-connected active and reference filaments in the detector divides, not equally as in the no-gas condition, but in proportion to the differing resistances. The more gas, the more heat from oxidation on the catalytic filament, and the higher the resistance of this filament. With higher resistance comes a larger voltage drop across the resistance, so that the voltage at the signal lead between the coupled resistors becomes less. Consequently, the signal voltage and the standard reference voltage at the two inputs of the operational amplifier differ, resulting in a signal output from the amplifier. The amplifier output signal, an electrical analog of the concentration of combustible gas at the detector, is conducted to the remote system control unit for further processing.

CONTROL UNIT PLUG-IN MODULE (Figure 1-2)

The CD850 control unit contains components and circuitry for processing detector signals, for indicating instrument operating state, for indicating gas conditions at the detector, and for switching external devices in response to warning-level, alarm-level, and failure-level signals.

In operation, the signal emanating from the amplifier in the remote junction box is applied to a second amplifier within the control unit, where it is compared with a reference voltage. Any signal present is applied to channel selector circuitry to turn on a channel indicator lamp serving either the detector with the strongest signal (auto mode), or the detector selected by the manual selection switch (manual selection mode). The amplified signal is also utilized to drive the percent L.E.L. meter located on the control unit front panel and to provide an output signal to drive a recorder or other high-impedance external analog device. The same amplified signal is also compared to reference voltages in a warning trigger circuit, an alarm trigger circuit, and a failure trigger circuit. When signal strength exceeds reference voltages, these circuits turn on channel indicator light-emitting

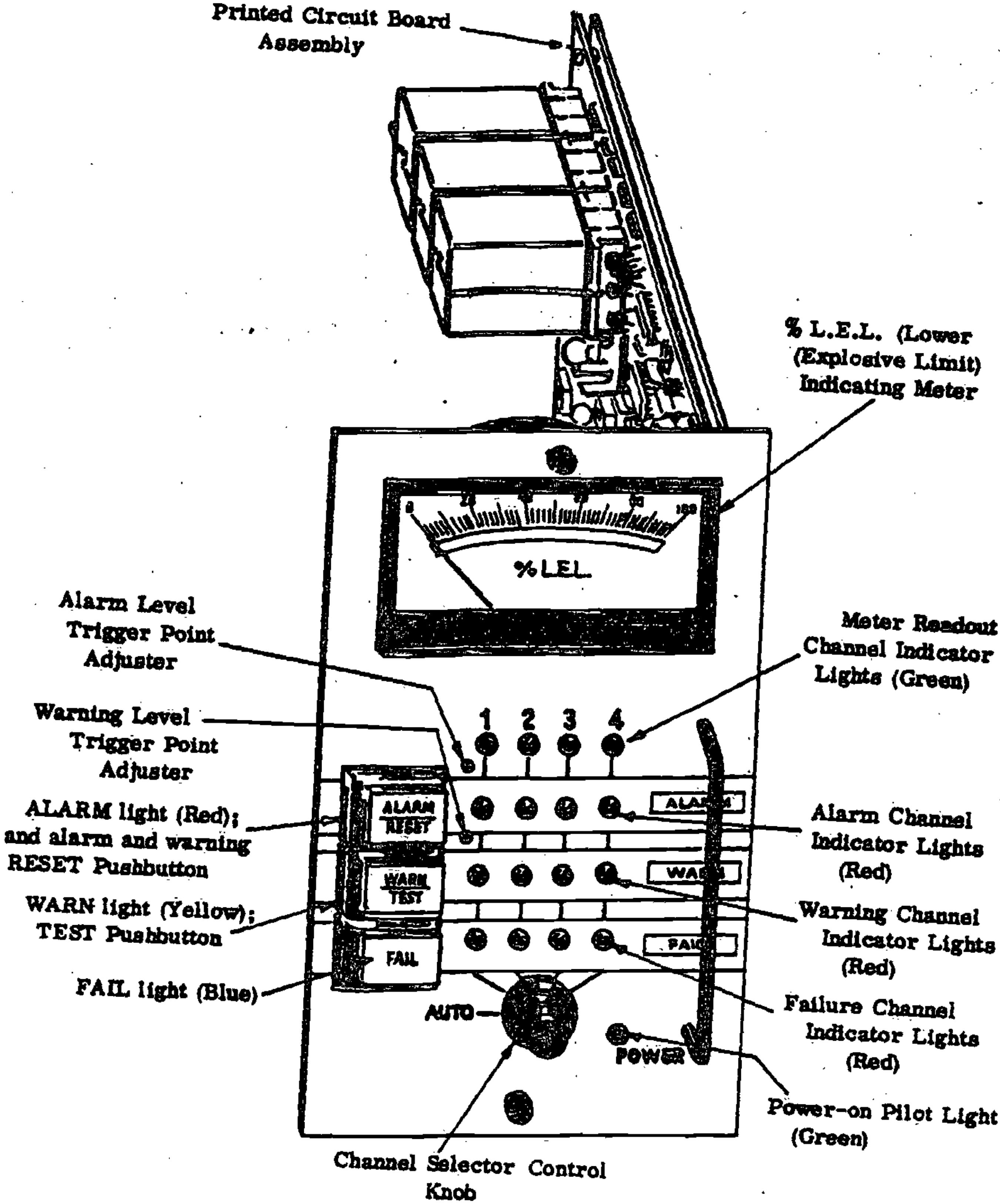
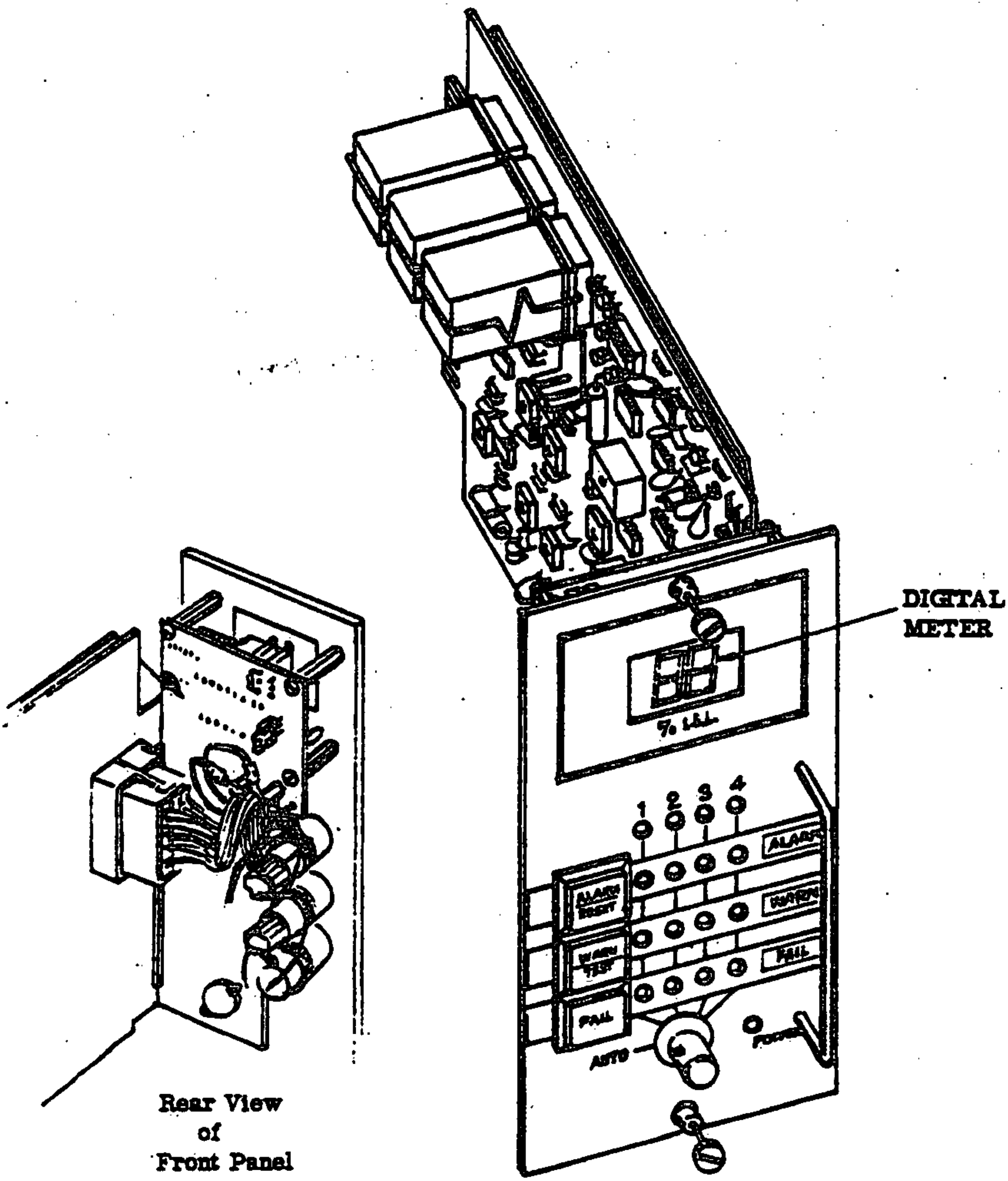
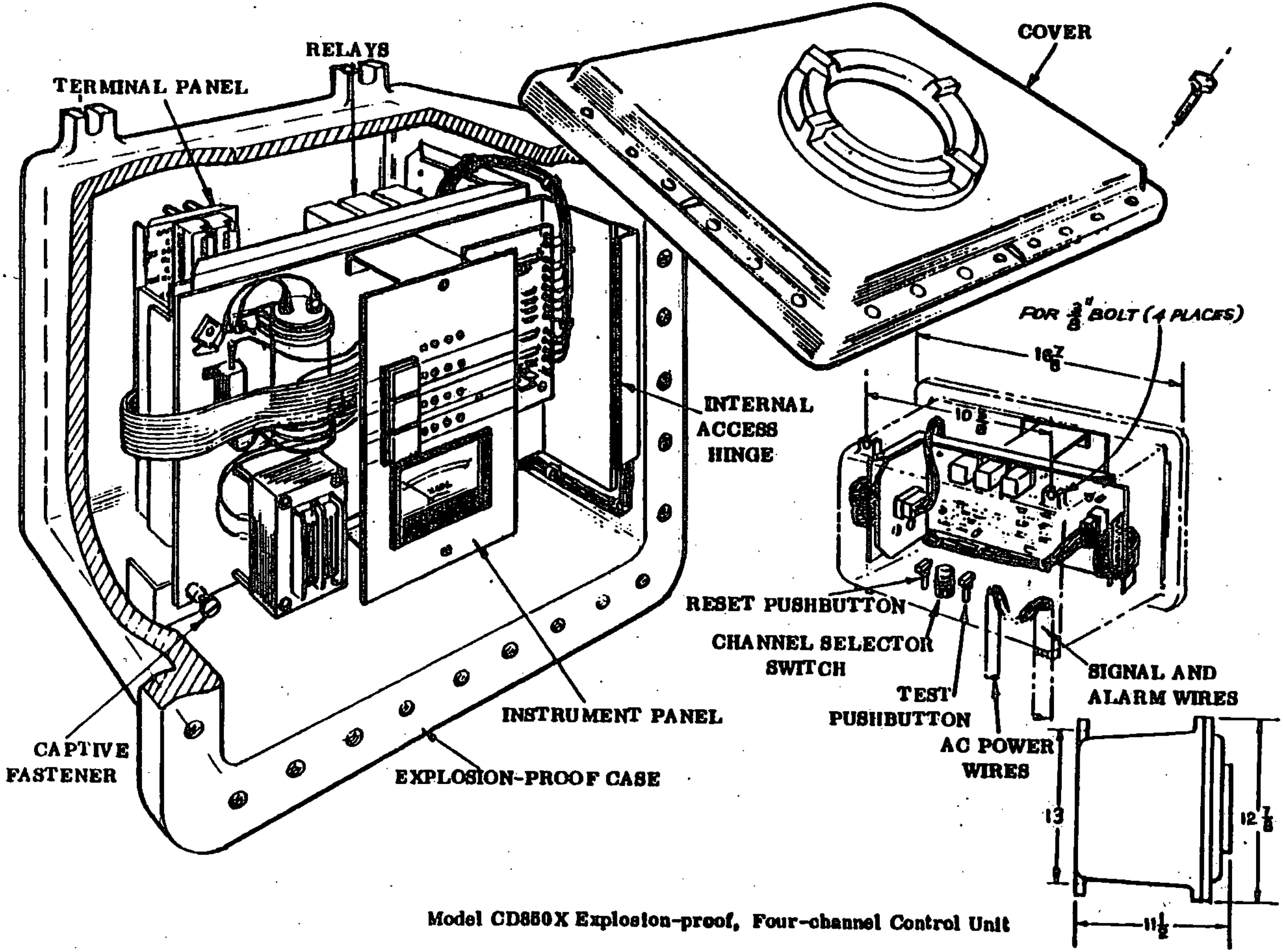


Figure 1-2. CD850 Plug-in Module Assembly 0023-4869: Front Panel Indicators, Controls, and Adjusters



CD860 Plug-in Module Assembly 0051-7096



Model CD850X Explosion-proof, Four-channel Control Unit diodes for channel identification, and larger, brighter, panel lights for signaling gas warnings and alarms or detector circuit failures. An oscillator circuit operates to blink the WARN and ALARM front panel lights until a front panel RESET pushbutton is pushed, whereupon the lights will go out if hazardous gas conditions have cleared at all detectors, or remain on steadily without blinking if hazardous conditions continue at any of the detectors. A subsequent high-gas-concentration signal from any of the detectors while a signal light is steadily on will cause the light to return to the blinking state.

INDICATORS (Figure 1-2)

PILOT LIGHT (Figure 1-2). A green, light-emitting diode, located at right near the bottom of the control unit front panel, glows to indicate that external power is applied to operate the control unit circuitry (AC or DC power applied to designated terminals).

PERCENT L.E.L. INDICATING METER (Figure 1-2). The percent L.E.L. (Lower Explosive Limit) indicating meter, located near the top of the control unit front panel, is scaled to indicate combustible gas or vapor at one of the detectors in concentrations from 0 to 100 percent of the Lower Explosive Limit. In auto mode, the meter responds to the detector sending the strongest signal—signifying the highest concentration of gas. In the manual operating mode, the meter responds to the detector channel to which the manual mode selection switch is set.

CHANNEL INDICATOR LIGHTS (Figure 1-2). A horizontal row of four green, light-emitting diodes, located on the control panel immediately below the percent L.E.L. meter, serves to indicate by number the detector to which the meter is responding. The number above the glowing light indicates the detector at which the highest concentration of combustible gas exists if the mode selector switch is set to AUTO, or the channel to which the selector switch is set if other than AUTO.

ALARM INDICATOR LIGHTS (Figure 1-2). An ALARM indicator light with red lens cover, located at left of the horizontal red band on the control unit front panel, glows red while alarm-level concentrations of combustible gas are present at any of the detectors. One or more of four red light-emitting diodes also glow in the red horizontal band to indicate the detector channels in which the alarm signal exists. The larger, square-lens alarm light at left blinks until the lens cover/RESET pushbutton is pushed, whereupon the light goes out if the alarm signal is no longer present in the circuitry, or glows steadily rather than intermittently if the signal persists.

INDICATORS (continued)

WARN INDICATOR LIGHTS (Figure 1-2). A WARN indicator light with yellow lens cover, located at the left end of the horizontal yellow band on the control unit front panel, glows yellow to indicate warning-level signals from any of the four detectors. One or more of four red, light-emitting diodes also glow in the yellow horizontal band to indicate the detector channel(s) in which a warning level signal exists. The WARN light blinks until the ALARM/RESET lens cover/pushbutton is pushed, whereupon the WARN light goes out if the warning signal is no longer present in the circuitry, or glows steadily rather than intermittently if the signal persists.

FAIL INDICATOR LIGHTS (Figure 1-2). A FAIL indicator light with blue lens cover, located at left of the horizontal blue band on the control unit front panel, glows blue to indicate electrical malfunctions in any of the detector circuits. One or more of the four red, light-emitting diodes in the blue horizontal band also glow to indicate the detector or detectors having sensor element or circuit malfunctions. The FAIL light will continue to glow until the malfunction is corrected.

METER/RECORDER SIGNAL OUTPUT. A signal output is provided across terminals 16 and 17 of control unit terminal board TB-1 (labeled SIGNAL OUTPUT, + and -, Figure 2-9) to operate an external remote meter or recorder if desired. Unless otherwise specified, this output is factory-set for a zero to 1-volt range, although other ranges are available on special order. A current output ranging from 4 mA (zero level) to 20 mA (full-scale level) is also available if so ordered.

CONTROLS (Figure 1-2)

CHANNEL SELECTOR (Figure 1-2). The channel selector control knob, located at bottom center on the control module front panel, may be turned to AUTO position to switch to the automatic mode in which the detector channel with the strongest signal is monitored with the percent L. E. L. meter and signal output. Or the control knob may be turned to select manually any one of the four channels for individual monitoring. (Warning, alarm, and failure signal lights and channel identification lights continue to respond to conditions in individual channels.)

TEST PUSHBUTTON (Figure 1-2). The TEST pushbutton operates a switch located behind the yellow WARN light lens cover (labeled WARN/TEST), which also serves as the pushbutton. When closed, the TEST pushbutton switch imposes a voltage equal to full-scale percent L. E. L. meter deflection (100% L. E. L.) on signal processing circuitry.

WARN and ALARM lights also respond to this test by blinking if control unit processing circuitry is functioning properly. Optionally, the TEST switch can be wired to prevent warning and alarm relays from operating in the test mode (by clipping jumper from "E7" to "E8" between large resistor R108 and CR32) if so specified.

RESET PUSHBUTTON (Figure 1-2). The RESET pushbutton operates a switch located behind the red ALARM light lens cover, which also serves as pushbutton. The RESET pushbutton switch acts to open the relay latching circuits for the WARN and ALARM lights and external warning and alarm annunciators if installed. The switch is used after incoming warning or alarm signals or operation of the TEST pushbutton have turned on WARN and ALARM lights and external annunciators. If warning and alarm signals have disappeared from all channels, the WARN light, ALARM light, and external annunciators will be switched off by operation of the RESET pushbutton. If warning or alarm level signals remain at any of the detectors, the WARN and ALARM lights will not go off, but will stop blinking and change to a steady glow in response to operation of the RESET switch. A subsequent high-gas-concentration signal from any of the detectors while a signal light is steadily on will cause the light to return to the blinking state and necessitate the reuse of the RESET pushbutton.

An optional remote, externally operated pushbutton switch may be installed as described in paragraph

OPTIONAL EXTERNAL ANNUNCIATORS AND CONTROL DEVICES

The XD550 control module contains relay circuit output terminals for switching optional external horns, buzzers, lights, fans, or solenoid control switches, etc., drawing currents not exceeding 3 amperes (non-inductive load). The internal relay switches may also be used to switch larger external relays to operate or turn off equipment such as air blowers or process control motors that may require greater-than-3-ampere currents. Common to all of the four channels of a control module are terminals provided for one normally open and one normally closed external circuit for warning, alarm, and failure signal outputs. Four additional channel high-alarm signal output terminals are also provided to which external relays may be connected for individual alarm signals from each channel. Maximum load at these terminals is 60 mA (400-ohm device) at 24 volts energized in alarm condition.

DETECTOR MODELS

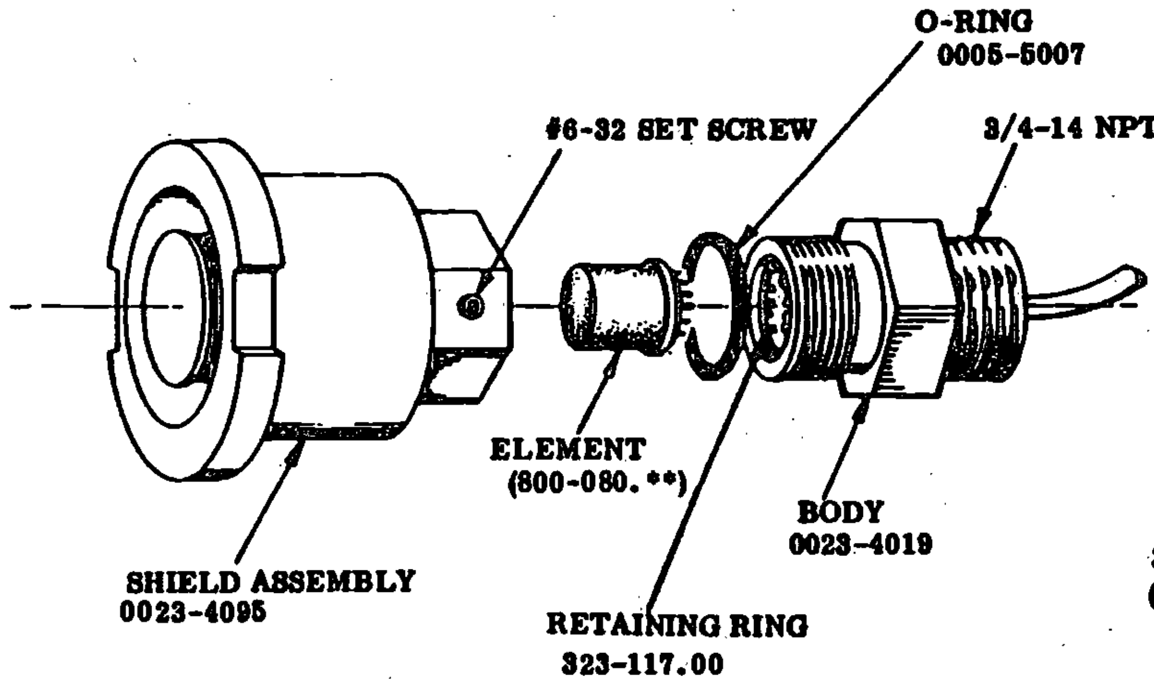
Different environments frequently require different detector housings and air sampling techniques. Three detector models are available to meet these varying needs. (Up-to-date Factory Mutual and Canadian Standards Association listings are available from the manufacturer.)

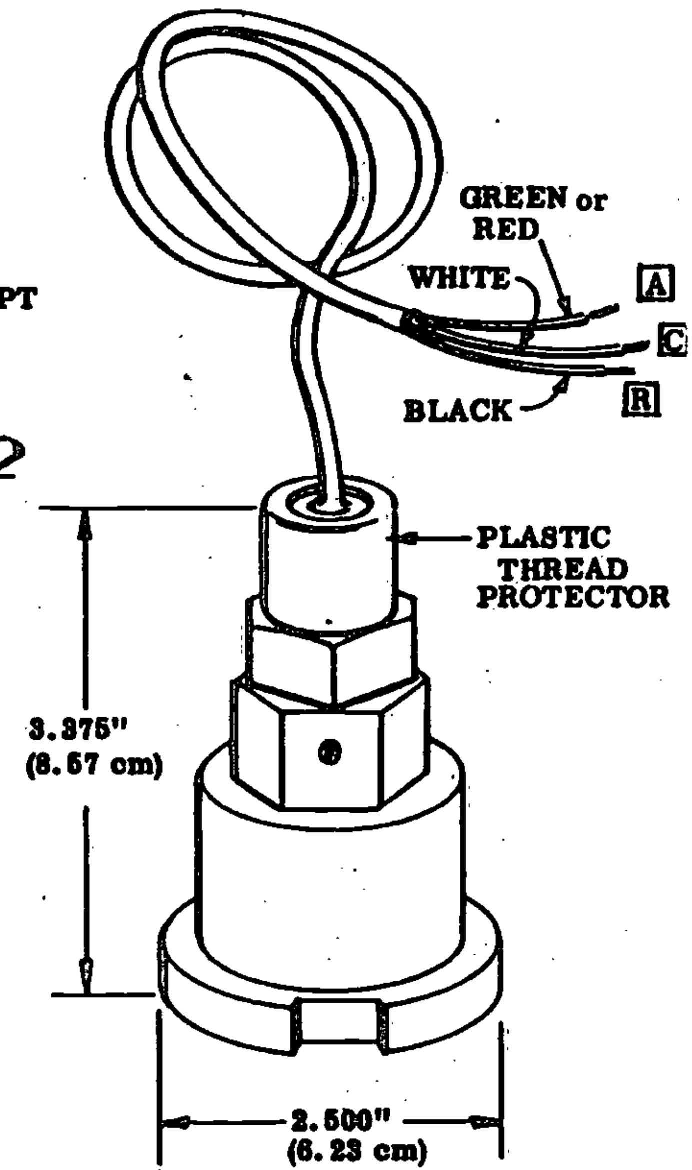
Catalytic sensor elements in all models have flame-arrestor caps to prevent ignition of combustible gases in the air. Each detector assembly has a 5-layer mesh monel screen enclosing the plug-in sensing element, providing redundant flame-arresting protection.

Detector model 0023-4012: remote mounting, explosion-proof, weatherproof detector housing; diffusion sampling; approved for use in hazardous areas as defined by National Electrical Code (N.E.C.), Class 1, Division 1, Groups A, B, C, and D.

Detector model 0023-4014: duct-mounting, explosion-proof detector housing; diffusion sampling; approved for use in N.E.C. Class 1, Division 1, Groups A, B, C, and D hazardous areas. Because the mounting plate may not always be a suitable interface between Division 1 and less hazardous areas, the 0023-4014 detector is approved for use entirely within a Class 1, Division 1 area, or for insertion into a Class 1, Division 2 area.

Detector model 0023-4017: remote mounting detector housing with integral air aspirator for continuous sample drawing. Sample gas is transported to the sensor through a length of tubing from enclosed areas, tanks, and vessels not otherwise accessible; from high-velocity gas streams; from areas containing more dirt or moisture than desirable for diffusion sampling; from nitrogen-inerted atmospheres where air blending is required; from elevated-temperature areas (200° F or higher); or in any situation where sample conditioning is required. (e.g.: If flash point of combustible material is greater than 70° F, sample line and detector must be heated to above flash point.) Approved for use in N.E.C. Class 1, Division 1, Groups A, B, C, and D hazardous areas.

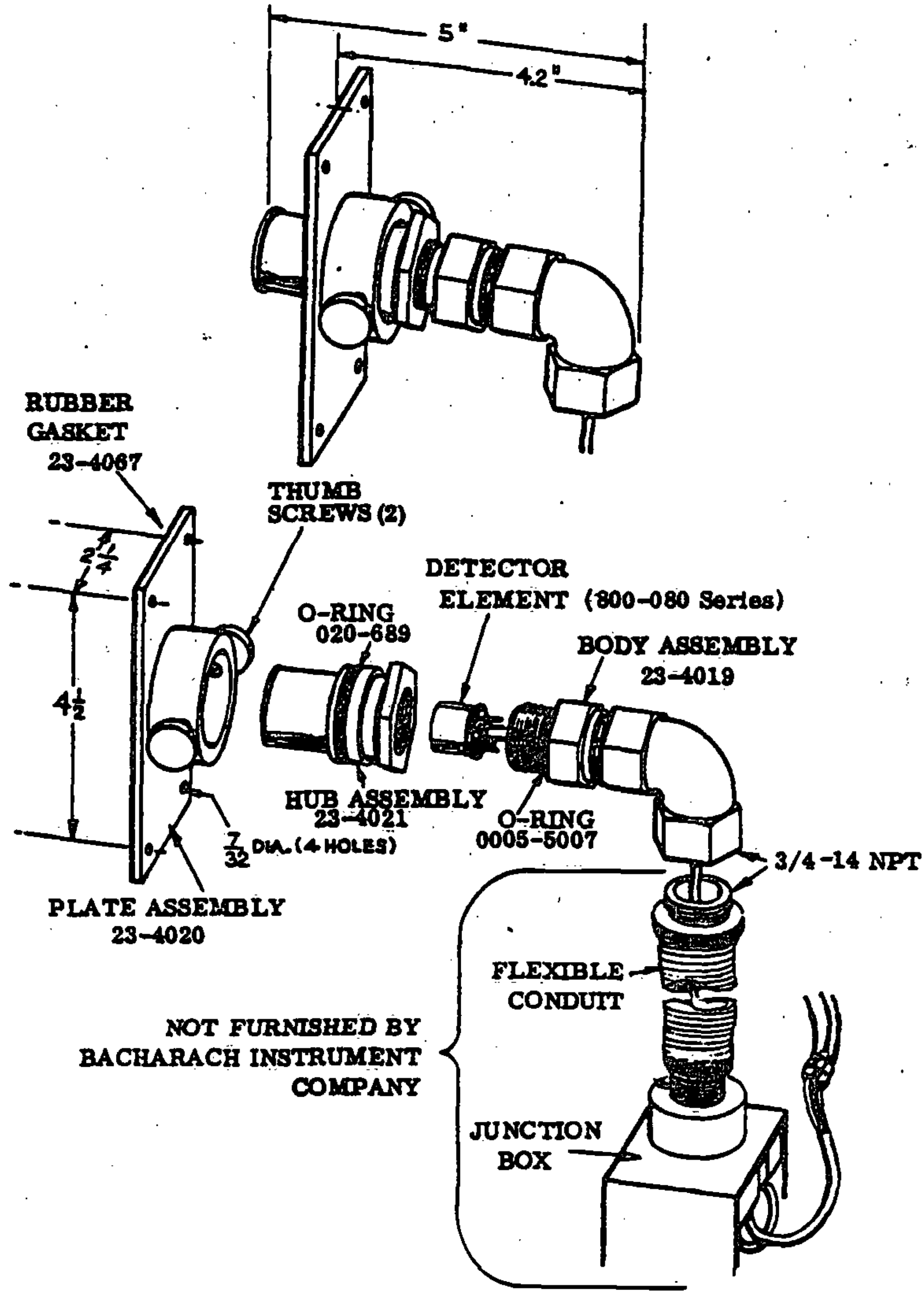




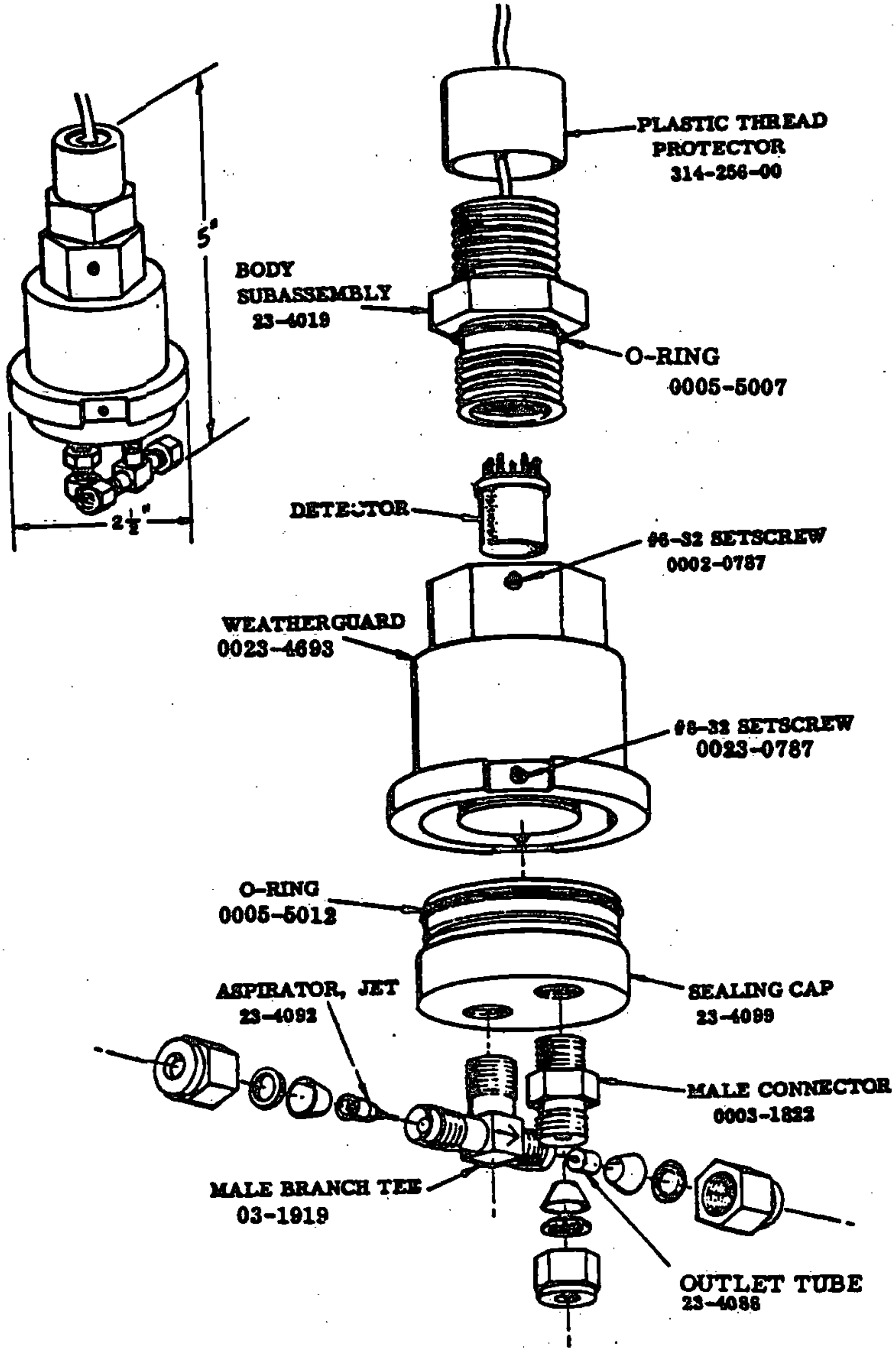
**

.10 for Methane and Natural Gas
.20 General-Purpose
.40 for Hydrogen
.50 for Olefins (Ethylene, Ethylene Oxide, etc.)

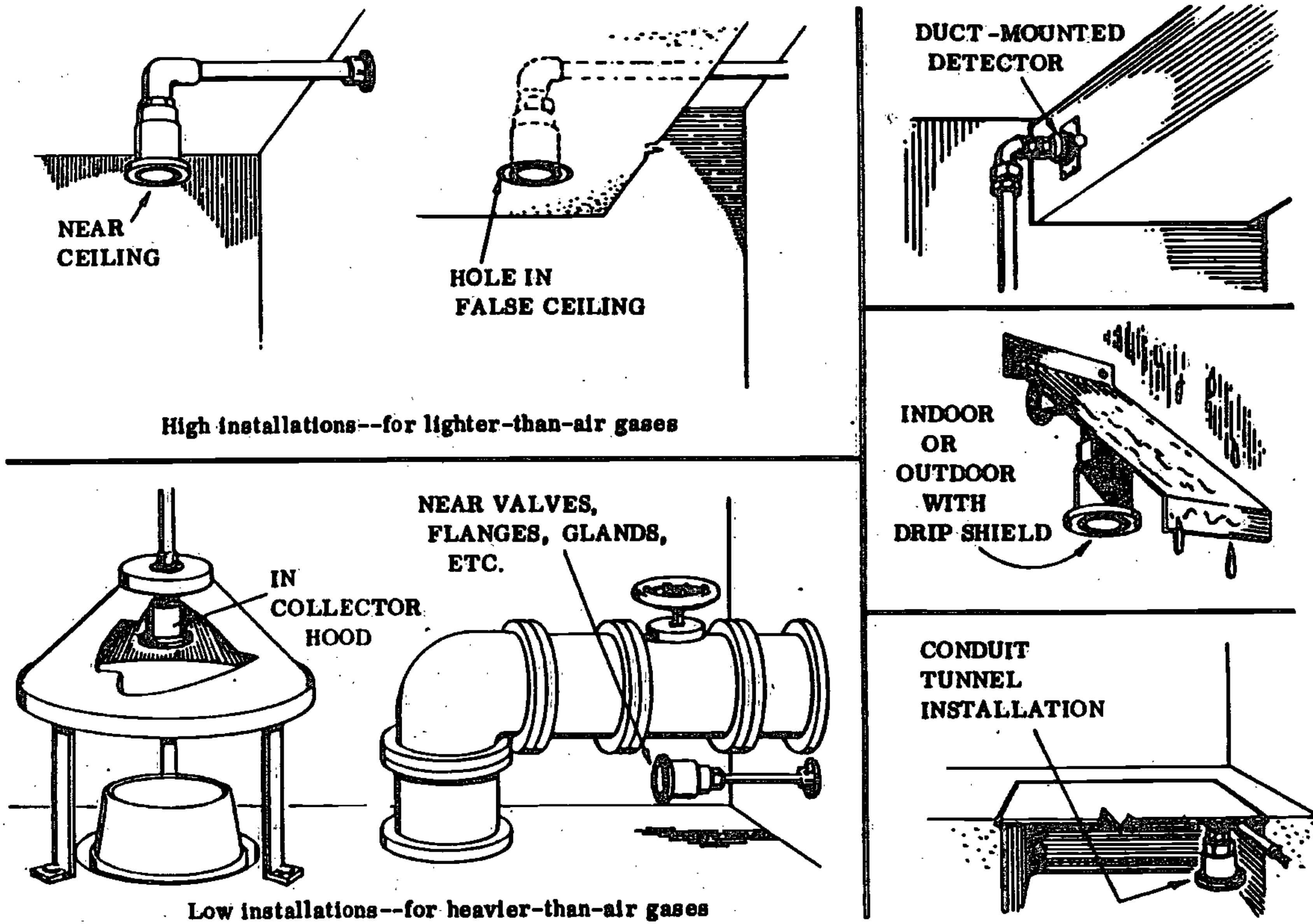
Detector Model 0023-4012 Exploded View



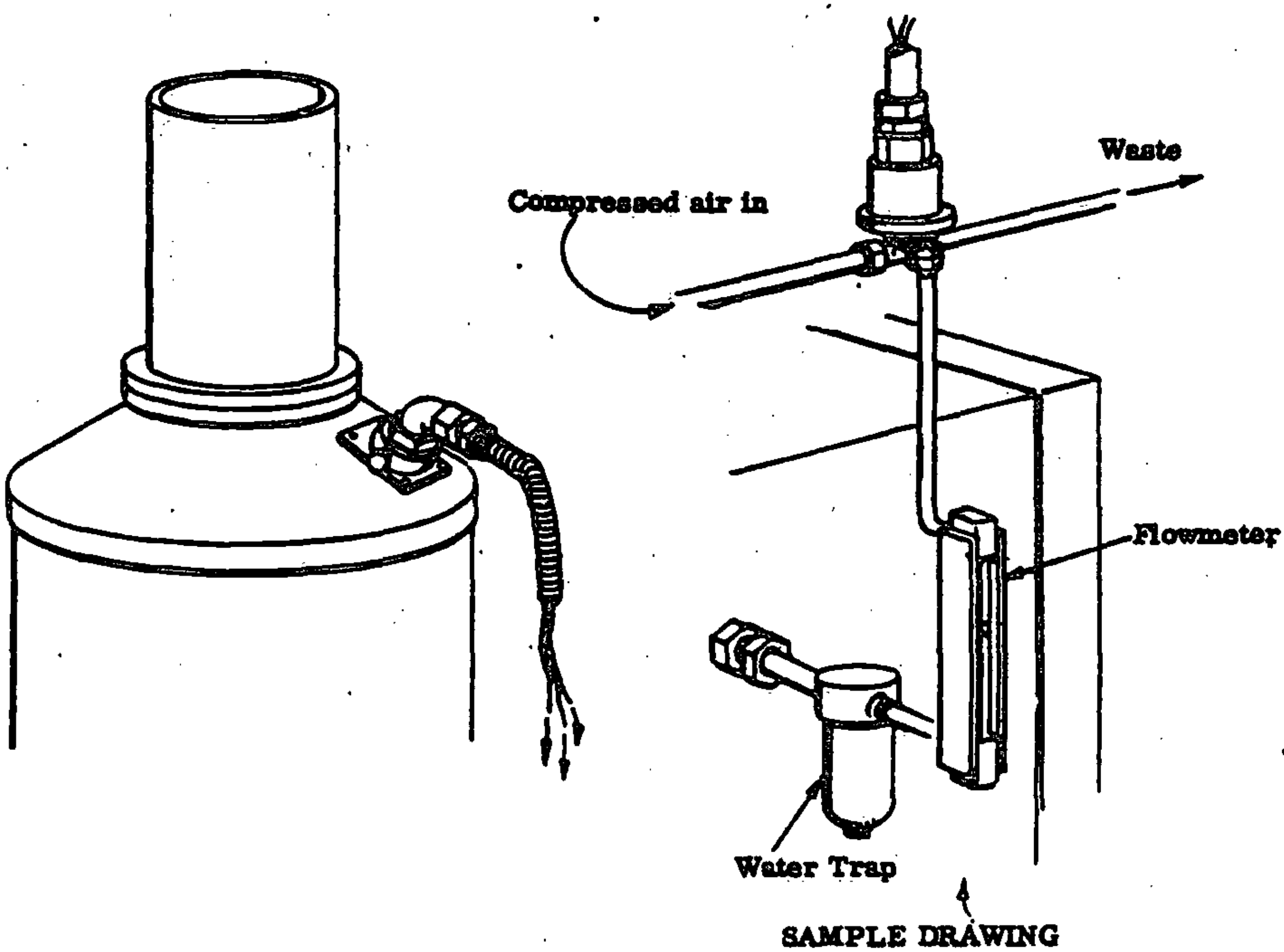
Detector Model 0023-4014 Exploded View



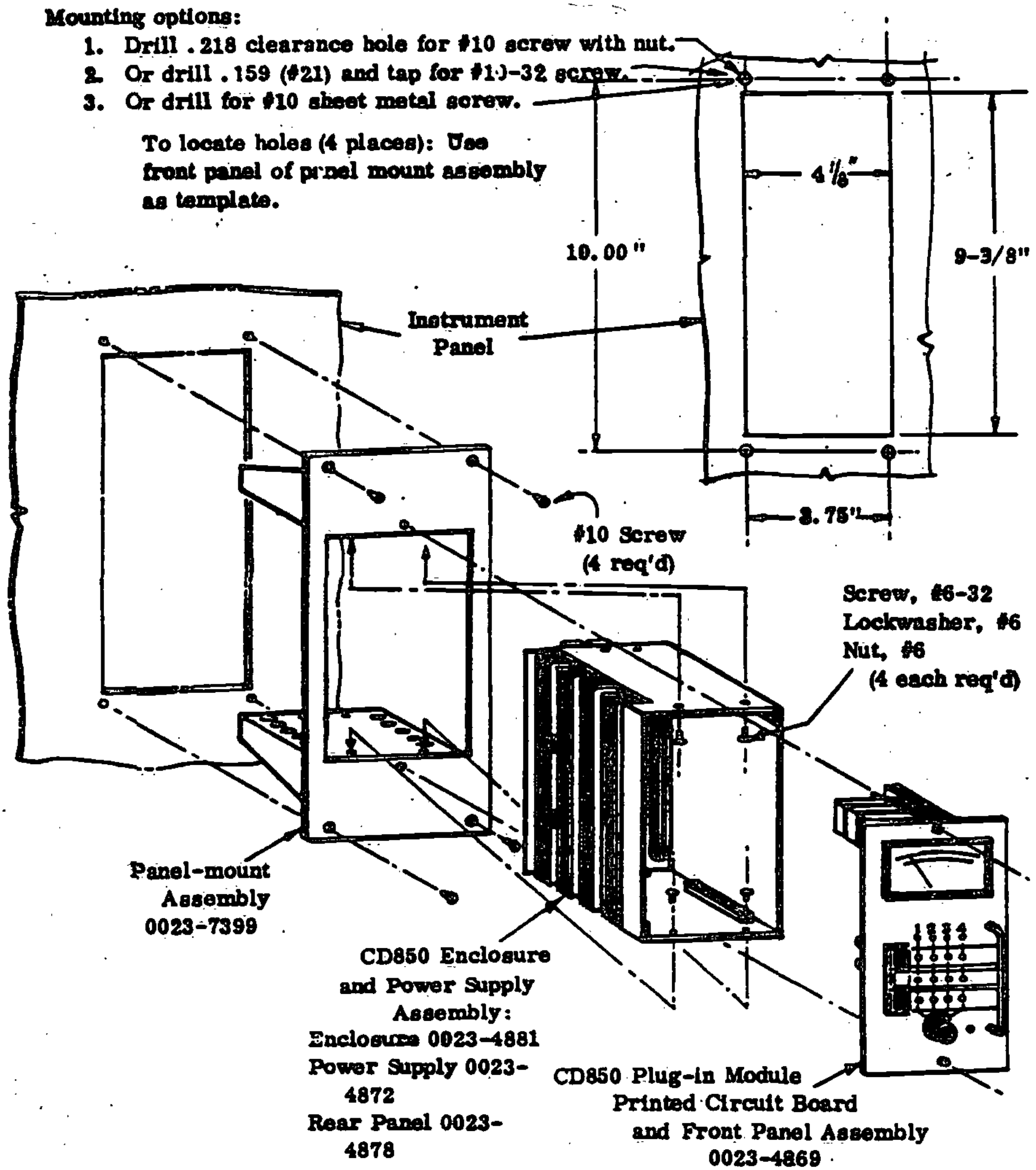
Detector Model 0023-4017 Exploded View



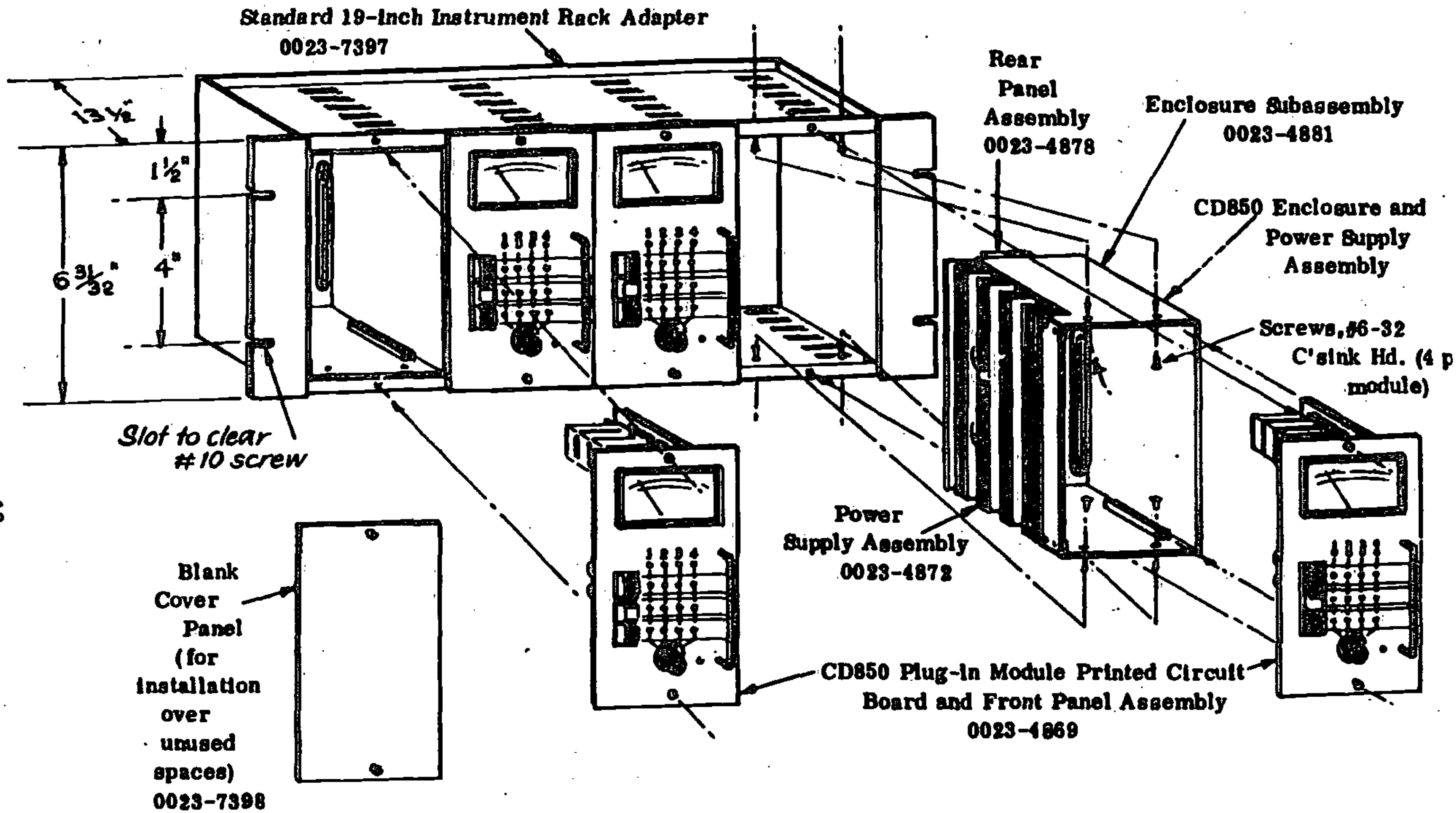
Typical Location Points for Detectors



Typical Through-bulkhead Installations

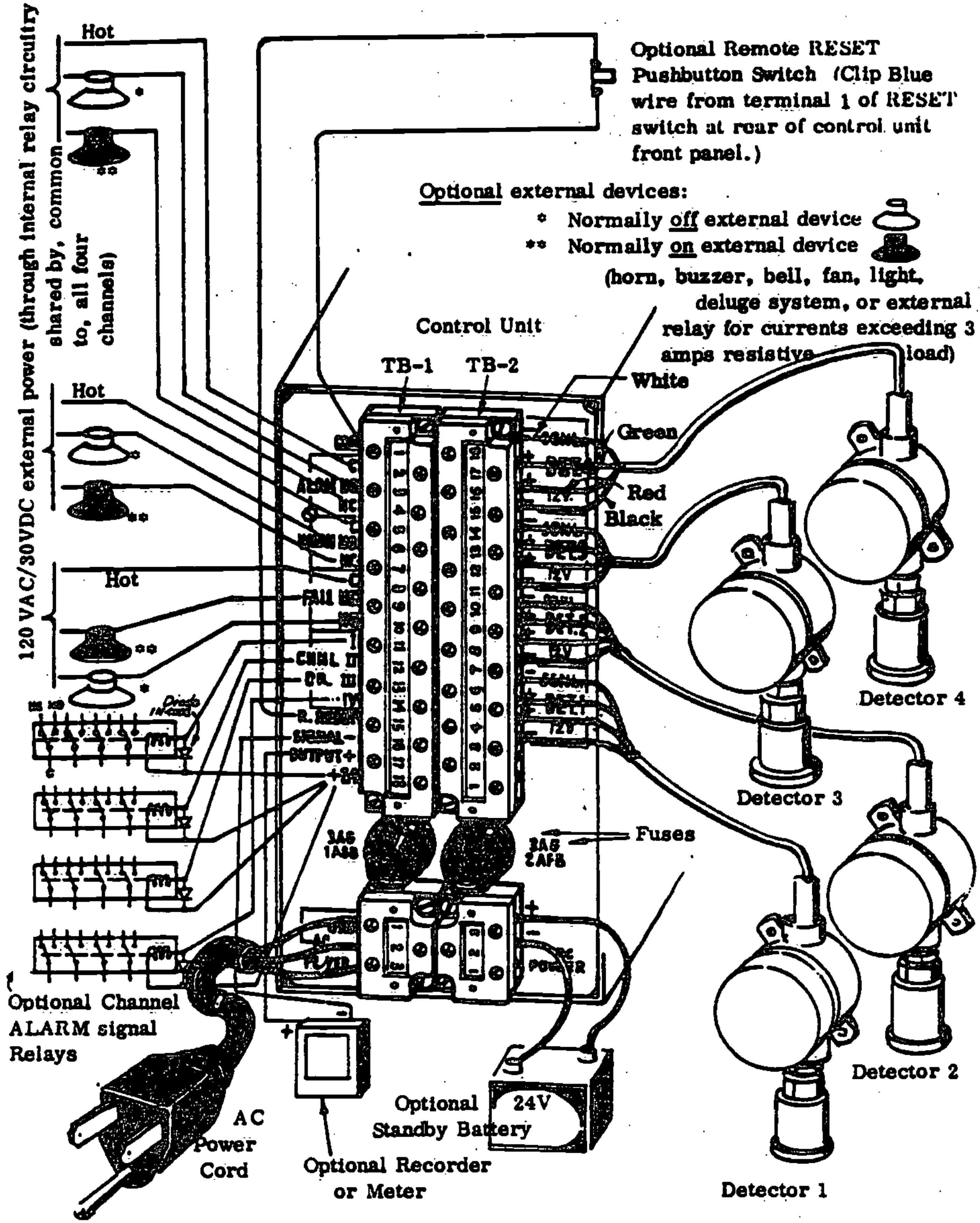


Instrument Panel Installation for One CD850 Control Unit



- 18 -

Standard 19-inch Instrument Rack Adapter for Up to Four CD850 Control Units



CD850 System Electrical Interconnections

RECOMMENDED WIRE SIZE FOR POWER LEADS (12V, "+" and "-")
FROM CONTROL UNIT TO REMOTE DETECTOR AMPLIFIER

RECOMMENDED WIRE SIZE (AWG)*	RESISTANCE IN OHMS PER 1000 FT.		MAXIMUM DISTANCE OF WIRE RUN (ONE WAY) AT 25°C (77°F)	MAXIMUM DISTANCE OF WIRE RUN (ONE WAY) AT 66°C (150°F)
	25°C(77°F)	66°C(150°F)		
#18	6.51	7.55	UP TO 900 FT.	UP TO 750 FT.
#16	4.09	4.74	900 TO 1400 FT.	750 TO 1200 FT.
#14	2.58	2.99	1400 TO 2300 FT.	1200 TO 1950 FT.
#12	1.62	1.88	2300 TO 3600 FT.	1950 TO 3000 FT.
#10	1.02	1.18	3600 TO 5800 FT.	3000 TO 5000 FT.

* Table based on values for solid, pure, copper wire.

NOTE: Signal leads may be #18 AWG or larger for any distance shown, preferably twisted-pair cable. Shielding is usually not required unless wiring is run in common conduit or raceway with electrically "noisy" wiring to other power circuits (equipment which may generate radio frequency signals, commutation noise, or ignition noise).

** Largest wire size recommended for terminal strips is #12. Long runs of #10 wire may be terminated with short splices of smaller wire for connections to terminal strips.

CALIBRATION AND ADJUSTMENTS

Before operation, and periodically during use, signal zero level and signal amplification should be measured and adjusted to assure specified signal range for accurate calibration of the Percent L.E.L. meter response to monitored gas. In certain installations, the factory-set 5.5-volt detector operating voltage must be reset before zero and signal amplification adjustments can be made.

DETECTOR OPERATING VOLTAGE ADJUSTMENTS

Detector amplifiers are factory-set to provide 5.5-volt power to the detector (the correct voltage for most applications). Detector operating voltage adjustments are necessary only if a detector is located more than 100 feet from the amplifier, or if methane, natural gas, or gasoline vapors will be monitored. If required, adjust operating voltage as follows:

1. Remove outer cover of amplifier junction box. Remove screws used to fasten inner plastic cover over amplifier and remove inner cover.

2. Insert screwdriver through access holes in amplifier and loosen two screws that fasten amplifier in junction box (Figure 2-4). Carefully withdraw amplifier from junction box.

3. At exposed detector-to-extension-cable splice, or at amplifier test points if detector is less than 100 feet from amplifier, attach high-impedance voltmeter; + lead to red wire or test point, and - lead to black wire or point.

4. With power applied at control module, turn detector power voltage adjuster (at middle left on amplifier printed circuit board, Figure 2-4) to obtain voltmeter readings as follows:

   a. If methane, natural gas, or gasoline vapors are not to be monitored, but detector is remote from amplifier more than 100 feet: Turn voltage adjuster to obtain a voltmeter reading of 5.5 volts at the remote detector.

   b. If methane, natural gas, or gasoline vapors are to be monitored, regardless of cable length: Turn voltage adjuster to obtain a voltmeter reading of 6.0 volts at the remote detector.

5. Detach voltmeter and tape detector-to-extension-cable splice for detectors more than 100 feet distant. Reinstall amplifier and inner cover plate in junction box.

DETECTOR ZERO SIGNAL LEVEL VOLTAGE ADJUSTMENT

WARNING: Prior to removal of detector amplifier cover, and at all times while cover remains open with circuits live, area must be monitored to assure absence of combustible gas.

Connect power to control module and set detector amplifier signal level voltage for each detector as follows:

NOTE: To prevent false alarms from circuit imbalances during warmup, a delay circuit operates to inhibit signal processing circuitry for approximately 40 seconds after power is applied to the instrument.

1. Remove outer cover from amplifier outlet box and connect multimeter (set to read voltage) across test points labeled DETECTOR OUTPUT, + and -, accessible through amplifier cover plate.

2. Set ZERO ADJ. adjuster, accessible through amplifier cover plate, to obtain a zero-volts meter reading while no combustible gas is present at the detector. If combustible gas or vapor is present at the detector, apply instrument air with the aid of a calibration cup (Figure 3-1), to assure absence of combustible gas at the sensor element of the detector. (Instrument air may be applied using Bacharach Test Kit 0023-7260, Figure 3-1, with Zero Gas/Dry Air gas cylinder 0023-4004 or equivalent. Alternately, instrument air can be applied with Bacharach Calibration Kit 51-7070 in accordance with Instruction 51-9001.)

CALIBRATION SETTING

Adjust signal amplification to obtain percent L. E. L. meter reading consistent with known concentration of sample combustible gas as follows:

1. Obtain cylinder containing sample combustible gas of known percent L. E. L. concentration (e. g., Bacharach gas cylinder 0023-4009 containing 1 percent propane in air—a propane L. E. L. concentration of 46 percent). (Alternately, the Bacharach Professional Calibration Kit 51-7070 can be used in accordance with kit Instruction 51-9001.)

CALIBRATION SETTING (continued)

2. With outer cover removed from amplifier outlet box, connect multimeter (set to read voltage) across test points labeled DETECTOR OUTPUT, + and -, accessible through amplifier cover plate.

3. Apply sample combustible gas of known percent L.E.L. concentration to detector as follows:

   a. Assemble sample gas cylinder, regulator, dispensing valve, and rubber hose as shown in Figure 3-1, or prepare to use Bacharach Professional Calibration Kit 51-7070 in accordance with kit instructions.

   b. Apply gas to detector as follows:

      (1) Detector 0023-4012: Attach sample cup 0023-4098 (Figure 3-1) to rubber hose and pass clamping arms of cup through slots at bottom of detector housing. Turn cup to engage clamping arms over rim of detector housing.

      (2) Detector 0023-4014: Disconnect detector from conduit (unless flexible conduit is installed), loosen thumbscrews of detector plate assembly (Figure 2-5), and withdraw detector from duct. Attach sample cup 347-095 (Figure 3-1) to end of rubber hose amd cover detector sensor element with cup.

      (3) Detector 0023-4017: (Sample-drawing): Attach rubber hose from gas sample dispensing outlet to tube and connector fitting and install fitting on SAMPLE inlet of instrument case.

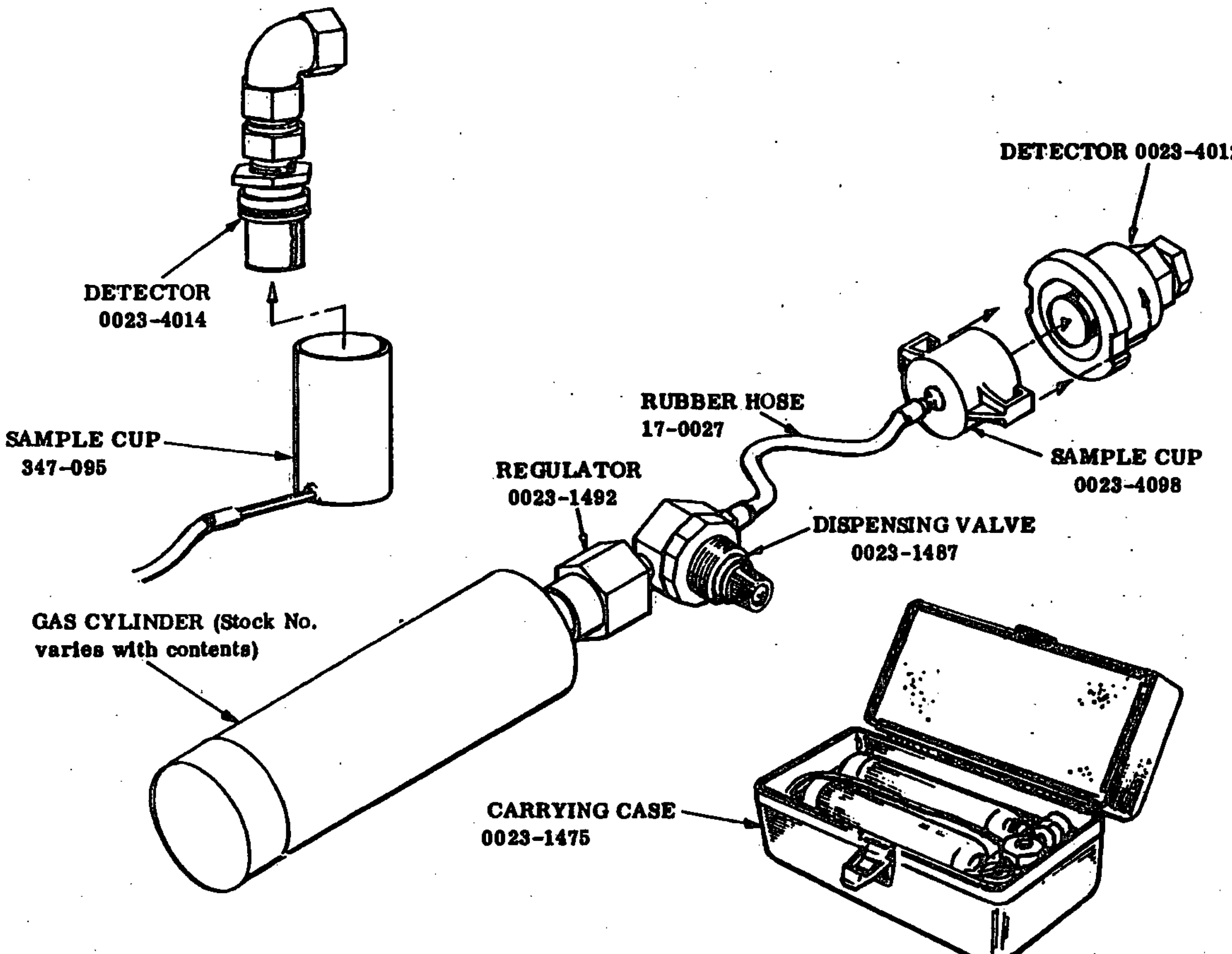
4. Open gas sample dispensing valve to flood detector with sample combustible gas.

5. When meter reading stabilizes, turn SPAN ADJ. screw (accessible through amplifier cover plate) as necessary to obtain a voltmeter reading that represents the same percent of 0.5 volt as the percent L.E.L. concentration of the sample gas applied at the detector. (Clockwise turn increases span; counterclockwise turn decreases span.)

   Example: A 1-percent propane-in-air gas sample has a percent L.E.L. concentration of 46 percent. Therefore: 46 percent of 0.5 volt requires a SPAN ADJ. adjustment to obtain a voltmeter reading of .46 x .5V, or .23 volt.

   If Professional Calibration Kit 51-7070 is used, multiply 0.5V by percent L.E.L. output of kit to obtain the corresponding voltmeter reading figure.

   Recommendation: Set adjuster to obtain a meter reading 10 percent above calculated figure to allow a margin of extra safety for warnings and alarms (compensates for normal, gradual depletion of sensor element).



Use of Test Kit 0023-7260 Dispensing Valve and Regulator, Gas Cylinder, and Sample Cup(s) at Diffusion Detectors for System Calibration Tests

Detector Element Selection Guide

SELECTION GUIDE

RATING KEY:

- A=CORRECT CHOICE
- B=WILL PERFORM WELL, BUT "A" CHOICE IS MORE ECONOMICAL
- C=WILL OPERATE BUT WITH DEGRADED PERFORMANCE
- D=NOT SUITABLE
- BLANK=NO EVALUATION HAS BEEN ATTEMPTED

LEAST EXPENSIVE	800-080.2
↑	800-080.1
↓	800-080.4
MOST EXPENSIVE	800-080.5

NOTE:

All catalytic-type detectors are inherently susceptible to a loss of sensitivity if exposed to silicone compounds. Special J-W design and manufacturing techniques provide substantial resistance to silicone "poisoning"; nevertheless, where rapid loss in detector sensitivity is noted, the presence of abnormally high concentrations of silicone should be considered as a possible cause.

GASES	800-080.1	800-080.2	800-080.4	800-080.5
ACETONE	D	D	C	A
ALCOHOL-ETHYL, BUTYL	C	A	D	D
ALCOHOL-METHYL	C	A	B	B
AMMONIA	C	A	C	C
ACETYLENE	D	D	C	A
ACRYLONITRILE	D	D	C	A
BENZOL	D	D	C	A
BUTADIENE	D	D	D	A
BUTANE	C	A	B	B
CYCLO HEXANE	D	D	D	A
CHLOROBENZENE	C	C	A	D
CHLOROFORM	C	C	C	A
DIETHYLAMINE	D	A	B	B
DICHLOROPROPANE	C	D	C	A
DICHLOROETHANE	C	D	D	A
ETHANE	A	C	B	C
ETHYL ACETATE	C	A	B	C
ETHYL ACRYLATE	C	A	B	B
ETHER	C	C	A	B
ETHYL CELLOSOLVE	C	C	A	B
ETHYL CHLOROACETATE	C	C	C	A
ETHYLENE	D	D	C	A
ETHYLENE OXIDE	D	D	D	A
ETHYL ETHER	D	D	C	A
FORMALDEHYDE	C	C	C	A
GASOLINE	C	A	B	B
HEPTANE	C	A	B	B
HEXANE	C	A	B	B
HYDROGEN	C	C	A	B

GASES	800-080.1	800-080.2	800-080.4	800-080.5
I.P.A. (ISOPROPYL ALCOHOL)	C	A	B	B
ISOPROPYLAMINE	D	A	B	B
J.P.4. (JET FUEL)	C	A	B	B
KEROSENE	C	A	B	B
KETONES	D	D	C	A
METHANE	A	D	C	B
METHYL CYCLOHEXANE	D	A	B	B
METHYL ACRYLATE	C	A	C	C
METHYL CHLORIDE	C	D	C	A
M.E.K.	D	D	C	A
METHYL ISOBUTYL KETONE	D	D	B	A
METHYL METHACRYLATE	C	A	B	B
METHYLENE CHLORIDE	C	D	C	A
NAPHTHA	C	A	B	B
NATURAL GAS	A	C	B	B
N-OCTANE	C	A	B	B
N-PENTANE	C	A	B	B
PROPANE	C	A	B	B
PROPYLENE	D	D	C	A
PROPYLENE OXIDE	D	D	C	A
PHENOL	C	C	A	B
STYRENE	D	D	C	A
TOLUENE	D	D	C	A
TRIETHYLAMINE	D	A	B	B
TRICHLOROETHANE	C	D	C	A
TURPENTINE	C	C	C	A
VINYL ACETATE	C	C	C	A
VINYL CHLORIDE	C	D	C	A
XYLENE	D	D	C	A

MSA

Mine Safety Appliances Company • 600 Penn Center Boulevard • Pittsburgh, Pennsylvania 15235
412/273-5000 Writer's Direct Dial Number

412/273-5091

March 4, 1983

RECEIVED
MAR 08 1983
KAISER ENGINEERS
LOS ANGELES

Kaiser Engineers
ATTN: Mr. P. P. Mohapatra
Metro P Project
425 South Main Street
Sixth Floor Annex B
Los Angeles, CA 90013

Gentlemen:

In response to your request to this office, I am pleased to provide Mine Safety's quotation on our Model 516 Gas Detection System. The system can be calibrated for a range of 0-100% of the lower explosive limit of methane vapors in air.

The quotation describes the two configurations available with the Model 516. The prices have been provided based on a 16 point system. The combustible gas sensing head can be located up to 5,000 feet from the control module.

Mine Safety will be presenting a new line of instruments for long-distance telemetering of signals at the ISA show in Houston this year. This system would use sensing head assemblies similar to the 516 and satellite telemetering relay assemblies to provide signals for long-line communications. May I suggest that you consider the new instrumentation for this project.

I trust the enclosed catalog, cuts, and information are sufficient for your current needs. Should you have any further questions or if Mine Safety may be of any further service, please do not hesitate to contact me or Mr. Steve Hernandez of our Los Angeles area office.

Sincerely yours,

WRFreeman

W. R. Freeman
Instrument Division

vld

Enclosure

Instrument Quotation

Page 1

MSA

Mine Safety Appliances Company
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235
Phone (412) 273-5101

Date March 1, 1983
Reference
Quotation No. 8705

Kaiser Engr.
Attn: P. P. Mohapatra
Metro P. Project
425 South Main - 6th Flr. Annex B
Los Angeles, CA 90013

Direct all correspondence to:
☐ MSA Pittsburgh or
☐ Mine Safety Appliances Company

See Telcon Report 6/10/

ITEM	QTY.	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		MSA Model 516 Gas Detection System consisting of:	$12,835.00 - Items 1 thru 3	
1	1	467445 M516 Gas Monitor Housing, suitable for rack or panel mounting. Housing will be complete with power supply, extender card, and common relays for warning, alarm, trouble, and horn circuits. Housing will incorporate a horn silence reset switch, and test push button for all LEDs and digital displays. Housing designed for general purpose installation.		
2	16	466652 M516 Control Modules calibrated for 0-100% LEL methane		
3	16	466562 M516 Combustible Sensing Head Assembly, aluminum body for methane		
	1	468131 M516 Relay Housing with one 466659 mother board for 1 thru 8 channels of discrete relays. Requires one (1) 467436 interconnecting cable assembly (4 ft. length)	$ 1,872.00 - Items 4 thru 7	
5	1	466659 M516 Mother Board, relay housing for 9-16 channels. Requires 467436 Cable listed below		
6	2	467436 M516 Cable Assembly, relay housing, 4 ft. length		
7	16	466658 M516 Plug-In Relay Assembly. One assembly required per channel of discrete relay operation. Provides 2 Form C contacts for each of warn, alarm and trouble circuits. Contacts rated 5 amp, 115 VAC resistive		
		MSA Model 516-N Gas Detection System consisting of:	$16,517.00 - Items 1 thru 4	
1	1	467446 M516 Gas Monitor in NEMA 12 wall-mount housing. Housing will be complete with power supply, extender card, and common relays for warn, alarm, trouble, and horn circuits. Housing will incorporate a horn silence/reset switch and test		

F.O.B. Pittsburgh, PA

DELIVERY 60-90 Days from receipt of order.

Mine Safety Appliances Company

W R Freeman
W. R. Freeman

Instrument Quotation

Mine Safety Appliances Company
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235
Phone (412) 273-5101

Continuation of Quotation No. 8705   Date March 1, 1983

ITEM	QTY.	DESCRIPTION	UNIT PRICE	TOTAL PRICE
		push button for all LEDs and digitial displays. Cabinet will contain mother boards for discrete relays for 1-16 channels. One 466658 plug-in relay assembly required for each channel of discrete relay operation		
2	16	466652 M516 Control Modules calibrated for 0-100% LEL methane vapors in air. Each module will contain a two digit LED display, over- and under-range LED indicators, and LEDs for warn, alarm, and ready indication.		
3	16	466562 M516 Combustible Sensing Head Assembly, aluminum body for 0-100% LEL methane		
4	16	466658 M516 Plug-in Relay Assembly. One assembly required per channel of discrete relay operation. Provides 2 Form C contacts for each of warn, alarm and trouble circuits. Contacts rated 5 amp, 115 VAC resistive.		

NOTES:

1. MSA's quote is based on information in our possession. MSA reserves the right to revise the quote should additional information or spec changes be received by MSA.

2. Two sets of instructions will be provided at no charge. Additional copies $10/set.

3. All for operation on 110V, 60 Hz power. Performance guaranteed for conditions specified.

4. See enclosed Schedule of Prices for Field Service.

5. Combustible Gas Sensors not intended for use in atmospheres containing halogenated hydrocarbons, silicones or heavy metals.

6. Recommended interconnecting cable between control unit and remote head - four conductor shielded:

up to	1,500 ft.	#20 AWG	28773	$ 1.10/ft.
	2,400 ft.	#18 AWG	600341	1.20/ft.

MSA INSTRUMENTS

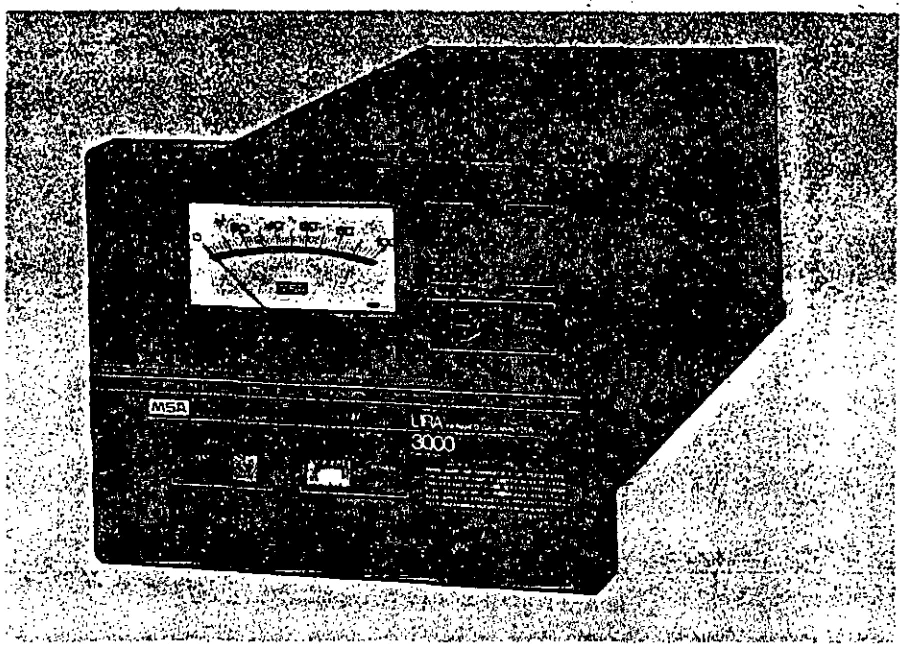
Lira® Model 3000 Nondispersive Infrared Analyzer

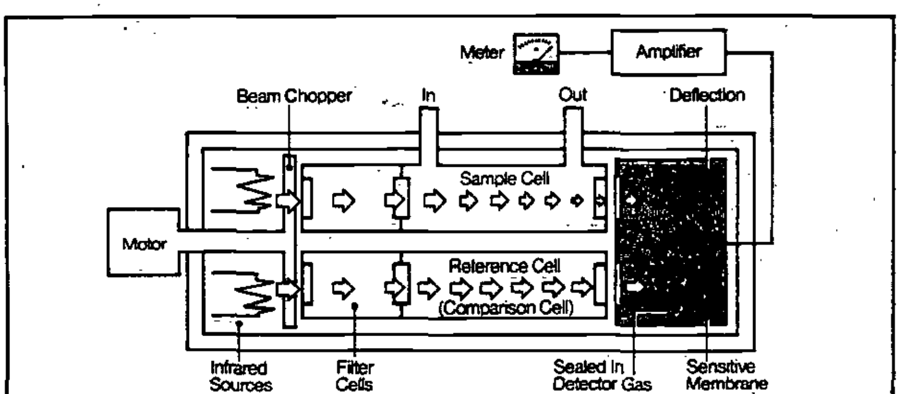
Application

The Lira Model 3000 Luft-type Infrared Analyzer is a selective, stable and economical instrument specifically designed to provide accurate and continuous analysis of a gas or vapor. The Model 3000 is capable of measuring a single component in a complex mixture of gases or vapors. It can be sensitized to detect any infrared active compound, including carbon monoxide, halogenated hydrocarbons, carbon dioxide, and most hydrocarbons. (Elemental diatomic gases such as hydrogen, oxygen, nitrogen, and chlorine are not infrared active.)

The Model 3000 is an ideal instrument for measuring hazardous gases in low concentrations. It is especially suited for the detection of combustible solvent vapors where the presence of contaminants or interferents precludes the use of other techniques.

Other applications include furnace atmosphere control, humidity dew point measurement, combustion control, chemical and petrochemical process stream control, and continuous laboratory analysis.





Description

The Lira Model 3000 Analyzer operates on the Nondispersive Infrared (NDIR) principle. Twin beams of infrared radiation are projected through parallel cells; one beam traverses the sample cell, the other beam the comparison cell. The emergent radiation is directed into a single detector cell that is responsive at an infrared wavelength where the component of interest absorbs infrared and background component(s) is transparent.

An interrupter, or "chopper," located between the radiation source and the cells alternately blocks radiation to the sample cell and the comparison cell. When the infrared beams are equal, an equal amount of radiation enters the detector cell from each beam.

When the gas to be analyzed is introduced into the sample cell, it absorbs (and reduces) the radiation reaching the detector via the sample beam. Consequently, the beams become unequal, the radiation entering the detector flickers as the beams are alternated, and the detector gas expands or contracts in response with the flicker.

This movement of the detector gas causes the microphone membrane to move in response. The membrane movement varies the condenser microphone's electrical capacity which, in turn, results in an electrical signal proportional to the difference between the two radiation beams; i.e., concentration of the component of interest. The signal is then amplified and fed to the indicating meter. The signal can be used as input to external recorders, alarms, or control loops.

Typical specifications

Performance

Principle of operation: Nondispersive infrared (NDIR) spectroscopy
Speed of response: 90% of final reading in 5 seconds
Warm-up time: 30 minutes
Noise level: Less than 1% of full scale
Zero drift: Less than 1% of full scale in 24 hours, typically less than 2% FS/week
Span drift: Less than 1% of full scale in 24 hours, typically less than 2% FS/week
Repeatability: ±0.5% of full scale
Linearity: (Without linearization option) Normally +5 to +10% nonlinear
Temperature effect: Instrument is operable over a temperature range from 32-122°F (0-50°C)

Operating

Power requirements:

As shipped—100 VA, 120 Vac, 60 Hz
Field selectable—50 or 60 Hz; 105, 120 or 220 Vac

Standard features

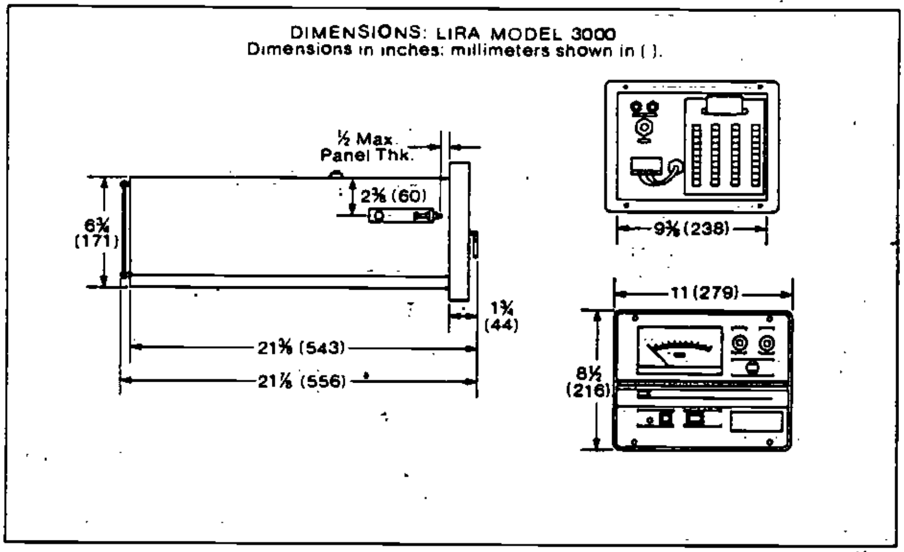
Outputs:

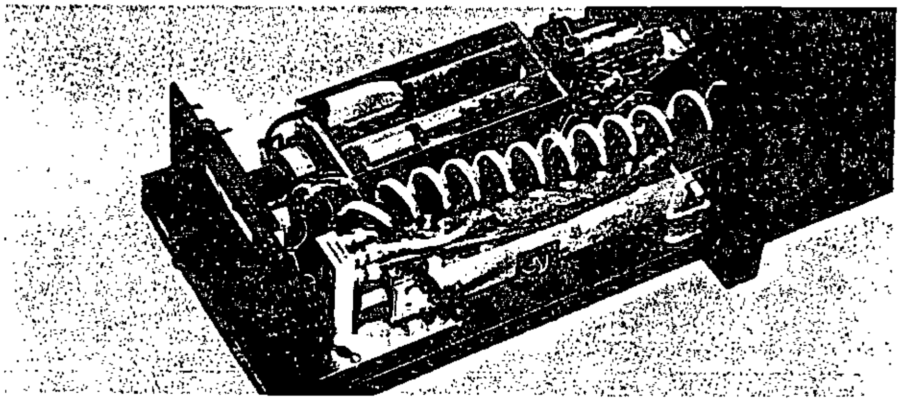
Millivolt—field selectable—0-10 or 0-100 mV
Voltage—0-5 Vdc
Controls: Push and latch lighted power switch. Precision multiturn potentiometer with lockable counting dials for zero and span.
Meter: 4½" analog meter with mirror scale; sealed type with pivot and jewel movement.
Ranges: Triple range with secondary ranges up to 10x the primary range. (Range multiplier may be limited on some gases due to optical considerations.)
Purge: Fittings for case purge provided
Span check: Front panel push-button switch activates an electrical circuit to simulate presence of sample gas

Optional features

Current outputs: Polar 4-20 mA into 2000 ohms maximum or 10-50 mA into 900 ohms maximum, field selectable; or bipolar 0-5, 0-10, 0-15, or 0-20 mA, field selectable; connection terminals provided

Note: This Data Sheet contains only a general description of the Lira Model 3000 Nondispersive Infrared Analyzer. While uses and performance capabilities are described, under no circumstances should this product be used except by qualified, trained personnel and not until the instructions, labels, and other literature accompanying the product have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.





Linearization: All ranges and outputs linearized to ±1% of a straight line response
Digital readout: .56" high 3½ digit LED meter factory programmed to direct read concentrations in each range. With this option all ranges and outputs are linearized.
Remote controls and indications: Remote meter, range change, and zero and span control can be provided.
Alarm: Integral alarm with three set points; linearization is included with this option.

Physical

Construction: Single general purpose case, sealed suitable for purge. Slide-out chassis with fold-down front panel. Plug-in modular, solid state electronics.
Weight: Approximately 44 lbs.
Inlet, outlet and purge fittings: ⅛NPT
Internal sample tubing: Nylon

Ordering information

For formal quotations, please contact MSA Instruments Division, describing compound to be analyzed and approximate stream analysis.

MSA
Mine Safety Appliances Company
Instrument Division
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235

Atlanta, Boston, Chicago, Cleveland, Detroit, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, Pittsburgh, San Francisco, St. Louis.
MSA CANADA, Downsview, Ontario (Metro Toronto)

Data Sheet 07-0526

Printed in U.S.A. 8110(L)

MSA
INSTRUMENTS

Model 516 Gas Monitor System

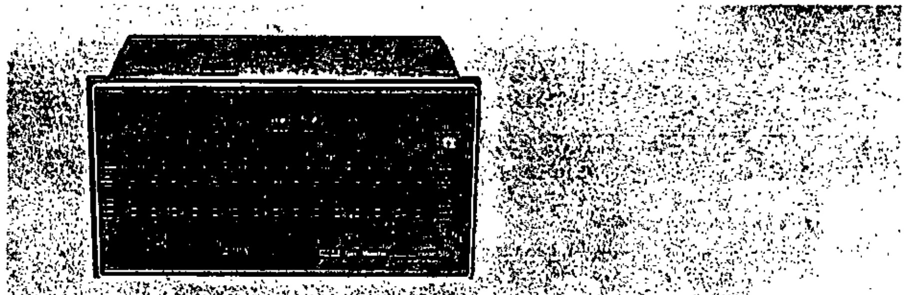
Application

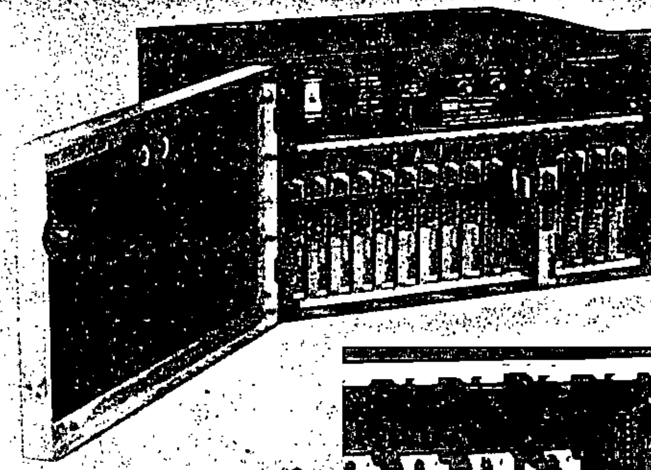
The MSA® Model 516 Gas Monitor System is capable of detecting a variety of combustible and toxic gases, as well as monitoring for oxygen deficiency. Applications for this universal monitor include garages, sewage plants, oil production and processing, steel mills, chemical process facilities, airport and bus terminals, combustible storage areas, pipeline pumping stations, oil tankers, and pharmaceutical plants.

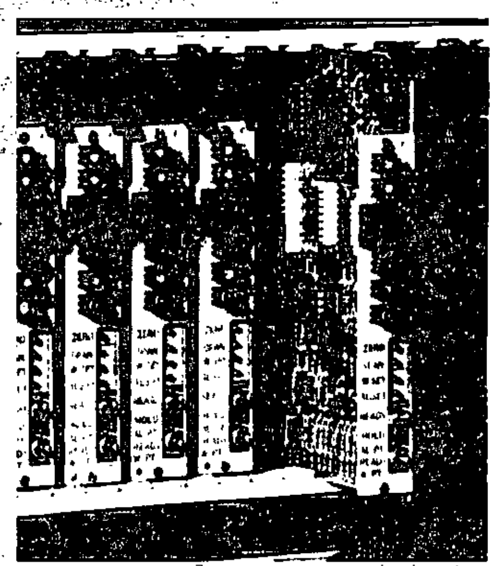
Description

The Model 516 Gas Monitor System consists of a high density housing which can include up to 16 individual control modules. Each module is capable of interfacing with a variety of sensors: either combustible gases, carbon monoxide, hydrogen sulfide, hydrogen cyanide, or oxygen. All control modules for the various sensors are identical, each employing a digital display.

The versatile Model 516 operates on 115 VAC, 50/60 Hz or optional 230 VAC, 50/60 Hz power. Designed for a 12 VDC battery backup in case of main power failure, the monitor system has a 12 VDC battery charger as standard equipment; 24 VDC or 48 VDC is another power supply option. Electronically, all modules are fully independent and up to 16 modules can be mounted in a housing that will fit a standard 19-in. relay rack. The housing may be flush mounted in an instrument panel or provided in a NEMA wall-mount enclosure.







Model 516 Gas Monitor System (top). As the middle photo shows, up to 16 independent control modules can be housed in each unit. The closeup indicates how easily the plug-in type modules can be removed for inspection or repairs.

Each control module contains a digital display and five light-emitting diodes (LED) for long operating life and minimum maintenance. Two (amber) LEDs for under-range and over-range indication are located above the digital display. Below the digital display are three LEDs—(red) Alarm; (amber) Warning; and (green), a normally lit Ready LED for "trouble" indication. In normal electrical operation, the (green) Ready LED and the digital display are lit.

Provisions for zero and span adjustments, as well as Warning and Alarm set-point adjustments are accessible on the front of the control module. In addition, two switches are located below these control adjustments. One switch will display the Warning and Alarm set-points on the digital display without operating Warning or Alarm relays. The second switch is used to lock out alarms during the calibration sequence.

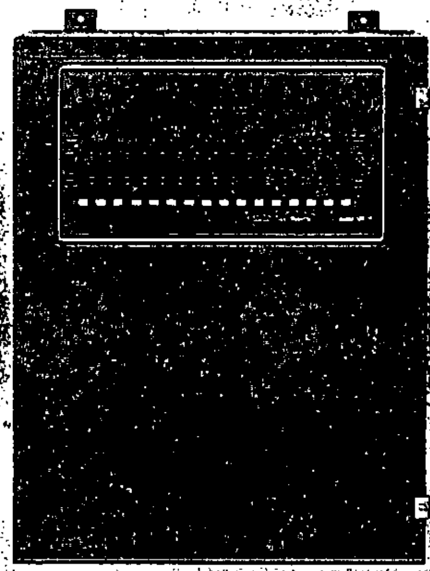
The combination of a high density design, solid state electronics, and a variety of sensors form a modern system for use in industrial combustible and toxic environments.

Standard features:

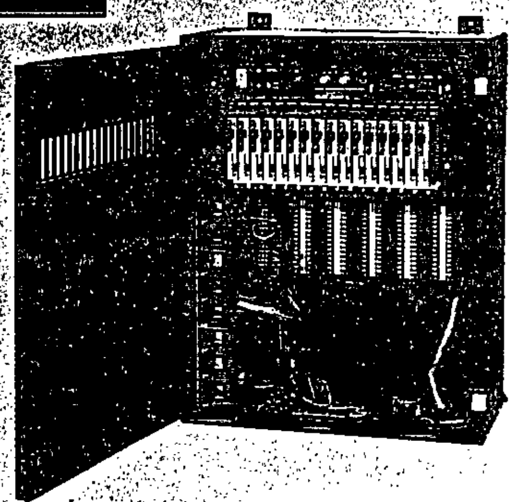
- Built-in charger for 12 VDC standby power rated 1 amp DC
- Local or remote reset of alarms
- Locked, transparent front door
- Test switch for all digital displays and all LEDs
- Alarm, Warning, Trouble, and Horn relay
- Horn silence/reset switch for all channels
- Test switch to display alarm and warning set points
- Ready LED (green) and Trouble relay in normally energized or fail-safe mode
- 30-second delay on start-up or momentary power failure to prevent false alarms
- Over- and under-range indication for digital display; display flashes on and off during over- or under-range conditions
- Warning and alarm relays are latching or nonlatching, normally energized or de-energized, all double pole, double throw
- Alarm and/or warning on decreasing signal
- Test switch to prevent false alarms during calibration process

Standard options

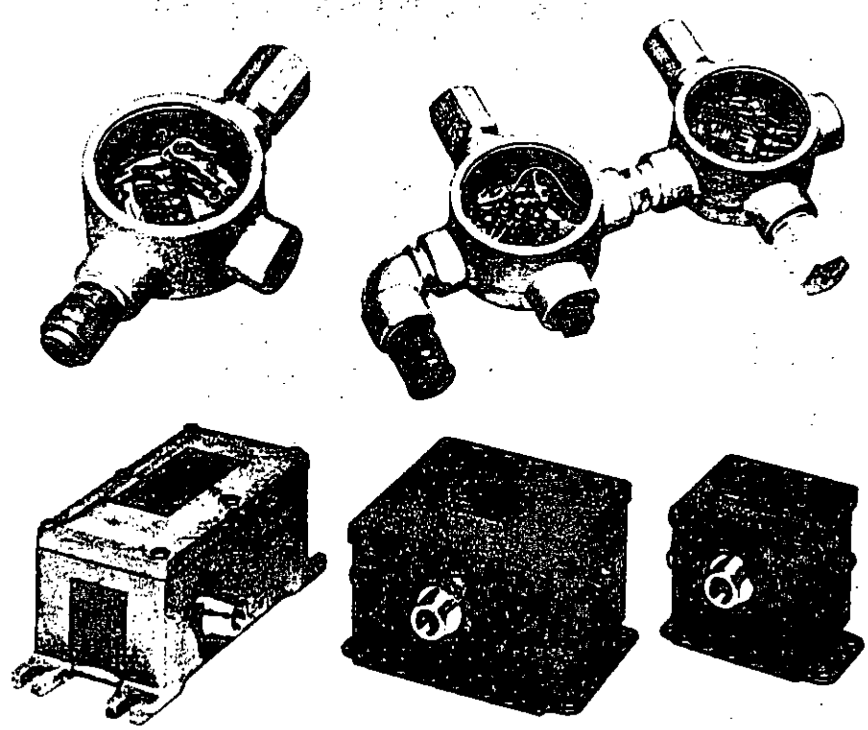
- Individual Alarm, Warning, and Trouble relays available for each module—plug-in module design
- Operation on 230 VAC, 50/60 Hz; 24 VDC or 48 VDC
- Hermetically sealed relays available
- Remote zero and span adjustment at the sensor
- 16 channels, with or without individual relays per module, in NEMA Type 12, wall-mounted cabinet with transparent front door



Model 516 Control Modules assembled in NEMA Type 12 housing



NEMA Housing, showing control module and optional discrete plug-in relays



▶

Model 516 samples the atmosphere by diffusion—no pumps required. Sensors shown left to right are: (top) Regular combustible gas sensor, remote calibration combustible gas sensor; (bottom) explosionproof sensor for toxics and oxygen, general-purpose sensor for toxics, and general-purpose sensor for oxygen.

Specifications

Operating

Temperature Range: Model 516 Housing and Control Modules—32°F to 125°F (0°C to 52°C)

Combustible Gas Sensors—20°F to 150°F (−29°C to 65°C)

Toxic Gas and Oxygen Sensors −40°F to 120°F (−40°C to 49°C)

Power: 115 VAC, 50/60 Hz, 12 VDC; Options: 230 VAC, 50/60 Hz; 24 VDC; 48 VDC

16 Channel Load: AC 230 watts, DC 120 watts

Gas Indicator: 2-Digit LED Display, ⅝-in. Digits

Electrical Class: Modules, General Purpose; Combustible Gas Sensors, Class I, Groups ABCD, Division 1; Toxic Gas and Oxygen Sensors, General Purpose or Class I, Group D, Division 1

Warning, Alarm, and Trouble Circuits: 115 VAC, 5 amp, non-inductive; 3 amp inductive or ⅛ HP; DPDT

Performance

Repeatability: ±1% of full scale

Linearity: Toxic and Oxygen Sensors, ±1% of full scale

Combustible Sensors, ±3% of full scale

Recorder Output: 0-1 VDC @ 1 mA max

LED Status Indicators: Red (Alarm), Amber (Warning), Green (Ready), Amber (Under/Over Range)

Physical

Dimensions:

Model 516 Housing; 19'' wide x 10¼'' high x 13½'' deep (483 mm x 260 mm x 343 mm)

Model 516 NEMA Housing: 24'' wide x 30'' high x 13¼'' deep (610 mm x 762 mm x 336 mm)

Discrete Relay Housing; 20'' wide x 20'' high x 7'' deep (508 mm x 508 mm x 178 mm)

Weight

Model 516 Housing with 16 Control Modules: 37 lb

Model 516 NEMA Housing with 16 Control Modules: 125 lb

Discrete Relay Housing: 50 lb

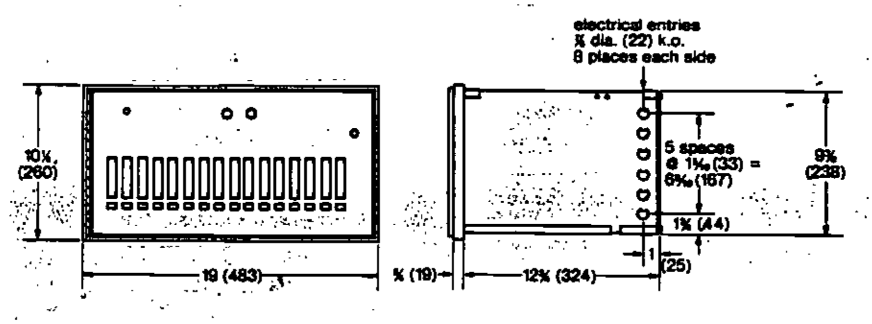
Mounting:

Model 516 Housing: Rack or Flush Panel

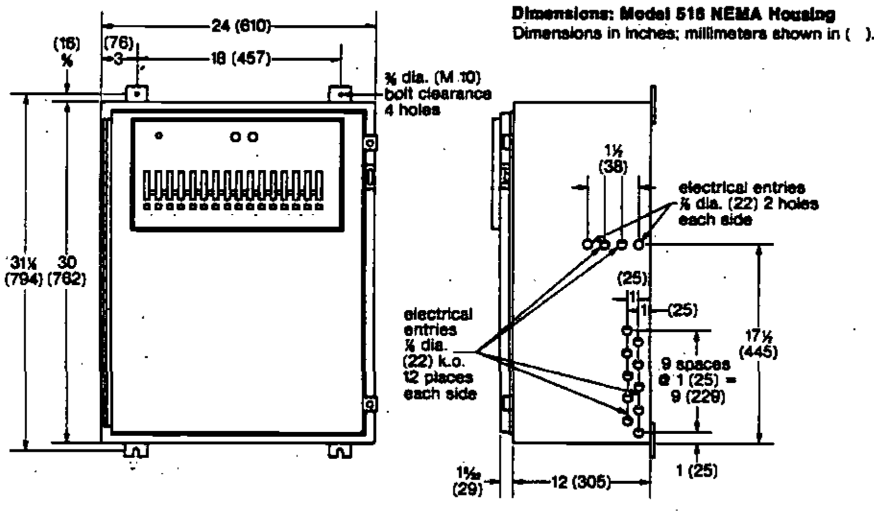
Model 516 NEMA Housing: Wall or Surface

Discrete Relay Housing: Wall or Surface

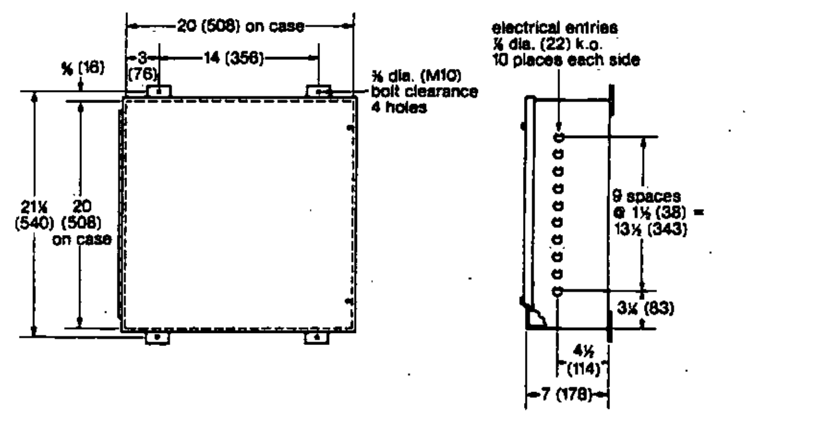
Dimensions: Basic Model 516 Housing
Dimensions in inches; millimeters shown in ( ).



Dimensions: Model 516 NEMA Housing
Dimensions in inches; millimeters shown in ( ).



Dimensions: Model 516 Discrete Relay Housing
Dimensions in inches; millimeters shown in ( ).

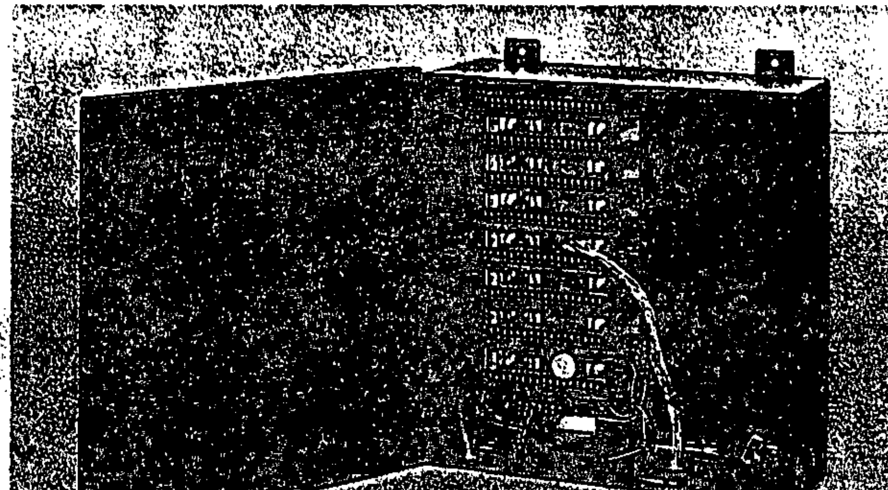


Ordering information

Catalog numbers

467445	Housing, M516
467446	Housing, M516N
466652	Control Module, M516
466562	Combustible Gas Sensor
466561	Combustible Gas Sensor, M516 remote calibration
468131	Housing, relay
466658	Plug-in relay assembly
466655	Extender

(Specify) Toxic Gas and Oxygen Sensors, if required



Discrete Relay Housing-Alarm, Warning, Trouble Relays for each channel.

Note: This Data Sheet contains only a general description of the Model 516 Gas Monitor. While uses and performance capabilities are described, under no circumstances should this product be used except by qualified, trained personnel and not until the instructions, labels, and other literature accompanying it have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.

MSA

Mine Safety Appliances Company
Instrument Division
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235

Atlanta, Boston, Chicago, Cleveland, Detroit, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, Pittsburgh, San Francisco, St. Louis, **MSA CANADA**, Downsview, Ontario (Metro Toronto)

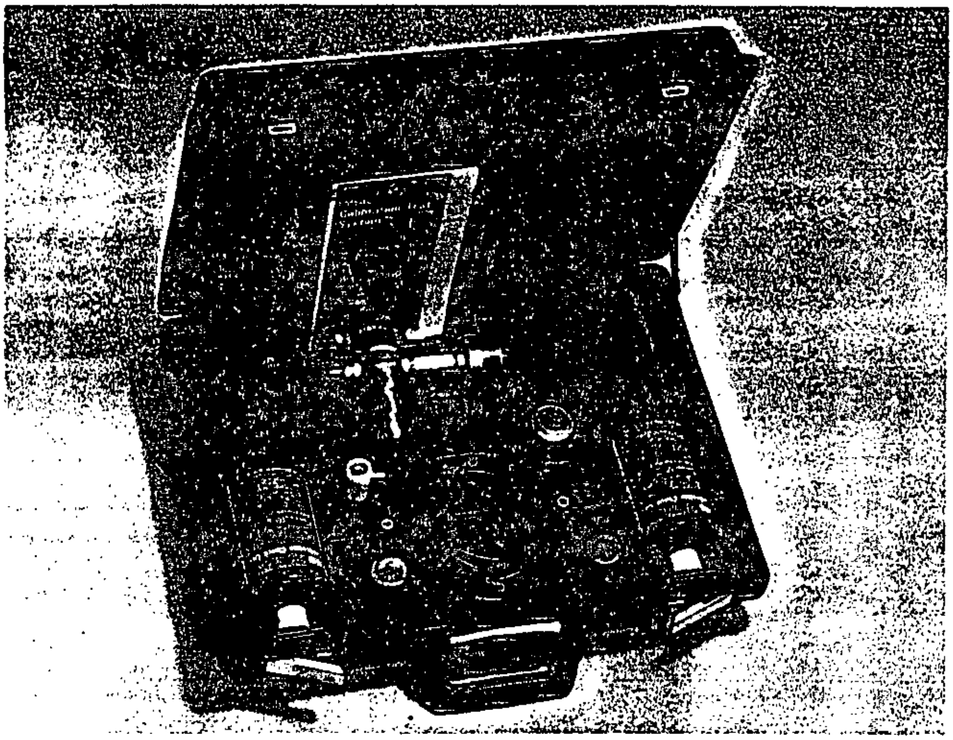
Data Sheet 07-0330

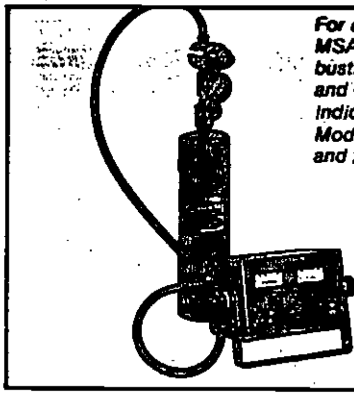
Printed in U.S.A. 8111(L)

MSA

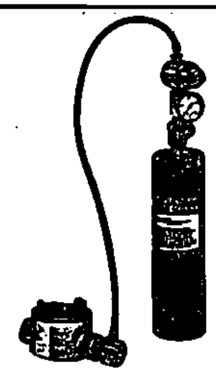
Data Sheet
08-00-28

Calibration Check Kit, Model R

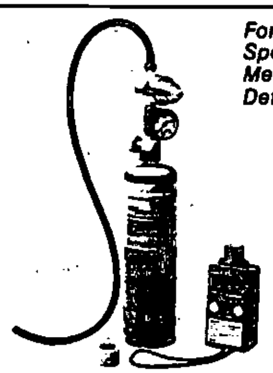




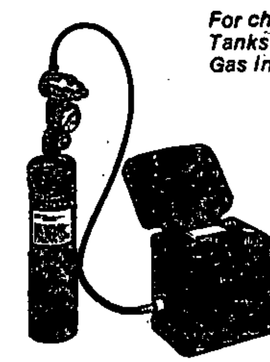
For checkin MSA Combustible Ga and Oxygen Indicator, Models 250 and 260



For checkin MSA 510 Series Combustible Ga Detectors



For checkin Spotter Methane Detector



For checkin Tankscope Gas Indicato

Application

The MSA® Calibration Check Kit, Model R, provides a quick, convenient, and economical method of checking the response of portable gas instruments. With the appropriate container of calibration check gas, it can be used with the following MSA portable instruments (the number of tests possible depends on the instrument being checked):

- Explosimeter® Combustible Gas Indicator, Models 2, 2A, 2B, 3, 4, 5
- Gascope® Indicator (calibrated for natural gas), 0-100% LEL range
- MSA Combustible Gas Indicator, Model 40, 0-100% LEL range
- Spotter™ Methane Detector
- Methanometer, Models 402 and 502
- MSA Methane Monitor, Models V and VI
- MSA Combustible Gas Alarm, Model 100
- I-500 Series MSA Combustible Gas Alarms
- MSA Combustible Gas and Oxygen Indicator, Model 250
- MSA Combustible Gas and Oxygen Alarm, Model 260
- MSA Portable CO Indicator
- MiniCO™ CO Indicators

Description

Testing is performed with known (± 5% tolerance) concentrations of pressurized gas-in-air, thus test results are reproducible.

The Check Kit consists of a small, lightweight steel container 10⅝" high and 2⅝" in diameter, containing approximately 19 liters of a specified gas-in-air mixture; a regulating valve; a hose adapter that connects the cylinder to the instrument. The two-stage regulator includes a gauge to measure container pressure. When not in use, the regulating valve and adapter hose can be easily detached from the expendable cylinder for convenient storage.

Operation: Preparing the Calibration Check Kit for use requires three basic steps: 1) connect the regulator assembly to the cylinder, 2) connect the adapter hose to the outlet of the regulator assembly, 3) connect the adapter hose to the inlet of the instrument (using Sensing Head Adapter where required). To calibrate or check the instrument, follow the detailed steps outlined in the instruction manual for the specific instrument.

Data She

Ordering Information When ordering calibration check gas cylinders and other components, please use part numbers:

MSA Instruments	Calibration Check Kit Parts	Numbers	Complete Kit
Explosimeter Models 2, 2A, 2B, 3, 4, 5	Regulator (1.5 L/m)	459948	
Combustible Gas Indicator, Model 40,	Adapter Hose	449401	
0-100% LEL range	Calibration Check Gas—0.75% Pentane in air	466193	466428
Gascope, Model 62	Calibration Check Gas—2.0% Methane in air	459945	
Gascope (calibrated for natural gas),	or Calibration Check Gas—2.5% Methane in air		
0-100% LEL range, Models 53 and 60	(except Model 5)	459942	466627
Tankscope (calibrated with butane)	Regulator (0.25 L/m)	459949	
	Adapter Hose	449401	
	Calibration Check Gas—8% Butane in Inert Gas (85% Nitrogen, 15% Carbon Dioxide)	460345	
Spotter Methane Detector	Regulator (0.25 L/m)	459949	
	Adapter, Sensing Head	457384	
	Adapter Hose	449482	
	Calibration Check Gas—2.0% Methane in air	459945	
	or Calibration Check Gas—2.5% Methane in air	459942	465916
Methanometer, Models 402 and 502	Regulator (0.25 L/m)	459949	
	Adapter Hose	449482	
	Calibration Check Gas—1.0% Methane in air	461047	
	Calibration Check Gas—2.0% Methane in air	459945	
	or Calibration Check Gas—2.5% Methane in air	459942	465916
Methane Monitor, Model V	Regulator (0.25 L/m)	459949	
Methane Monitor, Model VI	Adapter, Sensing Head	456673	
	Adapter Hose	449482	
	Calibration Check Gas—2.0% Methane in air	459945	
	or Calibration Check Gas—2.5% Methane in air	459942	465916
Combustible Gas Alarm, Model 100	Regulator (0.25 L/m)	459949	
	Adapter, Sensing Head	458302	
	Adapter Hose	449482	
	Calibration Check Gas—0.6% Propane in air	459943	465917
	Calibration Check Gas—0.75% Pentane in air	466193	466429
Combustible Gas and Oxygen Indicator, Model 250	Regulator (1.5 L/m)	459948	
	Adapter Hose	449401	
Combustible Gas and Oxygen Alarm, Model 260	Calibration Check Gas—0.6% Propane in air	459943	
	Calibration Check Gas—0.75% Pentane in air	466193	466428
MSA Portable CO Indicator, Model D	Regulator (1.5 L/m)	459948	
MSA Portable CO Indicator, Models 70 and 71	Adapter Hose	449401	
	Calibration Check Gas—		
	Carbon Monoxide, 60 ppm in air	461768	468108
	Carbon Monoxide, 150 ppm in air	459944	
	Carbon Monoxide, 300 ppm in air	461769	468107
510 Series MSA Combustible Gas Alarms	Regulator (0.25 L/m)	459949	
	Adapter	456673	
	Adapter Hose	449482	
	Cap, Zero	69217	
	Calibration Check Gas—		
	0.8% Hydrogen in air	459946	465918
	2.5% Methane in air	459942	465916
	0.6% Propane in air	459943	465917
	0.75% Pentane in air	466193	466429
MSA CO Indicator, MiniCO Models I, II, III, and IV	Regulator (0.25 L/m)	459949	
	Adapter	465898	
	Adapter Hose	449482	
	Calibration Check Gas—		
	Carbon Monoxide, 60 ppm in air	461768	
	Carbon Monoxide, 150 ppm in air	459944	
	Carbon Monoxide, 300 ppm in air	461769	
Hydrogen Sulfide Indicator Model 80	Regulator (0.25 L/m)	467895	
	Regulator (1.5 L/m)	467896	
	Adapter Hose	449401	
	Calibration Check Gas—		
	Hydrogen Sulfide, 10 ppm in nitrogen (0.25 L/m)	467898	465949
	Hydrogen Sulfide, 40 ppm in nitrogen (1.5 L/m)	467897	467922

Note: Instruction Manual, Part No. 996388, describes operation with Regulator 459948. Instruction Manual, Part No. 460981, describes operation with Regulator 459949.

Note: This Data Sheet contains only a general description of Calibration Check Kit, Model R. While uses and performance capabilities are described, under no circumstances should the product be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying it have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.

MSA
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA
Phone (412) 273-5000 • Telex 812453

Worldwide service: Branch offices throughout the United States.
Subsidiaries in: Amsterdam • Barcelona • Berlin • Calcutta • Glasgow Johannesburg • Lima • Mexico City • Milan • Ndola • Paris • Salisbury Santiago • São Paulo • Singapore • Sydney • Tokyo • Toronto.
Representatives in principal cities throughout the world.

Data Sheet 08-00-28

Printed in U.S.A. 822 (L)

LCS LANGFORD CONTROL SYSTEMS
185 FRONT STREET, SUITE 108
DANVILLE, CALIFORNIA 94526
(415) 838-1084

12/30/82

To: Fitz Consultants
555 Veterans Blvd. Suite 105
Redwood City, CA

Att: Katherine Fitz

Sub: L.A. Transit District.

Dear Mrs. Fitz,

Please find attached a drawing and literature on the following Instrumentation:

1. Tranistron's Intelligent Annunciator and Multiplexer system. The RTU will gather and digitize all the discrete contact and Analog information at the local stations and transmitt it over a single pair of wire to the Main Control Room. Maxium number of inputs + outputs is 1024. However if this number is easly reached another system can be used

LCS LANGFORD CONTROL SYSTEMS
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DANVILLE, CALIFORNIA 94526
(415) 838-1084

2/31/82

2. Taylor Instrument Analog Recording, Temperature Transmitters and sensor, will be able to measure Analog variables and record those continously.

I hope this very brief description will be sufficient for the time being. Please let us hear from you if you have future needs

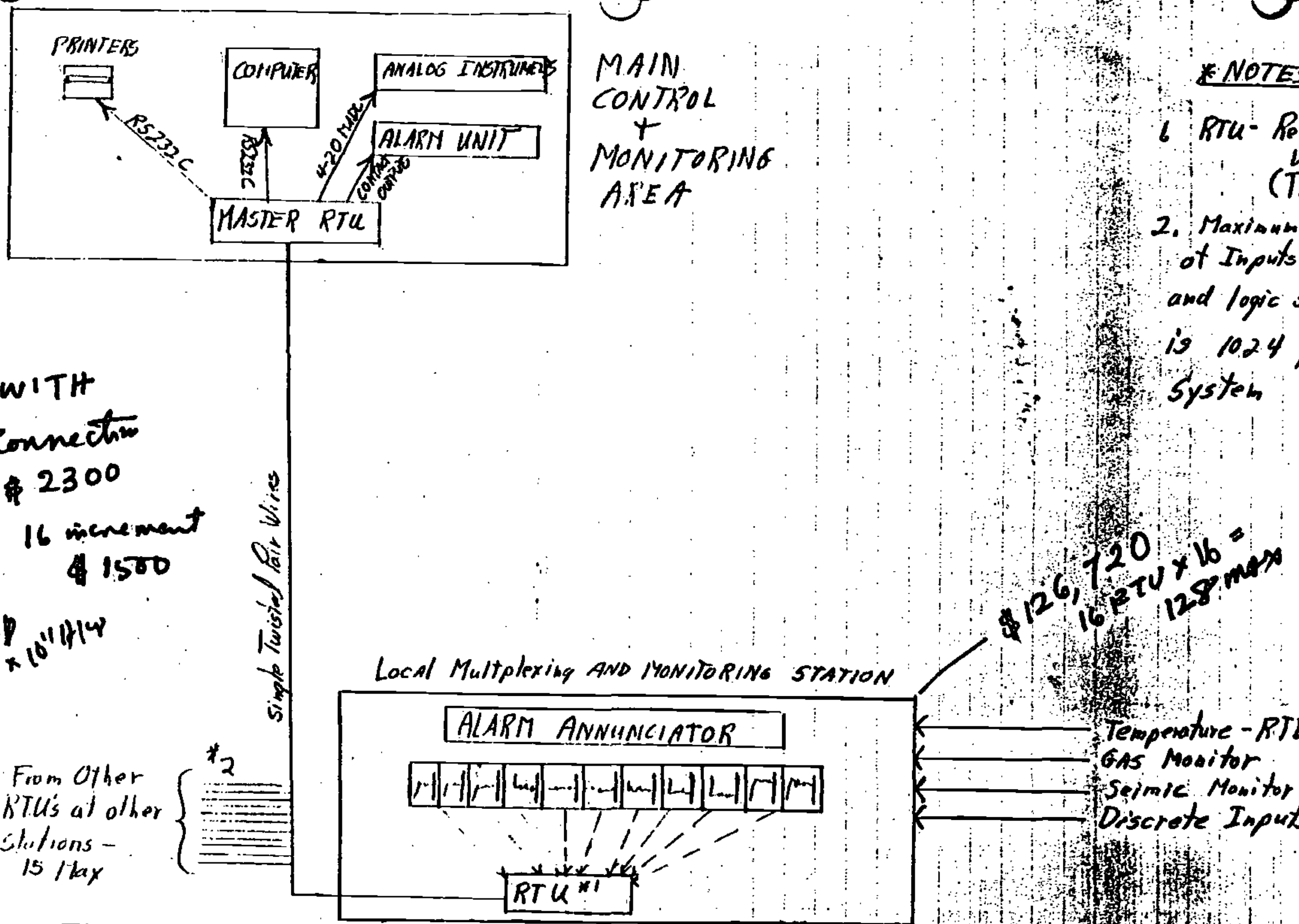
Sincerely

Automatic Control Engineering

William Meyer

Langford Control Systems

David [signature]



*NOTES

1. RTU - Remote Terminal Unit (Transitron)
2. Maximum Number of Inputs, Outputs and logic statements is 1024 per RTU System

1 RTU - WITH 16 Connection $2300

For every 16 increment $1500

wide deep
19 X 15 x 10 1/4

M/E Subsystem WES-16

PROPOSAL → Jan. 7, 1983

LANGFORD CONTROL SYSTEMS
FOR FITZ CONSULTANTS, INC.

LCS LANGFORD CONTROL SYSTEMS

DAVID D. ROSSEAU

185 FRONT ST.
SUITE 108
DANVILLE, CA 94526

Bus. (415) 838-1084

Please Excuse the delay - 1/7 D Ross

Transitron
CONTROLS

A SEQUENCE OF EVENTS RECORDER, A DATA LOGGER, A MULTIPLEXING SYSTEM ... THE INTELLIGENT ANNUNCIATOR™ FROM TRANSITRON CONTROLS

LCS LANGFORD CONTROL SYSTEMS

185 FRONT STREET, SUITE 108
DANVILLE, CALIFORNIA 94526

The Intelligent Annunciator™ from Transitron Controls is a compact, modular system, which functions like several discrete instruments. It is a Sequence of Events Recorder, a Data Logger, and a Multiplexing System as well as an Intelligent Annunciator.

For plant retrofit and modernization, where control panel space is at a premium and additional bulk wiring to the Control Room is not practical, the Intelligent Annunciator is ideal, for it provides a wide range of alarming and status reporting functions in a minimum control panel area.

For new installations, the Intelligent Annunciator is a cost effective solution to your monitoring requirements while supporting and backing up the computer control system.

For Your Industry:
- Utilities
- Petrochemicals
- Pulp and Paper
- Metals
- Textiles
- Food
- Glass
- Machinery

For Your Applications:
- Annunciation
- Sequence of Events
- Data Logging
- Process Monitoring
- Machinery Monitoring
- Tank Gauging
- Alarms

Features and Benefits

Modular architecture permits the monitoring of contact closures or analog signals in increments of 16 up to a combined total of 1024 points.

Resolution between events of 1 millisecond provides first-out and sequence of events capability.

Logic intelligence incorporated on a per point basis, blocks nuisance alarms and logically creates new alarm messages. Priority alarms and time delays may be specified.

A battery backed-up Event Memory can be accessed in several formats, including current alarms, current status, and point history.

Remote Termination Units (RTUs) save field wiring costs.

Remote inputs can be recreated or logically combined at the Display Module to drive control room instrumentation (e.g. annunciator windows, analog meters, process instrumentation, etc.)

The use of a 40 character alpha-numeric display for alarm messages and status information reduces required control panel space.

RS-232C or current loop interface to printer or plant computer.

Fault tolerant design with extensive on-line diagnostics assures reliable operation and simplified maintenance.

The ability to monitor dry or live contacts reduces installation costs.

Multi-level redundancy for non-stop operation.

Advanced menu driven "userware" simplifies set-up; no programming skills are required.

Multi communication media between modules (e.g. fiber optics, COAX, twisted pair).

LCS LANGFORD CONTROL SYSTEMS

1451 DANVILLE BLVD., SUITE 102
ALAMO, CALIFORNIA 94507
(415) 838-1084

Representing:

Taylor Instrument	SYBRON Taylor	RECORDERS CONTROLLERS TRANSMITTERS OXYGEN ANALYZERS DIGITAL CONTROL SYSTEMS CONTROL VALVES
:lectro-Chemical Devices, Inc.	ECD	pH, CONDUCTIVITY, ORP SENSO TRANSMITTERS AND CONTROLLER COOLING TOWER CONTROL SYSTE BOILER BLOWDOWN SYSTEMS SPECIFIC ION TRANSMITTER REMOTE DIGITAL INDICATORS
IQUID SOLIDS CONTROL CO.	LSC	PROCESS IN-LINE REFRACTOMET RECOVERY BOILER SUPERVISORY CONTROL SYSTEMS
;ORTEBERG CONTROLS CORP.	S	FORCE BRIDGE INSTRUMENTS PNEUMATIC ANALOG COMPUTERS AND RATIO SUMMATORS
INIVEN	by Conolog CORPORATION	SUPERVISORY CONTROL AND DAT ACQUISITION. AUDIO TONE/FREQUENCY MULTIP ING.
Masoneilan		PRESSURE REGULATORS PRESSURE REDUCING VALVES BACK PRESSURE REGULATORS
RESSURE APPLICATIONS		PORTABLE DIGITAL PRESSURE CALIBRATORS

REL-TEK CORPORATION

February 7, 1983

RECEIVED
FEB 15 1983
LOS ANGELES

D. P. Mohapatra
Kaiser Engineers
Metro Rail Project
425 S. Main Street
6th Floor, Annex B
Los Angeles, CA 90013

Dear Mr. Mohapatra,

I was pleased to receive your phone call Feb. 2 in which you expressed interest in our "M/C-8000" mine monitoring and control system.

As I understand your application, there are 36 miles of underground railway over which you will monitor methane levels at 500 ft intervals (some 380 sensors).

Our standard communication range is 10 miles, so 4 line amplifiers will be required to cover the total distance. Assuming one outstation (sensor interface module) every 10 sensors (5000 feet), a total of 38 outstations will be needed. Each outstation will have the capability of handling 10 analog inputs and transmitting this data in digital form to the central station every few seconds for analysis.

The surface control room will have a primary computer, a communication module, a desk console, a 19" color video monitor and a high speed printer. Voice output is available to assist the operating personnel in culling out any unusual conditions. Complete color graphic displays of methane vs time, comparative bar charts, and summary analyses are available thru the video monitor on keyboard command. Hard copy printouts of summaries and graphs are also available for permanent records.

As a budgetary estimate, the system will cost in the neighborhood of:

Control room equipment		$ 50,000
Outstations (38x$6000)		228,000
Cable (190,000x2x$.40)		152,000
Line amplifiers (4x$2000)		8,000
Sensors (380x$1000)		380,000
		$ 818,000
Contingency	5%	41,000
Estimate		$ 859,000

Naturally, there are trade-offs between numbers of outstations and lengths of sensor cables. And, the use of individual sensor transmitters is a possibility, although this would tend to reduce the system reliability and increase the complexity of underground diagnostics and repairs of sensor and cable faults.

We do not manufacture a CH_4 sensor, so the above estimate assumes the use of a high-grade device manufactured by J-Tec. Other, less costly ones are available; however, I feel confident recommending this one for its long term stability and trouble free operation. The final choice can be made later. The sensor is approved by MSHA for use in potentially gassy coal mines.

You may wish to add other sensors, such as air velocity, CO for fire or toxicity, oxygen, CO_2, HS, NOx, SOx, aldehydes, hydrocarbons, vibration, temperature, humidity, and the like (see attached specification). Additional analog or digital channels can be added to expand the outstation capacity at little additional cost.

Two kinds of cable are required: one 4-conductor for communication between outstations and the central station and one 7-conductor for bringing the sensor signals to the outstations. I assume 120 VAC power is available at the sensor and outstation locations... if not, we can power the sensors from the outstation location through additional cables. Miscellaneous cable hangers, power hookup cable, junction boxes, and other small items are are not included.

Please send me additional information on your specific needs, i.e. diagrams, specs, budgetary constraints, and the like. I look forward to working with you on this interesting project.

Yours very truly,

Albert E. Ketler
President

cc: R. Krishnaswamy, N.H. Parker and Associates

Enclosures:

M E M O R A N D U M

10 March, 1983

To: All Systems Manufacturers

From: Randy Brekke/Marketing Manager, J-TEC Associates, Inc.

The following J-TEC equipment has been investigated and approved by the Mine Safety and Health Administration. Following are the model numbers, description, M.S.H.A. classification numbers and single unit pricing.

Airflow Sensors VA216 & VA216B

The VA216 Airflow Sensor is constructed with a steel enclosure using an aluminum sensor head. The power requirements are 10 to 18 VOC and 9-21 VOC for our "B" version. The "B" version is totally constructed of stainless steel including sensor head. The output for both units is either 0-5 VOC or 4-20 mA One other major difference between the "B" version and the VA216 unit is that the "B" version has the capability to have a user card installed directly inside the stainless steel enclosure. The flow rates for both units are 50 to 3000 and 150 to 10,000 fpm.

NOTE: Please note the classification differences. The exact specifications of eac unit are defined in the enclosed brochures. A photo is included in our MMS1000 Brochure.

	M.S.H.A. Classifications	Price
VA216	E,F,G,L	$1,000.00 each
VA216B	C,O,E,F,G,L,H	$1,475.00 each

Methane Sensors VM101 & VM101B

There are three major differences in the VM101 and the VM101B:

1. VM101 enclosure is steel while the VM101B enclosure is stainless stee
2. VM101 uses an English Electric Value sensing unit and the VM101B uses a Scott Sensor.
3. VM101 input power is 10 to 18 VOC. VM101B input power is 9-21 VDC.

NOTE: Please note the classification differences. The exact specifications of each unit are defined on the enclosed brochures. A photo is included in our MMS1000 brochure.

	M.S.H.A. Classifications	Price
VM101	E,F,G,L	$ 515.00 each
VM101B	C,O,E,F,G,L	$ 950.00 each

Wafer Style Flowmeters VF580 & VF580B

The major differences between these two meters are that the "B" version electronics are enclosed in a stainless steel enclosure, much like our 101B & 216B, while the 580 electronics are housed in a steel enclosure. Both units have a wafer style sensing head constructed of stainless steel. The dynamic range for both units is 277 to 11,100 fpm. They can be installed in pipe sizes of ½" to 4". Again, the "B" version has input voltage of 9 to 21 VDC while the VF580 has an input voltage of 10 to 18 VDC. Both units provide 0-5 VDC or 4-20 mA signal output.

NOTE: Please note the classification differences. A picutre of the VF580 is in the MMS1000 brochure.

	M.S.H.A. Classifications	Price
VF580	E,F,G,L	$1,295.00 each
VF580B	D,C,E,F,G,L	$1,395.00 each

Insertion Style Flowmeter VF581 & VF581B

The differences between the two units are stainless steel enclosures vs. steel enclosures and power input. The "B" version has 9-21 VDC input and the 581 has 10-18 VDC input. The dynamic range of both insertion meters is 4.6 to 185 fps. It will fit into pipe sizes from 6" to 48". The mounting flanges for both units are 2", 150 lb. flanges.

NOTE: Please note the classification differences. A photo of the VF580 is in the MMS1000 borchure.

	M.S.H.A. Classifications	Price
VF581	E,F,G,L	$1,495.00
VF581B	C,D,E,F,G,L	$1,595.00

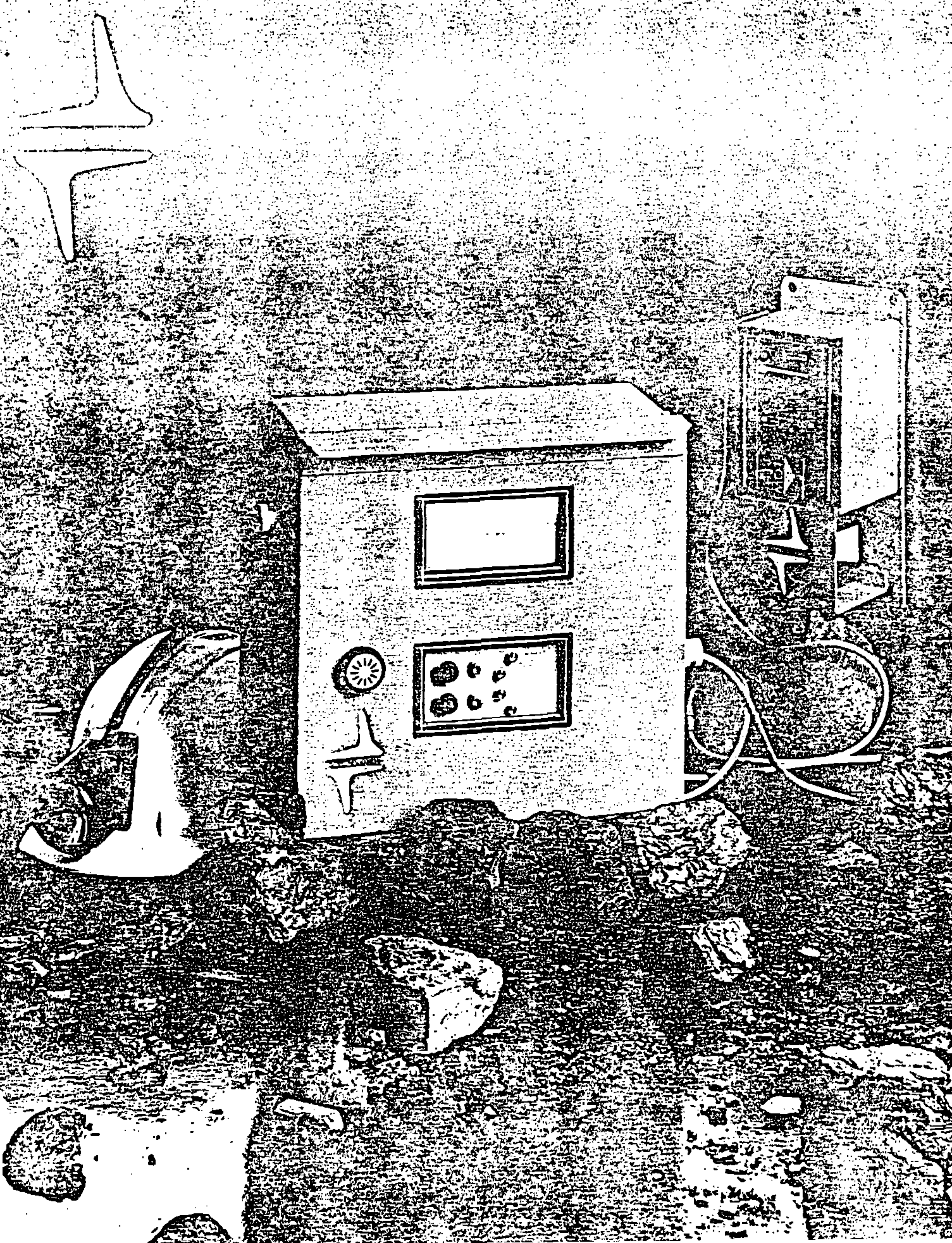
At the present time we do not have brochures on our flowmeter package. Should anyone have further questions concerning these products, please feel free to contact me.

Randy Brekke

Randy Brekke

Enclosures: VA216
VA216B
VM101
VM101B
MMS1000

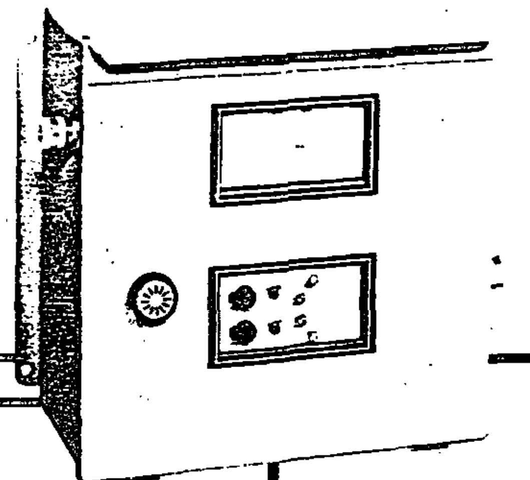
J-TEC REMOTE MONITORING SYSTEMS

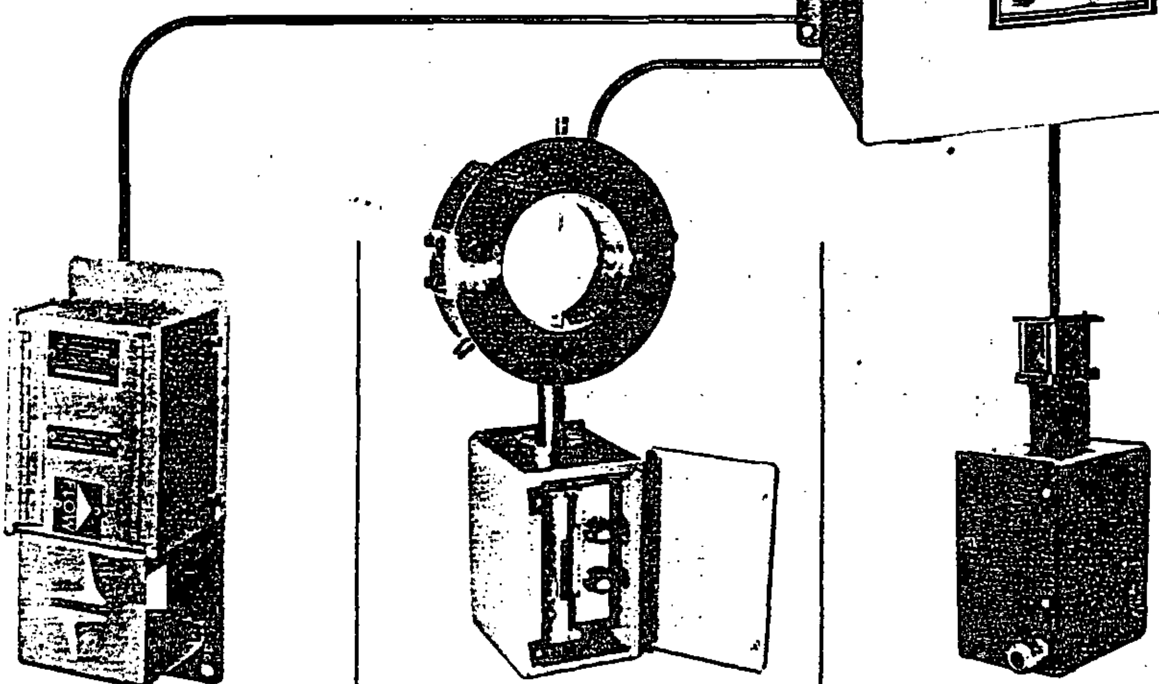


The MMS-1000 Series Monitoring System has been designed for dedicated continuous monitoring in hazardous areas. The system can be configured for the use of various sensing units and options to fit your specific requirements. Applications such as airflow in an entry, concentration of methane along the face, and volumetric flow inside a pipeline are ideal for the MMS-1000 series system.

DCU-100 DISPLAY AND CONTROL CONSOLE

The DCU-100 is the central element of the MMS-1000 series systems. It is located in fresh air and provides safe power for distribution to the sensors. The DCU-100 is powered by 115 VAC and includes power conditioning circuitry, a data interface module and a display. The DCU-100 provides numerous options designed to accommodate any one of the individual sensors illustrated below. The DCU-100 Control Console interfaces with the sensor of your choice to make up a MMS-1000 Series Monitoring System.





AIRFLOW MONITORING VA-216

The VA-216 sensor measures airflow in passageways. The solid state electronic vortex sensing technique eliminates the need for constant recalibration. Tested intrinsically safe, the VA-216 measures three airflow ranges from 50 — 10,000 fpm. A 0 — 5 volt analog signal is available and provides excellent repeatability. Virtually unaffected by humidity, temperature and pressure, the VA-216 is a prominent leader for airflow sensing.

MMS-1001

SMALL PIPELINE MONITORING VF-580

The VF-580 sensor is designed for pipeline diameters of ½" to 4". This brass pancake style sensor will continuously monitor gaseous flow in all types of corrosive atmospheres, using the vortex shedding principle to measure volumetric flow to within 2% of full scale. Tested intrinsically safe, the VF-580 is excellent over the entire flow range and is unaffected by changes in temperature, pressure and humidity.

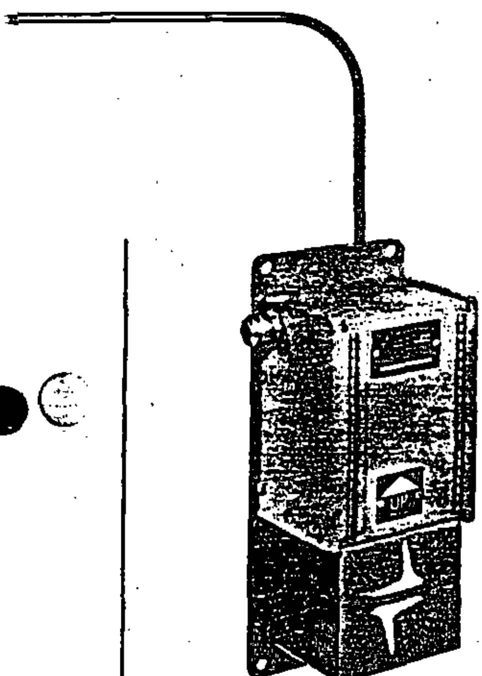
MMS-1002

LARGE PIPELINE MONITORING VF-581

The VF-581 sensor is an insertion style flowmeter for use in the continuous monitoring of gases in larger pipelines of 6" to 30" in diameter. Using the same vortex principle as the VF-580 and VA-216, the VF-581 has also been tested intrinsically safe for use in hazardous areas, featuring excellent repeatability, high accuracy, and minimal maintenance requirements.

MMS-1002

MMS-1000 SERIES MONITORING SYSTEM

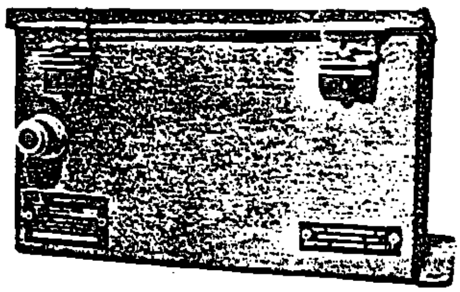


METHANE MONITORING VM-101

The intrinsically safe VM-101 sensor measures methane concentration from 0 — 5%. The sensing element consists of a matched pair of Pellistors mounted in a low voltage wheatstone bridge configuration, where both Pellistors are heated to an optimum temperature. The oxidation of the methane on the active pellement causes an increase in its electrical resistance. The bridge unbalance and its output becomes an accurate measurement of the methane concentration.

MMS-1003

OPTIONS



POWER SUPPLIES

The PS-200 and PS-201 Power Supplies operate on 110 VAC and provide up to 0.5 amps at 15 VDC. Located in fresh air, they provide a source of intrinsically safe power for distribution to the sensors in hazardous areas.

In certain MMS-1000 series systems configurations, the PS-200 or PS-201 Power Supplies may be used for the sensor power.

The PS-200 and PS-201 may also be used independently in conjunction with other existing intrinsically safe equipment.

DIGITAL DISPLAY

A brilliant red seven segment light emitting diode (LED) display provides fast, accurate readings especially in dimly lit areas. Three digits provide a rugged industrial display unaffected by dust or moisture.

CURRENT OUTPUT/ CURRENT INTERFACE

A 4-20 ma or 1-5 ma current output is available with the MMS-1000 Series Monitoring System. Along with a current interface card, this option allows the sensor to be placed as far as 15,000 feet away from the DCU-100 Control Console.

WATERTIGHT ENCLOSURE

A heavy gauge steel enclosure with a clean Lexan window is available for housing the DCU-100 Control Console, allowing the unit to be installed in areas of high moisture concentration.

DUAL ALARM SET POINT

The Dual Alarm Set Point can tailor the MMS-1000 series system to your application. The function of each set point is determined by the user. Set points can be defined as high and low alarm conditions, to indicate a warning condition or when flow level approaches the alarm point. Each point is continuously and independently settable throughout the range of the instrument by use of a front panel control.

Visual alarm is provided by a red lamp. Individual relays with Form C, 2 amp contacts are actuated at each set point. Relays remain energized until the flow condition has been corrected.

When the front panel set point button is pressed, the corresponding set point value is read on the meter. When the button is released the unit returns to normal operation.

A relay contact output may be used to control other devices at the set flow level.

The entire MMS-1000 series system has been tested by M.S.H.A. and meets the intrinsic safety requirement of 30 C.F.R., Part 18.68.

VA-216 AIR FLOW SENSOR

- Proven mine-worthy
- No calibration required
- Intrinsically safe
- Long term reliability
- Immune to dust and humidity
- Fast response
- No moving parts

THE VORTEX AIRDRAFT SENSOR
for use in mining and industry

The superiority of the J-TEC air flow sensor has been proven in over a hundred mine installations in the last several years. It is truly the leader in the field of mine monitoring.

The patented solid state electronic vortex sensing technique eliminates the need for constant recalibration, providing years of trouble-free operation.

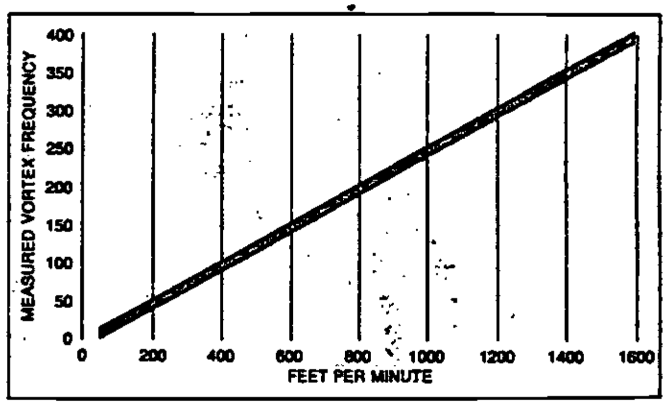
THE MMS-1001 IS THE ONLY SYSTEM OF ITS TYPE TO OFFER THIS RUGGED SENSOR.

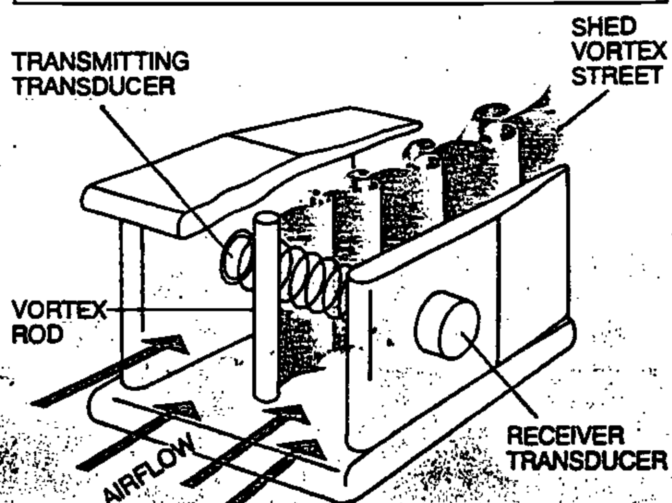
THEORY OF OPERATION

Air movement is sensed by measuring the rate of vortex formation in the wake of the vortex generating rod. (A sketch of a typical sensing head appears at the right.) Studies have shown that the vortex frequency is linearly related to the air speed, thus a measure of the vortex frequency is equivalent to an air speed measurement.

Vortex sensing is accomplished by passing the wake through an acoustic beam. Transducers are placed on each side of the vortex path. One transducer transmits and the other receives. Vortex passage through the acoustic beam is detected and processed in the sensor electronics.

TYPICAL MMS-1001 CALIBRATION





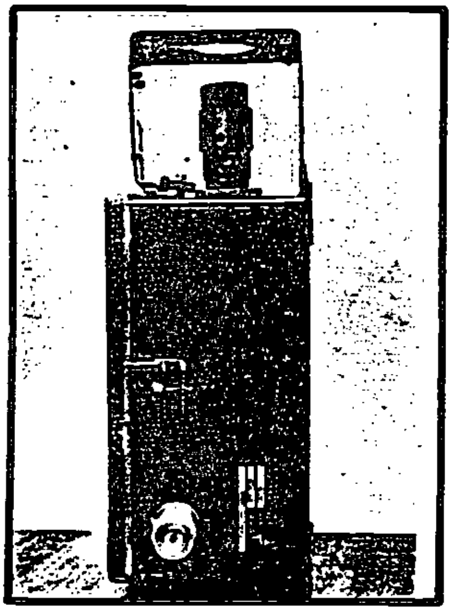
For more information about the MMS-1000 Series Monitoring System contact:

J-TEC

J-TEC ASSOCIATES, INC.
317-7th. Ave., S.E.
Cedar Rapids, Iowa 52401
(319) 366-7511

J-TEC ASSOCIATES, INC.

VM-101B METHANE SENSOR



VM101B Methane Sensor

GENERAL DESCRIPTION:

The J-TEC VM-101B Methane Sensors are designed with state-of-the-art components to provide continuous methane monitoring in hazardous areas.

J-TEC utilizes a plug-in sensor, consisting of two heated filaments housed within a sintered stainless steel flame arrestor. The active filament is coated with a catalytic material, while the reference filament is not catalytic, therefore creating a temperature/resistance difference. This difference is then converted to provide a 0 - 5 VDC signal directly proportional to methane concentration. Options available are: 1-5 ma or 4-20 ma current output, dual set points for indication of methane above or below preset levels and/or capability for a user-installed electronics board.

The VM-101B requires a DC voltage of 12-21 volts. Power requirements are 75 ma for the standard 0 - 5 VDC output, VM-101B, 85 ma for a unit with the 1-5 ma option, and 100 ma for the unit with 4-20 ma option. All connections are made to a well-defined terminal strip located directly inside the front cover. J-TEC recommends any other equipment connected to the analog line have a minimum input resistance of 10,000 ohm.

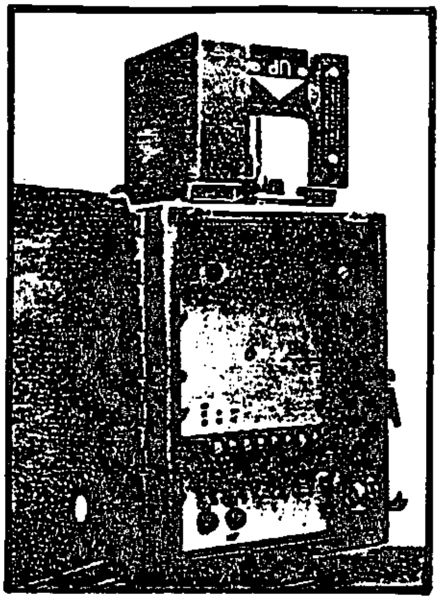
The VM-101B features a fail-safe indicator through logic level switching. The sensor failure output indicates the sensing element is operating. A circuit within the VM-101B detects whether the sensing element is shorted or open. A high output (at about 8 VDC) on the failure output indicates the sensor element is in normal operating condition. A low output (less than 1 VDC) indicates sensing element has failed. This feature allows the customer to be aware of the total condition of his sensor at all times.

Service is no problem with J-TEC's Methane Sensor. All the cards are modular designed for easy plug-in replacement.

FEATURES

- Easy Calibration
- Intrinsically Safe
- Easy to Maintain
- Continuous Monitoring
- Solid State Electronics
- Low Power Consumption
- Fast, Accurate, Stable Response
- Self-contained Unit
- High Reliability
- Rugged Construction
- Long Sensor Life
- Low Installation Costs
- Easy Sensor Replacement

EASY ACCESSIBILITY TO ALL MAJOR CARDS.



CALIBRATION:

The VM-101B is calibrated initially at the factory. The continued calibration accuracy will depend upon the installation and its environment. J-TEC recommends the VM-101B initially be recalibrated at intervals not exceeding one month. A log should be kept indicating any adjustments made. In this manner, the customer may either shorten or lengthen his calibration intervals.

VM-101B SPECIFICATIONS

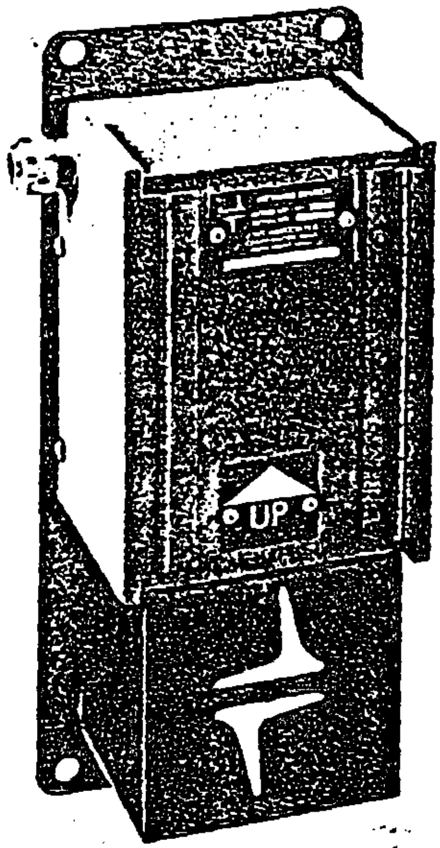
Range:	0-5% CH_4
Power:	12-21 VDC @ 75 ma maximum
Accuracy:	± .2% CH_4
Output Signal:	0-5 VDC Optional: 4-20 ma or 1-5 ma
Sensor Fail:	Logic level indications A) >6 volts for normal operation B) <1 volt for failure Option: Interaction with current output to cause current to go below lower signal level (4 ma or 1 ma)
Detector:	Catalytic type
Calibration:	Calibration by direct insertion of calibration gas, adjustable zero and span for direct voltage readouts.
Construction:	Stainless steel enclosure
Construction Sensor:	Explosion proof, stainless steel body and flame arrestor containing plug-in sensor.
Stabilization:	20 to 30 seconds nominal
Temperature:	-0° C to +50° C
Dimensions:	12.5" × 7" × 4"

FOR MORE INFORMATION CONTACT:

J-TEC

J-TEC ASSOCIATES, INC.
317-7th Ave., S.E.
Cedar Rapids, Iowa 52401
(319) 366-7511

METHANE SENSOR



The J-TEC VM-101 Methane Sensor was designed for the continuous monitoring of methane concentrations in coal mines. Sensing is accomplished through the use of a carefully matched pair of Pellistors consisting of a coil of platinum wire imbedded in pellets of alumina called refractory beads. One pellistor is made active by applying a special catalyst to the refractory bead.

The matched pair is mounted in a low voltage wheatstone bridge configuration. In the bridge circuit both Pellistors are heated to an optimum temperature. The oxidation of the methane on the active pellement causes an increase in its electrical resistance. The bridge unbalance and its output becomes an accurate measurement of the methane content in the atmosphere.

SPECIFICATIONS

FUNCTION:	Methane Sensor
RANGE:	0 to 5% Methane
POWER INPUT:	10 to 18 VDC @ 125 ma typical
OUTPUT:	A) Analog, 0 - 5 VDC B) Alarm, Logic Level 0 - 5 VDC at 1 & 2% Concentrations
TEMPERATURE:	0 to 50° C
ACCURACY:	$\pm$ .2%
SIZE:	10" H x 5" W x 4" D
WEIGHT:	7 Pounds
CONNECTIONS:	Barrier Strip
INTRINSIC SAFETY:	Tested by M.S.H.A. Meets intrinsic safety requirements of 30 C.F.R., Part 18.68.

Specification No: 100-

Purchasing Specification for A Mine Monitoring and Control System
* *

1.0 Scope---

This specification covers the performance and features of a monitoring and control (M/C) system (hereinafter, "System") which will be purchased by us (hereinafter "Customer") from "Vendor" and employed in our underground mining operations. It will be installed by "Customer" in accordance with "Vendor" instructions, and shall perform as specified herein, or as amended in writing, approved by Customer and Vendor. A mine map showing distances and general arrangements of underground and surface facilities is attached.

2.0 System description--- (see Appendix A for applicable items.)

The System shall have the capability of monitoring and controlling conveyors, section power centers, circuit breakers, rectifiers, dewatering pumps (including sump levels), ventilation fans, storage bins, crushers, vibro feeders, longwall faces, etc., and for monitoring the environment for methane, carbon monoxide, air velocity, etc. In addition, the System shall have the capability to monitor other mine factors, such as seismic events, roof movements, mining machine performance, etc. Specific capabilities and sensors to be supplied are detailed in Appendix A, attached. Additional capacity which can be used later for connecting a variety of sensor inputs and control output functions within the capability of the proposed System shall be as specified. The System shall be modular and easily adapted and expanded further by adding components to meet the future needs of our mining operations. A functional diagram of the System showing the arrangement of components shall be supplied.

3.0 Central control station---

The proposed central control station shall handle the initial requirements contained in Appendix A, but shall also have reserve capacity to expand up to a total of at least 168 outstations without obsoleting any of the components supplied. The central control station will be located in a convenient room or office near the entrance to the mine. It shall consist of an efficient, modern desk console with a sturdy metal cabinet for housing the computer components. On top of the desk shall be one (or two, as specified in Appendix A) 19-inch color video monitor(s), a keyboard, and a high speed printer. The metal cabinet shall contain the primary computer, the communication controllers, the video character generator, power supplies, ventilation fan, and a power conditioning module. A controlled, air conditioned environment shall not be required for reliable operation of the central control station, or for any other parts of the System. The ambient operating environment shall be as follows:

Temperature	0 to 40 C
Humidity	0 to 95 %, non-condensing
Dust	usual mine office or bath house

3.1 Primary computer---

The primary computer shall contain the instructions and data analysis capabilities to interpret sensor data in real time; generate summary reports and presentations; accept keyboard command inputs; drive the visual display unit(s), printer, and magnetic data storage unit; present data in summary and graphical forms; determine alarm levels; and control warning beepers and speech output at the central station. The computer shall be microprocessor based with sufficient capacity to handle the prescribed functions totally in solid state random access memory (RAM). Rechargeable batteries shall keep the memory alive for up to three days without mains power, to avoid loss of program instructions or stored data due to ordinary power outages. If specified in Appendix A, the primary computer shall also support up to two remote monitoring sites (each having a color VDU and keyboard) and shall be capable of interfacing with an off-line computer through an RS-232 interface for long term data storage and later analysis. Up to 1 megabit of non-volatile, long term data storage shall be supplied, if specified in Appendix A.

3.2 Communication controller---

This unit shall be located in the central control station and shall handle the communications to and from the outstations. It shall update its registers of outstation status every few seconds. One unit shall handle up to 28 outstations, using one or two communication circuits. As many as 6 communication controller units shall be supported by the primary computer, accommodating up to 168 outstations and up to 12 circuits. Analog outputs from the control unit, as specified in Appendix A, shall be available for driving panel meters or strip chart recorders.

3.3 Visual display unit (VDU)---

One or more 19-inch high resolution color video monitor shall be supplied (see Appendix A) for displaying data listings, summary tables, graphs, and mimic diagrams depicting the current status and conditions underground. The VDU shall provide real-time feedback to the operator by visual presentations. It shall have at least 700 vertical lines for good clarity and resolution. It shall employ a triple-gun, sealed CRT for long term stability. Video adjustments, including degaussing, shall be accessible from in front of the unit. If specified in Appendix A, as many as four VDUs shall be supported by the computer to enable independent listings or presentations to be viewed at the same time.

3.4 Character generator---

The interface between the primary computer and a VDU is the character generator unit. Encoded instructions from the computer shall be converted by the character generator into video signals for causing a VDU to display information in the proper format.

3.5 Keyboard---

The keyboard, with a "qwerty" format, shall be the primary means for the operator to communicate with the System. Instructions to list or print data, or commands to start or stop underground equipment, shall be entered by the operator through simple keyboard codes. The keyboard shall be physically separated from the VDU and printer units to enable the operator to position it for maximum convenience and comfort.

3.6 Remote VDU output sites---

The System shall be capable of accommodating the addition of up to two remote VDU/keyboard sites, within a distance not exceeding one half mile from the central control station. These remote units will be located in other offices (e.g. superintendent, maintenance, or engineering) to more fully utilize the management capability of the System. For safety, control commands from the remote keyboards shall be inhibited.

3.7 Printer---

A high speed printer shall be supplied to provide hard copy printout of listings, graphs, etc. which may be needed for permanent file records. The printer specs shall be: 150 characters per second (nominal), dot matrix type print head, tractor feed, using 8-1/2 inch width standard fan-fold paper and a replaceable nylon ribbon. It shall have the capability of making as many as 3 carbon copies plus an original.

3.8 Magnetic tape unit---

The mine layout, names and arrangements of outstations, complements of sensors and controls, definition of mimic diagrams, etc. shall be generated by management personnel behind a "password" and stored on magnetic tape, using the dual drive magnetic cartridge record/playback unit to be supplied with the System. The cartridges shall be effectively sealed to avoid problems with dust, which will be present in the central station area. The tape unit shall not be required for normal operation of the System, but shall be used only briefly and infrequently for storing the setup data and for down-loading the computer in the event of a power outage exceeding several days duration. Tape unit may also be used to save long term operating data which is not critical to the safe operation of the mine, if specified in Appendix A.

4.0 Outstations---

The data collection input and control output interfaces with the underground equipment shall be contained in the outstation units. Generally, one outstation shall handle one piece of major equipment, such as a conveyor, fan, power center, or the like. Each outstation shall be housed in a NEMA-12 type enclosure, measuring approximately 30" wide x 36" high x 12" deep. Sensor cables shall enter the enclosure through glands or connectors on the bottom. Rubber seals shall be provided to help keep dust and moisture out of the enclosure. Because of the rough nature of the underground environments and maintenance, there shall be no microprocessors in any outstations, only circuits having high level signals (i.e. TTL/CMOS logic, transformers, relays, etc.). Any sophisticated computer circuits shall be employed only in the control room components on the surface where proper care is possible. Outstations shall be powered from the 120 VAC (60 Hz) mine power. Start controls shall be implemented by providing a 5 second relay closure in the outstation to initiate the starting sequence in the starter control box, already available at the mine. Stopping shall be initiated by a 5 second relay contact opening, allowing the starter circuit to fall out. Key locked local control switches on the front door of the conveyor outstation shall be available to operate the conveyors in the event of loss of communications with the computer, if specified in Appendix A. Lockout commands through the keyboard shall be available to protect certain hazardous control actions from being implemented. Lockouts shall be displayed on the mimic diagrams. Outstations shall have means to automatically shut down the equipment in the event of serious faults, as defined in Appendix A, even in the event of loss of communications or local power. A prestart warning facility shall also be available, if specified in Appendix A, which sounds a horn in the vicinity of the drive prior to startup, then monitoring the horn sound using a microphone pickup to assure proper operation of the horn. Rechargeable standby batteries shall be supplied, if specified in Appendix A, for powering outstations for up to 8 hours following loss of mine power. The front door shall contain switches for local control and LED panel display for local indication of conveyor status, if specified in Appendix A.

4.1 Conveyor outstations---

Conveyor outstations shall be dedicated to the monitoring and control of conveyor flights. The input/output format shall consist of at least 16 digital (on/off) and 4 analog (1/2% resolution) inputs, and two remote control outputs to the conveyor starter box. Specific requirements of sensors and control options are specified in Appendix A.

4.1.1 Conveyor monitoring---

Production and safety oriented sensors to be included in the System are listed in Appendix A.

4.1.2 Conveyor remote control---

The System shall be capable of automatically starting and stopping flights of conveyors on keyboard command, with proper delays and in logical sequence to avoid spillage or pile-ups on the conveyors. Startup options from the control console shall include: individual, pyramid, and branch starts. A reverse sequence stop command shall be available to allow the operator to stop one, all, or any string of conveyors. An automatic shutdown on certain fault conditions shall be available if specified in Appendix A.

4.2 Environmental outstations---

Environmental outstations will be used to monitor environmental parameters, using digital or analog inputs from special sensors, see Appendix A. The computer System shall be capable of detecting alarm levels (thresholds) which are pre-set by keyboard inputs behind "password", and sounding alarms in the central control room. Environmental units shall have a capacity of at least 16 digital and 4 analog inputs, but no controls or front panel displays are required. These outstations shall have auxiliary power circuits for powering up to four 12-volt sensors, requiring a combined total of 750 milliamps. They may be sited centrally so as to handle sensors from different areas, with distances to sensors as specified. Any requirements for monitoring in a potentially explosive atmosphere are as specified in Appendix A.

4.3 Pump outstations---

Pump monitoring and control shall be performed using a special pump outstation with capabilities for automatically starting and stopping main and backup pumps based on sump water levels, time of day, or other specified conditions noted in Appendix A. Each pump outstation shall have the same channel format as the conveyor outstations, but with special circuit board logic pertaining to pump operating requirements, including the following:

a. The main pump automatically started and stopped at high and low sump levels.
b. Pumps prevented from starting or stopped in the event of a fault (faults specified in Appendix A).
c. A standby pump automatically started if the main pump fails or the water level becomes excessive.
d. Remote start/stop from operator console, provided no alarm conditions are present.

The front panel of the pump outstation enclosure shall contain key locked switches for operating pumps manually underground. Operator shal be automatically notified if outstation is switched to "local control".

4.4 Power center outstations---

These units will be connected to section power centers to monitor voltage, current, ground leakage, loss of phase, and breaker status, and for controlling circuit breakers. Using special instruments specified in Appendix A, the durations when electrical current demands exceed specified levels shall be accumulated for each shift. This will help management evaluate the work efficiency of each section, by machine, operator, and crew. Remote controls to switch power on/off and reset circuit breakers shall be incorporated, if specified in Appendix A.

4.5 Fan outstations---

The main and booster fans shall be monitored and controlled using these fan outstations. Parameters to be sensed and analyzed by the System may include air velocity, water gage pressure, fan speed, vibration, and bearing temperature, as specified in Appendix A. Alarm levels shall be pre-set in the computer, using keyboard commands, to alert management of adverse changes in fan performance, as well as any developing problems, such as increasing temperature, vibration, etc.

4.6 Bin outstation---

This outstation will be used to monitor the levels of storage bins, using ultrasonic bin level detectors. Sensors, as well as outstations, shall be supplied with the System, as specified in Appendix A. Bin levels, chute positions, and in and out conveyor status shall be monitored and controlled to help maintain continuous coal production, as specified in Appendix A.

4.7 Vibro-feeder outstation---

This outstation shall have analog control capability, as well as digital and analog input monitoring. By simple keyboard commands, the thru-put of a vibro-feeder shall increase or decreasd to maintain peak, continuous production, without overloading or spillage.

5.0 Sensors---

Sensors to be connected to the System are listed in Appendix A, some to be supplied with the System, while others are supplied by the customer, as indicated. Those sensors that are to be supplied in MSHA permissible configurations are specifically noted in Appendix A. Other sensors with standard output current/voltage levels, may be purchased later and connected to the System for detecting parameters and functions not considered for the initial installation.

6.0 Electrical cable and communication philosophy---

Communication shall use one four-conductor (AWG-16, two twisted pairs, shielded) cable for each communication controller circuit. The maximum cable length permitted on any communication circuit shall not be less than 10 miles, and line repeaters shall not be required. The communications between outstations and the central control station shall be digital and full duplex (continuous, both directions). The System shall utilize square wave AC communication signals at 600 baud rate. Trouble shooting cables for opens and shorts shall be possible using only a volt/ohm meter and an earphone, and shall not require the use of oscilloscopes, filters, or other exotic equipment underground. Communication circuits shall be transformer isolated to avoid problems with ground loops that may otherwise occur due to differing ground potentials throughout the mine. Modems or other frequency sensitive devices requiring periodic calibration using special instruments or trained personnel shall not be used. Sensor hook up cable shall be specified to meet requirements of particular sensors and distances involved.

7.0 System design---

For reliability, simplicity, and ease of maintenance, the System shall be designed to meet the following special requirements.

7.1 Control security---

The telemetry of critical data shall be made secure by repeat transmissions. No actions to start remote equipment shall be made without verification through at least three transmissions, in sequence and without discrepancy. Thus, minimizing false alarms and hazardous control actions resulting from electrical noise coupled to the outstation communication lines. Any loss of communications shall cause the stoppage of the controlled equipment.

8.0 Software---

All software necessary for performing the specified monitoring (digital or analog) and control (on/off or analog) functions shall be delivered with the System. Particular data analysis and graphics programs shall be made available from the following list:

Menu listings of options for readouts and commands.
Analog alarms (high/low/none or rate of change, with computer set alarm levels).
Digital alarms (on open or closed contacts).
Mimic diagrams (two available, listing all outstations--alarms noted using fault characters).
Conveyor sequencing (one outbye and four inbyes per flight).
Stoppage analysis (multiple, by "kind" of outstation).
Log of alarms (chronological, 4 pages, auto roll-over)
All current alarms (those still outstanding).
Conveyor start (individual, pyramid, and branch options).
" stop (reverse sequence and emergency stop).
Hold on stop, release holds, inhibit local operation.
Vibro-feeder (analog controls).
Pump operation (on/off timing to avoid peak demand time).
" analysis (total running times, numbers of starts/stops, failures, operation of backups, etc.).
Color graphs of analogs (colors identify status).
Hold/release of outstations from local or remote starts (one or all on any comm controller circuit).
Alarm display on VDU in red, yellow when acknowledged, and green when cleared (including beeper).
Longwall face monitoring.

All listings shall have provision for printout in hard copy, including time and date. The log of alarms shall be continually updated, retaining the last 100 alarm and rectification events in memory. This chronological file shall be available for listing or printing at any time along with the time of each occurrence of alarm and alarm rectification event. The log of alarm and stoppage analysis registers shall be capable of being cleared (reset to zeros) by operator command. A crystal controlled 24-hour clock and perpetual calendar shall be available in the computer and time and date shall be continually displayed on the video monitor.

8.1 Speech output---

A microcomputer based voice module in the central control station shall announce to the operator alarms and alarm rectification events, as well as keyboard inputs by the operator, if stated in Appendix A. Changes on the mimic diagram(s) and keyboard errors shall also be announced through a loudspeaker, to be supplied with the System. The voice output shall be switchable on or off at the discretion of the operator.

8.2 Password functions and System security---

An eight character password, selected by us, shall access a set-up mode using a simple menu format. Choices behind "password" shall include:

Change date/time
- password (any eight characters)

Define inputs/alarms/outputs/etc.
- outstation (name/kind/channels).
- transducers (analog scaling, thresholds, etc.).
- analogs (sensor/name/type).
- graphs (8 hour, 24 hour or 7 day periods).
- analog on display (perpetually at top of VDU screen).
- operating parameters (mine nomenclature).
- mimic diagrams (set-up, using VDU coordinate System).
- mimic fault characters (selectable by operator).
- conveyor sequencing (up to 100 conveyors, sequenced).
- stoppage analysis (eight auto shutdown sensor channels for each "kind" of outstation).

Save files on tape (and backup tape for security).

9.0 Documentation and drawings---

Two sets of installation, maintenance, and operating manuals and drawings shall be supplied with the System. Major documents shall include a System Manual and an Outstation Manual, both containing detailed technical information regarding operation and maintenance. Ten Operator Manuals containing information for personnel attending the control console shall also be supplied. On request, samples of documentation shall be provided to Customer for inspection at no cost.

10.0 Installation support and service---

The Supplier shall provide technical and training support at the mine site to assure proper startup of the System. Installation support shall include two technical people at our site for two weeks of supervision, testing, commissioning, and training work.

11.0 Workmanship and warranty---

All equipment supplied hereunder shall be manufactured using first class materials and workmanship, and shall be covered by a warranty for materials and workmanship for a period of 90 days following acceptance by us. All service policy statements and other terms and conditions of sale shall be included with the quotation.

12.0 Demonstrated performance---

System reliability is of the essence in this procurement. Components and software offered or supplied hereunder shall have been thoroughly tested and previously proved satisfactory for the intended use. To demonstrate a complete understanding of the usage and special problems involved in this application, the supplier shall have at least five years experience supplying similar systems for other deep coal mine applications: details to be provided to customer on request at no cost.

13.0 Permissability---

Any portions of the System that are specified for installation in potentially gassy areas of deep coal mines shall have been approved by the appropriate approval agencies, including MSHA and the PA Dept of Mines, as applicable, for such use.

14.0 Cost summary and delivery schedule---

The costs shall be broken down by item, and shall include all components, hardware, software, packaging, insurance, transportation to the mine site, documentation, training of operators and maintenance personnel, commissioning (including travel and living expenses), warranty, stated service, and any other specified costs involved in supplying a complete working system. Note that, unless specified otherwise, cable shall be supplied with the System. However, safe storage of components on site, miscellaneous hardware, and installation effort will be supplied by Customer. Delivery schedule shall be stated as applying to longest lead items, including hardware, software, documentation, etc.

Customer . . . .

Mine . . . .

Address . . . .

. . . .

Attention. . . . . Telephone. . . . .

This date. . . . . Bid due date . . . .

Attachments: Appendix A--- Equipment, functions, and sensors.
Other--- Mine map, sketches, delivery requirements, etc.

Equipment, functions, and sensors to be Included in M/C System
* *

(Customer should use this as a guide for preparing this Appendix to ensure covering all necessary and desired items. Actual listings can be made on separate sheets to avoid confusion with the many possible features that may not be used.)

System parameters---

Above ground central control station (specify quantities or data).

. . . * Number of color video display units.
. . . * Is speech output desired? (yes or no).
. . . * Number of remote VDU output sites desired.
. . . * Is standby power desired? (If so, specify number of hours).
. . . * Is long term data storage desired? (If so, specify days.)
. . . * Are panel meter or strip chart outputs desired? (Specify.)
. . . * Other special requirements. . . . .

System capabilities to be included are listed below. (Specify numbers of locations, and numbers of sensor and control channels per location).

. . . * Monitoring and controlling conveyors. (Prestart warning req'd?)
. . . * " " " section power centers.
. . . * " " " circuit breakers.
. . . * " " " rectifiers.
. . . * " " " dewatering pumps (including sumps).
. . . * " " " ventilation fans.
. . . * " " " storage bins and feeders.
. . . * " " " crushers.
. . . * " " " vibro feeders.
. . . * Monitoring of longwall operations.
. . . * " " atmosphere (gases) for fire and toxicity.
. . . * " " seismic events (earth movements).
. . . * " " roof and floor deflections.
. . . * " " diesel exhaust and operator environment.
. . . * " " face machinery (duration of operation).

. . . * Other . . . .

Note requirements for standby power on outstations, specifying number of hours of operation after mains power failure. Also, state whether local displays or push button controls are required on outstations. State whether auto shutdown, front panel LED displays, local pushbutton control switches, spare channels, etc. are required on the outstations.

Appendix A (equipment, functions, amd sensors, continued).

Sensors to be included: (Specify quantities and any special features. All are to be supplied with System, unless specifically noted.)

Conveyors-

. . . * Belt slip
. . . * " torn
. . . * " misaligned
. . . * Blocked chute (at all transfer points)
. . . * Bearing/motor temp (0 to 200 F)
. . . * Fire, carbon monoxide, analog (5 to 50 parts per million)
. . . * " , thermal, analog and digital (to 135 F)
. . . * " , ionization (smoke) detector.
. . . * Scale (0.1 %, 1 %, or % 5 accuracy required)

. . . * Other . . . .

Environmental (atmospheric parameters with suggested ranges)-

. . . * Air velocity, high (150 to 10,000 fpm)
. . . * " " , med (75 to 3000 fpm)
. . . * " " , low (50 to 1500 fpm)
. . . * Methane (0 to 3% by volume)
. . . * Oxygen (10 to 21%)
. . . * Carbon monoxide, fire (5 to 50 ppm)
. . . * " " , toxic (25 to 500 ppm)
. . . * Carbon dioxide (10 to 5000 ppm)
. . . * Humidity (to 100 %)
. . . * NO (0 to 25 ppm); NO2 (0 to 5 ppm)
. . . * H2S (0 to 10 ppm); SO2 (0 to 5 ppm)
. . . * Formaldehyde (0 to 2 ppm)
. . . * Dust, to MSHA specifications.

. . . * Other . . . .

Pumps, clusters for dewatering mine (analog or digital).

. . . * Sump level (high and extra high)
. . . * " " (low and extra low)
. . . * Pump flow (to 1000 gpm)
. . . * " pressure (to 2000 psi)
. . . * Bearing/motor temp (as specified)
. . . * Vibration.

. . . * Other . . . .

Appendix A (equipment, functions, and sensors, continued)

Power centers and face machinery (ac, analog or digital).

. . . * Current transformer (to 5000 amps)
. . . * Voltage " (110, 220, 440, 550, 960, 1000, and up)
. . . * Loss of phase
. . . * Ground leakage (warning at 100 ma, any phase)
. . . * Ground fault, to MSHA specifications.
. . . * Any DC equipment? (usually 12, 24, 90, 120, 300, or 600 volts)
. . . * Switchgear remote controls (multiple channels available).

. . . * Other . . . .

Ventilation fans and drive motors- (analog or digital.)

. . . * Air velocity (200 to 3000 feet per minute)
. . . * Differential pressure (to 20" water gage)
. . . * Vibration
. . . * Motor/Bearing temp (as specified)

. . . * Other . . . .

Surge bins and storage silos- (analog or digital).

. . . * Ultrasonic bin level sensors (with electronic controls and chute and conveyor inputs; range to 200 ft depth, non contacting, self cleaning, high/low trips plus analog output).

Other-

. . . * Specify any other equipment, functions, and sensors . . . . . .

. . . .

. . . .

Note that any M/C equipment or sensors to be installed inbye the last open crosscut or in return air of a deep coal mine, thereby requiring MSHA and or PA approvals, should be so indicated. Also, equipment to be installed in any deep coal mine within the Commonwealth of Pennsylvania should be clearly marked.

482-A

REMOTE ENVIRONMENTAL MONITORING

AT

NO. 26 COLLIERY

BY

S.K. SCHWARTZ, P. ENG.

SENIOR ELECTRICAL ENGINEER

THE EIGHTEENTH ANNUAL FALL MEETING
OF THE MINING SOCIETY OF NOVA SCOTIA

SYDNEY, NOV. 21, 1981

INTRODUCTION

Cape Breton coal mines have been pioneers in the use of the latest technology in mining coal on this continent. To mention just one example, continuous methane monitoring at the coal face was started in 1976 and the idea of automatically stopping the face conveyor during high gas levels using the face signalling system was conceived and developed by CBDC engineers.

With the introduction of remote environmental monitoring, No. 26 Colliery will be the first underground coal mine in Canada and possibly in North America to have computer-based comprehensive environmental monitoring.

Traditionally surveillance of the mine environment has been based mainly on periodic checks by portable or hand-held monitors. While this method proved adequate, it has some limitations, namely,

1) restricted number of observations and samples;
2) relatively long time between taking measurements and availability of results for assessment.

With remote monitoring the above limitations are overcome since (a) monitoring is continuous, (b) monitored data is updated quickly (typically 5 - 7 sec.). Remote monitoring also provides a centralized 'information center' at the surface from where the entire mine environment can be monitored. Details of modes in which data can be displayed and features available at the location will be discussed later in the paper.

GENERAL LAYOUT

Environmental monitoring scheme at No. 26 Colliery is divided into three sections (Fig. 1). They are:

A) Wall face ventilation

B) Fan performance

C) Methane drainage.

The parameters monitored at these sections are as follows:

A) Wall face (Fig. 2)

The quantity and quality of air entering the wall face monitored at outside end of the coal road with an air flow monitor and a methanometer. Similarly, air leaving the wall face is monitored in the material road about 10 m from the 'Cundy' hole towards the wall face. There are two air velocity monitors also in the material road to monitor the 'Cundy' ventilation system.

B) Fan Performance (Fig. 3)

The flow rate and the gas content of the air through the fan is monitored with a methanometer and a flow meter. A differential pressure transducer monitors the fan pressure.

Underground booster fan drive rooms are ventilated by a fresh air split. Should this system fail, there would be a gas build up in the drive room. A methanometer is therefore installed in the drive room to monitor the gas level.

Thermostats are fitted on fan and motor bearings to detect high temperature. High vibration is detected by vibration switches mounted on the fan shaft and the drive shaft. Provision has been made to monitor current drawn by fan motor when a suitable transducer is available. The surface fan is similarly monitored except methanometers are omitted and a barometric pressure and ambient air temperature transducers are added.

C) Methane Drainage (Fig. 4)

The purity of gas in the methane drainage pipe is monitored by a high concentration methanometer and the quantity is monitored by a flow meter. A vacuum switch is fitted to detect high and low vacuum levels.

Signals from the various sensors are wired to 7 strategically located outstations (Fig. 5) These outstations are at -

1) 13 North Material Road
2) 13 South Material Road
3) 9 South Booster Fan
4) 10 North Booster Fan
5) Main Booster Fan
6) Surface Fan.

Sensor signals are multiplexed at the outstation and transmitted to the surface console through a 7-pair signal cable.

Having seen the overall system, we shall now examine each component in detail and explain the features they offer.

SENSORS (TRANSDUCERS)

The starting point in any monitoring system is usually a transducer. In our case, you could call it the 'heart' of the system. Therefore, it had to be selected with extreme care.

While many transducers may be available for environmental monitoring in surface application, the majority are not suitable for underground installation where the following basic criteria apply.

1) Reliable operation with very little maintenance.
2) Rugged construction both mechanically and environmentally to withstand coal dust, rock dust, moisture, etc.

3) Suitable for use in a potentially explosive atmosphere. The instrument must be either flame-proof or intrinsically safe to EMR standards.

Methane

Methane concentration is the most important parameter to be measured in a coal mine to detect potentially explosive atmospheres. The Seiger BM1 was selected mainly because (a) with six years operational experience our maintenance people are familiar with the units;
(b) the BM1 meets criteria mentioned earlier in the paper;
(c) for its commercial considerations.

The BM1, a single head methanometer, has a range of 0 - 3% by volume and operates on the catalytic combustion principle. This instrument provides a local reading as well as output for remote monitoring.

Air Velocity

Measurement of air velocity is important to assure the mine ventilation system is operating properly. Air velocity measurements made simultaneously at strategic locations throughout the mine can also be a significant aid to ventilation technologists when adjustments are being made to the ventilation system.

Numerous types of air velocity transducers are available. Rotating vane anemometers were investigated but rejected because of poor service life, due to dirt contamination of the blades and bearing. Hot wire anemometers were also rejected because they were too fragile and some operate at excessive surface temperature which is not acceptable in a coal mine environment.

The J-Tec VA-216 airflow sensor was selected. These sensors do not have any moving parts which is a desirable feature in the mining environment. The sensor is based on the phenomenon of 'vortex shedding'. The operation depends on the fact that when air passes a strut, vortices (swirls) are formed in the air behind the strut at a rate which depends on the air velocity. An ultrasonic beam in the air flow behind the strut is modulated by the vortices and is converted to analogue signal electronically. The only known limitation is that the lower limit of flow at which the sensor is usable is about 0.25 m/sec. This should not present any problem in our application.

Methane Drainage Purity

Concentration of methane (purity) in the drainage pipe is monitored with the Seiger BM2H high concentration monitor with a range of 0 - 100%. The detector operates on the thermal conductivity principle; gas flows to and from a chamber in the detector head by means of two supply pipes connected across an orifice plate. The BM2H has local indication as well as output for remote monitoring.

Methane Drainage Flow

In flow rate or quantity of gas flow through the drainage pipe is monitored with a J-Tec VF-581 flow meter. This unit works on the same 'vortex shedding' principle as the J-Tec air velocity monitor. The sensing head of the flow meter is inserted into the drainage pipe. The main advantage of this type of flow meter is that its accuracy is unaffected by changes in temperature, density or pressure.

Fan Pressure

The fan pressure is monitored with Bailey solid-state differential pressure transmitter type BQ7. Similar units have proven successful elsewhere in the Corporation. The only drawback this unit had for underground application was that it required a 24 V DC intrinsically safe power supply with battery back-up. Such a power supply was commercially unavailable. It was decided to design and build these 'in-house' Three of these power supplies have been built in our shops. The units have been certified by EMR.

Bearing Temperature & Vibration

Surface or 'limpet' type thermostats are used to monitor fan bearings and motor bearings for high temperature. An inertia type vibration switch is used to detect high vibration in the fan drive train.

OUTSTATION LAYOUT

As mentioned previously, six (6) outstations are located strategically to minimize cable runs from the transducers. Some roadway transducers are located 1000 m away from the outstations.

The outstation with associated power supply, as well as power supplies for transducers, and the communication unit are mounted on vertical perforated metal panel consisting of one foot wide galvanized steel cable trays bolted together side by side, set in concrete at the bottom and clamped to the arches at the top. This results in a neat and flexible installation.

The outstations, manufactured by Transmitton Ltd., perform three functions:

1) It generates a local alarm and alarm indication independent of the surface computer. Local alarms must be muted and reset at the outstation. Alarms can be muted by a button on the door of the outstation, but alarm indication has to be reset by an authorized person.

2) Up to three trip-functions can be performed at each outstation. Any local alarm can be linked to trip any one of the three trip circuits. These trip circuits when appropriately linked, will trip without the aid of the surface computer as well as when a trip signal is received from the surface.

3) Each outstation will accept up to eight analogue signals and nine on/off signals. These signals are multiplexed at the outstation and transmitted to the surface master station.

The Transmitton TM 204 telemetry system uses time division multiplex (TDM) techniques for data transmission.

CABLES

A single 7-pair shielded cable connects all the outstations to the surface master station. The farthest outstation is approximately 8 kilometers away from the surface master station. Each pair is twisted and shielded to minimize external noise pick up. The 7 pair are divided as follows:

2 pair for ring 'A'
2 pair for ring 'B'
1 pair for Communication
2 pair for spare.

The cable has braided wire armour for mechanical protection and a fire-retardant PVC jacket.

Other cables that had to be purchased for this system are:

a) 2-conductor #16 AWG for signal transmission to the outstations.

b) 2-conductor #10 AWG for powering remotely located transducers.

c) 4-conductor #16 AWG for communication between outstation and remote transducer.

All the above mentioned cables have fire-retardant PVC jacket to meet underground regulations.

SURFACE CONTROL ROOM

The master station and the operator console are located in a 7 x 4m room in the mine management building.

The Transmitton master station comprises of:

- A front end driver (FED) which controls the operation of the outstations. Each FED can control two transmission rings with up to fourteen outstations per ring. In our system the fan outstations are connected to one ring and the wall face outstations are connected to the other.
- The primary computer (INTEL 8085 microprocessor) which monitors the information from the FED and sends operator and program commands to the FED. The primary computer can control up to five FEDs.
- Paper tape reader for loading programs.
- Paper tape punch for storing programs.

The Transmitton Console contains:

- Color T.V. Screen (CRT) which displays the monitored functions upon demand and displays alarms automatically.
- Keyboard which is used to configure plant, request information, send commands and acknowledge alarms.
- Printer which will give a hard copy of the displays on the CRT. The printer also has a secondary keyboard which can be used in the event of main keyboard failure.
- Fall-back panel which is used to monitor and control the FED in the event of primary computer failure.

The primary computer monitors the plant via the FED and the outstations (Fig. 6)

The signals transmitted by the outstations are used by the primary computer to:

A) Raise audible and visible alarms to bring to the attention of the console operator any changes in the status or when alarm levels are detected.

B) Accumulate data to display or print current operational data. Fig. 7, Fig. 8 and Fig. 9 show typical methods in which these displays can be formatted.

C) Accumulate data to produce operational history by use of graphs and tables. Fig. 10 shows a typical list of log alarms, Fig. 11 shows a typical 8 hour histograph. The same type of graph can be programmed for either 24 hours or 7 day time periods.

A dedicated intercom communication system is provided between the console operator, the outstation and the remote transducer locations. This communication network can, from any one of the above locations, be linked to the normal mine communication network.

SYSTEM PROTECTION

The system has built-in protection against the following:

a) Unauthorized changing of plant parameter: A password is required to configure the plant

b) Underground power failure: Protection against power failure is provided by an 8 hour battery-backup for the outstations and all the transducers.

c) Transducer Cable fault: The on/off inputs to the outstation are diode protected against open circuit and short circuit cable faults. The analogue signals have an off-set zero to detect transducer and cable faults.

d) Transmission cable failure: Since the outstations have stand-alone features, transmission cable fault will not affect tripping functions of the outstations.

e) Primary computer failure: In the event of primary computer failure, the fall-back panel can be used to update outstation status as well as send commands to the outstations.

f) Historical data: Historical data is protected by battery back-up in the event of primary computer failure or power failure to the surface console.

TRAINING

Training of the operational and maintenance people was handled as follows:

a) The technicians, electricians and supervisors who will be charged with the responsibility of maintaining the equipment are involved in the installation and commissioning of the system.

b) Four employees were sent to the factory during the testing phase of the equipment to familiarize them with the hardware and software.

c) A special training program has been set up for the operators during commissioning phase of the system.

CONCLUSION

The environmental monitoring system will serve as an effective management tool to make quick and effective decisions. It will also be a significant aid to the ventilation technologists when adjustments are made to the mine ventilation system. The historical data available from the system will help future mine planning.

ACKNOWLEDGEMENT

I would like to take this opportunity to thank the staff at the Electric Shop, Engineering Department, Mining Department and especially management and staff at No. 26 Colliery in particular Mr. Dennis Kelly, for the excellent cooperation in getting this project on the way.

I would also like to thank my colleagues and staff at the Devcoal Building, especially Mr. Bill Jaques and Ms. Lorraine White for the help in preparing the paper.

GENERAL LAYOUT

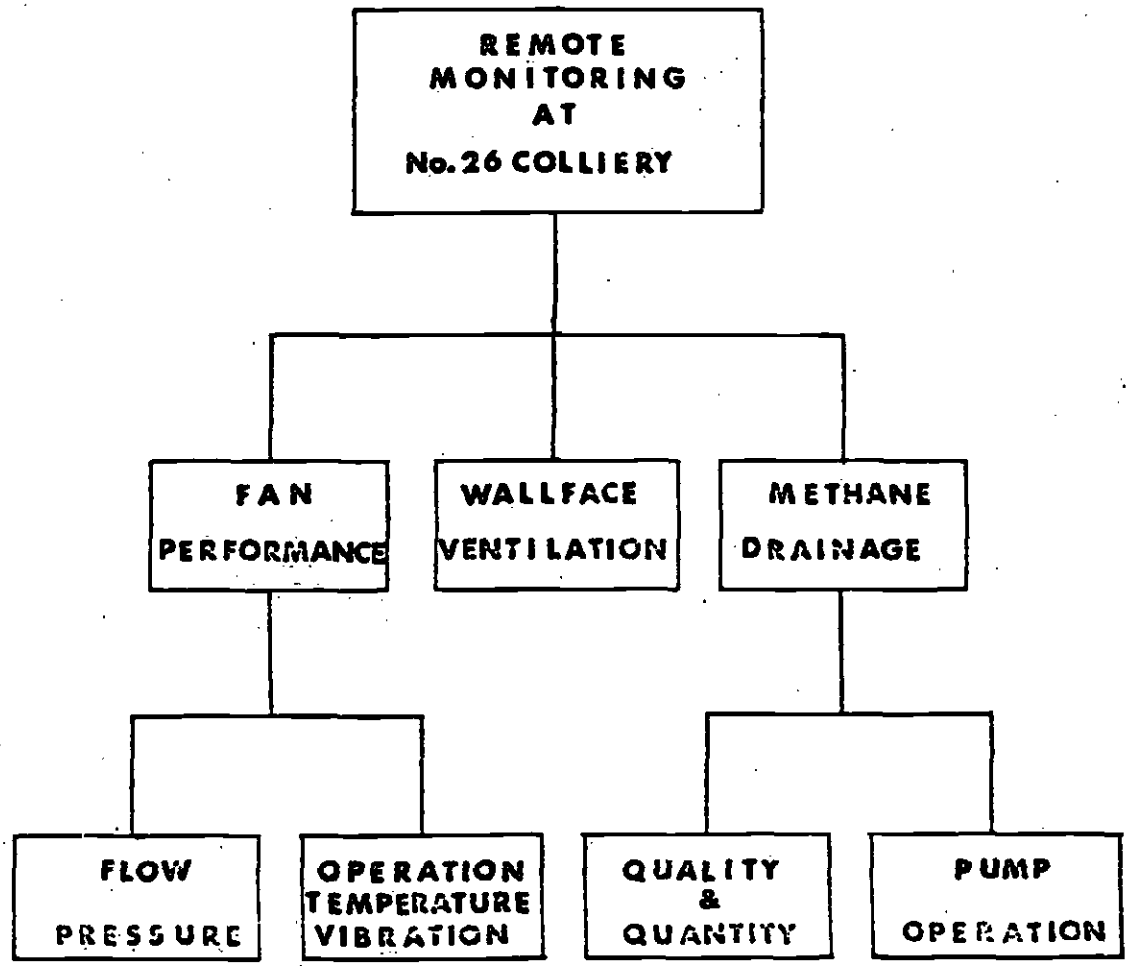


FIG-1

WALLFACE VENTILATION

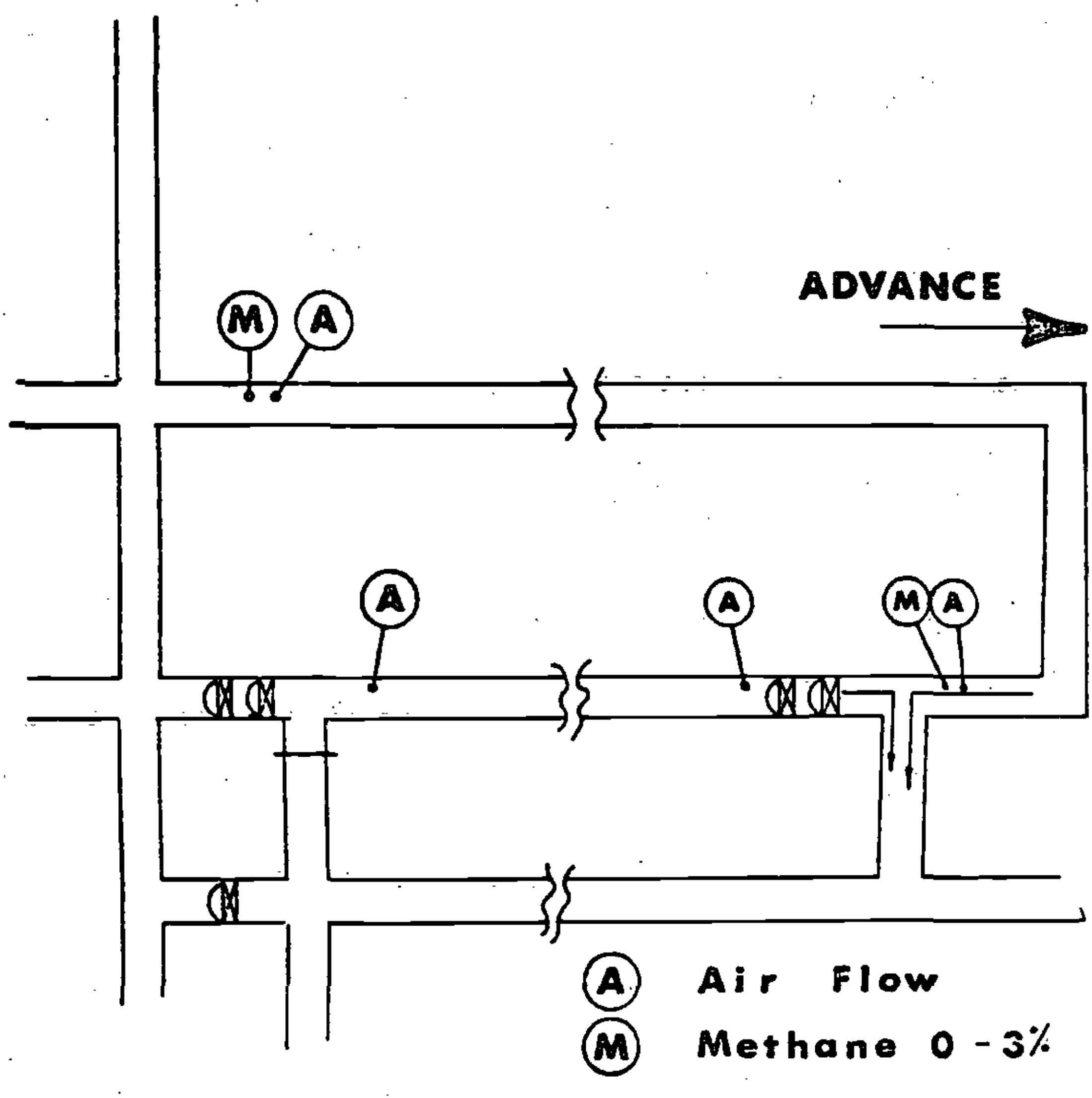
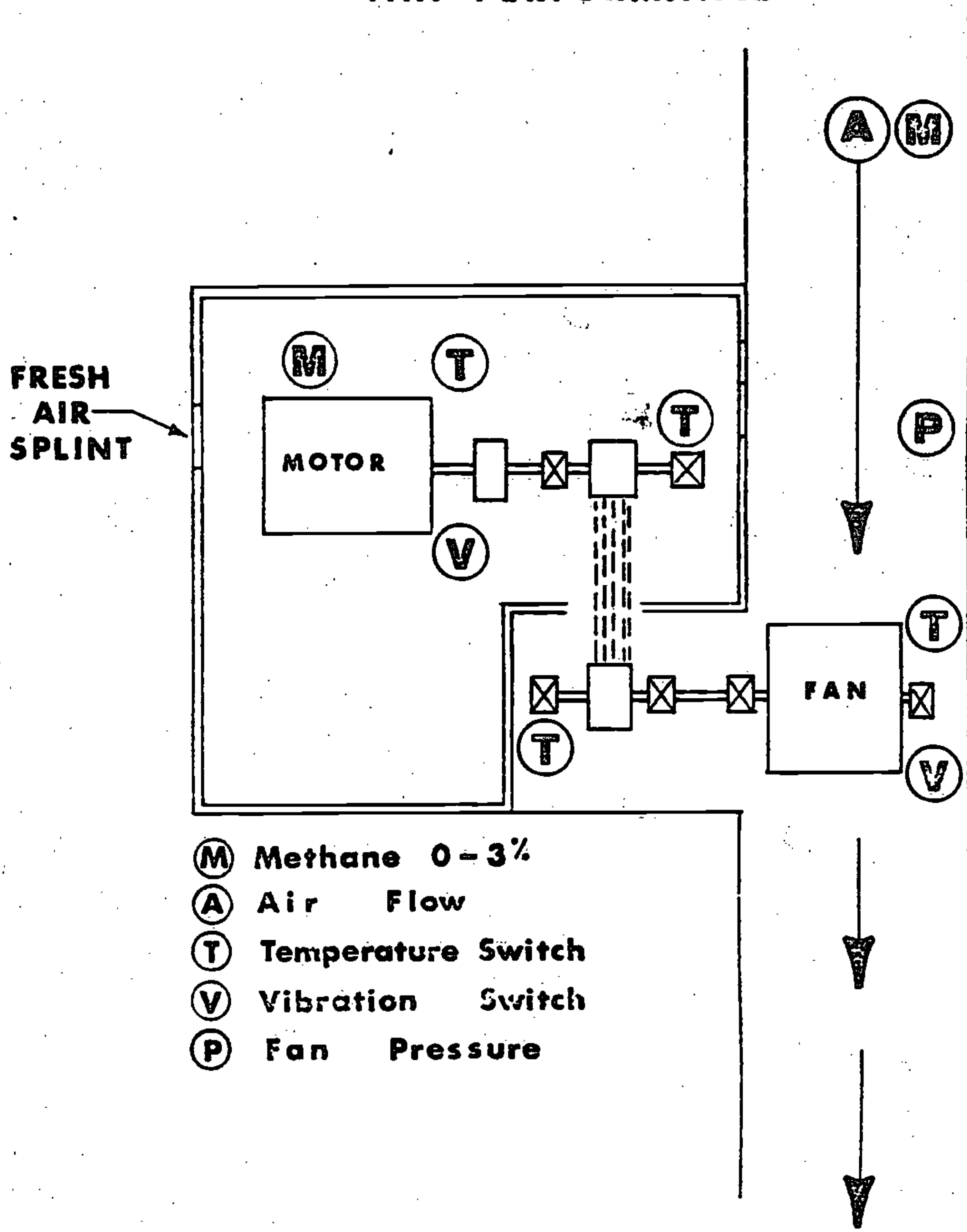


FIG-2

FAN PERFORMANCE



Ⓜ Methane 0 – 3%
Ⓐ Air Flow
Ⓣ Temperature Switch
Ⓥ Vibration Switch
Ⓟ Fan Pressure

FIG – 3

METHANE DRAINAGE

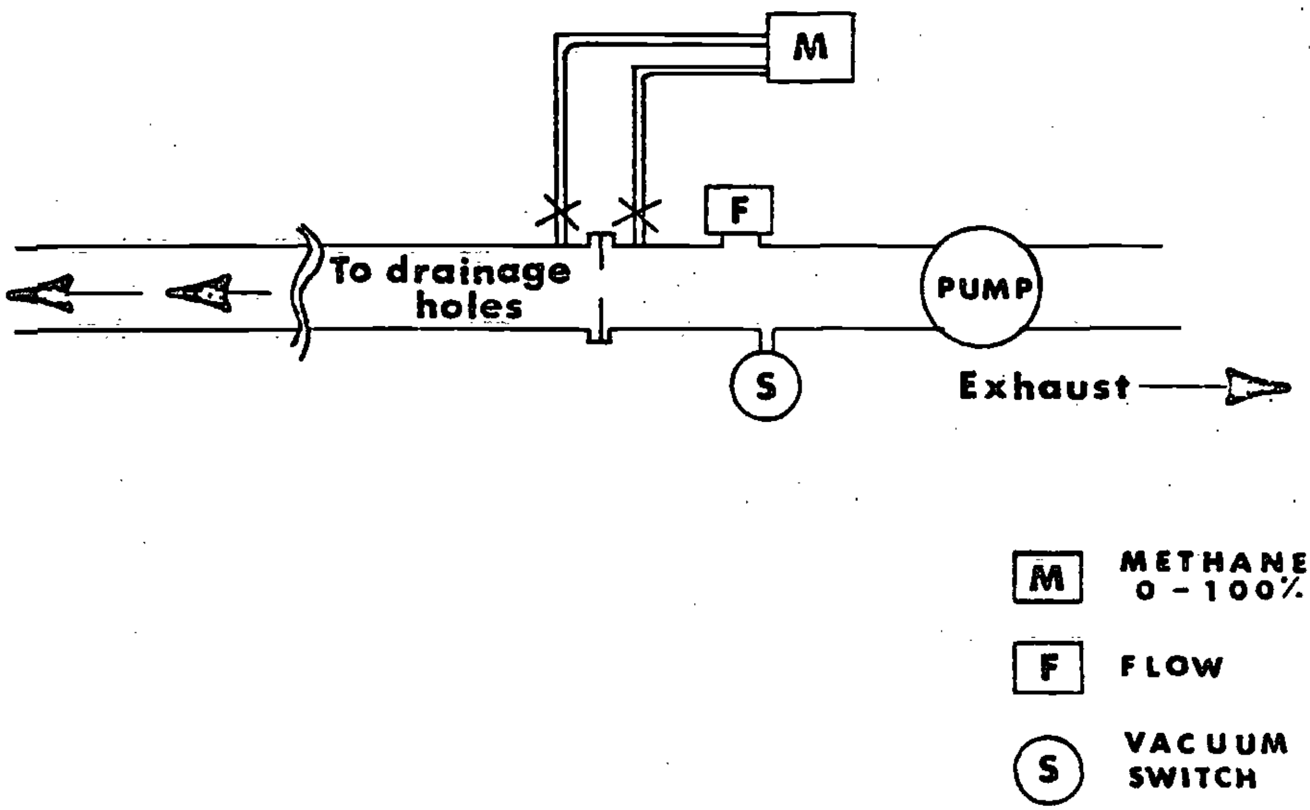


FIG-4

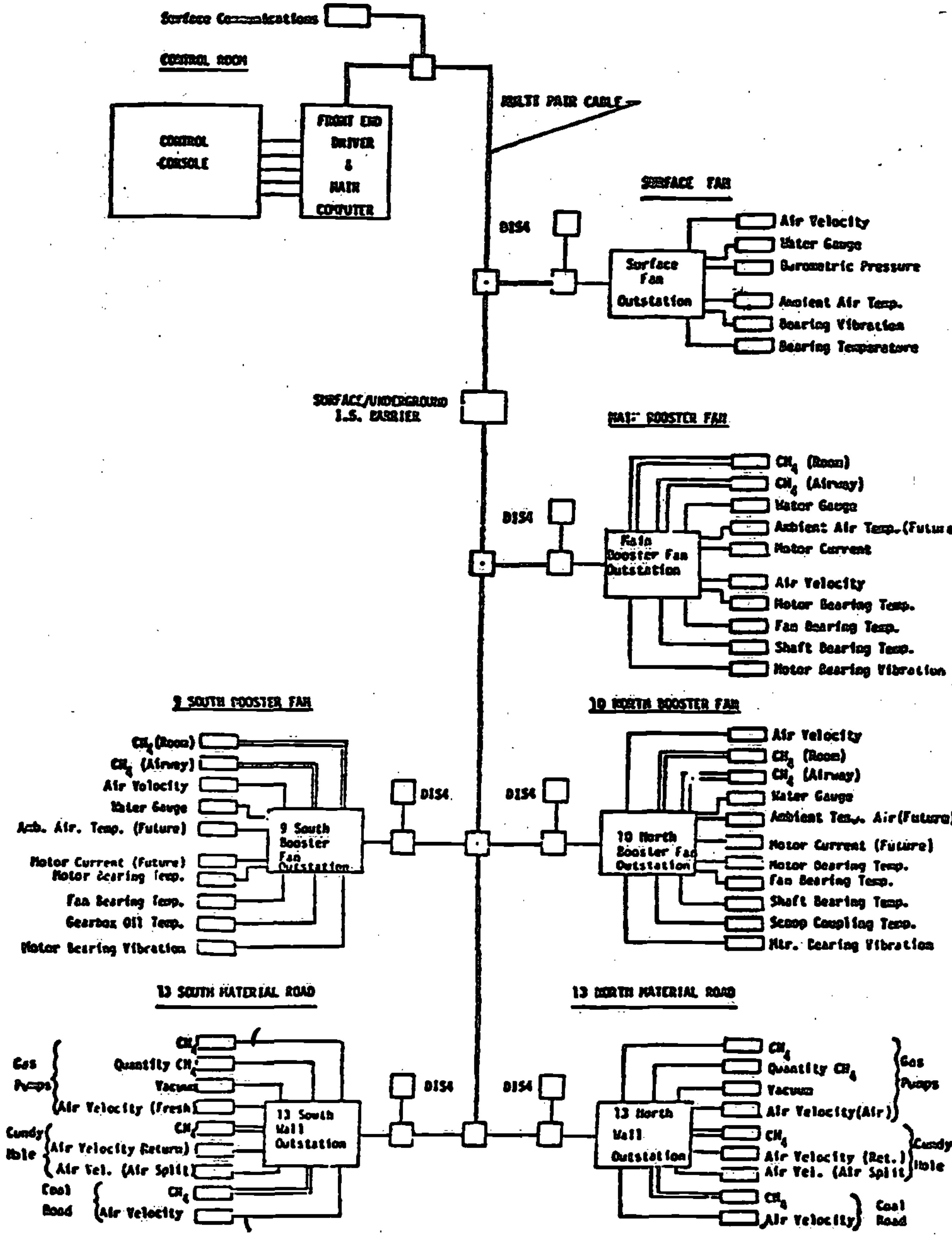

Surface Communications
CONTROL ROOM
CONTROL CONSOLE
FRONT END DRIVER & MAIN COMPUTER
MULTI PAIR CABLE
DIS4
SURFACE FAN
Surface Fan Outstation
Air Velocity
Water Gauge
Barometric Pressure
Ambient Air Temp.
Bearing Vibration
Bearing Temperature
SURFACE/UNDERGROUND I.S. BARRIER
MAIN BOOSTER FAN
Main Booster Fan Outstation
CH4 (Room)
CH4 (Airway)
Water Gauge
Ambient Air Temp.(Future)
Motor Current
Air Velocity
Motor Bearing Temp.
Fan Bearing Temp.
Shaft Bearing Temp.
Motor Bearing Vibration
9 SOUTH BOOSTER FAN
9 South Booster Fan Outstation
CH4 (Room)
CH4 (Airway)
Air Velocity
Water Gauge
Amb. Air. Temp. (Future)
Motor Current (Future)
Motor Bearing Temp.
Fan Bearing Temp.
Gearbox Oil Temp.
Motor Bearing Vibration
10 NORTH BOOSTER FAN
10 North Booster Fan Outstation
Air Velocity
CH4 (Room)
CH4 (Airway)
Water Gauge
Ambient Temp. Air(Future)
Motor Current (Future)
Motor Bearing Temp.
Fan Bearing Temp.
Shaft Bearing Temp.
Scoop Coupling Temp.
Mtr. Bearing Vibration
13 SOUTH MATERIAL ROAD
13 South Wall Outstation
Gas Pumps
CH4
Quantity CH4
Vacuum
Air Velocity (Fresh)
Cundy Hole
CH4
Air Velocity Return)
Air Vel. (Air Split)
Coal Road
CH4
Air Velocity
13 NORTH MATERIAL ROAD
13 North Wall Outstation
CH4
Quantity CH4
Vacuum
Air Velocity(Air)
Gas Pumps
CH4
Air Velocity (Ret.)
Air Vel. (Air Split)
Cundy Hole
CH4
Air Velocity
Coal Road

FIG-5

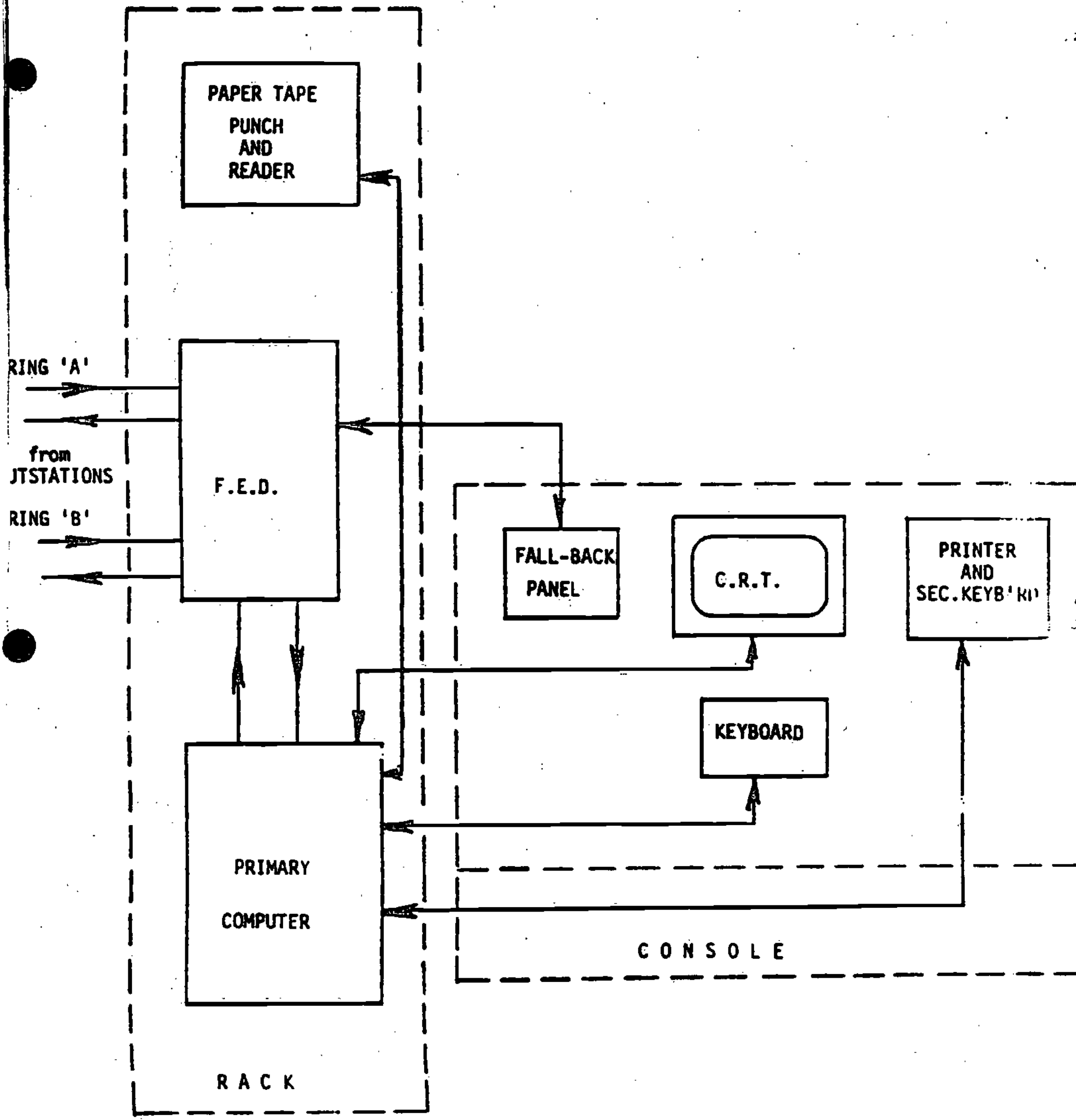


FIG- 6
MASTER STATION LAYOUT

21/11/81 Ø9:3Ø

SURFACE BAROMETR 8 98.9 KPASCALS LH (B

LIST OF ALL ALARMS

```
13 SOUTH LO LEVEL 1 BM1 BOT   AL
13 SOUTH LO LEVEL 5 IN CUNDY  AL
13 SOUTH LO LEVEL 6 OUTCUNDY  AL
13 SOUTH LO LEVEL 7 COAL RD.  AL
13 SOUTH LO LEVEL 8 MAT ROAD  AL
13 SOUTH HI LEVEL 1 BM1 BOT   AL
13 SOUTH HI LEVEL 3 BM2H      AL
13 SOUTH HI LEVEL 4 GAS FLOW  AL
13 SOUTH HI LEVEL 5 IN CUNDY  AL
10 NORTH ISOLATED             AL
LIST COMPLETE
```

LL 9:3Ø 1Ø NORTH FANVIBRATE OK

FIG - 7

EXAMPLE OF C.R.T. DISPLAY WITH LIST OF CURRENT ALARM

18/11/81 10:21

LIST OF OUTSTATION A01 STATUS

NAME: 13 SOUTH KIND: ENVRMNTL TYPE: 01

CHANNEL		STATE	CHANNEL		STATE	
01	LS ANALOG	N	15	SPARE 2	N	IN TRANSMISS
02	....	N	16	U/G ACFAIL	N	STOP 1 RELEA
03	....	N	17	COM FAULT	Y	STOP 2 RELEA
04	....	N	18	SPARE 3	N	STOP 3 RELEA
05	....	N	19	SPARE 4	N	
06	....	N	20	SPARE 5	N	
07	....	N	21	BM1BOTFAIL	N	
08	MS ANALOG	N	22	BM1BOTWARN	Y	
09	MUX1	N	23	BM1TOPFAIL	N	
10	MUX2	N	24	BM1TOPWARN	Y	
11	MUX4	N	25	BM2H FAIL	N	
12	HI VACUUM	N	26	BM2HLOWARN	Y	
13	LO VACUUM	N	27	BM2HLO ALM	N	
14	SPARE 1	N	28	BM2HHI ALM	Y	

COMMANDS: 1=N 2=N 3=N 4=N 5=N 6=N 7=N 8=N 9=N 10=N 11=N 12=N 13=N 14=N 15=N

ANALOG 1	BM1 BOT	1.15	%METHANE	LH	(82)
ANALOG 2	BM1 TOP	1.83	%METHANE	L	(B0)
ANALOG 3	BM2H	16.	%METHANE	L	(56)
ANALOG 4	GAS FLOW	1563	CFM	H	(B4)
ANALOG 5	IN CUNDY	1898	FT/MINUTE	LH	(B6)
ANALOG 6	OUTCUNDY	1945	FT/MINUTE	L	(B8)
ANALOG 7	COAL RD.	1945	FT/MINUTE	L	(B9)
ANALOG 8	MAT ROAD	1898	FT/MINUTE	L	(B6)

LIST COMPLETE

FIG - 8

EXAMPLE OF OUTSTATION STATUS PRINT-OUT

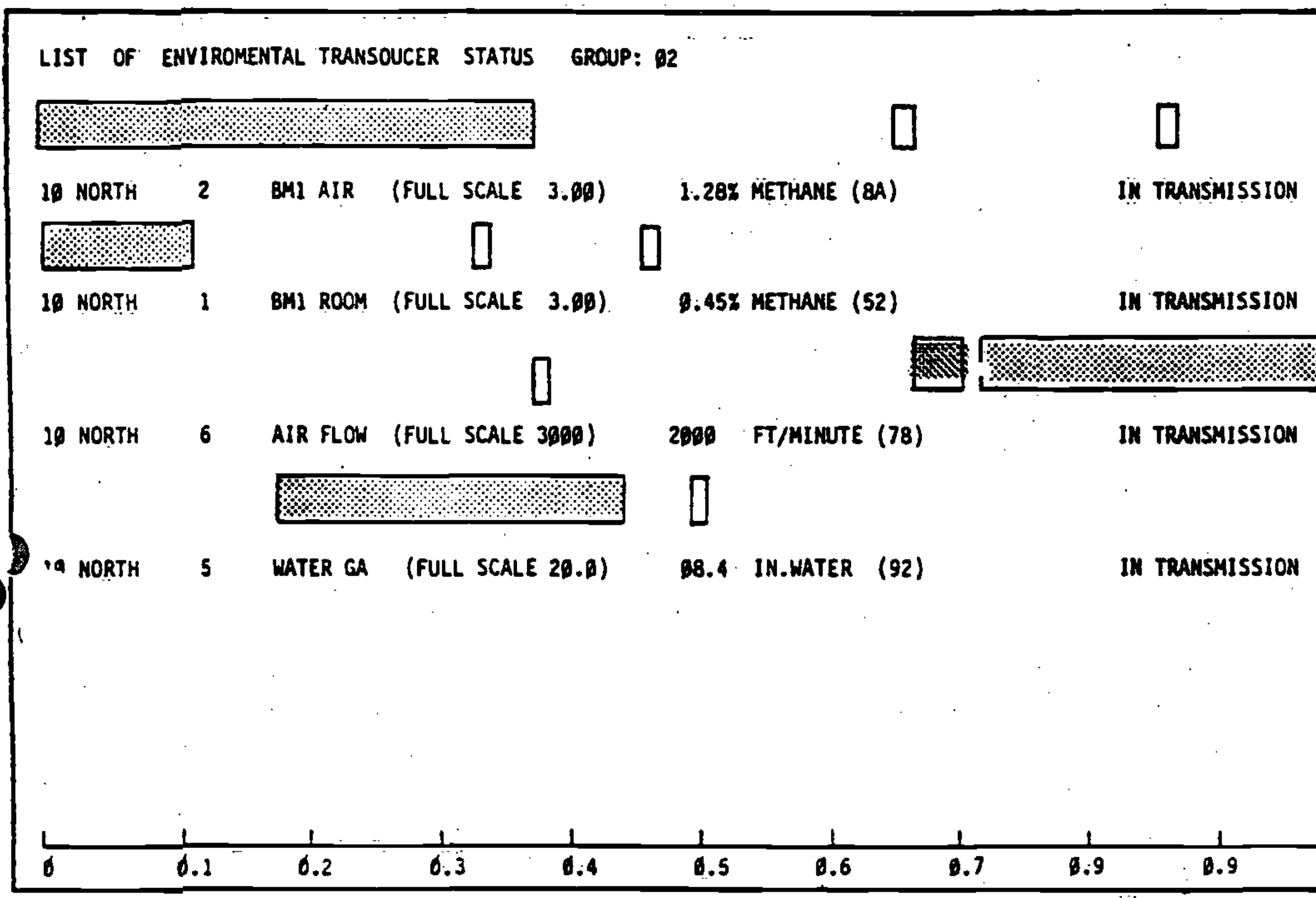


FIG - 9

EXAMPLE OF GRAPHICAL OISPLAY OF A GROUP OF TRANSDUCERS

```
LIST OF ALARM LOG SINCE   01/11/81     07:00
08:07  13 SOUTH   BM2H  3   LO LEVEL     AL
08:08  13 SOUTH   BM2H  3   LO LEVEL     OK
08:10  10 NORTH   SCOOP TEMP             AL
08:21   9 SOUTH   AIRFLO 6  LO LEVEL     AL
08:32  10 NORTH   SCOOP TEMP             OK
09:13   9 SOUTH   AIRFLO 6  LO LEVEL     OK
09:29  10 NORTH   FAN VIBRATE            AL
09:31  10 NORTH   FAN VIBRATE            OK
LIST COMPLETE



LL
```

FIG - 10
EXAMPLE OF LIST OF LOG ALARMS

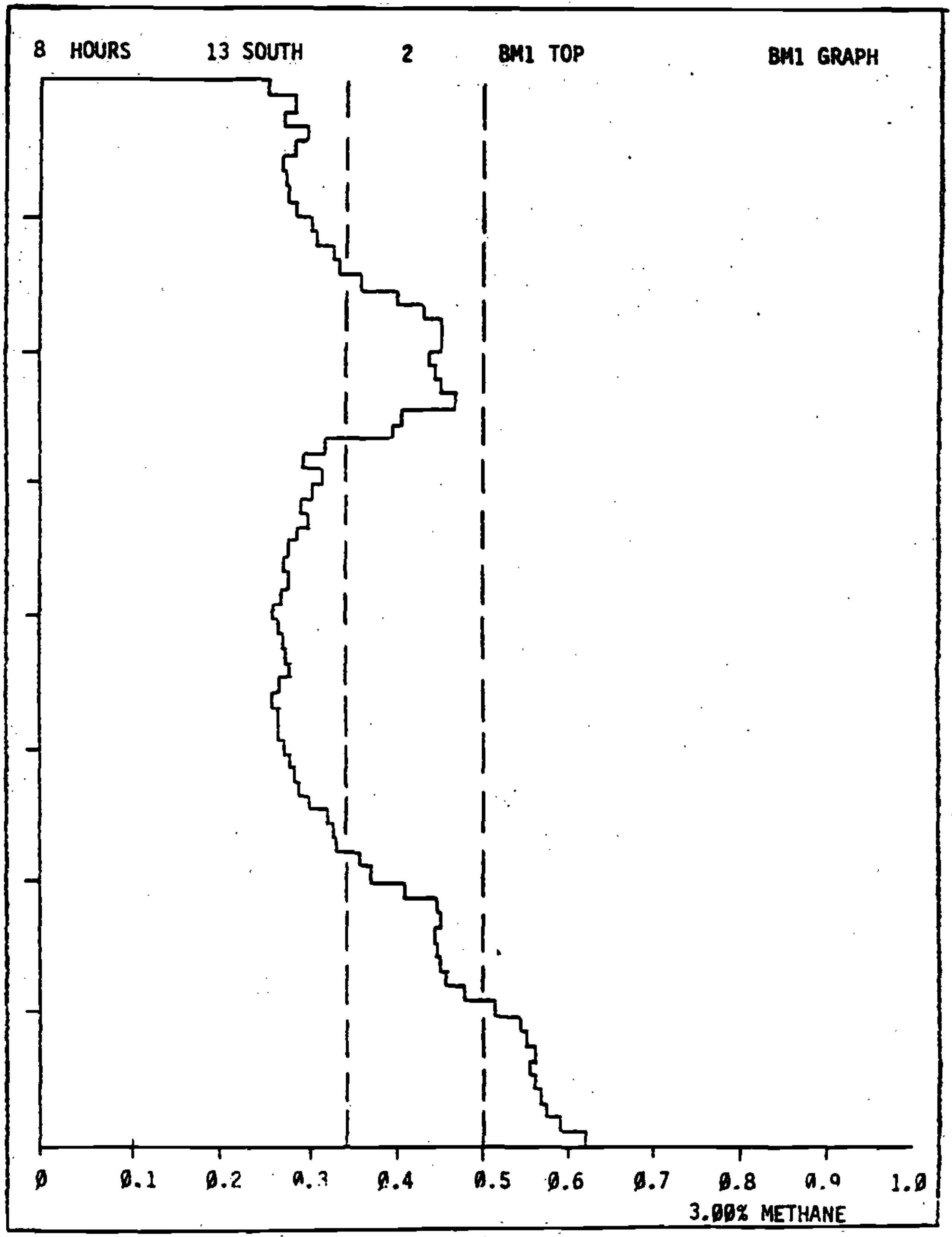


FIG - 11

EXAMPLE OF 8-HOUR HISTOGRAPH DISPLAY

Minetics Corporation
150 Plum Industrial Court
Pittsburgh, PA 15239
(412) 325-3121

MENTION YOU SAW THEIR PRODUCTS IN THE 1983 FIRE PROTECTION REFERENCE DIRECTORY AND BUYER'S GUIDE

Rescue Systems, Inc.
Truck Body & Equipment Assn.

Compressed air testing
Galiso, Inc.
Sub-Aquatics, Inc.
Texas Research Institute, Inc.

Computers
Adams/Alarm Device Manuf. Co.
Coded Communications Corp.
Communication Manufacturing Co.
Digitize, Inc.
Fire Research Corporation
Galiso, Inc.
Honeywell, Commercial Division
Kidde Automated Systems
Lama Corporation
MCC Powers
Motorola Comm. & Electronics
Sigma Design, Inc.
TriData
Valiant IMC

—Software/data systems
Customized Business
TriData

Concentrates, liquid, air foam
Alison Control, Inc.
D.K.O. Industries, Inc.
Feecon Corporation
Lorcon Foam, Inc.
National Foam System, Inc.

Conduit, electrical
AFC/American Flexible Conduit
Allied Tube & Conduit Corp.
Republic Steel Corporation

Consoles, control
Alarm Lock Corporation
Communication Manufacturing Co
Fire Research Corporation
Galiso, Inc.
Harrington Signal Company
Kidde Automated Systems
Locknetics
Medical Comm. & Instr., Inc.
Pieper Electric, Inc.
Protec, Inc.

Consultants, communications
Fisler & Associates

Consultants, sprinkler
Fire Sprinkler Consultants
Walsh Engineering, Inc.

Containers (materials handling, oxes, portable, safety, spray naterial, waste)
.A.H. Industries, Inc.
abelmaster
yon Metal Products
he Protectoseal Company
epublic Steel Corporation
chell, Inc.

ontrollers, pump
nco Wheaton, Inc.
re Research Corporation

ouplings (see pipes) 1961
roquip Corporation
D. Allen Mfg. Division
r-Way Manufacturing Co.
w Corporation
nac Corporation
mer Industries, Inc
sser Manufacturing Division

Emco Wheaton, Inc.
Grinnell Fire Prot. Systems Co
Grunau Sprinkler Mfg. Co., Inc.
Hydra-Shield Mfg., Inc.
ITT Grinnell Corporation
Jaffrey Fire Protection Co.
J.W. Moss, Inc.
Rockwell International Corp.
Scandia Industries, Inc.
Victaulic Company of America

—Fire hose
W. D. Allen Mfg. Division
Badger Powhatan
Elkhart Brass Mfg. Co., Inc.
Fire-End & Croker Corporation
Fire House
Grunau Sprinkler Mfg. Co., Inc.
Jaffrey Fire Protection Co.
J.W. Moss, Inc.
Per Mar Security & Research Corp.
Red Head Brass, Inc.
Scandia Industries, Inc.
Sierra Fire Equip. Co.
Snap-Tite, Inc.

—Flexible hose, reducing
Scandia Industries, Inc.

Covers, dust
W. D. Allen Mfg. Division
D.W.I. Industries, Inc.
W.S. Darley & Company
Easton Industrial Safety Corp.
Ehmke Mfg. Co., Inc.
Elkhart Brass Mfg. Co., Inc.
Emco Wheaton, Inc.
Envirometics, Inc.
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Monaco Enterprises, Inc.
J.W. Moss, Inc.
Schell, Inc.
A. Smith & Son, Inc.
Steiner Industries
Westfield Sheet Metal Works
Ziamatic Corp.

Cushioning material, flame resistant
Ehmke Mfg. Co., Inc.
Toyad Corporation

Cutting equipment
Amfire Industries, Inc.
Benner-Nawman, Inc.
W.S. Darley & Company
Firetrol, Inc.
Kenco Pumps, Inc.
Lincoln St. Louis
Midcontinent Conversion Co.
Pace Machinery & Fittings Inc.
Rockwell International Corp.
Textron, Inc.
Victaulic Company of America
Welders Service, Inc.
Ziamatic Corp.

— D —

Dampers
Air Balance, Inc.
Honeywell, Commercial Division
Northfab Systems, Inc.
Penn Ventilator Co., Inc.
Phillips Aire
Prefco Products Inc.
Reed National Corp.
Westfield Sheet Metal Works

Decals
American Knitwear & Fabric Emb
Cairns & Brother, Inc.
Cardinal Cap & Jacket Company
Civic Supply Company
El Colo Company
Creative Awards By Lane
Dixie USA, Inc.
Eagle Regalia Co., Inc.
Eastern Emblem Mfg. Corp.
E D Products
Fire House
Flo-Rite Uniform Co.
The Hinco Company
Johnston Holloway & Co.
Labelmaster
Midcontinent Conversion Co.
Reflexite Corporation
Seton Name Plate Corp.

Decoders
L. W. Bills Company
Coded Communications Corp.
Edwards Company, Inc.
Electrosonics Int'l, Inc.
Federal Signal Corporation, Signal Div.
Harrington Signal Company
[illegible] International Co., Inc.
Plectron Corporation
Reach Communications Corp.
[illegible] Inc.

Defibrillators
Datascope Corporation
Dixie USA, Inc.
Dyna Med, Inc.
Fire House
Midcontinent Conversion Co.
Narco Scientific
Zoe Medical Products Co., Inc.

Deluge systems
Central Sprinkler Corporation
Chemetron Fire Systems
Grinnell Fire Prot. Systems Co
Grunau Sprinkler Mfg. Co., Inc.
Hodgman Manufacturing Co., Inc
Maxitrol Company
Northfab Systems, Inc.
The Reliable Auto. Sprinkler Corp.

Deodorizers, smoke
~~Stevens Company~~

Detectors, automatic fire 72E
Adams/Alarm Device Manuf. Co.
Alison Control, Inc.
Aritech Corp.
[illegible] Industries, Inc.
L. W. Bills Company
Chemetron Fire Systems
Chloride Pyrotector
S. H. Couch Company
Detector Electronics Corporation
Dictograph Security Systems
Dynamation, Inc.
Edwards Company, Inc.
Electro Signal Lab, Inc.
Emergency Products Corp.
Environment/One Corp.
Federal Signal Corporation, Autocall Div.
Federal Signal Corporation, Signal Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
Fyrnetics, Inc.
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Heath Consultants, Inc.
Hochiki America Corp
Honeywell, Commercial Division
Johnson Controls, Inc.
Kay Systems, Inc.

Kidde Automated Systems
MCC Powers
MRL, Inc.
Moldow Dust Control, INc.
Monaco Enterprises, Inc.
National Mine Service Co.
National Time & Signal Corp.
Northfab Systems, Inc.
Notifier Company
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.
Porta-Matic Fire Ext. Mfg. Cor
The Protectowire Company
Pyrotronics
Security Engineering Co., Inc.
Square D Company
Statitrol, Inc.
Sunbeam Corporation
Unitec, Inc.
Walter Kidde
Wormald Electronics
Wormald Fire Systems

—Flame
Alison Control, Inc.
Armtec Industries, Inc.
Chloride Pyrotector
Detector Electronics Corporation
Electronics Corp. of America
Federal Signal Corporation, Signal Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Honeywell, Commercial Division
Kidde Automated Systems
Moldow Dust Control, INc.
Monaco Enterprises, Inc.
Northfab Systems, Inc.
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.
Wormald Electronics
Wormald Fire Systems

——Infra-red detection
L. W. Bills Company
Electronics Corp. of America
Fire Control Instruments, Inc.
Firetek Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Kidde Automated Systems
Monaco Enterprises, Inc.
Northfab Systems, Inc.
Per Mar Security & Research Corp.
Wormald Electronics

—Gas
Ademco/Alarm Device Manuf. Co.
Alison Control, Inc.
American Gas & Chemical Co.
Bacharach Instruments
The Bendix Corporation
Devco Engineering, Inc.
Dynamation, Inc.
Erdco Engineering Corporation
Enmet Corporation
Fire-Lite Alarms, Inc.
The Gamewell Corporation
GasTech, Inc.
Grace Industries, Inc.
Grunau Sprinkler Mfg. Co., Inc.
Heath Consultants, Inc.
Interscan Corporation
Kidde Automated Systems
Lumidor Safety Products
MRL, Inc.
Mallory Components Group
Moldow Dust Control, INc.
Monaco Enterprises, Inc.
National Mine Service Co.
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.

Product Production Mktg. Inc.
Quantum Instruments, Inc.
Rexnord
Ward International
Wormald Electronics
Wormald Fire Systems

—Heat
Ademco/Alarm Device Manuf. Co.
Alison Control, Inc.
Armtec Industries, Inc.
BRK Electronics
Dictograph Security Systems
Dyn-Optics, Inc.
Edwards Company, Inc.
Federal Signal Corporation, Autocall Div.
Federal Signal Corporation, Signal Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
The Gamewell Corporation
Grinnell Fire Prot. Systems Co
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Honeywell, Commercial Division
Key Systems, Inc.
Kidde Automated Systems
Moldow Dust Control, INc.
Monaco Enterprises, Inc.
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.
Porta-Matic Fire Ext. Mfg. Cor
Some's Uniforms, World Wide
Unitec, Inc.
Wormald Electronics
Wormald Fire Systems

—Smoke
Ademco/Alarm Device Manuf. Co.
Alison Control, Inc.
Aritech Corp.
L. W. Bills Company
Chemetron Fire Systems
Chloride Pyrotector
S. H. Couch Company
Detector Electronics Corporation
Dictograph Security Systems
Edwards Company, Inc.
Electro Signal Lab, Inc.
Electronics Corp. of America
Environment/One Corp.
Federal Signal Corporation, Autocall Div.
Federal Signal Corporation, Signal Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
Fyrnetics, Inc.
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Honeywell, Commercial Division
Key Systems, Inc.
Kidde Automated Systems
Kobishi America, Inc.
MCC Powers
Moldow Dust Control, INc.
Monaco Enterprises, Inc.
Nittan Corporation
Notifier Company
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.
Pyrotronics
Reliable Fire Equipment Co.
Rhodes-Firemark Division
Security Engineering Co., Inc.
Some's Uniforms, World Wide
Square D Company
Statitrol, Inc.
Sunbeam Corporation
Unitec, Inc.
Wormald Electronics
Wormald Fire Systems

——Cloud chamber
Edwards Company, Inc.
Environment/One Corp.

Grunau Sprinkler Mfg. Co., Inc.
Per Mar Security & Research Corp.

——Ionization duct
Alison Control, Inc.
BRK Electronics
L. W. Bills Company
Chloride Pyrotector
Edwards Company, Inc.
Electro Signal Lab, Inc.
Federal Signal Corporation, Autocall Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Honeywell, Commercial Division
Key Systems, Inc.
Kidde Automated Systems
Kobishi America, Inc.
MCC Powers
Monaco Enterprises, Inc.
Notifier Company
Pacific Fire Extinguisher Co.
Per Mar Security & Research Corp.
Unitec, Inc.

——Photoelectric duct
Aritech Corp.
L. W. Bills Company
Chloride Pyrotector
Federal Signal Corporation, Autocall Div.
Fenwal Incorporated
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Kidde Automated Systems
Kobishi America, Inc.
MCC Powers
Notifier Company
Per Mar Security & Research Corp.
Wormald Electronics

——Ionization type
Ademco/Alarm Device Manuf. Co.
Alison Control, Inc.
L. W. Bills Company
Chemetron Fire Systems
Chloride Pyrotector
Edwards Company, Inc.
Federal Signal Corporation, Autocall Div.
Fenwal Incorporated
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Kidde Automated Systems
Kobishi America, Inc.
MCC Powers
Notifier Company
Per Mar Security & Research Corp.
Pyrotronics
Security Engineering Co., Inc.
Square D Company
Wormald Electronics

——Photoelectric type
Ademco/Alarm Device Manuf. Co.
Aritech Corp.
BRK Electronics
L. W. Bills Company
Chloride Pyrotector
S. H. Couch Company
Dictograph Security Systems
Edwards Company, Inc.
Electro Signal Lab, Inc.
Electronics Corp. of America
Emergency Products Corp.
Federal Signal Corporation, Autocall Div.
Fenwal Incorporated
Fire Control Instruments, Inc.
Fire-Lite Alarms, Inc.
Firetek Corporation
The Gamewell Corporation
Grunau Sprinkler Mfg. Co., Inc.
Hochiki America Corp
Honeywell, Commercial Division

INSURANCE ORGANIZATIONS IN THE UNITED STATES WITH FIRE PROTECTION INTERESTS

Alliance of American Insurers
20 North Wacker Drive
Chicago, IL 60606

American Hull Insurance Syndicate
14 Wall Street
New York, NY 10005

American Institute of Marine Underwriters
99 John Street
New York, NY 10038

American Insurance Association
85 John Street
New York, NY 10038

American Nuclear Insurers
270 Farmington Avenue
Suite 245
Farmington, CT 06032

Association of Mill and Elevator Mutual Insurance Companies
2 North Riverside Plaza
Chicago, Il 60606

Assurex International
6500 Busch Blvd.
Columbus, OH 43229

Cotton Fire and Marine Underwriters
(Division of Marine Office — Appleton & Cox Corp.)
1810 Commerce Street, P.O. Box 1849
Dallas, TX 75221

Factory Mutual Systems
1151 Boston-Providence Turnpike
Norwood, MA 02062

G.A.B. Business Services, Inc.
123 William Street
New York, NY 10038

Improved Risk Mutuals
15 North Broadway
White Plains, NY 10601

Independent Insurance Agents of America
85 John Street
New York, NY 10038

Industrial Risk Insurers
85 Woodland Street
Hartford, CT 06102

Insurance Information Institute
110 William Street
New York, NY 10038

Insurance Institute for Highway Safety
Watergate 600
Washington, DC 20037

Insurance Services Office
160 Water Street
New York, NY 10038

Mill Mutual Fire Prevention Bureau
2 North Riverside Plaza
Chicago, IL 60606

Mutual Atomic Energy Reinsurance Pool
One East Wacker Drive
Chicago, IL 60601

Mutual Reinsurance Bureau
1550 Pearl Street
P.O. Box 188
Belvidere, IL 61008

National Association of Insurance Brokers, Inc.
1511 K Street N.W.
Suite 316
Washington, DC 20005

National Association of Insurance Commissioners
633 W. Wisconsin Avenue
Suite 1015
Milwaukee, WI 53203

National Association of Mutual Insurance Companies
7931 Castleway Drive
Indianapolis, IN 46250

National Association of Professional Insurance Agents
400 N. Washington Street
Alexandria, VA 22314

National Automobile Theft Bureau
30 E. 42nd Street
New York, NY 10017

National Cargo Bureau, Inc.
Suite 2757
One World Trade Center
New York, NY 10048

Property Loss Research Bureau
20 N. Wacker Drive
Chicago, IL 60606

Transportation Insurance Rating Bureau
175 W. Jackson Blvd.
Chicago, IL 60604

FIRE RESEARCH LABORATORIES

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

Factory Mutual Research Corporation
1151 Boston-Providence Turnpike
Norwood, MA 02062

Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78284

Center of Fire Research
National Bureau of Standards
Gaithersburg, Maryland

Ohio State University
Building Research Lab
College of Engineering
Columbus, OH

Costa

aci

alison control inc.

October 29, 1982

Kaiser Engineers, Inc.
425 South Main St.
6th floor
Los Angeles, California 90013

(408) 988-4212

Attention: Mr. Charles M. Costa, Jr.

Re: Los Angeles Metro Rail Project
ACI Proposal No. 216

Gentlemen:

We are pleased to offer the following equipment for your above referenced project.

We are proposing a custom designed fire detection system utilizing Alison 9090 Thermistor Sensor to detect overheat and fire conditions in your rail system.

There will be one Control Panel in each station (14 total); with a "Hot Spot" Indicator to pinpoint the fire condition. Once a fire is detected, another meter will activate to show temperature increase or decrease. Once a decision is made to enter the system for fire fighting, the panel will inform firefighters of the best entry point to the rail system.

Our present design is of individual panels with relay outputs to tie into your Multiplex System, we can however, furnish the signalling system is required.

Storage Area Only
2 zones, 2000 ft

Major Equipment List

\$25,000

14 - Panels - 1 NEMA 12
192,000 - Feet 9090 thermistor sensor 2 Zones, 1000 ft ea.
384 - junction boxes 2 junction box
48,000 - sensor mounting clamps 500
2 Hot spot indicators
Local Alarm
Net price $2,950,000.00
Relays

200,000

+ 2000 ft average temperature

\$15.36/ft

Need 2-wires, 16ga. in conduit, per zone.
1-wire, 16ga in conduit

Say \$25/ft 2000 ft
= \$50,000

TWX NO. 710 734-4355
ANSWERBACK: ACI FFLD
35 DANIEL ROAD WEST, FAIRFIELD, NEW JERSEY 07006 • 201-575-7100

Notes:

1. All equipment is F.O.B. Fairfield, New Jersey.

2. Pricing is based on 1982 prices.

3. Equipment delivery is estimated at twelve to eighteen months after receipt of purchase order.

4. No gas detection or POC detectors are included in above pricing. A more detailed plan of the system will be required for this pricing. An estimate of $3,000.00/point of gas detection and $125.00/point of POC detection may be used for estimating purposes.

5. Above equipment will be Factory Mutual approved.

Very truly yours,

ALISON CONTROL INC.

Nick J. Bacile

Nick J. Bacile

NJB/cas

9090 SERIES

CONTINUOUS THERMISTOR SENSORS

The 9090 Series of Continuous Thermistor Sensors consist of lengths of stainless steel tubing containing a specially formulated ceramic thermistor core. A center wire is imbedded in the core and runs the length of the element.

The detection elements have a negative temperature coefficient of resistance. This means that as the temperature increases, the electrical resistance of the sensor decreases exponentially. It is this decrease in resistance that is sensed by alarm instrumentation.

Hermetically sealed connectors at either end of the sensor protect the core against contamination and provide a means of obtaining electrical continuity between sections.

Any detection system can be tailored to allow for areas of normally higher temperatures by the use of higher temperature ceramic cores or even thermally inert sections.

Since electrical resistance is measured across two wires (center and sheath), the sensor has the ability to detect a high temperature on a short length as well as a lesser temperature on a longer length.

The elements are mounted by clamps spaced along their lengths. These clamps allow easy insertion or removal of sensor sections.

The detectors, being all solid state, have only two electrical failure modes: open circuit and short circuit. Both of these conditions can be caused only by mechanical means and are minimized by rigid mounting.

When combined with instrumentation which can supervise the detectors for these two known failure modes, the detector can offer continuous detection without periodic testing or replacement.

With supervision covering the possibility of mechanical short or open circuits, reliability analyses reveal that there are no known catastrophic failure modes in continuous thermistor sensors.

9090 SENSOR

PART NUMBERING SYSTEM

9090-100-2-05-P

9090 SERIES SENSORS

TEMPERATURE RANGE

100 - 150°-500° F
104 - 400°-700° F
108 - 600°-1200° F

TERMINATION

1 - One plug and one threaded socket
2 - Two plugs
3 - Two threaded sockets
4 - One 12 inch lead
5 - Two 12 inch leads

LENGTH

05 - 5 feet
10 - 10 feet
20 - 20 feet
100 - 100 feet

Any length may be specified by expressing the desired length in feet (i. e., 30 = 30 feet). Tolerance on length ± 0.5 feet.

MODIFICATIONS

T - Integral circuit terminator
P - Potted interconnections

EXAMPLE

9090-100-1-10-P

This is a 10 foot long sensor having one plug and one socket connector with potted interconnections designed to operate in the range of 150°-500° F.

Alison Control Inc. reserves the right to make changes at any time in order to improve design and to supply the best product possible.

3/6/75

9090-100 SERIES

RESISTANCE VS. TEMPERATURE CHARACTERISTIC

For 100 Ft. Length
ACI P/N 9090-100-1-100

Temp (F)	Resistance
300.00	529.
310.00	408.
320.00	316.
330.00	247.
340.00	194.
350.00	153.
360.00	121.
370.00	97.
380.00	78.
390.00	63.
400.00	51.
410.00	41.
420.00	34.
430.00	28.
440.00	23.
450.00	19.
460.00	16.
470.00	13.
480.00	11.
490.00	9.
500.00	8.
510.00	6.
520.00	5.
530.00	4.
540.00	4.
550.00	3.

3/1/77

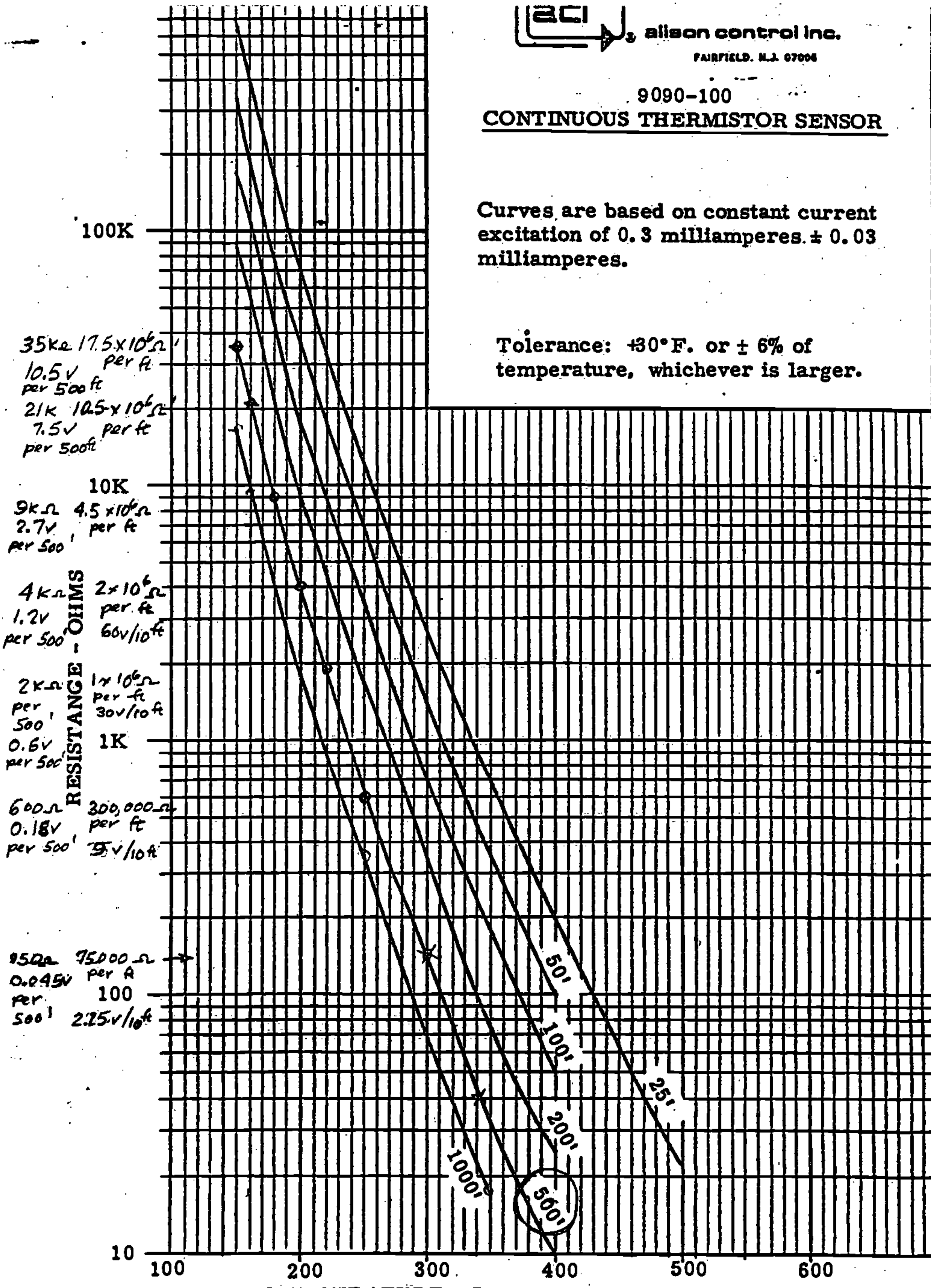
aci allison control inc.
FAIRFIELD, N.J. 07006

9090-100

CONTINUOUS THERMISTOR SENSOR

Curves are based on constant current excitation of 0.3 milliamperes ± 0.03 milliamperes.

Tolerance: ±30°F. or ± 6% of temperature, whichever is larger.



alison control inc.

FAIRFIELD, N.J. 07006

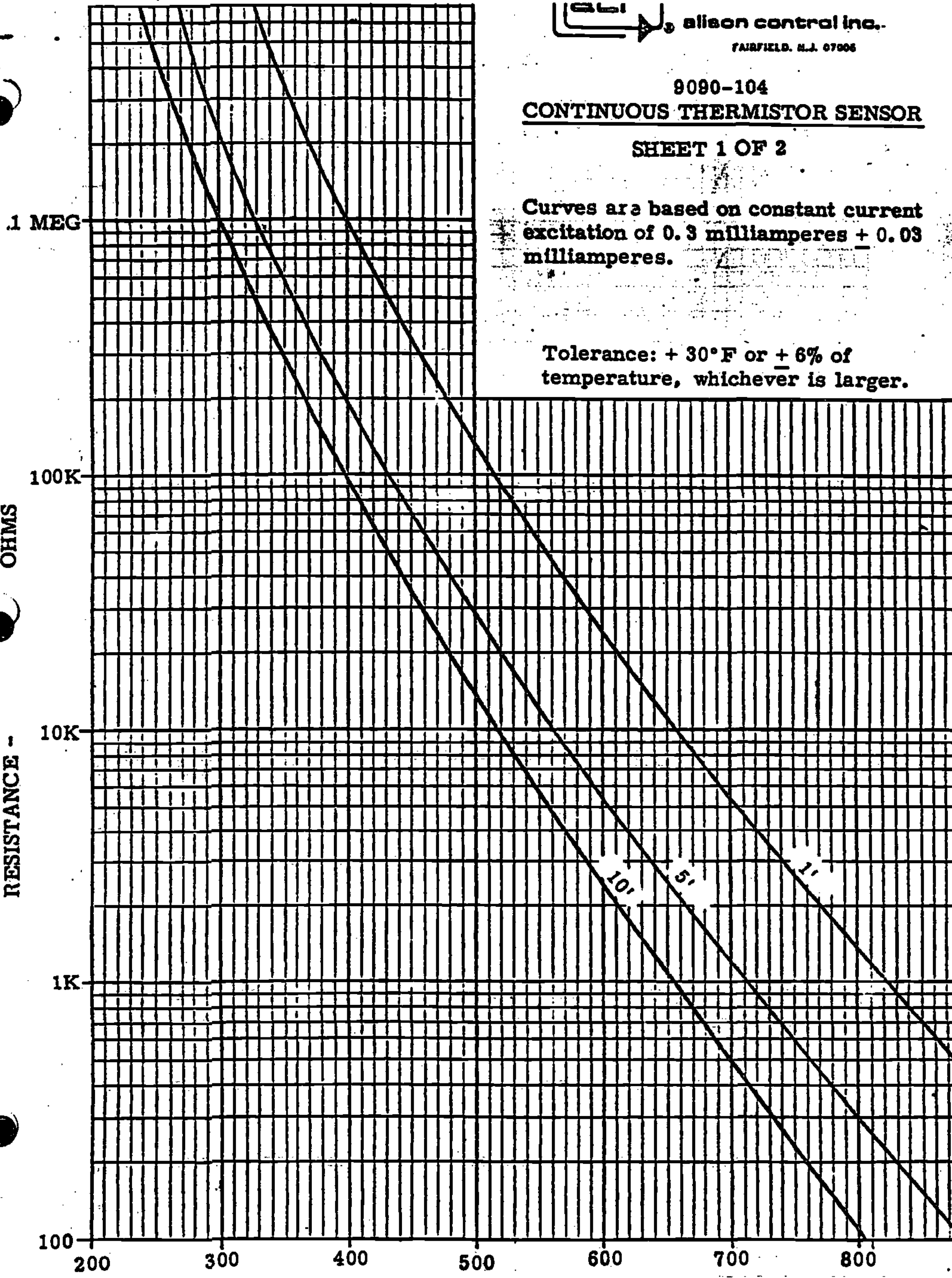
9090-104

CONTINUOUS THERMISTOR SENSOR

SHEET 1 OF 2

Curves are based on constant current excitation of 0.3 milliamperes ± 0.03 milliamperes.

Tolerance: + 30°F or ± 6% of temperature, whichever is larger.



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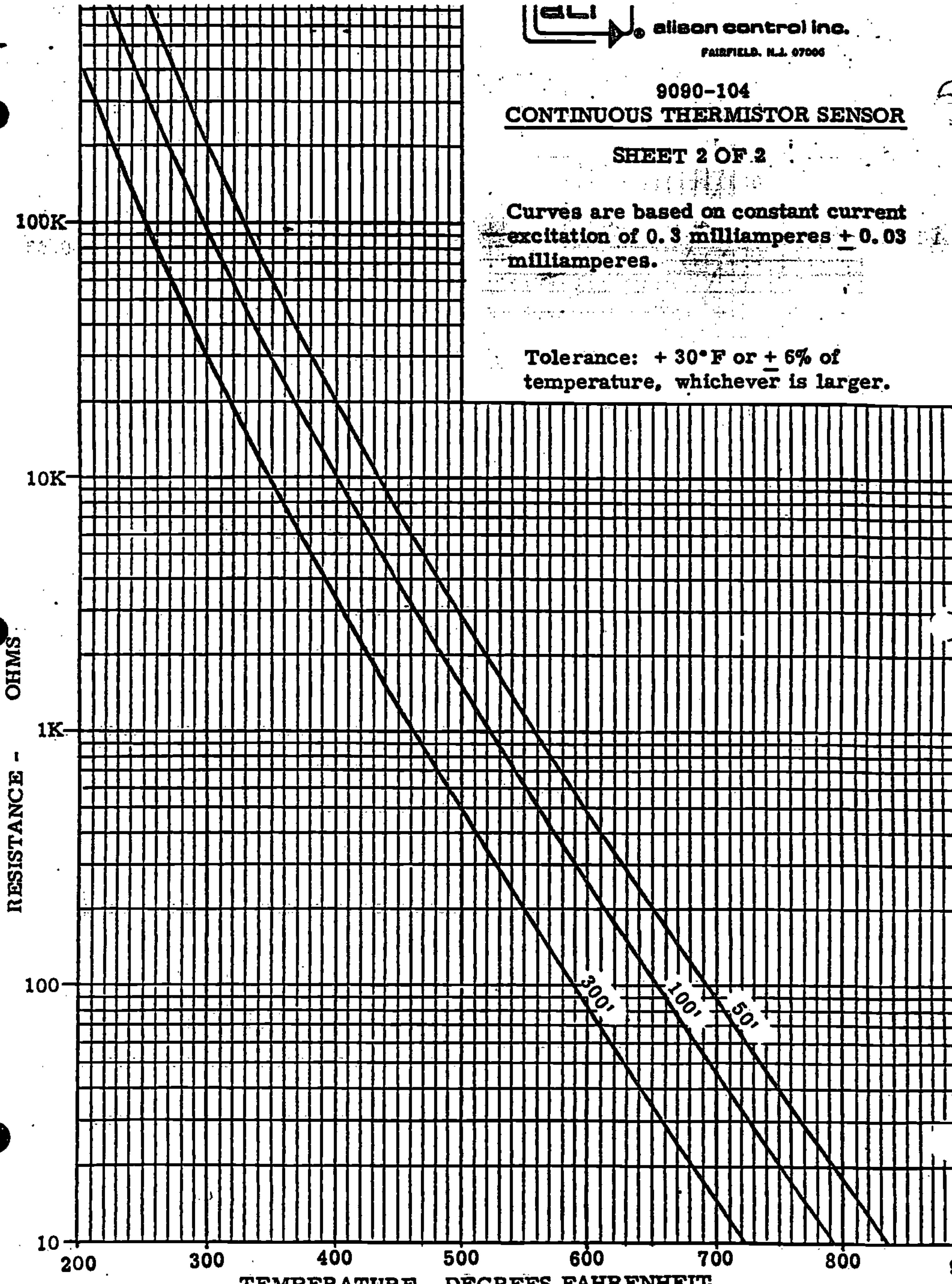
FAIRFIELD, N.J. 07006

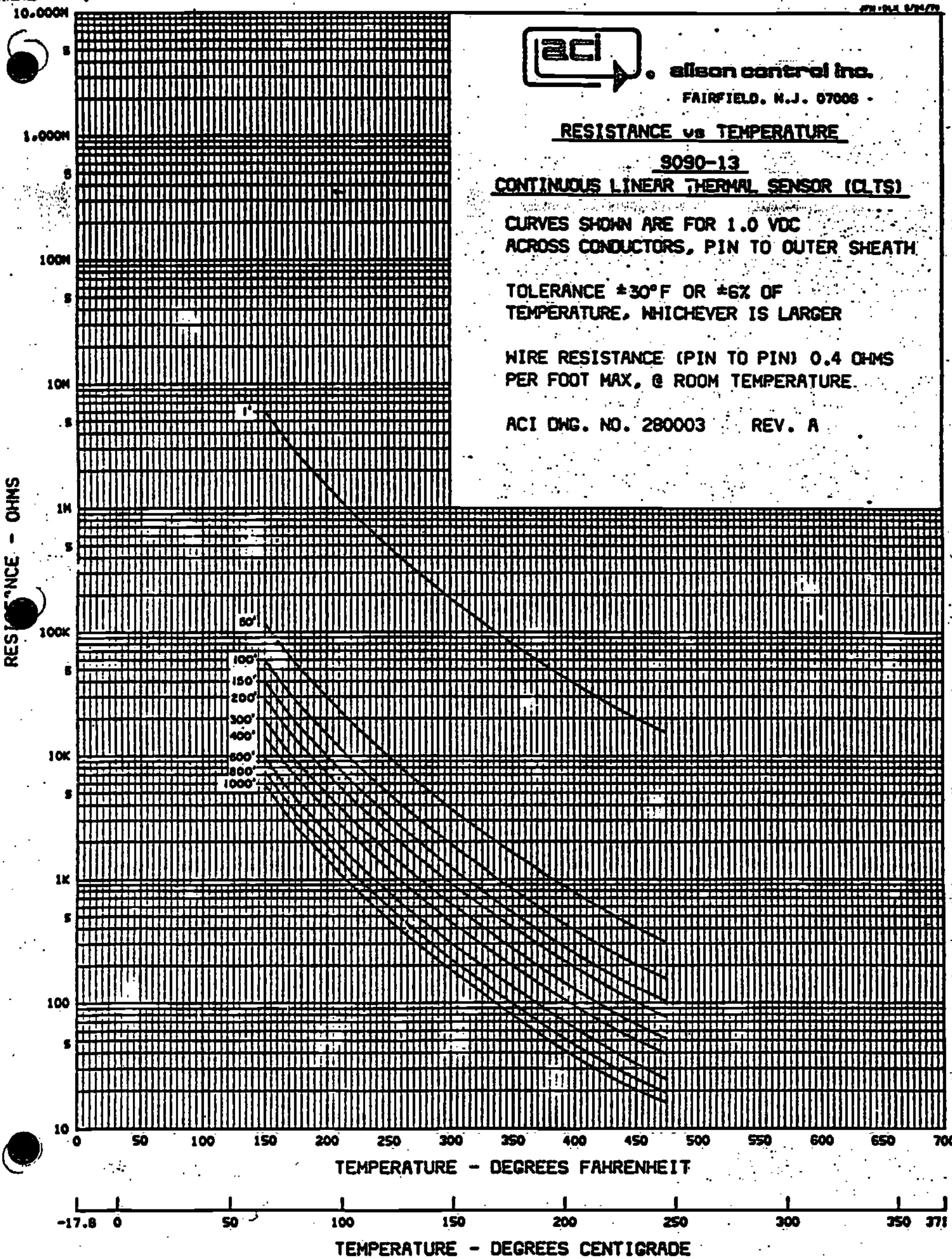
9090-104
CONTINUOUS THERMISTOR SENSOR

SHEET 2 OF 2

Curves are based on constant current excitation of 0.3 milliamperes ± 0.03 milliamperes.

Tolerance: + 30°F or ± 6% of temperature, whichever is larger.





aci
alison control inc.
FAIRFIELD, N.J. 07006
RESISTANCE vs TEMPERATURE
9090-13
CONTINUOUS LINEAR THERMAL SENSOR (CLTS)
CURVES SHOWN ARE FOR 1.0 VDC ACROSS CONDUCTORS, PIN TO OUTER SHEATH
TOLERANCE ±30°F OR ±6% OF TEMPERATURE, WHICHEVER IS LARGER
WIRE RESISTANCE (PIN TO PIN) 0.4 OHMS PER FOOT MAX, @ ROOM TEMPERATURE
ACI DWG. NO. 280003 REV. A
10,000M
1,000M
100M
10M
1M
100K
10K
1K
100
10
1'
50'
100'
150'
200'
300'
400'
600'
800'
1000'
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700
TEMPERATURE - DEGREES FAHRENHEIT
-17.8 0 50 100 150 200 250 300 350 371
TEMPERATURE - DEGREES CENTIGRADE

TECHNICAL REPORT #10

INTRINSICALLY SAFE FIRE DETECTION SYSTEMS

November 25, 1970

alison control inc.

35 DANIEL ROAD, FAIRFIELD, NEW JERSEY 07006 • 201-575-7100

It is obviously desirable to have a fire detection system that is capable of operating in and protecting hazardous areas.

The majority of hazardous areas requiring protection are those classified as Class I Group D Divisions I and II. These are hazardous areas involving vapors of the heavier hydrocarbons, such as gasoline and jet fuels.

By definition, Division I areas are those assumed to be hazardous at all times. In point of fact, Division I areas are probably hazardous for only a small percentage of time and some European regulation authorities have specified a division "0" which is truly hazardous all the time and reserved a probably hazardous definition for Division I.

Division II locations are those that are hazardous only in the presence of an equipment failure.

There are three ways to provide for the operation of control and alarm systems in hazardous locations. These are the employment of explosion proof housings, the use of purging air throughout a non-explosion proof housing, and the design of a system so as to make it intrinsically safe.

The first two methods of operation in a hazardous area - explosion proof housings and housing purging - are certainly not applicable to nor practical for fire detection and extinguishing systems if they effectively remove the sensor from the environment to be protected. In the best case, this would merely slow response, while total system effectiveness may be impaired in the worst case.

Since the first two methods are not applicable, the system design would have to be certified by a recognized authority as intrinsically safe.

Intrinsic safety is an expression that is much maligned and misused. To make the ground rules clear, an intrinsically safe design is one that by definition is:

> INCAPABLE OF RELEASING SUFFICIENT ELECTRICAL OR THERMAL ENERGY UNDER NORMAL OR ABNORMAL CONDITIONS TO CAUSE IGNITION OF A SPECIFIC HAZARDOUS ATMOSPHERIC MIXTURE IN ITS MOST EASILY IGNITED CONCENTRATION.

This definition is that based on and derived from the Instrument Society of America Specification RP 12.2 and the National Fire Protection Association Specification Number 493.

The 4000-4 Circuitry and 9090 Series Sensor have been designed and will be certified to meet the requirements of the above specifications.

To be intrinsically safe, two conditions must be met. These are that the energy available from the equipment in the hazardous area must be low enough under normal conditions to insure the impossibility of ignition and also that under abnormal conditions ignition of the atmosphere is still impossible.

To obtain an intrinsically safe certification, the system must still be safe under abnormal conditions consisting of obvious and not-obvious faults which are defined as follows:

An obvious fault gives evidence of its occurrence by alarm, meter or other equipment malfunctioning. A non-obvious fault is one which is not evident to the user under normal operating conditions.

For a system consisting of the 9090 Series Sensor and the 4000-4 Monitoring Instrument which does not have normally operating contacts in the Division I location, failure of field wiring is counted as an obvious fault.

With these criteria established, the 9090 Series Sensor and 4000-4 Instrument can be shown to be incapable of producing ignition under the following combinations of obvious and non-obvious faults:

1) Three non-obvious faults
2) Two non-obvious faults and one obvious fault
3) One non-obvious fault and two obvious faults

The attached diagram indicates in basic fashion how the combination of the 9090 Series Sensor and the 4000-4 Instrument achieve intrinsic safety. Normally, the sensor and junction box will be located in the hazardous or Division I location, while the 4000-4 will be located in a non-hazardous location. If it is impossible to locate the 4000-4 in a non-hazardous location, it would have to be installed in a suitable enclosure, that is, an enclosure that is explosion proof or purged.

The 4000-4 relies on three basic design features to assure compliance with NFPA Article 493 and ISA Specification RP 12.2. These are:

1) Supervised constant current probe excitation
2) Resistive interface barrier
3) Non-failing power supply transformer

The probe excitation of the 4000-4 is a constant current source of 100 microamperes DC nominal. This source operates the probe at a maximum voltage of 1.2 volts DC and, as opposed to bridge type systems, the current does not increase as the probe resistance falls. Instead, the voltage across the probe decreases to indicate the fire condition.

The maximum value of probe power (120 Microwatts) is low enough to meet the intrinsic safety requirements for Class I Group D hazards without further protection.

The constant current source is supervised so that any failure in it will indicate a malfunction by means of an indicator light, classifying failure in the constant current source as an obvious fault. However, it is possible under fault conditions for the constant current source to provide a possibly hazardous current to the field wiring. To counteract this, all connections to the field wiring are made through a resistive barrier constructed of non-failing type resistors. This barrier assures that regardless of the failures in the 4000-4 circuitry, it is impossible to have ignition energy on the field leads.

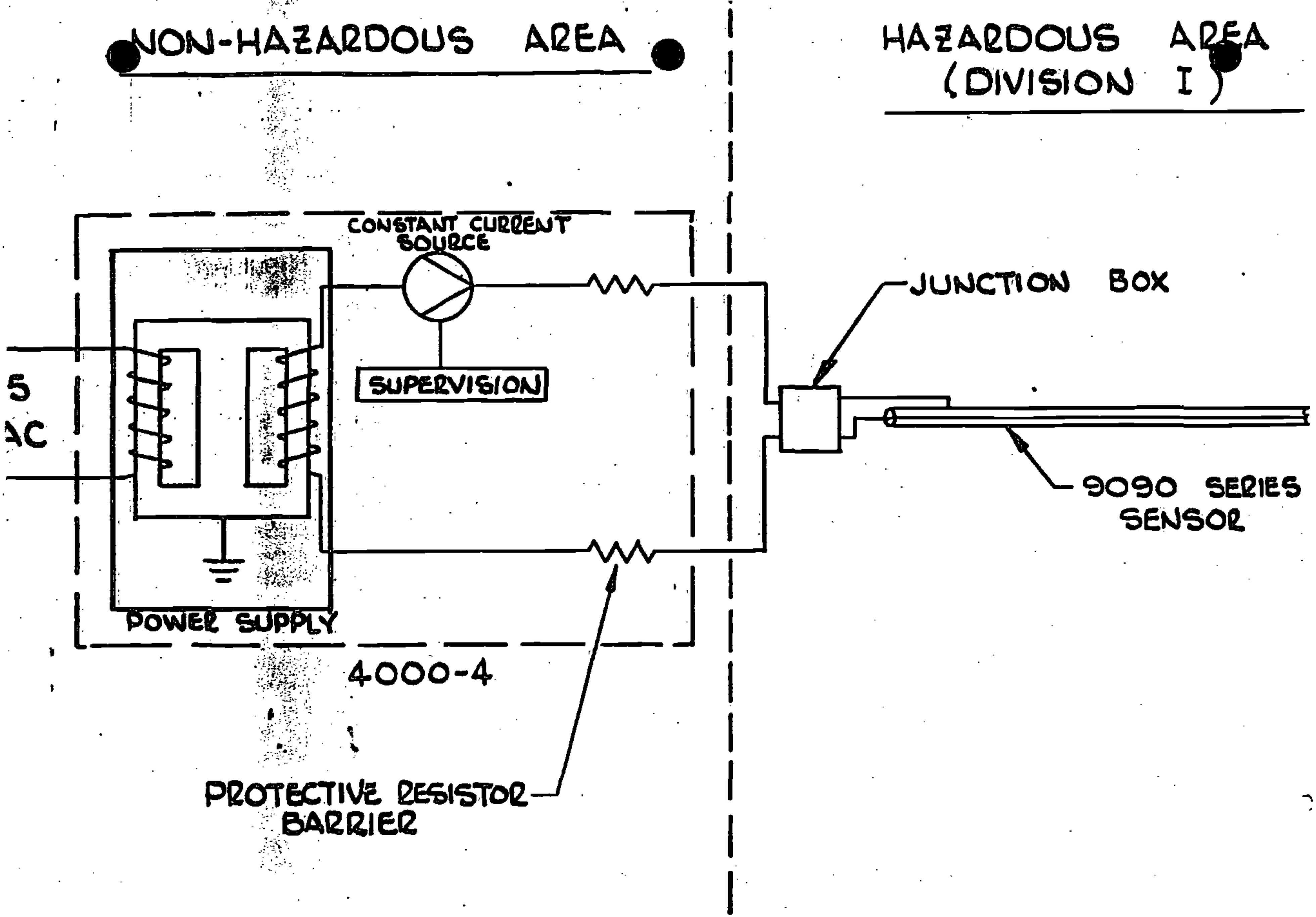
The resistors employed in this barrier are single layer wirewound resistors with ceramic cores, tested per NFPA Article 493 Section 622.

The monitored current source and non-failing resistive barrier render the system intrinsically safe under all fault combinations except that of a transformer failure in the power supply.

The resistors in the barrier network cannot be made of a sufficiently high ohmic value to insure safety of the field leads under line failure conditions.

To overcome this, a transformer certified as non-failing, according to NFPA Article 493 Par. 621, will be employed. This requires a transformer with primary and secondary windings on separate legs of a grounded core.

These basic design requirements as well as others have been followed in design of the 4000-4 : 9090 Sensor Alarm System and will result in certification as intrinsically safe.



INTRINSIC SAFETY

SYSTEM MANUAL

11700 SERIES

ULTRAVIOLET RADIATION FIRE DETECTION SYSTEMS

TABLE OF CONTENTS

alison control inc.

35 DANIEL ROAD, FAIRFIELD, NEW JERSEY 07006 • 201-575-7100

SYSTEM DESCRIPTION

The Alison Control 11700 Series of Ultraviolet Radiation Fire Detectors combines large scale integration circuit techniques with the stable, long-lived Alison Control ultraviolet detection assembly to form a simple yet flexible fire detection system.

Unique among ultraviolet detection systems, the 11700 detectors contain a dual time constant circuit (see Section 4.0) that permits the system to differentiate between ultraviolet energy emitted by electric arc welders and that emitted by actual fires.

An 11700 system when directly exposed to the high intensity constant radiation emitted by welding processes will not indicate an alarm condition. It must be noted that reflected welding energy cannot be rejected as efficiently.

By connection of either six (6) wires - two for operate power; two for alarm output; two for trouble output or of four (4) wires - two for operate power; two for a tristate alarm/trouble output, the user has a complete non-indicating fire detection system in operation.

The detector tube electrode/quartz viewing window combination employed in the 11700 Series is tailored to provide a visible radiation blind 2000-2450 angstrom unit wavelength response aperture.

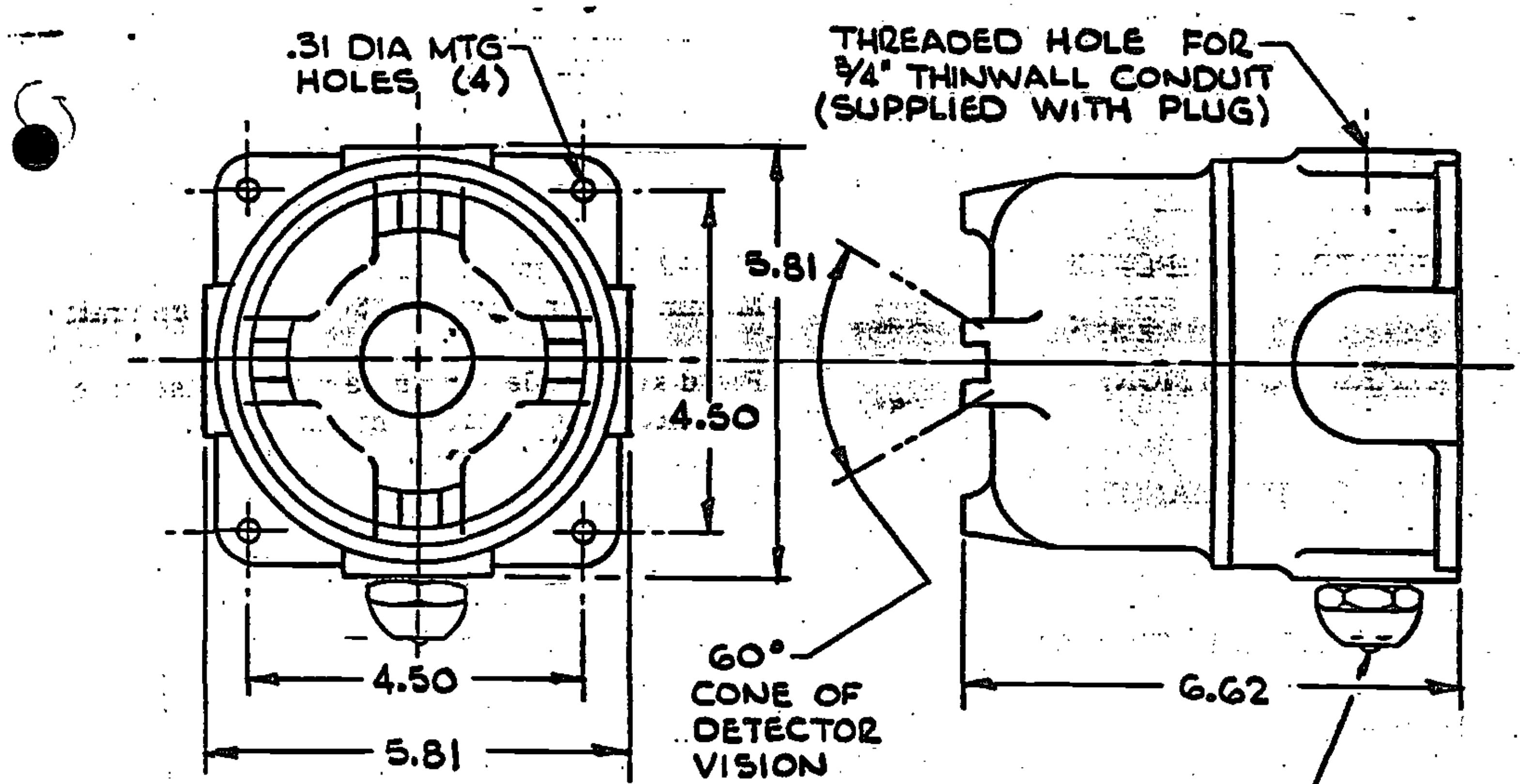
The detection tube receptor circuitry in the 11700 Series is field adjustable by means of potentiometers for alarm pulse rate; alarm pulse rate maintenance interval; and welding rejection threshold.

As with all Alison Control ultraviolet detectors, the 11700 Series is provided with detector tube excitation voltage regulation that completely removes the influence of operate voltage variations on system sensitivity.

The 11700 Series supervises the presence of both system operate power and detector high voltage power along with all critical electronic components and both the alarm and trouble relay coil continuity.

The 11700 detection system is contained in a cast aluminum enclosure that meets both the requirements for usage in Class I Group D Division I and Class II Groups E, F, and G Division I Hazardous Atmospheres. In addition, the enclosure meets the requirements of a NEMA 4 enclosure.

An accessory swivel mounting bracket, Alison Control Part Number 172005, is available to facilitate detection system mounting and orientation and is supplied with each detector.

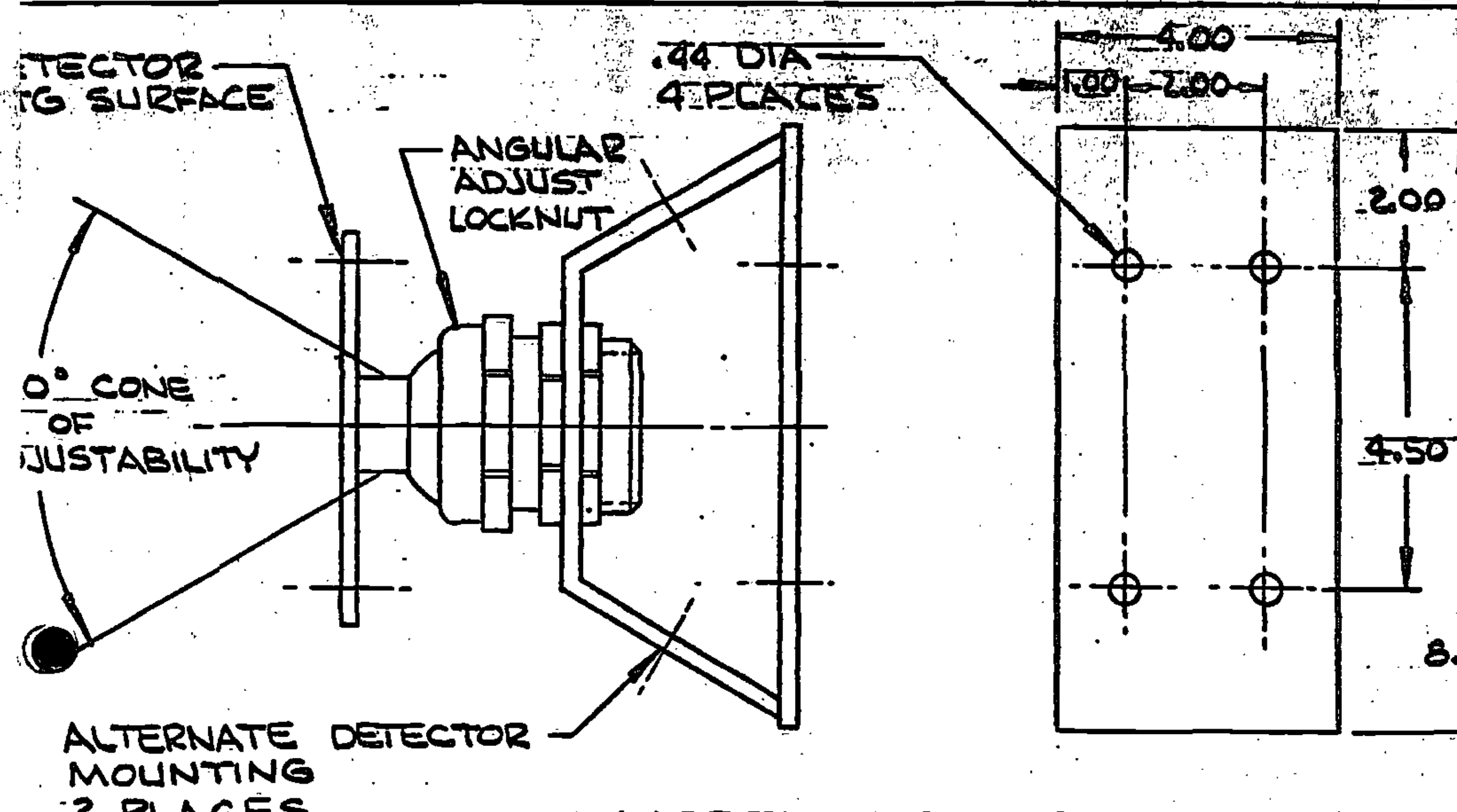


ENCLOSURE SUITABLE FOR:
CLASS I, GROUP D
CLASS II, GROUPS E, F, G.

COMBINATION DRAIN AND BREATHER VENT

MODEL 11700

ULTRAVIOLET FIRE DETECTOR



MODEL 172005

SPECIFICATIONS AND PART NUMBERS

SPECIFICATIONS

SPECTRAL RESPONSE:	2000-2450 angstrom units Maximum sensitivity: 2300 angstrom units
ALARM CONDITION:	Field adjustable for pulse rate, pulse rate duration, and welding threshold
SENSITIVITY RANGE:	0.3-30 pulses per second or 30-350 pulses per second
MINIMUM DURATION RANGE:	0.2-10.0 seconds
WELDING REJECTION THRESHOLD:	100-240 pulses per second
ALARM OUTPUT:	Single Form A (normally open) contact rated at 3 amperes at 120 VAC resistive load. Contact closes for alarm and resets automatically.
TROUBLE OUTPUT:	Single contact rated at 3 amperes at 120 VAC resistive load maintained closed in the system normal condition.
OPERATE VOLTAGE:	Specify either 120 VAC 50/60 Hz; 220 VAC 50/60 Hz; 24 VDC; 125 VDC; 250 VDC
POWER CONSUMPTION:	AC 6.0 volt amperes DC 5.0 watts
OPERATIONAL AMBIENT:	0°F - 125°F

PART NUMBERING

11700 - 25 - 10 - 1

11700 SERIES

SENSITIVITY SETTING

Specify actual setting in pulses per second between 0.3 and 350 in 5 pulse per second increments.

ALARM DURATION SETTING

Specify actual setting in tenths of a second between 0.2 and 10.0 seconds in 0.2 second increments up to 3.0 seconds and 0.5 second increments beyond this.

OPERATE VOLTAGE

1 - 120 VAC 50/60 Hz
2 - 220 VAC 50/60 Hz
3 - 24 VDC
4 - 125 VDC
5 - 250 VDC
6 - 12 VDC

EXAMPLE

11700-30-1.2-1

This number uniquely defines an 11700 detection system operating on 105-125 VAC 60 Hertz having an alarm condition of 30 pulses per second maintained for 1.2 seconds. Welding rejection threshold, although field adjustable, is established at the factory at 180 pulses per second.

THEORY OF OPERATION

The basis of the 11700 Series of ultraviolet radiation fire detectors is a gas detection tube employing the Geiger-Mueller principle to detect radiation wavelengths extending from 2000 angstrom units to 2450 angstrom units (1 angstrom unit = 10^{-8} centimeters).

Figure 1 attached at the end of this section displays the tube's radiation sensitive area and compares this area to other forms of radiation.

It should be noted that visible radiation does not extend into the detector's sensitive area. Similarly, radiation from artificial lighting sources does not extend into the detector's sensitive area.

Welding arcs and lightning strikes will generate radiation to which the detector is sensitive. The 11700, however, contains circuitry that minimizes the effects of welding and lightning.

Welding rejection is accomplished as indicated in Section 4.0.

Lightning created ultraviolet radiation is rejected by requiring that a cumulative photon effect be maintained for a given period of time before an alarm response is generated. This type of operation is possible because radiation is not emitted continuously, but is emitted in discrete mass/energy quantities known as photons.

The energy level of a photon is dependent upon the wavelength of the carrier radiation with energy being inversely proportional to wavelength, that is, a photon of visible light has more energy than a photon of infrared radiation and a photon of ultraviolet energy has more energy than a photon of visible light.

When a photon of radiation strikes the cathode of a Geiger-Mueller detector, its total energy is transferred to a single electron. If this energy is sufficient, the electron is liberated from the cathode and because of the characteristics of a Geiger-Mueller tube is accelerated toward the anode.

A Geiger-Mueller tube is a radiation detector that contains an oppositely charged anode and cathode sealed in an ionizable gas. When the cathode is exposed to radiation of sufficient energy level, an electron is emitted, the gas is ionized and a small aperiodic current flows.

The energy that must be transferred to the electron by the radiation photon to liberate it from the cathode is called the work function of the metal. Thus the sensitivity of a radiation detector is dependent for its upper wavelength limit on the cathode material of the tube. The 11700 Series uses a tungsten cathode to achieve an upper radiation wavelength cut off level of 2450 angstrom units.

The lower radiation wavelength cut off level of the detector is determined by the viewing window of the detection head. The 11700 Series detection head will not pass radiation with wavelengths shorter than 2000 angstrom units. Thus the radiation response of the tube is restricted to the area of 2000-2450 angstrom units.

To facilitate measurement of the liberated electron current flow, an ionizable gas is contained in the detector tube. The molecules of this gas cause an electron avalanche to occur by emitting an electron every time they are struck by a liberated electron. This causes the number of free electrons in the tube to increase in a geometric progression of the powers of two, resulting in a measurable current.

Since an electron avalanche is self propagating, the 11700 circuitry reduces the voltage applied to the tube so that the liberated electrons do not have enough energy to liberate electrons (ionize) from the gas molecules. This automatic action results in a typical detector voltage output pulse of ten (10) volts amplitude minimum and thirty (30) microseconds duration with a 2 microsecond rise time. It is these output pulses that are operated on by the remainder of the 11700 circuitry to generate fire alarm conditions.

FLAME RESPONSE CHARACTERISTICS

The ultraviolet radiation detectors locus of sensitive points is a sixty (60) degree spherical cone whose apex lies at the detector tube. Figure 2 attached at the end of this section indicates the relationship between viewing angle and relative sensitivity.

The sensitivity of the detector tube, being a characteristic of its cathode material, is fixed, but its voltage pulse output rate varies both with flame size and flame viewing distance.

The pulse output rate is directly proportional to flame size, that is, it increases with larger flame fronts presented to the detector. The pulse output rate is also inversely proportional to the distance of the flame front from the detector tube, that is, the pulse output rate decreases as the distance from the detector tube to the flame front increases.

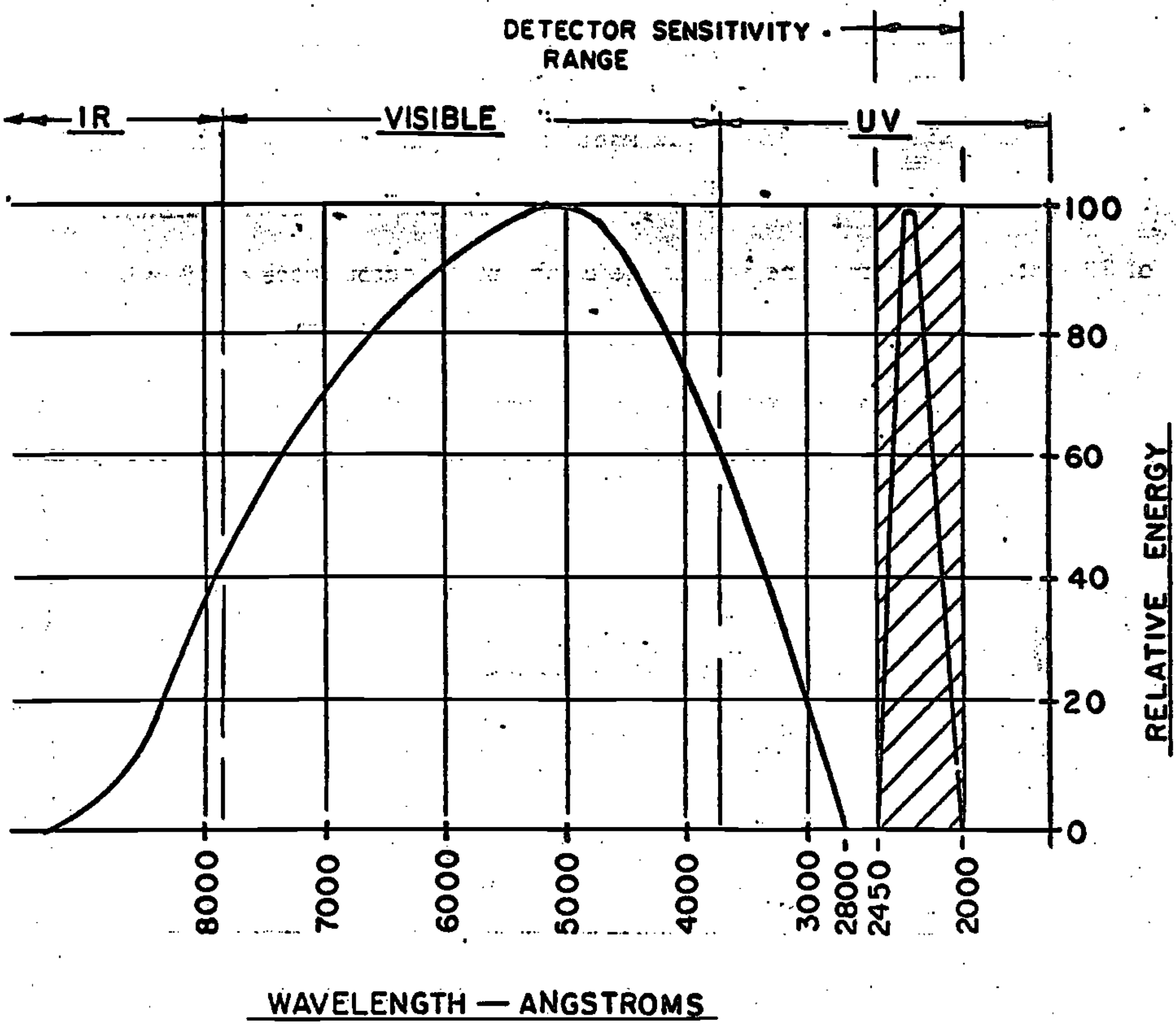
As an example of these qualities, a one square foot hydrocarbon fire will cause a pulse output rate of 3 pulses per second at a viewing distance of 30 feet. This same fire will cause a tube pulse output rate of 20 pulses per second at a viewing distance of 20 feet.

In a like manner, whereas a one square foot flame front must be located at a distance of 5 feet to create a pulse output rate of 30 pulses per second, a 16 square foot fire will create the same pulse output rate at a distance of 25 feet.

These attenuation characteristics are shown in Figure 3 attached at the end of this section.

The 11700 Series of self contained ultraviolet radiation detectors contains circuitry which provides for the generation of valid alarm conditions at varying detector tube pulse output rates. All three major system performance parameters; alarm pulse rate, alarm pulse rate maintenance interval, and welding threshold are factory preset, but may be field adjusted by means of potentiometers.

ULTRAVIOLET DETECTOR SENSITIVITY



CURVES INDICATE TYPICAL HYDROCARBON FIRE RADIATION PATTERNS

FIGURE 1

alison control inc.

RELATIVE SENSITIVITY
VERSUS PLANAR VIEWING
ANGLE - VALID AT ANY
ROTATIONAL ANGLE

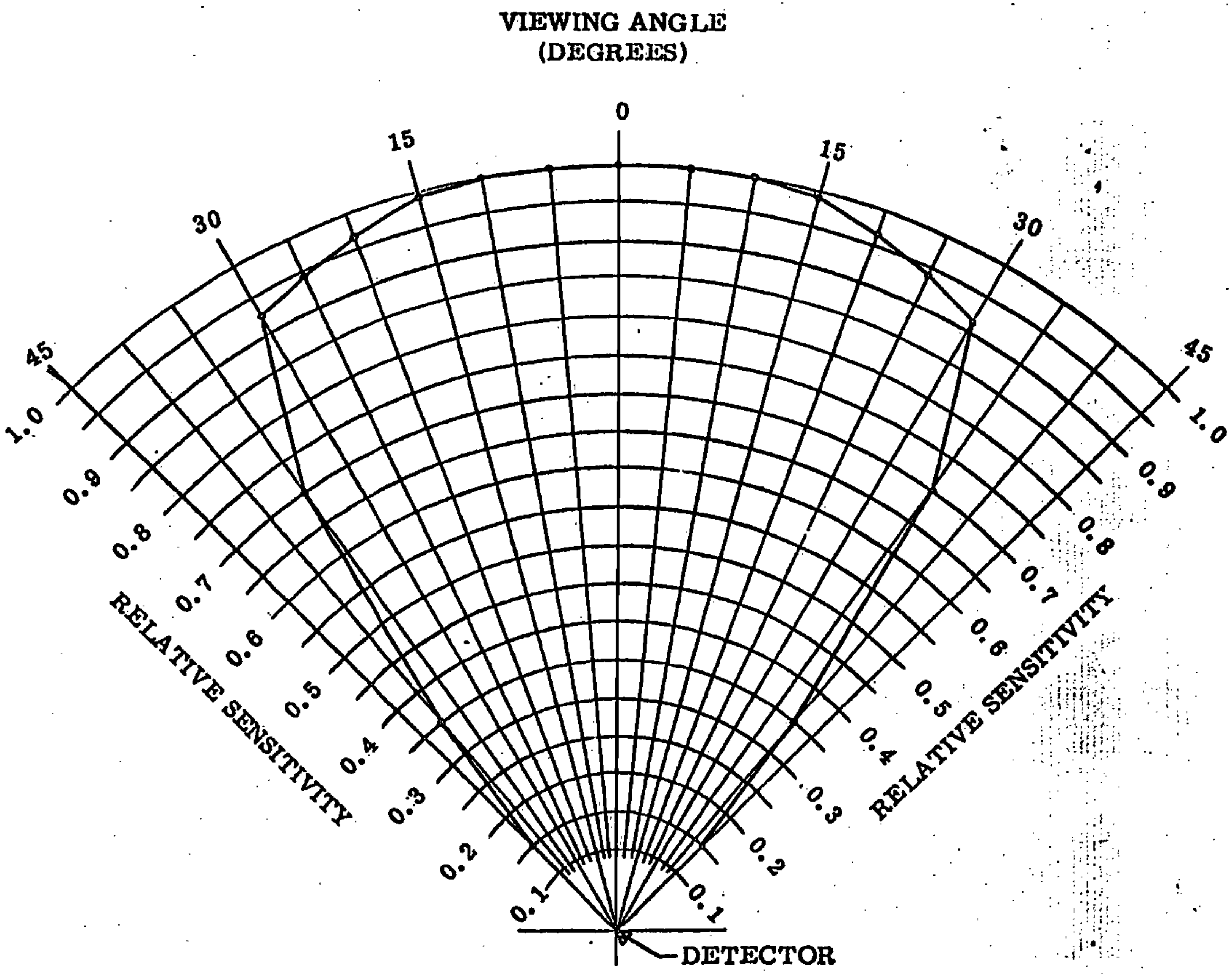


FIGURE 2

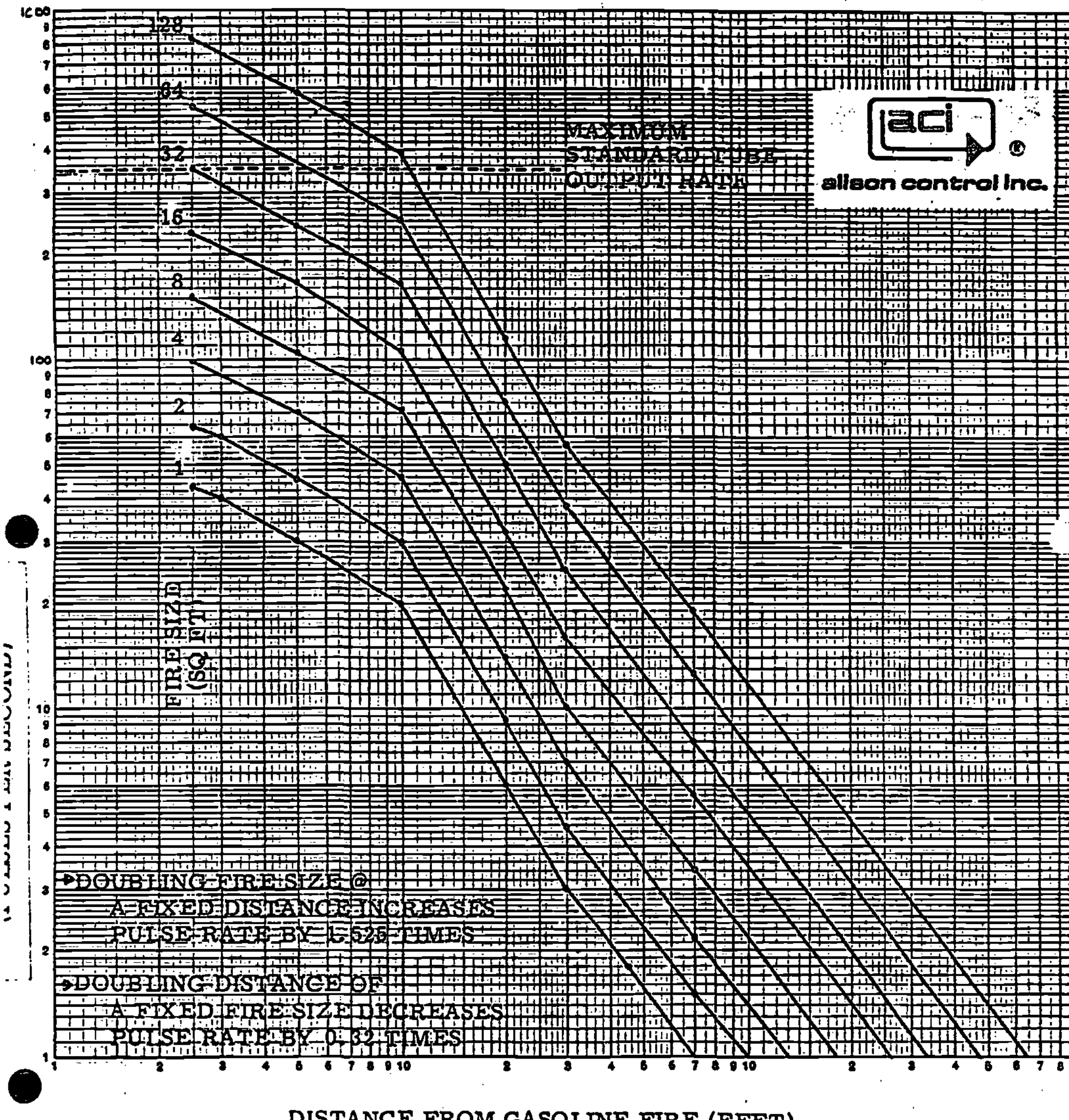

128
64
32
16
8
4
2
1
FIRE SIZE (SQ FT)
MAXIMUM STANDARD TUBE OUTPUT RATE
aci
allson control inc.
DOUBLING FIRE SIZE @ A FIXED DISTANCE INCREASES PULSE RATE BY 1.525 TIMES
DOUBLING DISTANCE OF A FIXED FIRE SIZE DECREASES PULSE RATE BY 0.32 TIMES
DISTANCE FROM GASOLINE FIRE (FEET)

FIGURE 3

constant of 5.0 microseconds insures that a sharply differentiated wave front is available to operate the alarm circuitry.

2: Also at all normal detector tube pulse output rates, the second time constant of the dual time constant network (5.0 milliseconds) allows the coupling circuitry to recover completely between pulses and to initiate a new sampling period.

3: At saturated detector pulse output rates, however, the charging mode capacitor can not recover fast enough and the alarm circuit input is effectively decoupled (disconnected) from the tube output by residual capacitance charge. This action causes the alarm circuit to try to respond as if no ultraviolet energy were present.

4: At the same time, the circuitry takes the first derivative of the detector tube output pulse rate. As long as the derivative is zero (constant output pulse rate), a no alarm condition is maintained in the presence of high pulse output rates. This derivative action provides insurance against the possibility of a very large fire creating detector output saturation pulse rates by requiring that the high impulse rate be constant before the alarm output is inhibited.

The dual time constant circuit changes its operational mode automatically and recovers within 5.0 milliseconds of the end of welding.

INSTALLATION AND WIRING

INSTALLATION

The 11700 Series detector unit may either be wall mounted or secured to a Model 172005 adjustable mounting bracket.

If the detector is wall mounted, it is important to determine the detector's field of view and covered area prior to mounting the detector. The detector should then be mounted using four 1/4 inch bolts with flat washers under the bolt heads to distribute the load.

If an adjustable mounting bracket is employed, the detector must be secured to the bracket plate by means of four 1/4 inch round head bolts, lockwashers and nuts.

The bracket is then wall mounted using four 1/4 inch flat head bolts and the entire assembly is then easily oriented by loosening the spherical guides tensioning nut, orienting the detector and then retightening the nut which will now grasp the sphere and maintain the desired detector view.

The protected area geometry sheet attached at the end of this section should be used as a guide to help in determination of the protected area.

WIRING

The six (6) position terminal strip in the 11700 Series has been designed for use <u>without</u> wiring lugs and will accept wire as large as 12 gauge solid.

Wire entrance to the 11700 is made by means of a threaded opening that is supplied plugged. The opening is threaded to mate with either 3/4 inch rigid conduit for those instances in which the detector is wall mounted or with 3/4 inch flexible conduit for those instances in which the adjustable swivel bracket is employed.

All connections to the detector should be made without removing the internal assembly from the enclosure base. This is done by bringing the wires into the enclosure and then cutting them off approximately 1 inch longer than the distance from the entrance to the terminal strip.

The wires should then be stripped back approximately 1/2 inch and the captivated wire nuts on the terminal block loosened. The stripped wires are then inserted under the wire nuts from the side nearest the wire entrance and the wire nuts secured.

The six (6) 11700 Series terminals are broken into three terminal pairs which are identified as indicated below:

IDENTIFICATION	FUNCTION
PWR	Connection of detector operate power.
ALM	Connection to normally open alarm output contact.
TBL	Connection to trouble contact that is maintained closed in the system normal condition.

Two connection schemes are recommended by Alison Control. These are indicated on the attached drawing and consist of a six (6) wire scheme in which the alarm and trouble output contacts are wired separately and a four (4) wire scheme in which a supervisory resistor is employed to create a three state alarm - normal - trouble output pair.

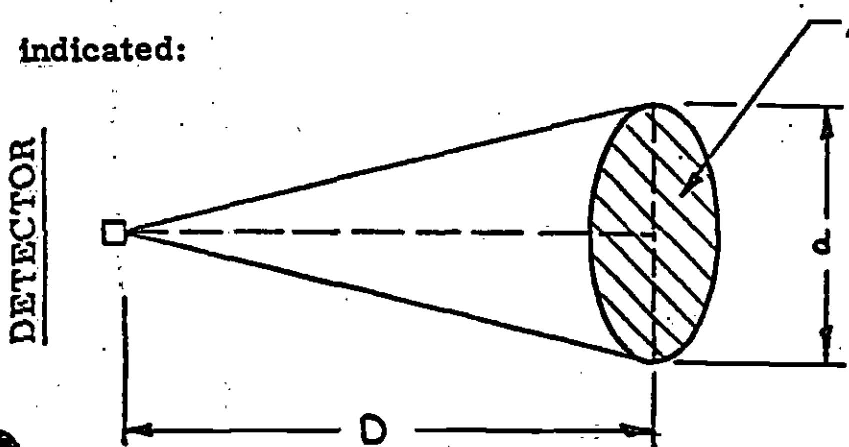
In both the six and four wire schemes, the operate power must be run separately to the terminals marked PWR. DC polarity must be observed on units designed to operate from DC power sources.

PROTECTED AREA GEOMETRY

11700 SERIES ULTRAVIOLET RADIATION DETECTORS

This document presents in tabular form the planar geometry associated with the protected areas generated at varying distances from a single 11700 Series detection system.

The parameters presented are indicated in the diagram below and defined as indicated:



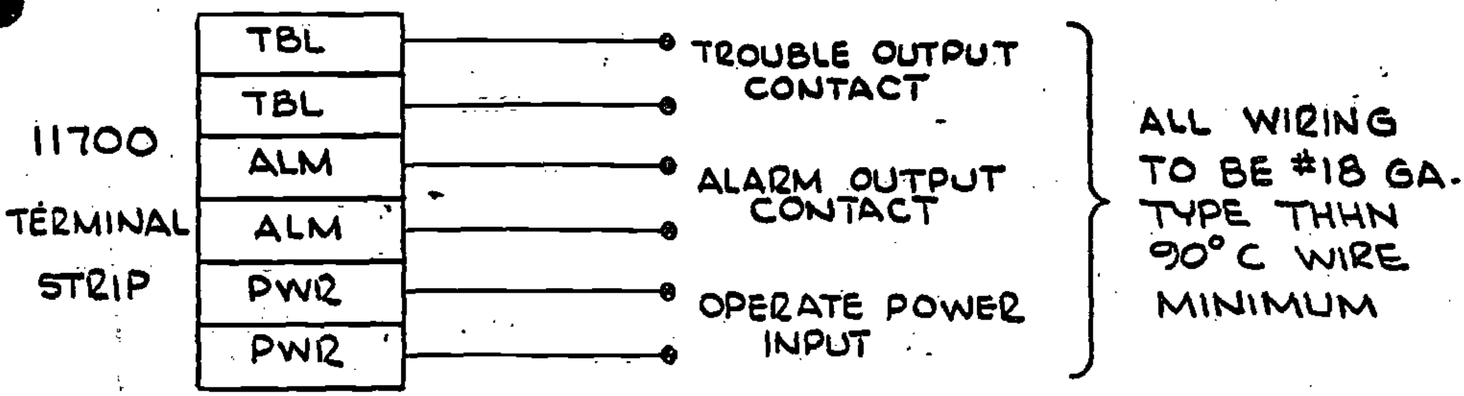
D: Axial distance from detector

d: Diameter of protected circle

A: Area of protected circle

D (FEET)	d (FEET)	A (SQ. FT.)	D (FEET)	d (FEET)	A (SQ. FT.)
5	5.77	26.1	85	98.1	7,560
10	11.5	103	90	103	8,330
15	17.3	235	95	109	9,330
20	23.0	415	100	115	10,300
25	28.8	651	105	121	11,400
30	34.6	940	110	127	12,600
35	40.4	1,280	115	132	13,600
40	46.1	1,670	120	138	14,900
45	51.9	2,110	125	144	16,200
50	57.7	2,610	130	150	17,600
55	63.5	3,160	135	155	18,800
60	69.2	3,760	140	161	20,300
65	75.0	4,410	145	167	21,900
70	80.8	5,120	150	173	23,500
75	86.5	5,870	155	179	25,160
80	92.3	6,690			

EXTERNAL WIRING

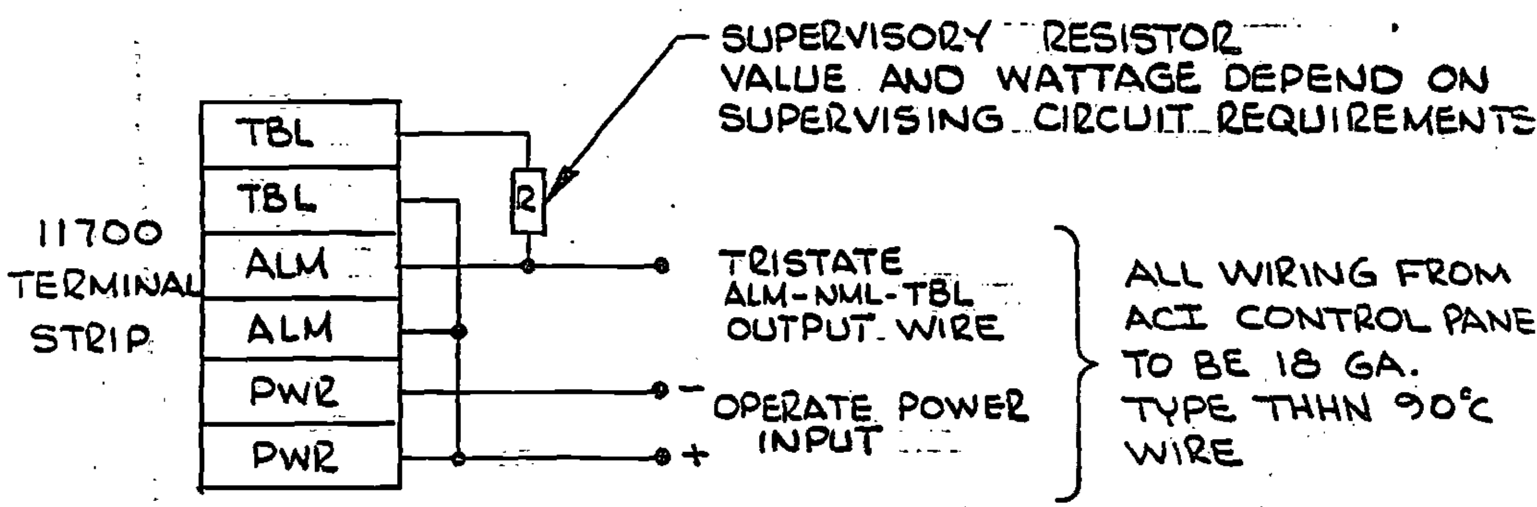


OUTPUT STATES

CONDITION	ALARM	TROUBLE
NORMAL	OPEN	CLOSED
ABNORMAL	OPEN	OPEN
ALARM	CLOSED	CLOSED

SIX WIRE CONNECTION

INDEPENDENT ALARM AND TROUBLE OUTPUTS



OUTPUT STATES

CONDITION	OUTPUT
NORMAL	R
ABNORMAL	OPEN
ALARM	CLOSED

THREE WIRE CONNECTION

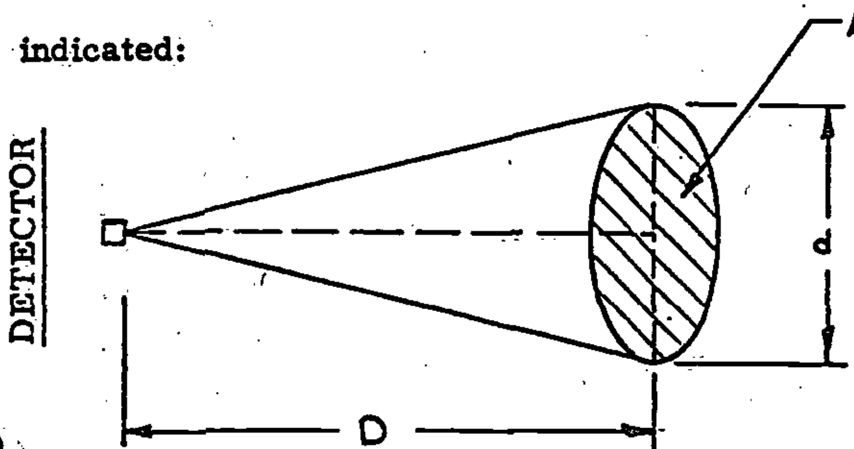
DC POWER AND TRISTATE SIGNAL OUTPUT

PROTECTED AREA GEOMETRY

11700 SERIES ULTRAVIOLET RADIATION DETECTORS

This document presents in tabular form the planar geometry associated with the protected areas generated at varying distances from a single 11700 Series detection system.

The parameters presented are indicated in the diagram below and defined as indicated:



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d: Diameter of protected circl

A: Area of protected circle

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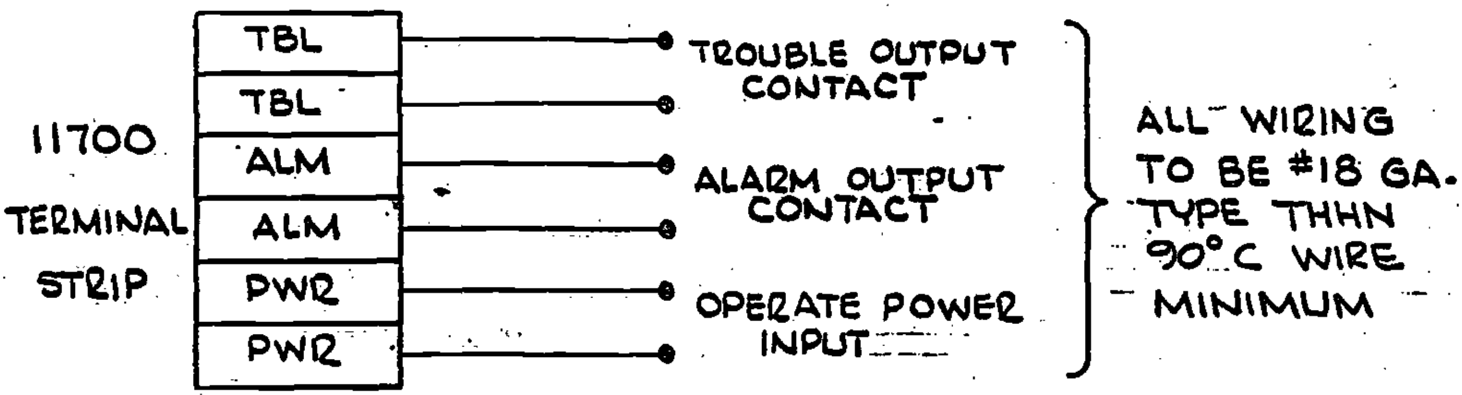
15	17.3	235	95	109	9,330
20	23.0	415	100	115	10,300
25	28.8	651	105	121	11,400
30	34.6	940	110	127	12,600
35	40.4	1,280	115	132	13,600
40	46.1	1,670	120	138	14,900
45	51.9	2,110	125	144	16,200
50	57.7	2,610	130	150	17,600
55	63.5	3,160	135	155	18,800
60	69.2	3,760	140	161	20,300
65	75.0	4,410	145	167	21,900
70	80.8	5,120	150	173	23,500
75	86.5	5,870	155	179	25,160
80	92.3	6,690			

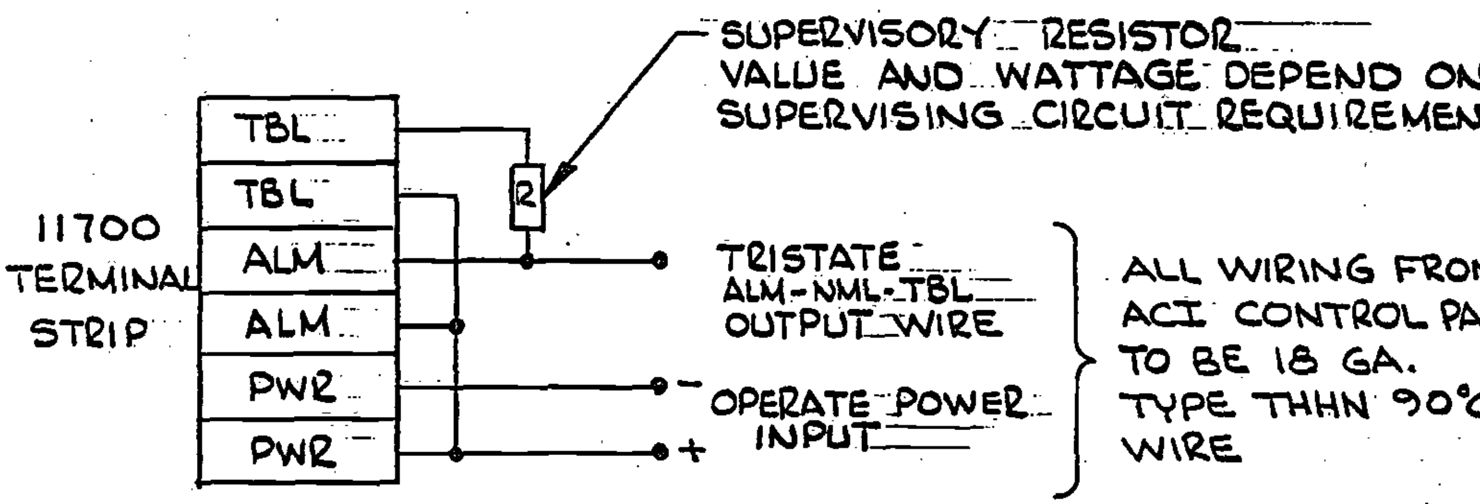


OUTPUT STATES

CONDITION	ALARM	TROUBLE
NORMAL	OPEN	CLOSED
ABNORMAL	OPEN	OPEN
ALARM	CLOSED	CLOSED

SIX WIRE CONNECTION

INDEPENDENT ALARM AND TROUBLE OUTPUTS



OUTPUT STATES

CONDITION	OUTPUT
NORMAL	R
ABNORMAL	OPEN
ALARM	CLOSED

THREE WIRE CONNECTIO

DC POWER AND TRISTATE SIGNAL OUTPUT

OPERATION

Once the 11700 Series detector is connected, no further user adjustments are required. Periodic testing of the detector is possible by use of an Alison Control Model 9015 Ultraviolet Test Source and the detection systems should be tested monthly.

The only possible user adjustment is changing of the detector output pulse alarm level; alarm level duration; and/or welding rejection threshold.

These adjustments are independent and are done by adjusting potentiometers in the detector.

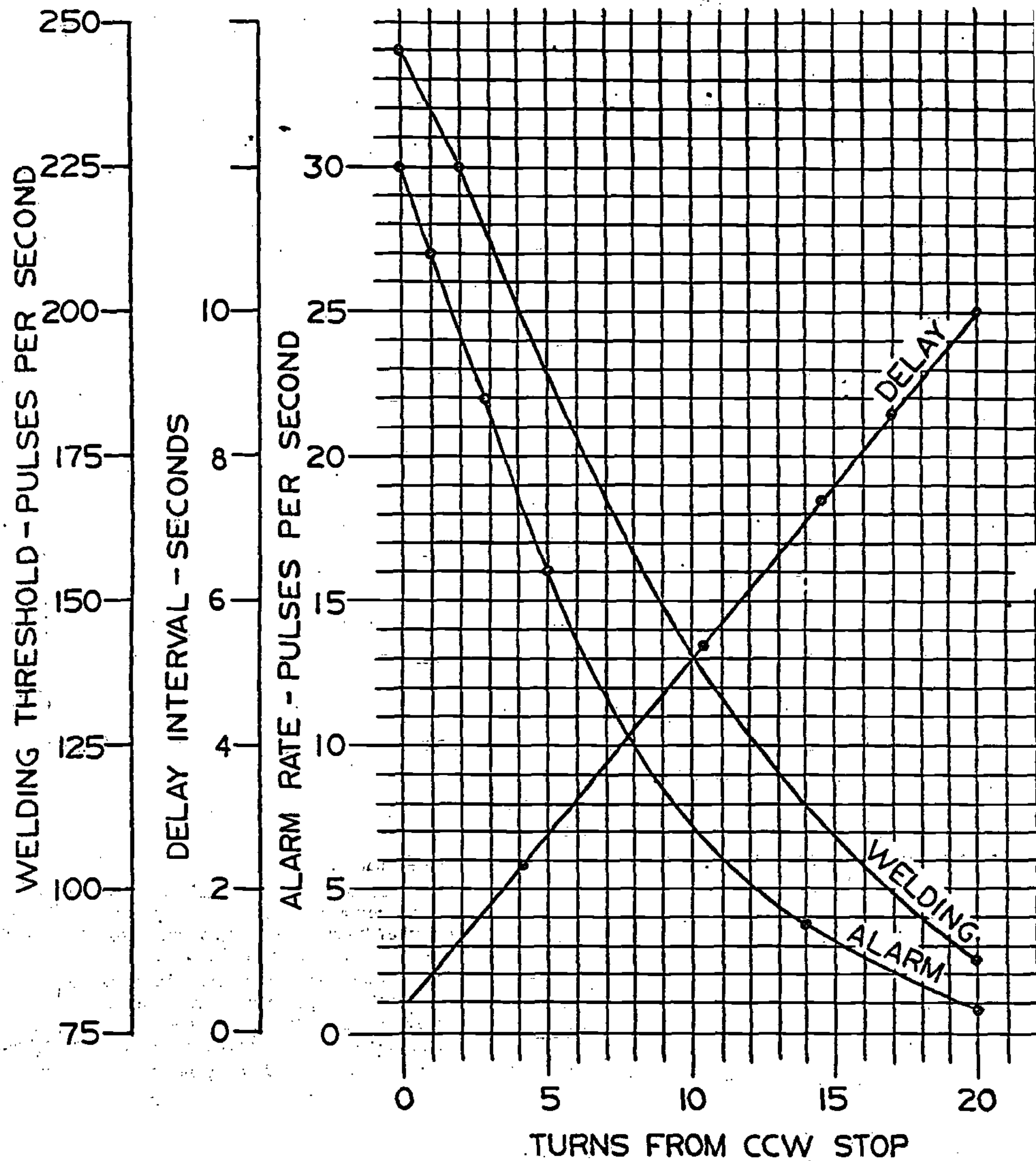
The detector output pulse alarm level potentiometer is closest to the printed circuit board. Clockwise rotation decreases the pulse per second rate required for alarm.

The interval for alarm potentiometer is the middle of the three potentiometers. The interval increases with clockwise potentiometer rotation.

The welding threshold potentiometer is the bottom of the three potentiometers. Clockwise rotation decreases the pulse rate at which the welding circuit is activated.

The graph attached at the end of this section displays potentiometer turns in a clockwise direction as a function of all three detector adjustments. Approximate settings can be made by using the graph, but precise detector adjustments require the use of test equipment monitored by Alison Control personnel.

11700 SERIES UV DETECTORS



elison control inc.

FAIRFIELD, N.J. 07006

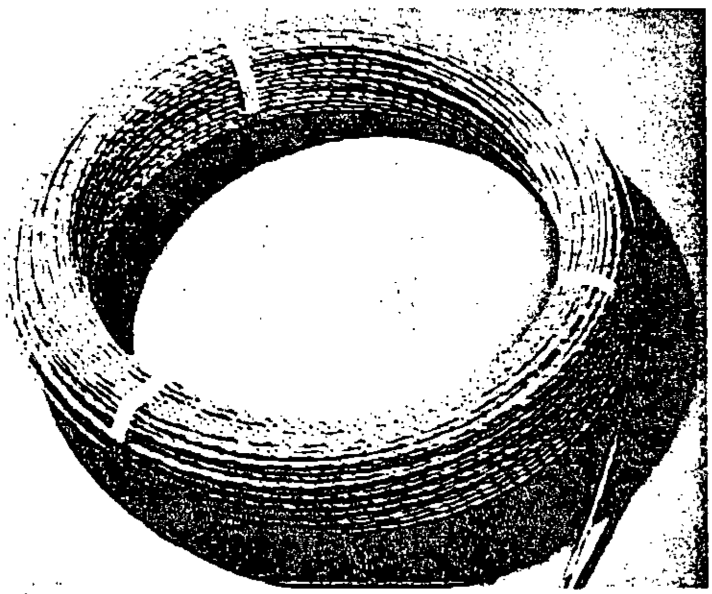
System component

$15/Meter
≈ 4.5/ft

PROTECTOWIRE

Features

- Line coverage . . . continuous sensitivity.
- Fail-safe security.
- Three temperature ratings.
- Withstands moisture, alkalies, dust, low temperatures.
- Approved for hazardous locations.
- No contacts to foul.
- Easy to install.
- Economical, no maintenance expense.
- Add to the system if expansion is required.



Protectowire line heat and fire detector

Application

Protectowire line heat and fire detector is a proprietary cable that detects heat anywhere along its length. An entire system wiring is turned into a continuous fire detector.

Ideally suited to industrial high risk hazards, this detector is used extensively in steel mills, power generation plants, pulp and paper mills, chemical, cement, aluminum and coal preparation plants. Line detection has unique advantages when used in areas of limited access and surveillance, pollution, dust and corrosion—where early detection of a fire in its incipient stages can be of inestimable value.

Equally adaptable to commercial applications, line heat and fire detection is widely used in schools and colleges, churches, historic sites, municipal buildings, government installations and agricultural buildings.

The detector can be run throughout all parts of a building including all rooms, halls, storage areas, basements, lofts and accessible spaces. Stairways, elevator shafts, closets and chutes may also be protected.

Detection is assured at any point along the run.

UL FM

Fast, dependable, proven fire protection

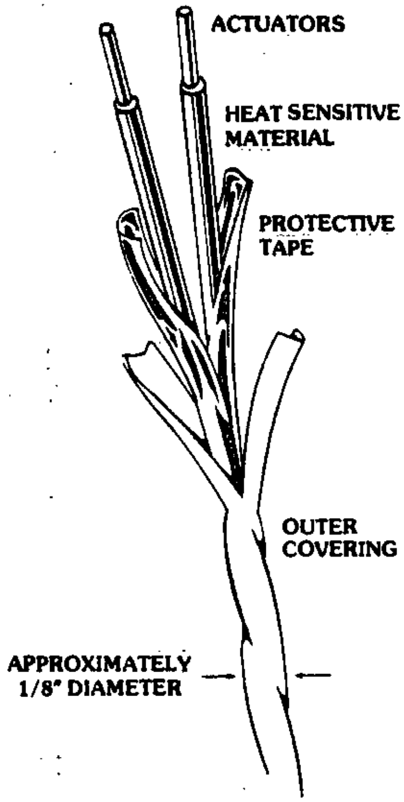


Figure 1

Line coverage point sensitivity

Protectowire line heat and fire detector is comprised of two actuators individually encased in a heat sensitive material. The encased actuators are twisted together to impose a spring pressure between them. then spirally wrapped with a protective tape and finished with an outer covering to suit the environment of use.

At installation a device is connected to one end of the actuators so that when a power source is added a small monitoring current passes continuously through the detector and supervisory circuit. At the critical or operating temperature the heat sensitive material yields to the pressure on it, permitting the actuators to move into contact with each other. **This action takes place at the first heated point anywhere along the detector. The heat does not have to result from open flame, nor produce any specified density of smoke, nor increase at any particular rate. Heat alone causes the alarm.**

Simple installation

The detector is installed in continuous runs without taps or branches in accordance with applicable sections of NFPA Standard 72E, National Electric Code and local codes and ordinances. Except for zoning requirements (alarm source indication) the length of runs is essentially unlimited being controlled only by electrical characteristics of the control equipment or transmitter with which the detector is associated.

The detector can be placed on the ceiling of the area to be protected or on the walls within 20 inches of the ceiling.

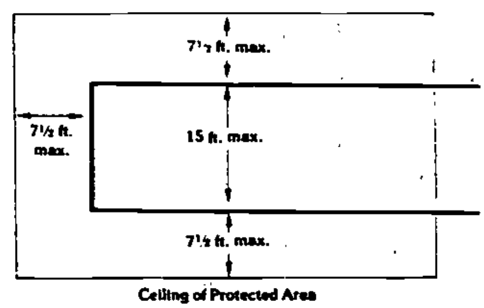


Figure 2

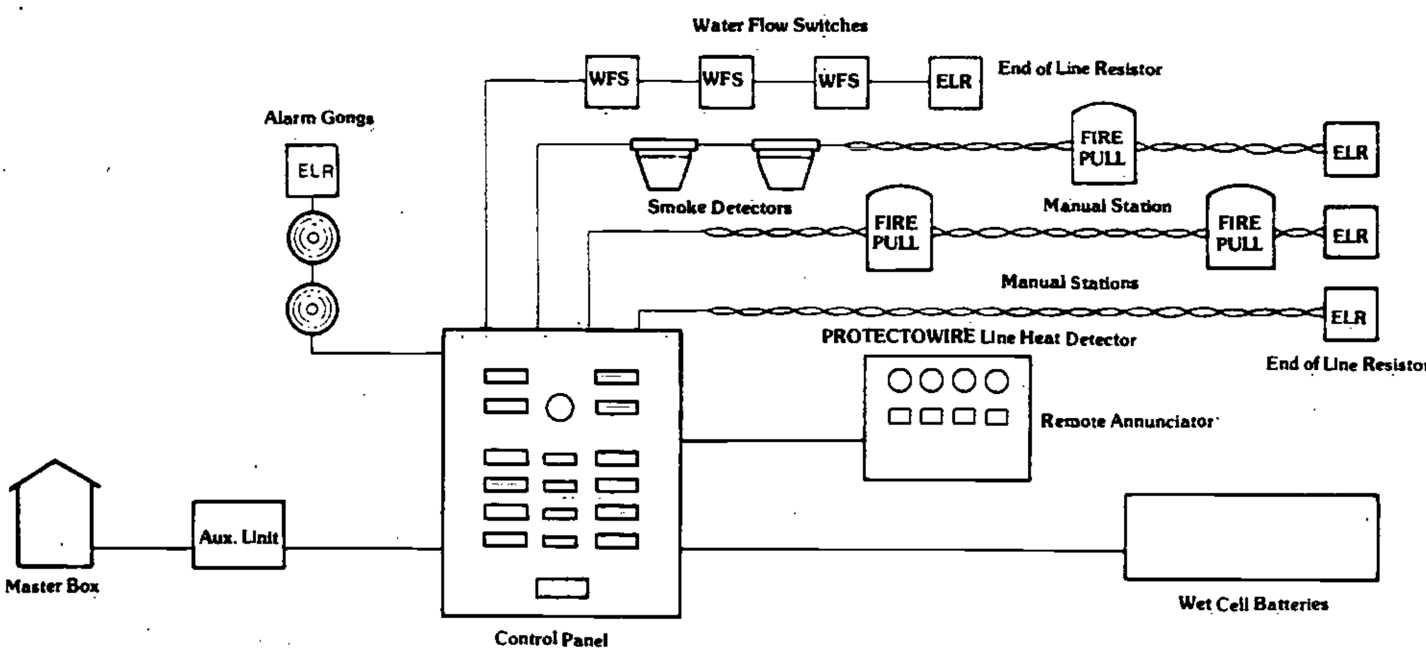


Figure 3 TYPICAL PROTECTOWIRE FIRE ALARM SYSTEM

Special hazard applications . . .

- CABLE TRAYS
- CONVEYORS
- DUST COLLECTORS/BAGHOUSES
- WAREHOUSE RACK STORAGE
- PIERS, MARINE VESSELS
- MINES
- POWER DISTRIBUTION APPARATUS:
  Switchgear, substations, transformers, motor control centers, resistor banks, etc.
- PIPELINES
- COLD STORAGE WAREHOUSES
- COOLING TOWERS

Protectowire line heat detector pinpoints the exact locations of an overheating condition anywhere in these high risk hazards and withstands all of their aggressive atmospheres indefinitely. Vital systems are kept in operation.

This detector meets intrinsically safe standards when used with Protectowire control panels FM approved for Class I, Div. 1, Groups A, B, C & D hazardous locations.

Irradiation tests prove no detector embrittlement.

Messenger wire

It is often advantageous to install Protectowire line heat detector on messenger wire. Any of the standard or special constructions will be furnished on order in coils approximating 500 feet wound one turn per foot with high tensile, stainless steel messenger wire.

Specifications

The detector is made in different temperature ratings to allow for differences in normal or ambient temperature. Guidelines for selecting the proper rating to be installed in a given area are the same as for automatic sprinklers and other heat actuated devices. For ambient temperatures not exceeding 100°F, install Regular Protectowire Detector. For ambient temperatures exceeding 100°F but not 150°F, install Intermediate Protectowire Detector. For ambient temperatures exceeding 150°F but not 225°F, install High Test Protectowire Detector. Regular, Intermediate and High Test Detectors all have the same principle of actuation and are easily spliced together in series with Protectowire PWS Splicing Sleeves. Each will operate at its specific alarm temperature without influence from adjacent line detectors that are rated differently.

Flexible leads are provided for connecting the detector to copper wire or terminals. Electrical rating is 50 volts or less, AC or DC. Resistance is approximately 10 ohms per 100 conductor feet.

Temperature ratings and color codings

	155°F	190°F	280°F
Indoor standard service	Regular WHITE White braid	Intermediate WHITE White braid, brown tracer	High Test RED Red braid, brown tracer
	Regular BROWN Brown braid	Intermediate BROWN Brown braid, white tracer	
	Regular RED Red braid	Intermediate RED Red braid, white tracer	
Moderate outdoor exposure, moisture resistant	Regular Type P, RED Red tape	Intermediate Type P, WHITE White tape	High Test Type P, BLUE Blue tape
Severe industrial exposure	Regular Type WPP, RED Red tape over asphalt	Intermediate Type WPP, WHITE White tape over asphalt	High Test Type WPP, BLUE Blue tape over asphalt
Water, flame and abrasion resistant	Regular Type WFR, WHITE White braid, blue tracer	Intermediate Type WFR, WHITE White braid, red tracer	High Test Type WFR, BLUE Blue braid, white tracer

Note: Any of the above can be supplied on Messenger Wire

Maximum temperature where detector is located	Rating of detector to use	Rated temperature
Up to 100°F (37.8°C)	Regular	155°F (68.3°C)
100°F (37.8°C) to 150°F (65.6°C)	Intermediate	190°F (87.8°C)
150°F (65.6°C) to 225°F (107.2°C)	High Test	280°F (137.8°C)

Installation

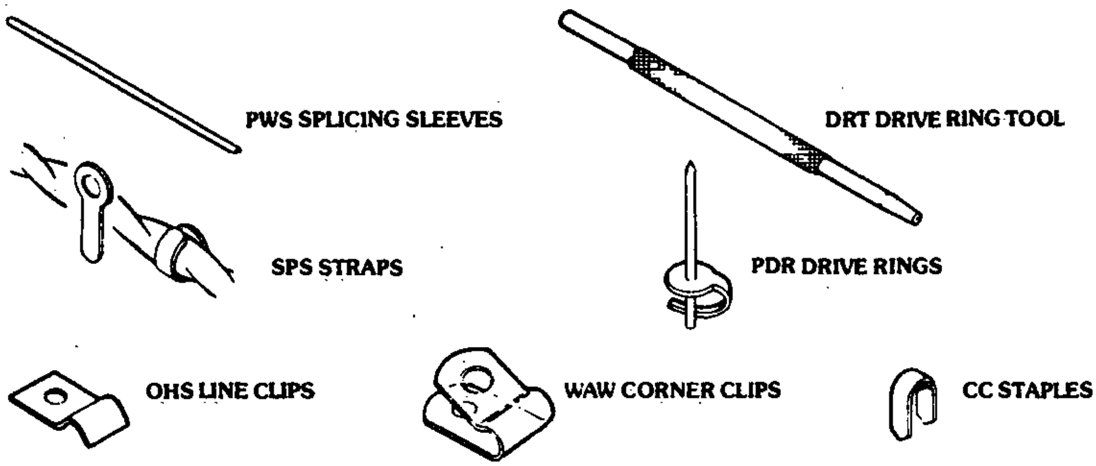
Numerous accessories are approved for installation of Protectowire line heat and fire detector. These include several types of clips and straps, drive rings, special copper clad staples, cable standoffs and messenger wire. Their proper use assures a neat and workmanlike installation. Other devices which are not specifically approved should not be used.

Splicing

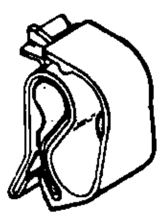
The different ratings of line detector all have the same size conductors and are readily spliced together by means of PWS Splicing Sleeves. These copper sleeves are manufactured to close tolerances for this specific purpose and are the only approved method of splicing the detector.

Accessories

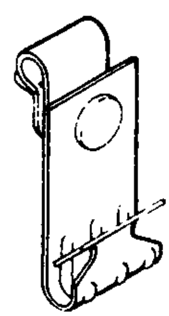
The Protectowire Co. offers an assortment of fastenings to facilitate installation for a wide variety of applications.



Special application items for cable tray installations



PC-2 MOUNTING CLIPS
Will clamp to trays
.030" (.76 mm) to .065" (1.65 mm) in thickness



CC-2N MOUNTING CLIPS
Will clamp to trays
.06" (1.52 mm) to .16" (4.06 mm)

Also available:
CC-2W MOUNTING CLIP
Will clamp to material between
.16" (4.06 mm) to .25" (6.35 mm)

System capabilities

Protectowire line heat and fire detector is a component of a complete family of systems manufactured by The Protectowire Company—a leader in fire detection for over forty years.

Capabilities include meeting any fire defense need from multiple alarm zones to auxiliary equipment shutdown and automatic extinguishing. Modular in design Protectowire detection systems meet specific individual requirements and allow for system expansion at any time, providing long range economy. For further information, call or write:

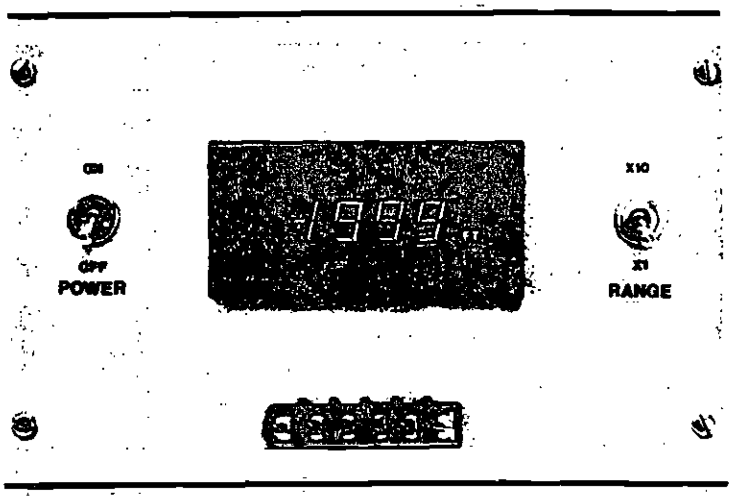
The Protectowire Company
P.O. Box A • Hanover, Ma 02339 • (617) 826-3878
Manufacturer of Fire Detection Systems

System component

PROTECTOWIRE

Features

- Pinpoint the exact location of overheating anywhere along Protectowire line heat detector.
- Direct reading in feet of detector.
- More accurate than analog meters — full range accuracy of 1%.
- No zero adjustments.
- Optional range switch.
- Large easy to read LED display.



Model PWM-D digital Protectowire meter

Application

The model PWM-D digital meter is designed to locate a heat actuated point on Protectowire line heat detector. This meter provides a means to read the distance in feet from the start of the detector portion of the circuit to the actuated point.

If this option is chosen it will be built into the main control panel.

The basic model has a full scale reading of 1999 feet with an accuracy of ± 1% of meter reading. Where installations of the cable exceed the basic full scale distance an optional (× 10) range switch may be incorporated. No zero adjustments are required.

The readout is a bright red LED display with numbers .43 inches (1.09cm) high. The device is powered from the system 24VDC power supply.

The Protectowire Company
P.O. Box A • Hanover, Ma 02339 • (617) 826-3878
Manufacturer of Fire Detection Systems

Litho in U.S.A.

Form 8007

users list

PROTECTOWIRE

Representative industrial users of Protectowire systems

Power generation –

Nuclear

Arkansas Power & Light Co.
Arizona Nuclear Power Project
Southern California Edison Co.
Commonwealth Edison Co.
Houston Lighting and Power Co.
Toledo Edison Co.
Iowa Electric Light and Power Co
Kansas City Power & Light Co.
Union Electric Co.
Florida Power Corp.
Philippines Nuclear Power Plant
Yankee Atomic Electric Co.
Baltimore Gas & Electric Co.

Fossil

Alabama Power Co.
Georgia Power Co.
Gulf Power Co.
Tampa Electric Co.
Detroit Edison Co.
Northern States Power Co.
Iowa-Illinois Gas & Electric Co.
Pennsylvania Electric Co.
Ontario Hydro

Hydro

Hydro-Quebec

Steel

Bethlehem Steel Corp.
U.S. Steel Corp.
Armco Steel Corp.
Republic Steel Corp.
Inland Steel Co.
Sharon Steel Corp.
Jones & Laughlin Steel Corp.
Lone Star Steel Co.
Granite City Steel Div., National Steel Corp.
Crucible Steel Div., Colt Ind. Canada, Ltd.

Petroleum

Shell Oil Co.
Texaco Corp.
Amdel Pipeline Inc.
Cosden Oil & Chemical Co.,
Div. of American Petrofina Co. of Texas

Pulp and paper

International Paper Co.
Georgia Pacific Corp.
Weyerhaeuser Co.
Bowater Carolina Co.

Chemical, petrochemical

E. I. duPont de Nemours & Co.
U.S. Steel Corp., Chemicals Div.
Shell Oil Co.
Phillips Petroleum Co.
Lederle Laboratories Div., American Cyanamid Co.
Rexene Polyolefins Co. Div., Dart Industries, Inc.
El Paso Natural Gas Products Co.
I/S Norpolefin, Polyolefins Complex, Norway
ATO Chimie, Unite de Polypropylene, France

Aluminum, brass, nickel, copper

Aluminum Company of America
The Anaconda Co., Brass Division
Kaiser Aluminum & Chemical Corp.
Kennecott Copper Corp.
Anaconda Aluminum Co.
Harvey Aluminum of Kentucky, Inc.
Continental Copper and Steel Industries, Inc.
Aluminum Company of Canada, Ltd.
The International Nickel Company of Canada
Falconbridge Nickel Mines Ltd.

Coal preparation, uranium refining and processing

K & J Coal Co.
U.S. Steel Corp.
Rochester Pittsburgh Coal Co.
Kerr-McGee Nuclear Corp.
Union Carbide Nuclear Co.
Peabody Coal Co.

Cement

Leeds Cement Co.
The Lyons Cement Co.
Capital Cement Co. Div., Martin Marietta Corp.
Universal Atlas Cement Div., U.S. Steel Corp.

Electronics

IBM Corp.
Honeywell, Inc.
General Instrument Corp.
Radio Corp. of America
Sanyo Manufacturing Corp.
Magnavox Company of Tennessee

Refrigerated warehouses

Quincy Market Cold Storage & Warehouse Co.
North East Cold Storage Corp.
M & M Refrigeration
Public Super Markets Inc.
United Grocers Ltd.

Piers, marine vessels

Port of Tacoma, Washington
Atlantic Dry Dock Corp.
Detyens Shipyards
Todd Shipyards Corp.
Savannah Machine and Shipyard Co.

Fuel distribution terminals, service centers

Texaco Corp.
Pennsylvania Power & Light Co.
Bethlehem Steel Corp.

Specifiers of Protectowire systems

Bechtel Corp.
Fluor Corp.
Brown & Root, Inc.
Kaiser Engineers
Stearns-Roger, Inc.
Sargent & Lundy Engineers
United Engineers & Constructors, Inc.
Gilbert/Commonwealth Companies
The Ortloff Corp.
Dravo Corp.
Wean United, Inc.
Allis-Chalmers
Koppers Co., Inc.
The Bendix Corp.
Mine Safety Appliances Co.
Pullman Kellogg Co., Div. of Pullman, Inc.
Pullman Swindell Co., Div. of Pullman, Inc.
The Litwin Corp., France
Comprimo, The Netherlands
Burns and Roe, Inc.

The Protectowire Company
P.O. Box A • Hanover, Ma 02339 • (617) 826-3878
Manufacturer of Fire Detection Systems

Litho in U.S.A.

Form 7295

Heat Compensated, heat detector

Thermotech operates within a controlled range of two to three degrees of its set point, regardless of the speed or rate of temperature rise. Depending upon the model, Thermotech is Underwriters Laboratories listed for 135 and 200 degrees Fahrenheit.

A normally-open-contact thermo-switch, Thermotech is especially designed for fire detection and alarm systems, but can be adapted for special temperature supervisory functions, such as that of a freeze detector.

Because of its rate anticipation principle, Thermotech responds and activates the fire alarm immediately whenever the ambient temperature reaches the pre-set temperature setting, regardless of how slow or how fast the temperature rises. Under rapid heat rise conditions, the rate anticipation feature causes the Thermotech to respond one to three degrees ahead of the setting. At the same time, however, it does not respond to momentary temperature fluctuations below the selected protection level. This eliminates false alarms.

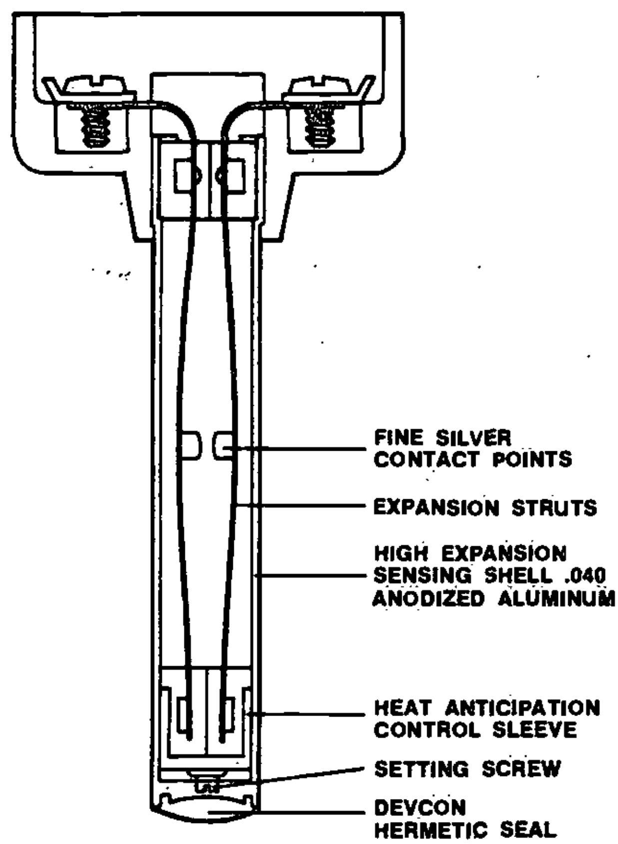
Thermotech is U/L rated for coverage up to 50′ x 50′ on models 302 and 302 A.W. and 40′ x 40′ on models 302H and 302 EPM. It automatically re-sets itself after an alarm when temperature drops back down below the protection level; it is hermetically sealed, shock and corrosion resistant, and temperproof. The electrical rating is 6-125 VAC/5 amps or 6-25 VDC/1 amp.

Rec'd
30 June 1983

#50-60/each
suggested spacing
to be confirmed,
30-40 ft

THERMOTECH...
Unrivalled for Precision

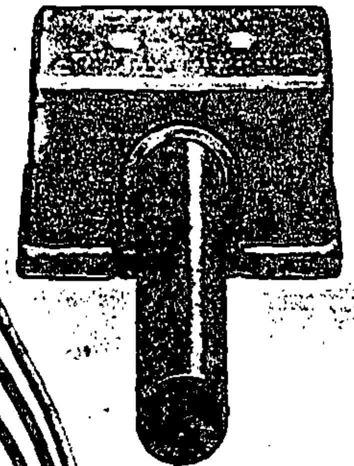
(CUT-AWAY VIEW - ACTUAL SIZE)



FOUR BASIC MODELS

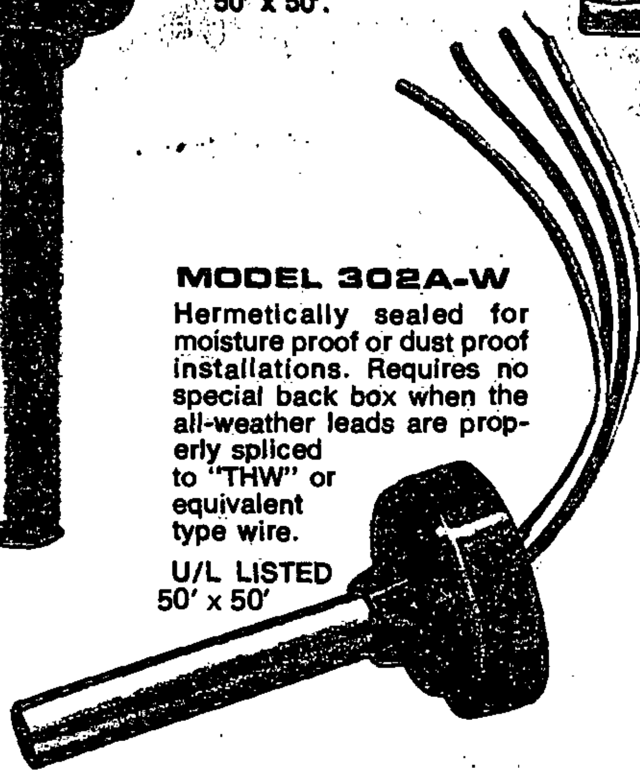
MODEL 302

For interior mounting in any atmosphere that is compatible with terminal screw type connections. U/L listed 50′ x 50′.



MODEL 302-H

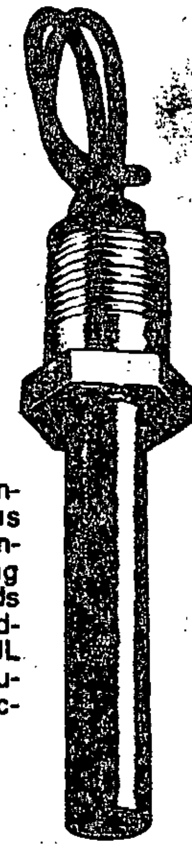
Same as Model 302 except designed for horizontal mounting. U/L listed 40′ x 40′.



MODEL 302A-W

Hermetically sealed for moisture proof or dust proof installations. Requires no special back box when the all-weather leads are properly spliced to "THW" or equivalent type wire.

U/L LISTED 50′ x 50′

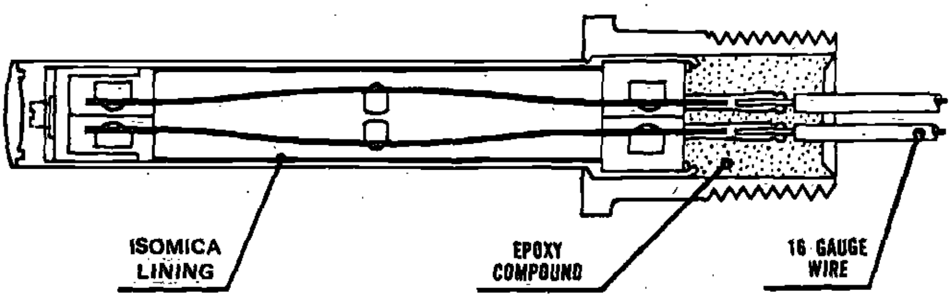


MODEL 302 EPM

Explosion proof for installation in hazardous locations. Has hexagonal wrench grip bushing with ½″ conduit threads for attachment to threaded hub cover of series JL fixture fitting as manufactured by Killark Electric Co., or equal.

U/L LISTED 40′ x 40′

MODEL NUMBER	DESCRIPTION
302 THERMOTECH	135° F. - Interior Vertical Mounting
302 THERMOTECH	200° F. - Interior Vertical Mounting
302 A-W THERMOTECH	135° F. - All-weather Vertical Mounting
302 A-W THERMOTECH	200° F. - All-weather Vertical Mounting
302 EPM THERMOTECH	135° F. - Explosion Proof Vertical Mounting
302 EPM THERMOTECH	200° F. - Explosion Proof Vertical Mounting
302 H THERMOTECH	135° F. - Interior Horizontal Mounting
302 H THERMOTECH	200° F. - Interior Horizontal Mounting



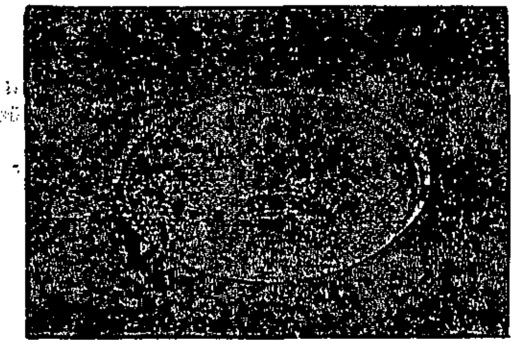
MODEL 302-EPM

FIRE DEVIC
15835 E. MAIN S
LA PUENTE, CALIFC
TEL. (213) 968

NOTIFIER EMHART

COMBINATION FIXED TEMPERATURE AND RATE-OF-RISE HEAT DETECTOR

CALIFORNIA LISTED 7270-028:34



Series 600, 620

#15-#16/each

SERIES 600 1 CIRCUIT   SERIES 620 2 CIRCUIT

APPLICATION

Designed for use as a means of initiating a signal when subjected to abnormal heat.

601, 621 & 602, 622 Models

Installed in large, open areas that are not subject to rapid temperature fluctuations because of danger of false alarms.

603, 623 & 604, 624 Models

Installed in locations subject to rapid temperature fluctuations.

Compatible with any appropriate control panel.

OPERATION

Operates as an open circuit, fixed temperature and rate-of-rise combination (601, 621 and 602, 622) or fixed temperature only (603, 623 and 604, 624) fire detection thermostat.

Operating temperature of the RATE-OF-RISE element distends a flexible metal diaphragm and closes the electrical contact when the rate of temperature rise exceeds 15° F. per minute. When air temperature rises very rapidly the air in the chamber of the RATE-OF-RISE element expands faster than it can be vented which distends the diaphragm.

Operating temperature of the FIXED TEMPERATURE element melts the eutectic fusible alloy which releases a spring and causes the switch to operate.

Resetting of an operated detector is automatic if only the RATE-OF-RISE element has been activated. If the FIXED TEMPERATURE element is operated then the whole unit must be replaced.

Standard temperature ratings:

Model 601-621 fixed temperature setting is 135° F. for normal conditions where ambient temperatures do not exceed 100° F.

Model 602-622 fixed temperature setting is 200° F. for use where ambient temperatures exceed 100° F. but not 150° F.

For conditions of rapid temperature changes:

Model 603-623 fixed temperature settings is 135° F.

Model 604-624 fixed temperature setting is 200° F.

CONSTRUCTION

The Series 600/620 projects a mere 1⅜", with all-white finish to make it blend into the ceiling surface unobtrusively.

Materials for the Series 600/620 have been carefully selected for high strength, corrosion resistance, integrity at points of hermetic sealing, and extended trouble-free service.

The Series 600/620 uses the same pneumatic rate-of-rise element as in former Models, with some structural improvements. The fixed temperature element uses fusible alloy — unsurpassed for long-term stability and reliability — in a new, more efficient way. It features an external heat collector that drops away when the alloy fuses, providing unmistakable visual indication that the element has operated.

NEW EASY INSTALLATION

A patented reversible mounting plate is supplied with each detector. In one position, it attaches to a 4" octagon junction box, a 3¼" octagon box, or a plaster ring. In the reverse position, it can be used for open wiring without junction boxes, and provides an extra ¼" of space between detector and mounting surface for wire connections. In either position, all mounting screws are concealed.

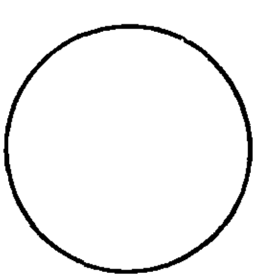
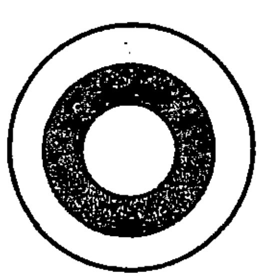
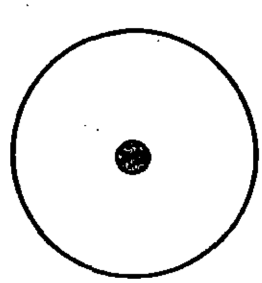
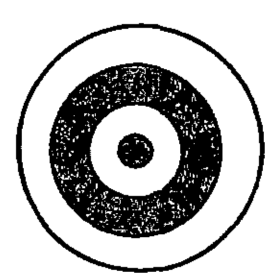
The detector attaches to the mounting plate with a simple push-and-twist motion. It can be detached with the same motion in reverse, without the use of tools.

The mounting plate is molded of white self-extinguishing thermoplastic, rated at 105° C. It is extremely strong, yet resilient enough to adapt to uneven mounting surfaces without cracking.

COMBINATION FIXED TEMPERATURE AND RATE-OF-RISE HEAT DETECTOR

ENGINEERS' SPECIFICATIONS

Automatic heat detectors shall be the combination rate-of-rise and fixed temperature type — rated at 135° F for areas where ambient temperatures do not exceed 100° F and rated at 200° F for areas where ambient temperatures exceed 100° F but not 150° F. The rate-of-rise element shall consist of an air chamber, a flexible metal diaphragm, and a factory calibrated moistureproof, trouble-free vent and shall operate when the rate of temperature rise exceeds 15° F per minute. The fixed temperature element shall consist of a heat collector held by standard sprinkler fusible solder. Detectors shall have a smooth ceiling rating of 2500 square feet and an electrical rating of 3 amp at 6 to 125 volts A.C. and 1 amp at 6 to 28 volts D.C. (Fixed temperature detectors shall have the same temperature and electrical ratings as combination thermostats but a smooth ceiling rating of 625 square feet.) Detectors shall be installed in accordance with appropriate articles of National Fire Protection Association and the spacing rating assigned by the Underwriters' Laboratories and located as shown on the drawings. Automatic heat detectors shall be Underwriters' Laboratories listed and Factory Mutual approved.

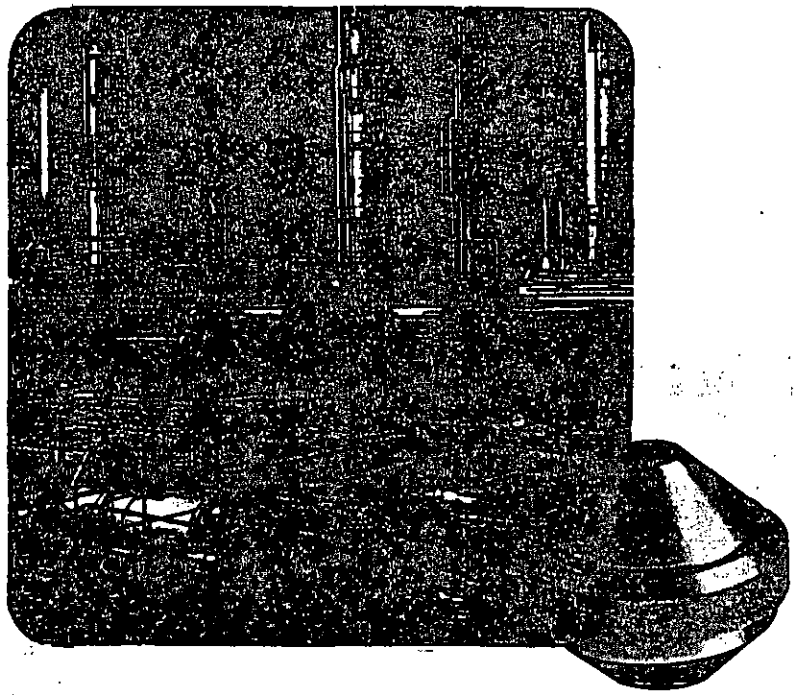
1-CIRCUIT MODEL	601	602	603	604
2-CIRCUIT MODEL	621	622	623	624
DESCRIPTION	Rate-of-Rise and Fixed Temperature, 135° F.	Rate-of-Rise and Fixed Temperature, 200° F.	Fixed Temperature Only, 135° F.	Fixed Temperature Only, 200° F.
USE	Where temperature fluctuations are normal, and ceiling temperatures do not exceed 100° F.	Where temperature fluctuations are normal, and ceiling temperatures exceed 100° but do not exceed 150° F.	Where temperature fluctuations may be unusually violent, and ceiling temperatures do not exceed 100° F.	Where temperature fluctuations may be unusually violent, and ceiling temperatures exceed 100° but do not exceed 150° F.
IDENTIFICATION ON HEAT COLLECTOR	 NONE	 GRAY RING	 GRAY SPOT	 GRAY SPOT & RING
U.L. MAXIMUM SPACING ALLOWANCE	50 x 50 ft.	50 x 50 ft.	25 x 25 ft.	25 x 25 ft.

TESTING THE SPOT FIRE LOWECATOR

Models 601/621 and 602/622 can be tested by the application of quick heat from any convenient source. Recommended is a common portable hair dryer. Models 603/623 and 604/624 cannot be tested. However, the fusible alloy element is generally considered so reliable that testing is not necessary.

ELECTRICAL RATINGS

6-125 Volts A.C. — 3.0 Amp.
6-28 Volts D.C. — 1.0 Amp.
125 Volts D.C. — 0.3 Amp.
250 Volts D.C. — 0.1 Amp.



Pyrotector

30-2056E*

Infrared Explosion-Proof

FIRE Detector

FM APPROVED

- **Minimizes false alarms by lightning, welding, sunlight**
- **Ultra-fast response to hydrocarbon fires**
- **Compatible with standard alarm systems**
- **Remote test feature**
- **Multi-positional viewing axis**

*Patent Pending

$600/each

Pyrotector

Introduction. Every fire gives off a broad spectrum of light — visible and invisible — from ultraviolet to infrared. Most industrial flame detectors concentrate on UV emissions because the frequency is relatively easy to detect. But UV brings with it a distinct problem — not only do fires emit UV, so also does the sun, fluorescent fixtures, welding flashes, lightning and a myriad of other light sources in the industrial environment. Thus, location of the UV detector is limited or it is subject to repeated false alarms.

Pyrotector's Model 30-2056E FIRE Detector has overcome the limitations imposed by UV because it is designed to sense only a narrow but dominant portion of the infrared spectral emissions . . . something created in an enormous quantity in every hydrocarbon fire compared to other light sources. The advanced technology involved in the sensing technique also has made possible detecting the flame in milliseconds, plus a degree of reliability not possible before. Thus, the FIRE Detector adds a new dimension to industrial flame detection and a new standard for safety.

Minimizes false alarms caused by lightning, welding and sunlight. The infrared FIRE Detector is designed to minimize triggering of the alarm by lightning, arc welding, sunlight and most other extraneous light sources.

Unlike conventional ultraviolet and infrared flame detectors, it's engineered to respond *only* to a nominal 4.3 micron band of infrared radiation that is highly specific to hydrocarbon fires. Optical filters contained in the housing cause the detector to reject extraneous background radiation.

The FIRE Detector can be used indoors or outdoors, in virtually any lighting environment from direct sun to total darkness, including the full range of artificial lighting environments.

Significantly faster response to hydrocarbon fires. Response time varies depending on fire size, rate of propagation, and proximity to the detector. Average response time to a flash of 12 inch square gasoline fire at any light level is 75 milliseconds at 10 feet.

Compatible with standard fire alarm systems. The FIRE Detector is compatible with most 24 volt filtered DC 4-wire fire alarm control panels. It requires no junction box, since terminations are made to terminal strip mounted directly in the unit.

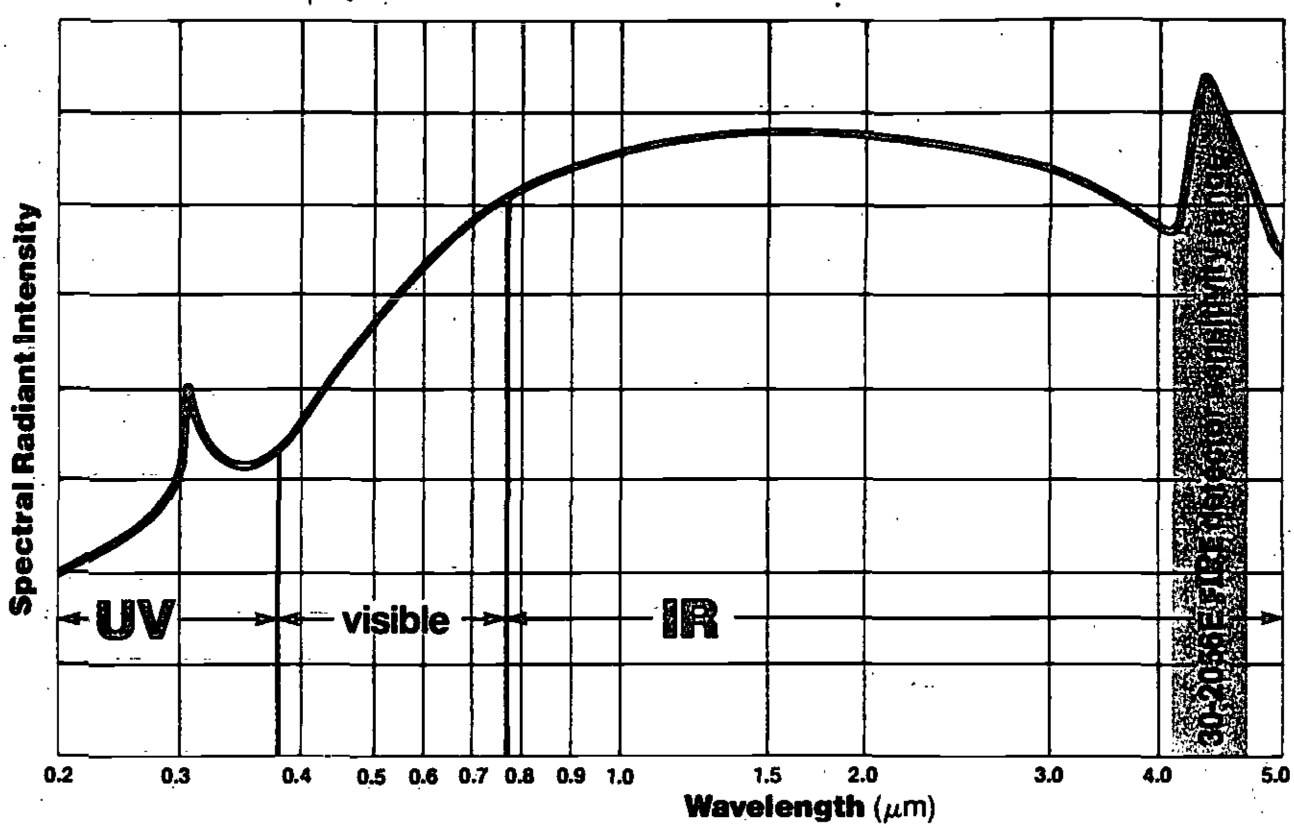
Enclosure is explosion proof, water-tight and dust-tight, per applicable NEMA and NEC requirements (see specifications).

Remote test feature. The remote test feature checks the optical integrity of the lens and the sensing and alarm circuitry from outside the unit. A self-contained energy source mounted outside the lens is energized, simulating a flickering fire. The detector latches into alarm, indicating that it is operating.

To remote-test the unit, the operator simply activates a test switch on the control panel. The detector can be reset to the normal mode from the control panel simply by interrupting power to the unit.

Multi-positional viewing axis. The FIRE Detector can be rotated up to 360° to place the desired area of surveillance within its 90° cone of vision. The direction of the viewing angle can be set or changed without special tools, additional hardware or mounting components.

Typical Hydrocarbon Fire Spectrum



Better protection against false alarms. The FIRE Detector provides significantly better discrimination against false alarms than conventional ultraviolet and infrared flame detectors.

The reasons can be seen clearly on the spectrum above. Conventional ultraviolet and infrared detectors, which characteristically operate in the .185 to .245 micron (UV) or 1.0 to 3.0 micron (IR) range, are sensitive to radiation emitted by many light sources in addition to hydrocarbon (gasoline) fires. Lightning, arc welding flashes, some types of artificial light, even sunlight can trigger false alarms in these detectors.

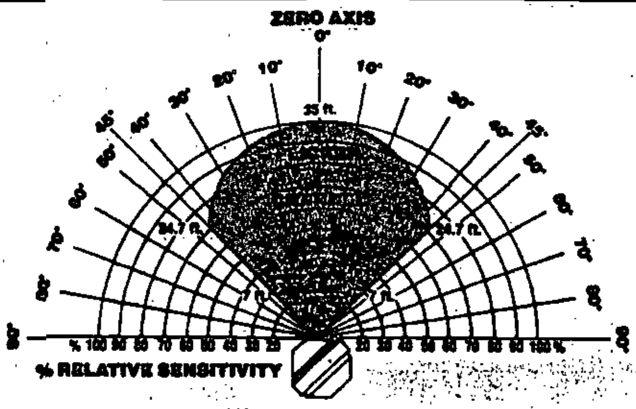
Sensitive to hydrocarbon fires. In contrast, the FIRE Detector *is sensitive only* to the energy produced by hydrocarbon fires in the infrared region extending from 4.1 to 4.7 microns.

The emission spectrum of every hydrocarbon fire is characterized by a strong emission band in this spectral region. This band, known as the CO_2 *Spike*, is caused by the emission of energy generated by excited CO_2 molecules. *It is found in abundance in hydrocarbon fires.*

Therefore, because it is by far the dominant feature of the emission spectra for hydrocarbon fires, it is an ideal spectral area for fire detection.

Unresponsive to most extraneous light sources. The FIRE Detector is highly sensitive to radiant energy in the CO_2 spike. Special optical filters in the detector's housing discriminate against radiant energy from other light sources. As a result, the FIRE Detector is designed to minimize triggering by lightning, welding flashes, and sunlight. In addition, it is designed to ignore such artificial light sources as sodium vapor, fluorescent, and incandescent fixtures.

With its many safeguards, the FIRE Detector can be used in many environments, indoors and outdoors.



90° Cone of Vision

The FIRE Detector has a nominal 90° cone of vision. Sensitivity at 45°±2° of zero axis is approximately 70% of sensitivity at zero axis, as illustrated.

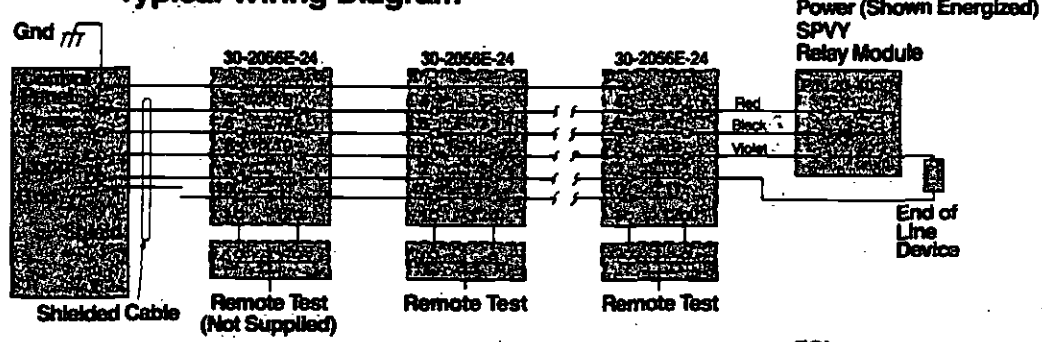
Product description and theory of operation.
The detector assembly is a compact, unitized package containing the detection cell, solid state electronics, and a 12-position terminal block with a dry contact form C (SPDT) alarm relay assembly.

The detection cell is a broadband pyroelectric cell with an integral filter window, which restricts incoming light to the wavelength band of 4.1 to 4.7 microns (the CO_2 spike). The detection cell responds to this energy by producing a proportional voltage signal to the electronic circuitry.

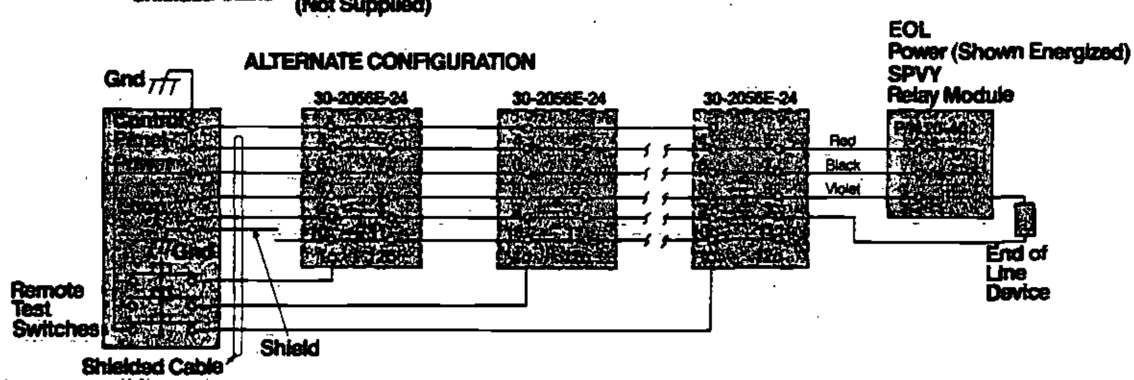
This circuitry has dual channels. The first, for flicker response, ignores spurious light sources such as lightning and welding, which permits the detector to minimize false alarms. The flicker rate and count are factory-set at levels simulating a hydrocarbon fire (three flickers within 3 to 6 seconds). A flicker rate which exceeds a preset alarm threshold will energize the alarm relay.

The second channel is for large signal response. A flash of gasoline fire one square foot 10 feet away will trigger this channel to energize the relay in less than 75 milliseconds at zero degrees axis to the detector.

Typical Wiring Diagram



ALTERNATE CONFIGURATION



Engineering Specifications

The flame detector shall be an infrared sensing device designed to operate on 24 VDC. It shall be explosion proof and weatherproof to meet NEC standards for Class 1, Group A, B, C, D and Class 2, Group E, F and G. It shall be compatible with standard fire alarm systems and shall include a Form C alarm contact.

The detector shall respond to a 12 inch square gasoline fire at a distance of 35 feet in less than six seconds when viewed head-on. It shall respond to a 12 inch square gasoline fire at 10 feet in less than 75 milliseconds.

The detector shall not respond to normal ambient light conditions such as sunlight, incandescent and fluorescent lighting, and it shall not respond to arc welding or lightning.

The detector shall have an integral test feature capable of remote switching. The test radiation source shall be external to the lens of the detector.

The peak sensitivity of the detector shall be at a wavelength of 4.3 microns. The detector shall incorporate a flicker channel as a discrimination against unwanted alarms due to spurious signals.

SPECIFICATIONS

Electrical

Operating Voltage Range = 18.0–30 VDC *Filtered*
Max Ripple =
0.5 Vpp/60 Hz–120 Hz
Stand By Current = 16 mA
Alarm Current = 30 mA Max
Relay Contact Rating = 1.0A at 26 VDC
(Form C)

Spectral Sensitivity Range = 4.1 to 4.7 micron typical

Sensitivity
(Detector sensitivity
is factory set)

Response time to a = 6 Sec Max at 35 Ft.*
one square foot pan
of gasoline fire = 75 m. Sec Max at 10 Ft.*
*At zero axis to the detector

Dimensions

Diameter = 5.00"
Height = 4.38"
Weight = 3.0 lbs.

Cone of Vision

Nominal Cone of Vision = 90°
Sensitivity of 45 ± 2° of zero axis = 70%

Temperature

Operating = −20°C to +70°C
Storage = −25°C to +85°C

Mechanical Enclosure

Explosion proof and water-tight, corrosion resistant, hard anodized aluminum 6061T6 (standard), 304 stainless steel (optional)
Explosion-Proof: Class I, Div. 1, Group A, B, C, D
Class II, Div. 1, Group E, F, G.
Water-Tight: NEMA 4
Conduit fitting ¾" NPT (Female)
Optional housing with metric threads also available

Shock And Vibration:

Shock: 10G
Vibration .02 in. at 10–30 Hz.

Note 1: Specifications are subject to change without notice. Please contact factory to verify.

Note 2: Provide ¾" conduit to the mounting point of the detector. Conduit must be grounded. All cables to the detectors must be shielded and the shield grounded.

Pyrotector, Inc.

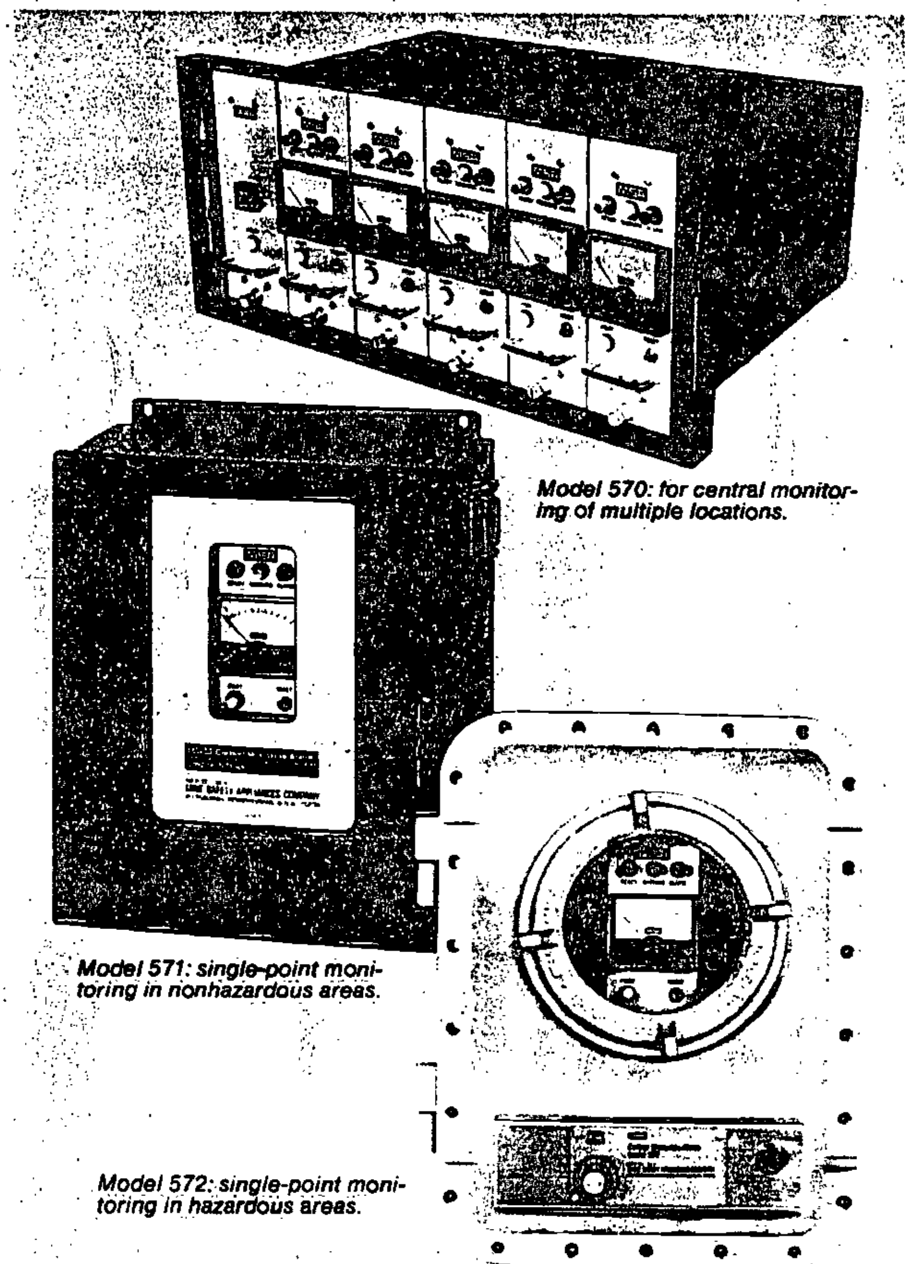
Subsidiary of Grinnell Fire Protection Systems Company, Inc.

333 Lincoln Street, Hingham, MA 02043 Tel. (617) 749-3466

PRINTED IN U.S.A. 2/83

MSA
INSTRUMENTS

Carbon Monoxide Detection System, Series 570



Model 570: for central monitoring of multiple locations.

Model 571: single-point monitoring in nonhazardous areas.

Model 572: single-point monitoring in hazardous areas.

Application

The MSA® Series 570 Carbon Monoxide Detector is a remote sensing system that continuously monitors ambient air for carbon monoxide. The detector will actuate an alarm if the concentration of carbon monoxide exceeds pre-set limits. The user can set alarms at two different concentrations: a low-level alarm for potential hazards and a high-level alarm for immediate hazards. The alarms can be used to control ventilation equipment, automatic shutdown circuits, and similar devices.

Typical applications include industrial plants, garages, vaults, blast and open hearth furnace areas, test cells, mines, and other areas where carbon monoxide may be present due to combustion of gases, operation of internal combustion engines, chemical/metallurgical processing, and other causes.

The Series 570 System is available in three models: 570, for central monitoring of multiple locations; 571 (described on Page 3), for single-location monitoring; and 572 (described on Page 3), an explosionproof system for monitoring a single location.

Description

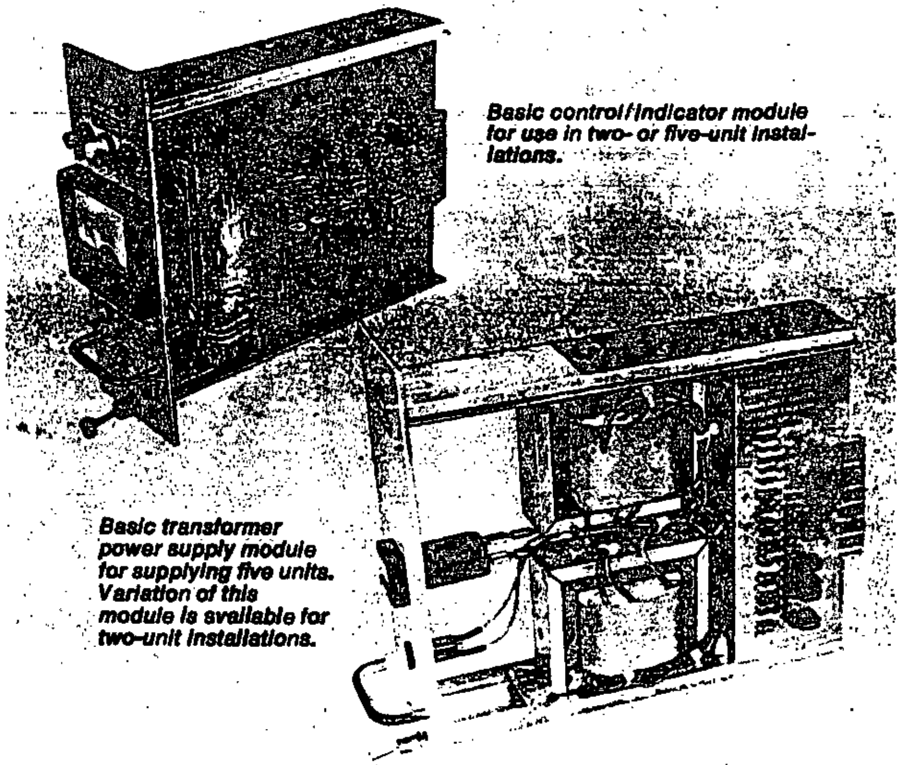
The Series 570 Carbon Monoxide Detector consists of four basic components: a remote sensor; a centrally mounted control/indicating module; a transformer module, and a metal housing to contain the control and transformer modules. The Series 570 can be used for single-point or multipoint sensing. Several control modules can be mounted side by side in a single housing, and one transformer unit can supply several control modules. The Series 570 Carbon Monoxide Detector can be wall, rack, or panel mounted, alone or in combination with other Series 500 Remote Sensing Systems.

The remote sensor contains an electronic interface and an electrochemical polarographic cell. Air samples diffuse through a gas-porous membrane and a sintered metal disc and enter a sample area within the cell. The cell electro-oxidizes CO to CO_2 in proportion to the partial pressure of CO within the sample. The oxidation generates an electrochemical signal that is proportional to the concentration of CO in the ambient air. Because the sensor is completely enclosed in a metal housing, it is shielded from radio frequency radiation, such as from "walkie-talkie" radios, etc.

The control/indicating module amplifies the electrochemical output of the remote sensor to drive an analog meter. Two meter ranges are available: 0-100 or 0-500 ppm CO in air. If the carbon monoxide concentration exceeds the user-programmed limits, the control module will activate built-in warning or high-level alarms.

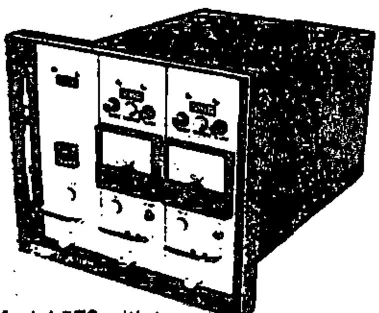
Model 570

The 570 Analyzers are tamper resistant, with all critical controls placed inside. A malfunction light and relay are deactivated in the event of lost power, severed or shorted cable. Alarm and warning relays may be programmed to be either latching or nonlatching. Short-circuit protection is built in. All units run on ac or external battery power, and they automatically switch to battery if line power is lost. The control housing and modules are designed for installation in nonhazardous areas.

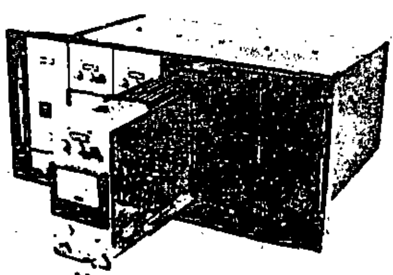


Basic control/indicator module for use in two- or five-unit installations.

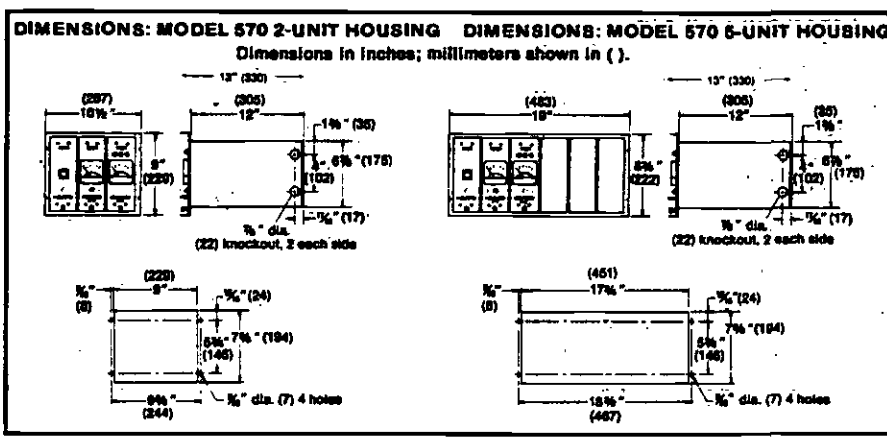
Basic transformer power supply module for supplying five units. Variation of this module is available for two-unit installations.

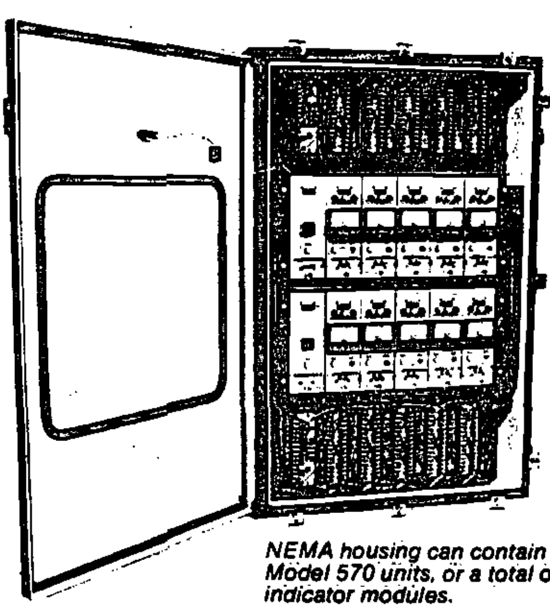


Model 570 with two control/indicating modules and transformer for monitoring two locations.

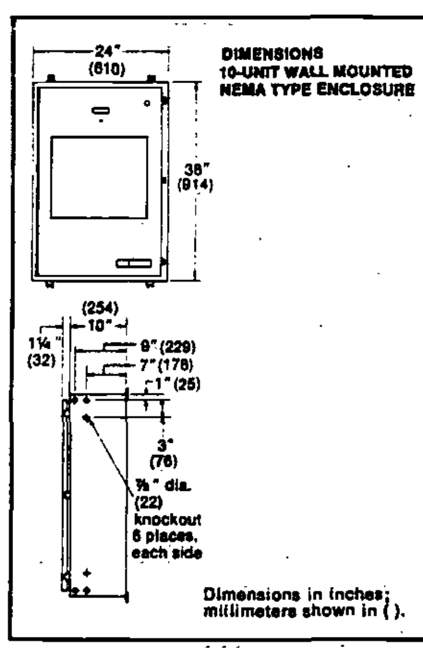


Model 570 five-unit cabinet. Modules are easily inserted or withdrawn for servicing.





NEMA housing can contain two five-module Model 570 units, or a total of 10 control/indicator modules.



Model 571

The Model 571 is a version of the Model 570 (described earlier) intended for quick, simple installation in a non-hazardous area. Performance and operating characteristics are the same as the Model 570. It is, except for remote sensing head, entirely self contained within a sturdy metal case. A front window in the swing-open, front-latchable door allows visual inspection of the indicator panel. The exposed reset button can be operated from outside the case. An "SR" version, which operates on 19 to 60 volts dc standby (instead of the standard model's 11 to 15 volts dc standby), is also available. Dimensions and mounting profiles are illustrated below.

Model 572

The Model 572 is the same as the Model 571 described above except that it is designed and built as a fully explosionproof Class I, Group D, Division 1 instrument for single-point monitoring. As such, it is enclosed in a rugged, bolt-closed aluminum casing. The Model 572 sensing head assembly can be located remotely or mounted adjacent to the case. An "SR" version, which operates on 19 to 60 volts dc standby (instead of the standard model's 11 to 15 volts dc standby), is also available.

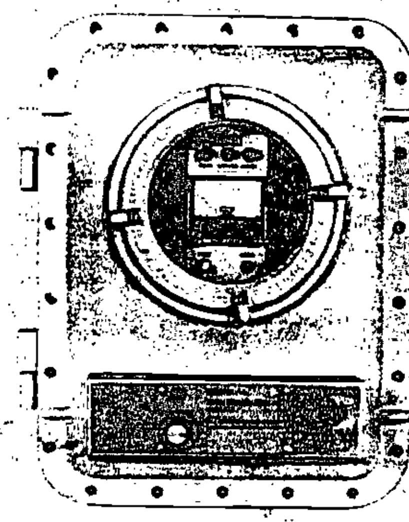
All models

The MSA Series 570 CO Detector samples the atmosphere by diffusion—pumps are not required.

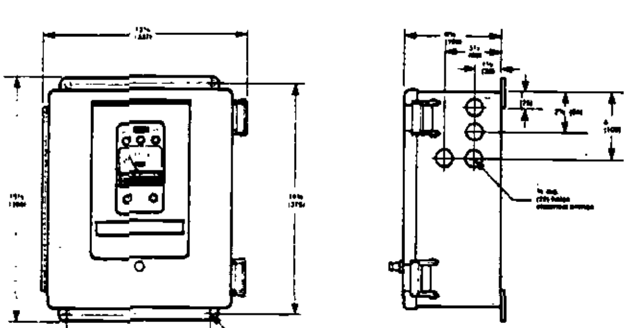
The sensors are designed for either general-purpose areas or to meet the requirements of explosionproof Class I, Groups C and D, Division 1 areas as specified by the National Electrical Code.

The Series 570 System is tamper resistant, with all critical controls placed inside the control module. An integral malfunction relay is automatically deactivated in the event of loss of power, a severed cable, or a failed circuit. The unit features an automatic time-delay circuit for start-up and the electronics have noise and voltage spike protection. The Series 570's alarm and warning relays may be programmed to be either latching or nonlatching as desired. Short circuit protection is built in, and the unit operates on ac or external battery power, automatically switching to battery power if line voltage is lost. An output connection enables the Series 570 to interface with external analog and recording devices. The remote sensor may be mounted up to 5,000 feet from the control module.

Model 571 single-point monitor

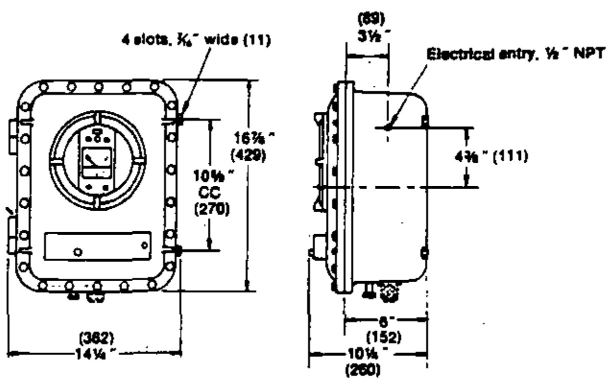


Model 572 explosionproof monitor



Dimensions in inches; millimeters shown in ( ).

DIMENSIONS: MODEL 571



Dimensions in inches; millimeters shown in ( ).

DIMENSIONS: MODEL 572

Specifications

Performance

Sensor type: Electrochemical polarographic cell

Zero drift: 1% of full scale in 24 hours

Span drift: 1% of full scale in 24 hours

Response time: 90% final reading in 90 seconds

Noise level: 1%

Range: 0-100 ppm or 0-500 ppm CO

Repeatability: ± 1%

Sensor life: 12 months

Linearity: ±2%

Operating

Power requirements: 115 volts, 80 VA, 50/60 Hz; 11-15 or 19-60 volts dc (220 Vac with auxiliary transformer)

Sensor cable requirements: 4-conductor, 14 ohms closed loop, maximum resistance (16-22 AWG)

Analog signal: 0-1 Vdc (each channel), 1 mA max

Sensor compensated temperature: 32° to 122°F (0° to 50°C)

Sensor operating temperature: 14° to 122°F (-10° to 50°C)

Sensor warm-up: 5 hours new sensor, ½ hour after usage

Control module operating temperature: 0° to 130°F (-18° to 54°C)

Relays: 3 (Trouble, Warning, Alarm) S.P.D.T.; 5-amp contacts, resistive load

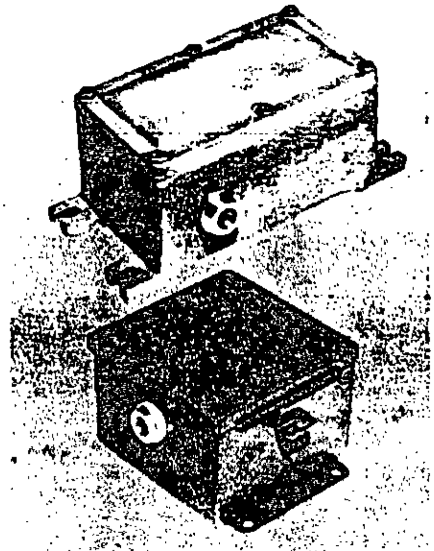
Sensor remote mounting: Up to 5,000 ft

Ordering information

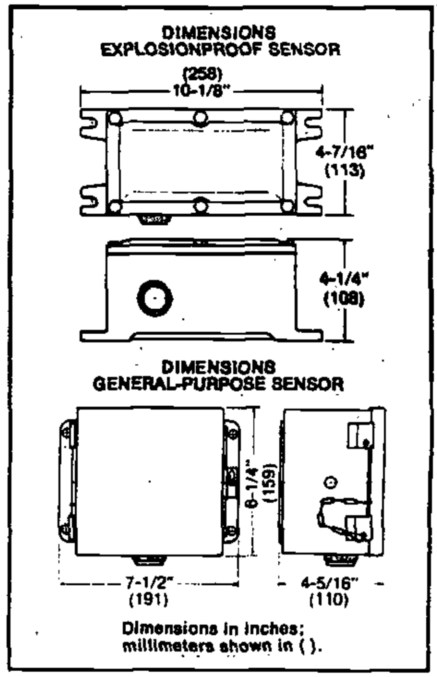
Catalog numbers

Model 570—100 ppm

467056	Control Module
467051	Control Module—570SR/ 19-60 Vdc



Diffusion heads for Series 570 Systems



Model 570—500 ppm

467057	Control Module
467052	Control Module—570SR/ 19-60 Vdc
462364	Transformer Module, 5 units
462379	Transformer Module, 2 units
462385	Housing, 2 units w/tran. module
462360	Housing, 5 units w/tran. module
462497	NEMA housing, 1 to 5 Control Modules
462402	NEMA housing, 1 to 10 Control Modules
462372	Connector assembly for housing
462404	Test fixture

Model 571—100 ppm

467259	Control Unit
467256	Control Unit—571SR/ 19-60 Vdc

Model 571—500 ppm

467260	Control Unit
467257	Control Unit—571SR/ 19-60 Vdc

Model 572—100 ppm

467293	Explosionproof Control Unit
467290	Explosionproof Control Unit—572SR/19-60 Vdc

Model 572—500 ppm

467294	Explosionproof Control Unit
467291	Explosionproof Control Unit—572SR/19-60 Vdc

Sensors and assemblies

467378	Explosionproof Assy. with sensor, 100 ppm
467375	Sensor, 100 ppm
467464	Explosionproof Assy. with sensor, 500 ppm
467375	Sensor, 500 ppm
467381	General-purpose Assy. with sensor, 100 ppm
467465	General-purpose Assy. with sensor, 500 ppm

MSA

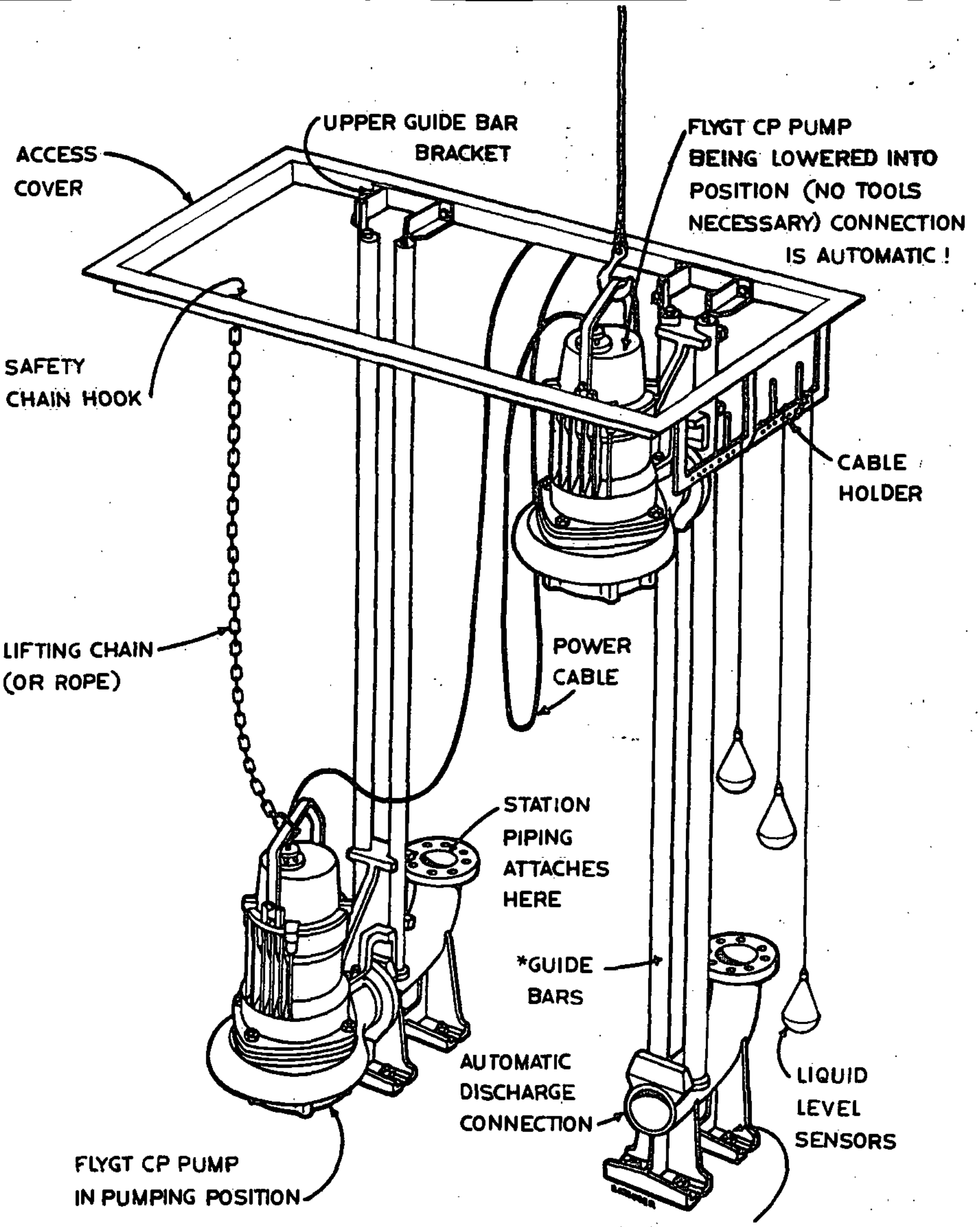
Mine Safety Appliances Company
Instrument Division
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235

Atlanta, Boston, Chicago, Cleveland, Detroit, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, Pittsburgh, San Francisco, St. Louis, **MSA CANADA,** Downsview, Ontario (Metro Toronto)

Printed in U.S.A. 814 (L)

A FLYGT DUPLEX "CP" PUMPING STATION

C	40
SUPERSEDES	ISSUED JAN 75

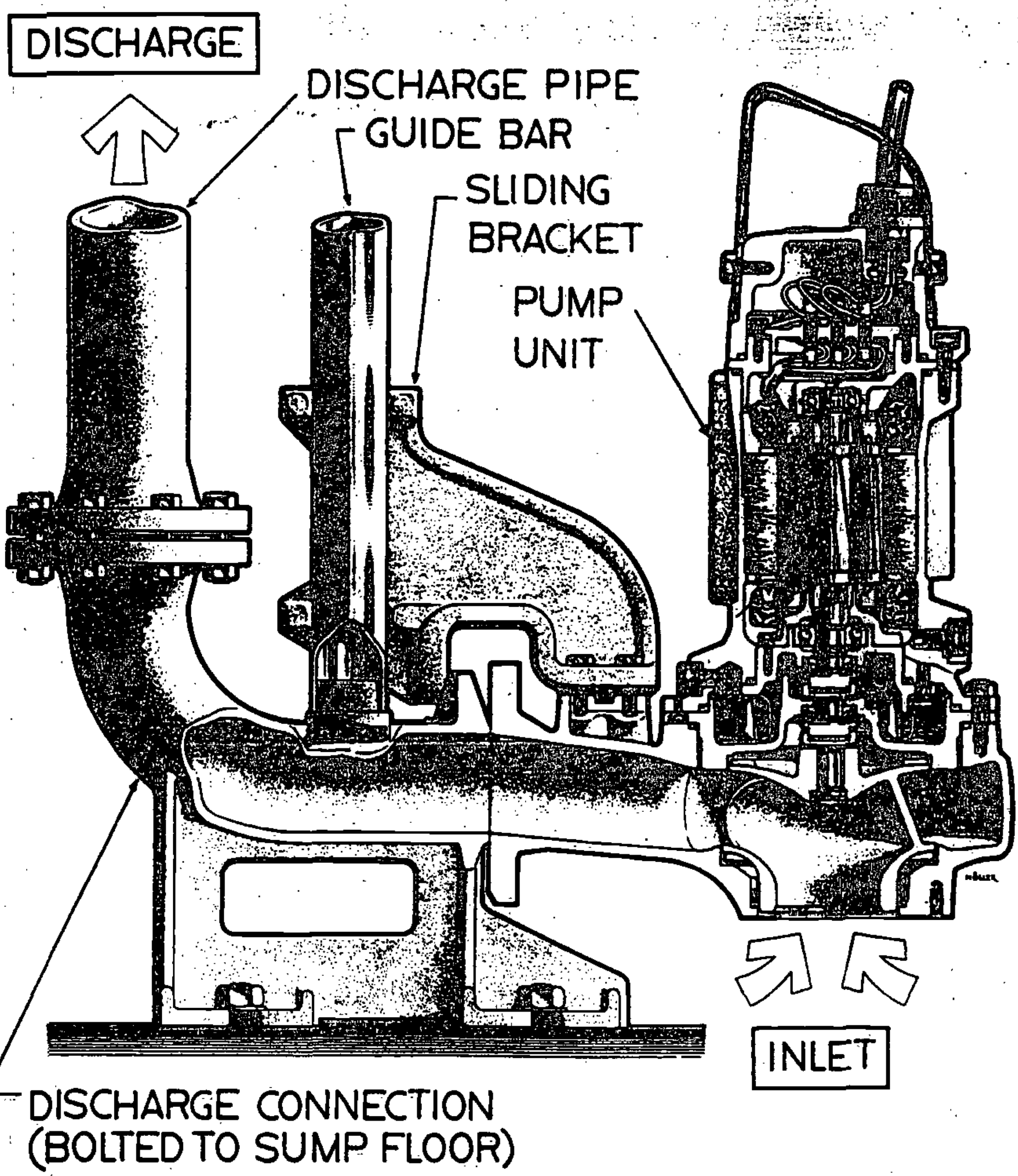


*GUIDE BARS ARE STD PIPE (NOT SUPPLIED)

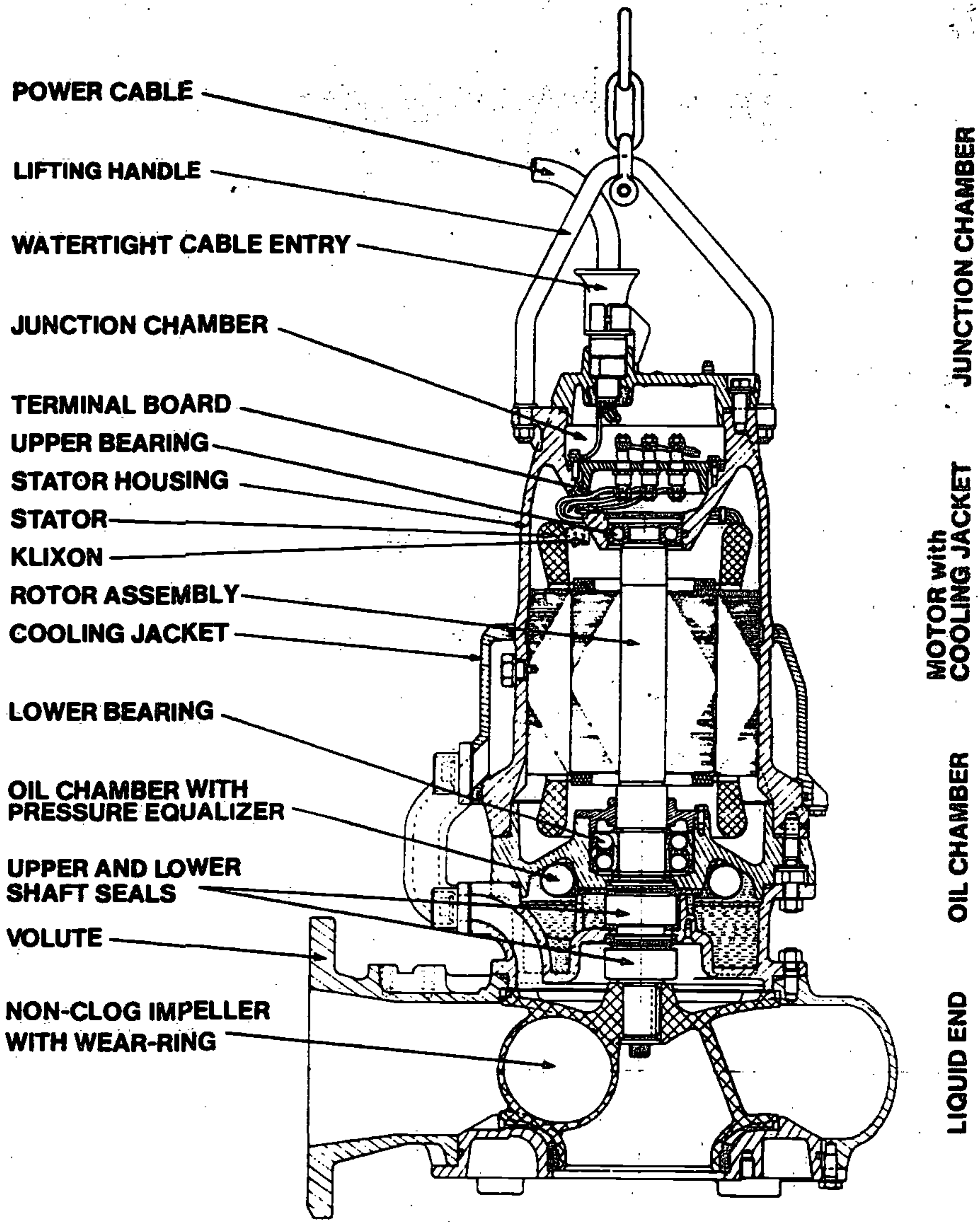
FLYGT CORPORATION
A SUBSIDIARY OF ITT
129 GLOVER AVE., NORWALK, CT. 06856

CP PUMP WITH AUTOMATIC DISCHARGE CONNECTION

C	20
SUPERSEDES	ISSUED JAN 75



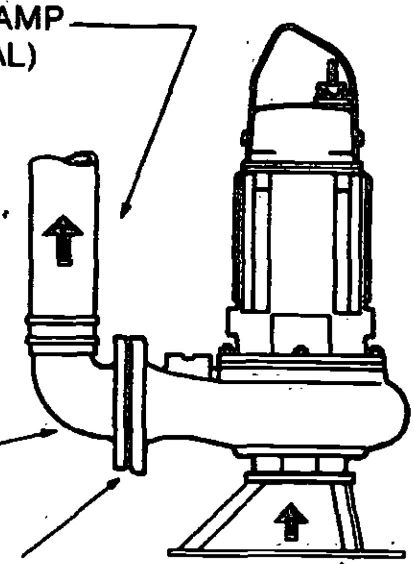
THE FLYGT ELECTRIC SUBMERSIBLE SEWAGE PUMP*



(*MODEL 6"C-3152 PUMP WITH INTERNAL COOLING AND KLIXON PROTECTION IN STATOR WINDING.)

THE "CS" AND "CT" ARRANGEMENTS

THE "CS" ARRANGEMENT



THIS IS A PORTABLE WASTEWATER PUMP INTENDED TO WORK ENTIRELY OR PARTLY SUBMERGED

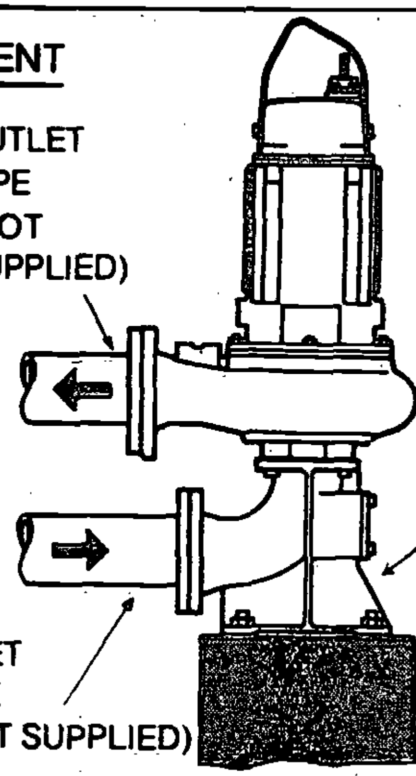
(CS-3101 SHOWN)

THE "CT" ARRANGEMENT

THIS IS A PERMANENTLY INSTALLED WASTEWATER PUMP FOR DRY SUMP INSTALLATION

PROVIDED WITH STANDARD CLASS 125 CAST IRON INLET AND OUTLET FLANGE DRILLING.

PUMP'S WATERTIGHT DESIGN PREVENTS DAMAGE IN THE EVENT OF FLOODING.



(CT-3101 SHOWN)

RECEIVED
DEC 29 1982
KAISER ENGINEERS
LOS ANGELES

December 27, 1982

Kaiser Engineers Corporation
425 S. Main Street
6th Floor
Los Angeles, CA 90013

Attention: Mr. Chuck Costa

Subject: L.A. Metro System
Seismic Monitoring System

Gentlemen:

In response to a recent telephone request from Fitz Consultants, enclosed are copies of operating instructions which describe the various types of seismic alarm systems Kinemetrics has produced for applications similar to the one proposed for the L. A. Metro System. Also enclosed is literature describing our complete earthquake engineering product line, systems capabilities, and support services.

If you have any questions regarding the enclosed, or require any additional information, please do not hesitate to call us.

Very truly yours,

R. J. Dielman

R. J. Dielman
Regional Sales Manager

RJD:lap

(Called again — will come
1/19/83 10 AM tomorrow
9 AM) on 20th of Jan.

KINEMETRICS

SEISMOLOGICAL OBSERVATORY INSTRUMENTS

DOMESTIC PRICE LIST

Seismic Triggers

MODEL	PART NO.	DESCRIPTION	PRICE
VS-1	100100	Vertical Seismic Trigger.................	$ 355.00
VS-3	101928	Triaxial Vertical Seismic Trigger	1,420.00
HS-1	100740	Horizontal Seismic Trigger...............	385.00
TS-3	101175	Triaxial Seismic Trigger(without batteries)	1,610.00
TS-3A	101190	Triaxial Seismic Trigger (with batteries, charger)	1,710.00
SP-1	101330	Seismic Switch Test Panel................	850.00
FC-1	100750	Field Calibrator.........................	465.00
EST-2	101835	-Elevator Seismic Trigger with automatic reset....................	495.00
	101349	-Cable, 8 ft., for switch connections....	13.00
		-Cable, if purchased separately..........	60.00
EST-2M	101901	Elevator Seismic Trigger with manual reset.......................	500.00
	101348	-Cable, 8 ft., for switch connections and reset..................................	13.00
		-Cable, if purchased separately..........	60.00
		Spares for EST-2, EST-2M and TS-3A	
		-Spare 6 volt Rechargeable Batteries (set of 2 GC610).......................	40.00
	700084	-Float Charger...........................	27.00

1 October 1982

KINEMETRICS

EARTHQUAK
ENGINEERING
INSTRUMENT

EXPERIENCE

Nuclear Power Plants

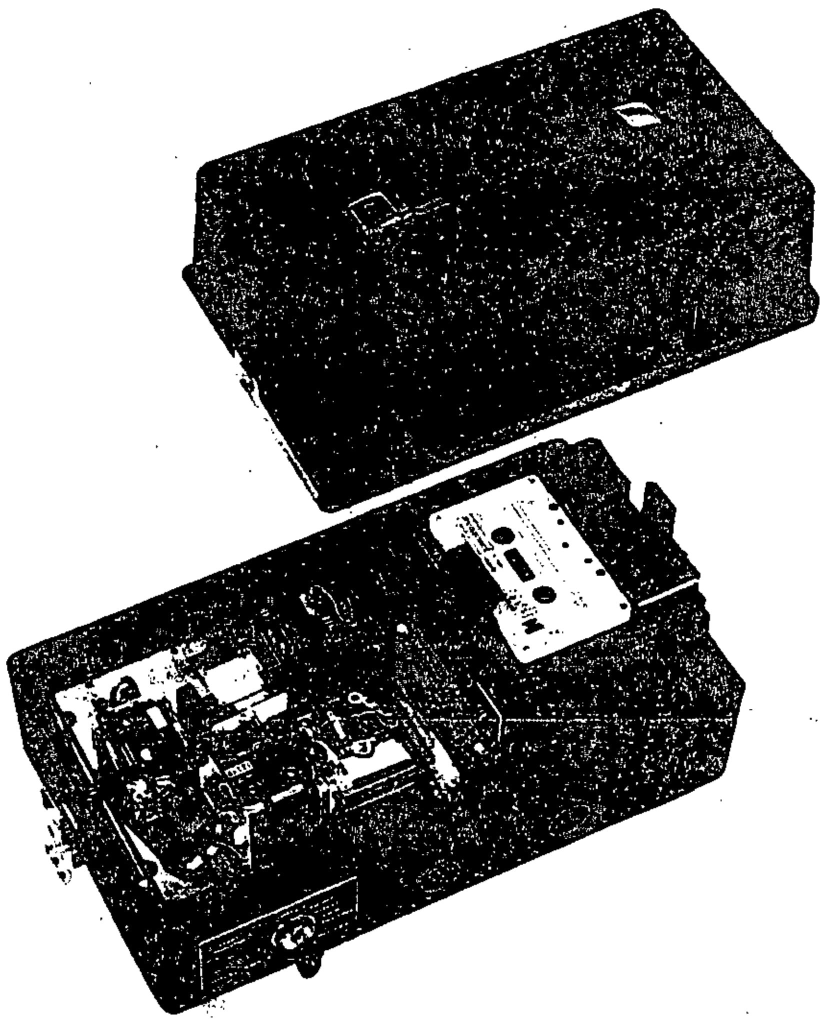
		Plant	Owner	Product	Engineer
	1	Turkey Point 3	Florida Power & Light	SMA-1	Bechtel
	2	Pilgrim 1	Boston Edison	SMA-1	Bechtel
	3	Maine Yankee	Maine Yankee	SMA-1	Stone & Webster
	4	Vermont Yankee	Vermont Yankee	SMA-1	Ebasco
	5	Point Beach 1	Wisconsin/Michigan	SMA-1	Ebasco
	6	Fort St. Vrain	Public Service Colo.	SMA-1	Sargent & Lundy
	7	Storage Facil	Atlantic Richield	SMA-1	
	8	ENEL IV (caorso)	ENEL	SMA-1	D'Appolonia
	9	Ancona	CNEN	SMA-1	CNEN
	10	Tullnerfield 1	GKT, Austria	SMA-1	GKT
1975	11	San Onofre 1	So. Calif. Edison	SMA-3	SCE
	12	Nine Mile Pt. 1	Niagara Mohawk	SMA-3	Niagara-Mohawk
1972	13	Surry 1	Virginia Electric	SMA-3	VEPCo
	14	Brown's Ferry	TVA	SMA-1,2	TVA
1974	15	Calvert Cliffs 1	Baltimore Gas & Electric	SMA-3	Bechtel
1972	16	E.I. Hatch 1	Georgia Power	SMA-3	Bechtel
1973	17	Barnwell Fuel Re-processing Plant	Allied Gulf	SMA-3	Bechtel
1972	18	J.A. Fitzpatrick	PASNY	SMA-3	Stone & Webster
1974	19	D.C. Cook 1	Indiana & Michigan	SMA-3	AEPSC
1972	20	Brunswick 1	Carolina P&L	SMA-3	United Engrs.
1972	21	Brunswick 2	Carolina P&L	SMA-3	United Engrs.
1973	22	Millstone 2	Northeast Utilities	SMA-3	Bechtel
1972	23	Cooper Station	Nebraska Public Power	SMA-3	Burns & Roe
1973	24	Fort Calhoun 1	Omaha Public Power	SMA-3	Gibbs & Hill
1973	25	Chin Shan 1	Taiwan Power Co.	SMA-2,3	Ebasco
1973	26	Three Mile Island	Metropolitan Edison	SMA-3	Gilbert Assoc.
1974	27	Salem 1	Public Service New Jersey	SMA-3	PSE&G
1974	28	J.M. Farley 1	Alabama Power	SMA-2,3	Bechtel
	29	Duane Arnold	Iowa Electric	SMA-2	Bechtel
1974	30	Sequoyah	TVA	SMA-2,3	TVA

31 Three Mile Isl 2	Gen. Public Utilities	SMA-3	Burns & Roe
32 Indian Point 3	Con Edison	SMA-2	Con Edison
33 Crystal River 3	Florida Power Corp.	SMA-3	Gilbert Assoc.
34 Diablo Canyon	Pacific Gas & Electric	SMA-3	PG&E
35 Biblis A	Rheinisch-Westfalisches	SMA-3	Kraftwerk Union
36 Oconee	Duke Power Company	SMA-3	Duke Power
37 St. Lucie	Florida Power & Light	SMA-3	Ebasco
38 North Anna 1,2	Virginia Electric Power	SMA-3	Stone & Webster
39 Angra 1	Furnas (Brazil)	SMA-3	Westinghouse
40 Fessenheim 1	Electricité de France	SMA-3	EdF
41 Philippsburg 1	KKP	SMA-3	Kraftwerk Union
42 San Onofre 2,3	So. Calif. Edison	SMA-3	Bechtel
43 Grand Gulf	Middle South Energy	SMA-3	Bechtel
44 Almaraz	Central Nuc. de Almaraz	SMA-3	Agrupacion
45 Shippingport	Bettis Atomic Power Lab.	TS-3	Westinghouse
46 Zimmer	Cincinnati Gas & Elec.	SMA-3	Sargent & Lundy
47 WNP-2	Washington Public Power	SMA-3	Burns & Roe
48 Neckar	GKN (Germany)	SMA-3	Kraftwerk Union
49 McGuire	Duke Power	SMA-3	Duke Power
50 Karlsruhe	Kernf. Karlruhe	SMA-3	Siemens
51 WNP-2	Washington Public Power	SMA-3	United Engrs.
52 Tokai 2	Japan Atomic Power Co.	SMA-1	Ebasco
53 Lemoniz 1	C.N. Lemoniz	SMA-3	Iberduerco
54 Lemoniz 2	C.N. Lemoniz	SMA-3	Iberduerco
55 Kousheng	Taiwan Power Company	SMA-3	Bechtel
56 WNP-4	Washington Public Power	SMA-3	United Engrs.
57 Ko-Ri	Korea Electric Company	TS-3A	Gilbert Assoc.
58 Biblis B	Rheinisch-Westfalisches	SMA-3	Kraftwerk Union
59 Watts Bar	TVA	SMA-3	TVA
60 Caorso	ENEL	SMA-3	ENEL
61 V.C. Summer	South Carolina	DSA-3	Gilbert Assoc/
62 Catawba	Duke Power Company	SMA-3	Duke Power
63 River Bend 1,2	Gulf States	SMA-3	Stone & Webster
64 Perry	Cleveland Electric	SMA-3	Gilbert Assoc.
65 Limerick	Philadelphia Electric	SMA-3	Bechtel
66 Iran 1	A.E.O. of Iran	SMA-3	Kraftwerk Union
67 Hope Creek	Public Service New Jersey	SMA-3	Bechtel
68 Waterford	Louisiana Power	SMA-3	Ebasco
69 Shoreham	Long Island Lighting	SMA-3	Stone & Webster
70 Bellefonte	TVA	SMA-3	TVA
71 Comanche Peak	Texas Utilities	SMA-3	Gibbs & Hill
72 ASCO-1	FESCA	SMA-3	Initec
73 ASCO-2	Assn. ASCO-II	SMA-3	Initec
74 Hartsville	TVA	SMA-3	TVA
75 Phipps Bend	TVA	SMA-3	TVA

SMA-2

Strong Motion Accelerograph

~ $5000.00



The SMA-2 Strong Motion Accelerograph provides a practical and reliable means of obtaining ground motion and structural response data on strong local earthquakes. Typically, the SMA-2 remains on standby until an earthquake occurs, and then actuates to full operation within 100 milliseconds. Since the SMA-2 records on magnetic tape, rapid and accurate electronic digitization and conversion to computer-compatible tape is possible using the Kinemetrics SMP-1 Tape Playback and DDS-1105 Digital Data Acquisition System.

The recording system offers FM modulation on a four-track magnetic tape cassette. A feature of interest in the SMA-2 is the single "record" head, preventing any possibility of erasing or rerecording. Thus, the all-important earthquake record cannot be lost unless deliberately erased by means other than those built into the SMA-2.

GENERAL DESCRIPTION

The SMA-2 Strong Motion Accelerograph is the magnetic tape version of the popular Kinemetrics SMA-1 photographic recording Strong Motion Accelerograph. Although similar in function and almost identical in external appearance to the SMA-1, the use of magnetic tape recording in the SMA-2 facilitates data processing by digital computer, and electronic analog-digital equipment such as the SMP-1 and DDS-1105 can be employed.

The tape deck is of Kinemetrics design and incorporates the important features of rapid start-up (less than 100 milliseconds) and ultra-reliable operation. Three tape tracks are used to record the triaxial acceleration data with a separate track for each axis. The fourth track records the 1024 Hz signal generated by the timing oscillator within the SMA-2; that signal is then used by the SMP Playback System for tape speed compensation and for timing marks (2 Hz). The VCO for each accelerometer, and the timing oscillator/voltage regulator are contained on pull-out printed circuit boards accessible below the tape deck.

The triaxial accelerometers are of the force-balance type with a natural frequency of 50 Hz. Simultaneous calibration of all three accelerometers is accomplished with a single key switch which provides a record of natural frequency and damping of each accelerometer preceding and following each earthquake event (or series of events). The triaxial accelerometers are also available optionally in a separate watertight housing for installation remote from the recorder module. The watertight case of the SMA-2 also houses the seismic trigger(s), which can be either vertical or horizontal (or, as an option, both) and which actuate the SMA-2 when an earthquake occurs. During standby the SMA-2 draws only about 0.15 mA of current which is replaced by the dual 12 Vdc float charger supplied. For remote locations this current can also be supplied by two SG-1 solar cells.

TECHNICAL SPECIFICATIONS

Recording System

Recording Medium
    Magnetic tape instrumentation cassette, 0.150" wide, 1⅞"/sec.

Recording Head
    4 separate tracks (3 acceleration, 1 timing).

Modulation Type
    Frequency modulation.

Center Frequency and Percent Modulation
    1 KHz ±50%.

Timing and Tape Speed Compensation
    1024 Hz ±1% signal on fourth track provides accurate timing, SMP-1 also employs same signal for tape speed compensation.

Bandwidth
    0 to 50 Hz.

Dynamic Range
    46 dB.

Recording Time
    30 minutes maximum.

Start-up Time
    Less than 100 milliseconds.

System Accuracy
    ±5% overall.

Operation Cycle
    Self-actuating for duration of earthquake, with automatic reset.

Controls
    External Function Switch: OFF, OPERATE, TEST, CALIB and NAT. FREQ. Internal Timing Switch: MASTER SLAVE.

Transducers

Type
    Force-balance.

Natural Frequency
    50 Hz.

Range
    1 g full scale (¼, ½ and 2 g, optionally available).

Damping
    70% of critical.

Temperature Effects
    0° to 160°F (−18° to 71°C) ±2% of full-scale input.

Bandwidth
    DC to 50 Hz.

Calibration
    Step function voltage input to 3 channels simultaneously to evaluate natural frequency and damping.

Output
    2.5 volts full scale.

Seismic Trigger and Alarm System

Starter
    Vertical (0.01 g nominal setting).

Event Indication
    Electromagnetic event indicator.

External Event Alarm
    12 Vdc to actuate external alarm through external connector.

Power Requirements

Power Consumption
    Approximately 0.15 mA standby; 0.5A recording.

Battery Capacity
    Four 6-volt, 1 AH internal batteries provide minimum 1 hour recording time fully charged.

Battery Charging
    Float charger (110/220 Vac to ±12 Vdc) supplied.

PHYSICAL CHARACTERISTICS

Mounting
    Single tie-down bolt (¼-20).

Housing
    8" x 8" x 14" (20.3 x 20.3 x 35.6 cm), 25 pounds (11.4 kg.) net weight, 30 pounds (14 kg) shipping weight. cast aluminum watertight case. Desiccant provided for high humidity applications.

Operating Temperature
    30° to 130°F (0° to 55°C).

Humidity
    100% (watertight).

Interconnection
    External connector for linking two or more SMA-2 accelerographs for common starting and timing.

OPTIONS

1. Seismic trigger: horizontal, or horizontal and vertical inside case of SMA-2.
2. Charger for locations with no AC power (Model SG-1 Solar Cell, 2 required).
3. Remote accelerometer: cast aluminum weathertight triaxial accelerometer package for use up to 1000 feet (300 m) from recorder, using mating connector on SMA-2 housing.

RECOMMENDED ACCESSORIES

SMP-1
    Magnetic Tape Playback System provides visual strip chart recording of SMA-2 data and FM or demodulated outputs.

DDS-1105
    Digital Data Acquisition System provides computer compatible tape from SMP-1.

ORDERING INFORMATION

1. Specify sensitivity: 1 g, ½ g, ¼ g or 2 g.
2. Specify desired options or accessories.

EARTHQUAKE ENGINEERING INSTRUMENTS

KINEMETRICS

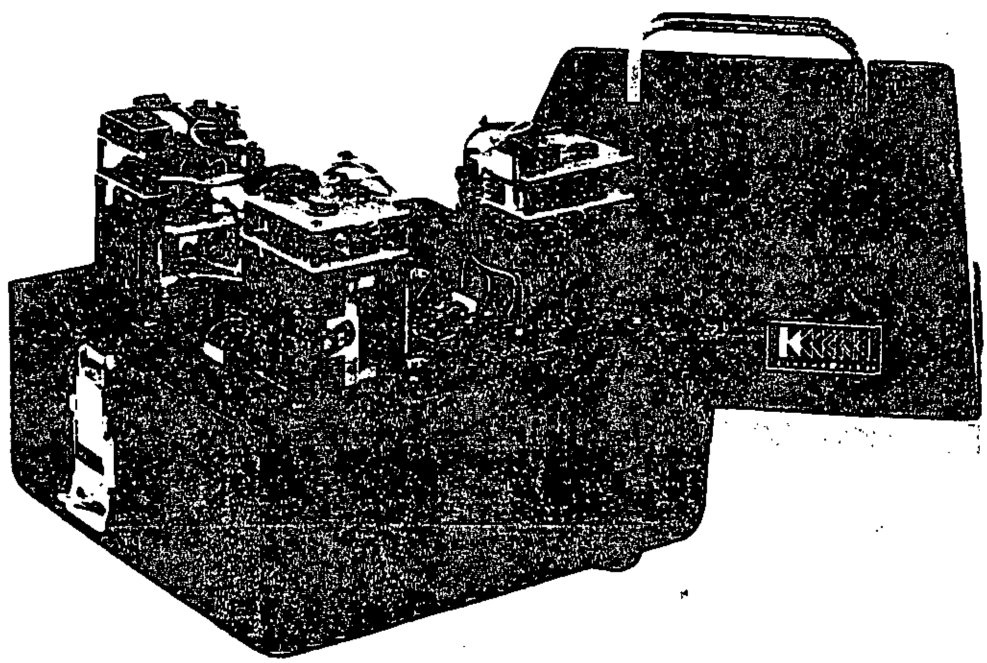
W/O Battery   W/Battery

TS-3/TS-3A

Seismic Trigger

(Supplied to BART)

$1200



The TS-3/TS-3A Seismic Trigger (also available as a seismic switch) is a triaxial version of the very successful vertical seismic trigger used in over 4,000 Kinemetrics strong motion accelerographs throughout the world. The TS-3 is used with a remote 12 Vdc power supply, while the TS-3A carries its own internal 12 Vdc rechargeable battery. Typical applications include nuclear power plants, oil or gas pipe lines, offshore oil platforms or similar applications where reliability and field-adjustable triggering levels are essential.

GENERAL DESCRIPTION

The TS-3/TS-3A consists of orthogonal acceleration transducers which are individually adjustable and are mounted in a rugged, watertight housing. As a triaxial seismic trigger for centrally-located accelerographs (SMA-3, DSA-3 or CRA-1), external starter (for the SMA-1, DSA-1 or SMA-2) or for low-level alarms, the set point of the TS-3/TS-3A is adjustable from 0.005 g to 0.05 g. As a seismic switch for remote alarms (for nuclear plant annunciation) the TS-3/TS-3A set point is adjustable from 0.025 g to 0.25 g. The detectors for the unit are small moving coils of 4 Hz natural frequency, and the seismic trigger version includes a filter which limits the flat response to the 1 Hz-10 Hz band. Energy outside this band is attenuated to preclude trigger response to non-earthquake events such as rotating equipment, blasts, vehicles and industrial vibrations.

When seismic energy exceeds the set point on any axis, a relay in the TS-3/TS-3A housing closes, remains closed from 6 to 20 seconds (adjustable) beyond the last acceleration and then resets automatically. On the TS-3, an MS connector on the housing links a remote 12 Vdc power supply and the user's remote accelerograph or alarm on the TS-3. On the TS-3A, the power supply is an internal rechargeable battery. The components of the TS-3 can withstand up to 1×10^7 rads radiation. The set points in either unit may be tested or adjusted in the field with the FC-1 Field Calibrator (see Accessories).

TECHNICAL SPECIFICATIONS

Natural Frequency
4 Hz.

Actuating Acceleration
0.005 g to 0.05 g, field adjustable with FC-1; optional range 0.025 g to 0.25 g.

Damping
1.5 critical, provides flat response between 1 Hz and 10 Hz (optional damping 3.5 critical used for 0.025 g to 0.25 g range to provide flat response between 0.5 Hz and 15 Hz.)

Output
Switch closure SPST contact rating 10 watts dc, 12 Vac, 0.5 amp. maximum.

Closure Timing
On actuation the relay contacts close and stay closed for 6 to 20 seconds (adjustable) after motion falls below preset displacement threshold.

Current Drain
0.45 mA standby, 60 mA operating from 12 Vdc.

PHYSICAL CHARACTERISTICS

Dimensions
8" x 8" x 8" (20.3 cm x 20.3 cm x 20.3 cm).

Weight
14 pounds (6.3 kg).

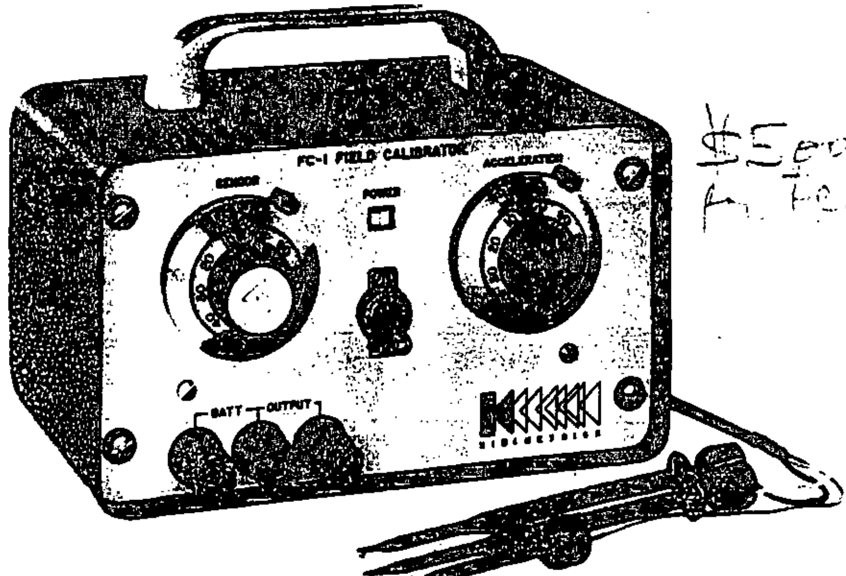
Operating Temperature
0° to 130°F (20°C to 55°C).

RECOMMENDED ACCESSORIES

1. FC-1 Field Calibrator, designed to adjust electromagnetic triggers to the desired actuation acceleration; powered by internal batteries.
2. SP-1 Seismic Switch Power Supply for use with TS-3 (SP-1 data sheet available).

ORDERING INFORMATION

1. Specify actuating acceleration.



FC1 Field Calibrator

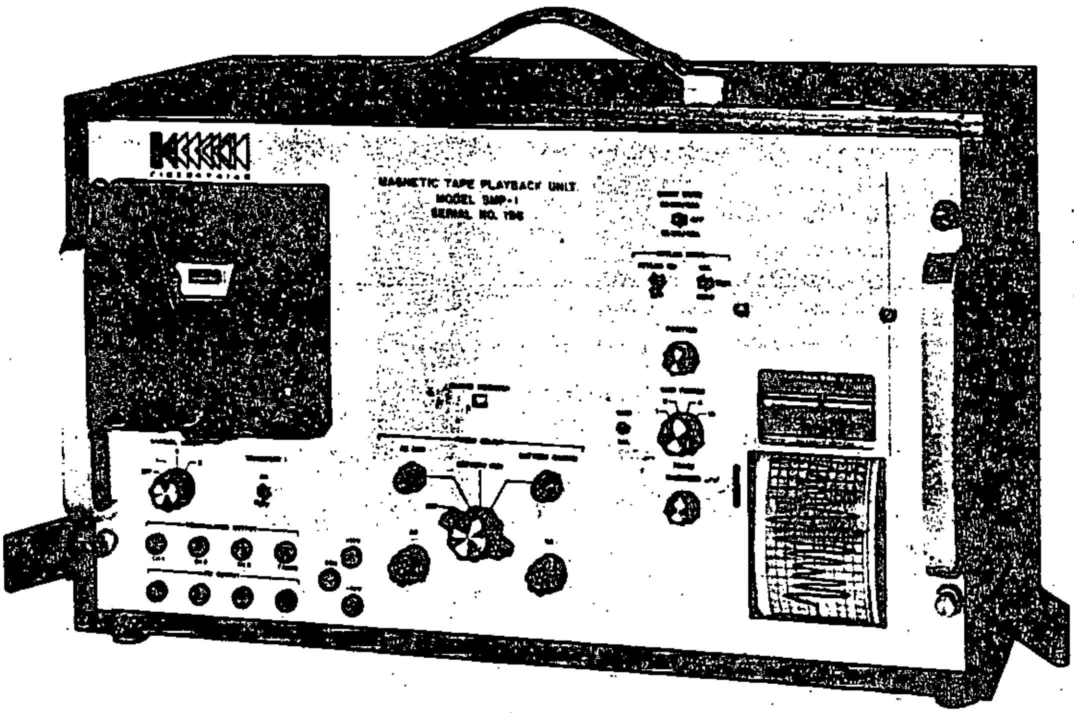
KINEMETRICS INC., TWO TWENTY TWO VISTA AVENUE, PASADENA, CA. 91107 (213) 795-2220 - TELEX 67-5402 KMETRICS PSD

EARTHQUAKE ENGINEERING INSTRUMENTS

SMP-1

Magnetic Tape Playback System

~$6000.00



The SMP-1 is a versatile magnetic tape playback system designed for use with the Kinemetrics SMA-2 and SMA-3 Magnetic Tape Acceleration Systems. The combination of the SMA-2 or SMA-3 Acceleration Systems with the SMP-1 Magnetic Tape Playback System meets the applicable requirements of US NRC Regulatory Guide 1.12, and provides immediate visual playback capability of recorded acceleration data.

The SMP-1 is portable and may be operated either from 110 Vac or internal rechargeable batteries. Optionally the unit may be mounted in a standard 19-inch cabinet. An internal battery charger is included with the unit.

GENERAL DESCRIPTION

The SMP-1 is used exclusively with the SMA-2 and SMA-3 cassette recorders. It will play back four channels of information recorded on a cassette: 3 signal channels and 1 timing channel. An immediate analog record of any one signal channel, with timing marks included, is available on the built-in strip chart recorder. Also, the 4 channels are available simultaneously for use with appropriate digitizing equipment, either as analog or frequency-modulated outputs.

The playback system consists of a tape transport, a 4-track cassette head, 4 preamplifiers, 4 pulse averaging demodulators, a chart recorder, a power supply and various operating controls.

Tape speed compensation is used with the chart recorder to reduce effects of tape speed variations. Timing marks are provided by dividing the 1024 Hz timing signal frequency to 2 Hz. The tape transport uses three DC motors for capstan drive, fast forward and rewind functions.

TECHNICAL SPECIFICATIONS

System

Demodulator
  Pulse averaging type.
Output Filter
  Third order lowpass, cutoff frequency 50 Hz (3 dB)
Dynamic Range
  40 dB (60° to 90°F); 35 dB (30° to 130°F)
Accuracy
  ±1% of full scale (playback system only); ±5% of full scale (with SMA-2 or SMA-3) changing linearly to ±1.5% of full scale at zero input.

Strip Chart Recorder

Channels
  One signal (selectable); one timing (2 marks per second)
Gain
  ±0.25, ±0.625, ±1.25 or ±2.5V full scale
Paper Speed
  25 or 50 mm/second
Frequency Response
  DC to 50 Hz (—3 dB) for stylus excursions to ±10mm

System Controls

Power Select
  Off, AC, Battery, Battery Charge
Tape Transport
  On-Off, Forward-Rewind
Recorder Channel Select
  Off, 1, 2 or 3
Chart Drive
  Off, 25 or 50 mm/second
Stylus Drive
  On-Off, Calibrate-Run-Zero
Stylus Position
  Adjustable
Recorder Gain Factor
  1, 2, 4 or 10 (with gain calibration potentiometer)
Trace Darkness
  Variable

PHYSICAL CHARACTERISTICS

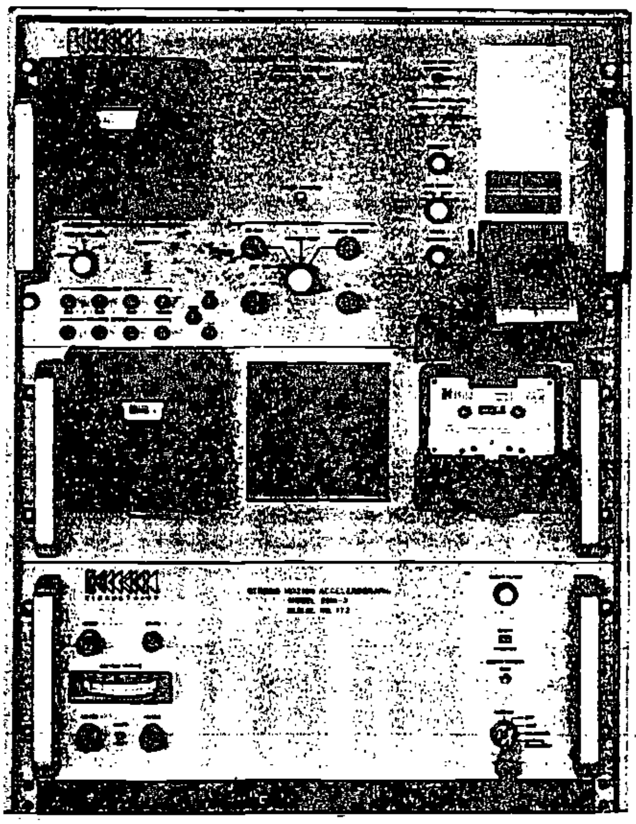
Operating Temperature
  30° to 130°F (0° to 55°C)
Weight
  35 lbs. (16 kg) net, 56 lbs. (26 kg) shipping weight.
Dimensions
  19 x 10½ x 9 in. (48 x 27 x 23 cm)
Power
  110Vac, 60 Hz, or internal rechargeable batteries, switch selectable
Battery Operation Time
  One hour without charging

OPTIONS

1. External, plug-in tape speed compensator for analog channel output jacks.
2. SMP-2; similar to SMP-1 but without chart recorder (110Vac, 50 or 60 Hz power required, no battery operation).

ORDERING INFORMATION

1. Specify whether 220 Vac, 50 Hz or both (110 Vac/60 Hz standard).



SMP-1 Playback Unit shown mounted with SMA-3 record and control panels.

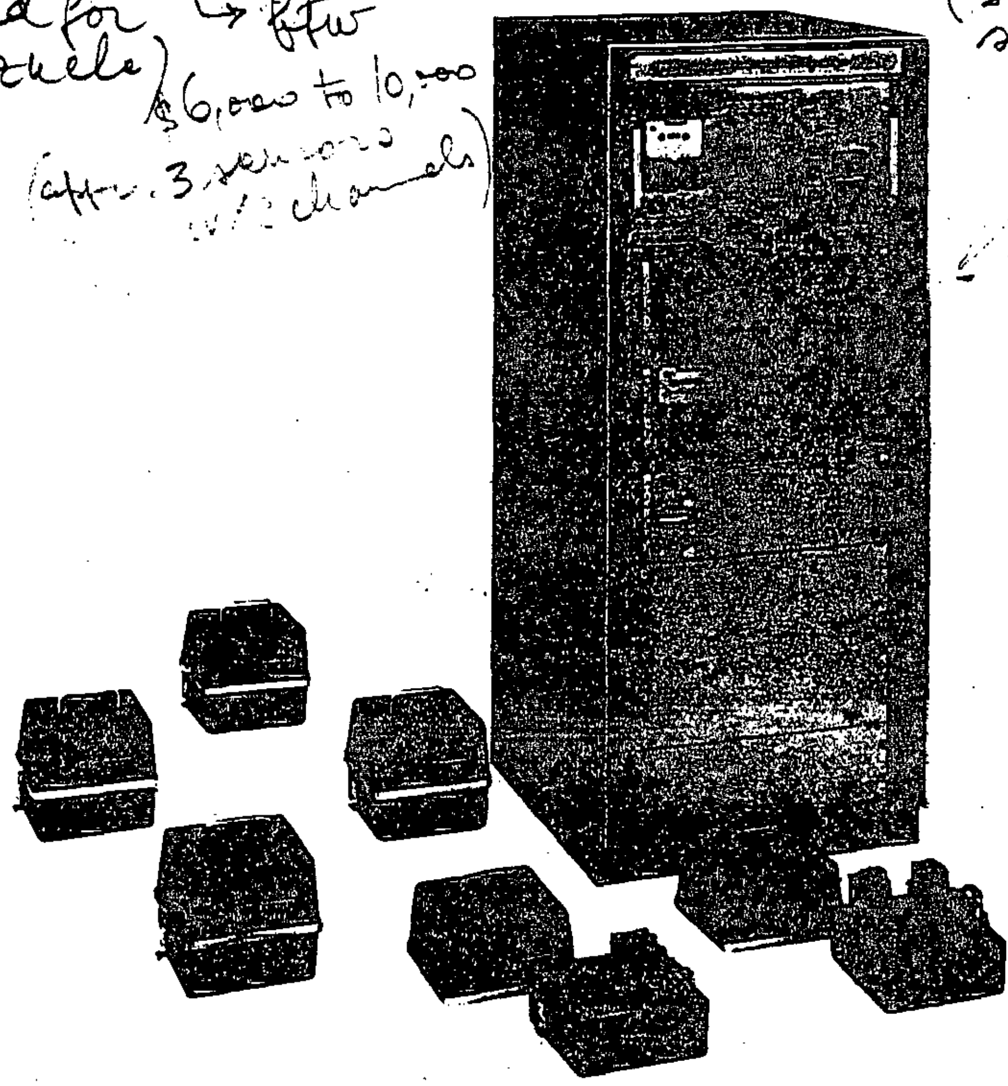
EARTHQUAKE ENGINEERING INSTRUMENTS

SMA-3

Strong Motion Acceleration System

(provided for Venezuela) → ftw $6,000 to 10,000 (appr. 3 sensors w/ 3 channels)

(sends signal SMP-1 → $6,000 built-in



The SMA-3 is a multi-channel, centralized recording, magnetic tape acceleration system designed to detect and record strong local earthquakes. Typical structural applications include nuclear power plants, tall buildings, dams, offshore platforms and bridges. The SMA-3 system used with the companion SMP-1 Playback system meets the requirements of U.S. NRC Regulatory Guide 1.12 and is being used at over 70 nuclear power plants worldwide.

Each FBA-3 triaxial accelerometer package is connected to the recording section by electrical cables. A triaxial seismic trigger, the TS-3, is standard with the SMA-3 system. Uniaxial and biaxial accelerometer packages are available in several configurations, including a down-hole package.

GENERAL DESCRIPTION

The SMA-3 is a versatile multi-channel acceleration recording system. It is self-actuating when a strong local earthquake exceeds a predetermined level of ground acceleration. When this level falls below the preset level, the SMA-3 automatically returns to the previous standby condition to prepare for any succeeding earthquakes.

In the recording section, the signals from the accelerometers are buffered, frequency-modulated by the voltage-controlled oscillator (VCO), and fed into a magnetic recording head. Each acceleration signal occupies its own track on the magnetic tape. The fourth track of each head is used for a timing signal. The timing signal generator is common for all transports in the system.

The standard FBA-3 triaxial accelerometer package is approximately 8″x8″x8″. It contains three force-balance acceleration sensors. The accelerometer package accepts calibration commands for damping and natural frequency.

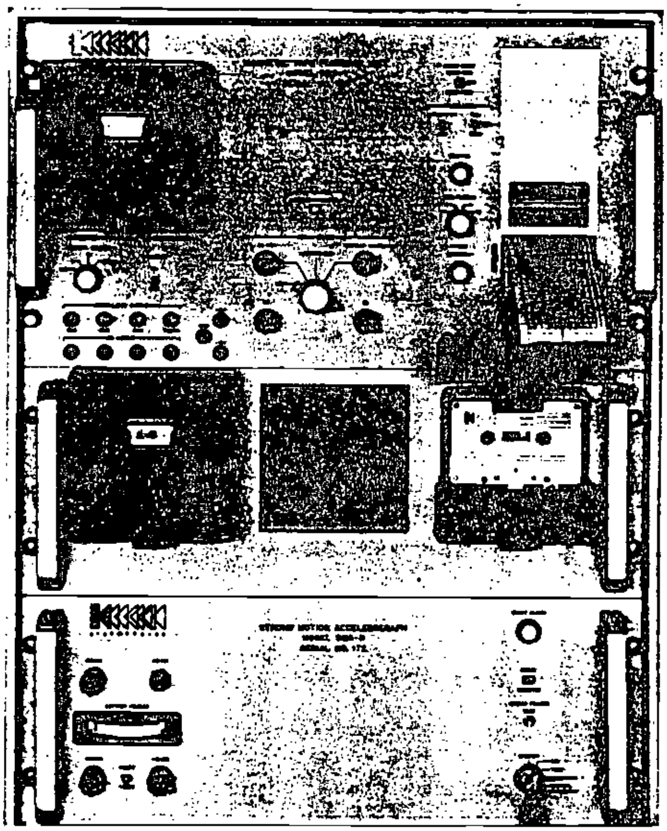
TECHNICAL SPECIFICATIONS

Recording System

Type
FM modulation.
Tape
Instrumentation cassette, 1⅞ inch per second.
Head
4 track.
Recording Time
Thirty minutes.
Center frequency and percent modulation
Acceleration channels 1000 Hz ±50%.
Timing 1024 Hz. ±0.2%.
Bandwidth
0 to 50 Hz.
Dynamic Range
40 dB at 60° to 90°F (with SMP-1).
Start-up Time
Less than 100 ms.
System Accuracy (with SMP-1)
±5% at full scale, changing linearly to ±1.5% of full scale at 0.01 g.

Transducers

Type
Force balance.
Natural frequency
50 Hz.
Range
±1 g full scale.
Damping
70% critical.
Temperature Effects
±1½ % of full scale from 0° to 160°F (–18° to 71°C).
Bandwidth
0 to 50 Hz.
Output
±2.5 volts full scale.
Functional Calibration
Step function for damping and natural frequency.



Event Alarm
Normally open contacts, rated at 3 amps.
Event Indicator
Electromagnetic event indicator.

Seismic Triggers

Type
Triaxial acceleration triggers in waterproof housing (TS-3).

Power Requirements

Type
Two 12 volt internal rechargeable batteries. An internal battery charger is supplied, which operates from 110 Vac.

PHYSICAL CHARACTERISTICS

Operating Temperature
30° to 130°F (–1° to 54°C).
Humidity
Remote packages: 100% R.H.
Cabinet-mounted panels: 80% R.H., non-condensing.

OPTIONS

1. Cabinet (standard or seismically braced).
2. 0.5 g, 0.25 g, 0.10 g or 2 g.
3. Up to 27 accelerometer channels.
4. Specify AC voltage, 110 V or 220 V.
5. Specify interconnecting cable length.
6. Flame resistant wiring available.

RECOMMENDED SPARE PARTS AND SUPPLIES

1. Spare magnetic tape cassettes, P/N 700030.
2. Desiccant envelope, P/N 700049.

ORDERING INFORMATION

1. Specify number of triaxial accelerometers/recorders.
2. Specify accelerometer sensitivity.
3. Specify trigger set-point (0.01 g is standard).

McKenna
ENGINEERING & EQUIPMENT CO., INC.
340 Maple Avenue Torrance, CA 90503

L.A. (213) 775-2613
Torrance (213) 328-5520
Telex 18-1912

March 17, 1983

RECEIVED
MAR 23 1983
KAISER ENGINEERS
LOS ANGELES

Kaiser Engineers
425 South Main
6th Floor Annex B
Los Angeles, Calif. 90013

Attention: Deba Mohapatra

Reference: McKenna Proposal # 1099-83

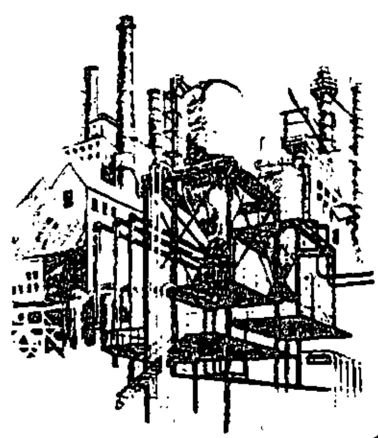
Gentlemen:

Per our conversation of March 3, 1983, McKenna Engineering is pleased to quote on the following Goulds Pumps:

One (1) Goulds model 3196 MT, 3x4-10H, in a ductile iron construction, complete with packing and direct coupled through a Samiflex flexible spacer coupling to a 25 HP, 1800 RPM, explosion proof, 3-60-230/460 horizontal motor. The entire unit is mounted on a cast iron style bedplate.

One (1) Goulds model 3171 vertical sump pump 3x4-11 in an all iron construction with a 20 HP, 1800 RPM, 3-60-230/460 volt vertical motor. This pump is designed for a 8' sump.

continued...



Goulds model 3196MT 3x4-10H - Complete unit
Price $3,752.00

Delivery is stock
F.O.B. Torrance, CA
Terms net 20 days

Goulds model 3171 vertical sump pump 3x4-11 -

Complete unit
Price $5,860.00

Delivery is 8 - 12 weeks
F.O.B. Lubbock, Texas
Terms net 20 days

Please note all prices are budget only.

We look forward to receiving an order on the above mentioned equipment and if you have any questions or need any additional information, please do not hesitate to contact us.

Sincerely,

Edward J. McKenna, Jr.

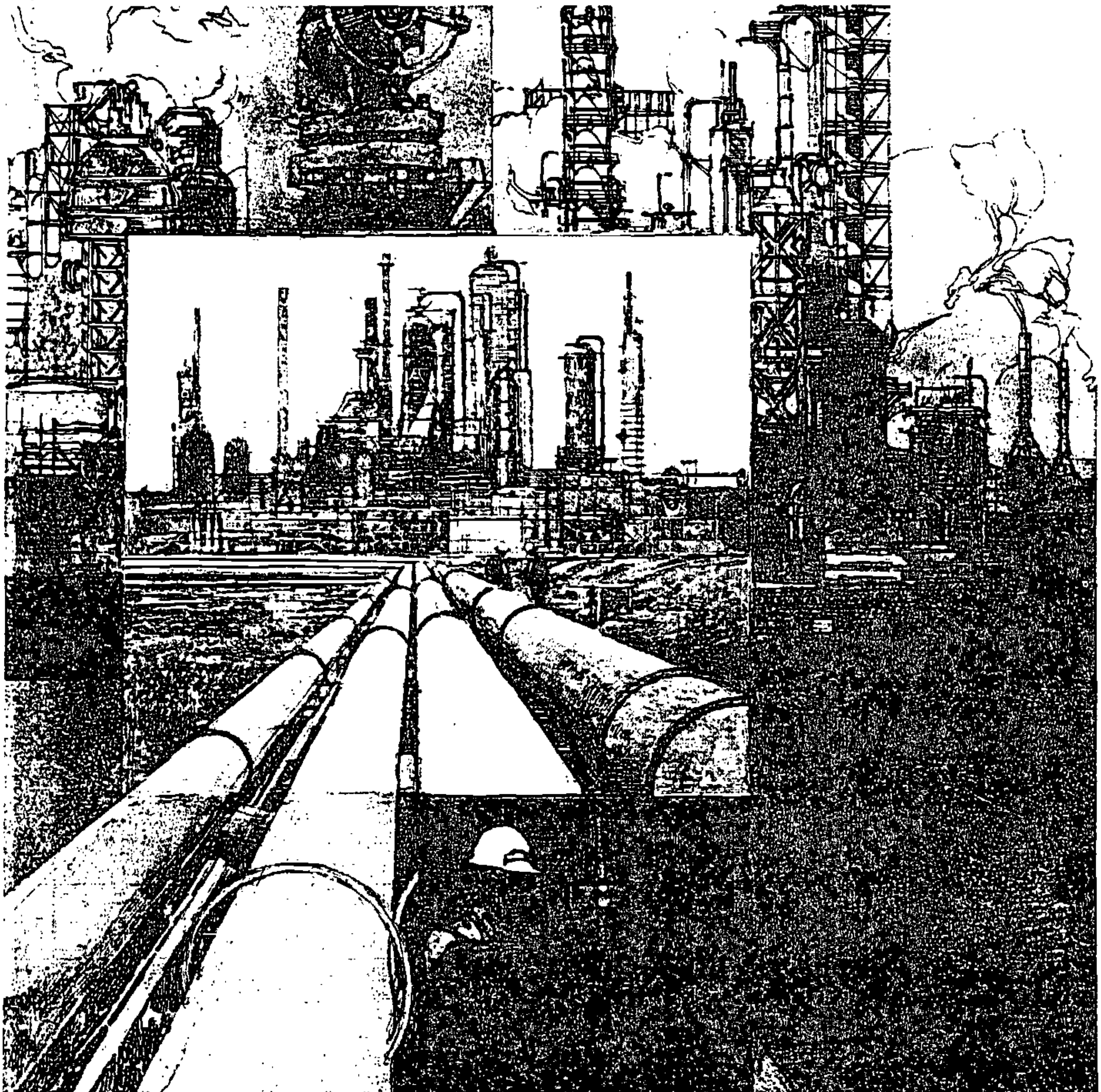
Edward J. McKenna, Jr.
Applications Engineer

/jdr

BULLETIN 725.1
January 1980

GOULDS PUMPS

Goulds Model 3196 ANSI Standard Dimension Process Pumps



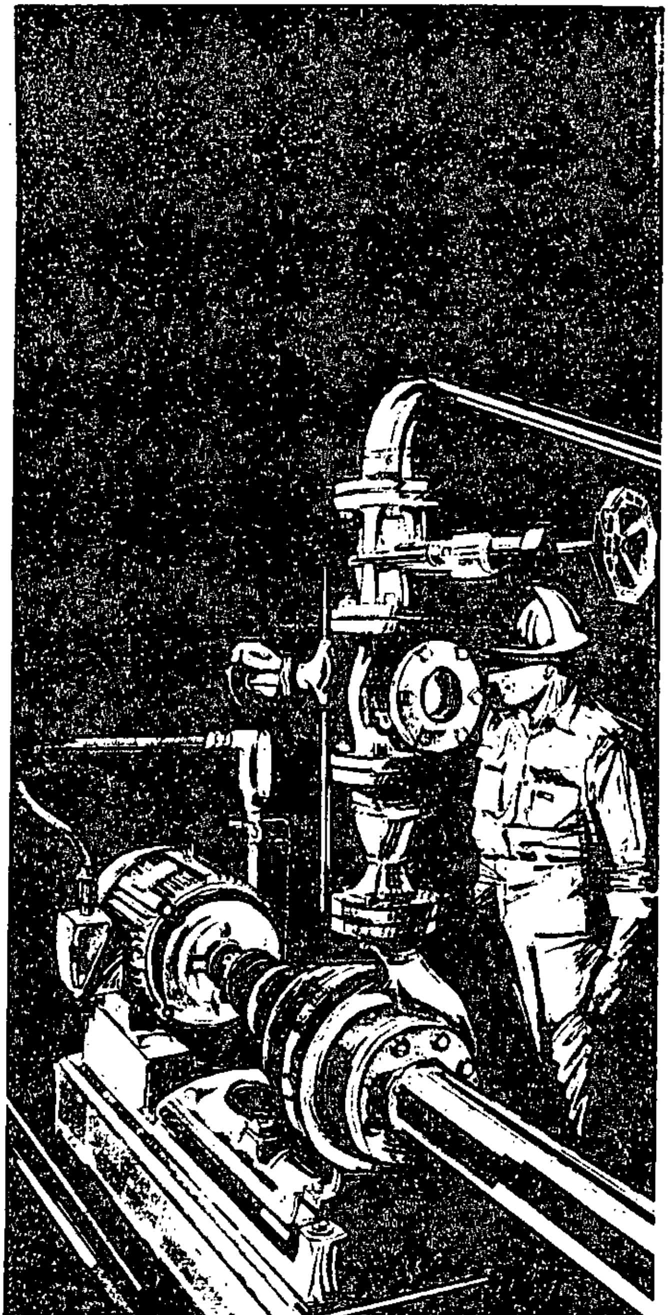
Goulds 3196...the standard of the industry.

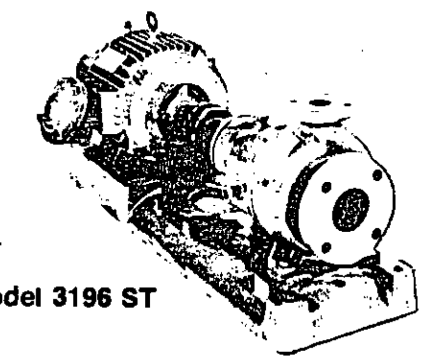
Goulds pioneered the AVS standard dimension process pump in 1960 and since then hundreds of thousands Model 3196 process pumps have been installed. Because of its remarkable record the 3196 has become the standard of the industry. And, it meets or exceeds all the requirements of ANSI B-73.1.

The 3196 is everything a chemical pump should be. It's copied, but no one makes a pump like the 3196. The original high efficiency is the best in the industry — and it can be maintained by an easy external adjustment.

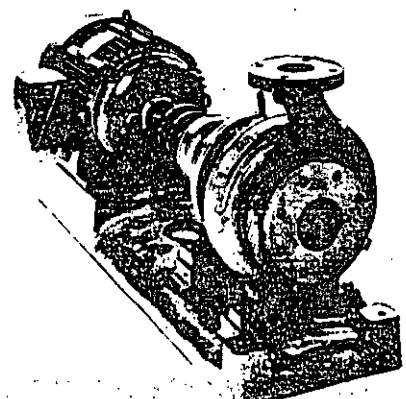
Just look at the standard features: open impeller, bearing cooling, cast iron bedplate, double row thrust bearing, maximum interchangeability — two bearing frames fit five different process pumps (56 sizes), a hook-type shaft sleeve, bonus casing thickness, precision fits and positive liquid sealing at the impeller. These features (and many more) have made Goulds 3196 the preferred process pump. And independent market surveys show Goulds Pumps to be number one in preference in the Chemical and Pulp & Paper industries.

These reasons, and others shown throughout this brochure, show that you can make no better choice than the best — Goulds 3196 — the standard of the industry.

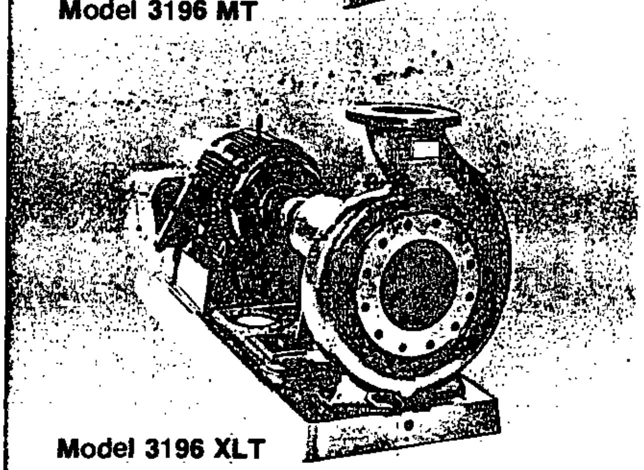




Model 3196 ST



Model 3196 MT



Model 3196 XLT

3196 ANSI* Standard Dimension P

Heavy Duty Design Features for Total Range of Process Se

(Model 3196 MT illustrated. Same features apply to 3196 ST and 3196 XLT.)

*ANSI B-73.1

RENEWABLE SHAFT SLEEVE

Hook-type shaft sleeve is relieved for easy removal, even with mechanical seal pre-set. The sleeve is free to expand with temperature variation. A drive pin assures positive rotation. Option solid shaft (less sleeve) available.

BONUS CASING THICKNESS

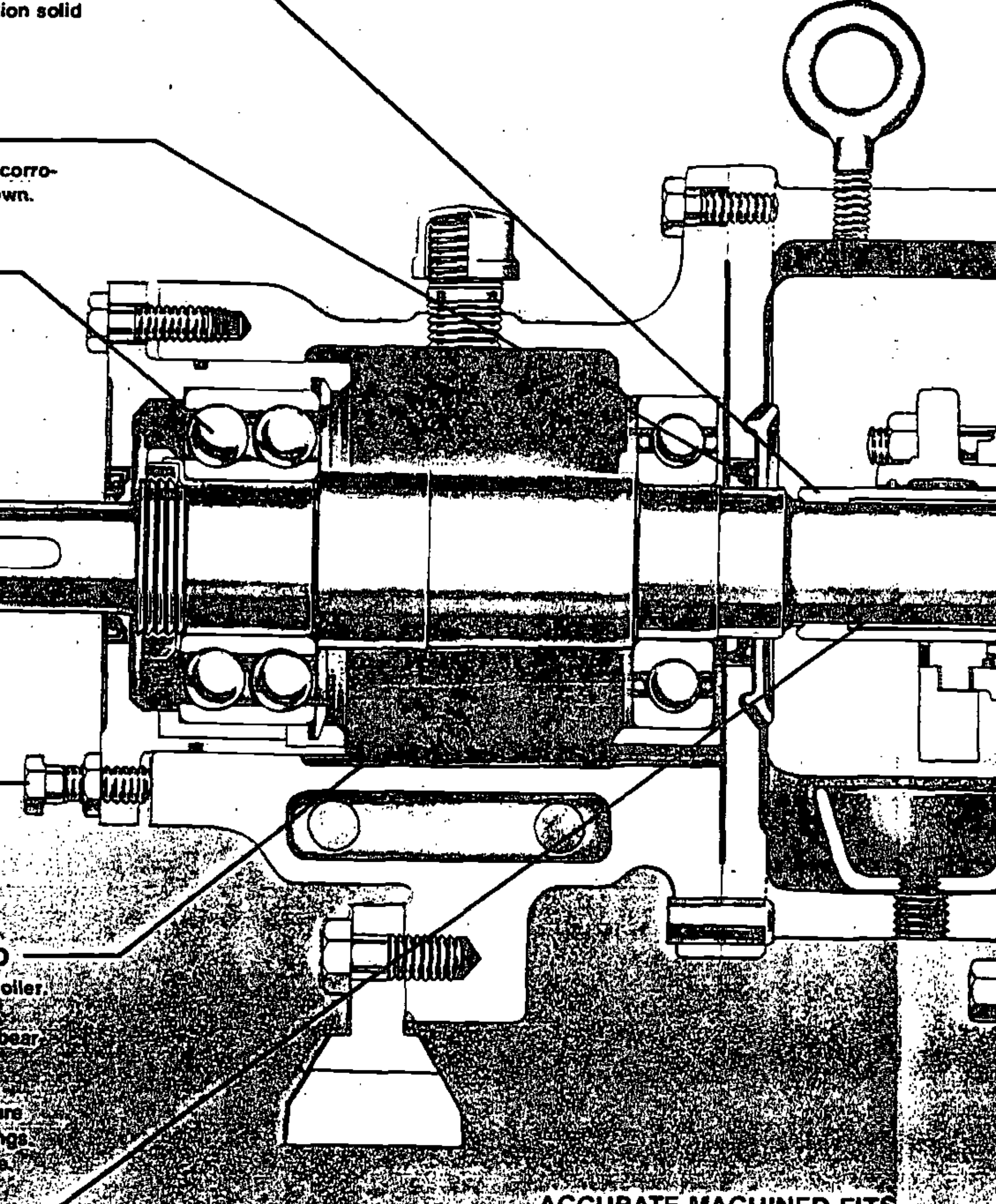
All 150 psi pumps have 300 psi wall thickness as standard for longer life under corrosive/erosive conditions.

BEARING HOUSING

Sealed to prevent contamination from corrosive atmosphere, leakage and wash-down.

DOUBLE ROW THRUST BEARING

Permits operation exceeding speed and suction pressure capabilities of single row bearings — minimizes shaft end play (.001") for effective stuffing box sealing and maximum mechanical seal life.



EXTERNAL IMPELLER ADJUSTMENT FOR CONTINUOUS HIGH PERFORMANCE

Original high efficiency maintained by simple adjustment resulting in long-term energy savings.

OIL LUBRICATION STANDARD

- Oil level maintained by constant level oiler. Rugged bearing housing vent.
- Large cooling jacket assures proper bearing temperature on high temperature services.
- Oil return drains under bearings assure uniform oil circulation through bearings.
- Alternate lubrication options available.

HEAVY DUTY SHAFT

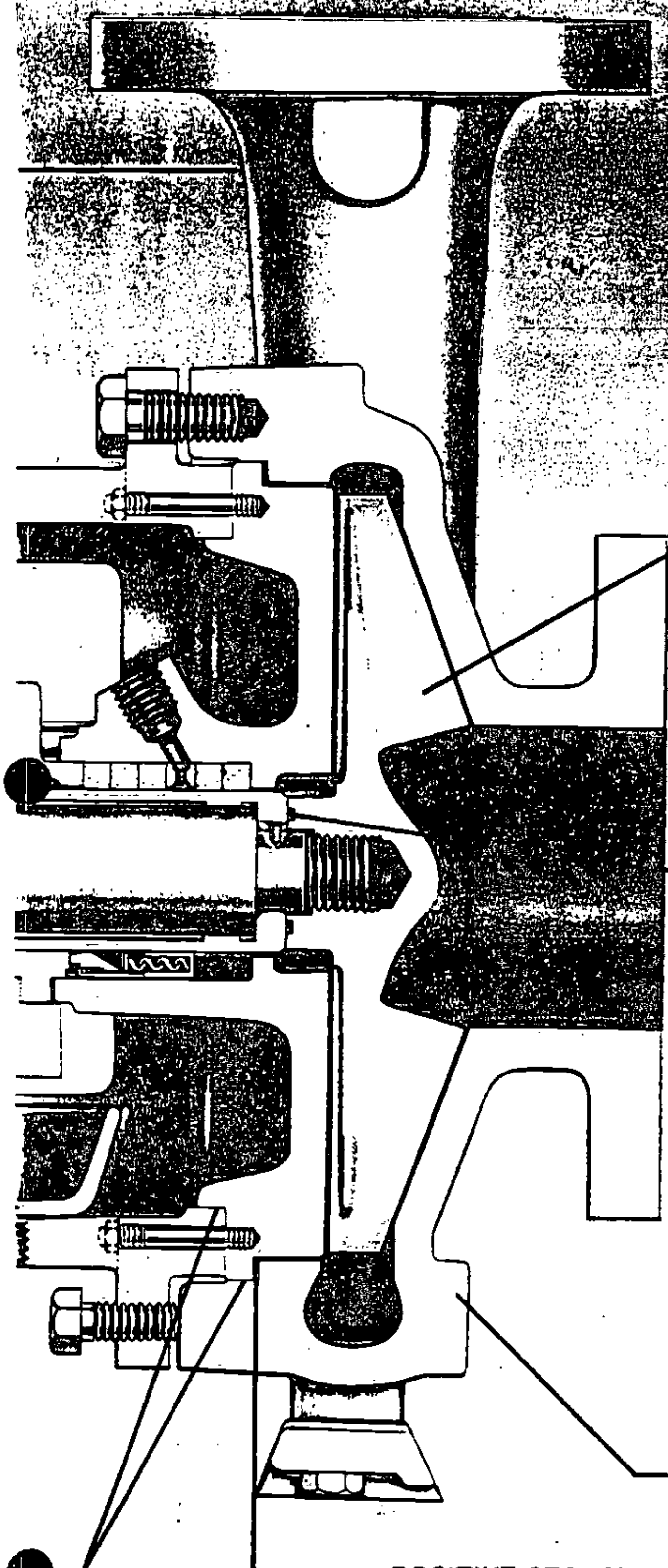
Designed for toughest services. Insures long seal and bearing life, low maintenance.

ACCURATE MACHINED FITS MAINTAIN POSITIVE ALIGNMENT

Achieved by rabbeted joints and dowel pins for long seal life and maximum hydraulic efficiency.

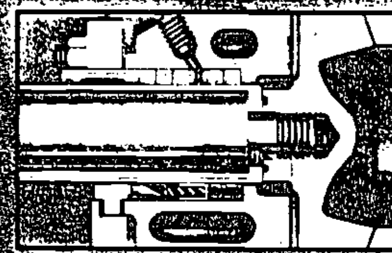
Process Pumps

Services



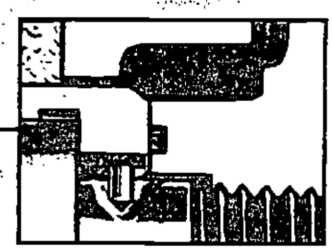
JACKETED STUFFING BOX OPTIONAL

Jacketed stuffing box for cooling packing or seal in temperatures to 500°F (260°C).



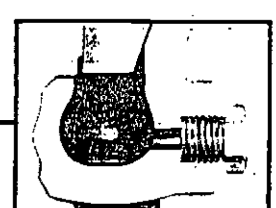
FULLY OPEN IMPELLER

With back pump-out vanes — best design for solids handling, stringy material and corrosives/abrasives.



POSITIVE LIQUID SEALING AT IMPELLER

Impeller threaded on shaft with Teflon O-ring in controlled compression for positive seal — no bolt to corrode or gaskets to leak.



POSITIVE SEALING AT CASING JOINT

With fully confined gasket. Alignment fit protected from liquid.

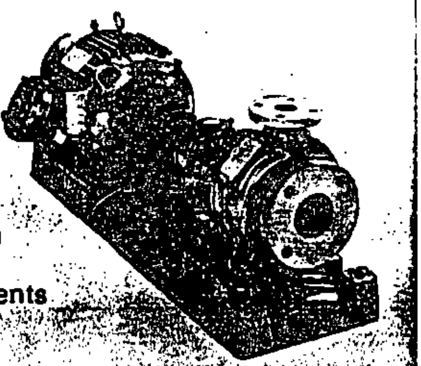
CASING DRAIN OPTIONAL

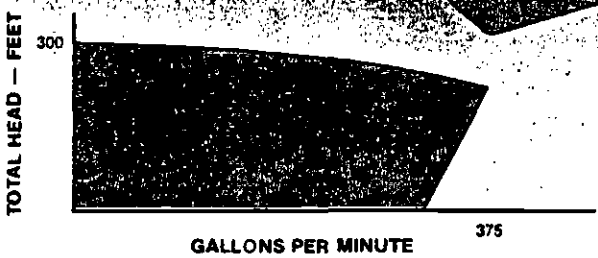
Gasket protects threaded casing against corrosion.

15

Model 3196 ST

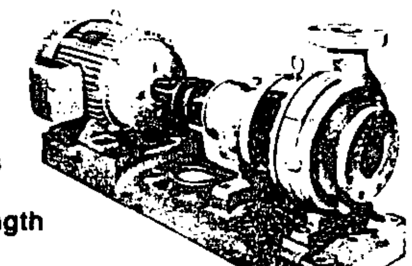
5 ANSI Pumps
with 1⅜" Shaft
17½" Pump Length
Handles 45% of all
Industry Requirements

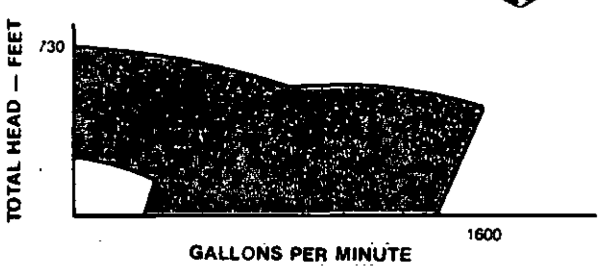




Model 3196 MT

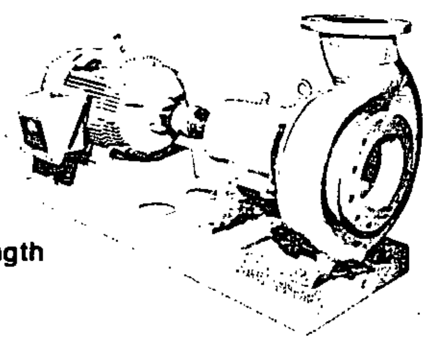
15 ANSI Pumps
with 1¾" Shaft
23½" Pump Length

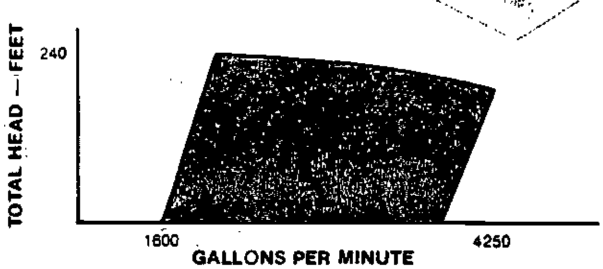




Model 3196 XLT

5 ANSI
Pumps with
2½" Shaft
33⅞" Pump Length





Goulds Model 3196

ANSI Standard Dimension Process Pumps Designed for Total Range of Industry Services

- Capacities to 4500 GPM (1022 m^3/h)
- Heads to 730 feet (222 m)
- Temperatures from -350° to 500°F (-212° to 260°C)
- Pressures from full vacuum to 375 PSIG (2586 kPa)

Process Industries

Chemical Caustic transfer, Acid unloading, Monomer and polymer transfer, Molten sulphur and urea, Liquid ammonia, Liquid nitrogen

Petrochemical Reflux and light tower bottoms. Aromatics, Light hydrocarbons, Gas oil

Pulp and Paper Digester make-up — green and white liquor, Black liquor recovery, Coating slurries — clay and titanium dioxide

Primary Metals Waste acid recovery, Scrubber service, Pickle liquor circulation

Brewing Beer, Hot Wort, Spent Grain

Corn Processing Steeped corn, starch, corn slurry

General Textile, Food, Pharmaceutical and Pollution Control — Chilled water, Condensate return, Acid recovery, Stack scrubbers, Filter feed

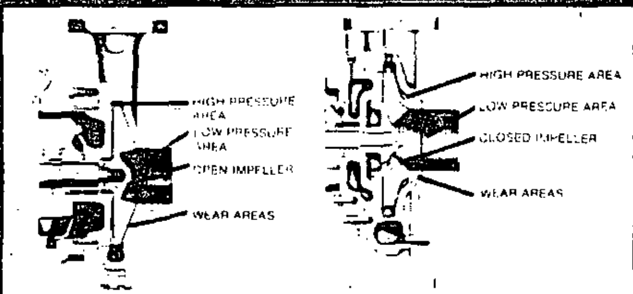
Design Features

Back Pull-Out Construction
Fully Open Impeller
Standard Dimensions/Maximum Pump & Parts Interchangeability
Widest Hydraulic Coverage in the Industry
Heavy Duty Construction
External Impeller Adjustment
Hook-Type Shaft Sleeve
Rigid Cast Iron Bedplate
Bonus Casing Thickness
Double Row Thrust Bearing
Available in Wide Range of Alloys

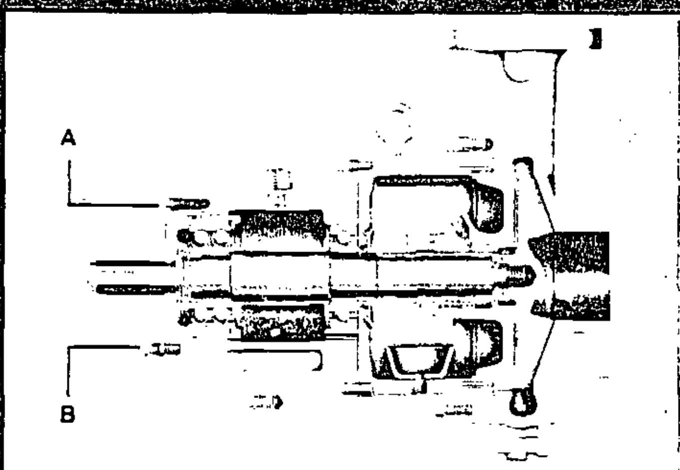
Long Life/High Efficiency/Low Maintenance

Open Impeller Design/Wide Range Liquid Handling

Open Impeller vs Closed Impeller



Maintain Original Pump Performance with Goulds Easy External Adjustment



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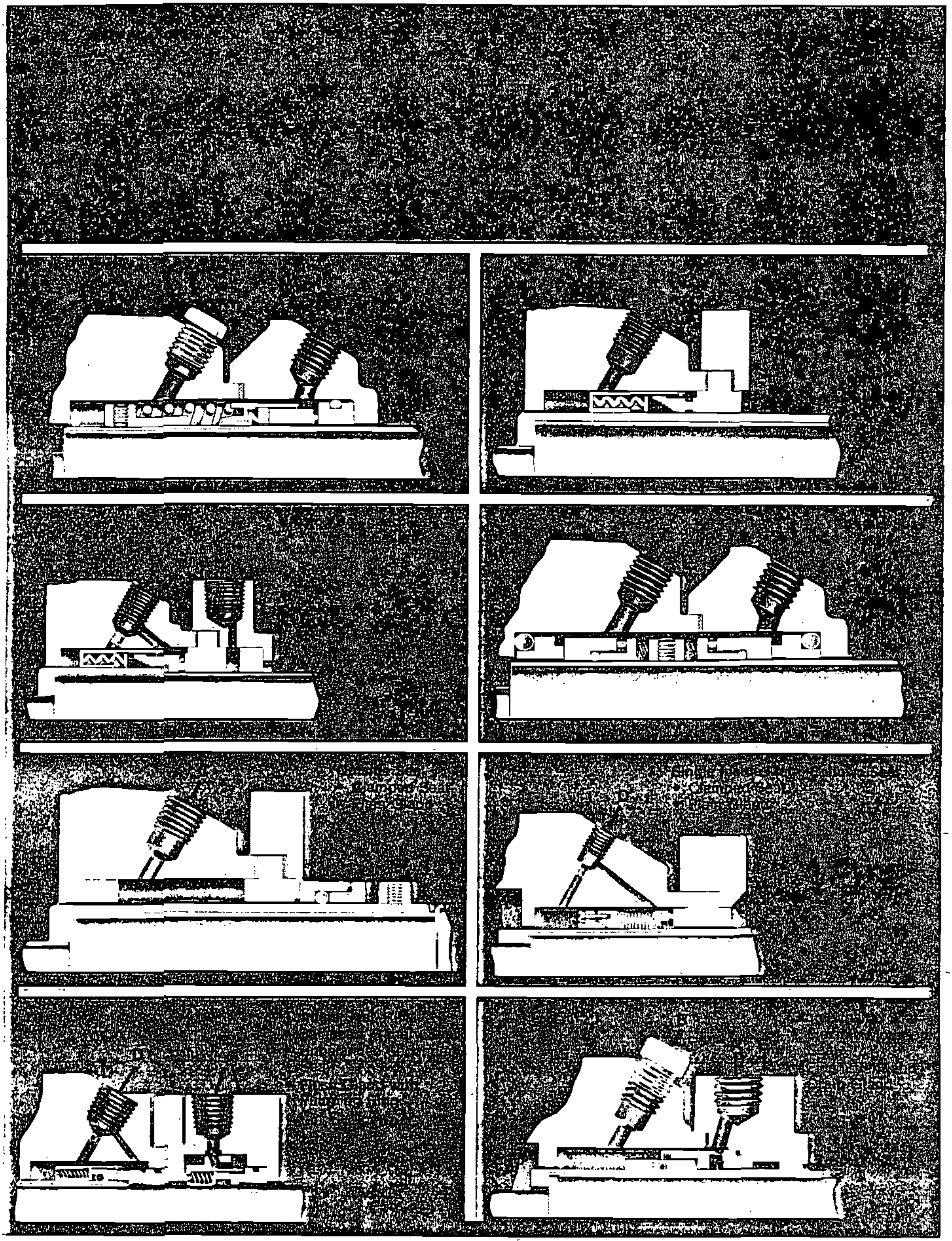
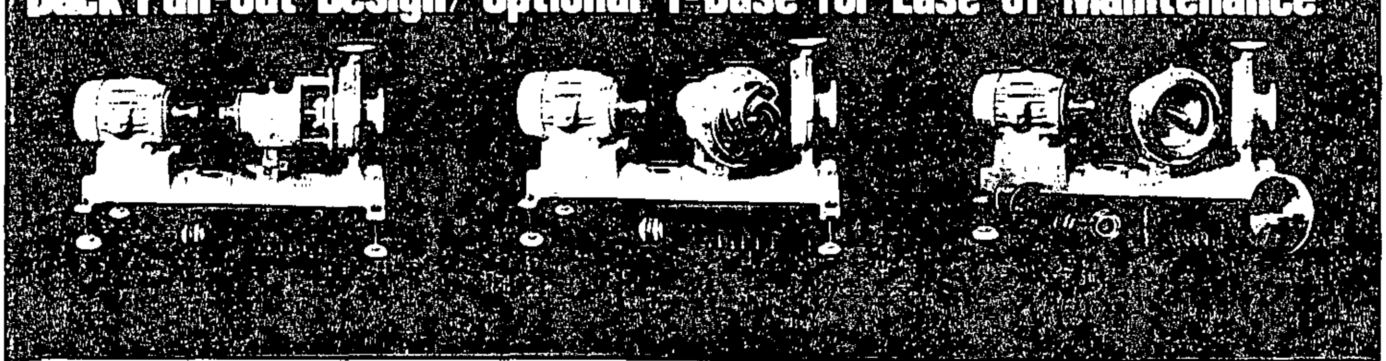
Maximum Sealing Flexibility

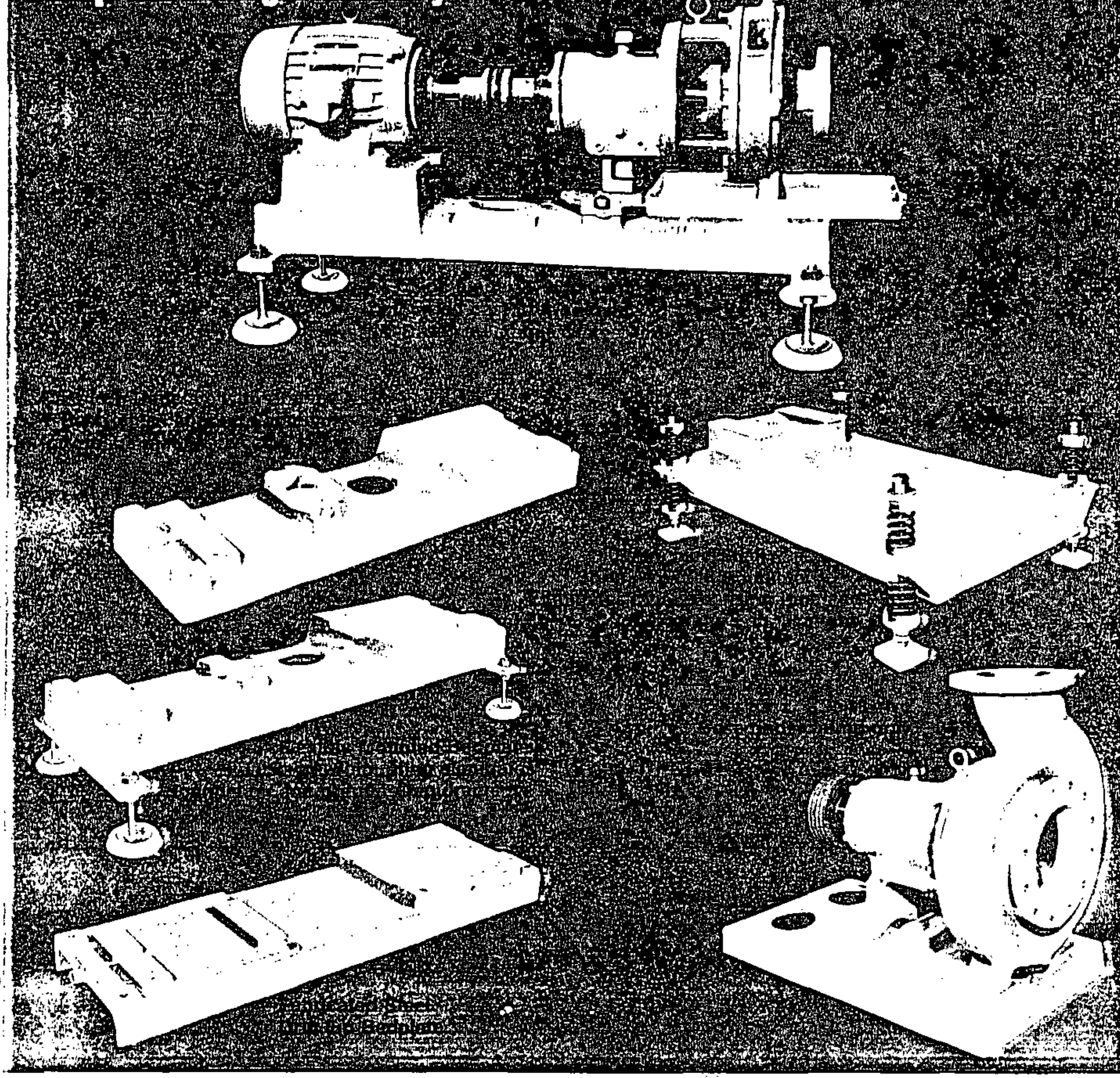


Pump Mounting and Drive Flexibility

Back Pull-Out Design/ Optional Y-Base for Ease of Maintenance

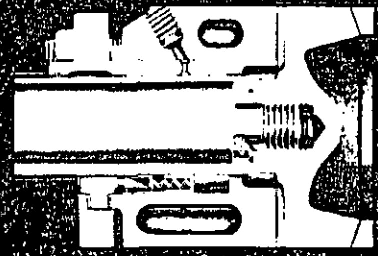


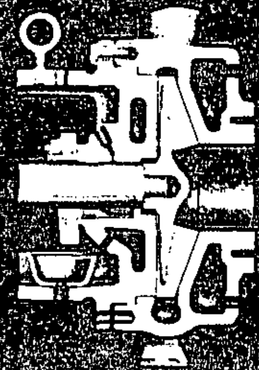
Pump Mounting Flexibility

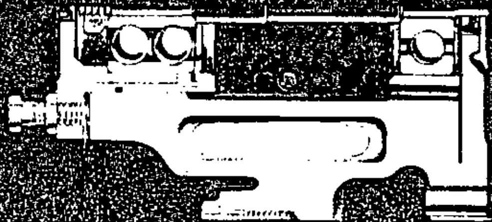


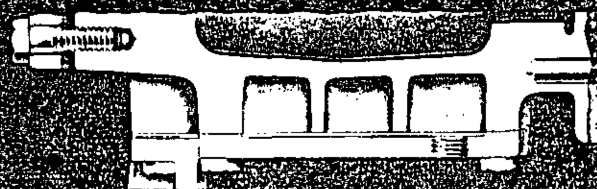
Custom Built Pumps/Special Applications

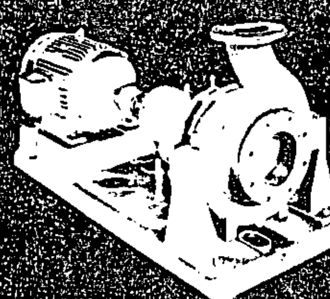
High Temperature Capability

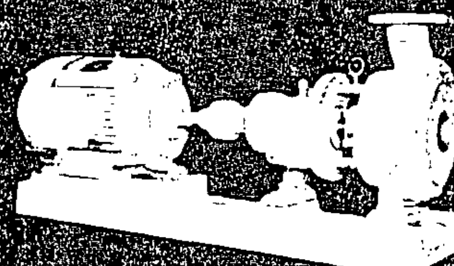




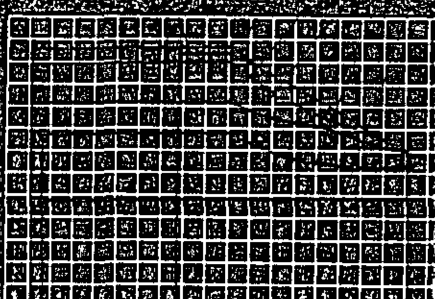


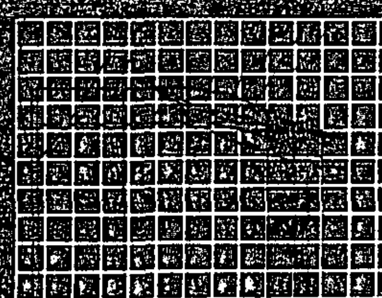






Pressure & Temperature Capability





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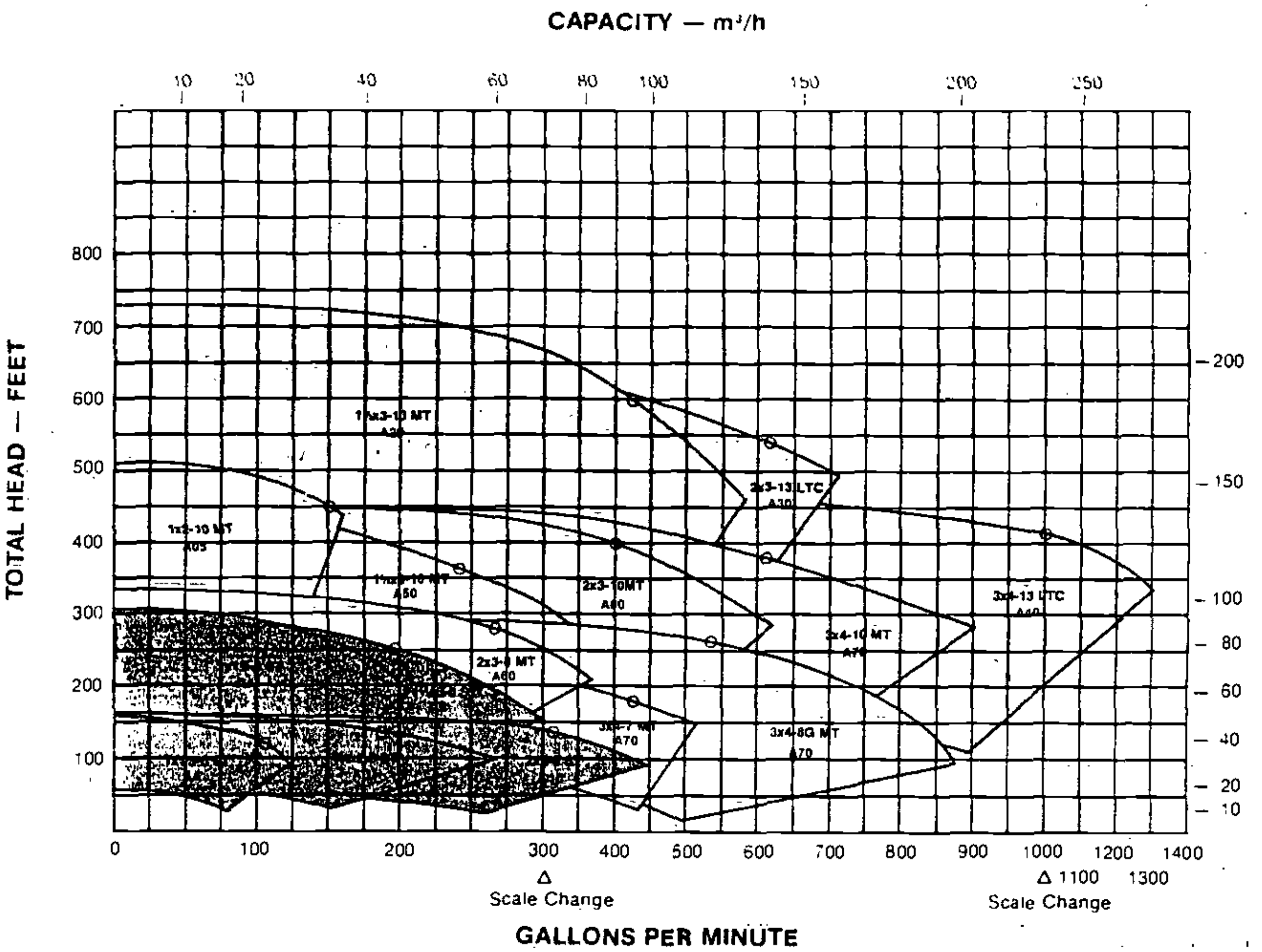
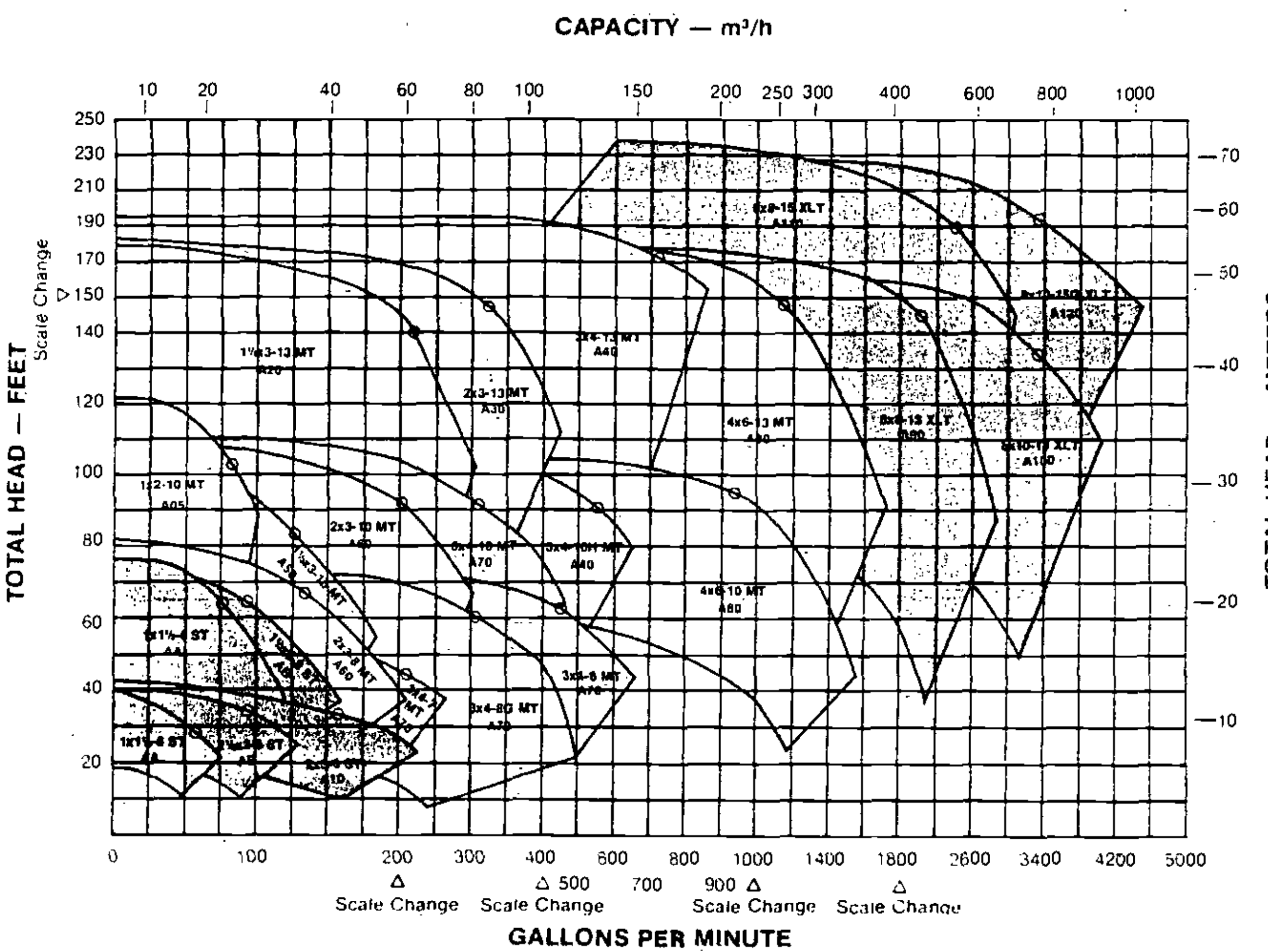
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ductile Iron	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Nickel	Titanium

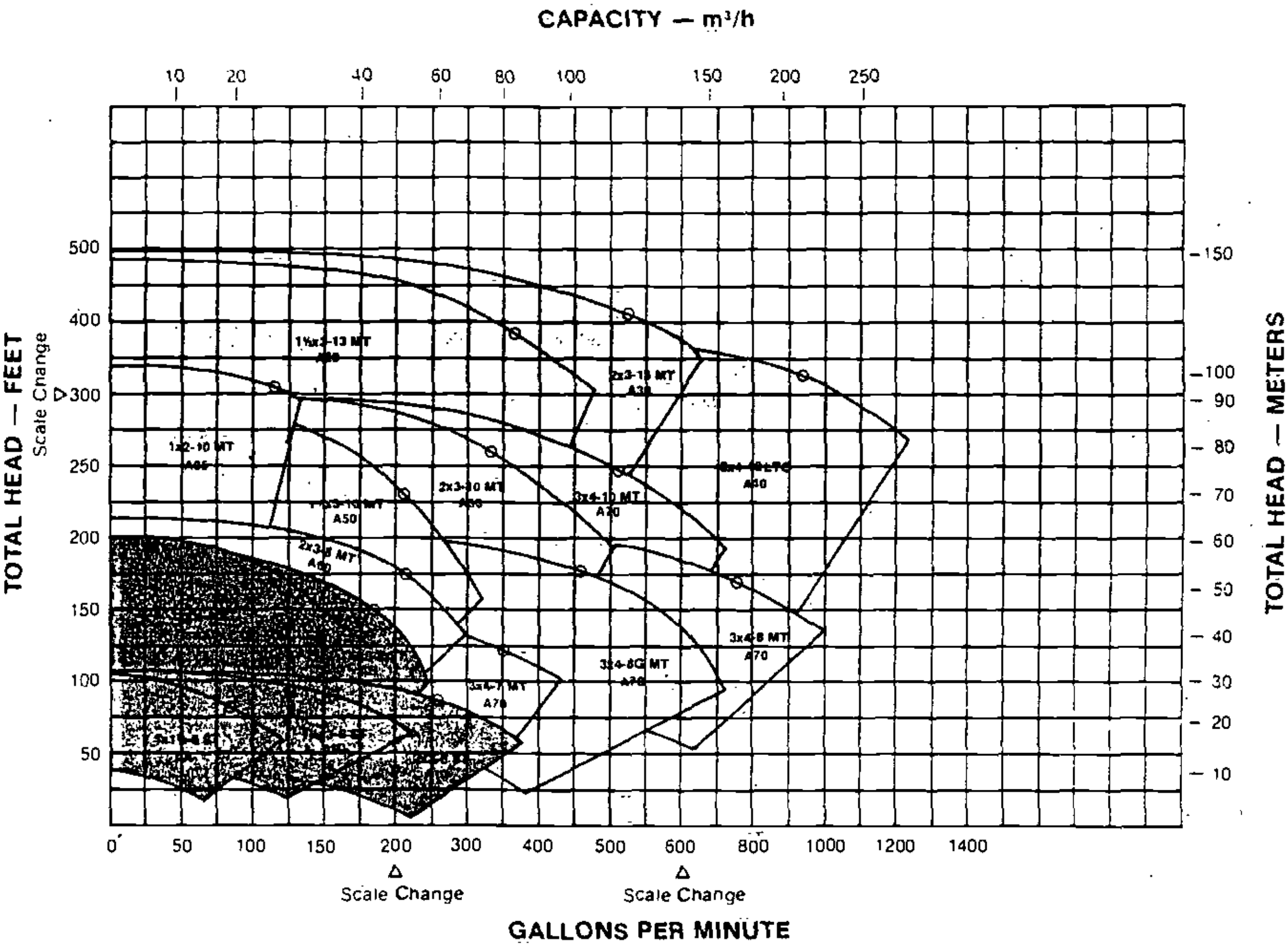
3500 R.P.M. Performance Curve



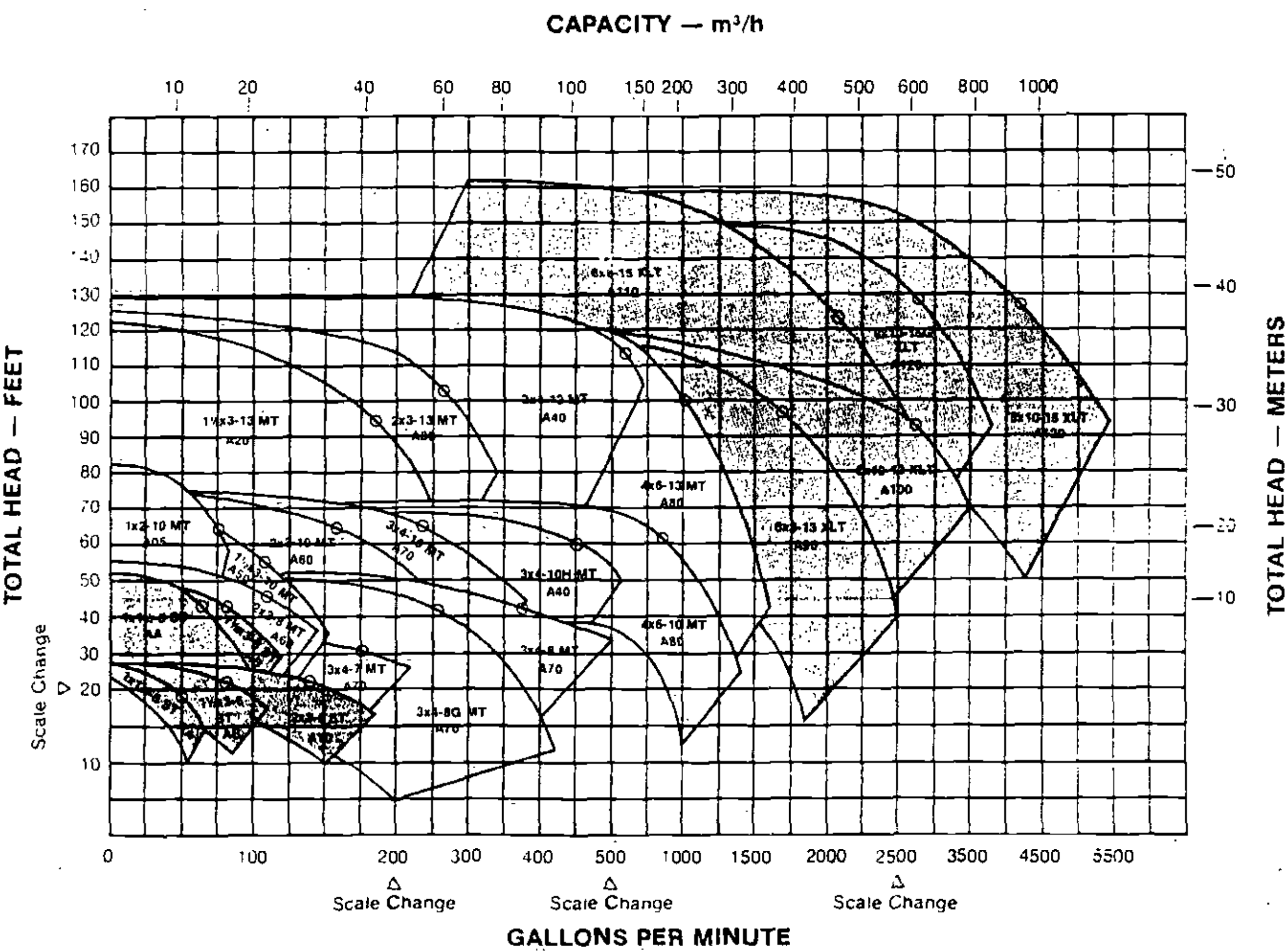
1750 R.P.M. Performance Curve



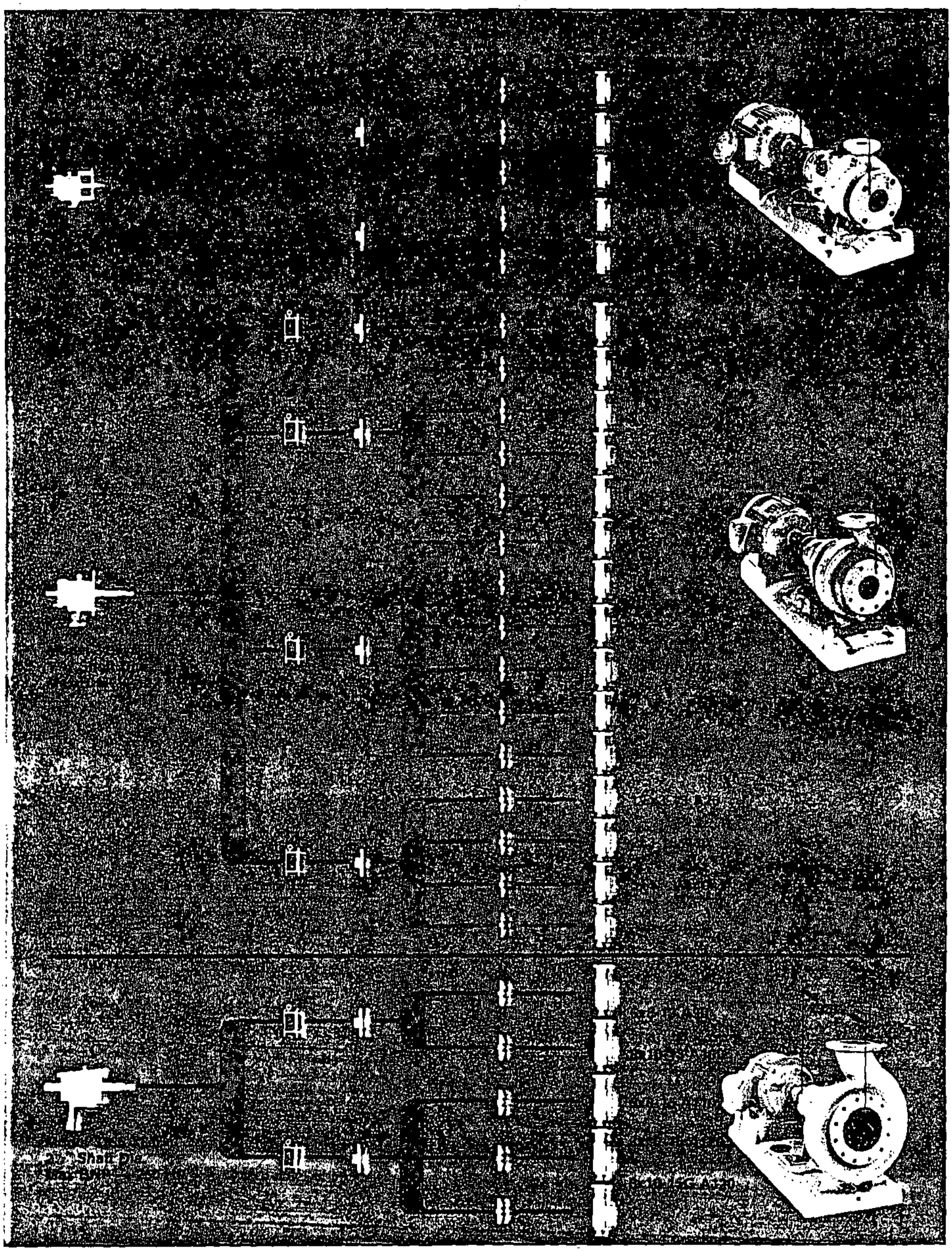
2900 R.P.M. Performance Curve



1450 R.P.M. Performance Curve



Modular/Dimensional Interchangeability



POWER END		MODEL 3196 ST	MODEL 3196 MT	MODEL 3196 LTC	MODEL 3196 XLT
Shaft Diameters	At Impeller	3/4" (19.0)	1" (25.4)	1 1/4" (31.8)	1 1/2" (38.1)
	In Stuffing Box (Less Sleeve)	1 3/8" (34.9)	1 3/4" (44.5)	2 1/8" (54.0)	2 1/2" (63.5)
	In Stuffing Box (With Sleeve)	1 1/8" (28.6)	1 1/2" (38.1)	1 7/8" (47.6)	2" (50.8)
	Sleeve Outside Diameter	1 3/8" (34.9)	1 3/4" (44.5)	2 1/8" (54.0)	2 1/2" (63.5)
	Between Bearings	1 1/2" (38.1)	2 1/8" (54.0)	2 1/2" (63.5)	3 1/8" (79.4)
	At Coupling	7/8" (22.2)	1 1/8" (28.6)	1 7/8" (47.6)	2 3/8" (60.3)
Bearings	Radial	207-S	309-S	311-S	313-S
	Coupling End (Double Row)	5306	5309	5311	5313
	Bearing Span	4 1/8" (105)	6 3/4" (171)	6 7/16" (164)	9 1/4" (235)
	Shaft Overhang	6 1/8" (156)	8 3/8" (213)	8 3/8" (213)	9 31/32" (253)
Stuffing Box	Bore	2" (50.8)	2 1/2" (63.5)	2 7/8" (73.0)	3 3/8" (85.7)
	Depth	2 1/8" (54.0)	2 5/8" (66.7)	2 5/8" (66.7)	3" (76.2)
	Packing Size	5/16" x 5/16" (7.9 x 7.9)	3/8" x 3/8" (9.5 x 9.5)	3/8" x 3/8" (9.5 x 9.5)	7/16" x 7/16" (11.1 x 11.1)
	No. of Rings	5	5	5	5
	Width of Lantern Ring	7/16" (11.1)	5/8" (15.9)	5/8" (15.9)	5/8" (15.9)
	Distance — End of Box to Nearest Obstruction	2 3/16" (55.6)	3" (76.2)	3" (76.2)	2 15/16" (74.6)

*Optional 3196 LTC Shaft and Bearing Frame Assembly Available for Customer Preference or Special Applications on 10" and 13" Pumps. General Construction Details Identical to 3196 MT, except for coupling and shaft diameter.

PUMP END		3196 ST					3196 MT															3196 XLT				
		1 x 1½-8	1½ x 3-6	2 x 3-6	1 x 1½-8	1½ x 3-8	2 x 3-6	3 x 4-7	2 x 3-8	3 x 4-8	3 x 4-8G	1 x 2-10	1½ x 3-10	2 x 3-10	3 x 4-10	3 x 4-10H	4 x 6-10	1½ x 3-13	2 x 3-13	3 x 4-13	4 x 6-13	6 x 8-13	8 x 10-13	6 x 8-15	8 x 10-15	8 x 10-15G
Maximum Diameter Solids		11/32" (8.6)	7/16" (11.2)	3/8" (9.5)	11/32" (8.6)	7/16" (11.2)	3/8" (9.5)	1/2" (12.7)	1/2" (12.7)	1 1/8" (28.6)	11/16" (17.5)	7/16" (11.2)	7/32" (5.6)	3/8" (9.5)	5/8" (15.9)	5/8" (15.9)	1" (25.4)	7/32" (5.6)	3/8" (9.5)	5/8" (15.9)	1" (25.4)	11/16" (17.5)	1" (25.4)	13/16" (20.6)	1 1/8" (28.6)	13/16" (20.6)
Shaft Deflection Load Factor (M)	3500 RPM	3	6.2	7	6	7.8	6.2	7.9	8.6	—	15	7.2	8.6	9.8	15	—	—	10	15.7	35.5	—	—	—	—	—	—
	1750 RPM	.8	1.6	1.8	1.5	2	1.6	2.0	2.2	7	4.1	1.9	2.2	2.5	4.1	4.1	16.5	2.6	4.6	11.5	16.5	8	15	10	—	30
	1150 RPM	.3	.7	.8	.7	.9	.7	0.9	1	3.1	1.8	.8	1	1.1	1.7	1.7	6.8	1.2	1.9	5	6.8	3.6	8.7	4.5	11.5	13.6
Minimum Casing Thickness		3/8" (9.5)					7/16" (11.2)					1/2" (12.7)							9/16" (14.3)	5/8" (15.9)		1/2" (12.7) ◇		9/16" (14.3) ◇		
Casing Corrosion Allowance		1/8" (3.2)																								
Working Pressure		SEE PRESSURE — TEMPERATURE CHART																								
Test Pressure		150% of Working Pressure at 100°F (38°C)																								
Max. Liquid Temp. (w/out cooling)		350°F (177°C)																								
Max. Liquid Temp. (w/cooling)		500°F (260°C) (700°F (371°C) on 3196 XLT with centerline supported casing)																								
Unit Weight lbs. (Kg)		SEE DIMENSIONS																								

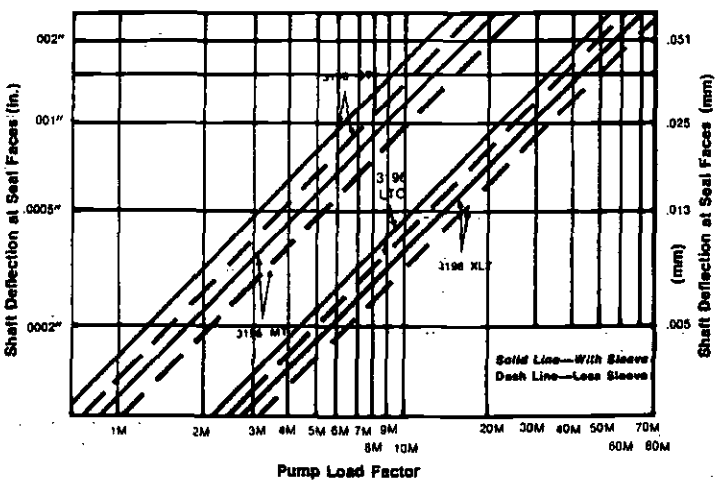
◇Minimum Thickness Titanium Casing — 3/8" (9.5)

Engineering Data

MAXIMUM SHAFT DEFLECTION AT SEAL FACES

(Based upon shut-off head, maximum diameter impeller and 1.0 specific gravity)

To determine maximum shaft deflection at seal faces, select pump load factor "M" from Construction Details at rated speed and enter chart. Intersection with selected shaft will give shaft deflection. To correct load factor for liquid handled, multiply by specific gravity.



B.H.P. Limits

Model	R.P.M. 3560	2900	1780	1450	1180	880
3196 ST	40.0 (30.0)	32.7 (24.4)	20.0 (14.9)	16.3 (12.2)	13.3 (9.9)	9.9 (7.4)
3196 MT	122.0 (91.0)	99.5 (74.2)	61.0 (45.5)	49.7 (37.1)	40.5 (30.2)	30.2 (22.5)
3196 LTC	200.0 (149.1)	165.0 (123.0)	100.0 (74.6)	81.5 (60.8)	66.4 (49.5)	49.5 (36.9)
3196 XLT	—	—	250.0 (186.4)	204.0 (152.1)	166.0 (123.6)	124.0 (92.5)

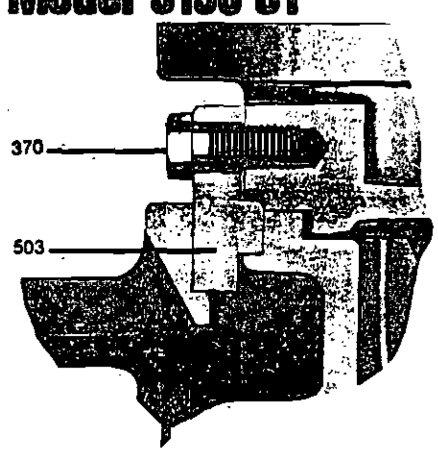
Parts List and Materials of Construction

Item No.	No. Reqd. Per Pump	Part Name	Material							
			All Ductile Iron	All 316SS	All CD4MCu	All GA-20	All Monel	All Nickel	**All Hast.	All[1] Titanium
100	1	Casing	D.I.•	316	CD4M	GA-20	Monel	Nickel	Hast.	Titanium
101	1	Impeller	D.I.■	316	CD4M	GA-20	Monel	Nickel	Hast.	Titanium
105	1	Lantern Ring	Glass Filled Teflon							
106	1 Set	Stuffing Box Packing	Asbestos		Asbestos Impregnated w/Teflon					
107	1	Gland Packed Box	316		GA-20	GA-20	Monel	Nickel	Hast.	Titanium
108	1	Frame Adapter	Cast Iron							
112A	1	Ball Bearing — Outboard End	Steel							
122*	1	Pump Shaft (Less Sleeve)	SAE4150[2]	316		C-20	Monel	Nickel	Hast.	Titanium
122A	1	Pump Shaft (With Sleeve)	SAE4140				316			
123	1	Deflector	Glass Reinforced Nylon							
126	1	Shaft Sleeve	316		CD4M	C-20	Monel	Nickel	Hast.	Titanium
134A	1	Bearing Housing	Cast Iron							
136	1	Bearing Locknut	Steel							
168A	1	Ball Bearing — Inboard	Steel							
184	1	Stuffing Box Cover — Standard	D.I.■	316	CD4M	GA-20	Monel	Nickel	Hast.	Titanium
184A	1	Stuffing Box Cover — Water Jacketed	D.I.■	316	CD4M	GA-20	Monel	Nickel	Hast.	Titanium
210	1	Gland Packing	White African Asbestos							
228A	1	Bearing Frame	Cast Iron							
247	1	Drip Basin	—	316						
251	1	Constent Level Oiler (Not Illustrated)	Glass and White Metal							
261	1	Gasket — Adapter to Stuffing Box	Manila Paper							
332A	1	Oil Seal — Coupling End	Buna Rubber							
333A	1	Oil Seal — Inboard End	Buna Rubber							
351	1	Gasket — Casing	White African Asbestos							
353	2	Gland Stud	316				Monel			
355	2	Gland Stud Nut	304				Monel			
361A	1	Retaining Ring — Bearing Housing	Steel							
370	4-24	Cap Screw — Frame Adapt. to Casing	Steel	304						
370C	3-4	Tap Bolt — Bearing Housing	Steel							
370D	3-4	Tap Bolt — w/Jam Nut — Impeller Adjust.	Steel							
370H	2	Stud & Nut — Cover to Adapter	304							
371C	6	Cap Screw — End Cover to Brg. Hsg.	Steel							
382	1	Bearing Lockwasher	Steel							
412A	1	"O" Ring — Impeller	Teflon							
418	2-3	Tap Bolt — Jacking	304							
469B	2	Dowel Pin — Frame to Adapter	Steel							
469D	1	Drive Pin — Shaft Sleeve	420							
496	1	"O" Ring — Bearing Housing	Buna Rubber							
503	1	Adapter Ring	D.I.•							

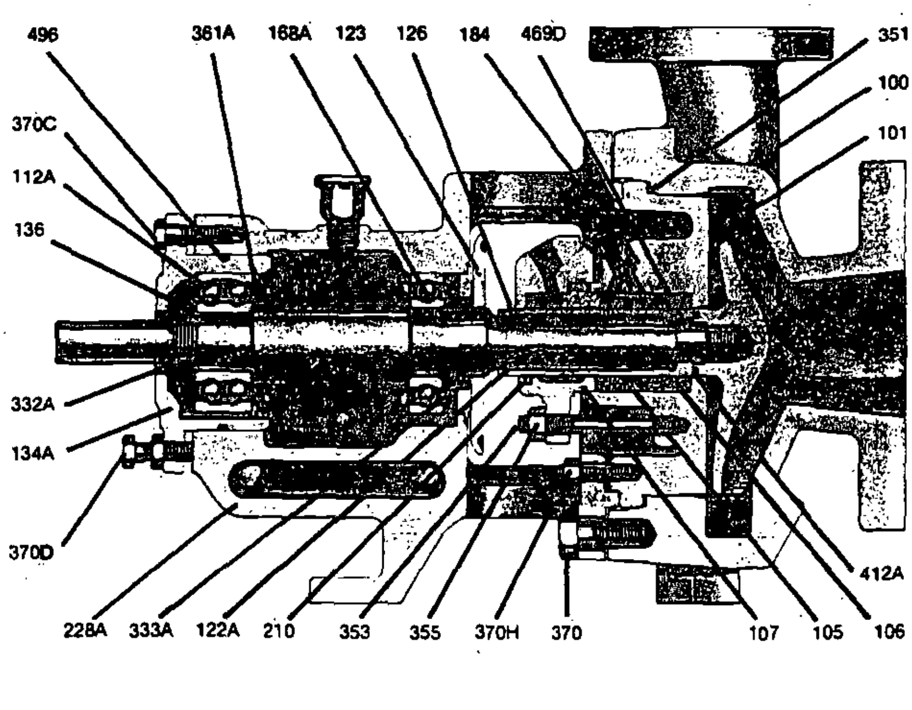
*Optional
**Available in Hast-B or Hast-C Material.
NR — Not required.

NOTES: [1]Not available on all sizes.
[2]Flame hardened to 500 Brinnell through stuffing box.

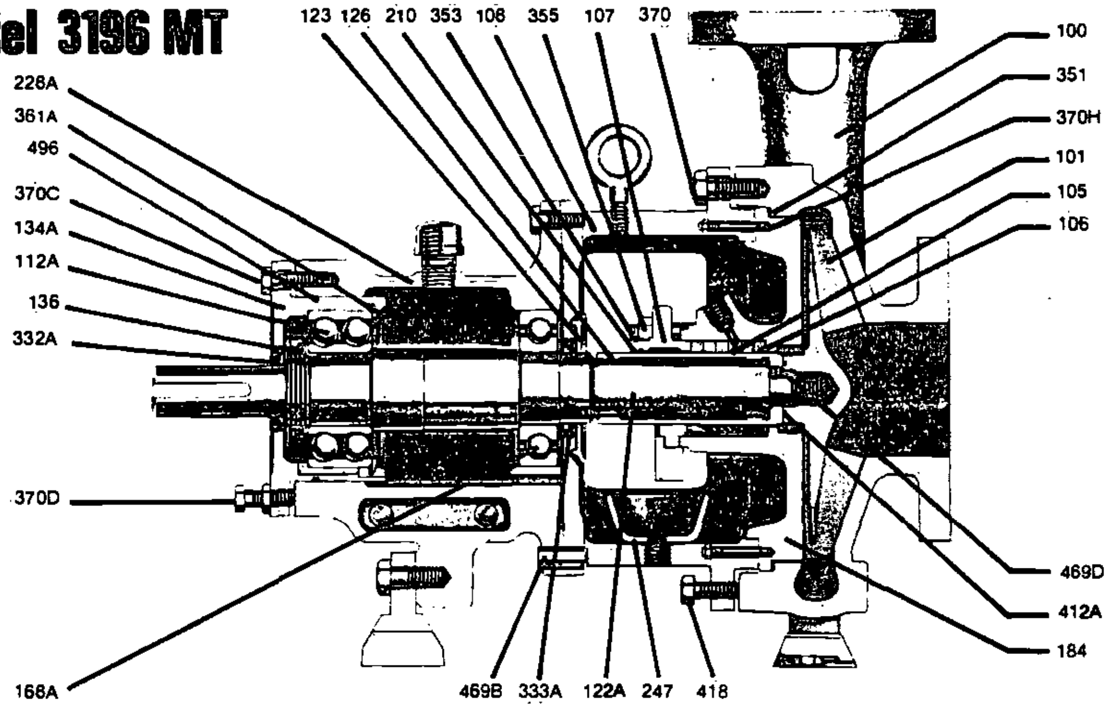
Sectional View
Model 3196 ST



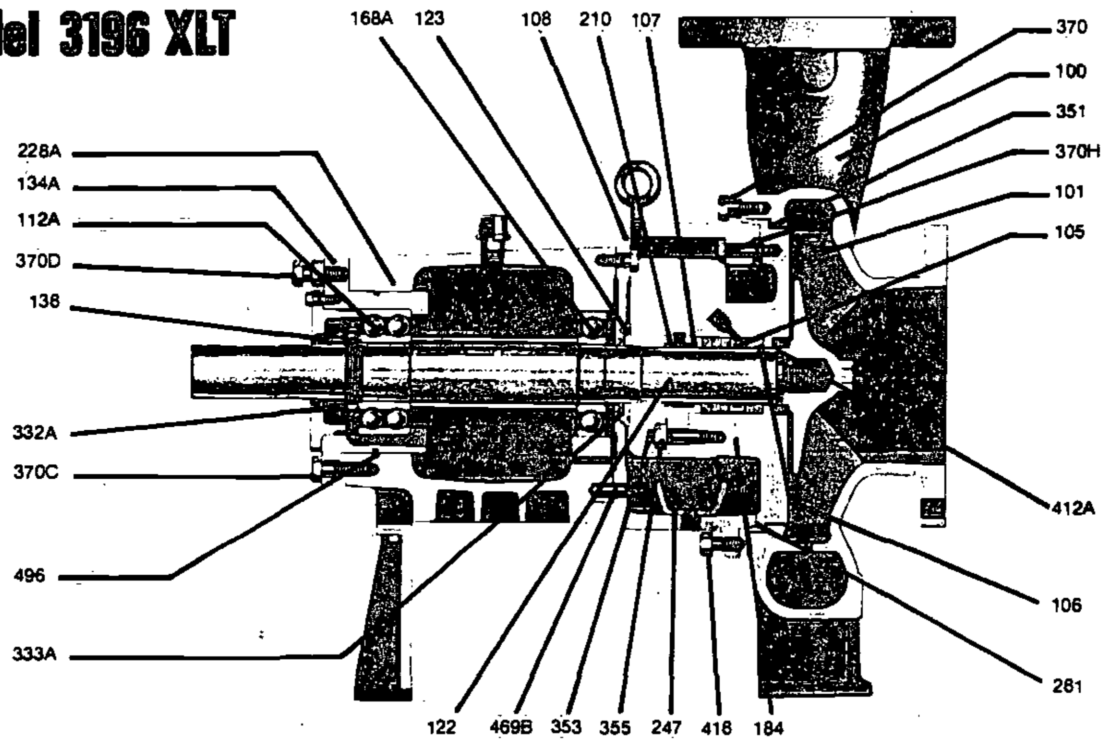
Assembly View of 1x1½-8 & 1½x3-8



Model 3196 MT



Model 3196 XLT



Materials of Construction

D.I. •	Cast Ductile Iron, Heat Treated — ASTM A395 Gr. 60-40-18
D.I. ■	Cast Ductile Iron — ASTM 536 Gr. 80-60-13
316	Cast Stainless ASTM A296 Gr. CF-8M Wrought Stainless ASTN A276 Type 316
CD4MCu	Cast Chrome — Nickel Alloy ASTM A296 Gr. CD4MCu
GA-20	Cast Gould-A-Loy 20 ASTM A296 Gr. CN-7M
Monel	Cast Monel ASTM A296 Gr. M-35 Wrought Monel ASTM B164 CL-A
Nickel	Cast Nickel ASTM A296 Gr. CZ-100 Wrought Nickel ASTM B160

Hast-C	Cast Hast-C ASTM A296 Gr. CW-12M Wrought Hast-C ASTM B336
Hast-B	Cast Hast-B ASTM A296 Gr. N-12M Wrought Hast-B ASTM B335
Titanium	Cast Titanium ASTM B367 Gr. C-3 Wrought Titanium ASTM B348 Gr. 2
Cast Iron (C.I.)	Cast Iron ASTM A48
SAE 4150	Wrought Steel ASTM A322 Gr. 4150
SAE 4140	Wrought Steel ASTM A322 Gr. 4140
C-20	Wrought Carpenter 20 CB3 ASTM B473
304	Wrought Stainless ASTM A276 Type 304

Specifications

Casing Top centerline discharge, self venting. Fully confined gasket. Foot support under casing for maximum resistance to misalignment and distortion from pipe loads. 150 lb. flanges standard 300 lb. optional. Dual volute casing standard on XLT sizes.

Impeller Fully open, partial shrouds for maximum vane support. Matched to casing for high efficiency and low NPSH. Impeller threaded on shaft, threads sealed by Teflon O-ring. Smoothly contoured passages for good solids and slurry handling. Statically balanced. Performance maintained by external impeller adjustment.

Stuffing Box Cover Encloses back of casing and contains stuffing box chamber. Cover available with jacket for cooling stuffing box chamber in high temperature services or heating viscous or high freezing point liquids.

Packed box has 5 rings of packing and a lantern ring. Quench gland with auxiliary ring of packing is standard. Gland is split for easy removal. Tapped opening to lantern ring permits external flushing or lubrication as required. Stuffing box completely machined for mechanical seal installation, either originally or as a field conversion. Inside or outside, tandem, double or single, balanced or unbalanced seals, with any required gland, restricting bushing and flushing lines furnished to meet individual sealing requirements. Gland completely confines stationary seat gasket.

Frame Adapter Machined rabbet fit to stuffing box cover. Contains stuffing box drip basin, non-sparking rotating deflectors, and inboard bearing oil seal. Model 3196 ST adapter is integral with bearing frame.

Bearing Frame Heavy cast iron construction. Contains large oil reservoir, with water jacket, standard on 3196 ST, MT and LTC. Oil level maintained by constant level oiler with visible oil supply. Oil seals on each end and breather fully protects oil from contamination. Dowel pins between frame and adapter provide precision alignment. Regreasable, greased-for-life, and oil mist lube arrangements available.

Shaft designed for .002" (.05 mm) maximum deflection at stuffing box face. All bearing and packing surfaces ground to less than 32 microinches. Shaft available with or without sleeve provides utmost flexibility to solve shaft sealing requirements.

Shaft Sleeve Renewable shaft sleeve is positively driven, hooktype, with one end free to expand with temperature variations. Teflon O-ring prevents leakage under sleeve. Sleeve permits application of inside balanced mechanical seals where required.

Bearings Inboard bearing is pressed on shaft and free to float axially in frame — carries radial load only. Outboard bearing is shouldered and locked on shaft with locknut and washer, and locked in bearing housing to carry radial and any unbalanced axial thrust load. All bearing fits are precision (bored or ground) machined.

Inboard bearing is single row, deep groove. Outboard bearing is double row, deep groove angular contact.

Both bearings are sized for two year minimum life.

Total Delivery and Repair Parts Service

Goulds Qwikship Program

Goulds QWIKSHIP program . . . the best pump delivery service in the industry. QWIKSHIP works — no reschedules. In fact, 90% of all QWIKSHIP orders have been shipped early.

QWIKSHIP

Advantages of using QWIKSHIP:

- Insure on-time startups
- Meet construction schedules
- Reduce process downtime
- Eliminate expediting
- No additional cost when shipped from factory
- Reduces in-plant inventory requirements

Total Repair Parts Service

1. SDS — Same Day Shipment If you urgently need a shaft or shaft sleeve, use Goulds SDS — your part will be shipped the same day we receive your order.

2. Breakdown Orders Get back on stream with Goulds Breakdown Order service. Any stocked part will be snipped the same day order is received.

3. Emergency Orders If you have an emergency after hours, your order will receive special handling even though the factory is closed.

4. Non-Stock Quick React Program For parts that are not stocked. Special handling assures best delivery.

5. Standard Orders If you need any pump part but in no particular hurry.

Goulds Warehouses Bring the Factory to You

Goulds warehouses are strategically located around the country to provide "next door" service. Call the nearest Goulds warehouse facility or write for details.

● Goulds Warehouse

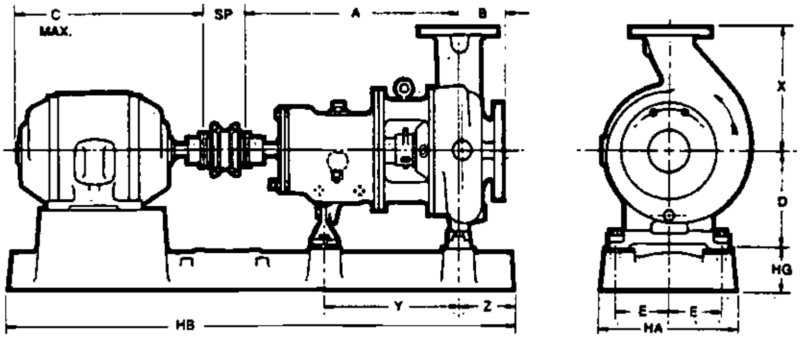
- Portland, OR
- Chicago, IL
- Houston, TX
- Atlanta, GA
- Fairfield, NJ
- Benton Station, ME

□ Distributor Warehouse

- Los Angeles, CA
- Casper, WY
- Green River, WY
- Lakeland, FL
- Little Rock, AR
- Nitro, WV
- Winfield, PA
- Amarillo, TX
- Corpus Christi, TX
- Odessa, TX
- Kilgore, TX
- Houma, LA
- Metairie, LA
- Shreveport, LA
- Oklahoma City, OK
- Tulsa, OK

Dimensions Model 3196

All dimensions in inches and (mm.) Not to be used for construction.



Model	Pump Size	ANSI Designation	Discharge Size	Suction Size	X	A	B	D	Y	Z	E	SP	Shaft Diameter at Cplg.	Key-Way	Pump Weight lbs. (kg.)
3196 ST	1 x 1½-6	AA	1	1½	6½ (165)	13½ (343)	4 (102)	5¼ (133)	7¼ (184)	4½ (114)	3 (76.2)	3¾ (95.3)	⅞ (22.2)	3/16 x 3/32 (4.8 x 2.4)	84 (38)
	1½ x 3-6	AB	1½	3											92 (42)
	2 x 3-6		2	3											95 (43)
	1 x 1½-8	AA	1	1½											100 (45)
	1½ x 3-8	AB	1½	3											108 (49)
3196 MT**	2 x 3-6	A10	2	3	8¼ (210)	19½ (495)	4 (102)	8¼ (210)	12½ (318)	4½ (114)	4⅞ (124)	3¾ (95.3)	1⅛ (28.6)	¼ x ⅛ (6.4 x 3.2)	160 (62)
	3 x 4-7	A70	3	4	11 (280)										220 (100)
	2 x 3-8	A60	2	3	9½ (242)										200 (91)
	3 x 4-8	A70	3	4	11 (280)										220 (100)
	3 x 4-8G	A70	3	4	11 (280)										220 (100)
	1 x 2-10	A05	1	2	8½ (216)										200 (91)
	1½ x 3-10	A50	1½	3	8½ (216)										220 (100)
	2 x 3-10	A60	2	3	9½ (242)										230 (104)
	3 x 4-10	A70	3	4	11 (280)										265 (120)
	3 x 4-10H	A40	3	4	12½ (318)	19½ (495)	4 (102)	10 (254)							275 (125)
	4 x 6-10	A80	4	6	13½ (343)										305 (138)
	1½ x 3-13	A20	1½	3	10½ (267)										245 (111)
	2 x 3-13	A30	2	3	11½ (292)										275 (125)
	3 x 4-13	A40	3	4	12½ (316)										330 (150)
	4 x 6-13	A80	4	6	13½ (343)										405 (184)
3196 XLT	6 x 8-13	A90	6	8	16 (406)	27⅞ (708)	6 (152)	14½ (368)	18¾ (476)	6½ (165)	8 (203)	5¼ (133)	2⅜ (60.3)	⅝ x 5/16 (15.9 x 7.9)	560 (254)
	8 x 10-13	A100	8	10	18 (457)										670 (304)
	6 x 8-15	A110	6	8	18 (457)										610 (277)
	8 x 10-15	A120	8	10	19 (483)										740 (336)
	8 x 10-15G	A120	8	10	12 (483)										710 (322)

**On LTC frame, shaft diameter at coupling is 1⅞. (47.6) keyway is ½" x ¼". (12.7) x (6.4) ps.

Model	Bed-plate	MOTOR: Motor Frame Sizes Applicable	MOTOR: C Max.	BEDPLATE: HA	BEDPLATE: HB	BEDPLATE: HG +⅜ (9.5) −⅛ (3.2)	BEDPLATE: Approx. Bedplate Weight Lbs. (kg.)
3196 ST	1	56-145	13½ (343)	10 (254)	35 (889)	3 (76.2)	75 (34)
	2	182-215	19½ (495)	12 (305)	39 (991)	3¼ (62.6)	80 (36)
	3	254-286	27 (686)	15 (381)	46 (1168)	4⅛ (105)	120 (54)
3196 MT	1	143-215	19½ (495)	12 (305)	45 (1143)	[1] 3¾ (95.3) / [2] 3¾ (95.3)	105 (48)
	2	254-286	27 (686)	15 (381)	52 (1321)	4⅛ (105) / 4⅛ (105)	155 (70)
	3	324-326	30 (762)	18 (457)	58 (1473)	4¾ (121) / 4¾ (121)	205 (93)
		364-365	34 (864)	18 (457)	58 (1473)	5¾ (146) / 4¾ (121)	
	4	404-405	35½ (902)	18 (457)	60 (1524)	6¾ (171) / 5 (127)	240 (109)
		440 SER	46½ (1181)	18 (457)	60 (1524)	7¾ (197) / 6 (152)	
3196 XLT	1	213-256	24 (610)	26 (660)	62 (1575)	4 (102)	375 (170)
	2	284-365	34 (864)	22 (559)	68 (1730)	4¾ (121)	
	3	404-445	46½ (1181)	22 (559)	80 (2032)	4¾ (121)	460 (209)
	4	447	46½ (181)	26 (660)	74 (1880)	4 (102)	435 (198)

[1] Applies to pumps where D = 8¼"
[2] Applies to pumps where D = 10"

PURPOSE	No. of Taps	TAP SIZE: 3196 ST	TAP SIZE: 3196 MT	TAP SIZE: 3196 XLT
Lantern Ring Connection or Seal Flush	1	¼"	⅜"	⅜"
Frame Adapter Drain	1	SLOT	1"	1"
Casing Drain (with asbestos gasket)	1	⅜"	⅜"	⅜"
Alternate Casing Drain	1	½"	½"	½"
Bearing Frame Cooling	4□	½"	½"	½"
Discharge Gage Connection	1	¼"	⅜"	⅜"
Suction Gage Connection	1	¼"	⅜" ■	⅜"
Bypass Connection	1	¼"	½"	½"
Quench Gland Connection (packing gland)	2	¼"	¼"	¼"

□ 2 Taps on Model 3196 XLT.
■ 4x6-10 and 4x6-13 have no tap. 3x4-8 and 3x4-13 have ¼" (6.4) tap.

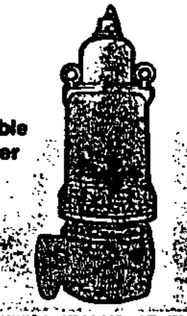
Model 3196 MT illustrated. Dimensions apply to 3196 ST, 3196 MT and 3196 XLT. Dimensions apply to both 150 and 300 pound flanges. Flanges are drilled to ANSI dimensions.

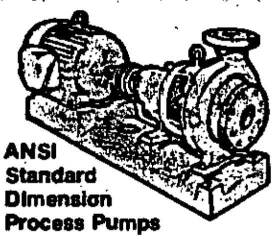
Widest Range of Pumps in Industry

Goulds makes pumps... nothing but pumps, and is totally committed to building better pumps. And, no manufacturer has the breadth of line of Goulds Pumps. Pumps made from many different materials to handle a wide range of applications: from moving plain water to the most severe corrosives and erosives, from pumping a few gallons a minute to hundreds of thousands of gallons.

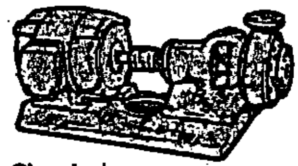
ANSI In-Line Process Pumps

Submersible Wastewater Pumps

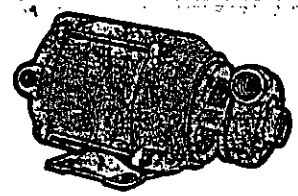




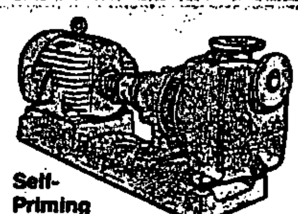
ANSI Standard Dimension Process Pumps



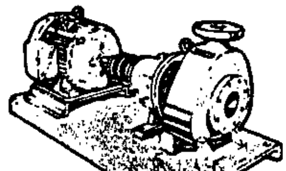
Chemical and General Service Pumps



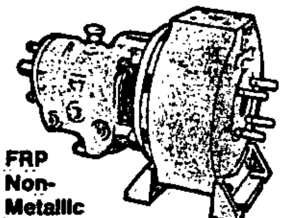
Chemical Circulating and Transfer Pumps



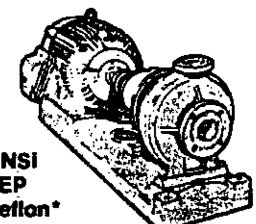
Self-Priming Process Pumps



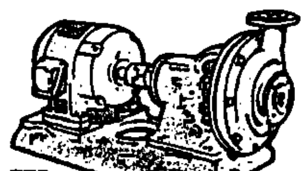
FRP Non-Metallic Chemical Process Pumps



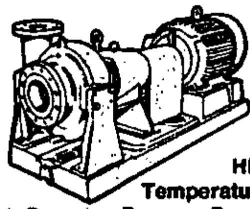
FRP Non-Metallic Process Pumps



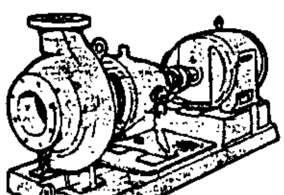
ANSI FEP Teflon* Process Pumps



FEP Teflon* Process Pumps

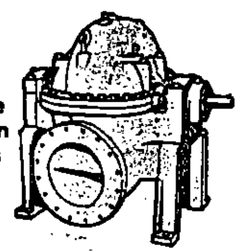


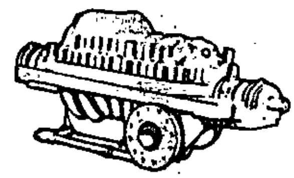
High Temperature/ High Pressure Process Pumps



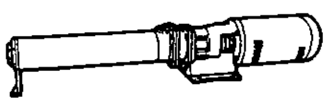
Heavy Duty Process Pumps

Double Suction Pumps

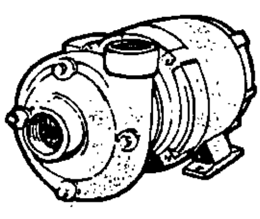




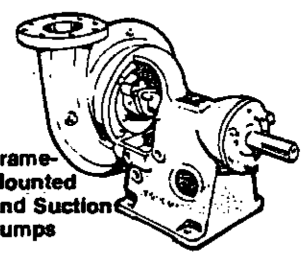
High Pressure Multi-Stage Pumps



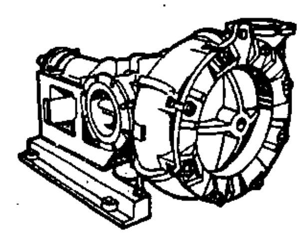
Low Flow/High Head Multi-Stage Pumps



Close-Coupled Pumps

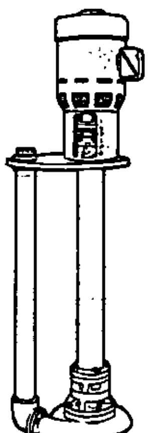


Frame-Mounted End Suction Pumps

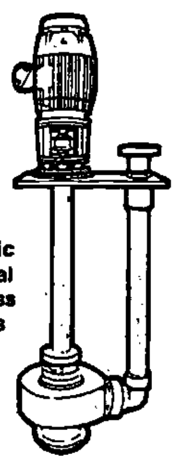


Solids Handling Pumps

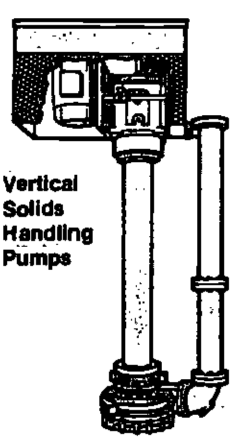
Vertical Sump & Process Pumps



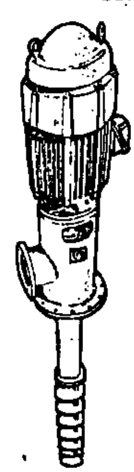
FRP Non-Metallic Vertical Process Pumps



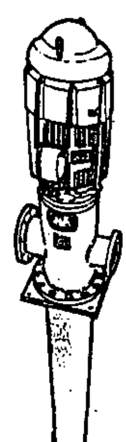
Vertical Solids Handling Pumps



Vertical Industrial Turbine Pumps



Vertical Industrial Can-Type Pumps

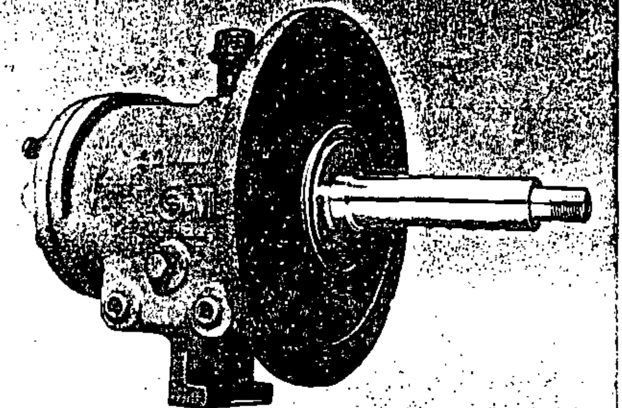


*E.I. DuPont Reg. Trademark

Power End Designed for Maximum Interchangeability

Two bearing frames fit 5 pump models: consider the advantages of Goulds interchangeability

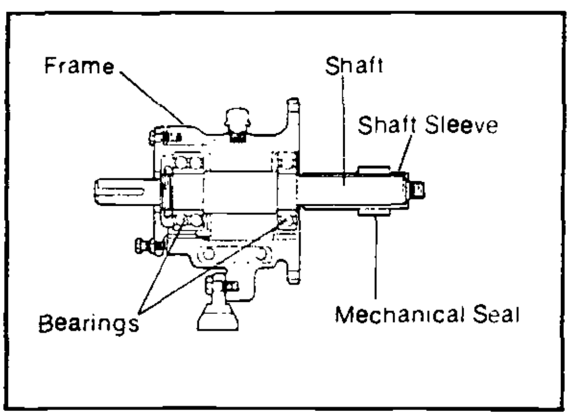
Approximately 90% of pump maintenance is performed on the power end... important that the power end is designed for maximum interchangeability.



Goulds ST & MT power ends are completely interchangeable with five different process pumps.

Consider the advantages of Goulds interchangeability:

- **Minimum Inventory** You need stock only two power ends — savings are substantial.
- **Flexibility in Changing Processes** Meet changing processes most economically with minimum downtime.
- **Minimum Downtime** Ready availability of spare power end reduces downtime and cuts costs. Cost of spare pump is eliminated.
- **Mechanical Reliability** All five Goulds models meet or exceed ANSI standards for mechanical reliability.
- **Save Energy** Original pump performance maintained with fully open impeller and easy external adjustment.



2 power ends/5 ANSI process pumps/56 sizes

1. Model 3996

In-Line Process Pumps
- Capacities to 1500 GPM (340 m³/h)
- Heads to 700 feet (207 m)

13 sizes — **Bulletin 725.2**

2. Model 3198

FEP Teflon* Process Pumps
- Capacities to 800 GPM (182 m³/h)
- Heads to 440 feet (134 m)

*E.I. DuPont Reg. Trademark

4 sizes — **Bulletin 725.3**

3. Model 3196

Standard Dimension Process Pumps
- Capacities to 4500 GPM (1022 m³/h)
- Heads to 730 feet (222 m)

20 sizes — **Bulletin 725.1**

4. Models NM4100-4120

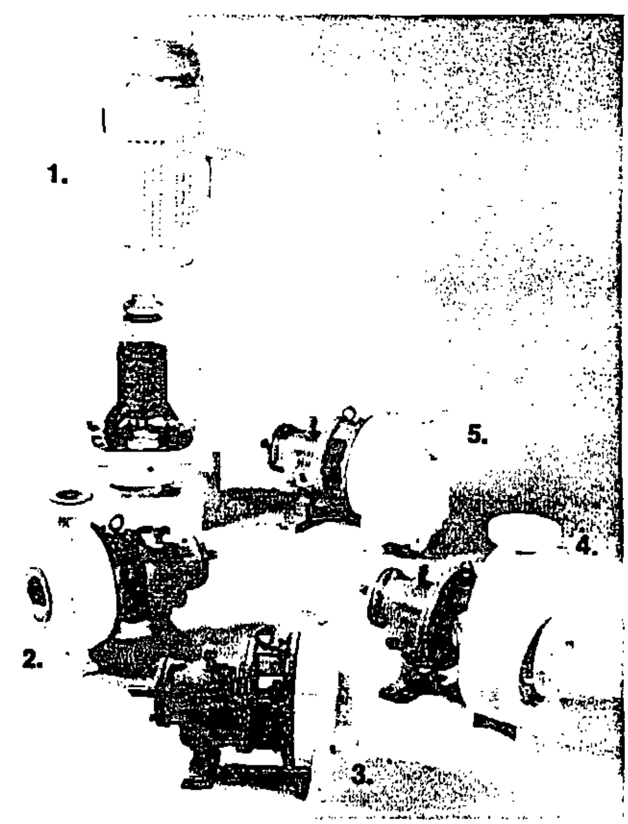
FRP Non-Metallic Process Pumps
- Capacities to 2200 GPM (500 m³/h)
- Heads to 290 feet (88 m)

12 sizes — **Bulletins 725.5 & .5A**

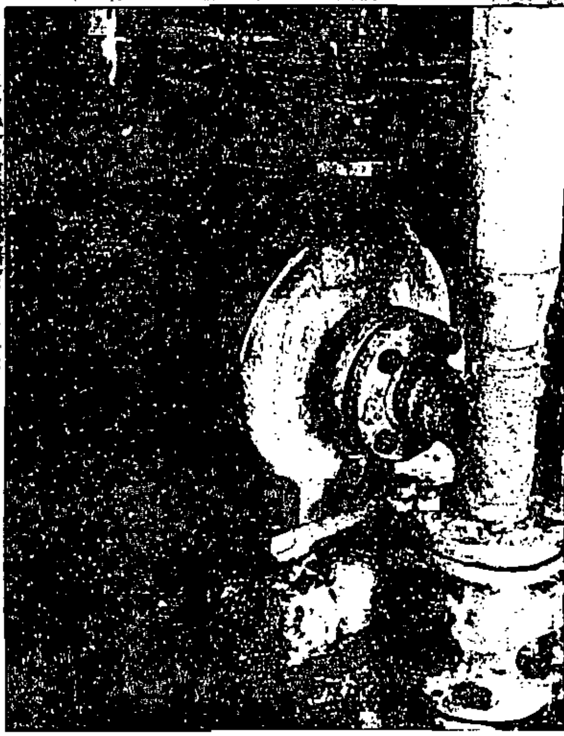
5. Model 3796

Self-Priming Process Pumps
- Capacities to 1500 GPM (340 m³/h)
- Heads to 375 feet (114 m)

7 sizes — **Bulletin 725.2**



Goulds Model 3196...Proven Operating Experience



It's still the pump it used to be

The best way to measure a pump's performance is over its entire working life — and no other pump can measure up to Goulds 3196. The 3196 pictured here is a good example. [illegible] it's still the pump it was when installed in a major chemical plant in 1966. Even after pumping millions of gallons of corrosive slurry, it's still pumping within one percent of its original high efficiency — a benefit of the external impeller adjustment feature. As the impeller wore, the clearance was simply and quickly re-established (on-site).

Also, maintenance records showed no breakdowns or repairs since it was installed. A remarkable record considering the severe service.

The 3196 is built to last. Pound for pound, dollar for dollar, you can't buy a better pump than Goulds 3196.

Branch Sales Offices

*Atlanta—Atlanta, GA (404) 455-4800
Baltimore—Hunt Valley, MD (301) 666-7900
Baton Rouge—Baton Rouge, LA (504) 927-3870
Beaumont—Beaumont, TX (713) 832-3447
*Benton Station—ME (207) 453-9794
Birmingham—Birmingham, AL (205) 939-0533
Boston—Wellesley Hills, MA (617) 235-3635
Buffalo—Cheektowaga, NY (716) 634-3114
Charleston—St. Albans, WV (304) 722-4241
Charlotte—Charlotte, NC (704) 527-2177
*Chicago—Lisle, IL (312) 960-3400
Cincinnati—Cincinnati, OH (513) 528-5770
Cleveland—Parma, OH (216) 842-7470
Dallas—Richardson, TX (214) 234-3967
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*Portland—Beaverton, OR (503) 644-7867
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Seattle—Lynnwood, WA (206) 774-1258
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Tampa—Lutz, FL (813) 961-5085
Tulsa—Tulsa, OK (918) 622-2400
Wilmington—Newark, DE (302) 737-8708

International Sales Offices

Goulds Pumps, Inc.—Headquarters, Seneca Falls, NY (315) 568-2811 (TLX 93-7290)
Goulds Pumps Southeast Asia Office—Singapore, Republic of Singapore 235-5715 (TLX 26126)
Goulds Pumps European Office—The Hague, Netherlands (070) 64-38-42 (TLX 31441)
Goulds Pumps—Middle East Office—Athens, Greece (30-1) 728-506 (TLX 218464)
Goulds Pumps Latin American Office—Coral Gables, Florida (305) 446-1607 (TLX 803286)
Dammam, Saudi Arabia—383-29758 (TLX 602016)

Manufacturing Plants

Engineered Products Division—Seneca Falls, NY (315) 568-2811 (TLX 93-7290)
Vertical Pump Division—City of Industry, California (213) 692-0211 (TLX 67-0458)
Texas Division—Lubbock, Texas (806) 763-2361 (TLX 744411)
Goyne Pump Division—Ashland, Pennsylvania (717) 875-2660
Bombas Goulds de Mexico, S.A. de C.V.—Mexico City, Mexico 593-6730
Goulds Bombas e Equipamentos LTDA—Salto, S.P., Brazil (11) 251-1035 (TLX 113953)
Goulds Pumps (Phil.) Inc.—Manila, Philippines 88-74-71 (TLX 63663)
Goulds Pumps Europe AG—Zofingen, Switzerland (062) 52-19-91 (TLX 68246)

Manufacturing Licensees

Beloit Canada Ltee/Ltd.—Goulds Pumps Division—Pointe Claire, Quebec, Canada (514) 695-8520 (TLX 05-821528)
Goulds D-P. Drakos Polemis Pumps Manufacturers Inc.—Kifissia, Greece (30-1) 80-34-411 (TLX 216929)
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Houston PRO Shop—Houston, TX (713) 433-0055

Corporate Headquarters

Goulds Pumps, Inc.—Seneca Falls, NY (315) 568-2811 (TLX 93-7290)

*Stocking Warehouses

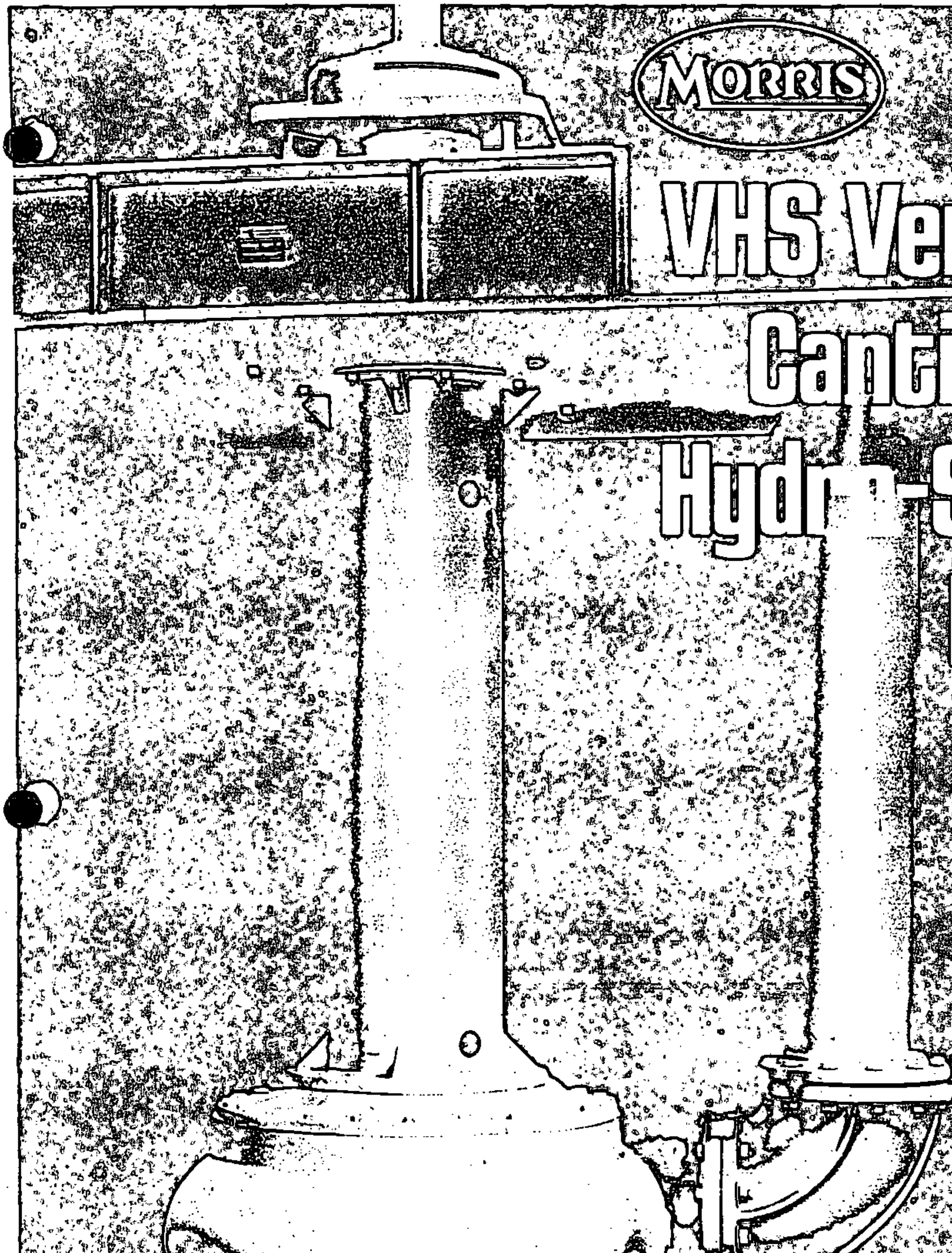
GOULDS PUMPS, INC.
SENECA FALLS, NEW YORK 13148

Form EP01

Printed in U.S.A.

MORRIS

VHS Vertical Cantilever Hydro-Solids Pump



You Can't Match a Morris Pump

MORRIS PUMPS, INC.
BALDWINSVILLE, NEW YORK 13027

VHS Vertical Cantilever Pump

Offers Unmatched Solids-Handling Ability in Process and Waste Sump Applications

RECESSED IMPELLER VERSATILITY

The VHS pumps all kinds of large solids, and certain frothy liquids, because its impeller is totally recessed within an extra-deep casing. Maximum solid size equals the pump's suction diameter! In addition, the recessed impeller allows the VHS to run dry without creating excessive hydraulic or mechanical shock when prime is regained.

VERTICAL CANTILEVER DESIGN

All maintenance and downtime costs created by submerged bearing failures are eliminated with the VHS' vertical cantilever design. Axial and radial loads are transmitted by an extra-rigid pump shaft to high-capacity bearings (25,000 hour minimum B-10 life) located in a sealed bearing frame above the floor plate. Because no oil or water lines are required to lubricate submerged bearings, the VHS is simpler to install and is well-suited to remote installations.

MATERIALS OF CONSTRUCTION

Three basic alloys are offered to allow the VHS to handle a wide range of liquids. Cast iron is standard and offers good life when pumping non-corrosive liquids containing mildly abrasive solids. Hardened High Chromium is available for use in the more abrasive applications. 316 Stainless Steel construction is supplied for corrosive services.

OTHER MORRIS "HYDRO-SOLIDS" PUMPS

Morris offers the horizontal HS, the vertical dry-pit HSD, the vertical wet-pit HSV, and the submersible HSU to handle similar liquid/solid combinations. With the exception of the HSU, all share the same pumping ends. Whatever your application, you can be sure of skilled assistance from Morris' Sales Representatives and factory personnel.

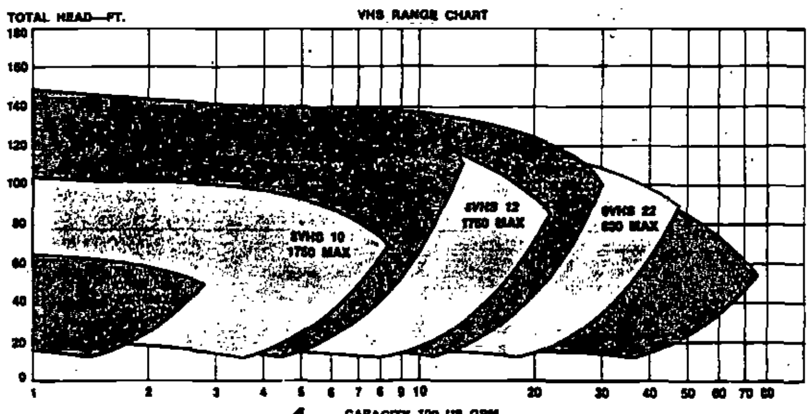
TYPICAL VHS APPLICATIONS

Allied Chemical Corporation	Ash Slurry
Aluminum Company of America	Bauxite Slurry
American Electric Power Corporation	Ash Slurry
American Synthetic Rubber Corp.	Wastewater with Latex
Bethlehem Steel Corporation	Mill Scale
Charmin Paper Products	Waste Paper Stock
Chevrolet Motor Div. GMC	Sand Slurry
Duke Power Company	Fly Ash
Fiber Industries, Inc.	Settled Sludge
Freeman Coal Company	Coal Slurry
International Paper Company	Black Liquor
Interpace Corporation	Clay and Water
Ohio Power Company	Coal and Water
Owens-Corning Fiberglas	Fiber Glass Strands
Reynolds Metals Company	Milk of Lime
Charles Simkin and Sons, Inc.	Plating Wastes
Sun Oil Company	Water, Oil, Sand
United States Steel	Coal Fines
Utah-Idaho Sugar Company	Settling Basin Underflow
White Pigment Company	Water and Marble Chips

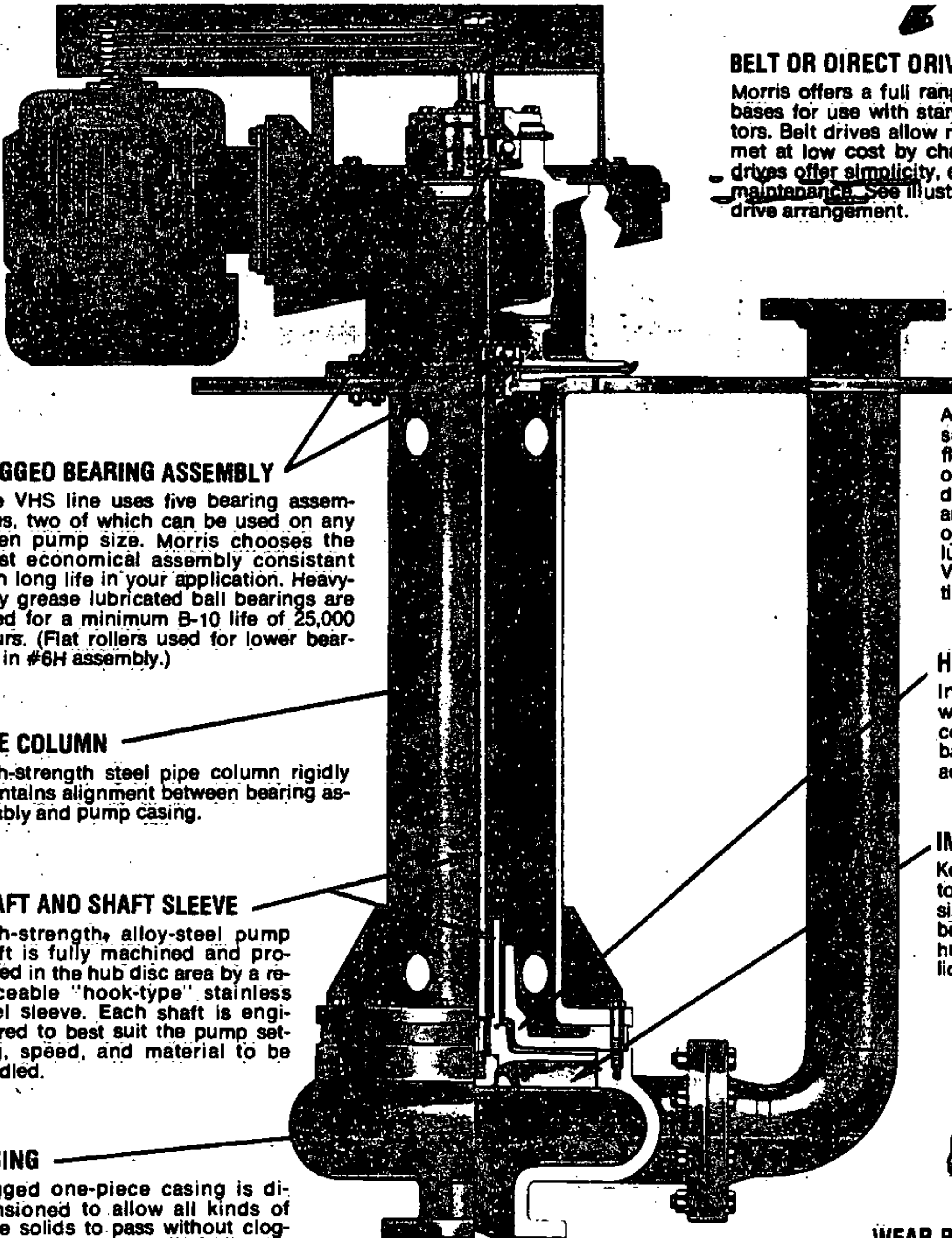
SIZES, DRIVES, AND SETTINGS

VHS pumps are offered in 2, 3, 4, 6, 8, and 10-inch models for capacities to 7,000 USGPM and heads to 140 feet. Motor supports for direct or belt drives are available for all standard NEMA motor frame sizes. Maximum settings range from 4 feet in the 2 VHS to 8 feet in the 10 VHS; deeper sumps can be pumped by using extended suction pipes.

500 GPM – 140' TH
up to large 4" ϕ solid
$8,000 = pump
1,500
50HP motor
Ca. abt $10,000



TOTAL HEAD DOES NOT TAKE INTO CONSIDERATION LOSSES IN DISCHARGE PIPE AND ELBOW.



BELT OR DIRECT DRIVES

Morris offers a full range of belt and direct drive motor bases for use with standard NEMA T (or TP) frame motors. Belt drives allow new operating requirements to be met at low cost by changing belts and sheaves. Direct drives offer simplicity, ease of installation, and minimum maintenance. See illustration on page 4 for typical direct drive arrangement.

VERTICAL CANTILEVER DESIGN

All pump bearings are located in a single housing above the pump floor plate—out of the sump and out of trouble. This means reduced installation, maintenance and downtime costs. Because no oil or water lines are required to lubricate submerged bearings, the VHS is ideal for remote installations.

RUGGED BEARING ASSEMBLY

The VHS line uses five bearing assemblies, two of which can be used on any given pump size. Morris chooses the most economical assembly consistant with long life in your application. Heavy-duty grease lubricated ball bearings are sized for a minimum B-10 life of 25,000 hours. (Flat rollers used for lower bearing in #6H assembly.)

PIPE COLUMN

High-strength steel pipe column rigidly maintains alignment between bearing assembly and pump casing.

HUB DISC

Independent hub disc is sandwiched between casing and pipe column. Minimizes liquid "blow-back" around shaft sleeve without actual sealing contact.

SHAFT AND SHAFT SLEEVE

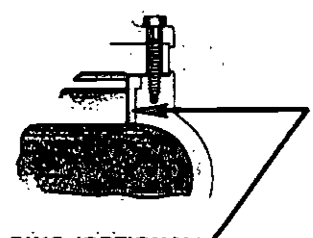
High-strength, alloy-steel pump shaft is fully machined and protected in the hub disc area by a replaceable "hook-type" stainless steel sleeve. Each shaft is engineered to best suit the pump setting, speed, and material to be handled.

IMPELLER

Keyed-on impeller is fully recessed to allow passage of solids equal in size to pump suction. "O" rings behind impeller nut and impeller hub seal shaft end from corrosive liquids.

CASING

Rugged one-piece casing is dimensioned to allow all kinds of large solids to pass without clogging. Circular casing design enhances vortex pumping action.



WEAR RING (OPTIONAL)

Replaceable wear ring offers added casing protection against abrasives.

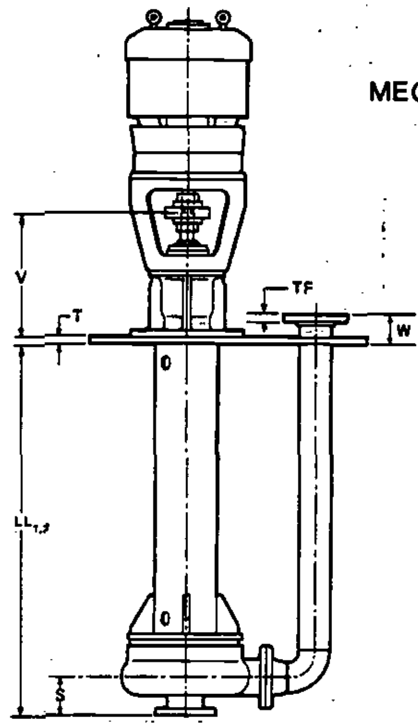
VHS PUMP CONSTRUCTION

100	*Casing	Cast Iron	High Chr. Iron	316 S.S.	316 S.S.
200	*Impeller	Cast Iron	High Chr. Iron	316 S.S.	316 S.S.
220	*Impeller Nut	316 S.S.	316 S.S.	316 S.S.	316 S.S.
400	*Hub Disc	Cast Iron	High Chr. Iron	316 S.S.	F.R.P.—A
600	Shaft	Steel—1045	Steel—1045	316 S.S.	316 S.S.
619	*Shaft Sleeve	416 S.S.	416 S.S.	316 S.S.	316 S.S.
1600	Pipe Column	Struc. Steel	Struc. Steel	316 S.S.	F.R.P.—A
2800	Floor Plate	Plate Steel	Plate Steel	Plate Steel	Plate Steel
9000	Discharge Elbow	Steel	Steel	316 S.S.	F.R.P.—B
9001-3	Discharge Pipe & Flange	Steel	Steel	316 S.S.	F.R.P.—B
	Hardware Below Floorplate	302 S.S.	302 S.S.	302 S.S.	302 S.S.

*Part interchanges with HS horizontal pump of like size.

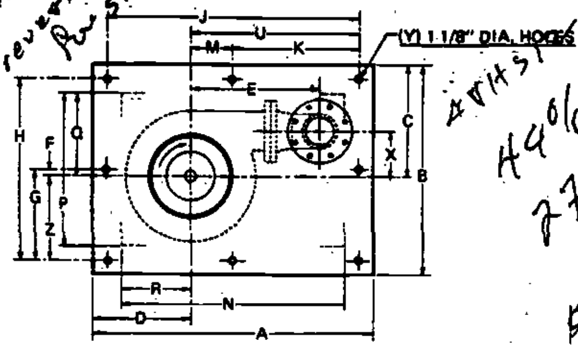
Cast Iron	ASTM A 48, Classes 25 & 35
High Chromium Iron	ASTM A 532, Class III, Type A—Hardened
316 Stainless Steel	AISI 316 or ASTM A 296, Grade CF-8M (cast)
416 Stainless Steel	AISI 416
F.R.P.—A	Fiberglass Reinforced Plastic (Polyester)
F.R.P.—B	Fiberglass Reinforced Plastic (Vinyl Ester)
302 Stainless Steel	AISI 302

MORRIS VHS Vertical Cantilever Hydro-Solids Pump



MECHANICAL SPECIFICATIONS AND DIMENSIONAL DATA

Capable of running dry
can reverse w/o damage
Run short time



4VHS?
44% eff
27-28 bhp
30 to 40 hp mtr
$7500.00
w/motor only
2,000#
4" outlet
4" solids

2 VHS	2	6	⅝	4¾	4	¾
3 VHS	3	7½	¾	6	4	¾
4 VHS	4	9	15/16	7½	8	¾
6 VHS	6	11	1	9½	8	⅞
8 VHS	8	13½	1⅛	11¾	8	⅞
10 VHS	10	16	1 3/16	14¼	12	1

V	15¼	17¾	22	27¾	27¾
Shaft Dia. at Coupling	1⅜	1¾	2⅜	3½	3½

2 VHS 8	8	8	6	2
3 VHS 10	8	10	7	3
4 VHS 12	8	12	9	4
6 VHS 12	8	12	9	6
6 VHS 18	8	18	12	6
8 VHS 22	8	22	16	8
10 VHS 26	8	26	18	10

A	30	36	40	48	60	66	78
B	24	30	30	36	40	48	60
C	13	16	16	19	21	25	31
D	12	14	14	16	23	23	28
E	12 9/16	15 7/16	18 9/16	22 9/16	25 9/16	32 9/16	38 1/16
F	—	—	—	—	—	1"	1"
G	—	—	—	—	—	22	28
H	20	26	26	32	36	44	56
J	26	32	36	44	56	62	74
K	—	—	18	22	28	31	37
M	—	—	6	8	7	10	11
N	22	28	32	40	52	58	70
P	16	22	22	28	32	40	52
Q	9	12	12	15	17	21	27
R	8	10	10	12	19	19	24
S	3	4½	5½	7½	7½	9	10½
T	¾	¾	¾	¾	¾	¾	¾
U	16	20	24	30	35	41	48
W	4½	4½	4½	6½	6½	6½	6½
X	4⅜	5½	6½	6½	9⅝	12	14
Y	4	4	6	6	6	8	8
Z	9	12	12	15	17	21	27

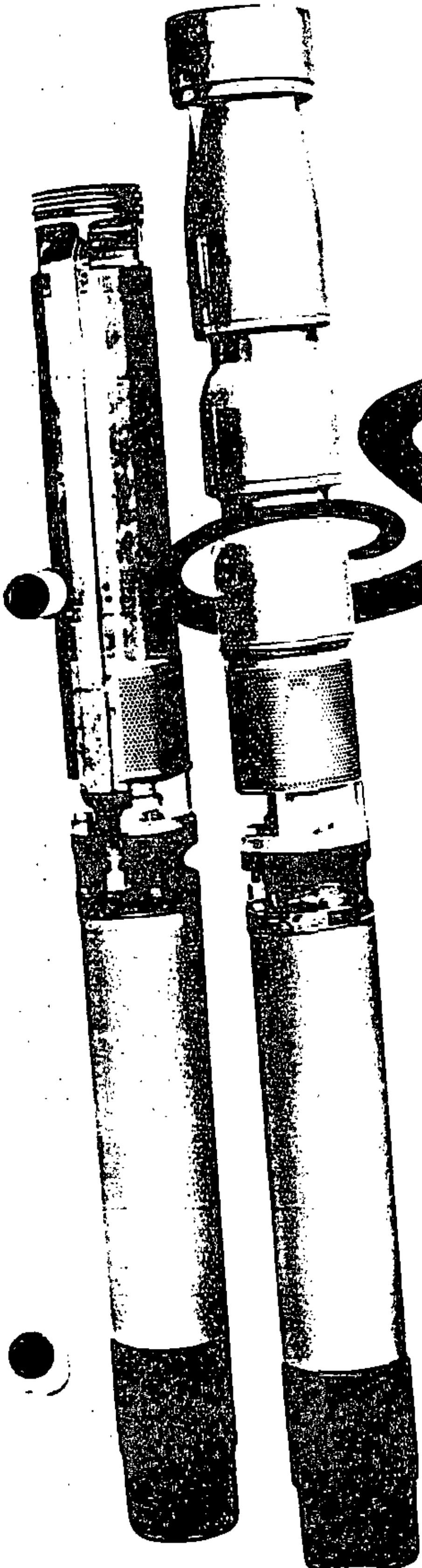
LL_1	24	36	36	48	48	48	72
Brg. #	II	III	III	III, IV	IV	V	V
LL_2	48	72	72	96	96	96	96
Brg. #	III	IV	IV	V	V	VI	VI

Construction details and dimensions are for general information only and are subject to change without notice.

MORRIS PUMPS, INC.
BALDWINSVILLE, NEW YORK 13027

CRANE

DEMING PUMPS



HEAVY DUTY

Submersible

TURBINE PUMPS

Quality and Dependability

CAPACITIES

10 GPM TO 850 GPM

TOTAL HEADS TO 1000 FT.

Heavy-Duty Submersible Turbine Pumps

Figure 6721

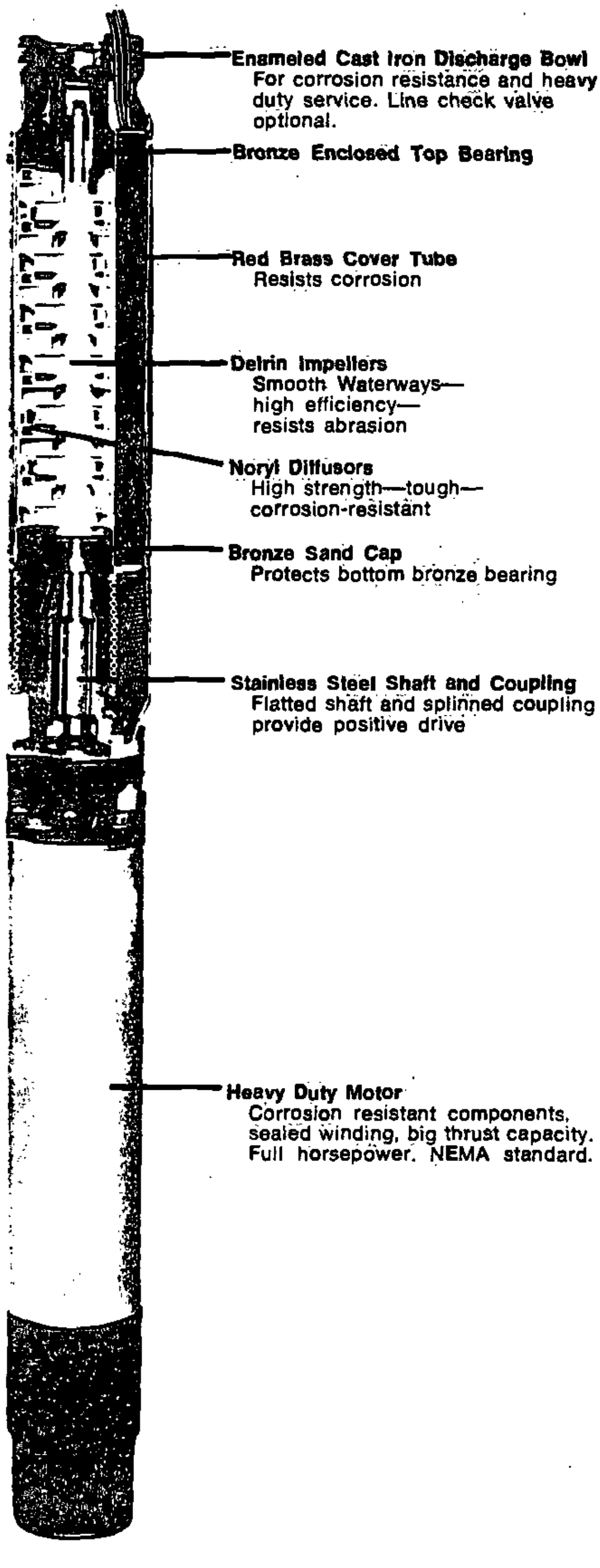
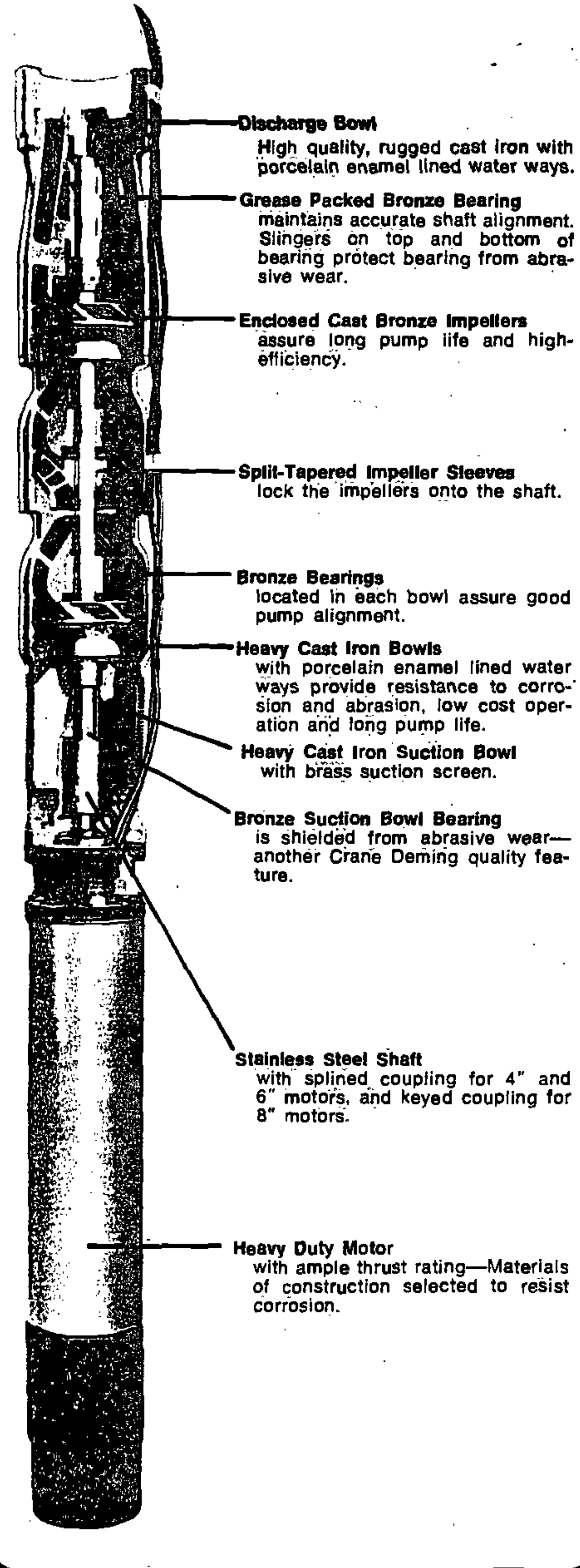


Figure 6730



CRANE DEMING SUBMERSIBLE TUR

CAPACITY IN GPM

		HP	No. Stages	Recommended Riser Pipe Size I.D.	Unit No.	VERTICAL DISTANCE TO LOWEST WATE																				
						60		80		100		120		140		160		180		200		240		280		3
						Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tan
						0	50	0	50	0	50	0	50	0	50	0	50	0	50	0	50	0	50	0	50	0
For Wells 6" I.D. and Larger	30 GPM Series "XL"	2	5	2	2XL5		21	41		39		36		32		26		19								
		3	7		3XL7						28		24	39		37		34		31		22				
		5	13		5XL13										38		38		35		33	39	30	36	26	
		7½	17		7½XL17																39		38		34	
		10	25		10XL25																					
	50 GPM Series "L"	3	5	2½	3L5		42		30	60		57		53		47		40		25						
		5	7		5L7		56		53		49		44	60	38	58	28	55		52		43		24		
		7½	10		7½L10				61		59		58		56		54		52	60	49	57	42	53	28	45
		10	13		10L13												60		59		58		55	60	51	58
		15	20		15L20																				61	
		20	25		20L25																					
	75 GPM Series "M"	5	5	2½	5M5		88	90	55	89	35	85		81		74		66		53						
		7½	7		7½M7		85		83		78		72		64	87	53	85	33	81		70		51		
		10	10		10M10								88		86		84		80		77	88	66	83	51	[illegible]
		15	15		15M15																89		87		84	
		20	20		20M20																					
		25	25		25M25																					
	100 GPM Series "H"	7½	5	3	7½H5			109	96		80		53	120		115		105		93						
		10	7		10H7						118		111		104		95		83	120	70	110		92		
		15	10		15H10														120		116		107	120	94	[illegible]
		20	13		20H13																		120		114	
		25	17		25H17																					
	110 GPM Series "M5E"	5	3	4	5M5E3		62	122		120		109		94		78		58								
		7½	4		7½M5E4		101		88		74		57	120	32	110		98		85		52				
		10	6		10M5E6				120		116		110		103		98		88	120	78	108	56	95		[illegible]
		15	9		15M5E9														120		117		109		101	[illegible]
		20	12		20M5E12																					
		25	15		25M5E15																					
	150 GPM Series "H5E"	5	2	4	5H5E2			160		136		97														
		7½	3		7½H5E3		105	170		168		159		144		125		98								
		10	4		10H5E4		152		139		123		102	168	70	160		148		135		96				
		15	6		15H5E6						166		162		155		148		139	169	128	160	102	146	50	125
		20	9		20H5E9																167		159		149	166
		25	11		25H5E11																		172		166	
		30	13		30H5E13																					
	180 GPM Series "XH5E"	5	2	4	5XH5E2			76		122																
		7½	3		7½XH5E3					205		188		160		120										
		10	4		10XH5E4		160		126		88	215		200		160		154		120						
		15	5		15XH5E5				212		200		164		166		142		112	210	70	180		137		
		20	6		20XH5E6										213		202		189		176		139	199		[illegible]
		25	8		25XH5E8														216		209		192		173	[illegible]
		30	10		30XH5E10																				209	
For Wells 6½" I.D. and Larger	250 GPM Series "M6E"	10	2	4	10M6E2					280		250		204		85										
		15	3		15M6E3		260		232		180		102			274		257		222		93				
		20	4		20M6E4				262		272		255		235		198		142	280	94	252		183		[illegible]
		25	5		25M6E5												275		254		232		155	270	89	[illegible]
		30	6		30M6E6																		256		216	
		40	8		40M6E8																					
		50	10		50M6E10																					
	340 GPM Series "H6E"	10	2	4	10H6E2	370		340		305		235		160												
		15	3		15H6E3		248	393	190	375	120	352		325		288		240		175						
		20	4		20H6E4		332		308	400	276	385	240	370	196	350	144	328		300		231		130		
		25	5		25H6E5		367		350		330	400	308	391	284	378	256	363	225	344	188	302		249		
		30	6		30H6E6		385		372		360		348		330	393	314	382	295	345	272	302	224	310	180	[illegible]
		40	8		40H6E8						393		385		379		369		360	400	350	384	329	368	305	[illegible]
		50	10		50H6E10														400		394		379		360	[illegible]
For Wells 9" I.D. and Larger	700 GPM Series "M8E"	15*	1	6	15M8E1	690		530		325																
		20*	1		20M8E1	770		650		480																
		25*	2		25M8E2	800		730		662		582		495		385										
		30	2		30M8E2	850	478	605	372	760		700		635		550		455		345						
		40	2		40M8E2		615		520	830	405	790		740		675		600		500		230				
		50	3		50M8E3		760		725		682	835	633	810	575	785	513	750	440	715		620		495		[illegible]
		60	4		60M8E4		813		785		758		728	850	693	825	652	805	613	780	565	720	463	645	350	550
		75	5		75M8E5		850		835		815		797		775	855	755	845	727	830	700	795	632	750	558	[illegible]

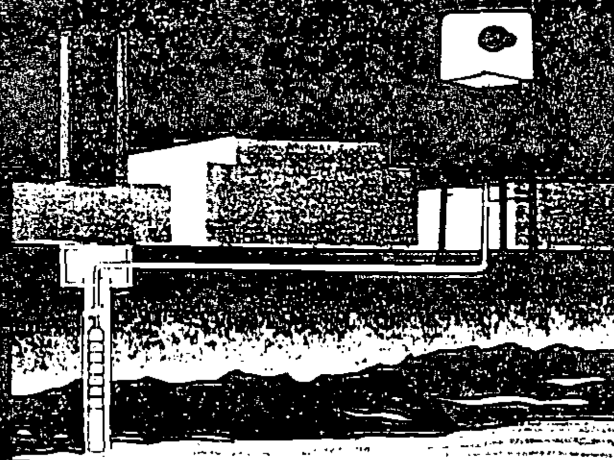
SIBLE TURBINE SELECTION CHART

CAPACITY IN GPM

VERTICAL DISTANCE TO LOWEST WATER LEVEL IN WELL (Feet) — ADD FOR FRICTION IN RISER PIPE

	180	200		240		280		320		360		400		440		480		520		560		600		640		680		720		760		800	
	nk PSI	Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI	
	60	[illegible]	60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9																																	
4		31		22																													
	35		33	39	30	36	26	33	21	30	13	25		20		13																	
			39		36		34	39	31	36	28	33	24	30	20	27	16	24		20		15											
											36		36	39	35	38	33	36	31	34	29	33	27	31	25	29	22	27	19	24		22	
0		25																															
5		52		43		24																											
	52	60	49	57	42	53	28	48		40		26																					
	59		58		55	60	51	58	46	55	38	50	25	45		37																	
							61		60		59	61	57	60	55	59	52	57	49	55	44	52	38	48	29	44		37		28			
															81		80		58	61	57	60	54	58	52	56	49	54	45	52	40	49	32
8		53																															
5	33	81		70		51																											
	80		77	88	66	83	51	75		65		49																					
			89		87		84		80	87	76	84	70	80	62	75		69		61		48											
									88		87		85	88	83	87	80	85	76	83	71	79	65	76	57	70	45	64		56		43	
															89		86		84	88	81	86	79	83	78	81	73	79	69	76	65	83	60
5		93																															
	83	120	70	110		92		65																									
	120		116		107	120	94	115	75	105		91		72																			
					120		114		107	119	100	113	90	106	78	98	57	89		75		54											
											119		115		110	119	104	114	98	109	90	104	80	97	64	88		78		62			
8																																	
8		85		52																													
	86	120	78	108	56	95		78		54																							
	120		117		109		101	116	90	108	79	100	64	90	45	78		62		40													
									117		110		103	117	95	109	86	102	77	94	66	85	53	75	35	65		50					
															116		111		105	115	100	110	94	104	87	98	81	93	72	87	62	80	48
8																																	
8		135		96																													
	139	169	128	160	102	146	50	125		97																							
			167		159		149	166	138	158	125	148	106	136	81	123		104		78													
					172		166		159		150	165	142	158	130	150	117	140	100	129	80	115	53	98		79		50					
									172		165		157	170	148	164	139	156	130	147	119	138	107	128	93	118	76	105	54	91		73	
4		120																															
	112	210	70	160		137																											
	189		176		139	199		172		132																							
	218		209		192		173	207	149	190	113	170		145		108																	
							209		195		180	208	162	194	141	178	112	160	66	138		107											
57		222		93																													
	142	280	94	252		183		86																									
	254		232		155	270	89	226		146		85																					
					256		216		144	253	66	206		135		83																	
									275		254		223	273	177	252	130	220	91	172		125		86									
															273		254		229	271	199	250	158	226	120	195	84	155		116			
40		175																															
28		300		231		130																											
63	225	344	188	302		249		180																									
82	295	345	272	302	224	310	160	268		218		154																					
	360	400	350	384	329	368	305	348	276	327	242	302	196	272	140	238		190		136													
	400		394		379		360	392	344	376	324	380	302	342	275	322	244	298	204	272	160	240		200		148							
55		345																															
00		500		230																													
50	440	715		820		495		335																									
05	613	780	585	720	463	645	350	550		450		335		220																			
45	727	830	700	795	632	750	558	690	475	625	383	550		465		375		280		200													

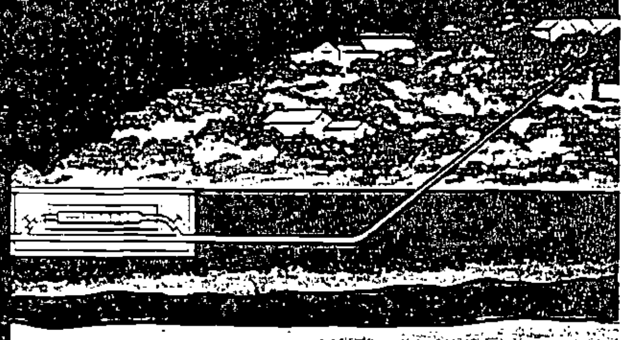
64		680		720		760		800	
Tank PSI		Tank PSI		Tank PSI		Tank PSI		Tank PSI	
0	50	0	50	0	50	0	50	0	50
31	25	29	22	27	19	24		22	
48	29	44		37		28			
58	52	56	49	54	45	52	40	49	32
76	57	70	45	64		56		43	
83	78	81	73	79	69	76	65	83	60
97	64	88		78		62			
75	35	65		50					
104	87	96	81	93	72	87	62	80	48
98		79		50					
128	93	118	76	105	54	91		73	
86									
228	120	195	84	155		116			
200		148							



WATER SUPPLY

CRANE DEMING Submersibles for water supply in municipal, industrial and commercial systems. Silent operation, free from vandals, best efficiency, save pumphouse cost.

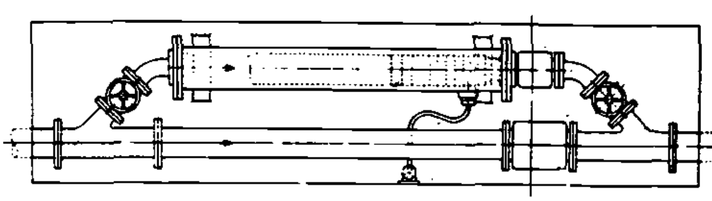
Save on operator's expenses — install a CRANE DEMING SUBMERSIBLE.



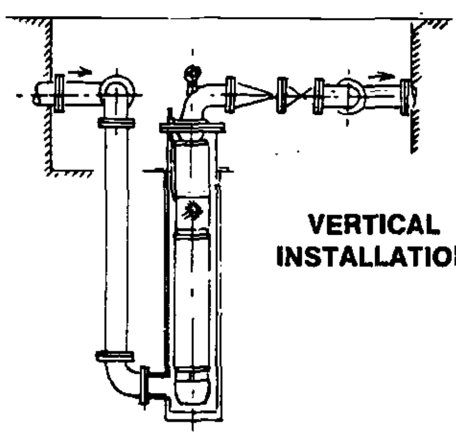
BOOSTER SERVICE

Extra pressure to satisfy municipal growing pains can be easily handled by CRANE DEMING Submersible pumps.

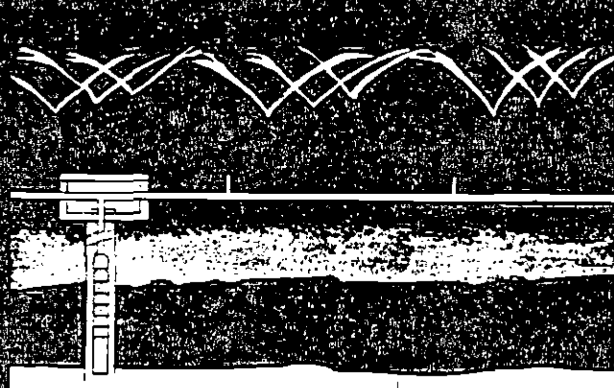
Install these units in-line, underground, vertically or horizontally, in easily constructed pits. Be a good ecology neighbor — preserve valuable real estate — no pumphouse required.



HORIZONTAL INSTALLATION WITH BY-PASS



VERTICAL INSTALLATION



IRRIGATION

CRANE DEMING Submersible Turbines pump large capacities at low cost for flood or sprinkler irrigation. Save maintenance on above ground equipment. Save the cost of erecting a pumphouse.—If the water level drops in the well, add cable and riser pipe and lower the pump as required.

CRANE DEMING Submersibles work for you as a profit maker.

FIG. 6721

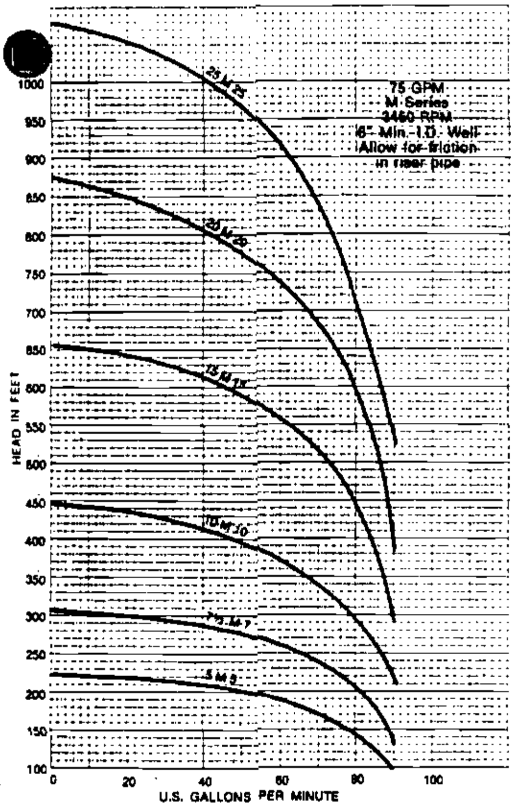


FIG. 6721

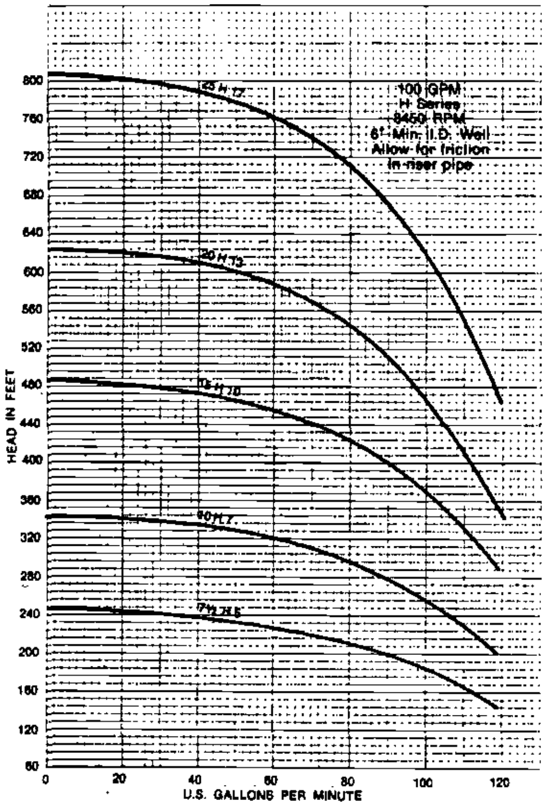


FIG. 6730

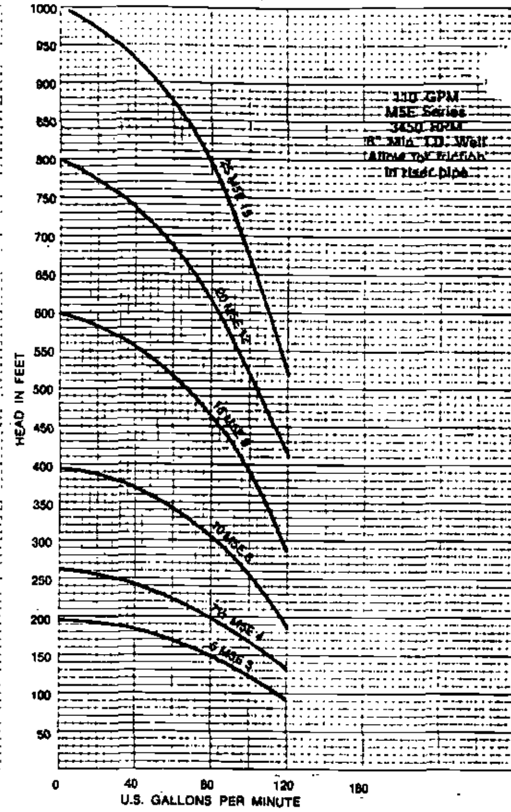


FIG. 6730

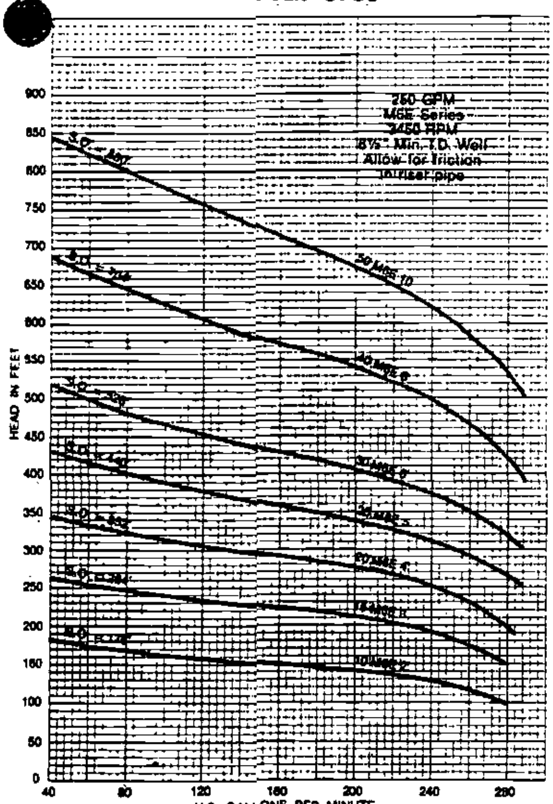


FIG. 6730

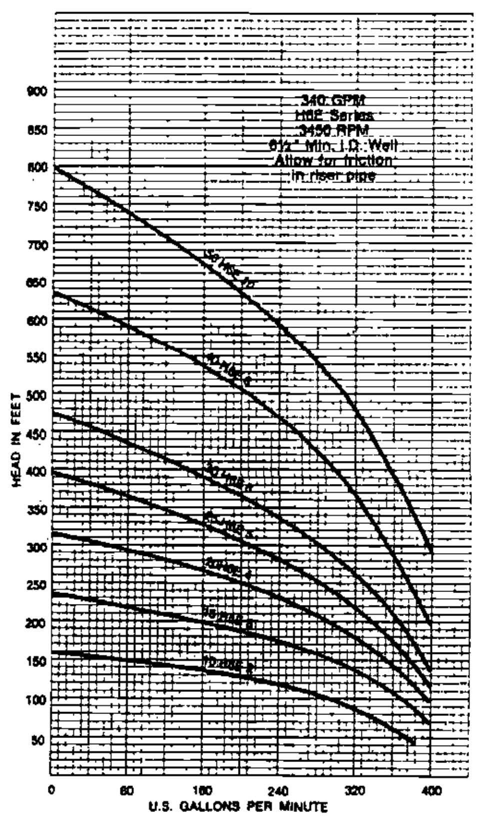


FIG. 6730

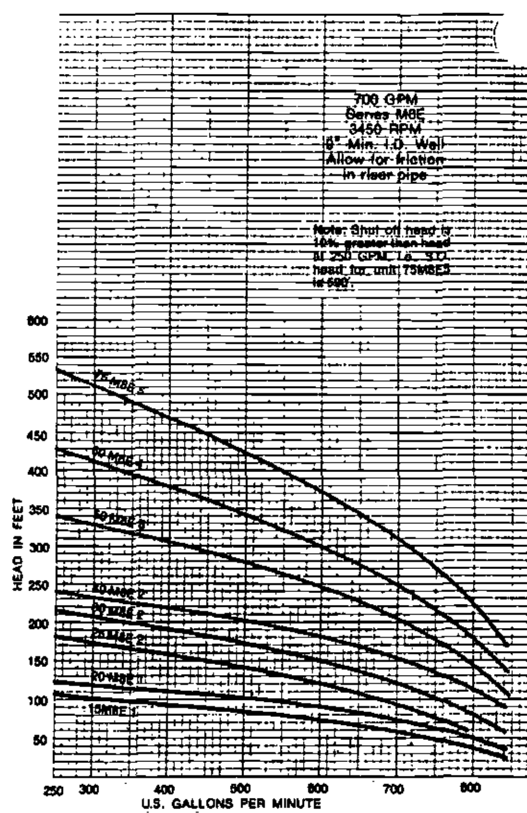


FIG. 6721

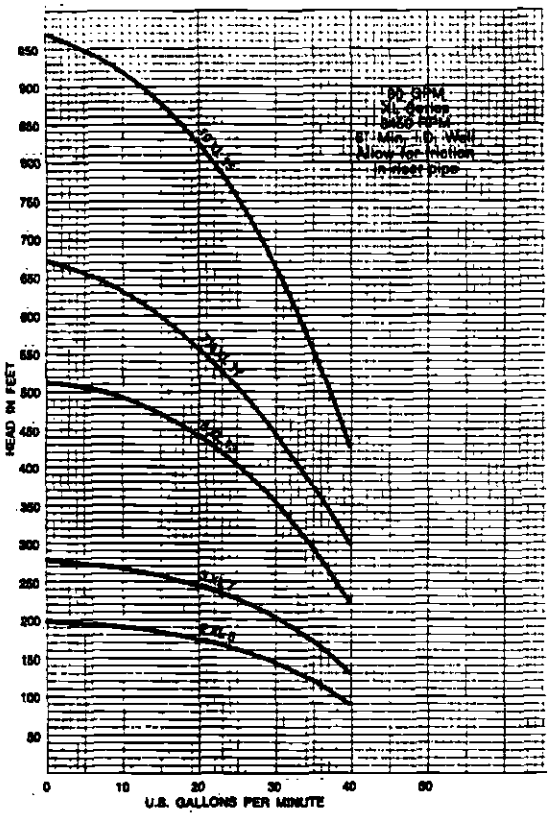
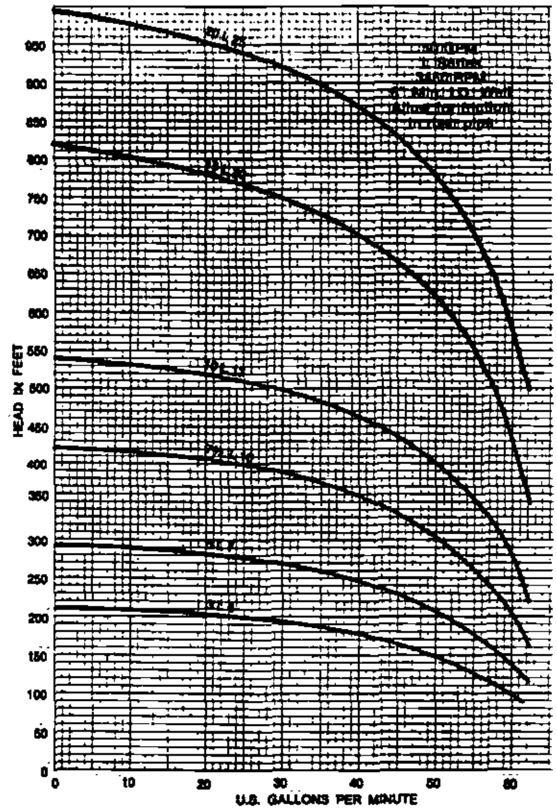


FIG. 6721



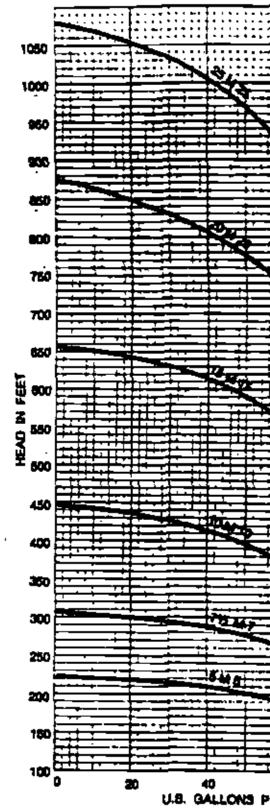


FIG. 6730

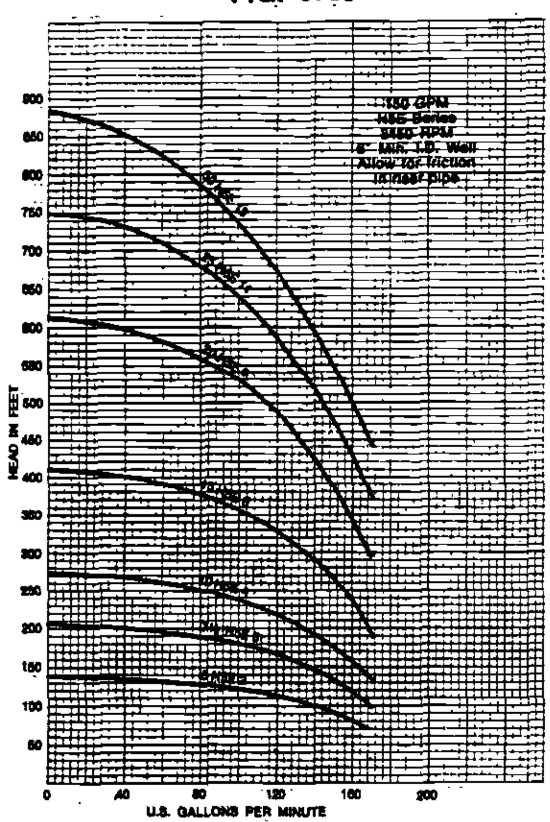
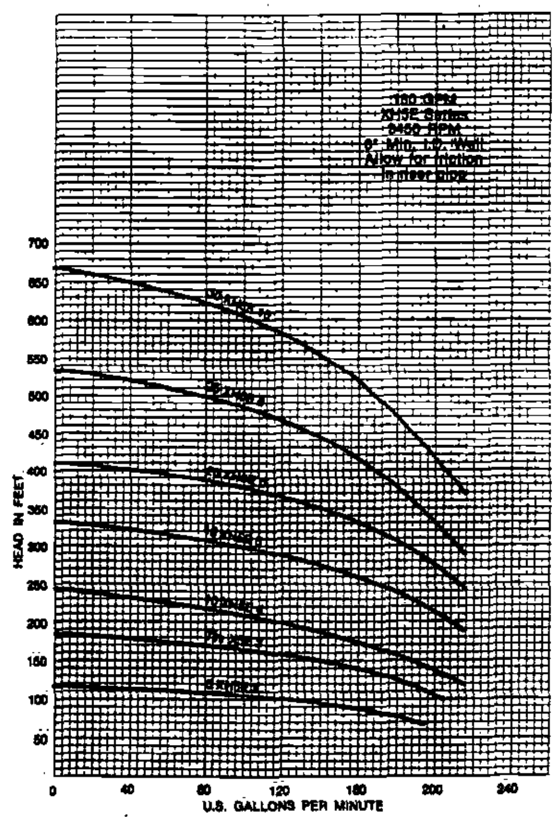
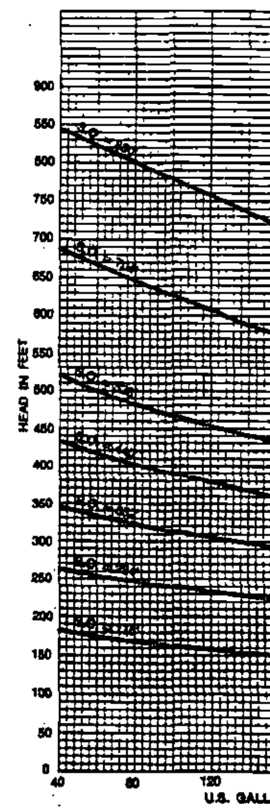
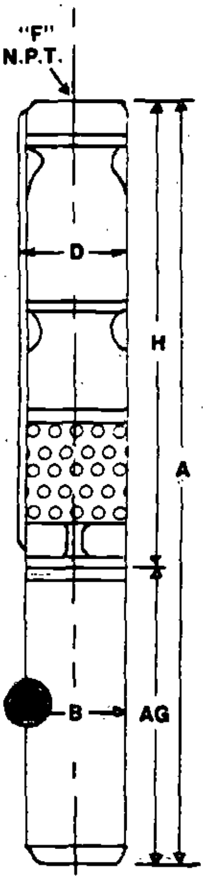


FIG. 6730





CRA



Specifications

Dimensions in inches

GPM SERIES	UNIT NO.	HP	No. Stages	A	B	D	F	H	AG	Wt. Lbs.	Min I.D. Well Size In.
30 GPM Series	2XL5	2	5	43¾	3¾	5⅝	2	23¾	20	102	6
	3XL7	3	7	52	3¾	5⅝	2	29½	22½	111	6
	5XL13	5	13	69¼	3¾	5⅝	2	40¾	28½	130	8
	7½XL17	7½	17	76	5⅜	5⅝	2	48¼	27¾	185	8
	10XL25	10	25	93¾	5⅜	5⅝	2	63¼	30½	224	6
50 GPM Series	3L5	3	5	48¼	3¾	5⅝	2½	23¾	22½	109	6
	5L7	5	7	58	3¾	5⅝	2½	29½	28½	124	8
	7½L10	7½	10	80¼	5⅜	5⅝	2½	32½	27¾	171	6
	10L13	10	13	68⅝	5⅜	5⅝	2½	38⅛	30½	190	6
	15L20	15	20	88	5⅜	5⅝	2½	53⅞	34⅛	230	6
	20L25	20	25	101⅜	5⅜	5⅝	2½	63¼	38⅛	280	6
75 GPM Series	5M5	5	5	52¼	3¾	5⅝	2½	23¾	28½	120	6
	7½M7	7½	7	54⅝	5⅜	5⅝	2½	26⅞	27¾	185	8
	10M10	10	10	63	5⅜	5⅝	2½	32½	30½	191	6
	15M15	15	15	78	5⅜	5⅝	2½	41⅞	34⅛	210	8
	20M20	20	20	92	5⅜	5⅝	2½	53⅞	38⅛	250	8
	25M25	25	25	105⅜	5⅜	5⅝	2½	63¼	42⅛	268	6
100 GPM Series	7½H5	7½	5	48⅞	5⅜	5⅝	3	20⅞	27¾	154	6
	10H7	10	7	57⅜	5⅜	5⅝	3	26⅞	30½	178	8
	15H10	15	10	66⅝	5⅜	5⅝	3	32½	34⅛	200	6
	20H13	20	13	76¼	5⅜	5⅝	3	38⅛	38⅛	228	8
	25H17	25	17	90⅜	5⅜	5⅝	3	48¼	42⅛	269	6
110 GPM Series	5M5E3	5	3	58	5⅜	5⅝	3" or 4"	32½	25½	225	8
	7½M5E4	7½	4	65¾	5⅜	5⅝		38	27¾	258	6
	10M5E6	10	6	79½	5⅜	5⅝		49	30½	307	6
	15M5E9	15	9	99⅝	5⅜	5⅝		65½	34⅛	398	6
	20M5E12	20	12	120⅛	5⅜	5⅝		82	38⅛	477	6
	25M5E15	25	15	140⅝	5⅜	5⅝		98½	42⅛	630	6
150 GPM Series	5H5E2	5	2	52½	5⅜	5⅝		27	25½	205	6
	7½H5E3	7½	3	60¼	5⅜	5⅝		32½	27¾	238	6
	10H5E4	10	4	68½	5⅜	5⅝		38	30½	267	6
	15H5E6	15	6	83⅛	5⅜	5⅝		49	34⅛	336	6
	20H5E9	20	9	103⅝	5⅜	5⅝		65½	38⅛	417	6
	25H5E11	25	11	118⅝	5⅜	5⅝		78½	42⅛	550	8
	30H5E13	30	13	129⅝	5⅜	5⅝		87½	42⅛	614	6
180 GPM Series	5XH5E2	5	2	52½	5⅜	5⅝		27	25½	205	6
	7½XH5E3	7½	3	60¼	5⅜	5⅝		32½	27¾	238	6
	10XH5E4	10	4	68½	5⅜	5⅝		38	30½	267	6
	15XH5E5	15	5	77⅝	5⅜	5⅝		43½	34⅛	316	6
	20XH5E6	20	6	87⅛	5⅜	5⅝		49	38⅛	357	6
	25XH5E8	25	8	102⅛	5⅜	5⅝		60	42⅛	490	6
	30XH5E10	30	10	113⅛	5⅜	5⅝		71	42⅛	554	6
250 GPM Series	10M6E2	10	2	58	5⅜	6⅛	4	27½	30½	280	6½
	15M6E3	15	3	68⅛	5⅜	6⅛	4	34	34⅛	340	6½
	20M6E4	20	4	78⅝	5⅜	6⅛	4	40½	38⅛	400	6½
	25M6E5	25	5	89⅛	5⅜	6⅛	4	47	42⅛	475	6½
	30M6E6	30	6	95⅝	5⅜	6⅛	4	53½	42⅛	515	6½
	40M6E8	40	8	135	5⅜	6⅛	4	66½	68½	700	6½
	50M6E10	50	10	156	5⅜	6⅛	4	79½	76½	840	6½
340 GPM Series	10H6E2	10	2	58	5⅜	6⅛	4	27½	30½	280	6½
	15H6E3	15	3	68⅛	5⅜	6⅛	4	34	34⅛	340	6½
	20H6E4	20	4	78⅝	5⅜	6⅛	4	40½	38⅛	400	6½
	25H6E5	25	5	89⅛	5⅜	6⅛	4	47	42⅛	475	6½
	30H6E6	30	6	95⅝	5⅜	6⅛	4	53½	42⅛	515	6½
	40H6E8	40	8	135	5⅜	6⅛	4	66½	68½	700	6½
	50H6E10	50	10	156	5⅜	6⅛	4	79½	76½	840	6½
700 GPM Series	15M8E1	15	1	66⅛	5⅜	6¼	5" or 6"	32	34⅛	294	9
	20M8E1	20	1	70⅛	5⅜	6¼		32	38⅛	314	9
	25M8E2	25	2	80⅞	5⅜	6¼		38¾	42⅛	402	9
	30M8E2	30	2	75¼	7¼	8¼		38¾	36½	495	9
	40M8E2	40	2	79¼	7¼	8¼		38¾	40½	550	9
	50M8E3	50	3	90	7¼	8¼		45½	44½	881	9
	60M8E4	60	4	101¾	7¼	8¼		52¼	49½	786	9
	75M8E5	75	5	113½	7¼	8¼		59	54½	910	9

FIG. 6721

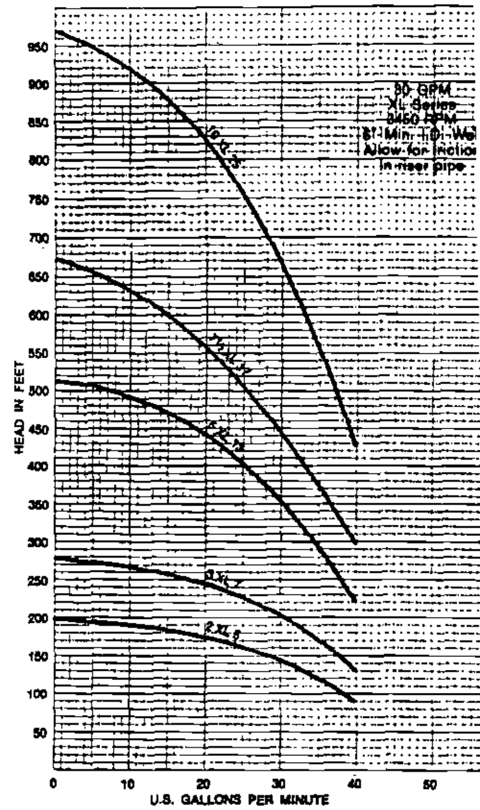
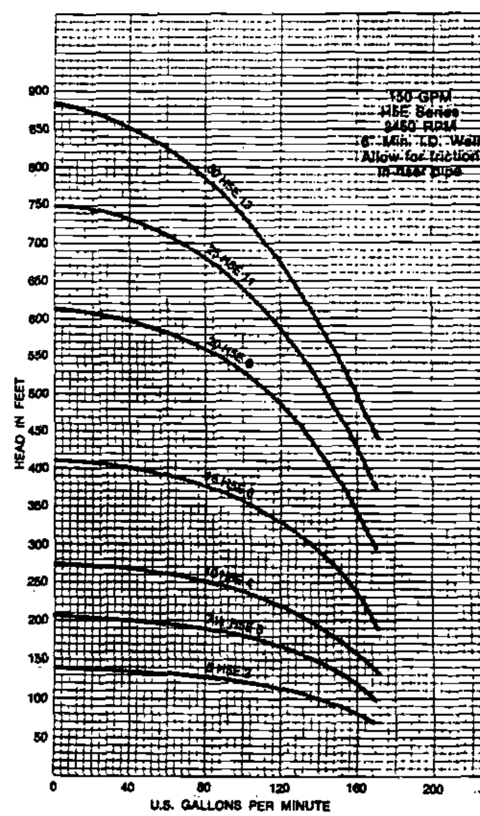


FIG. 6730



RUSH REPRESENTATIVES
Representing manufacturers of power, process, and industrial plant equipment

.. North Ellsworth, Suite 210
P.O. Box 5134
San Mateo, California 94402

Phone (415) 579-2911
Telex 17-1969

February 18, 1983

Kaiser Engineering Corporation
Southern California Rapid Transit
425 South Main Street, 6th. Floor
Annex B
Los Angeles, California 90013

Attention: Mr. Deba Mohapatra

Regarding: Southern California Rapid Transit
Pump Estimate
SF02028
SALA Pumps

Gentlemen:

Per your request, we are pleased to provide the following estimate for your Rock Slurry Pump requirements:

One (1) - SALA, VASA "G", 284-4, constructed of Ni-Hard wear parts, with a setting of 47.2", complete with V-belt drive, drive guards, X-P duplex float switch with probe, oversized bearing housing, and a 100 horsepower, 1750 rpm, X-P, 3 phase, 60 cycle, 460 volt electric motor, and motor mount.

Net Price Each: $15,368.00

Delivery: 16 - 18 weeks.

Thank you for this opportunity to be of service. Should you have any further questions, please feel free to contact us.

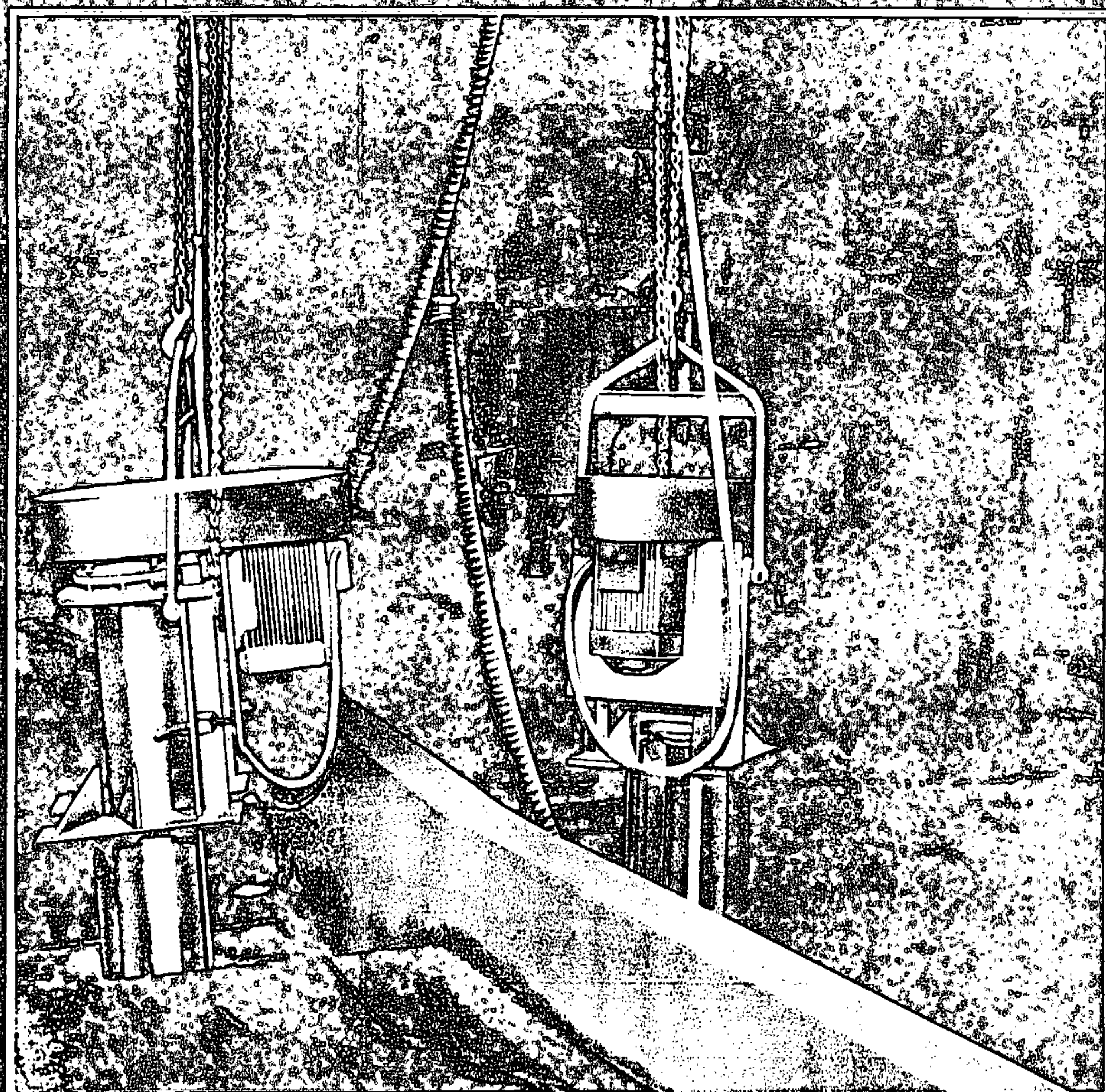
Very truly yours,

Kenneth W. Rush
vs

Kenneth W. Rush
RUSH REPRESENTATIVES
Agent for SALA Machine Works

Enclosure: Bulletin

KWR/ves



Leaflet 211 E

SALA

SALA SUMP PUMPS type VASA G

are slurry pumps specifically designed for abrasive slurries.

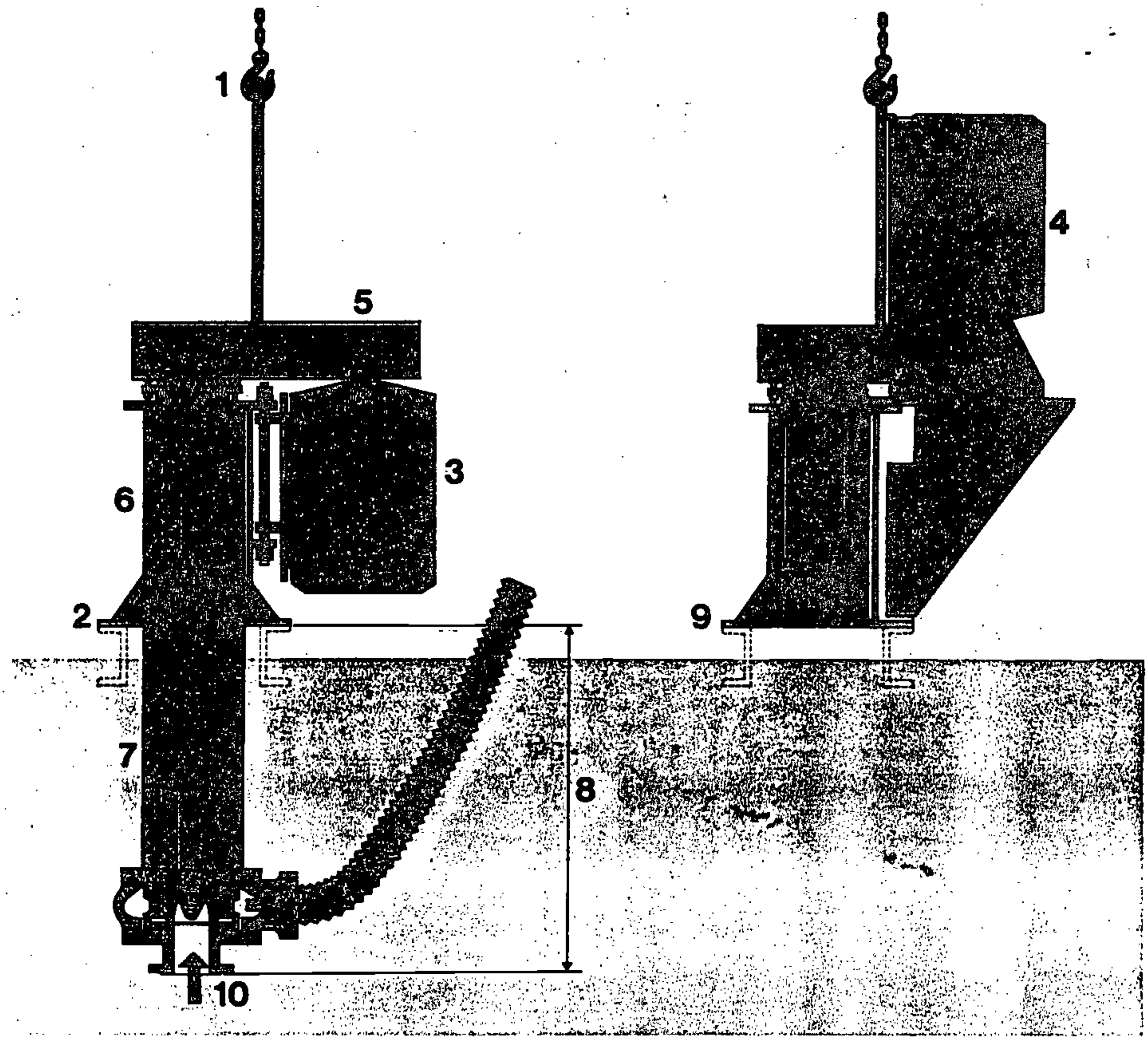


Fig. 1

1 Lifting bracket for supporting the pump in a chain block. Recommended when using the pump for intermittent emptying of sumps when the pump has to be raised and lowered.

2 Bracket for fixed erection. Used for continuous operation.

3 Low mounted motor (standard).

4 High mounted motor.

5 V-belt drive for simple adaption to suitable pump speed.

6 The shaft is mounted in heavy duty roller bearings in a common bearing housing above slurry level. The shaft and bearing assembly can be moved in the frame to adjust the impeller clearance in the pump casing.

7 The shaft has no submerged bearings or seals.

8 The pump frame below the bracket can be made in various lengths. See dimension table page 5.

9 The slurry level must not rise above the bracket.

10 The pump parts (wear parts) are available in several configurations and materials. See page 3.

The front cover picture shows two VASA G 80-214-3" S sump pumps in an ore-dressing plant.

Pump parts

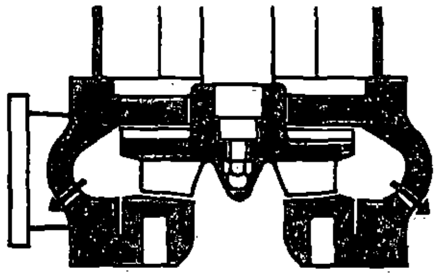


Fig. 2 Open impeller. Casing with two holes through which a part of the slurry sprays back to the sump. Through these jet-sprays the settled solids will be stirred up and extra flush-water is not needed. Through the holes the pump will be de-aired, and the pump therefore will never be air-locked.

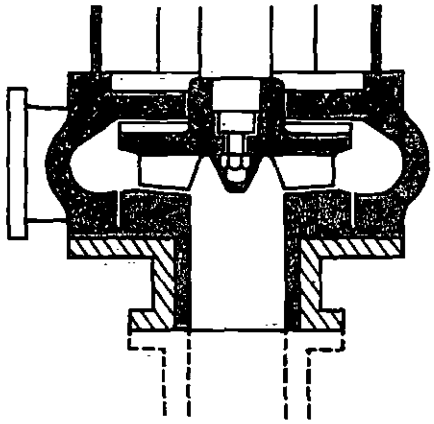


Fig. 3 Open impeller and casing with possibilities to connect suction-pipe in order to extend the working depth for the pump. Maximum length for suction-pipe 2–3 m (8–10 ft.)

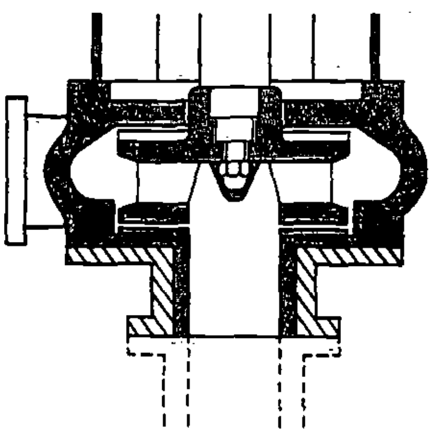


Fig. 4 Closed impeller and inlet with flange to which suction-pipe can be connected. The pump parts are the same as for SALA horizontal pumps, type VASA.

Material in pump parts

Ni-Hard is a Ni-Cr alloyed cast iron with very good wear features. In pumps used for pumping of coarse particles Ni-hard is suitable.

Rubber. The special rubber quality used by SALA as lining for wear parts has usually longer lifetime than Ni-hard if the max. particle size is below 3 mm (1/8"). However, the rubber will easily be ripped if coarser particles enter the pump. Therefore a strainer or a trap should be arranged in front of the pump inlet.

SALA can supply the pump parts in silicon-carbide and other materials for certain pumps.

NOTE! The casing has to be submerged in order to get the pump working.

With configuration according to fig. 3 and 4 the pump may be airlocked if it sucks air. In order to de-air the pump it has to be stopped momentarily. The air-locking can be prevented by stopping the pump before the slurry level is too low. The pump can be started again as soon as the level has risen above the casing. This can be automated by means of level controls.

The vortex flow-pump

is of a special design, which is described in a separate leaflet. The pump parts can be connected to the VASA G frame.

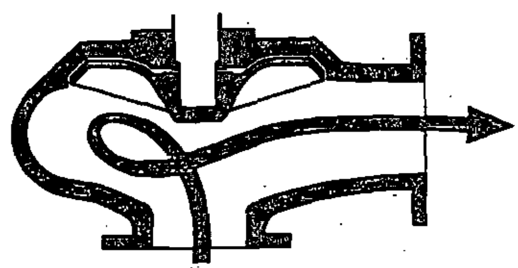


Fig. 5 The recessed impeller is located completely out of the flow pattern. The pumping effect is performed by the vortex that the impeller generates in the slurry. The passage through the vortex flow pump is fully open, therefore it is especially suited for pumping fibres, etc.

Definition of the pump

Example:

VASA G 180-285-4" S

- **Variant designation**: No letter = Fig. 4; S = Fig. 2; U = Fig. 3
- Discharge diameter in inches
- Smallest passage in cm
- Impeller diameter in cm
- Frame length below the bracket in cm
- Type designation

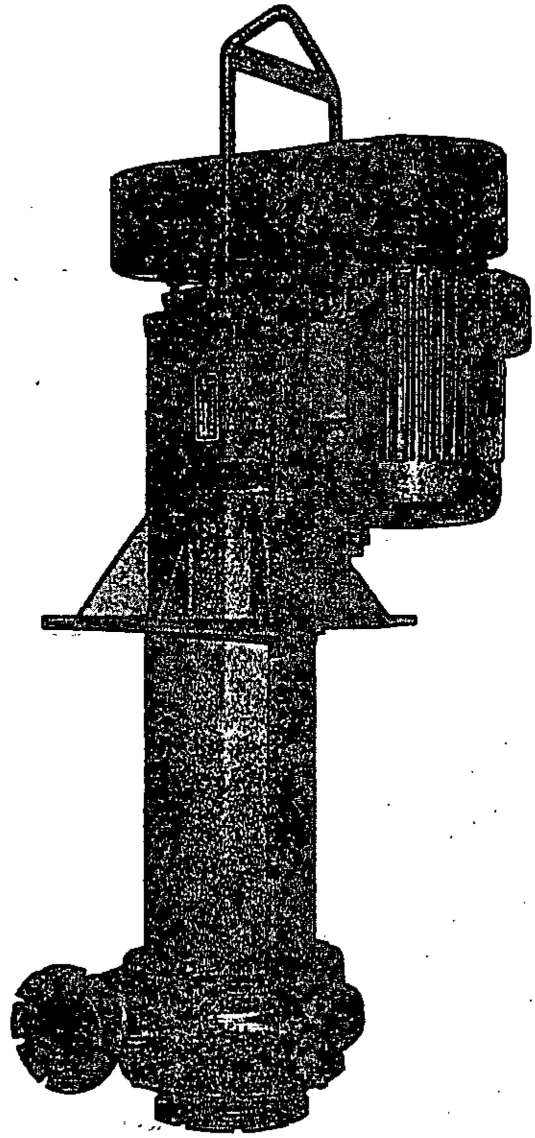
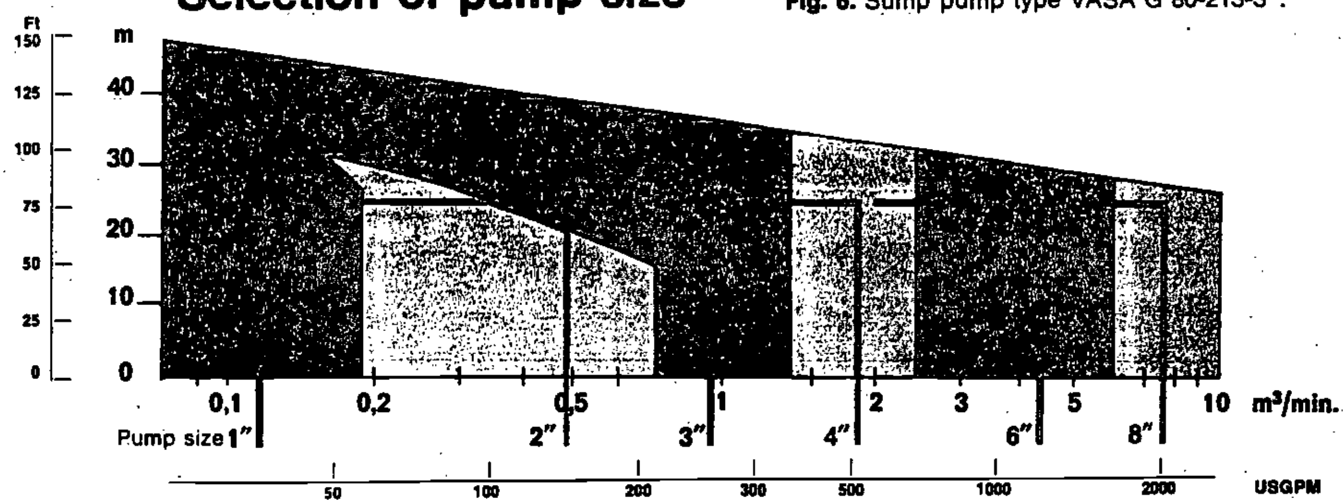


Fig. 6. Sump pump type VASA G 80-213-3".

Selection of pump size

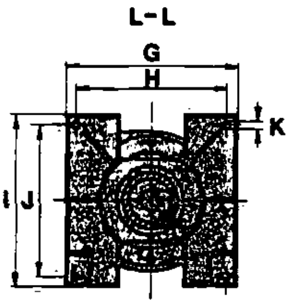


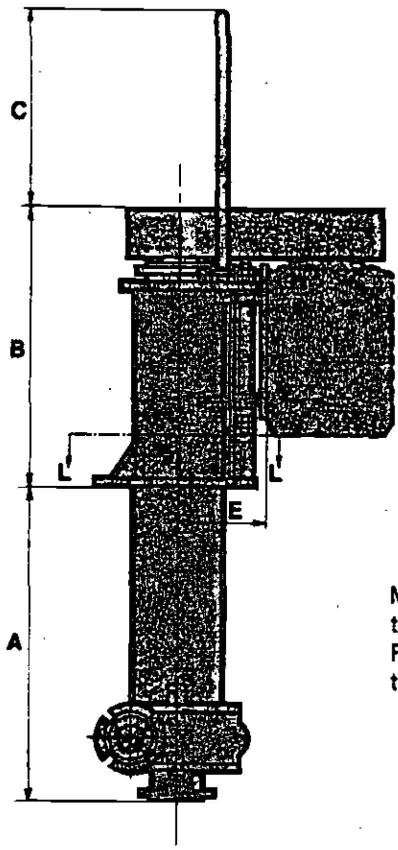
The size of the pump is indicated by the discharge diameter in inches. In the diagram the coloured areas give the working limits for the different sizes.

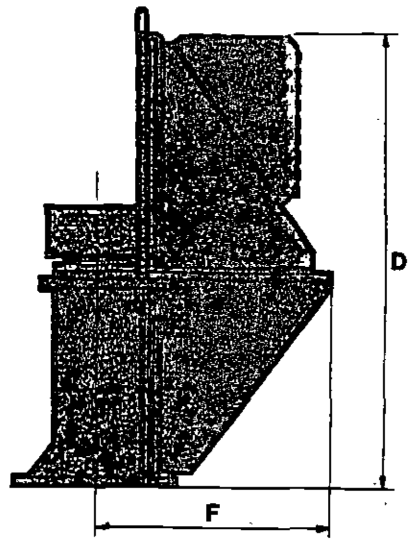
The bold lines show the recommended working areas when pumping slurries with high density and very abrasive goods.

Dimensions

mm and inches







Motor size and V-belt drive varies with the pump duty.
Required data in order to determine the RPM and motor size for a pump are:

- Desired capacity (l/min, m^3/h, GPM etc.)
- Specific gravity of the slurry.
- Total dynamic head (m, ft, etc.)

600 23 3/4	540 21 1/4	300 11 3/4		130 5 1/8		320 12 5/8	250 9 7/8	320 12 5/8	250 9 7/8	15 11/32	100 220	10
1200 47 1/4	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	665 26 1/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	310 675	40
1500 59	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	665 26 1/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	380 835	40
1800 71	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	665 26 1/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	330 725	40
800 31 1/2	540 21 1/4	300 11 3/4		130 5 1/8		320 12 5/8	250 9 7/8	320 12 5/8	250 9 7/8	15 19/32	150 330	10
1200 47 1/4	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	655 25 3/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	440 970	40
1500 59	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	665 26 1/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	450 990	40
1800 71	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	655 25 3/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	460 1010	40
800 31 1/2	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	655 25 3/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	375 825	40
1200 47 1/4	1000 39 3/8	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	560 1230	60
1500 59	1000 39 3/4	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	580 1275	60
1800 71	1000 39 3/8	720 28 3/4	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 3/8	520 20 1/2	22 7/8	600 1320	60
800 31 1/2	830 32 3/4	875 34 1/2	1285 50 1/2	250 9 7/8	655 25 3/4	500 19 3/4	440 17 5/16	500 19 3/4	440 17 5/16	22 7/8	420 925	40
1200 47 1/4	1000 39 3/8	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	590 1300	60
1500 59	1000 39 3/8	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	610 1340	60
1800 71	1000 39 3/8	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	630 1390	60
1000 39 3/8	1000 39 3/8	720 28 3/8	1375 54	285 11 1/4	655 25 3/4	600 23 5/8	520 20 1/2	600 23 5/8	520 20 1/2	22 7/8	660 1450	60
1500 59	1190 47			500 19 3/4	1000 39 3/8	1500 59	1300 51 1/4	1000 39 3/8	900 35 3/8	25 1	1190 2620	180
1800 71	1190 47			500 19 3/4	1000 39 3/8	1500 59	1300 51 1/4	1000 39 3/8	900 35 3/8	25 1	1250 2750	180
1200 47 1/4	1180 47			500 19 3/4	1000 39 3/8	1500 59	1300 51 1/4	1000 39 3/8	900 35 3/8	25 1	1225 2700	180
1500 59	1190 47			500 19 3/4	1000 39 3/8	1500 59	1300 51 1/4	1000 39 3/8	900 35 3/8	25 1	1300 2860	180

*) Standard lengths

QUOTATION

DURCO

No. 133084-T

THE DURIRON COMPANY INC.

SERVES THE PROCESS INDUSTRIES

DAYTON, OHIO 45401

PLEASE MENTION THIS NUMBER WHEN ORDERING

TO: Fitz Consultants
555 Veterans
Redwood City, Ca. 94000

ISSUED AT: 415/827-3173
1980-C Olivera Rd.
Concord, Ca. 94520

ATTN: Ms. Catherine Fitz

DATE: February 22, 1983

SUBJECT:

PAGE 1 OF 1

WE PROPOSE TO FURNISH THE FOLLOWING:

Dear Ms. Fitz:

Thanks for the opportunity to quote a budget price for our Mark II Unitized Self-Primer. We are offering our 4x3US-13 in ductile iron for your tunnel water run-off.

The Mark II features our unique semi-open reverse vane impeller which utilizes the rear cover as the wear surface rather than the more costly front casing. This design reduces turbulence in the suction, resulting in increased efficiency and lower predictable stuffing box pressure. Durco's back pull out design allows you to make all adjustments and service without disturbing the piping.

Delivery on quoted pumps is 4 to 6 weeks, F.O.B. Concord, Ca. Terms are net 30 days. This quotation will remain valid for 30 days.

If there is anything else we can do for you, please contact me at 415/827-3173.

Sincerely,

THE DURIRON COMPANY, INC.

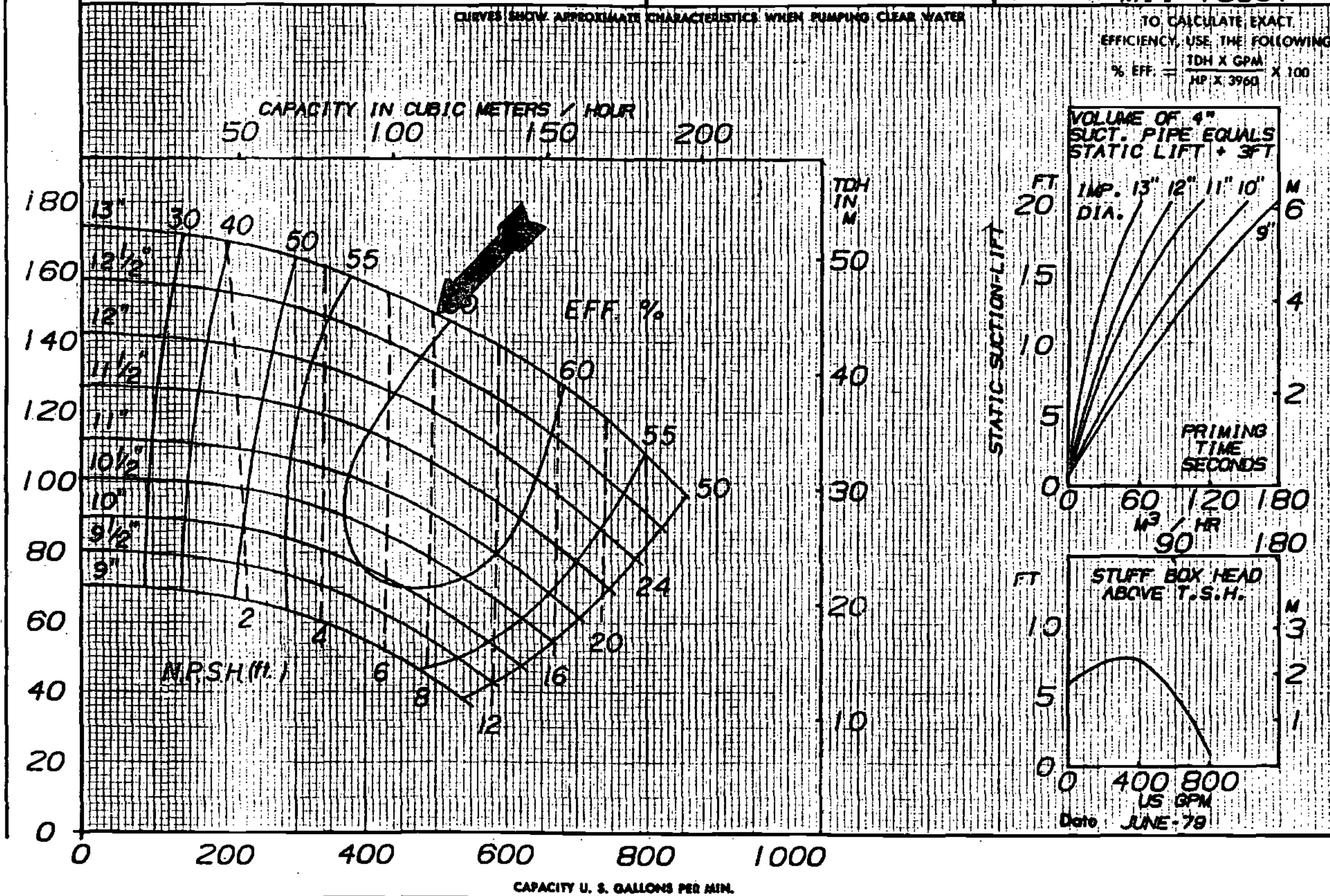
Stacie Smith

Stacie Smith
Sales Engineer

SS/mk
Attach.

SUBJECT TO ADDITIONAL TERMS AND CONDITIONS ON REVERSE SIDE

B.H.P.	T.D.H. IN FEET	THE DURIRON COMPANY, INC. DAYTON, OHIO DURCOPUMP PERFORMANCE CHARACTERISTICS	EYE AREA 15.17 SQ. IN MAX. SPHERE 11/16 IN. IMP. PATT. CT36847A	DURCO MARK II 4X3US-13 SPEED 1750 RPM CURVE NO. MII 7560V



Form No. 62-2561

DURCO

DATE 2/22/83

QUOTE NO. 133084-T

CUSTOMER ORDER NO.	ITEM NO. FOR NAMEPLATE	QUANTITY	DURIRON ORDER NO.	PAGE
		1	A0P	1 OF

OWNER: Fitz Consultants

[redacted] QUOTED DEL. DATE | DATE REQ'D. [redacted]

DESTINATION: Redwood City, Ca.

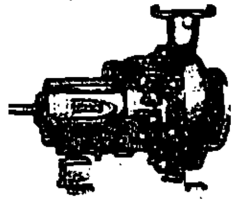
PUMP SERIES & ALLOY: 4x3US-13/130

MARK II DURCOPUMPS

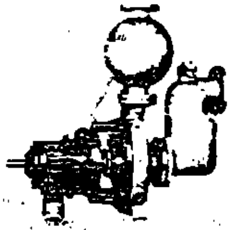
CASING ALLOY DCI
TAP I ____ TAP II ____
TAP III ____ TAP IV ____
JACKET ☐ FULL ☐ PART ☐ THERM ☐
OTHER ____
REAR COVER ALLOY DCI
TAP V ____ TAP VI ____ TAP VII ____
JACKET: S. BOX ☐ RCP ☐ THERMONIZED ☐
GASKET ____
IN LINE SBA # ____
IMPELLER ALLOY DCI
SPEC. GASKET ☐ ____
SEALM REP. TYPE ____ ALLOY ____
SHAFT BBU
HOOK SLEEVE ____
BEARING HSG ADAPTER ALLOY CI
BEARING HOUSING ALLOY CI
COOLED ☐ OIL MIST ☐ GREASE ☐
SEALED ☐ SWINGAWAY FOOT ☐
OTHER ____
BASEPLATE NO. 54 MAT. Steel
304 SS BASIN ☐ DRIP LIP ☐
SWIVEL STILT ☐ OTHER ____
STILT ALLOY ____
CPLG. MFR. Woods SIZE SC9H
NON-SPACER ☐ SPACER ☐
GUARD - YES ☒ MAT. Steel
BYPASS LINE TAP ____ TO TAP ____
STD. TFE/ ____
API PLAN ____ MAT. ____
PIPE ☐ TUBING ☐ SIZE ____
SPECIAL PAINT ☐ ____

TESTS	WIT.	NON WIT.
HYDRO (PARTS ONLY)	☐	☐
PERFORMANCE	☐	☐
NPSH	☐	☐

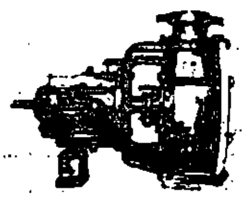
☐ CERTIFIED NOISE LEVEL



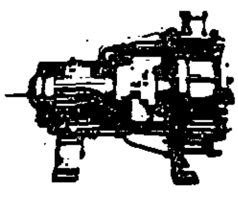
STANDARD



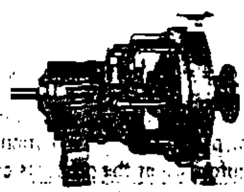
SELF-PRIMING



SUPERCHLOR



DURCON



WE'VE ELIMINATED THE STUFFING BOX

SEALMATIC

REAL VALUE in a process pump is the MARK II Durcopump's unequaled interchangeability

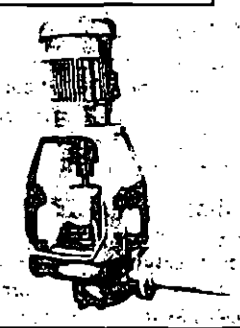
LIQUID PUMPED		
TEMP./SUCT. PRESS	/	
S.G./VISCOSITY (CP.)	/	
PERFORMANCE GPM	500	
TDH REQ'D./OFF'D. (FT)	150 /	148
NPSH-AVAIL/REQ'D. (FT)	/	8
BHP-OP. COND./MAX.	31 /	41.5
CURVE NUMBER	MTI 7560Y	
IMPELLER DIA. OFF'D./MAX.	13" /	13"

STUFFING BOX [redacted]
PACKED STD. ☒ SPECIAL ____
MFGR. ____ TYPE ____ CODE ____
SGL ☐ DBL ☐ INT ☐ EXT ☐ MTD ☐ UN-MTD ☐
FOR BUT LESS SEAL ☐

	SINGLE OR INNER	DOUBLE OUTER
SEAL RING		
SEAT		
SEAT MTG.		
SHAFT PKG.		
METAL PARTS		
SET SCREW & SPRINGS		

FOLLOWER FLG. ALLOY ____ BY ____
FLUSH ☐ V & D ☐ WITH ____ BUSHING
OTHER ____
SEAT PINNED HORIZ. ☐ VERT. ☐ ANGLE ☐
LIP SEAL ____ TEMP. SEAL ☐
THROTTLE BUSHING IN BOX ____

DURCO MARK II IN-LINE



DRIVER DATA
MOTOR ☒ TURB. ☐ OTHER ____
HP/RPM 50 1750 FRAME 326TS TYPE TEFC
PH/HZ/VOLTS 3/60/230/460 MFR West.
SPECIAL ____
TAG OR MARK ____
FURN. BY CUST. ☐ MTD. BY CUST. ☐
DURCO ☒ DURCO ☒

TOTAL UNIT NET	$ 5180.00

6473-R9
PRINTED IN U.S.A.

QUOTATION DATA SHEET 3

INSTALLATION, OPERATION AND MAINTENANCE OF MARK II ANSI STANDARD, SELF-PRIMING, AND RECESSED IMPELLER DURCO PUMPS

Bulletin P-10-200L

This bulletin contains instructions for the installation, operation and maintenance of the MARK II Standard, Self-Priming and Recessed Impeller pumps. As pump service conditions and specifications vary considerably in pump installations, this Bulletin cannot possibly cover every situation, but it is hoped that the information included will serve as a guide. Should questions arise, or start-up problems occur, it is suggested that you contact your Durco Sales Engineer or the nearest sales office.

SECTION I
MARK II STANDARD PUMP
Installation

ALIGNMENT

The centerline of the pump shaft must be aligned with the centerline of the motor shaft. The accuracy required for this alignment varies with the type of coupling involved. The shear type using a non-metallic resilient center or spacer member is recommended, as this type is easily aligned to manufacturer's tolerances by using a steel straightedge. Other types of couplings require closer alignment and the detailed instructions are included in the box containing the coupling spacer.

Alignment is the responsibility of the installer. *Do not assume* that factory alignment has been maintained in transit. Any baseplate or assembly, regardless of the size or sturdiness, may be slightly distorted during shipment, handling or during installation. Therefore, after the baseplate is leveled, a rough alignment check should be made using a steel straightedge. If an adjustable type base has been supplied, the unit is now ready for piping. If a rigid poured foundation is used, the permanent installation can now be accomplished. After piping, final alignment is made. Motor fasteners are in accordance with NEMA Standards. The pump can be moved to accomplish final alignment by loosening the hold-down fasteners, and on Group II and Group III pumps, by loosening cap screw (#136).

If a spacer type coupling has been furnished, the spacer portion will normally be removed prior to shipment. This will allow rotational check of the motor prior to hookup of the pump, and will alert installation personnel to the need for final alignment of the pump and motor shafts.

FOUNDATION

Durco Adjustable Baseplate: The low vibration level in MARK II pumps allows use of foot mounted adjustable baseplates. The baseplate is merely set on a flat surface, with no tie down bolts or other means of securing it to the floor (Figure A). If a stilt mounted baseplate is furnished, merely adjust the feet so the top surface of the baseplate is level.

Grouted Type: When a rigid foundation is to be used, the entire pumping unit should be mounted on a concrete foundation and accurately leveled with wedges or shims. The baseplate may then be grouted to the foundation. After the concrete hardens, the wedges should be removed and the unit tightened down, ensuring that it is level in all directions. The location and size of the foundation bolts are shown in dimension drawings.

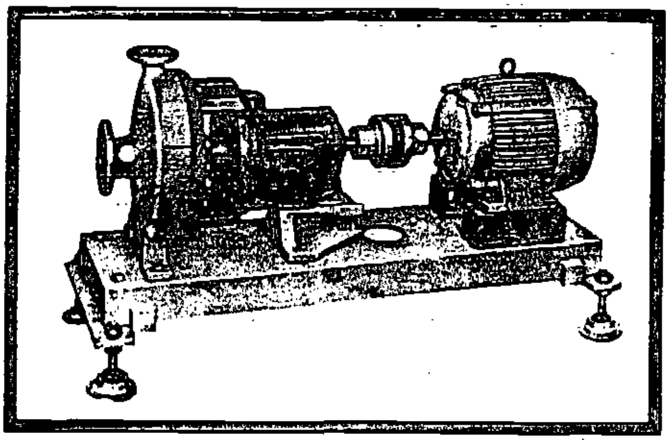


FIGURE A

PIPING

The suction line should have a straight run into the pump of a length equivalent to at least ten times its diameter. The suction line should be no smaller than the suction flange, and should have no high points in which air pockets can form. Avoid the use of throttling valves, diaphragm valves, and line strainers in the suction line when possible. *Never* place a valve directly on the suction nozzle of the pump. If a reducer is required it must be the eccentric type installed straight side up.

When the static discharge head is high, a check valve on the discharge side of the pump (Standard pump only) will prevent water hammer and undue pressure on the stuffing box when the pump is stopped.

Normally, a shut-off valve is installed in both the suction and discharge lines so that the pump can be isolated for maintenance. All piping should be independently supported, accurately aligned and preferably, connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. All piping must be tight. Standard pumps may air-bind and self-priming pumps may fail to prime if air is allowed to leak into the piping.

MOTOR ROTATION

It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump for even a short time can dislodge and damage the impeller, casing and shaft. The pump shaft must turn clockwise when viewed from the motor end.

Preparation For Operation

LUBRICATION

The correct oil level is obtained with the Trico Oiler in its lowest position, which results in the oil level being at the top of the oil inlet pipe nipple. To fill bearing housing to proper oil level, remove the plastic bottle from the Trico Oiler base and pour oil slowly until the base is full. Then fill the plastic bottle with oil, invert, and replace it in the base. Oil must be visible in the bottle at all times.

Oil lubrication is standard unless otherwise specified. Before operating, fill bearing housing to required level using the following amounts:

Amounts of Oil

Pump Size	oz.	kg
Group I	6 to 7	(.17-.20)
Group II	8 to 9	(.22-.25)
Group III	24 to 25	(.67-.70)

Oil Viscosity Number

SAE	°F*	°C*
20	125	(52)
30	125-150	(52-66)
40	150-180	(66-82)

Be sure to check the lubrication of the motor bearings and the flexible coupling, where required. Special instructions are furnished for the coupling, where required, in the instruction envelope.

*Skin temperature of housing at bearing should not exceed 180°F (82°C) with oil lubrication. Thirteen-inch pumps at 3500 rpm require bearing housing cooling. All pumps require bearing cooling when wet end temperatures exceed 400°F (204°C). Consult factory for bearing cooling options.

Grease lubrication is optional. When specified, bearing housings are provided with grease fittings and single shielded bearings. Such units will not include oiler and slinger. Grease lubricated bearings are packed prior to shipment. Replacement bearings should be grease packed to fill the void space within the races, most of which will be extruded on start-up to form an adjacent reservoir. The skin temperature of housing at bearing is 200°F (93°C) maximum. Recommended grease: Chevron BRB#2, Aeroshell #16, Exxon Andok-260 or similar type.

Sealed bearings are furnished when specified and are grease packed by the bearing manufacturer. Such bearings should not be relubricated and should be replaced on a regular maintenance schedule. Skin temperature of bearing housing should not exceed 200°F (93°C).

When oil mist lubrication is specified, Group I and Group II bearing housings are furnished with a single inlet tap, weep holes at inboard and outboard bearings, and bottom drain. Group III pumps include two inlet taps. Complete oil mist systems can be supplied where existing systems are not available. Skin temperatures of housing at bearing should not exceed 180°F (82°C).

During the first few hours of operating, bearing temperatures should level off and usually drop slightly after the initial run-in period. If temperatures continue to rise after a few hours of continuous operation, supply of lubricant should be checked. If oil is used, the oil level should allow the slinger on Group II and Group III pumps to dip ⅜" (10 mm) to ½" (13 mm). Group I level should be approximately ¼" (6 mm) above the outer bearing races.

STUFFING BOX SEAL

Standard Packing: If the pump is furnished with packing, it will be necessary to install the packing and the PTFE seal cage. When installing these items, twist the rings sideways just enough to get them around the shaft. Do not attempt to pull the rings straight out to get them over the shaft, as this will damage them. Install three rings of packing, followed by the PTFE seal cage, then two more rings of packing. Seat each ring individually into the stuffing box. As each ring is added, stagger the joints 90 degrees (1.5 rad.). When special graphite or foil packings are supplied, special instructions will be furnished.

Some form of packing lubrication is normally required. In some cases, the lubrication qualities of the liquid pumped are sufficient. If this is not the case, a line must be connected for clean lubrication from an external source. A grease cup can also be used, providing the pumped liquid is compatible with the grease.

In abrasive services, it is often desirable to install a lip seal into the bottom of the stuffing box, followed by seal cages and packing (See Figure B). A small flow of clear flush liquid is then supplied at all times during pump operation. Pressure and flow must be regulated so that no more than 1-2 gallon per hour (0.2 –0.5 m^3/h) of the flush liquid enters the product. This may be accomplished by careful regulation, or by use of a purge type rotometer.

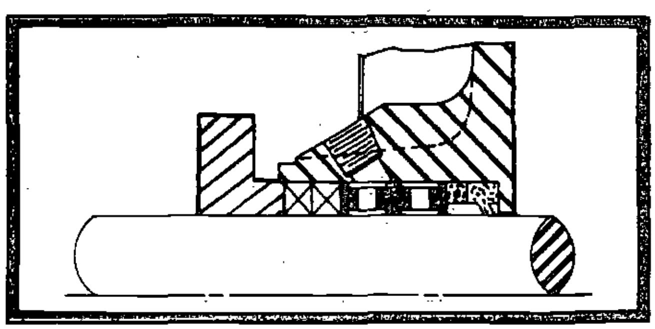


FIGURE B
SPECIAL PACKING ARRANGEMENT WITH FLUSH FOR EXTREMELY ABRASIVE SERVICES

Mechanical Seals: MARK II pumps are designed to handle virtually every type of mechanical seal available, and with little or no modification. The MARK II Sealmatic option is also available as described in Bulletin P-18-100 and P-18-200. When pumps are ordered with mechanical seals, a set of seal *manufacturer's operating instructions* and a seal drawing will be shipped with the pump. Figure C illustrates several typical seal and accessory piping arrangements, together with appropriate notes and recommendations. Figure D illustrates a typical by-pass line installation with pumped liquid by-pass from discharge to flush inlet at the stuffing box. Other by-pass arrangements are provided, some more complex, including heat exchangers, strainers, valves, and other accessories. Examples of these are illustrated in *Figures* E *and* F. Normally these *systems* are assembled at the factory, but occasionally they are dismantled to prevent damage during shipment. In the latter cases, an assembly sketch or schematic diagram is included with the components.

Be certain that the pump suction valve is open, and that all piping is properly connected and that all flush systems or circulating systems are functioning before starting the pump. Very rapid seal failure can occur if the seal runs dry – even if only for a few seconds! If there is anything questionable or unusual about the seal assembly or system, it is suggested that you telephone the nearest Durco Sales Office or the office of the mechanical seal representative for clarification.

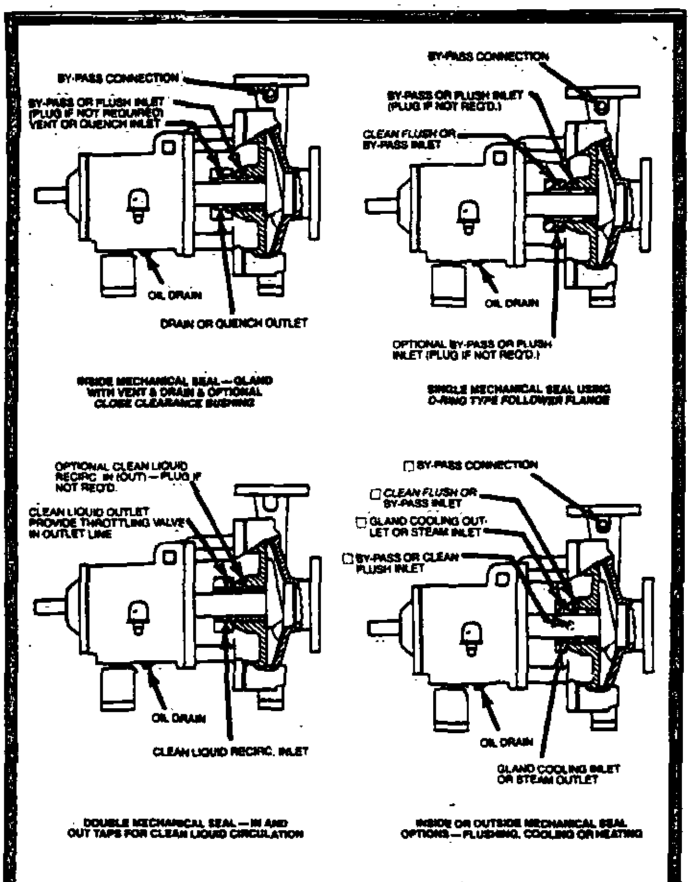


FIGURE C

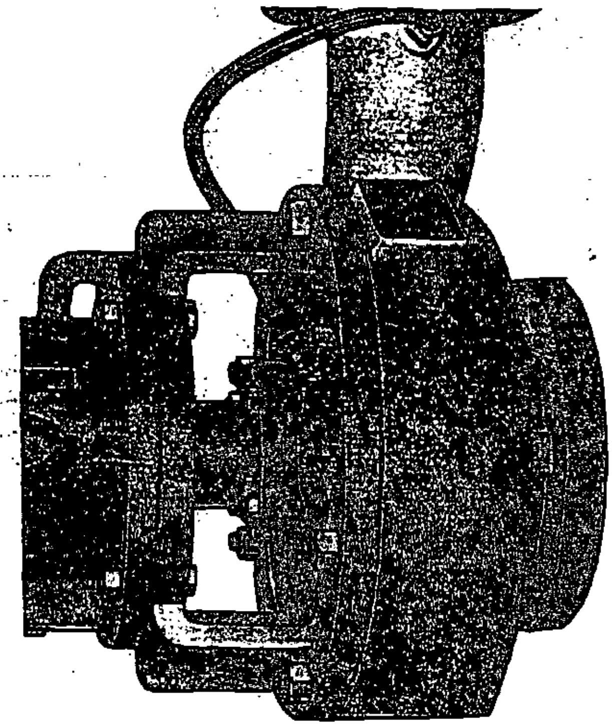


FIGURE D

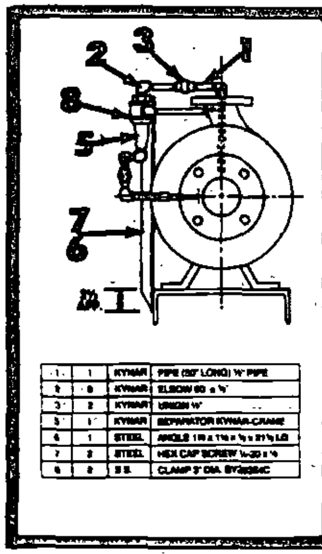


FIGURE E

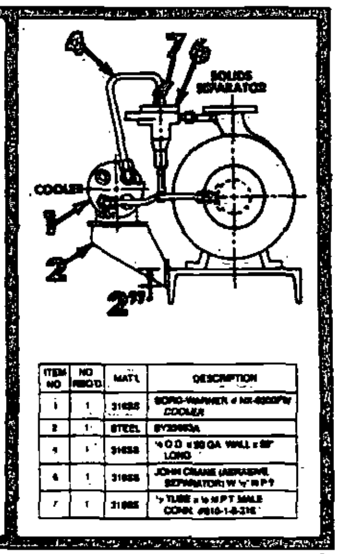


FIGURE F

ROTATE THE SHAFT

As a final step in preparation for operation, it is important to rotate the shaft by hand to be certain that all rotating parts move freely, and that there are no *foreign objects* in the pump casing.

Operation

START-UP

The following procedure is recommended for starting MARK II Standard pumps:

1) Open suction valve to full open position.
2) Open discharge valve a slight amount.
3) Make certain the pump is primed.
4) Start driver (motor, *turbine, etc.*)
5) After pump is running, open discharge valve to full open position.

Maintenance

Refer to the cross section drawings and parts list, pages 9 and 10. Loosen the cap screws in both halves of the spacer coupling and remove the spacer portion of the coupling. Remove cap screws holding the bearing housing foot to baseplate. Remove hex nut (#115) from casing studs, back power end assembly out of casing, and transfer to shop for further disassembly.

When power end unit arrives in shop, carefully remove the pump side coupling hub. The impeller (#103) is removed from the shaft by turning sharply counterclockwise while holding shaft stationary. A special impeller wrench can be provided to facilitate removal of the impeller. (See Figure G) This type of device can be duplicated by merely welding a steel bar to an old coupling hub.

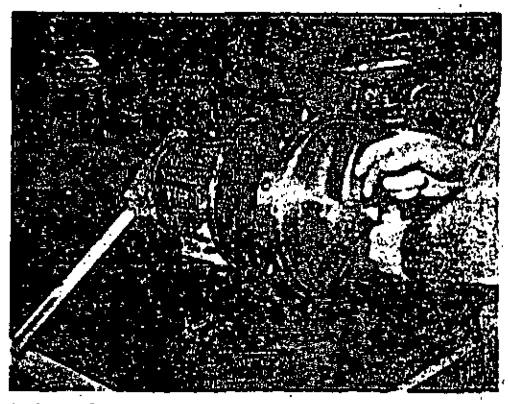
The flange studs with hex nuts (#111) retaining the mechanical seal follower flange are removed. This allows the mechanical seal stationary face to be backed away from the end of the stuffing box. If the pump is packed, remove the gland studs with hex nuts (#111) and slide the packing gland (#110) back on the shaft. Remove packing (#113) and seal cage (#112).

The two cap screws (#140) retaining the rear cover plate (#106) are removed and the rear cover plate is *carefully* removed. The set screws which lock the mechanical seal to the shaft are then loosened and the seal rotating unit is removed. If the pump was furnished with a hook type sleeve, the rotating unit can be removed after the sleeve has been slipped off the shaft. Be certain to measure and record the position of the rotating unit on the sleeve. A replacement rotating unit of the same type can merely be relocated at the same position on the same or on a new hook type sleeve. The stationary seat and follower flange are then carefully slid off the end of the shaft. If the pump is being maintained for mechanical seal replacement only, no further disassembly is required. The pump can be reassembled by merely reversing the preceding steps.

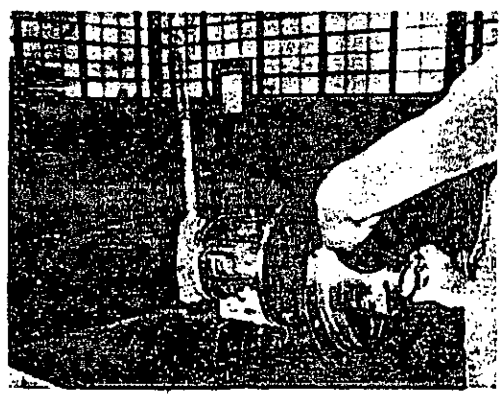
If shaft or bearing replacement is required, remove the vented drain plug (#134) and drain oil from bearing housing (#119). Remove bearing cover cap screws (#138) and outboard bearing cover (#123). The entire shaft and bearing assembly can then be slid out the outboard end of the bearing housing. The bearings can then be checked and replaced if necessary.

To remove the outboard bearing (#121), raise the tab on the bearing lockwasher (#125) and remove the bearing locknut (#124) and lockwasher. The bearing can then be removed using an arbor press. The inboard bearing (#120) should also be removed in an arbor press. The inboard and outboard oil seals (#118) and (#129) are pried out, and new oil seals are pressed into place.

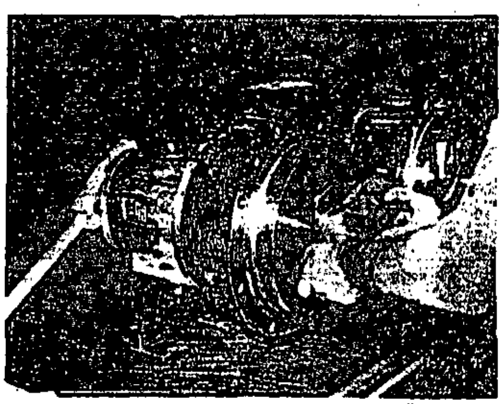
1. After removal from the rest of the pump, the power end can be taken to the shop for easy maintenance. The key and wrench are then mounted on the shaft with the wrench pointing to the right when viewed from the impeller end of the pump.



2. Grasping the impeller firmly, spin the wrench quickly in a counter-clockwise direction so that it makes sharp contact with the bench.



3. The gasket seal should be broken and the impeller should start to move easily along its threads after several sharp raps.



4. The impeller is then easily removed. The procedure can be reversed, moving the wrench in a clockwise direction, to ensure accurate feeler gauge measurements when reinstalling the impeller.

FIGURE G

The shaft (#105) should be carefully inspected. If in good condition, the inboard bearing (#120) and outboard bearing (#121) can be installed using an arbor press. Both bearings have a slight interference fit, so care must be taken to ensure that the outboard bearing (#121) is pressed firmly home against the shaft shoulder. The bearing lockwasher (#125) is then slid into position, and the bearing locknut (#124) is tightened firmly. Bend the tab of the lockwasher (#125) that lines up with a milled slot in the locknut (#124). An alternate method of installing bearings is to heat them in a 200°F (93°C) oven for 2 hours, then place them in position on the shaft. If this method is used, the bearing locknut (#124) should be drawn up tight against the outboard bearing (#121) and left there until the bearing cools. This will retain the bearing in proper position against the shaft shoulder. The locknut (#124) is removed, the lockwasher (#125) installed, and the locknut (#124) reassembled and tightened firmly. The tab of the lockwasher (#125) that lines up with a milled slot in the locknut (#124) is then bent over.

SECTION II
MARK II UNITIZED SELF-PRIMING PUMP

The MARK II Self-Priming pump is basically a Standard pump with a special casing. The entire rotating unit (back pullout portion) is identical to that of a MARK II Standard pump. For normal maintenance the casing should be left piped up in place.

Installation

ALIGNMENT
Refer to Standard Pump Installation, page 1.

FOUNDATION
Refer to Standard Pump Foundation, page 1.

PIPING
Refer to Standard Pump Piping, page 1. In addition, the following piping recommendations should be followed:

Check valves should not be used in the discharge line, as they retain a head of liquid above them and make it extremely difficult to vent air and gases. If it is absolutely essential that a check valve be used, then some provision should be made to include a small vent line between the casing and the check valve, returning to the supply tank or sump.

Extra care should be taken to be certain that all flanged joints and pipe fittings on the suction piping are completely air-tight. Any leakage in the suction piping system will reduce the efficiency of the self-priming pump and will increase the amount of time required to reach full prime. Suction piping should be no larger than the pump inlet, and should be as short and straight as practical.

MOTOR ROTATION
Be certain to check rotation of motor before connecting spacer portion of coupling. An arrow is cast on the bearing cover (#123) showing proper rotation.

Preparation For Operation

LUBRICATION
Refer to Standard Pump Lubrication, Page 2.

STUFFING BOX SEAL
The MARK II Self-Priming Pump creates a vacuum in the suction piping which allows liquid to be pushed up into the pump. The stuffing box must be sealed so that air will not leak into the pump and break the vacuum. Where packing is used, liquid must be supplied to the stuffing box to lubricate the packing and to provide a liquid seal. This can be accomplished by piping water or a clear liquid from an external source, or by installing a by-pass line from the ¼" pipe tap in the casing to the lubricating port in the stuffing box.

If a single mechanical seal is used, provision must be made to constantly supply liquid at the seal faces. This can be accomplished by installing a by-pass line from the ¼" pipe tap in the casing to the stuffing box.

For other information refer to the Standard Pump Stuffing Box Seal, page 2.

ROTATE SHAFT
Refer to Standard Pump Rotate Shaft, page 3.

Operation

START-UP
When starting the MARK II Self-Priming Pump for the first time, make certain that all suction and discharge valves are wide open and that the casing is full of liquid. Insure that all flush or by-pass lines are open and connected properly, and that flush liquid is getting to the pump. Do not throttle discharge valves in an attempt to assist priming. All lines should be wide open for the most effective priming.

The amount of time required by the pump to attain full prime is a function of the volume of air in the suction piping at start-up. Consult Bulletin P-12-101 for approximate priming time. If pump does not prime within a few minutes, the following points should be checked:

1) Check suction system and stuffing box for possible air leaks.
2) Recheck pump rotation.
3) Recheck lubrication or flush line.
4) Check liquid level in sump.
5) Insure that some foreign matter has not been drawn against or into the suction pipe.
6) Insure that discharge piping is open so that the air or gas from the suction can escape.

Maintenance

Refer to Standard Pump Maintenance, page 4. The entire rotating unit of the MARK II Self-Priming Pump is identical to that of the Standard Pump. It is usually unnecessary to remove the casing (#100) from its installed position. If the pump has a by-pass line (See Figure D) to stuffing box, this is disconnected.

Assembly is accomplished by merely reversing the disassembly procedure.

SECTION III
MARK II RECESSED IMPELLER PUMP

The MARK II Recessed Impeller Pump is basically a Standard Pump with a special casing and impeller. The entire rotating unit (back pullout portion) is identical to that of a MARK II Standard Pump. For normal maintenance the casing should be left piped up in place.

Installation

ALIGNMENT

Refer to Standard Pump Alignment, page 1.

FOUNDATION

Refer to Standard Pump Foundation, page 1.

PIPING

Refer to Standard Pump Piping, page 1.

MOTOR ROTATION

Refer to Standard Pump Motor Rotation, page 2.

Preparation For Operation

LUBRICATION

Refer to Standard Pump Lubrication, page 2.

STUFFING BOX SEAL

The Durco MARK II Recessed Impeller Pump will accept any mechanical seal including inside, outside, double internal, and balanced seals, plus all other seal and flush combinations common to the MARK II Standard Pump. The MARK II Sealmatic option is also available as described in Bulletins P-18-100 and P-18-200.

ROTATE SHAFT

Refer to Standard Pump Rotate Shaft, page 3.

Operation

START-UP

The following procedure is recommended for starting the MARK II Recessed Impeller Pump:

1) Open suction valve to full open position.
2) Open discharge valve a slight amount.
3) Make certain the pump is primed.
4) Start driver (motor, turbine, etc.).
5) After pump is running, open discharge valve to full open position.

Maintenance

For Maintenance of Recessed Impeller Pumps refer to Standard Pump Maintenance, page 4.

SECTION IV
GENERAL INFORMATION

ASSEMBLY OF MARK II PUMPS

After bearings are mounted, reassembly is simply a reversal of the disassembly procedure. The bearing and shaft assembly is inserted into the bearing housing. The outboard bearing has a snap ring assembled to the outer race. This is a shim retainer used when adjusting the impeller running clearance. No shims should be present at this point.

The rear cover plate (#106) is assembled to the bearing housing adapter (#108) or bearing housing (#119) in Group I pumps. To facilitate relocating the rear cover plate (#106), it is suggested that a stud be placed in one of the cap screw (#140) holes in the rear cover plate (#106). The two retaining cap screws (#140) are drawn up firmly. If the pump is furnished with a hook type sleeve, it should now be assembled, using an ample amount of Molykote* or similar lubricant on the OD of the shaft and the ID of the sleeve. It is always advisable to use a new impeller gasket (#104) each time the pump is disassembled for major maintenance. The impeller (#103) is carefully threaded onto the end of the shaft, and an impeller wrench can be used to assist in tightening the impeller. The running clearance of the impeller

*Tradename of Dow Corning Corporation.

is now set. Make certain that the shaft is all the way forward so that the snap ring is snug against the end of the bearing housing. The clearance between the impeller vanes and the rear cover plate is measured with a feeler gauge. The impeller clearance should be set at 0.015" (0.38 mm) minimum for pumps handling liquids at temperatures up to 100°F (38°C). If the pump will be on intermittent service at elevated temperatures, this clearance should be increased 0.002" (0.05 mm) for every 50°F (10°C) above 100°F (38°C). To obtain the proper thickness of shims required, subtract the desired clearance from the clearance measured. *For example, feeler gauge shows 0.030" (0.76 mm) minimum between impeller vanes and rear cover plate. Pumpage temperature is 250°F (121°C). Desired clearance, 0.015" plus 0.006" equals 0.21" (0.38 mm) plus (0.15 mm) equals (0.53 mm). Shim thickness required is 0.030" minus 0.021" equals 0.009" (0.76 mm) minus (0.53 mm) equals (0.23 mm).* The snap ring is then removed and the required shims are slid onto the outboard bearing (#121). . The snap ring is returned to its original position in the groove. Cork bearing cover gaskets (#126) of total thickness slightly greater than shim thickness plus snap ring thickness are then applied over the shims and snap rings. The outboard bearing cover (#123) is reassembled and the cap screws (#138) are drawn up snugly. The clearance between the impeller vanes and rear cover plate is rechecked to make certain it is a minimum of 0.015" (0.38 mm). No additional work is required to set the impeller running clearance.

The following procedure should be used for installing John Crane Type 9 or 9T, and Durametallic Type RO or ROTT mechanical seals with clamped seats. For other types of mechanical seals, refer to the seal drawings accompanying the pump.

To install the mechanical seal, the shaft or sleeve should be scribed or marked (if not previously marked) by holding a scale or marker firmly and squarely against the end of the stuffing box and rotating the shaft. The impeller and rear cover plate are then removed. The new or relapped stationary seat of the mechanical seal is carefully inserted into the follower flange. A drop of oil is applied to the face of the stationary seat and spread uniformly over the face with a clean tissue. The follower flange and stationary seat are then carefully slid onto the shaft or sleeve. The rotating unit is installed next. A tapered cone, easily fabricated in the maintenance shop, can be used here to prevent damage to the PTFE or elastomer shaft seal (See Figure H). The cone is threaded into the shaft and the rotary is slid over it onto the shaft and forward until the seal face is at the scribed mark. The set screws *(always use new ones)* are firmly tightened so that the rotating unit cannot slip. The rear cover plate is then carefully reassembled to the bearing housing adapter (bearing housing for Group I pumps) and the two retaining cap screws (#140) are drawn up firmly. The follower flange is tightened uniformly against the end of the stuffing box. The impeller is then threaded onto the shaft and tightened. The impeller running clearance should be checked, but will normally be exactly as originally set. No further adjustment of the seal or impeller will be required.

If the pump is packed with molded ring packing, refer to Standard Pump Stuffing Box Seal, page 2.

The oil breather tube is reassembled into the housing, and the pumping unit is now ready for reassembly into the casing, using a new rear cover gasket (#107). Remove the bottle of the Trico oiler and fill bearing housing with oil to proper level. The pump side coupling hub is replaced on the shaft extension and the spacer portion is reassembled into the coupling and firmly tightened. Check coupling with a steel straightedge to determine whether or not it returned to alignment. Rotate the shaft by hand to be certain all parts rotate freely. Reconnect any external piping or accessory equipment that is a part of the pump installation. Refer to Standard Pump Start-up, page 3.

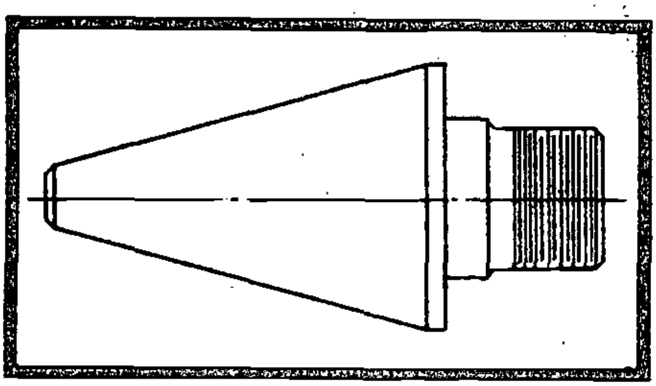


FIGURE H

PERIODIC INSPECTION

The *following inspections* should be made periodically:

1) **Bearing Lubrication** – Check to be sure that there is oil in the Trico Oiler.
2) **Packing** – Be certain that the packing is lubricated with a high melting point, acid-resistant lubricant. Check for crystallization of solution or embedded abrasives. Be sure that packing is proper grade.
3) **Leakage** – Be sure that the gasketed joints at casing drain, casing cover, suction and discharge connections are free from leaks.
4) **Bearing Wear** – Check bearings for excessive wear. Worn bearings may result in excessive shaft runout, necessitating frequent repacking of the stuffing box.
5) **Alignment** – Check shaft for proper alignment, and the baseplate for levelness.

IN PLACE SEAL REPLACEMENT

In some large industrial plants, pump installations are far from the general maintenance shop and it is often convenient to maintain the pump in place. Durco MARK II pumps offer a unique type of rear footpiece that becomes a field workbench and allows minor maintenance such as visual inspection of the wet end parts or mechanical seal replacement at the pump location. This sequence is illustrated in Figure J, for pumps with a replacement sleeve. The same procedure can be used for pumps with DC8 or Superchlor shafts. The rotating unit is backed out of the casing and swung around until it is at a right angle to the original installation line. The bearing housing cap screw is then retightened to hold the power end unit firmly in place.

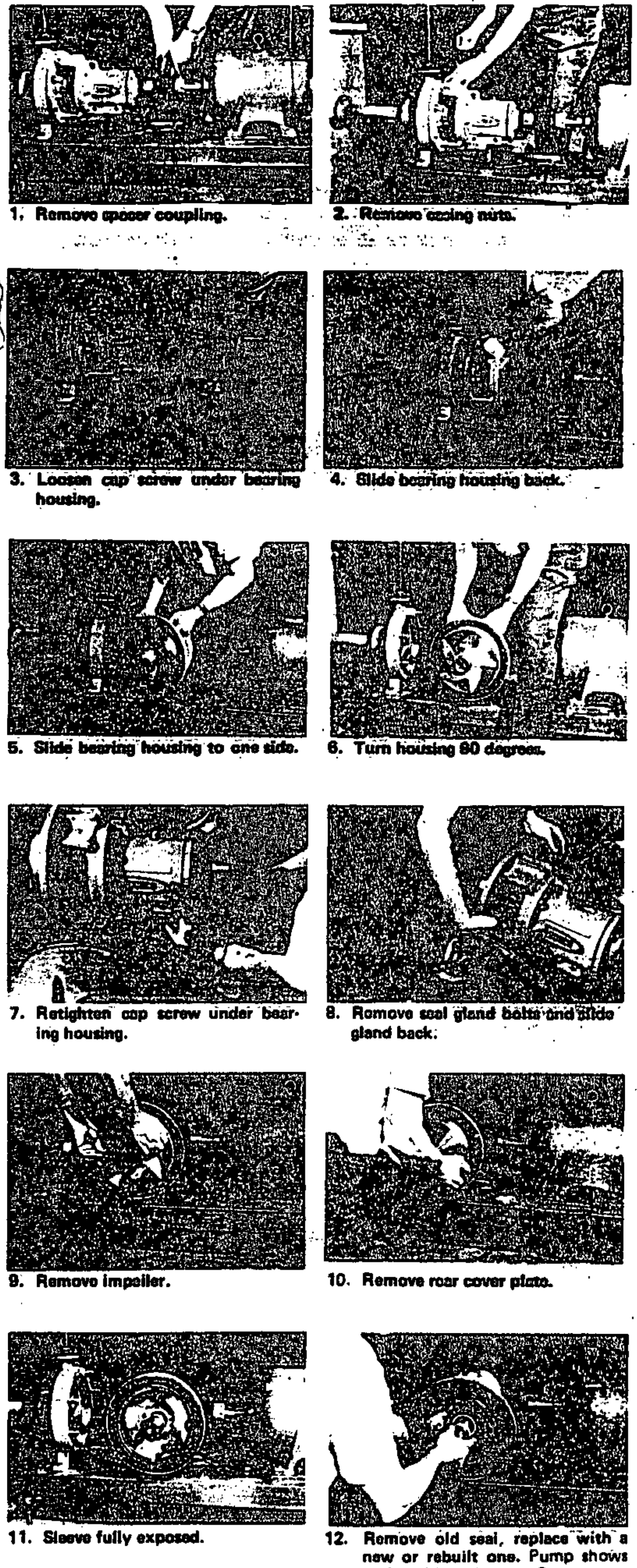
This same field maintenance and inspection procedure is accomplished on the Durco Group I pump without the special footpiece. After the bearing housing cap screw is removed, the rotating unit is backed out of the casing, swung around at a right angle to the original installation line, and is secured by reinserting the cap screw through the bearing housing foot.

In Figure J, the replacement is shown of a hook type sleeve with a mechanical seal rotary unit mounted on it. A measurement is taken from the end of the sleeve to the retainer portion of the mechanical seal. The new rotary unit merely goes back in the same position and is firmly affixed to the shaft sleeve, making certain that the new set screws are used. A drop of clean light oil is applied to the new stationary seat and spread uniformly over the face with a clean tissue. The follower flange and stationary seat are then carefully reassembled on the shaft. Before reassembling the shaft sleeve, a heavy coating of Molykote or similar lubricant should be applied over the shaft and around the inside diameter of the sleeve to prevent galling and binding. A drop of oil is also applied to the rotating face and again spread uniformly with a clean tissue. The sleeve is then applied over the shaft and firmly pressed home. After the seal is replaced, the rear cover and impeller are reassembled, as described in Section I, and the pump is merely swung back into position. After the coupling spacer is reassembled, the pump is ready to run.

PUMP RECORDS

Maintain pump records to provide information for ordering spare parts, and for evaluating pumps and mechanical seal performance. The following information should be included:

1) Pump equipment number and serial number.
2) Pump model number, impeller diameter and material of construction.
3) Mechanical seal manufacturer, type and code.
4) Motor horsepower and speed of operation.
5) Service conditions and frequency of operation.
6) Records of maintenance including spare parts usage and general condition of pump.



1. Remove spacer coupling.
2. Remove casing nuts.
3. Loosen cap screw under bearing housing.
4. Slide bearing housing back.
5. Slide bearing housing to one side.
6. Turn housing 90 degrees.
7. Retighten cap screw under bearing housing.
8. Remove seal gland bolts and slide gland back.
9. Remove impeller.
10. Remove rear cover plate.
11. Sleeve fully exposed.
12. Remove old seal, replace with a new or rebuilt one. Pump shows replaceable sleeve. Same procedure can be used for DC8 shaft.

FIGURE J

Parts and Materials

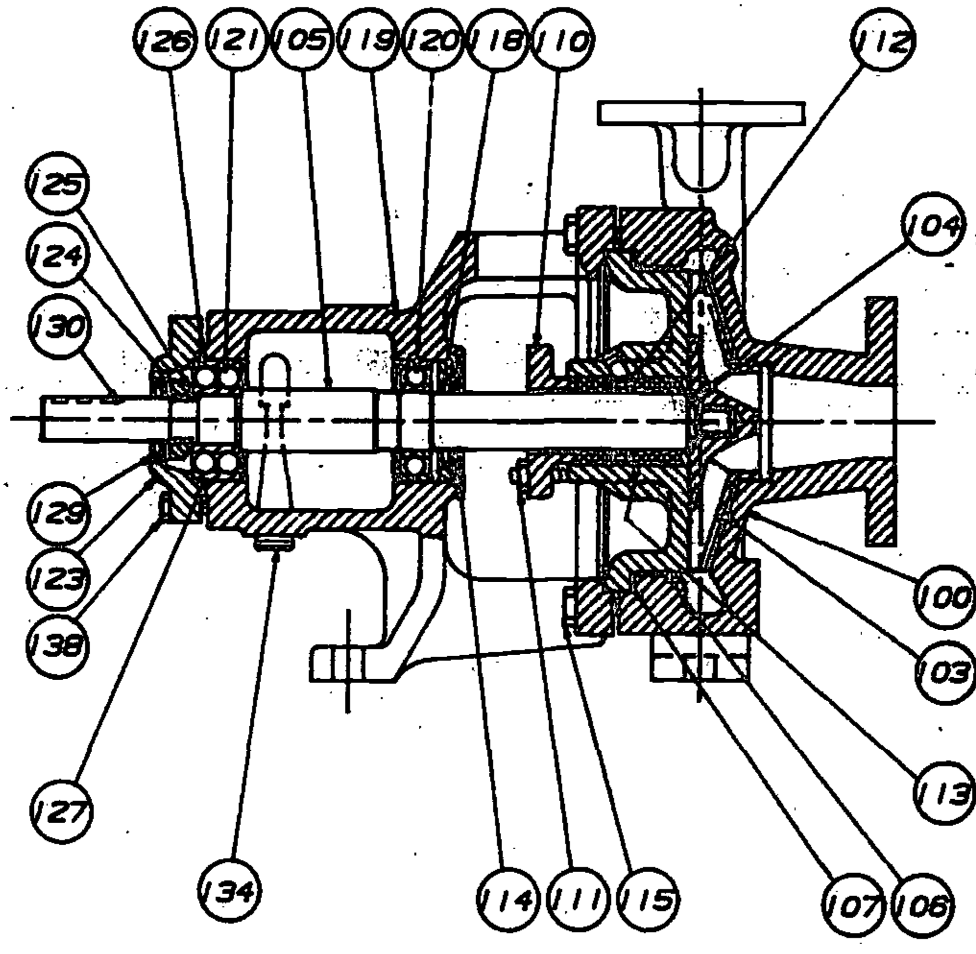
Item No.	Part	WET END ALLOY								
		Ductile Iron[A]	Durcomet 100	316 S.S.	Durimet 20	Monel**	Nickel	Chlorimet 2[B]	Chlorimet 3	Titanium[A,B]
100	Casing	Ductile Iron[C]	Durcomet 100	316 S.S.	Durimet 20	Monel	Nickel	Chlorimet 2	Chlorimet 3	Titanium
101	Drain Plug	Steel	Alloy 20	316 S.S.	Alloy 20	Monel	Nickel	Hastelloy B	Hastelloy C	Titanium
103	Impeller	Ductile Iron	Durcomet 100	316 S.S.	Durimet 20	Monel	Nickel	Chlorimet 2	Chlorimet 3	Titanium
105	Shaft*	Steel	DC8	DC8	DC8	316 S.S.	316 S.S.	316 S.S.	316 S.S.	316 S.S.
177	Sleeve	—	—	—	—	Monel	Nickel	Chlorimet 2	Chlorimet 3	Titanium
106	Rear Cover Plate	Ductile Iron[D]	Durcomet 100	316 S.S.	Durimet 20	Monel	Nickel	Chlorimet 2	Chlorimet 3	Titanium
110	Gland[E]	Durimet 20	Durimet 20	Durimet 20	Durimet 20	Monel	Nickel	Chlorimet 2	Chlorimet 3	Titanium

Materials Common to all Alloys Unless Otherwise Noted

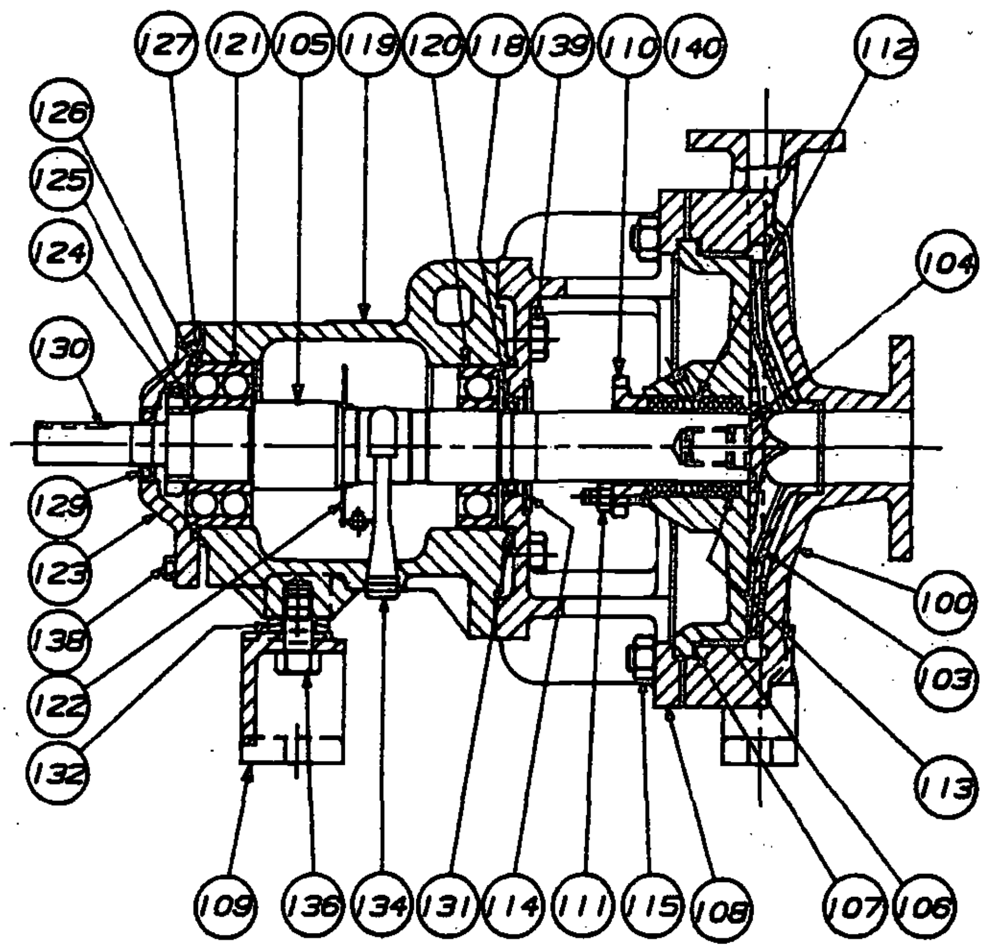
Part No.	Part	Material
104	Impeller Gasket*	TFR[F]
107	Rear Cover Plate Gasket*	Durabla
108	Bearing Housing Adapter	Cast Iron
109	Bearing Housing Foot	Cast Iron
111	Gland Studs or Flange Studs with Hex Nuts	304 S.S./303 S.S.
112	Seal Cage*[E]	PTFE
113	Molded Ring Packing*[E]	Kevlar[H]
114	Inboard Deflector	PTFE
115	Casing Studs/Hex Nuts	304 S.S./316 S.S.[G]
118	Inboard Oil Seal*	TFSR
119	Bearing Housing	Cast Iron
120	Inboard Bearing*	Steel
121	Outboard Bearing*	Steel
122	Oil Slinger	Steel
123	Bearing Cover	Cast Iron
124	Bearing LockNut	Steel
125	Bearing LockWasher	Steel
126	Bearing Cover Gasket	Cork
127	Bearing Shim*	Steel
129	Outboard Oil Seal*	TFSR
130	Shaft Coupling Key	Steel
131	Bearing Housing Adapter "O" Ring	SBR
132	Spherical Washer for Foot	Steel
133	Trico Oiler (not shown)	Steel-Plastic
134	Bearing Housing Vented Drain Plug	Plastic
136	Cap Screw for Foot	Steel
138	Cap Screws for Bearing Cover	Steel
139	Machine Bolts for Bearing Housing	Steel
140	Cap Screws for Adapter to Cover	Steel
X	Spacer Bushing	Plastic

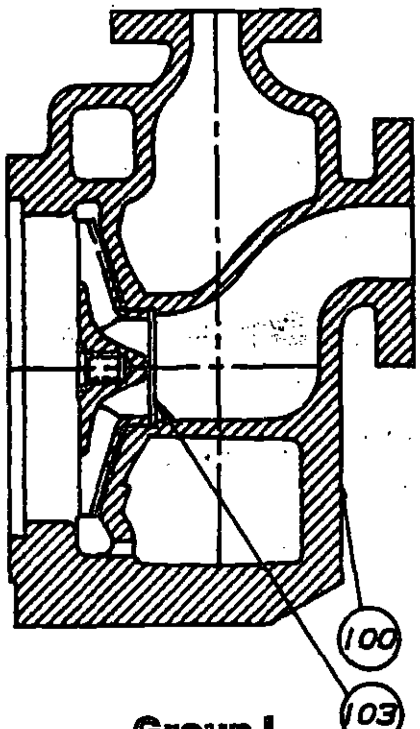
*Parts normally stocked by customer for emergency repairs.
**Tradename of International Nickel Company.
(A) Not available in Recessed Impeller pumps.
(B) Not available in Self-Priming pumps.
(C) Not available on 4x3 US-10H, 4x3 US-13, or 6x4 US-13A (cast steel substituted).
(D) Jacketed cover plates are carbon steel.
(E) Used in packed pumps only.
(F) Titanium pumps have Grafoil impeller gaskets.
Grafoil is a registered trade name of Union Carbide Corporation.
(G) Alloy is B7/Sr on Ductile Iron and Carbon Steel pumps.
(H) Tradename of E.I. Dupont deNemours & Company, Inc.

Group I
Standard Pump

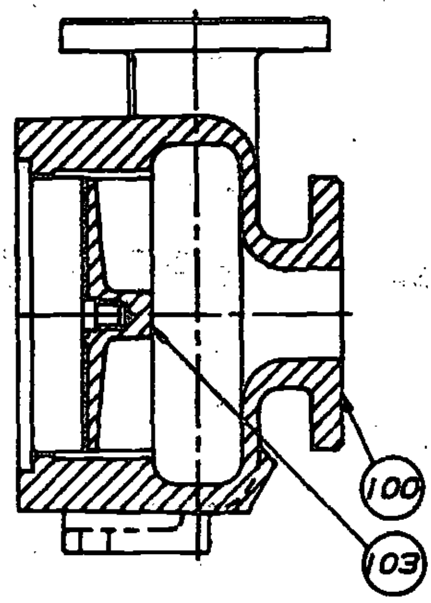


Group II and III
Standard Pumps

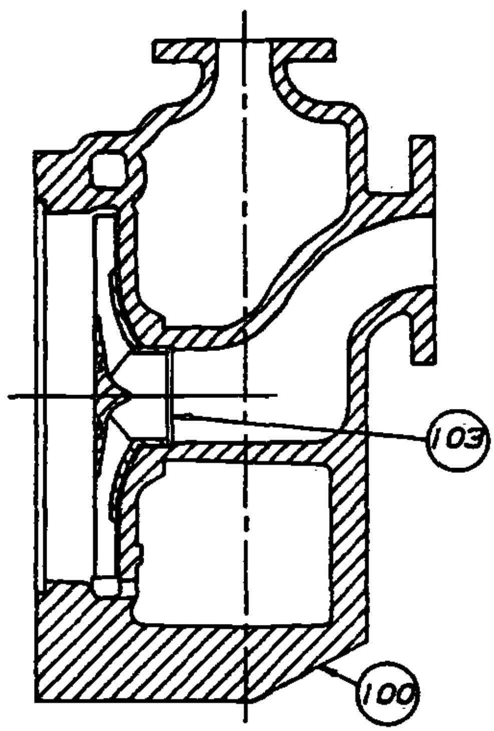




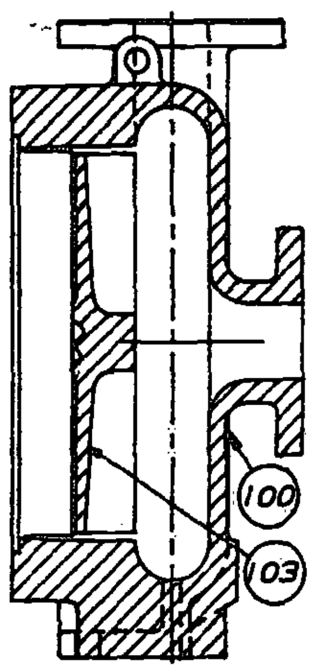
Group I
Self-Priming Pump



Group I
Recessed Impeller Pump



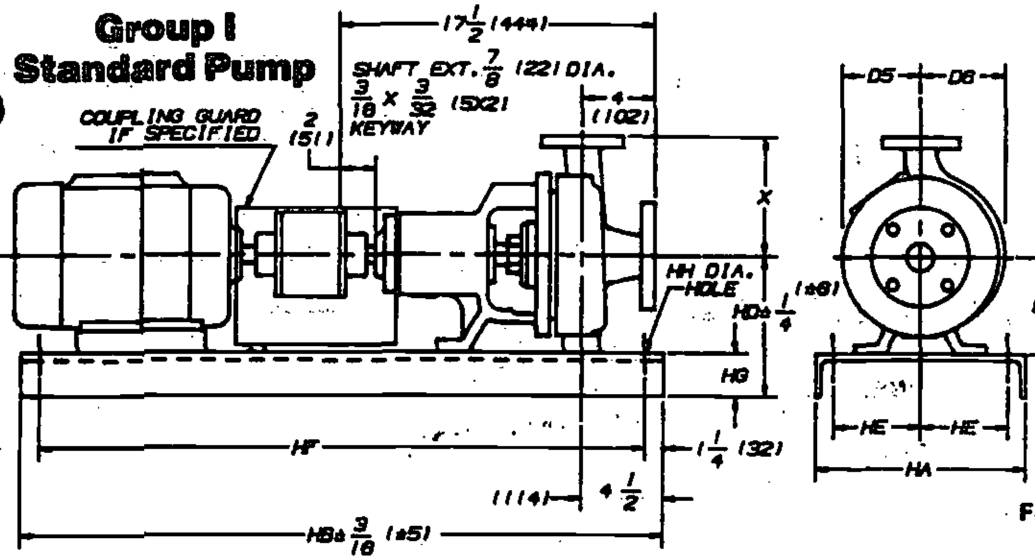
Group II
Self-Priming Pump



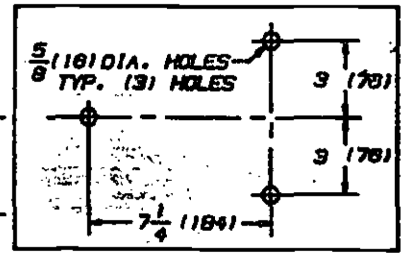
Group II
Recessed Impeller Pump

DIMENSIONS

Group I Standard Pump

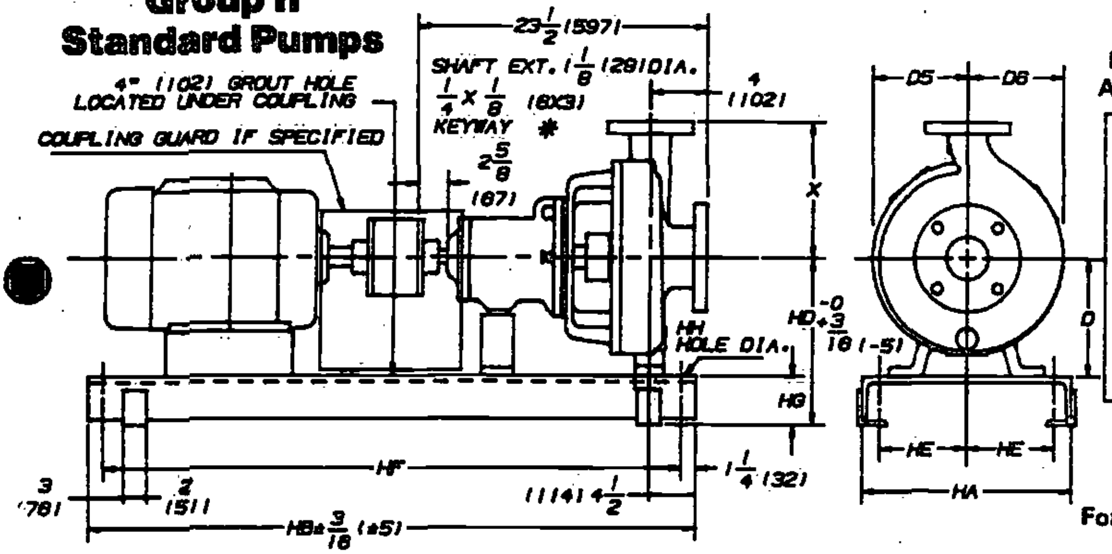


BARE PUMP MOUNTING HOLES FOR STANDARD, SELF-PRIMING AND RECESSED IMPELLER PUMPS

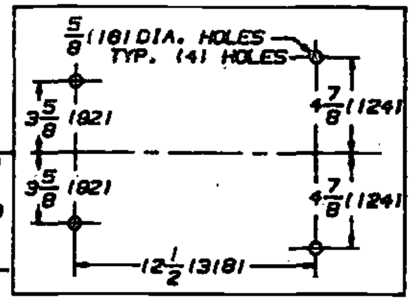


For Baseplate Dimensions, See Page 16.

Group II Standard Pumps



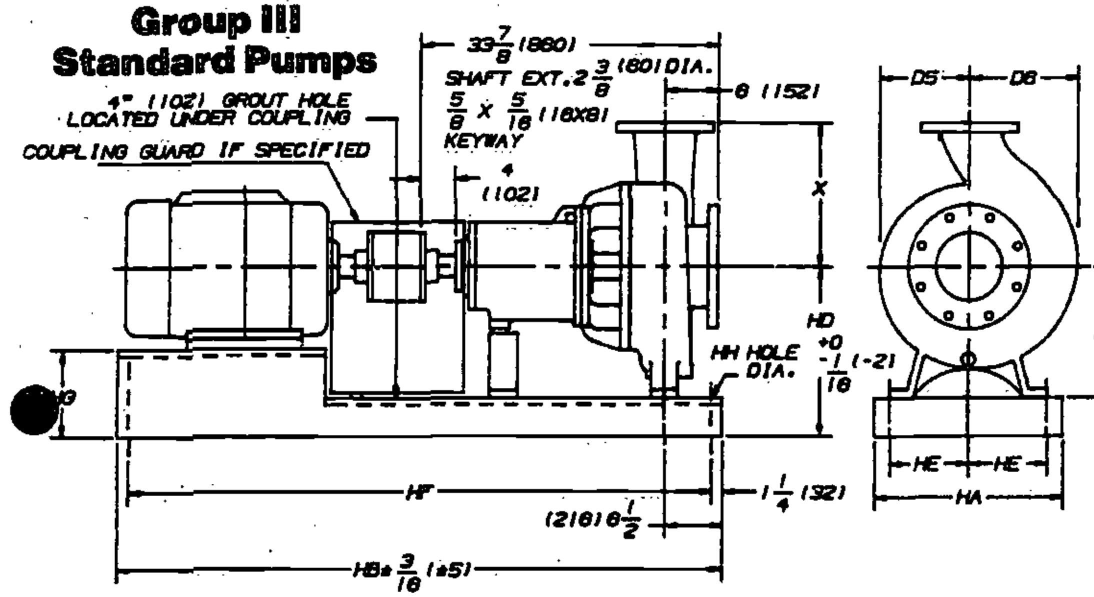
BARE PUMP MOUNTING HOLES FOR STANDARD, SELF-PRIMING AND RECESSED IMPELLER PUMPS



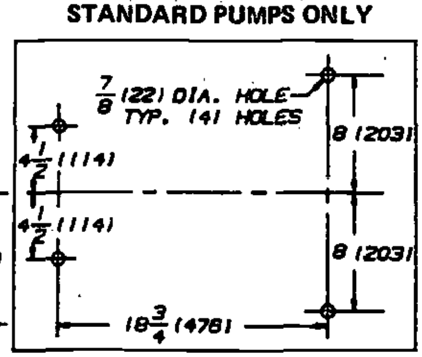
For Baseplate Dimensions, See Page 16.

* SHAFT EXTENSION 1 1/2 (38mm) DIAMETER 3/8 X 3/16 (10X5mm) KEYWAY 6 X 4-10 PUMP

Group III Standard Pumps



BARE PUMP MOUNTING HOLES FOR GROUP III STANDARD PUMPS ONLY



For Baseplate Dimensions, See Page 16.

GROUP I
STANDARD SIZES

Pump	Suct. Size In (mm)	Dis. Size In (mm)	Wt. lbs (kg)	D** In (mm)	D5 In (mm)	D6 In (mm)	X In (mm)
1½x1-6	1½ (40)	1 (25)	70 (31.5)	5¼ (133)	4⁵⁄₁₆ (110)	4½ (114)	6½ (165)
1½x1-8	1½ (40)	1 (25)	81 (36.4)	5¼ (133)	5⅜ (137)	5⅝ (143)	6½ (165)
3x1½-6	3 (80)	1½ (40)	78 (35.1)	5¼ (133)	4⁵⁄₁₆ (110)	4⅝ (117)	6½ (165)

GROUP II
STANDARD SIZES

Pump	Suct. Size In (mm)	Dis. Size In (mm)	Wt. lbs (kg)	D** In (mm)	D5 In (mm)	D6 In (mm)	X In (mm)
2x1-10A	2 (50)	1 (25)	210 (94.5)	8¼ (210)	6¾ (171)	6¾ (171)	8½ (216)
3x1½-8	3 (80)	1½ (40)	196 (89.0)	8¼ (210)	5½ (140)	5¹³⁄₁₆ (148)	8½ (216)
3x1½-10	3 (80)	1½ (40)	200 (90.0)	8¼ (210)	6¾ (171)	6¾ (171)	8½ (216)
3x2-8	3 (80)	2 (50)	200 (90.0)	8¼ (210)	5½ (140)	6¹⁄₁₆ (154)	9½ (241)
3x2-10	3 (80)	2 (50)	206 (92.7)	8¼ (210)	6¾ (171)	6¾ (171)	9½ (241)
4x3-8	4 (100)	3 (80)	227 (103.1)	8¼ (210)	5¹¹⁄₁₆ (145)	6¹¹⁄₁₆ (170)	11 (279)
4x3-10	4 (100)	3 (80)	225 (101.2)	8¼ (210)	6¾ (171)	7½ (190)	11 (279)
4x3-10H	4 (100)	3 (80)	249 (112.0)	10 (254)	6¾ (171)	8½ (216)	12½ (318)
6x4-10	6 (150)	4 (100)	290 (130)	10 (254)	7⅜ (187)	9¹⁄₁₆ (230)	13½ (343)
3x1½-13	3 (80)	1½ (40)	250 (112.5)	10 (254)	8¼ (210)	8¼ (210)	10½ (267)
3x2-13	3 (80)	2 (50)	258 (116.1)	10 (254)	8¼ (210)	8¾ (222)	11½ (292)
4x3-13	4 (100)	3 (80)	281 (126.4)	10 (254)	8¼ (210)	9⅜ (238)	12½ (318)
6x4-13A	6 (150)	4 (100)	324 (145.8)	10 (254)	9 (229)	10⁵⁄₁₆ (262)	13½ (343)

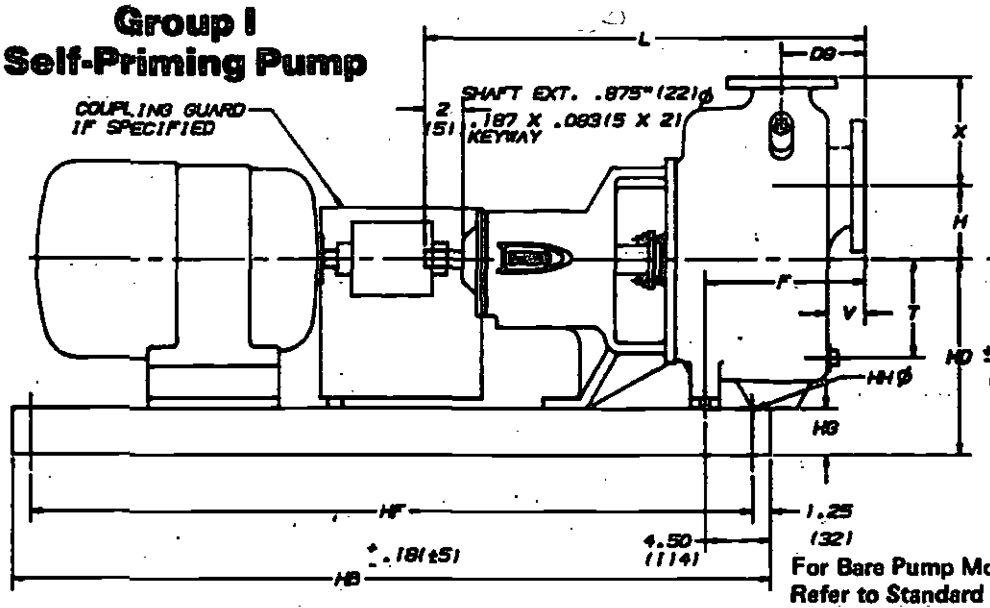
GROUP III
STANDARD SIZES

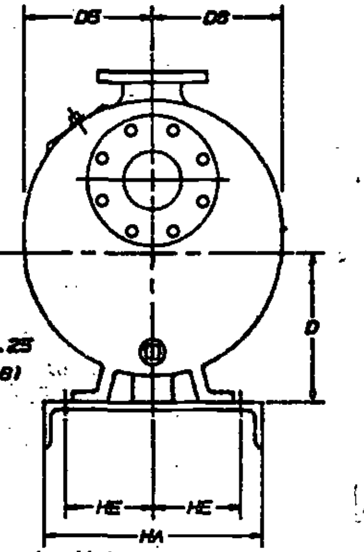
Pump	Suct. Size In (mm)	Dis. Size In (mm)	Wt. lbs (kg)	D** In (mm)	D5 In (mm)	D6 In (mm)	X In (mm)
8x6-14A	8 (200)	6 (150)	680 (306.0)	14½ (368)	10¼ (260)	12⅜ (314)	16 (406)
10x8-14	10 (250)	8 (200)	899 (408)	14½ (368)	10¹⁵⁄₁₆ (278)	14¼ (361)	18 (457)
8x6-16A	8 (200)	6 (150)	832 (377)	14½ (368)	11⅛ (282)	13¹¹⁄₁₆ (348)	18 (457)
8x6-16	8 (200)	6 (150)	740 (333)	14½ (368)	11¾ (298)	14 (357)	18 (457)
10x8-16	10 (250)	8 (200)	917 (416)	14½ (368)	11¾ (298)	15 (381)	19 (483)
10x8-16H	10 (250)	8 (200)	992 (450)	14½ (368)	12¼ (311)	15¹³⁄₁₆ (402)	19 (483)
10x8-17	10 (250)	8 (200)	835 (379)	14½ (368)	12⅞ (327)	15³⁄₁₆ (386)	20 (508)*

*ANSI B73.1 ("X") dimension = 19" (483 mm).

**"D" dimension is from shaft center line to bottom of casing feet. To determine shims, if required, see "HD" and "HG" on Baseplate Dimension Chart page 16.

Group I Self-Priming Pump

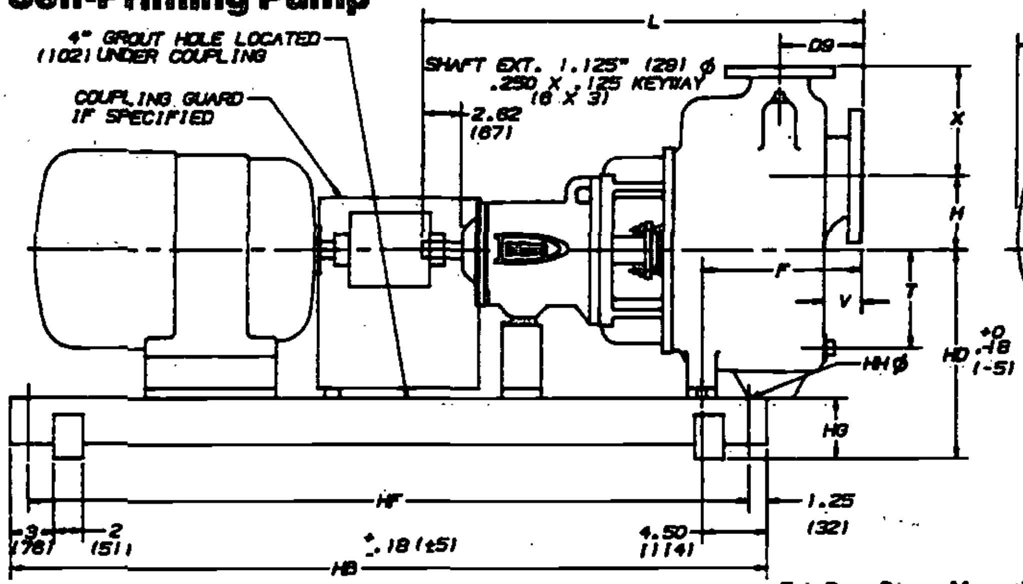


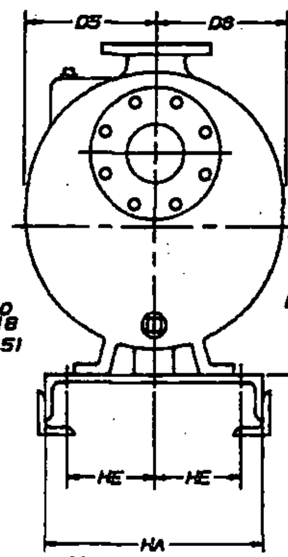


For Bare Pump Mounting Holes, Refer to Standard Pump Dimensions Drawings on Page 12.

For Baseplate Dimensions, See Page 16.

Group II Self-Priming Pump





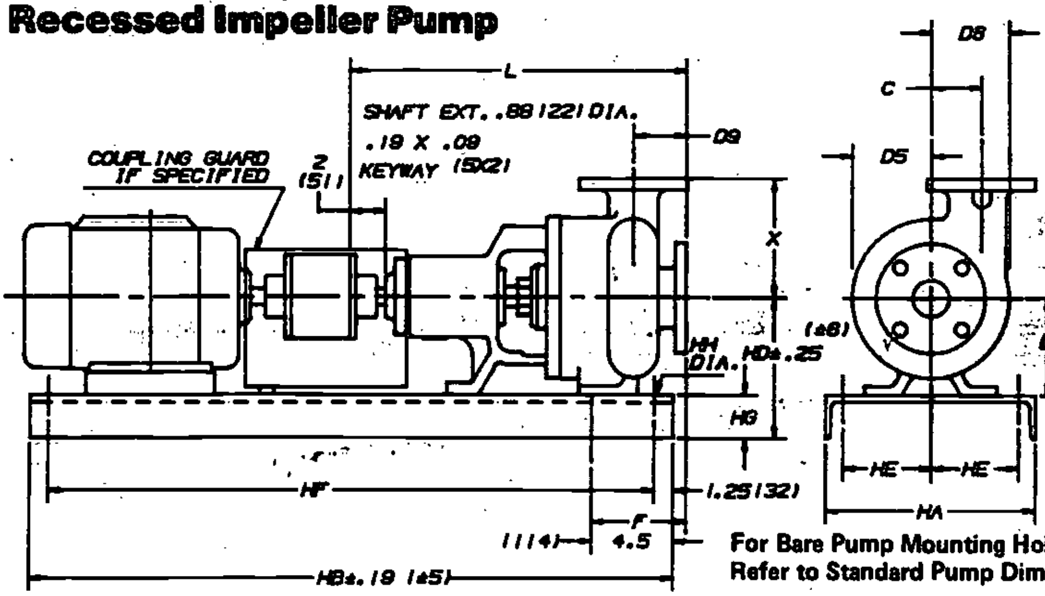
For Bare Pump Mounting Holes, Refer to Standard Pump Dimensions Drawings on Page 12.

For Baseplate Dimensions, See Page 16.

Pump	Suction Size in (mm)	Discharge Size in (mm)	D* in (mm)	D5 in (mm)	D6 in (mm)	D9 in (mm)	F in (mm)	H in (mm)	L in (mm)	T in (mm)	V in (mm)	X in (mm)	Bare Pump Weight lbs (kg)
1.5 x 1US-6	1.5 (40)	1 (25)	5.25 (133)	4.53 (115)	4.53 (115)	4.00 (102)	6.62 (168)	2.5 (64)	20.12 (511)	3.51 (89)	1.5 (38)	4.75 (121)	120 (54)
2 x 1.5US-10A	2 (50)	1.5 (40)	8.25 (210)	6.88 (175)	6.88 (175)	5.25 (133)	9.00 (229)	4.0 (102)	28.56 (725)	5.43 (138)	1.88 (48)	6.00 (152)	320 (145)
3 x 2US-10	3 (80)	2 (50)	8.25 (210)	7.30 (185)	7.30 (185)	5.25 (133)	9.00 (229)	4.0 (102)	28.56 (725)	5.68 (144)	2.75 (70)	6.50 (165)	340 (154)
4 x 3US-10H	4 (100)	3 (80)	10.00 (254)	8.87 (225)	8.87 (225)	5.75 (146)	11.00 (279)	5.0 (127)	30.56 (776)	6.87 (175)	2.56 (65)	7.50 (191)	430 (195)
3 x 2US-13	3 (80)	2 (50)	10.00 (254)	8.87 (225)	8.87 (225)	5.25 (133)	9.00 (229)	4.0 (102)	28.56 (725)	7.26 (184)	2.75 (70)	8.00 (203)	420 (191)
4 x 3US-13	4 (100)	3 (80)	10.00 (254)	9.56 (243)	9.56 (243)	5.75 (146)	11.00 (279)	5.0 (127)	30.56 (776)	7.75 (197)	2.56 (65)	8.50 (216)	520 (236)
6 x 4US-13A	6 (150)	4 (100)	11.00 (279)	10.56 (268)	10.56 (268)	6.00 (152)	12.43 (316)	5.0 (127)	32.00 (813)	8.62 (219)	2.93 (75)	10.00 (254)	630 (286)

*"D" dimension is from shaft center line to bottom of casing feet. To determine shims if required see "HD" and "HG" on Baseplate Dimension Chart on page 16.

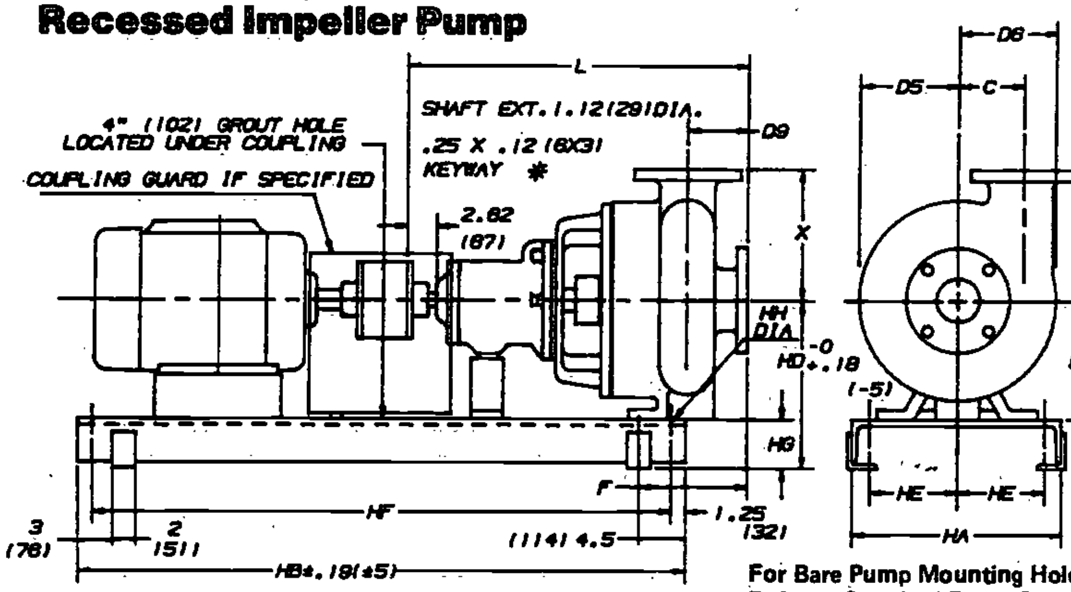
Group I
Recessed Impeller Pump



For Bare Pump Mounting Holes,
Refer to Standard Pump Dimensions Drawings on Page 12.

For Baseplate Dimensions, See Page 16.

Group II
Recessed Impeller Pump



For Bare Pump Mounting Holes,
Refer to Standard Pump Dimensions Drawings on Page 12.

For Baseplate Dimensions, See Page 16.

* SHAFT EXTENSION 1.5 (38mm) DIAMETER .38 X .19 (10X5mm) KEYWAY ON 4 X3R-13 AND 6 X 4R-13 PUMPS

Pump	Suction Size in (mm)	Discharge Size in (mm)	C in (mm)	D* in (mm)	D5 in (mm)	D6 in (mm)	D9 in (mm)	F in (mm)	L in (mm)	X in (mm)	Bare Pump Weight lbs (kg)
2 x 2R-6	2 (50)	2 (50)	2.75 (70)	5.25 (133)	4.31 (109)	4.31 (109)	2.75 (70)	5.56 (141)	19.06 (484)	6.50 (165)	100 (45)
2 x 2R-10	2 (50)	2 (50)	5.25 (133)	8.25 (210)	6.82 (173)	6.82 (173)	3.50 (89)	5.75 (146)	25.25 (641)	8.50 (216)	260 (118)
3 x 3R-10	3 (80)	3 (80)	5.12 (130)	8.25 (210)	7.18 (182)	7.18 (182)	4.25 (108)	7.50 (190)	27.00 (686)	9.00 (229)	300 (136)
4 x 3R-13	4 (100)	3 (80)	6.62 (168)	10.00 (254)	8.69 (221)	8.69 (221)	4.12 (105)	7.12 (181)	26.62 (676)	10.50 (267)	360 (163)
6 x 4R-13	6 (150)	4 (100)	6.62 (168)	10.00 (254)	9.19 (233)	9.19 (233)	4.75 (121)	8.38 (213)	27.88 (708)	11.50 (292)	390 (177)

*"D" dimension is from shaft center line to bottom of casing feet. To determine shims, if required, see "HD" and "HG" on Baseplate Dimension Chart on page 16.

BASEPLATE DIMENSIONS FOR STANDARD, SELF-PRIMING AND RECESSED IMPELLER PUMPS

GROUP I PUMPS

Baseplate	Weight lbs (kg)	HA in (mm)	HB in (mm)	HE in (mm)	HF in (mm)	HG in (mm)	HH in (mm)	Maximum Motor Frame	HD * in (mm)
50	73 (33)	10 (254)	35 (889)	4.0 (102)	32.5 (826)	3.00 (76)	0.75 (19)	182T	8.25 (210)
51	97 (44)	12 (305)	39 (991)	4.5 (114)	36.5 (927)	3.25 (83)	0.75 (19)	215T	8.50 (216)
53A	146 (66)	15 (381)	44 (1118)	6.0 (152)	41.5 (1054)	3.50 (89)	0.75 (19)	256T	9.88 (251)
								284T	10.75 (273)

GROUP II PUMPS

Baseplate	Weight lbs (kg)	HA in (mm)	HB in (mm)	HE in (mm)	HF in (mm)	HG in (mm)	HH in (mm)	Maximum Motor Frame	HD * 1 in (mm)	HD * 2 in (mm)	HD * 3 in (mm)
52	115 (52)	12 (305)	45.00 (1143)	4.5 (114)	42.50 (1080)	3.75 (95)	0.75 (19)	215T	12.00 (305)	13.75 (349)	14.75 (375)
53	178 (81)	15 (381)	52.00 (1321)	6.0 (152)	49.50 (1257)	4.13 (105)	0.75 (19)	286T	12.38 (314)	14.13 (359)	15.13 (384)
54	234 (106)	18 (457)	58.00 (1473)	7.5 (190)	55.50 (1410)	4.75 (121)	1.00 (25)	326T	13.00 (330)	14.75 (375)	15.75 (400)
								365T	14.00 (356)		
55	304 (138)	18** (457)	60.00 (1524)	7.5 (190)	57.50 (1460)	4.75 (121)	1.00 (25)	404T 405TS	15.00 (381)	15.00 (381)	15.75 (400)
								444T	16.00 (406)	16.00 (406)	16.75 (425)
56	320 (145)	18** (457)	61.75 (1568)	7.5 (190)	59.25 (1505)	4.75 (121)	1.00 (25)	405T 445TS	16.00 (406)	16.00 (406)	16.00 (406)

GROUP III PUMPS

Baseplate	Weight lbs (kg)	HA in (mm)	HB in (mm)	HE in (mm)	HF in (mm)	HG in (mm)	HH in (mm)	Maximum Motor Frame	HD * in (mm)
58	390 (177)	20 (508)	68 (1727)	8.5 (216)	65.5 (1664)	9.75 (248)	1.25 (29)	365T 365TS	18.75 (476)
59	540 (245)	22 (559)	80 (2032)	9.5 (241)	77.5 (1968)	7.75 (197)	1.25 (29)	445T 447TS	18.75 (476)
60	580 (263)	25 (635)	84 (2134)	11 (279)	81.5 (2070)	6.25 (159)	1.25 (29)	447T 449TS	18.75 (476)
61	594 (269)	25 (635)	88 (2235)	11 (279)	85.5 (2172)	7.75 (197)	1.25 (29)	449T	18.75 (476)

*Includes shims under pump if required.
**The motor end of this baseplate is 22" (559 mm) wide because extensions are welded to the top to allow mounting of large motors.

HD 1 for the following pumps:
Standard – 2 x 1-10A, 3 x 1½-8, 3 x 1½-10, 3 x 2-8, 3 x 2-10, 4 x 3-8 and 4 x 3-10.
Self-Primer – 2 x 1½US-10A and 3 x 2US-10.
Recessed Impeller – 2 x 2R-10 and 3 x 3R-10.

HD 2 for the following pumps:
Standard – 4 x 3-10H, 3 x 1½-13, 3 x 2-13, 4 x 3-13, 6 x 4-10 and 6 x 4-13A.
Self-Primer – 4 x 3US-10H, 4 x 3US-13 and 3 x 2US-13.
Recessed Impeller – 4 x 3R-13 and 6 x 4R-13.

HD 3 for the following pump:
Self-Primer – 6 x 4US-13A.

B|W Controls Inc.

Liquid Level Controls
Solid State Relays
Solenoids
Motor Controls

2200 East Maple Road
Birmingham, Michigan
48012 U.S.A.

Phone 313/643/8800
Telex 23/5359

APR 11 '80

April 3, 1980

Kaiser Engineers
300 Lakeside Drive
Oakland, California 94623

Attention: Mr. D.L. Browne
Principal Instrumentation Engineer
Engineering Division

Dear Dave:

It was a pleasure meeting you on my recent visit to California. I hope by now you have your technical literature sorted out and neatly restacked after my successful attempt to destroy your filing system.

To add to your pile I have enclosed a copy of our consulting engineers catalog which I hope you or your staff may find useful.

If you have any questions regarding our product line please do not hesitate to contact our local representative Sharman, Inc., or us directly at the factory.

Again, it was a pleasure meeting you.

Very truly yours,

B/W CONTROLS INC.

313 - 6 [illegible]

Roger

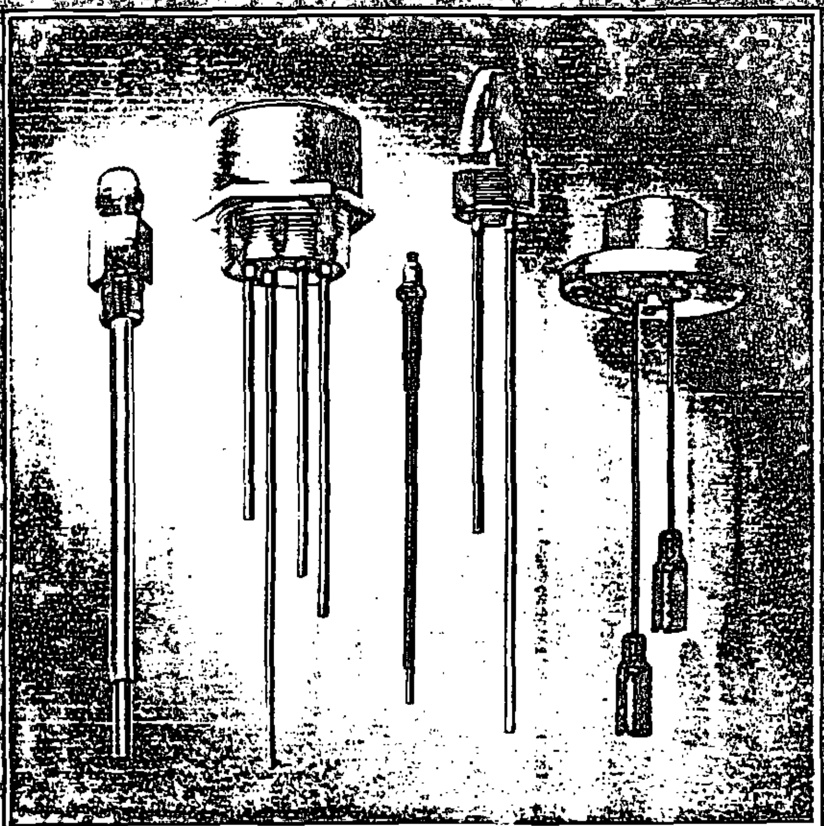
Roger G. Mosier
Sales Manager

RGM:bb
enclosure

cc: Sharman, Inc.
P. O. Box 31
344 Village Square
Orinda, California 94563
Phone: 415 254-4616

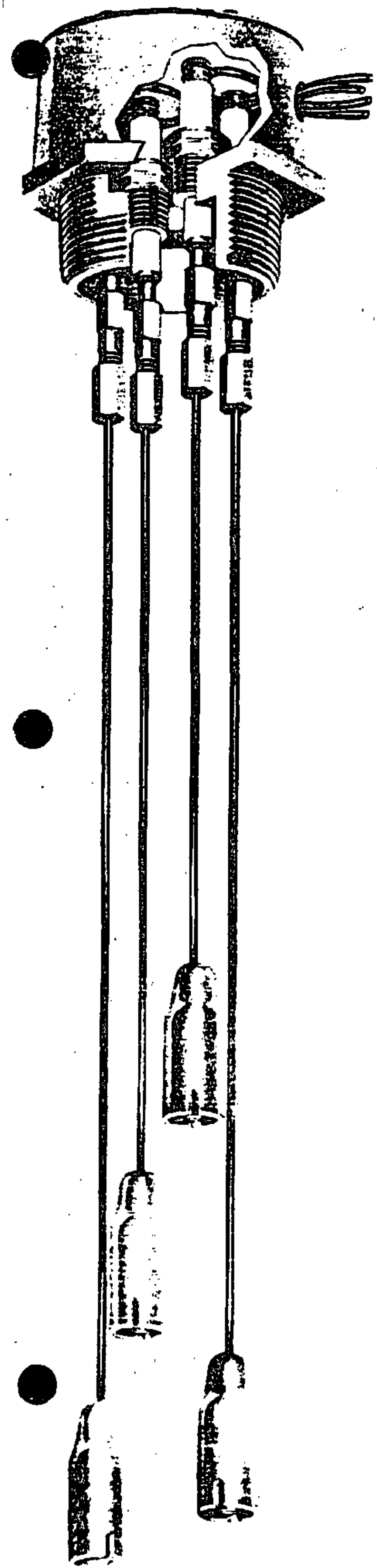
Section II

Electrodes and Electrode Holders



In the B/W system of floatless liquid level control, electrodes or probes are suspended in the container to make contact with the liquid and thus complete a circuit which actuates the relay to control the load. Electrodes are normally used with a suitable holder and, wherever possible, should be suspended vertically downward from the top of the tank or other vessel containing the liquid.

Electrodes and holders should be selected according to the specific characteristics of the material involved, the lengths required to obtain the desired control of levels and the physical nature of the container. Because of these factors, the B/W line of electrodes and holders presented in this Section has been developed to provide a practical, economical solution to almost every conceivable application and installation problem. When necessary, special equipment can also be supplied to meet specific needs.



Electrode Plugs

B|W offers a wide variety of standard plugs and connectors designed for use in assembling solid rod and wire suspension electrodes in the cast pressure-tight holders described on page 16—as well as for direct installation through the top of a tank. Among them:

Plug #04-126400 — This plug is furnished as standard with brass and cast iron Type E pressure-tight electrode holders to meet the requirements of most applications.

Plug #04-134900 — A replacement plug for use with B|W cast pressure-tight electrode holders manufactured prior to 1951.

Plug #04-141300 — Equipped with an internal Teflon gasket, this plug is furnished as standard with 316 stainless steel electrode holders and is suitable for steam applications up to 400 psi.

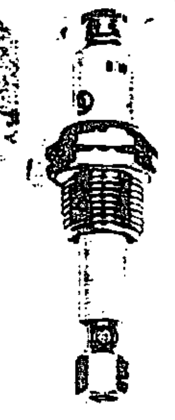
Plug #04-143300 — This plug is designed for applications involving very high operating pressures and is not for use with cast electrode holders. Special machining is required for direct mounting through top of tank.

Plug #04-149600 — This plug maintains its insulating properties under adverse operating conditions. Furnished with Teflon insulation, it is recommended for use in applications involving many highly corrosive chemicals.

Plug #12-065800 — A gland type plug with Teflon packing and a Teflon insulated solid rod electrode of any specified length required. Rugged pass-through construction provides added strength to withstand vibration. The threaded plug body is available in 303 and 316 stainless steel, Carpenter 20, Monel, titanium and nickel for many corrosive conditions. Please specify material desired.

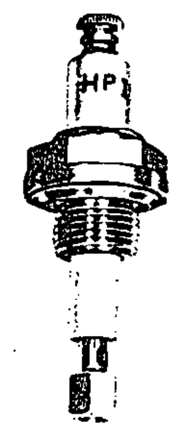
Plug #12-065900 — This plug is the same as Plug #12-065800 above except that the solid rod electrode insulation is polyvinyl chloride. Threaded body is also available in 303 and 316 stainless steel, Carpenter 20, Monel, titanium and nickel. Please specify.

PLUG #12-065800 OR #12-065900

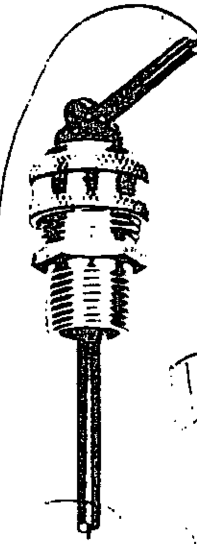


PLUG #04-126400 ~~OR #04-141300~~

PLUG #04-149600



PLUG #04-143300



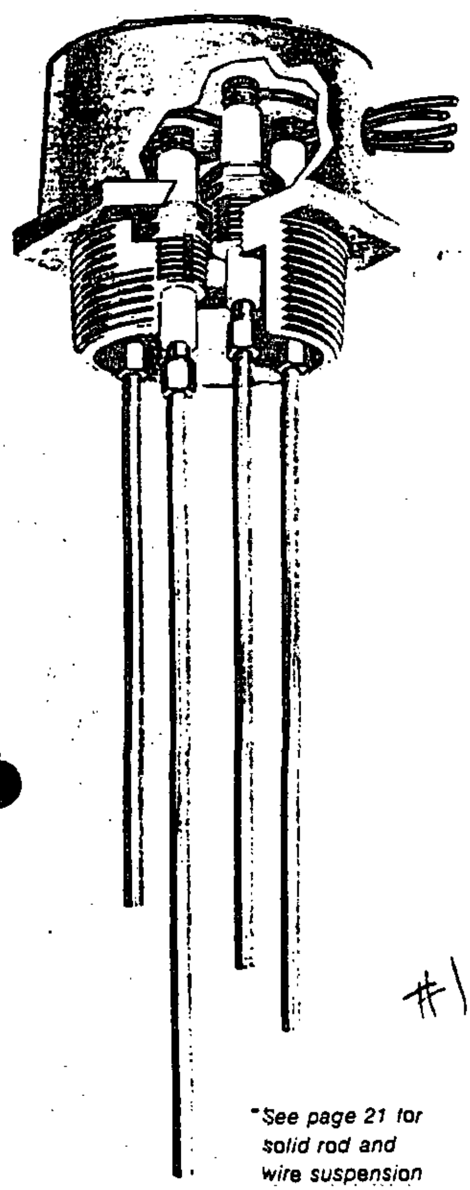
PLUG #12-066400

TEN2

Plug #12-066400 — This cord grip type plug is designed for use with Type E holders to support wire suspension electrodes in many non-pressure applications where operating temperatures do not exceed 190°F and where maximum insulation is required because of possible flooding.

PART NUMBER	MOUNTING THREAD	SIZE OF HEX	INSULATOR MATERIAL	MAXIMUM OPERATING PRESSURE
#04-126400	¾" pipe	13/16"	Alumina	2,000 psi @ 200°F
#04-134900	⅝-24	13/16"	Alumina	2,000 psi @ 200°F
#04-141300	¾" pipe	13/16"	Alumina	2,000 psi @ 200°F 400 psi @ 450°F
#04-143300	18mm x 1.5mm	1"	Alumina	10,000 psi @ 200°F 400 psi @ 450°F
#04-149600	¾" pipe	13/16"	Teflon	250 psi @ 400°F
#12-065800	¾" pipe	13/16"	Teflon	250 psi @ 400°F
#12-065900	¾" pipe	13/16"	PVC	100 psi @ 150°F
#12-066400	¾" pipe	¾"	—	Non-Pressure

Cast Pressure-Tight Electrode Holders



B/W pressure-tight electrode holders are designed especially for use in applications requiring a positive, leak-proof mounting in the tank or vessel containing the liquid to be controlled. Such installations include boiler feed and condensate return systems, hydropneumatic tanks, and various types of chemical processing equipment, etc.

Featuring rugged, water-tight construction, these cast threaded holders are available in three standard sizes as shown below — all of which are normally stocked in brass, cast iron, and 316 stainless steel for use at the temperatures and pressure listed at right.

Electrode Options — Because these holders are most commonly used with bare or insulated solid rod electrodes* in lengths of six feet or less, they are furnished as standard with electrode plugs having a ¼-20 female thread to support from one to seven electrodes. While plug #04-126400 is suitable for most applications involving pressures of up to 2000 psi at temperatures up to 200°F, various other plugs as listed on page 17 are also available on request to meet specific requirements.

For applications requiring longer electrode lengths — or where there is insufficient head room to permit the installation of solid rod electrodes, these pressure-tight holders can also be supplied with either brass or 303 stainless connectors designed to support wire suspension electrodes* of any length required to control liquids at desired operating levels. In addition, all pressure-tight holders can be furnished with a separate grounding screw mounted inside if desired.

Installation Recommendations — Wherever possible, these holders should be mounted in a vertical position through the top of the tank with the electrodes extending downward to the desired operating levels. If it is necessary to mount them horizontally through the side of a tank, insulated rod electrodes at least six inches long must be used.

Temperature/Pressure Limitations

ELECTRODE HOLDER MATERIAL	MAXIMUM OPERATING TEMPERATURE	MAXIMUM OPERATING PRESSURE
Brass	200°F	500 psi
	400°F*	250 psi
Cast Iron	200°F	500 psi
	400°F*	250 psi
316 Stainless	200°F	2000 psi
	450°F	400 psi

Specify #04-141300 Electrode Plug

Ordering Information — When ordering, please specify: (1) Type of holder desired; (2) Material; (3) Type and length of each electrode required; (4) Electrode plugs, if other than standard; (5) Wire connector material, required for wire suspension electrodes.

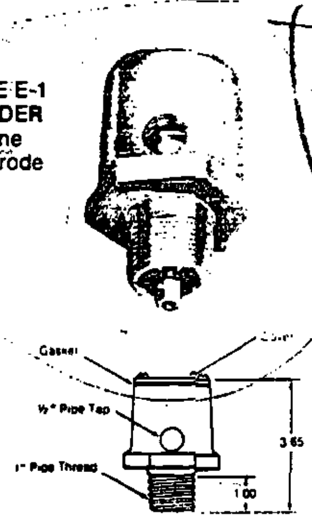
#1

HOLDER TYPE	NUMBER OF ELECTRODES	MATERIALS AND PART NUMBERS			SHIPPING WEIGHT
		BRASS	CAST IRON	316 STAINLESS	
E-1	1	12-048000	12-048100	12-048200	1.5 lbs.
E-2	2	12-048400	12-048500	12-048600	3.0 lbs.
E-3	3	12-048800	12-048900	12-049000	3.0 lbs.
E-4	4	12-049200	12-049300	12-049400	4.5 lbs.
E-5	5	12-049600	12-049700	12-049800	5.0 lbs.
E-6	6	12-050000	12-050100	12-050200	5.0 lbs.
E-7	7	12-050400	12-050500	12-050600	5.5 lbs.

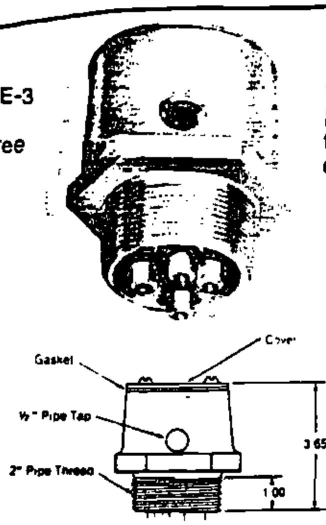
NOTE: All brass and cast iron holders are furnished as standard with #04-126400 electrode plugs; 316 stainless holders are equipped with #04-141300 electrode plugs. If holders are to be used with wire suspension electrodes, please specify the wire connectors desired: Brass — #12-038400; 303 Stainless Steel — #12-043800.

*See page 21 for solid rod and wire suspension electrodes.

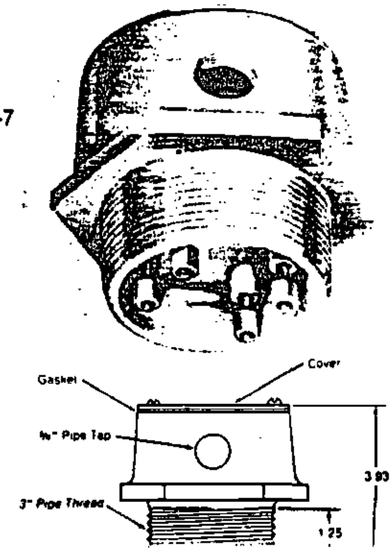
TYPE E-1 HOLDER for one electrode



TYPE E-2 & E-3 HOLDERS for two or three electrodes



TYPE E-4 TO E-7 HOLDERS for four to seven electrodes



Special-Purpose Electrode Holders

The electrode holders described below are available as standard to meet the requirements of many unusual applications. Other special holders can be made to order to meet specific operating and/or installation conditions.

Concentric Electrode Holders

These patented B W electrode assemblies were developed primarily for use in original equipment applications where space is limited and where dual level control is required. They consist of: (1) An electrode assembly which includes a ½-20 UNF-2A threaded stainless steel fitting for direct mounting into the tank or vessel, and two concentrically mounted and hermetically sealed insulated rod electrodes: and (2) a snap-on cord set of any practical length that consists of multiconductor type SJT cable and a molded snap on cover that fits over the electrode assembly fitting.

As shown at left, these concentric electrode assemblies can also be supplied with a plastic splash shield to assure positive control operation at desired levels in applications where excessive turbulence is encountered.

When ordering, please specify high and low control level desired and length of cord set.

Adjustable Gland Electrode Holders

B W adjustable gland electrode holders are designed for use in applications that require occasional changing of the high or low level control settings. Typical installations include conveyor feed, liquid proportioning, and container filling machines.

Made of 303 stainless steel with positive pressure-tight ½" pipe thread mounting plus Teflon or Neoprene insulation and packing these holders are used with insulated solid rod electrodes of any desired length. To adjust level settings, simply loosen the top of the holder and slide the electrode up or down to required depth. Electrodes must be insulated over the full range of adjustability.

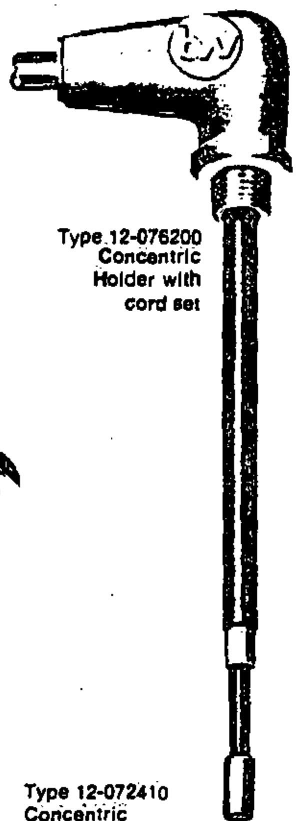
Cord Grip Electrode Holders

B W cord grip electrode holders provide a simple, low-cost means of sealing lead wire openings against leakage of gases and liquids in non-pressure applications requiring use of wire suspension electrodes. These include submersible pump installations with low level cutoff control, underground water storage tanks, covered sumps, and sewage pumping stations.

Made of aluminum machined for ½" pipe thread mounting, they are furnished with compressible Neoprene packing to support either one or two wire suspension electrodes.

Condulet Electrode Holders

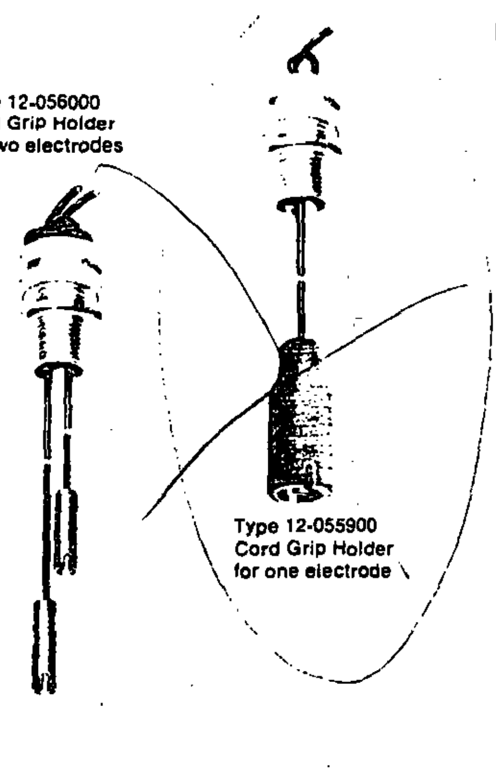
Designed for use with B W Type E-1P wire suspension electrodes, these versatile low-cost holders are recommended for underground drainage sumps, septic dosing tanks, open sumps and similar applications. Available in cadmium plated cast iron and rigid polyvinyl chloride in sizes to accommodate from one to eight electrodes, they may be installed in areas where flooding is apt to occur as well as in corrosive atmospheres.



Type 12-076200 Concentric Holder with cord set

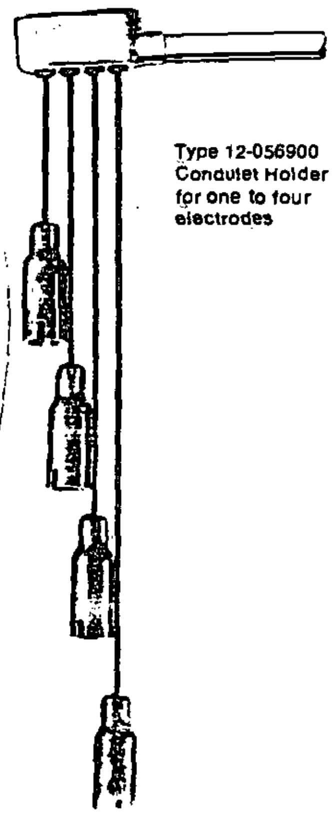
Type 12-072410 Concentric Holder with splash shield

Type 12-057000 Adjustable Gland Electrode Holder



Type 12-056000 Cord Grip Holder for two electrodes

Type 12-055900 Cord Grip Holder for one electrode



Type 12-056900 Condulet Holder for one to four electrodes

B|W Level Sensing Electrodes

Solid Rod Electrodes

B|W solid rod level sensing electrodes are generally used in applications which require relatively short lengths of six feet or less from the top of the tank or vessel to reach the control levels desired.

Threaded ¼-20 at one end to fit electrode plugs listed on page 17, these ¼" diameter rods are available in the choice of corrosion resistant materials shown at right — all of which can be supplied either bare or insulated and with or without carbon tips for added resistance to chemical and electrolytic attack.

Standard insulation materials are polyvinyl chloride for applications involving operating temperatures up to 190°F., and Teflon for use at temperatures up to 550°F. Both of these materials provide excellent insulation between the electrodes and ground, protect personnel against shock hazards, reduce corrosion, and make electrodes insensitive to foam.

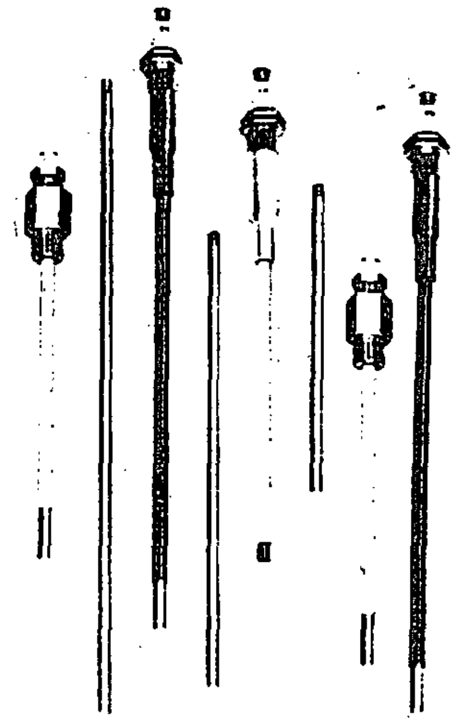
Bare and PVC-insulated brass and stainless steel rods are furnished as standard in 1-foot increments up to 6-feet long for cutting to any intermediate length desired in the field. After cutting insulated rods, strip about 1" of insulation off lower end to expose bare rod.

When ordering, please specify: (1) Type of material desired; (2) Overall length required; (3) Insulation and/or carbon tip, if desired.

Standard Electrode Materials

MATERIALS	LIQUIDS TO BE CONTROLLED
Brass	Soft water; Condensate
316 Stainless Steel	Water and sewage; Alkaline solutions
Monel	Salt water; Acid solutions
Nickel	Salt water; Acid solutions
Carpenter 20	Acid solutions
Hastelloy C	Acid solutions; Hypochlorite
Titanium	Strong acid solutions

Other special materials available on request.



Wire Suspension Electrodes

Wire suspension electrodes are designed for use in applications requiring long lengths, or where limited head room prevents installation of solid rod electrodes. Generally used with flanged cast iron, cord grip, or condulet type holders described on pages 18 and 20, they are suspended in the liquid by means of Type SW insulated suspension wire.

Available as standard in brass or stainless steel, they can be supplied with or without molded plastic shields for use at operating temperatures up to 150° and 190° respectively.

Type E-1P—Shielded: This electrode is approximately 4" long and assembled in a molded plastic insulating shield 1⅞" in diameter. Designed for general purpose use, it is ideal for elevated tanks, sewage pumping stations, and deep well installations.

Type E-1P—Less Shield: This 4" electrode is used in hydropneumatic and condensate return tanks where limited head room prevents the use of rod electrodes and where vertical spacing between electrodes is 4" or more.

Type E-1S—Shielded: A 2" long electrode assembled in a molded plastic shield ¾" in diameter. Ideal for use in submersible pump installations and other applications where little clearance is provided for installation.

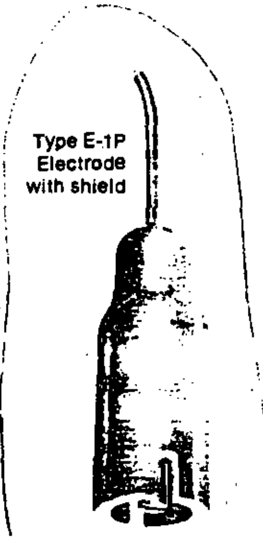
Type 13-064700: This special electrode for highly corrosive liquids can be furnished in any of the materials listed above for solid rod electrodes. It is 3" long by ½" diameter and insulated with polyvinyl chloride which completely bonds to the insulation of Type SW suspension wire. Since it is only furnished assembled to the SW wire, please specify desired electrode material and overall

Type SW Suspension Wire: Designed to provide maximum strength and insulation, Type SW wire should always be used with B|W wire suspension electrodes to assure that a water-tight seal is accomplished by the packing in the electrode. The wire is single conductor 18 gauge, 41 strand copper with ⁵⁄₆₄" vinyl insulation.

Wire Connectors—If wire suspension electrodes are to be used with Type E cast pressure-tight holders, a special wire connector is required to support each electrode from the plugs furnished with each holder. Assembly details are shown below. These connectors are available in brass or 303 stainless. Please specify type number or material desired.

Type 13-064700 Insulated Electrode

Type E-1P Electrode less shield



Type E-1P Electrode with shield

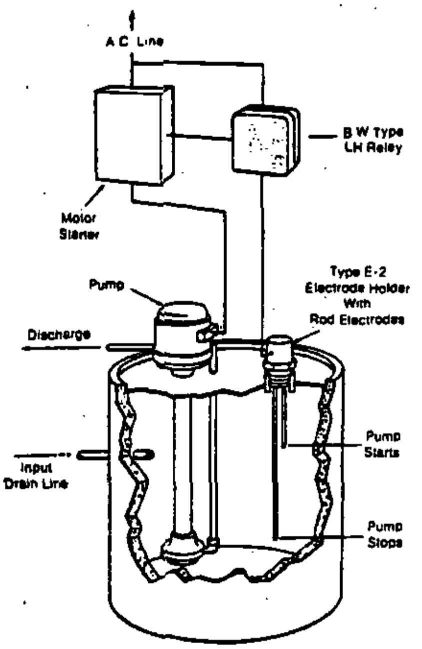
Type E-1S Electrode with shield

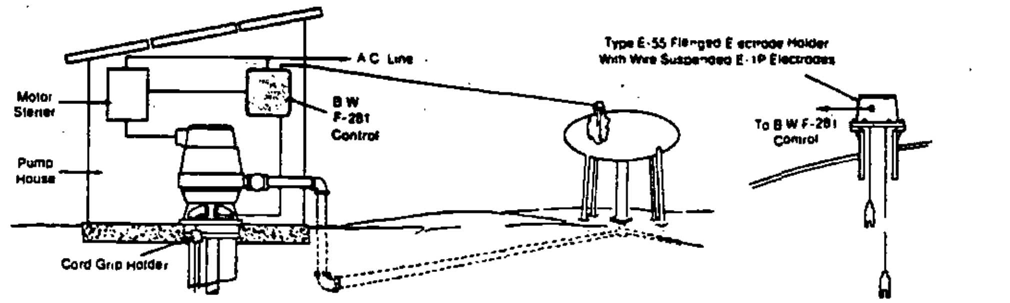
Type 12-043800 Wire Connector assembled to electrode plug

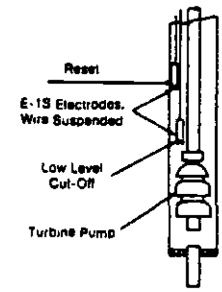
Typical Level Control Installations

Single Pump, Pump Down
Diagram F-55

B|W Type LH relay automatically starts the pump when liquid contacts upper electrode and stops the pump when the liquid falls below the lower electrode. Electrode equipment shown is typical for most sump applications.





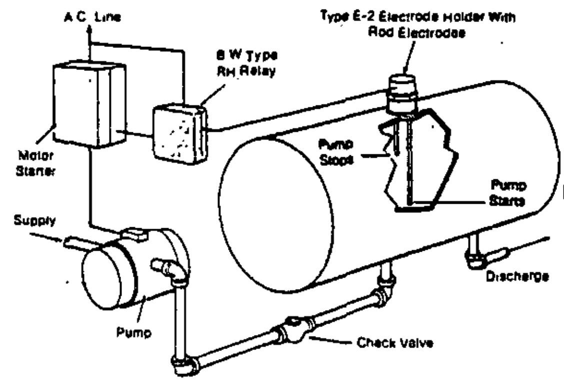


Pump Up with Low Level Cut-Off
Diagram F-281

This combination of a Type RH relay and Type LH relay provides automatic control of a pump to maintain water level in a storage tank, and at the same time provides low water cutoff protection for the pump should the water level in the well or supply tank fall below the lower electrode. The pump will automatically re-start — if demand still exists — when the level in the well or supply tank rises to the reset electrode.

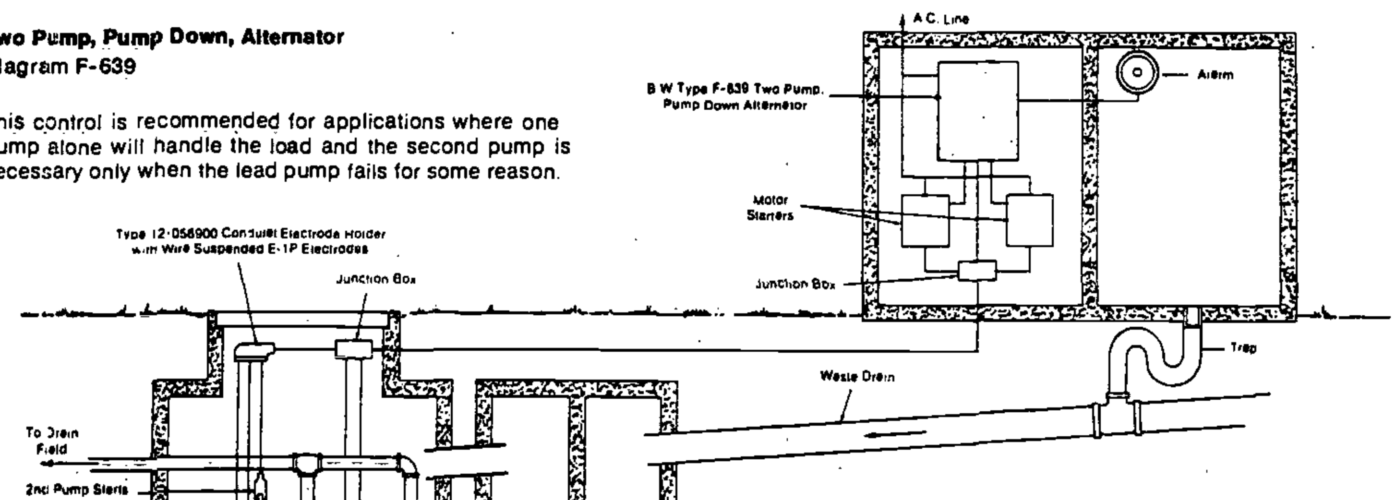
Single Pump, Pump Up
Diagram F-57

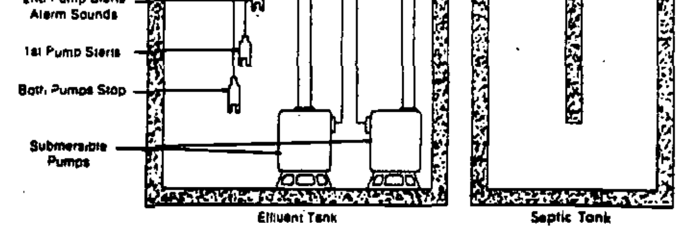
B|W Type RH relay automatically starts the pump when liquid falls below the lower electrode and stops pump when liquid contacts the upper electrode. Relay should be connected to same source of power that supplies pump. The electrode equipment shown is typical for small process tanks and suitable for pressure and high temperature applications.



Two Pump, Pump Down, Alternator
Diagram F-639

This control is recommended for applications where one pump alone will handle the load and the second pump is necessary only when the lead pump fails for some reason.





Whenever the second pump is required, an alarm will sound to indicate a pump has failed, and the system will continue to operate on the remaining pump until repairs are made. For septic tank effluent applications, it is desirable to mount all the electrical controls in the building rather than in the corrosive atmosphere at the tank.

MAGNETROL INTERNATIONAL, INCORPORATED

BULLETIN: 45-115
EFFECTIVE: NOVEMBER, 1
SUPERSEDES: 45-110

DISPLACEMENT TYPE LIQUID LEVEL CONTROLS

INTRODUCTION

Magnetrol Displacement Type Controls are in daily service across the world in such diverse applications as remote unattended pumping stations in the Libyan desert to petrochemical processing in Texas and nuclear power generators in Tennessee. They are well suited for standard as well as difficult applications, such as foaming or surging liquids or agitated fluids, and usually cost less than other types of controls.

ENGINEERING FEATURES

VERSATILE... displacer type units can conveniently and effectively be used on applications ranging from water to sewage handling, and paints, varnishes, heavy oils, or surging liquids.

CHOICE OF SINGLE OR MULTIPLE SWITCHING... Standard models are available for single or dual level stage control and for narrow or wide level ranges. Triplex models for three switch function applications are also available.

ADJUSTABLE... Each level sensing displacer may be positioned at any point along its suspension cable to accommodate any desired operating level or level differential.

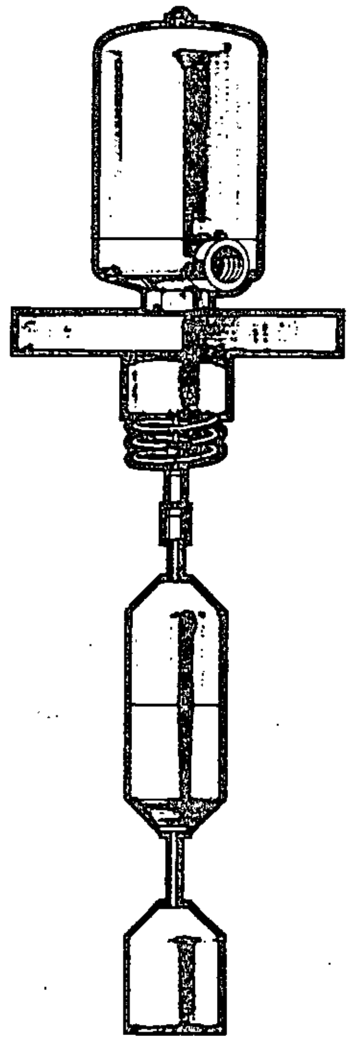
CORROSION RESISTANT... Magnetrol displacement controls feature stainless steel operating components and a choice of displacer material.

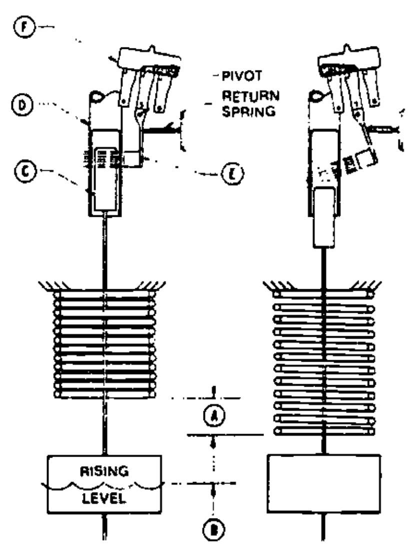
ANTI-SURGE DESIGN... Since the displacers are heavier than the liquid under control they do not "bob" with wave or surge action, eliminating the possibility of switch shortcycling.

EASY INSTALLATION... Little head room is required to install the flexible cable and displacer assembly into a tank and a choice of threaded or flanged mounting is available.

OPERATING PRINCIPLE

Operation is based upon a buoyancy principle whereby a spring is loaded with weighted displacers which are heavier than the liquid. Immersion of the displacers in the liquid results in a buoyancy force change, which moves the spring upward. Since the spring moves only when the level moves on a displacer, spring movement Ⓐ is always a small fraction of the level travel between displacers Ⓑ. A magnetic sleeve Ⓒ is connected to the spring and operates within a non-magnetic barrier tube Ⓓ. Spring movement causes the magnetic sleeve to attract a pivoted magnet Ⓔ, actu-





APPLICATION AND SELECTION DATA

Consideration should be given to the following factors to assure selection of the most appropriate instrument.

LEVEL RANGE . . . Displacement type Magnetrols are defined as having either "narrow" or "wide" level differential bands. Narrow differential type units are factory set with a fixed minimum level travel band between switch "off" and "on." The position of the band is adjustable along the suspension cable and its width varies slightly with specific gravity of the liquid, increasing as the specific gravity decreases.

Wide differential units can be field adjusted to operate off-to-on over any level range limited by the length of suspension cable: The "minimum" level differential band obtainable with a wide differential unit is usually several times greater than that available with the narrow band unit.

NUMBER OF SWITCHES . . . Both single and dual switch (tandem) models are available with either narrow or wide level differential bands. The tandem models effectively perform the functions of two separate controls. Triplex (three switch function) models are also available.

LIQUID SPECIFIC GRAVITY . . . For the greatest application flexibility, all Magnetrol displacement controls except the Models A-103-Tandem Series* are factory calibrated to operate over a very wide range of specific gravity as indicated in the tables on the following pages. Should the specific gravity of the controlled liquid fall outside the range values given, a special calibration will usually allow the use of a standard model.

* Each Model A-103-Tandem unit (page 6) is individually calibrated to operate on a *given liquid specific gravity value*. The table on page 6 indicates the minimum and maximum value limits.

PRESSURE-TEMPERATURE RATINGS

Models with threaded tank connection are rated 400 PSI @ 100°F, 250 PSI @ 400°F.

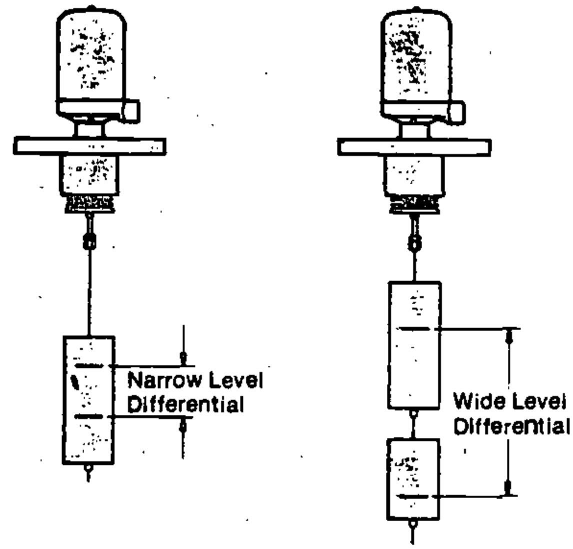
Flanged models are limited to the pressure rating of the selected flange. Cast iron flanges are flat face type; steel flanges are raised face type conforming to ANSI dimensional standards.

Stainless steel displacers are rated 600 PSI @ 100°F, 375 PSI @ 500°F. Karbate displacers are limited to a maximum temperature of 300°F. Do not use porcelain

TYPES OF LEVEL DIFFERENTIALS

CATALOG MODEL
A-153 SERIES
(Level Alarm Applications)

CATALOG MODEL
A-103 SERIES
(Pump or Valve Control Applications)

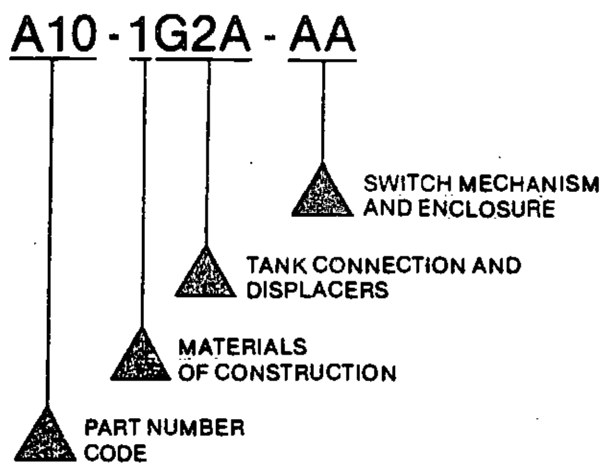


HOW TO SPECIFY AND ORDER

Displacer type controls are identified by an alphanumeric part number system. The part number provides exact specification of unit configuration, materials, switches and other options vital to the performance and function of the instrument.

The system is comprised of four distinct components, each of which describes a specific part or feature of the instrument. A definition of each of the four components and an example are given below. Product selection data are listed on pages four through eight.

MODEL NUMBER EXAMPLE:

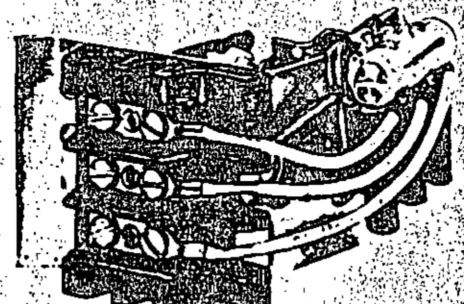


EXPEDITE SHIP PLAN (ESP)

Many standard displacer units and options are available for quick shipment, usually within two weeks after factory receipt of a purchase order. The most popular models and options covered by "ESP" service are conveniently color coded on pages 5 & 7. To take advantage of "ESP", simply match color coded part number codes and options; standard dimensions apply. Contact your area Magnetrol Representative for lead times on other

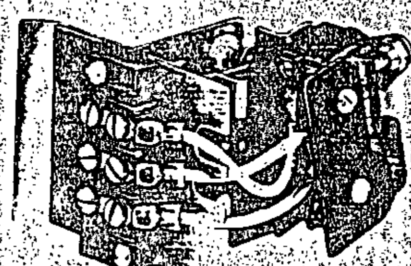
AVAILABLE SWITCH MECHANISMS AND APPLICATION DATA

Displacement type controls are available with several different switch mechanisms—each designed for specific service conditions. Brief descriptions of the individual switch mechanisms and their application are given below. Pages 5 and 7 list detailed selection data for standard models.



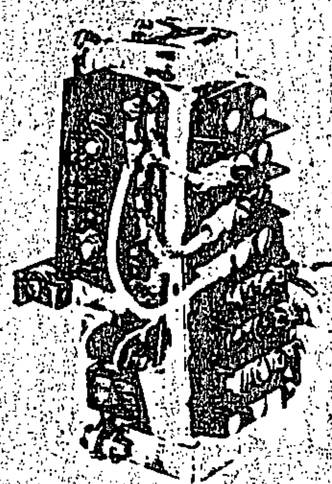
MERCURY SWITCHES
Series "A" & "E"

Mercury switches offer the advantage of quick visual inspection of contact conditions. Series "A" switches are heavy duty units with high load carrying capability. Series "E" switches are specially designed to provide greater vibration resistance.



DRY CONTACT SWITCHES
Series "B", "C" & "D"

These switches are specified in applications where mercury must be avoided—such as in nuclear power plant installations. Series "B" and "C" switches are general purpose units with electrical ratings dependent upon maximum liquid temperature. Series "D" switches are designed for DC current applications.

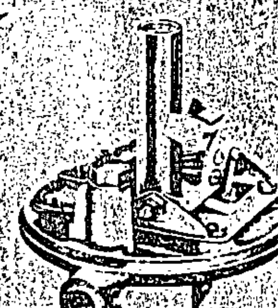


DRY CONTACT SWITCHES
Series "G", "H" & "I"

These special duty mechanisms are intended for vibration service applications or marine installations that would interfere with the normal operation of standard mercury or dry contact switches. Series "G" and "H" units are intended for AC current applications, while Series "I" switches are designed for DC current loads.

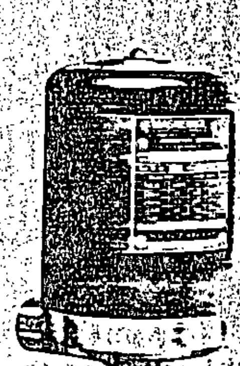
PNEUMATIC SWITCHES
Series "J" & "K"

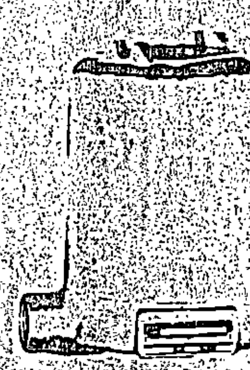
Pneumatic switches are employed in process industry applications where electrical power is not available or where hazardous conditions exist. The "J" series bleed-type switch is intended for general purpose applications. "K" series units are specifically designed to provide non-bleed operation with a high degree of vibration resistance.



SWITCH ENCLOSURES

Electric switches are available with a choice of enclosure design. NEMA-4 enclosures are weather resistant units for non-hazardous areas. NEMA-7 and -9 enclosures are designed explosion proof for use in hazardous areas. Pneumatic switches are standard with a NEMA 1 enclosure.





SINGLE SWITCH MODELS

MODEL A-103 SERIES, WIDE DIFFERENTIAL TYPE

These *wide* differential units are factory calibrated to actuate as a liquid level reaches a given displacer and to remain actuated until the level reaches a second displacer. A typical application is the control of a pump to fill a vessel .... by starting the pump as the level approaches the bottom of the vessel and stopping the operation at a pre-set high level point.

The minimum differential band is approximately 6.00 inches in water and varies somewhat with liquid specific gravity. The maximum differential is determined by the length of the displacer suspension cable.

MODEL A-153 SERIES, NARROW DIFFERENTIAL TYPE

These instruments are factory calibrated to operate over a *narrow* level differential band and are ideally suited for liquid level alarm applications, on either high or low level.

The operating level is fully adjustable by simply repositioning the displacer along its suspension cable. The differential band varies slightly with liquid specific gravity.

CONSTRUCTION

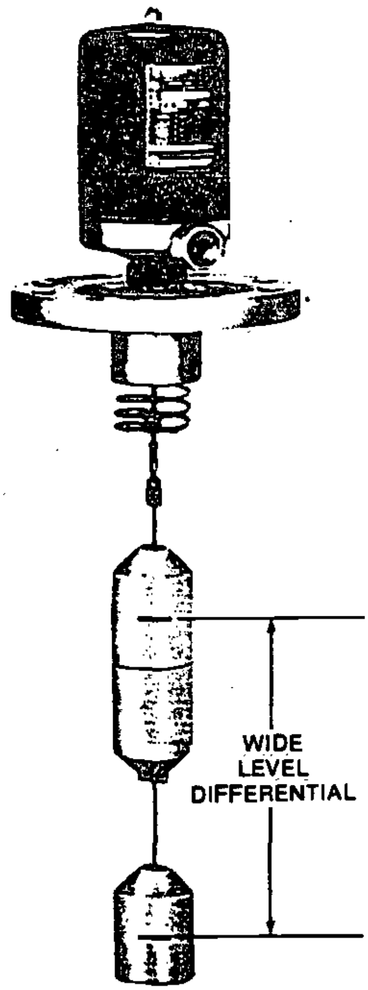
Standard models utilize an Inconel support spring, Type 316 S.S. trim, displacer clamps and suspension cable (10'0" long), with a 400 S.S. magnetic sleeve.

Tank Connection . . . 2½" NPT carbon steel bushing or selected mounting flange (3" flange size minimum). See page two for pressure ratings.

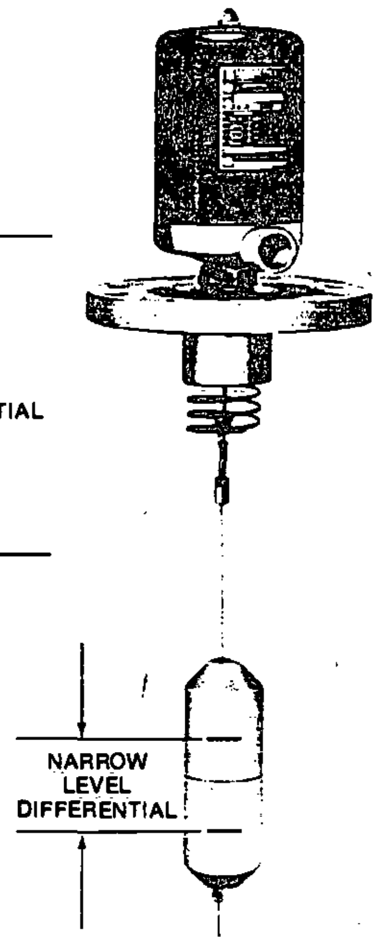
DISPLACER AND SWITCH SELECTION

The tables below specify the minimum and maximum liquid specific gravity values and service temperature limits for the various combinations of displacers and switches.

MODEL A-103 SERIES



MODEL A-153 SERIES



MODEL A-103 SERIES SPECIFIC GRAVITY LIMITS

Liquid Temp. °F.	For Use with Series A thru E and J Switch		
	Porcelain	Karbate	Stainless Steel
100	0.60 to 1.20	0.60 to 1.20	0.60 to 1.20
200	0.70 to 1.20	0.70 to 1.20	0.70 to 1.20
300	0.80 to 1.20	0.80 to 1.20	0.80 to 1.20
400	1.00 to 1.20	—	0.90 to 1.20
500	1.10 to 1.20	—	1.00 to 1.20

Liquid Temp. °F.	For Use with Series G, H, I & K Switch		
	Porcelain	Karbate	Stainless Steel
100	0.65 to 1.20	0.80 to 1.20	0.60 to 1.20
200	0.75 to 1.20	0.90 to 1.20	0.70 to 1.20
300	0.85 to 1.20	1.00 to 1.20	0.80 to 1.20
400	0.95 to 1.20	—	0.90 to 1.20

MODEL A-153 SERIES SPECIFIC GRAVITY LIMITS

Liquid Temp. °F.	For Use with Series A thru E and J Switch		
	Porcelain	Karbate	Stainless Steel
100	0.60 to 2.40	0.40 to 1.65	0.40 to 1.65
200	0.62 to 2.40	0.45 to 1.65	0.40 to 1.65
300	0.65 to 2.40	0.50 to 1.65	0.50 to 1.65
400	0.70 to 2.40	—	0.55 to 1.65
500	0.75 to 2.40	—	0.60 to 1.65

Liquid Temp. °F.	For Use with Series G, H, I & K Switch		
	Porcelain	Karbate	Stainless Steel
100	0.85 to 2.40	0.65 to 1.65	0.65 to 1.65
200	0.90 to 2.40	0.70 to 1.65	0.70 to 1.65
300	0.95 to 2.40	0.75 to 1.65	0.75 to 1.65
400	1.00 to 2.40	—	0.80 to 1.65

SELECTION DATA, SINGLE SWITCH MODELS

MODEL NUMBER EXAMPLE:

A10 - 1G2A - AA

- SWITCH MECHANISM AND ENCLOSURE
- TANK CONNECTION AND DISPLACERS
- MATERIALS OF CONSTRUCTION
- PART NUMBER CODE

SELECT PART NUMBER CODE

CATALOG MODEL NUMBER	PART NUMBER CODE	DESCRIPTION
A-103	A10-	Wide Differential Unit
A-153	A15-	Narrow Differential Unit

SELECT MATERIALS OF CONSTRUCTION

DESCRIPTION	SPECIFY
Standard Construction	1
Standard Construction, Magnetic Sleeve with Type 316 S.S. Jacket	2
Complete Type 316 S.S. Construction, Except Choice of Displacers. Flanged Models only. Includes 316 S.S. Flange.	4
Standard with Monel Displacer Cable and Displacer clamps.	5
Standard with Hastelloy "C" Displacer Cable and Displacer clamps.	6

SELECT TANK CONNECTION AND DISPLACERS (1)

Tank Connection	DISPLACER TYPE		
	Porcelain	Stainless Steel (2)	Karbate
Threaded 2½" NPT	E2A	E2B	E2C
Mounting Flanges			
3" 125 LB. Cast Iron	G2A	G2B	G2C
3" 150 LB. Steel	G3A	G3B	G3C
4" 125 LB. Cast Iron	H2A	H2B	H2C
4" 150 LB. Steel	H3A	H3B	H3C
4" 300 LB. Steel	H4A	H4B	H4C
6" 125 LB. Cast Iron	K2A	K2B	K2C
6" 150 LB. Steel	K3A	K3B	K3C

SELECT SWITCH MECHANISM AND SWITCH ENCLOSURE

Switch Description	Max. Process Temp.	Contacts Single Switch	SWITCH ENCLOSURE				
			NEMA 4		NEMA 7 & 9 EP		
			Std.	With Heater	Std.	With Heater	With Drain
SERIES (A) Mercury Switch	500°F	SPDT	AA	AF	AK	AP	AU
		DPDT	AD	AI	AN	AS	AX
SERIES (B) Snap Switch	250°F	SPDT	BA	BF	BK	BP	BU
		DPDT	BD	BI	BN	BS	BX
SERIES (C) Snap Switch	450°F	SPDT	CA	Not Avail.	CK	Not Avail.	CU
		DPDT	CD		CN		CX
SERIES (D) Snap Switch DC Current	250°F	SPDT	DA	DF	DK	DP	DU
		DPDT	DD	DI	DN	DS	DX
SERIES (E) Mercury Vibration Resistant	500°F	SPDT	EA	EF	EK	EP	EU
		DPDT	ED	EI	EN	ES	EX
SERIES (G) Snap Switch Dual Magnet	250°F	SPDT	GA	Not Avail.	GK	Not Avail.	GU
		DPDT	GD		GN		GX
SERIES (H) Snap Switch Dual Magnet	450°F	SPDT	HA		HK		HU
		DPDT	HD		HN		HX
SERIES (I) Snap Switch DC Current	250°F	SPDT	IA		IK		IU
		DPDT	ID		IN		IX

SELECT PNEUMATIC SWITCH

Switch Description	Maximum Supply Pressure	Maximum Liquid Temp.	Bleed Orifice Dia.	Code (NEMA 1 Enclosure)
SERIES (J) Bleed Type Pneumatic Switch	100 PSI	400°F	1/16"	JA
	60 PSI		3/32"	JB
SERIES (K) Non Bleed Pneumatic Switch	40 PSI	400°F	—	KA
	100 PSI			KB

BASIC ELECTRICAL RATINGS

(FULL DETAILS IN BULLETIN 42-120)

VOLTAGE	Switch Series and Non-Inductive Ampere Rating							
	A	B	C	D	E	G	H	I
120 VAC	13	15	5	10	4	15	5	10
220 VAC	6.5	15	5	—	2	15	5	—
120 VDC	10	0.40	0.40	10	4	0.40	0.40	10
220 VDC	5	0.20	0.20	3	2	0.20	0.20	—

DUAL SWITCH MODELS

MODEL A-103-TANDEM SERIES, WIDE DIFFERENTIAL TYPE

Wide differential tandem units are the most versatile of all Magnetrol displacement controls. They are available factory calibrated with a choice of several operating sequences, designed to meet virtually any application. Typically, they can be used for the control of a pump or valve *plus* level alarm (either high or low level) or for the control of two pumps (or valves)—starting at individual levels, stopping at one common level.

MODEL A-153-TANDEM SERIES, NARROW DIFFERENTIAL TYPE

Model A-153 Tandem Series utilize two switches, each actuated at a different level and each calibrated with a narrow differential band. These models are most often used to provide separate high and low level alarm actuations.

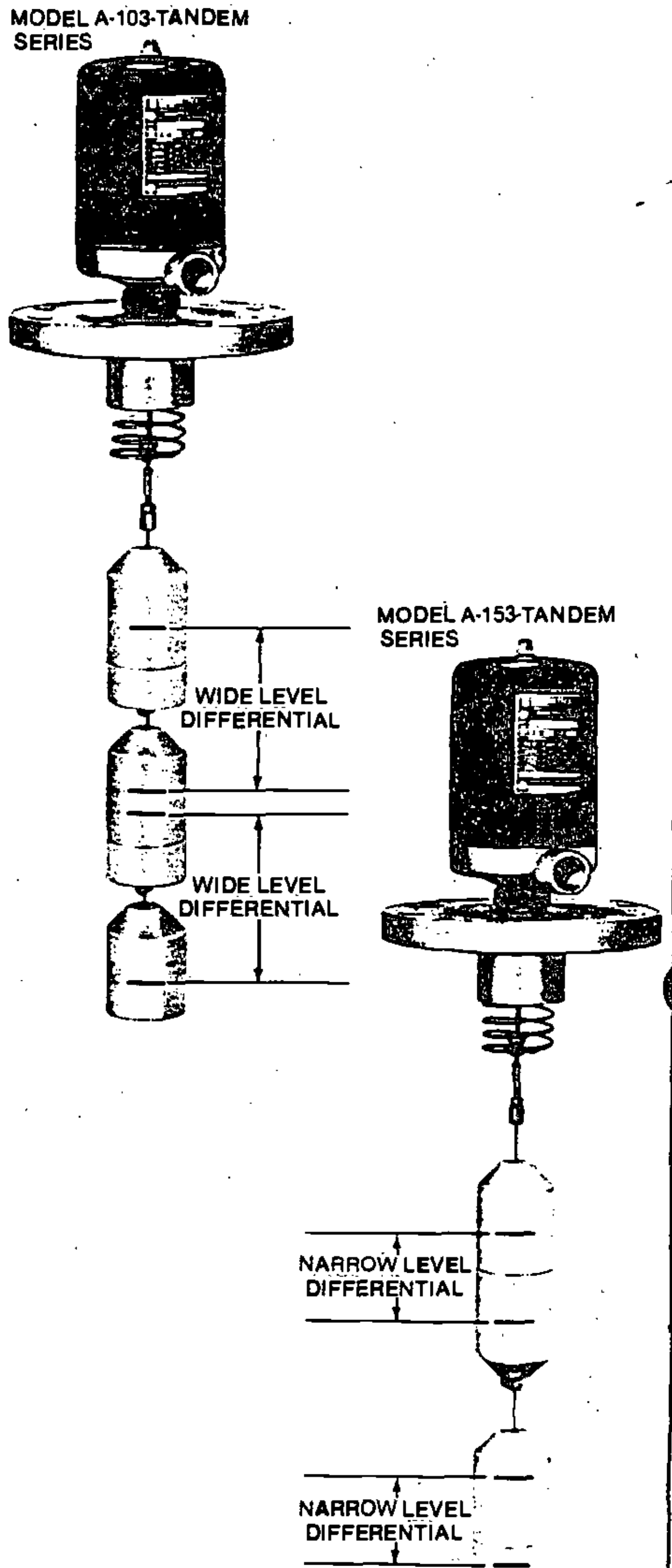
CONSTRUCTION

Standard models utilize an Inconel support spring, Type 316 S.S. trim, displacer clamps and suspension cable (10′0″ long), with a 400 S.S. magnetic sleeve.

Tank Connection . . . 2½″ NPT carbon steel bushing or selected mounting flange (3″ flange size minimum). See page two for pressure ratings.

DISPLACER AND SWITCH SELECTION

The tables below specify the minimum and maximum liquid specific gravity values and service temperature limits for the various combinations of displacers and switches.



MODEL A-103-TANDEM SERIES SPECIFIC GRAVITY LIMITS*

Liquid Temp. °F.	For Use with Series A thru E Switches		
	Porcelain	Karbate	Stainless Steel
100	0.60 to 1.50	0.50 to 1.00	0.50 to 1.00
200	0.64 to 1.50	0.50 to 1.00	0.50 to 1.00
300	0.80 to 1.50	0.60 to 1.00	0.60 to 1.00
400	1.00 to 1.50	—	0.72 to 1.00
500	1.10 to 1.50	—	0.84 to 1.00

*Each instrument is calibrated to operate on a given specific gravity

MODEL A-153-TANDEM SERIES SPECIFIC GRAVITY LIMITS

Liquid Temp. °F.	For Use with Series A thru E Switches		
	Porcelain	Karbate	Stainless Steel
100	0.95 to 1.20	0.70 to 1.20	0.70 to 1.20
200	1.10 to 1.20	0.80 to 1.20	0.80 to 1.20
300	—	0.90 to 1.20	0.90 to 1.20
400	—	—	1.00 to 1.20
500	—	—	1.04 to 1.20

SELECTION DATA, TANDEM MODELS

MODEL NUMBER EXAMPLE:

B10 - 1G2A - AB

SWITCH MECHANISM AND ENCLOSURE

TANK CONNECTION AND DISPLACERS

MATERIALS OF CONSTRUCTION

PART NUMBER CODE

SELECT PART NUMBER CODE

CATALOG MODEL NUMBER	PART NUMBER CODE	DESCRIPTION
A-103-Tandem	B10-	Wide Differential Unit
A-153-Tandem	B15-	Narrow Differential Unit

SELECT MATERIALS OF CONSTRUCTION

DESCRIPTION	SPECIFY
Standard Construction	1
Standard Construction, Magnetic Sleeve with Type 316 S.S. Jacket	2
Complete Type 316 S.S. Construction, Except Choice of Displacers. Flanged Models only. Includes 316 S.S. Flange.	4
Standard with Monel Displacer Cable and Displacer clamps.	5
Standard with Hastelloy "C" Displacer Cable and Displacer clamps.	6

SELECT TANK CONNECTION AND DISPLACERS ①

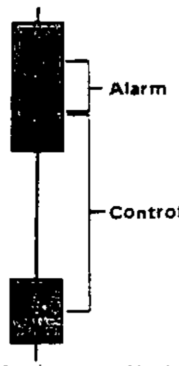
Tank Connection	DISPLACER TYPE		
	Porcelain	Stainless Steel ②	Karbate
Threaded 2½" NPT	E2A	E2B	E2C
Mounting Flanges			
3" 125 LB. Cast Iron	G2A	G2B	G2C
3" 150 LB. Steel	G3A	G3B	G3C
4" 125 LB. Cast Iron	H2A	H2B	H2C
4" 150 LB. Steel	H3A	H3B	H3C
4" 300 LB. Steel	H4A	H4B	H4C
6" 125 LB. Cast Iron	K2A	K2B	K2C
6" 150 LB.	K3A	K3B	K3C

SELECT SWITCH MECHANISM AND SWITCH ENCLOSURE

Switch Description	Max. Process Temp.	Contacts Single Switches	SWITCH ENCLOSURE				
			NEMA 4		NEMA 7 & 9 (EP)		
			Std.	With Heater	Std.	With Heater	With Drain
SERIES Ⓐ Mercury Switch	500°F	2 SPDT	AB	AG	AL	AQ	AV
		2 DPDT	AE	AJ	AO	AT	AY
SERIES Ⓑ Snap Switch	250°F	2 SPDT	BB	BG	BL	BQ	BV
		2 DPDT	BE	BJ	BO	BT	BY
SERIES Ⓒ Snap Switch	450°F	2 SPDT	CB	Not Avail.	CL	Not Avail.	CV
		2 DPDT	CE		CO		CY
SERIES Ⓓ Snap Switch DC Current	250°F	2 SPDT	DB	DG	DL	DQ	DV
		2 DPDT	DE	DJ	DO	DT	DY
SERIES Ⓔ Mercury Switch Vibration Resistant	500°F	2 SPDT	EB	EG	EL	EQ	EV
		2 DPDT	EE	EJ	EO	ET	EY

OPERATING SEQUENCES

Model A-103-Tandem units are available factory calibrated with a choice of switch operating sequence. Five of the most popular sequences are described below. When ordering, specify operating sequence number and specific gravity of the liquid.

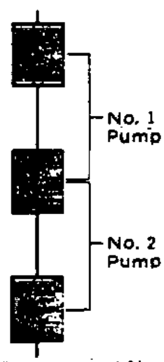


Arrangement No. 1

PUMP CONTROL PLUS ALARM

Arrangement No. 1 (Illustrated): At the lowest level the pump starts. When the level rises to the middle displacer, the pump stops. If the level continues to rise, the upper displacer actuates the alarm switch which remains actuated until the level drops to the middle displacer.

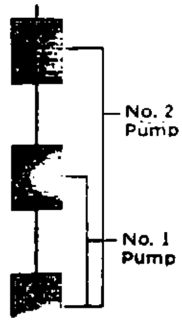
Arrangement No. 2: The sequence of Arrangement No. 1 can be reversed to provide pump start at high level and pump stop at low level followed by low level alarm operation.



Arrangement No. 3

CONTROL OF TWO PUMPS OF DIFFERENT CAPACITY

Arrangement No. 3 (Illustrated): Two pumps are used to keep a tank filled. When the level falls to the middle displacer, a small No. 1 pump starts. A second larger pump is started should the level continue to fall to the bottom displacer.



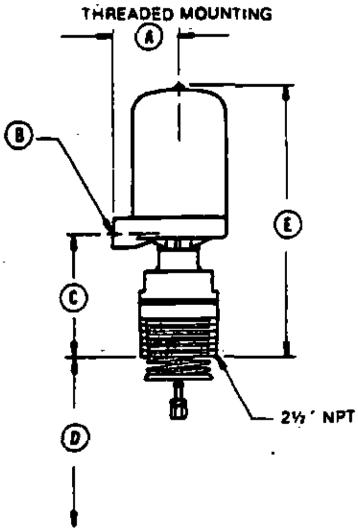
CONTROL OF TWO PUMPS

Arrangement No. 4 (Illustrated): In this sequence No. 1 pump starts as the level rises to the middle displacer. Should the level continue to rise to the upper displacer, No. 2 pump is actuated. Both pumps operate until the level is dropped to the lower displacer.

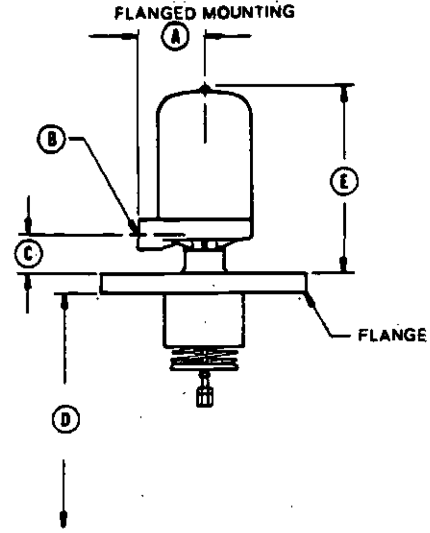
Arrangement No. 5: The pumping se-

DIMENSIONAL DATA

THREADED MOUNTING



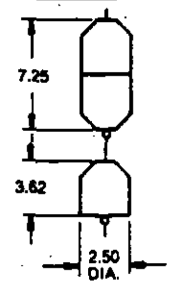
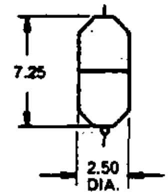
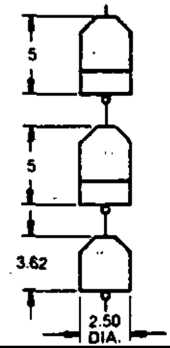
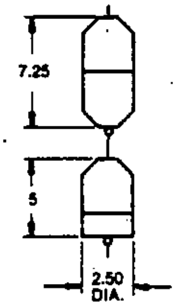
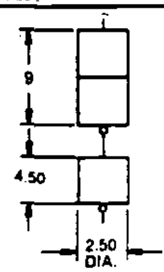
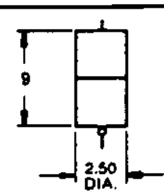
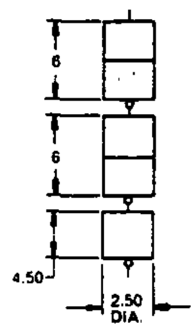
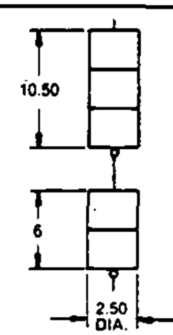
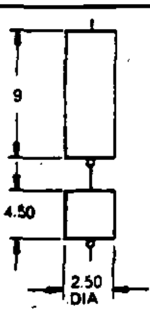
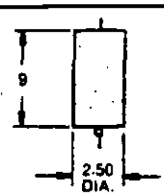
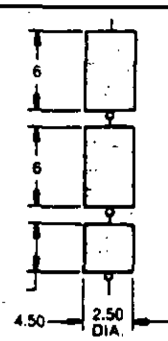
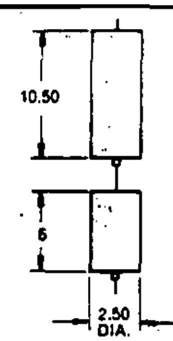
FLANGED MOUNTING



OUTLINE DIMENSIONS (INCHES)

DIM.	THREADED MOUNTING	FLANGED MOUNTING
A	3.30 Standard Housing 4.00 Explosion Proof Housing	
B	Conduit Connection. ¾" NPT Standard Housing. 1" NPT EXP. Proof Housing. ¼" NPT Pneumatic Switches.	
C	4.75	1.50
D	Minimum Distance to Top of Upper Displacer; 5.50	
E	11.75	9.80

DISPLACER DIMENSIONS (INCHES)

DISPLACER MATERIAL	CATALOG MODEL (PART NUMBER CODE)			
	A-103 (A10)	A-153 (A15)	A-103-TANDEM (B10)	A-153-TANDEM (B15)
PORCELAIN	 7.25 3.62 2.50 DIA.	 7.25 2.50 DIA.	 5 5 3.62 2.50 DIA.	 7.25 5 2.50 DIA.
KARBATE	 9 4.50 2.50 DIA.	 9 2.50 DIA.	 6 6 4.50 2.50 DIA.	 10.50 6 2.50 DIA.
STAINLESS STEEL	 9 4.50 2.50 DIA	 9 2.50 DIA.	 6 6 4.50 2.50 DIA.	 10.50 6 2.50 DIA.

MAGNETROL
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BULLETIN: 45-310
EFFECTIVE: January 8, 1979
SUPERSEDES: –

MAGNETROL®
THREE LEVEL STAGE DISPLACEMENT TYPE LIQUID LEVEL CONTROLS

APPLICATION

Three level stage displacement type instruments are employed in applications where it is desirable to provide three electrically separate control signals in sequence as a liquid level varies. A typical application could include the control of two individual pumps to supply a tank as the liquid level drops, plus initiation of an alarm signal at a predetermined low liquid level set point.

MOUNTING STYLES

A choice of mounting is available between a 3" NPT threaded bushing or 4" 125 lb. cast iron flange. Larger flanges are available.

Threaded mounting . . . . Model A-103-3X-Tandem
Flanged mounting . . . . Model A-103-F3X-Tandem

CONSTRUCTION

Standard construction includes: (A) Three SPDT mercury switches with NEMA-4 enclosure; (B) Cast iron mounting bushing or flange; (C) Inconel support spring with Type 316 SS trim components and 400-series stainless steel magnetic sleeves; (D) Porcelain displacers with 10 ft. of Type 316 SS suspension cable. *The displacers are individually adjustable along the suspension cable.*

OPTIONS

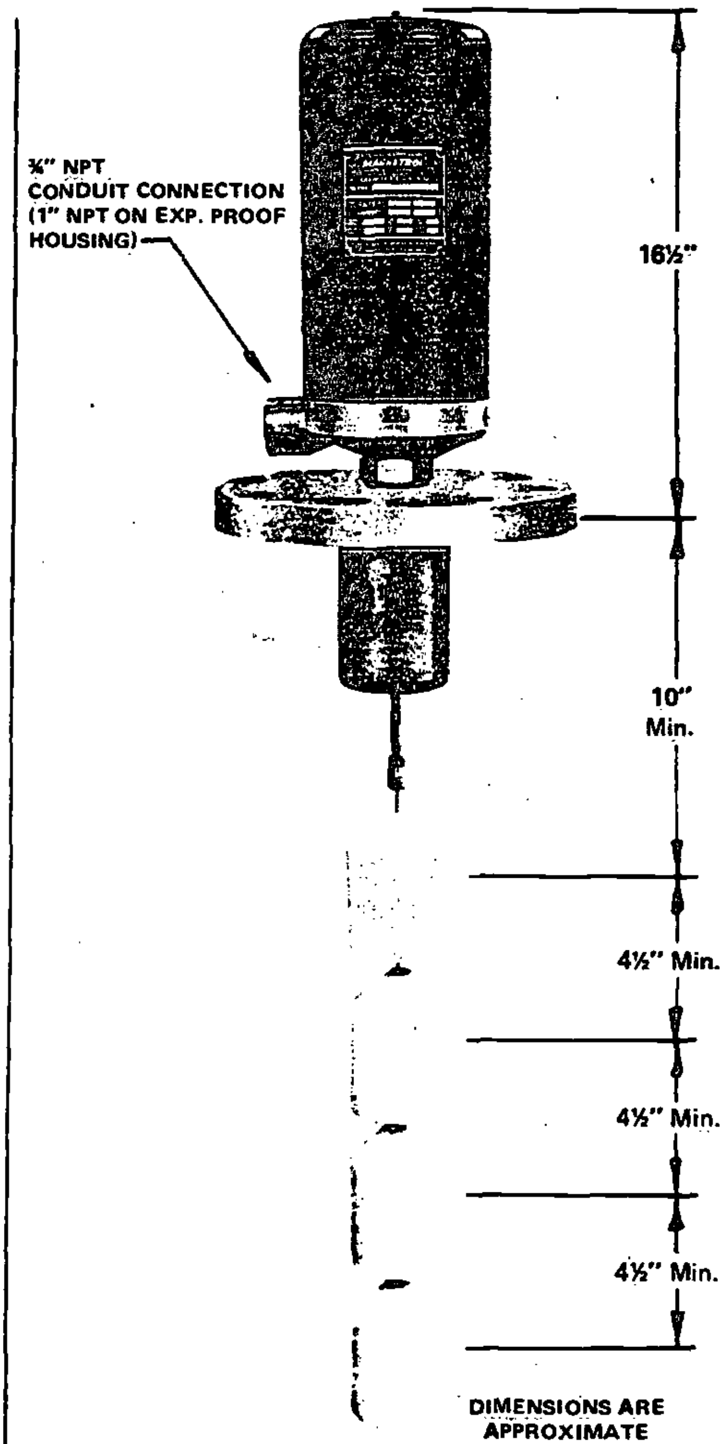
Available standard options include: (A) SPDT dry contact switches; (B) Explosion proof vapor tight switch enclosure (NEMA-7 and -9); (C) Larger flanges of cast iron or steel; (D) Karbate or Type 304 SS displacers.

SPECIFIC GRAVITY RANGE

Three level stage instruments are intended for service on liquids which have a constant specific gravity. Each unit is factory calibrated to function properly on the specified liquid within a specific gravity range tolerance of ±0.02.

OPERATIONAL SEQUENCES

Seven standard operating sequences are available as tabulated on page two. Each instrument is factory calibrated to operate within the specified sequence.



Typical Model A-103-F3X-Tandem, flange mounted with

DISPLACER SELECTION AND SPECIFIC GRAVITY RATING

Type of Displacer	Size Each	Sp. Gr. at 100°F. Oper. Temp. ⊙ Min.	Max.	Range
"Small" Porcelain	2½" dia. 3⅝" tall	0.95	1.45	±0.02 of Specified Specific Gravity
"Large" Porcelain	3⅛" dia. 3¼" tall.	1.45	2.20	
"Small" Karbate	2½" dia. 4½" tall	0.70	1.20	
"Large" Karbate	3" dia. 4¼" tall	1.05	1.65	
Type 304 Stainless Steel	3" dia. Length per job	0.45	2.00	

⊙ Each control is factory calibrated for any single specific gravity within the limits indicated. Vapor density effects specific gravity rating. Consult factory for application assistance on installations over 250 psi.

SPECIFIC GRAVITY AT ELEVATED OPERATING TEMP. ⊙

Temp. °F.	Small Porcelain	Large Porcelain	Small Karbate	Large Karbate	S.S.	Range
200	1.06-1.50	1.50-2.20	0.76-1.15	1.15-1.65	0.45 to 1.80	±0.02
300	1.42-1.50	1.50-2.20	1.03-1.15	1.15-1.65		
400	–	1.50-2.20	–	–	0.55 to 1.50	
500	–	1.80-2.20	–	–		

AVAILABLE FACTORY SET OPERATING SEQUENCES