

Manual for Highway Storm Water Pumping Stations Vol. II

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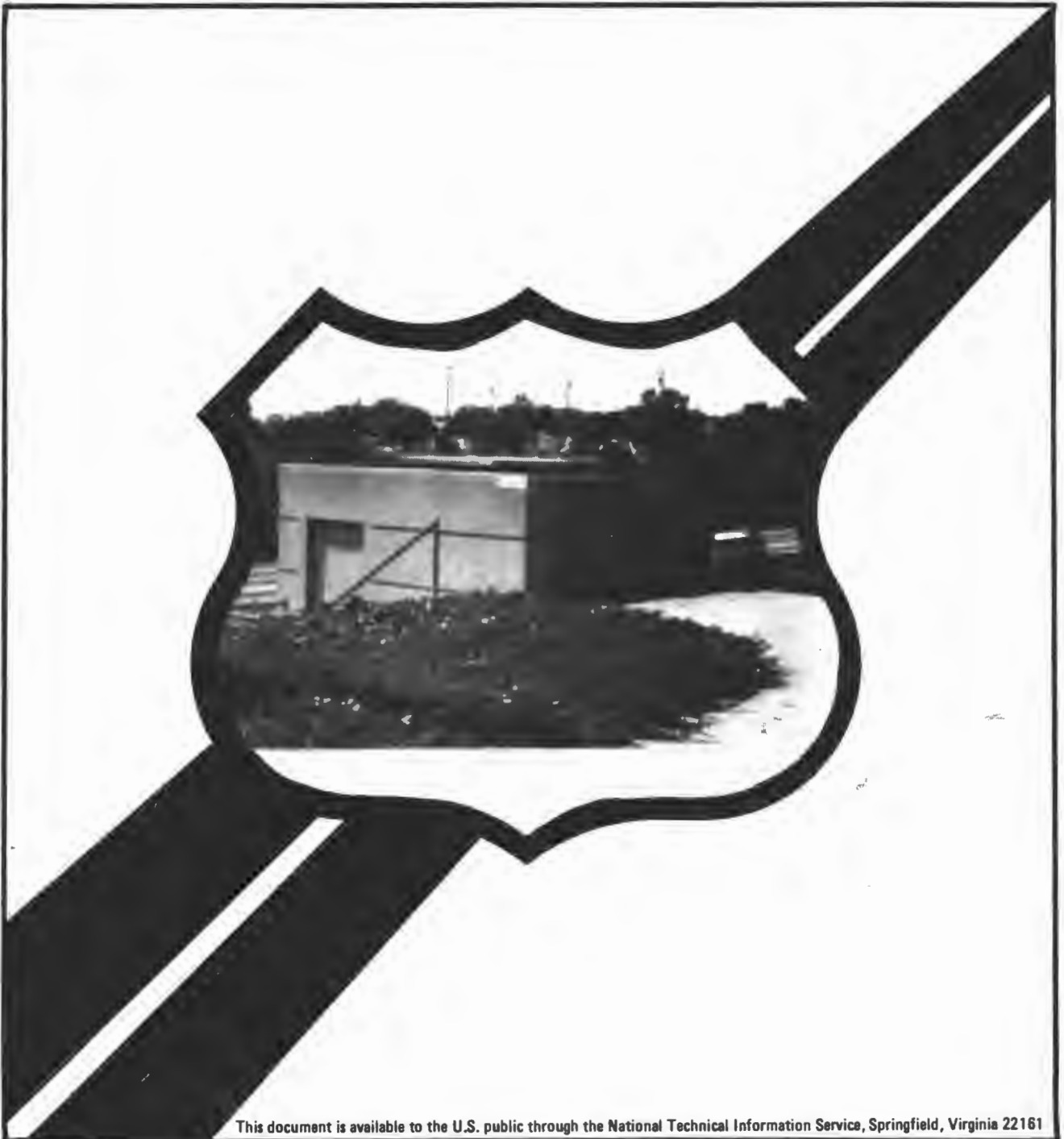
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of Transportation

**Federal Highway
Administration**



Foreword

This manual provides design information for highway storm water pumping stations. Pumping stations are necessary where gravity drainage flow is impossible or uneconomic. The manual should be of interest to hydraulic, construction, and maintenance engineers.

State highway agencies, and the Los Angeles County Flood Control District, provided valuable data for this manual and cooperated in on-site field reviews. The Hydraulic Institute, numerous manufacturers of pumps and pumping equipment, and several experts in the design of stations also provide data and assistance in this study. The assistance of all parties who contributed to this manual is sincerely appreciated.

Additional copies of the manual can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.



R. J. Betsold
Director, Office of Implementation

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This report does not constitute a standard or regulation.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein only because they are considered essential to the object of this document.

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16. Abstract <p>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.</p> <p>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.</p> <p>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.</p> <p>Later chapters deal with station machinery and features, including electrical systems. A number of appendices cover specifications, construction costs, energy economics, and maintenance.</p>					
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APPENDIX A

LIST OF MANUFACTURERS

The following list of manufacturers has been compiled to aid the designer in identifying manufacturers of pump station equipment. No approval of products is implied nor is omission of a company intended to be a negative reflection on any of their products. It is the responsibility of the designer to evaluate the products of any company to determine whether or not they are suitable and will function acceptably in any given application. A list of addresses for the manufacturers listed follows this Section.

CATHODIC PROTECTION EQUIPMENT

Harco Corp.
Heath Consultants, Inc.
Wallace & Tiernan, Div.
Pennwalt Co.

COATING AND LINING, METAL
PROTECTIVE: COAT TAR

Ameron
Bethlehem Steel Corp.
Engard Coatings Corp.
Independent Fitting Co.
Koppers Co., Inc.
Mead Pipe-Alabama
Progressive Fabricators, Inc.
Reilly Tar & Chemical Corp.
Russell Pipe & Foundry Co., Inc.
Rust-Oleum Corp.
Tapecoat Co., Div. TC Mfg. Co.
Tnemec Co., Inc.

COATING AND LINING, METAL
PROTECTIVE: PAINT AND/OR EPOXY

Ameron
Bethlehem Steel Corp.
Engard Coatings Corp.
International Oil Corp.
Koppers Co., Inc.
Progressive Fabricators, Inc.
Russell Pipe & Foundry Co., Inc.
Rust-Oleum Corp.
Tapecoat Co., Div. TC Mfg. Co.
Tnemec Co., Inc.

COUPLINGS, FLEXIBLE

A/C Pipe Inc.
Badger Meter Inc.
R.H. Baker & Co., Inc.
Dresser Mfg. Div., Dresser
Industries
Ford Meter Box Co., Inc.
Johns-Manville
Limitorque Corp.
Mueller Co.
Superior Utility Products Inc.
Victaulic Co. of America
Zurn Industries, Inc.

CRANES, OVERHEAD

Checo
Cleveland Tramrail
Craneveyor Corporation
Jarvis Webb Co.

ENGINES, DIESEL

Allis-Chalmers Corp.
Caterpillar Tractor Company
Waukesha Engine Div., Dresser
Industries
White-Superior Div./White
Motor Corp.
Detroit Diesel Allison Div.
General Motors Corp.

ENGINES, GAS

Allis-Chalmers Corp.
Caterpillar Tractor Company
International Harvester Co.
Teledyne Wisconsin Motor
Waukesha Engine Div.,
Dresser Industries
White-Superior Div./White
Motor Corp.

GATES, LIQUID LEVEL

A/C Pipe Inc.
BIF-Unit of General Signal
Corp.
Bristol Div. of Acco
Brooks Instrument Div.,
Emerson Electric Co.
Hersey Products Inc.
Leopold Co., Div. of Sybron
Corp.
Sparling Div., Envirotech

GATES, SHEAR AND SLUICE

A/C Pipe Inc.
American Bridge Div., US Steel
Corp.
Armco Steel Corp., Metal
Products Div.
Carlson Metalcraft Co., Inc.
Clow Corp.
Dresser Mfg. Div., Dresser
Industries
Rodney Hunt Co., Water Control
Equipment Div.
Kubota, Ltd.
Mueller Co.
Traverse City Iron Works
Waterman Industries, Inc.

GEARS, SPEED-REDUCING

General Electric Co.
Limitorque Corp.

GEARS, RIGHT ANGLE

Amarillo Gear Co.
Johnson Gear & Mfg. Co., Ltd.
Philadelphia Gear Corp.
Randolph Mfg. Co.
Western Gear Corp.

HOISTS

Eaton Corp. Hoisting Equip-
ment Div.
Harnischfeger Corporation
Ingersoll-Rand
Kamiuchi Electric Works, Ltd.
Robbins & Myers
Ube Industries, Ltd.
Wright Hoist Div., Acc, Inc.

INSTRUMENTS, INDICATING AND
RECORDING

Autocon Industries Inc.,
Subsidiary Control Data
BIF-Unit of General Signal
Corp.
Badger Meter Inc.
Beckman Instruments Inc.
F.S. Brainard & Co.
Bristol Div. of Acco
Brooks Instrument Div.,
Emerson Electric Co.
Calgon Corp.
Capital Controls Co.
Fischer & Porter Co.,
Environmental Div.
Fisher Scientific Co.
General Electric Co.
Hach Chemical Co.
Hellige Inc.
Ionics, Inc.
Johnson Div. Universal Oil
Products
Leopold Co., Div. of Sybron
Corp.
Leupold & Stevens Inc.

INSTRUMENTS, INDICATING AND RECORDING (cont'd)

Muesco Inc.
Neptune Water Meter Co.,
Subsidiary Neptune Intl.
Rockwell Intl., Municipal and
Utility Div.
Sparling Div., Envirotech
Turner Designs
Universal Engineered Systems,
Inc.
Wallace & Tiernan, Div.
Pennwalt Co.

METERS, WATER, FLOW,
ULTRASONIC

Accusonic Div. of O R E Inc.
Badger Meter Inc.
Bethlehem Corp.
F.S. Brainard & Co.
Neptune Microfloc Inc.
Subsidiary Neptune Intl.
Sparling Div., Envirotech

METERS, WATER, VENTURI

BIF-Unit of General Signal
Corp.
Badger Meter Inc.
Bristol Div. of Acco
Kubota, Ltd.
Leopold Co., Div. of Sybron
Corp.
Universal Engineered Systems,
Inc.
Vickery Simms, Inc.

MOTORS, ELECTRIC

Allis-Chalmers Corp.
Baldor Electric Company
Century Electric Div., Gould
Inc.
General Electric Co.
The Ideal Electric & Mfg. Co.
The Lincoln Electric Co.
Marathon Electric
Reliance Electric Co.
Reuland Electric Co.

MOTORS, ELECTRIC (cont'd)

U.S. Electrical Motors, Div.
of Emerson Electric Co.
Westinghouse Electric Corp.
Yaskawa Electric Mfg. Co.,
Ltd.

PIPE, ASBESTOS-CEMENT

A/C Pipe Inc.
Cement Asbestos Products Co.
Certain-Teed Corp., Pipe &
Plastics Group
Johns-Manville
Traverse City Iron Works

PIPE, CAST IRON

A/C Pipe Inc.
American Cast Iron Pipe Co.
Clow Corp.
Griffin Pipe Products Co.
Lone Star Steel Co.
McWane Cast Iron Pipe Co.
Mead Pipe-Alabama
Traverse City Iron Works
US Pipe & Foundry Co.

PIPE, CONCRETE (PRESSURE)

Ameron
Gifford-Hill-American Inc.
Interpace Corp.

PIPE, DUCTILE IRON

A/C Pipe Inc.
American Cast Iron Pipe Co.
Clow Corp.
Griffin Pipe Products Co.
Lynchburgh Foundry, A Mead Co.
McWane Cast Iron Pipe Co.
Mead Pipe-Alabama
Traverse City Iron Works
US Pipe & Foundry Co.

PIPE, STEEL

A/C Pipe Inc.
American Bridge Div., US Steel Corp.
Ameron
Bethlehem Steel Corp.
Gifford-Hill-American Inc.
Lone Star Steel Co.
Progressive Fabricators, Inc.

PIPE FITTINGS, DISTRIBUTION

A/C Pipe Inc.
American Cast Iron Pipe Co.
Ameron
R.H. Baker & Co., Inc.
Clow Corp.
Dayton Foundry Co.
Dresser Mfg. Div., Dresser Industries
Ductile Iron Co. of America
Gifford-Hill-American Inc.
Goodall Rubber Co.
Griffin Pipe Products Co.
Independent Fitting Co.
Johns-Manville
Lynchburgh Foundry, A Mead Co.
McWane Cast Iron Pipe Co.
Mead Pipe-Alabama
Mueller Co.
Russell Pipe & Foundry Co., Inc.
R & G Sloane Mfg. Co. Inc.
A.O. Smith-Inland Inc.
Superior Utility Products Inc.
Traverse City Iron Works
Tyler Pipe Industries Inc.
US Pipe & Foundry Co.
Victaulic Co. of America

PUMPS, CENTRIFUGAL, HORIZONTAL

Allis-Chalmers Corp.
Aurora Pump, Unit General Signal Corp.
Bingham-Willamette Co.
Byron Jackson Pump Div. Borg-Warner
Delaval Turbine Inc.

PUMPS, CENTRIFUGAL, HORIZONTAL
(cont'd.)

Door-Oliver Inc.
Fairbanks Morse Pump Div./Colt Industries
Hayward Tayler Inc.
Kubota, Ltd.
Pacific Pumping Co.
Peerless Pump
TRW Mission Mfg. Co.
E.H. Wachs Co.
Waterous Co.
Worthington Pump Inc.

PUMPS, VERTICAL

Allis-Chalmers Corp.
Aurora Pump, Unit General Signal Corp.
Byron Jackson Pump Div. Borg-Warner
Cascade Pump Co.
Johnston Pump Co.
Kubota, Ltd.
Patterson Pump Div., Dubie-Clark Co.
Peerless Pump
U.S. Pumps
Worthington Pump Inc.

PUMPS, SCREW

Lakeside Pump Co.
Link-Belt, Div. of FMC
Passevant Mfg.

PUMPS, SUBMERSIBLE

A/C Pipe Inc.
Aurora Pump, Unit General Signal Corp.
Byron Jackson Pump Div. Borg-Warner
Dorr-Oliver Inc.
EMU Pollution Equipment Co.
ESSCO
Flygt Corp./ITT
Hayward Tyler Inc.
Johnston Pump Co.

PUMPS, SUBMERSIBLE (cont'd)

Kubota, Ltd.
Midland Pump Co.
Pacific Pumping Co.
E.H. Wachs Co.
Wemco Div. of Envirotech
Worthington Pump Inc.

PUMPS, SUMP

A/C Pipe Inc.
Aurora Pump, Unit General
Signal Corp.
Byron Jackson Pump Div.
Borg-Warner
Clow Corp.
ESSCO
Hayward Tyler Inc.
Johnston Pump Co.
Wemco Div. of Envirotech
Worthington Pump Inc.

TELEMETERING EQUIPMENT

A/C Pipe Inc.
Autocon Industries Inc.,
Subsidiary Control Data
Automation Assoc. Inc.
BIF-Unit of General Signal
Corp.
Bristol Div. of ACCO
McCrometer Corp.
Sparling Div., Envirotech
Universal Engineered Systems,
Inc.
Teleproducts, Inc.

VACUUM TRUCKS

Central Engineering Company,
Inc.

VALVE OPERATING UNITS

A/C Pipe Inc.
Bingham-Willamette Co.
The Cavins Co.
E-I-M Company, Inc.
Kennedy Valve Mfg. Co. Inc.
Keystone Valve Div., Keystone
Intl.

VALVE OPERATING UNITS
(cont'd.)

Limitorque Corp.
Raymond Control Systems,
Div. Vapor Corp.
Rotork, Inc.
Seibu Electric Mfg. Co., Ltd.
E.H. Wachs Co.

VALVES, AIR RELIEF

A/C Pipe Inc.
APCO/Valve & Primer Corp.
CLA-VAL Co.
James Jones Co.
Kubota, Ltd.
Multiplex Mfg. Co. Crispin
Valve Div.
Simplex Valve & Meter Co.
Traverse City Iron Works

VALVES, BACKFLOW PREVENTION

A/C Pipe Inc.
APCO/Valve & Primer Corp.
Badger Meter Inc.
Braukmann Controls Corp.
CLA-VAL Co.
Hersey Products Inc.
Kennedy Valve Mfg. Co. Inc.
Kent Meter Sales Inc.
Neptune Water Meter Co.,
Subsidiary of Neptune Intl.
Rockwell Intl., Municipal &
Utility Div.
Toro Technology Center, Div.
of Toro Co.
Watts Regulator Co.

VALVES, BALL

A/C Pipe Inc.
Bingham-Willamette Co.
Ford Meter Box Co. Inc.
Jenkins Bros. Ltd.
James Jones Co.
A.Y. McDonald Mfg. Co.
Multiplex Mfg. Co., Crispin
Valve Div.
Pacific Valve Co.

VALVES, BALL (cont'd.)

Henry Pratt Co.
R. & G. Sloane Mfg. Co. Inc.
Watts Regulator Co.
Zurn Industries, Inc.

VALVES, BUTTERFLY

A/C Pipe Inc.
Allis-Chalmers Corp.
American Cast Iron Pipe
Co.
APCO/Valve & Primer Corp.
BIF-Unit of General Signal
Corp.
Bingham-Willamette Co.
Clow Corp.
Dresser Mfg. Div., Dresser
Industries
FMC Corp., Fluid Control
Operations
Jankins Bros. Ltd.
Kennedy Valve Mfg. Co., Inc.
Keystone Valve Div., Keystone
Intl.
Kubota, Ltd.
MCC Center Line, Unit Mark
Controls Corp.
Mueller Co.
Henry Pratt Co.
TRW Mission Mfg. Co.
Traverse City Iron Works
Victaulic Co. of America

VALVES, CHECK

A/C Pipe Inc.
Allis-Chalmers Corp.
American Cast Iron Pipe Co.
APCO/Valve & Primer Corp.
Braukmann Controls Corp.
Chapman
CLA-VAL Co.
Clow Corp.
Crane Co.
Dresser Mfg. Div., Dresser
Industries
FMC Corp., Fluid Control
Operations
Ford Meter Box Co., Inc.

VALVES, CHECK (cont'd.)

Kubota, Ltd.
The Wm. Powell Valve Co.

VALVES, FLAP

A/C Pipe Inc.
Armco Steel Corp., Metal
Products Civ.
Carlson Metalcraft Co. Inc.
Clow Corp.
Dresser Mfg. Div., Dresser
Industries
Rodney Hunt Co., Water
Control Equipment Div.
Kubota, Ltd.
Mueller Co.
Traverse City Iron Works
Waterman Industries, Inc.

VALVES, GATE

A/C Pipe Inc.
American Cast Iron Pipe Co.
Clow Corp.
Crane Co.
Dresser Mfg. Div., Dresser
Industries
East Jordan Iron Works, Inc.
Griffin Pipe Products Co.
James Jones Co.
Kennedy Valve Mfg. Co. Inc.
Kubota, Ltd.
Mueller Co.
Patterson Industries Inc.,
Valve Div.
The Wm. Powell Valve Co.
Standard Fire Protection
Equipment
Traverse City Iron Works
US Pipe & Foundry Co.

VACUUM LOADERS

Peabody Myers

ADDRESSES OF MANUFACTURERS

A/C PIPE INC.
Boro & Secane Road
Box 443
Primos, Pa. 19018

ACCUSONIC DIV. OF O R E INC.
Box 709
Falmouth, Ma. 02541

ALLIS-CHALMERS CORP.
Box 512
Milwaukee, Wi. 53201

AMARILLO GEAR COMPANY
Box 1789
Amarillo Tx. 79105

AMERICAN BRIDGE DIV., U.S.
STEEL CORP.
600 Grant Street
Pittsburgh, Pa. 15230

AMERICAN CAST IRON PIPE CO.
Box 2727
Birmingham, Al. 35202

AMERON
4700 Ramona Boulevard
Box 3000
Monterey Park, Ca. 91754

APCO/VALVE & PRIMER CORP.
1420 So. Wright Boulevard
Schaumburg, Il. 60196

ARMCO STEEL CORP. METAL
PRODUCTS DIV.
Box 800
Middletown, Oh. 45042

AURORA PUMP, UNIT GENERAL
SIGNAL CORP.
800 Airport Road
North Aurora, Il. 60542

AUTOCON INDUSTRIES INC., SUB-
SIDIARY CONTROL DATA
2300 Berkshire Lane
Minneapolis, Mn. 55441

AUTOMATION ASSOC. INC.
1339 Lawrence Drive
Newbury Park, Ca. 91320

BIF-UNIT OF GENERAL SIGNAL
CORP.
1600 Division Road
West Warwick, R.I. 02893

BADGER METER INC.
4545 W. Brown Deer Road
Milwaukee, Wi. 53223

R.H. BAKER & CO. INC.
2929 So. Santa Fe Avenue
Los Angeles, Ca. 90058

BALDOR ELECTRIC COMPANY
Box 6238
Ft. Smith, Ar. 72901

BECKMAN INSTRUMENTS INC.
2500 Harbor Boulevard
Fullerton, Ca. 92634

BETHLEHEM CORP.
25th & Lenox Street
Box 348
Easton, Pa. 18042

BETHLEHEM STEEL CORP.
701 E. 3rd Street
Bethlehem, Pa. 18016

BINGHAM-WILLAMETTE CO.
2800 N.W. Front Avenue
Portland, Or. 97210

F.S. BRAINARD & CO.
231 Penn Street
Burlington, N.J. 08016

BRAUKMANN CONTROLS CORP.
56 Harvester Avenue
Batavia, N.Y. 14020

BRISTOL DIV. OF ACCO
40 Bristol Street
Waterbury Ct. 06720

BROOKS INSTRUMENT DIV.
EMERSON ELECTRIC CO.
407 West Vine Street
Hatfield, Pa. 19440

BYRON JACKSON PUMP DIV.
BORG-WARNER
2300 East Vernon Avenue
Los Angeles, Ca. 90058

CALGON CORP.
Box 1346
Pittsburgh, Pa. 15230

CAPITAL CONTROLS CO.
202 Advance Lane
Colmar, Pa. 18915

CARLSON METALCRAFT CO. INC.
828 Hingham Street
Rockland, Ma. 02370

CASCADE PUMP CO.
11212 Norwalk Boulevard
Santa Fe Springs, Ca. 90670

CATERPILLAR TRACTOR CO.
100 N.E. Adam Street
Peoria, Il. 61602

THE CAVINS CO.
2853 Cherry Avenue
Long Beach, Ca. 90806

CEMENT ASBESTOS PRODUCTS CO.
Box 3435
Birmingham, Al. 35205

CENTURY ELECTRIC DIVISION,
GOULD INC.
1831 Chestnut Street
St. Louis, Mo. 63166

CERTAIN-TEED CORP., PIPE &
PLASTICS GROUP
Box 860
Valley Forge, Pa. 19483

CHECO CRANE HOIST ENGINEERING
CORP.
6515 Salt Lake Avenue
Bell, Cal. 90201

CLA-VAL CO.
Box 1325
Newport Beach, Ca. 92663

CLEVELAND TRAMRAIL
2115 W. Crescent Avenue
Suite H
Anaheim, Ca. 92801

CLOW CORP.
1211 W. 22nd Street
Executive Plaza East
Oak Brook, Il. 60521

CRANE CO.
4100 South Kedzie Avenue
Chicago, Il. 60632

CRANEVEYOR CORP.
1524 No. Potrero Avenue
So. El Monte, Ca. 91733

DAYTON FOUNDRY CO.
11803 Industrial Avenue
South Gate, Ca. 90280

DELAVAL TURBINE INC.
Box 251
Trenton, N.J. 08602

DORR-OLIVER INC.
77 Havemeyer Lane
Stamford, Ct. 06904

DRESSER MFG. DIV., DRESSER
INDUSTRIES
41 Fisher Avenue
Bradford, Pa. 16701

DUCTILE IRON CO. OF AMERICA
Carolyn Avenue
Savannah, Ga. 31401

ESSCO
4935 Telegraph Road
Los Angeles, Ca. 90022

E-I-M COMPANY, INC.
Box 8
Missouri City, Tx. 77459

EAST JORDAN IRON WORKS, INC.
East Jordan, Mi. 49727

EATON CORPORATION HOISTING
EQUIPMENT DIV.
Highway No. 1 North
Forrest City, Ak. 72335

ENGARD COATINGS CORPORATION
2020 West 15th Street
Long Beach, Ca. 90813

FAIRBANKS MORSE PUMP DIVISION
of COLT INDUSTRIES
3601 FAIRBANKS AVENUE
KANSAS CITY, KANSAS 66110

FMC CORP., FLUID CONTROL
OPERATIONS
10516 Old Katy Road
Box 19465
Houston, Tx. 77024

FISCHER & PORTER CO.,
ENVIRONMENTAL DIV.
County Line Road
Warminster, Pa. 18974

FISHER SCIENTIFIC CO.
711 Forbes Avenue
Pittsburgh, Pa. 15219

FORD METER BOX CO. INC.
775 Manchester Avenue
Box 443
Wabash, In. 46992

GENERAL ELECTRIC CO.
Sac Building 81-111
1 River Road
Schenectady, N.Y. 12345

GENERAL MOTORS CORPORATION
DETROIT DIESEL ALLISON DIV.
13400 West Outer Drive
Detroit, MI 48228

GIFFORD-HILL-AMERICAN INC.
Box 47127
Dallas, Tx. 75247

GOODALL RUBBER CO.
Box 631
Trenton, N.J. 08604

GRIFFIN PIPE PRODUCTS CO.
2000 Spring Road
Oak Brook, Il. 60521

HAC CHEMICAL CO.
Box 907
Ames, Ia. 50010

HARCO CORP.
1055 West Smith Road
Medina, Oh. 44256

HARNISCHFEGER CORPORATION
Box 554
Milwaukee, Wi. 53201

HAYWARD TYLER INC.
25 Harbor Avenue
Norwalk, Ct. 06850

HEATH CONSULTANTS INC.
100 Tosca Drive
Box 456
Stoughton, Ma. 02072

HELLIGE INC.
877 Steward Avenue
Garden City, N.Y. 11530

HERSEY PRODUCTS INC.
250 Elm Street
Dedham, Ma. 02026

RODNEY HUNT CO., WATER
CONTROL EQUIPMENT DIV.
102 Water Street
Orange, Ma. 01364

THE IDEAL ELECTRIC &
MANUFACTURING CO.
330 East First Street
Mansfield, Oh. 44903

INDEPENDENT FITTING CO.
10775 S.W. Cascale Boulevard
Box 23294
Portland, Or. 97223

INGERSOLL-RAND
Woodcliff Lake, N.J. 07675

INTERNATIONAL HARVESTER
Pay Line Division
600 Woodfield Drive
Schaumburg, Il. 60172

INTERNATIONAL OIL CORP.
301 S. 21st Street
Birmingham, A. 35210

INTERPACE CORP.
260 Cherry Hill Road
Parsippany, N.J. 07054

IONICS, INC.
65 Grove Street
Watertown, Ma. 02172

JARVIS-WEBB CO.
739 Moore Road
Avon Lake, Oh. 44012

JOHNS-MANVILLE
Box 5108
Denver, Co. 80217

JOHNSON DIV. UNIVERSAL OIL
PRODUCTS
Box 3118
St. Paul, Mn. 55165

JOHNSON GEAR & MANUFACTURING
CO., LTD.
921 Parker
Berkeley, Ca. 94710

JOHNSTON PUMP CO.
1775 East Allen Avenue
Glendora, Ca. 91740

JAMES JONES CO.
4127 Temple City Boulevard
El Monte, Ca. 91734

KAMIUCHI ELECTRIC WORKS, LTD.
U.S. Representative:

Marubeni America Corp.
Hydraulic Machinery Dept.
624 South Grand Avenue
Los Angeles, Ca. 90017

KENNEDY VALVE MFG. CO. INC.
1021 East Water Street
Elmira, N.Y. 14902

KENT METER SALES INC.
7 E. Silver Springs Blvd.
Suite 400
Ocala, Fl. 32670

KEYSTONE VALVE DIV.,
KEYSTONE INTL.
9600 West Gulf Bank Drive
Houston, Tx. 77040

KOPPERS CO. INC.
1900 Koppers Building
Pittsburgh, Pa. 15219

KUBOTA, LTD.
U.S. Representative:

Marubeni America Corp.
Hydraulic Machinery Dept.
624 South Grand Avenue
Los Angeles, Ca. 90017

LEOPOLD CO., DIV. OF
SYBRON CORP.
227 South Division Street
Zelienope, Pa. 16063

LEUPOLD & STEVENS INC.
Box 688
Beaverton, Or. 97005

LIMITORQUE CORP.
181 South Gulph Road
King of Prussia, Pa. 19333

THE LINCOLN ELECTRIC COMPANY
22801 St. Clair Avenue
Cleveland, Oh. 44117

LONE STAR STEEL CO.
2200 West Mockingbird Lane
Box 35888
Dallas, Tx. 75235

LYNCHBURGH FOUNDRY, A MEAD CO.
Dwr. 411
Lynchburg, Va. 24505

MARATHON ELECTRIC
Box 630
Randolph & Cherry Streets
Wausau, Wi.

MCC CENTER LINE, UNIT MARK
CONTROLS CORP.
1007 East Admiral
Tulsa, Ok. 74101

MCCROMETER CORP.
3255 West Stetson Avenue
Hemet, Ca. 92343

A.Y. McDONALD MFG. CO.
Box 508
Dubuque, Ia. 52001

MCWANE CAST IRON PIPE CO.
Box 607
Birmingham, Al. 35201

MEAD PIPE-ALABAMA
Box 309
Anniston, Al. 36201

MUELLER CO.
500 West El Dorado Street
Decatur, Il. 62525

MUESCO INC.
Box 36425
Houston, Tx. 77036

MULTIPLEX MFG. CO.
CRISPIN VALVE DIV.
600 Fowler Avenue
Berwick, Pa. 18603

PEABODY MYERS
1621 South Illinois Street
Streator, IL 61364

NEPTUNE MICROFLOC INC.,
SUBSIDIARY NEPTUNE INTL.
Box 612
Corvallis, Or. 97330

NEPTUNE WATER METER CO.,
SUBSIDIARY NEPTUNE INTL.
Route 229 S.
Box 458
Tallasse, Al. 36078

PACIFIC PUMPING CO.
9201 San Leandro Street
Oakland, Ca. 94604

PACIFIC VALVE CO.
3201 Walnut Avenue
Long Beach, Ca. 90807

PASSAVANT CORP.
Carson Road
Box 2503
Birmingham, Al. 35201

PATTERSON INDUSTRIES INC.,
VALVE DIV.
1250 St. George Street
Box 1069
East Liverpool, Oh. 43920

PATTERSON PUMP DIVISION
DUBIE-CLARK COMPANY
Box 790
Toccoa, Ga. 30577

PEERLESS PUMP
1200 Sycamore Street
Montebello, Ca. 90640

PHILADELPHIA GEAR CORPORATION
King of Prussia, Pa. 19406

THE WM. POWELL VALVE COMPANY
2503 Spring Grove Avenue
Cincinnati, Oh. 45214

HENRY PRATT CO.
430 So. Highland Avenue
Aurora, Il. 60507

PROGRESSIVE FABRICATORS, INC.
6800 Prescott Avenue
St. Louis, Mo. 63147

RAYMOND CONTROL SYSTEMS,
DIV. VAPOR CORP.
315 Kirk Road
St. Charles, Il. 60174

REILLY TAR & CHEMICAL CORP.
1510 Market Square Center
151 North Delaware Street
Indianapolis, In. 46204

RANDOLPH MFG. CO.
1110 N. Avenue T
Box 5306
Lubbock, Tx. 79417

RELIANCE ELECTRIC CO.
24701 Euclid Avenue
Cleveland, Oh. 44117

REULAND ELECTRIC COMPANY
17969 East Railroad Street
Industry, Ca. 91749

ROBBINS & MYERS
1345 Lagonda Avenue
Springfield, Oh. 45501

ROCKWELL INTL., MUNICIPAL
& UTILITY DIV.
400 N. Lexington Avenue
Pittsburgh, Pa. 15208

ROTORK, INC.
Box 278
Babylon, N.Y. 11702

RUSSELL PIPE & FOUNDRY CO. INC.
Box 730
Alexander City, Al. 35010

RUST-OLEUM CORP.
3201 Oakton Street
Evanston, Il. 60204

SEIBU ELECTRIC MFG. CO., LTD.
U.S. Representative:

Marubeni America Corp.
Hydraulic Machinery Dept.
624 South Grand Avenue
Los Angeles, Ca. 90017

SIMPLEX VALVE & METER CO.
50 Fulton
Lancaster, Pa. 17602

R. & G. SLOANE MFG. CO. INC.
7606 N. Clybourn Avenue
Sun Valley, Ca. 91352

A.O. SMITH-INLAND INC.
2700 W. 65th Street
Little Rock, Ar. 72209

SPARLING DIV., ENVIROTECH
4097 N. Temple City Boulevard
El Monte, Ca. 91731

STANDARD FIRE PROTECTION
EQUIPMENT
2210 N. Tryon Street
Charlotte, N.C. 28231

SUPERIOR UTILITY PRODUCTS
INC.
2590 Lafayette Street
Santa Clara, Ca. 95050

TRW MISSION MFG. CO.
Box 40402
Houston, Tx. 77040

TAPECOAT CO., DIV. TC MFG.
CO.
1521 Lyons Street
Evanston, Il. 60204

TELEDYNE WISCONSIN MOTOR
1910 South 53
Milwaukee, Wi. 53246

TNEMEC CO. INC.
Box 1749
Kansas City, Mo. 64141

TORO TECHNOLOGY CENTER,
DIV. OF TORO CO.
1709 La Costa Meadows Drive
San Marcos, Ca. 92069

TRAVERSE CITY IRON WORKS
Box 848
Traverse City, Mi. 49684

TURNER DESIGNS
2247A Gold Middlefield Way
Mountain View, Ca. 94043

TYLER PIPE INDUSTRIES INC.
Box 2027
Tyler, Tx. 75710

UNIVERSAL ENGINEERED SYSTEMS,
INC.
7070 Commerce Circle
Pleasanton, Ca. 94550

U.S. ELECTRICAL MOTORS DIV.
OF EMERSON ELECTRIC CO.
125 Old Gate Lane
Milford, Ct. 06460

U.S. PIPE & FOUNDRY CO.
Box 10406
North Birmingham, Al. 35202

U.S. PUMPS
2325 East 49th Street
Los Angeles, Ca. 90058

UBE INDUSTRIES, LTD.
U.S. Representative:

Marubeni America Corp.
Hydraulic Machinery Dept.
624 South Grand Avenue
Los Angeles, Ca. 90017

VICKERY SIMMS, INC.
905 Mayfield Road
Box 459
Arlington, Tx. 76010

VICTAULIC CO. OF AMERICA
3100 Hamilton Boulevard
South Plainfield, N.J. 07080

E.H. WACHS CO.
100 Shepard Street
Wheeling, Il. 60090

WALLACE & TIERNAN, DIV.
PENNWALT CO.
25 Main Street
Belleville, N.J. 07109

WATERMAN INDUSTRIES, INC.
Box 458
Exeter, Ca. 93221

WATEROUS CO.
300 John E. Carroll Ave. E.
South St. Paul, Mn. 55075

WATTS REGULATOR CO.
Box 628
Lawrence, Ma. 01842

WAUKESHA ENGINE DIV.,
DRESSER INDUSTRIES
100 W. St. Paul Avenue
Waukesha, Wi. 53186

WEMCO, DIVISION OF
ENVIROTECH CORP.
Box 15619
721 North B Street
Sacramento, Ca. 95813

WESTERN GEAR CORP.
2600 E. Imperial Hwy.
Lynwood, Ca. 90262

WESTINGHOUSE ELECTRIC CORP.
4454 Genesee Street
Buffalo, N.Y. 14240

WHITE SUPERIOR DIV.
WHITE MOTOR CO.
1401 Sheridan Avenue
Springfield, Oh. 45501

WORTHINGTON PUMP INC.
2700 Sheffield Street
Mountainside, N.J. 07092

WRIGHT HOIST DIV., ACCO INC.
1110 Princess Street
York, Pa. 17403

YASKAWA ELECTRIC MFG. CO., LTD.
U.S. Representative:

Marubeni America Corp.
Hydraulic Machinery Dept.
624 South Grand Avenue
Los Angeles, Ca. 90017

ZURN INDUSTRIES, INC.
One Zurn Place
Erie, Pa. 16512

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APPENDIX B

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APPENDIX C

CONSTRUCTION COSTS

It has not been possible within the scope of this Manual to accumulate cost data which would permit meaningful comparisons to be made between the various types of station illustrated. The cost of identical construction will vary from one part of the nation to another, and the construction market conditions prevailing at the time of inviting bids may cause significant variations. However, in the case of the Westside Pump Station, Long Beach, Ca., complete data is available from the Bid Form which was utilized. Bids were taken in January 1978 and a contract was awarded for the entire construction, based on the total price bid by the lowest of five bidders. Construction was completed in April 1979 for substantially the same figure as bid, there being no significant change in plans or extra costs incurred. Figures 15-1 through 15-5 show the scope of work.

The lowest total price bid for the station of 181 cfs Q was \$1,100,106.00, representing a unit cost of \$6,078 per cfs of pumping capacity. The construction extended from a four-foot length of 75" diameter R.C.P. inlet pipe upstream of the station to the downstream end of the discharge manifold. The station was constructed complete as one unit, with separate contracts being awarded for the collection lines upstream of the station and the discharge line downstream of the station. There was a difference between the low bid and second low bid of \$33,387.00 while the high bid of five received was \$1,293,261.70.

The merits of itemizing quantities in a bid form may be argued, because there is usually some unbalancing of items, but study and analysis generally provides some worthwhile insights into the mysteries of the bidding and pricing process.

Finally, it is possible to arrive at some yardstick estimates of the cost of pumping stations, expressed in dollars per cubic foot per second pumped. A range of \$3,000 - \$8,000 per cfs in 1982 dollars is suggested. The unit cost for small stations will tend to be higher, while larger stations will benefit from economies of scale, unless elaborate design and complexities nullify this advantage. Costs of forebay or storage box should be included as part of the cost of the station. Costs of collection system upstream or discharge lines or channels downstream of the station are usually accounted for separately from the station. Their cost is not included in the range quoted. A rectangular wet-pit station of 400 cfs Q, with 4 engine-driven pumps and 2 electric pumps, also in Long Beach, CA., bid in December 1980 for approximately \$2.6 million, or \$6,500 per cfs. Equipment and features were generally similar to Westside, but of larger size.

CITY OF LONG BEACH, CALIFORNIA
WESTSIDE INDUSTRIAL PARK STORM DRAIN
UNIT 2-B -- WESTSIDE PUMP STATION

CONSTRUCTION BID - January 1978

All quantities shown are estimated quantities. All work is to be installed complete and all machinery and equipment is to be tested and in operable condition acceptable to the City. Any items of work or equipment not listed herein, but shown on the plans or referred to in the specifications shall be included in the price bid for the appropriate item herein. The total price bid shall be for the work complete and acceptable in every way.

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
1	Demolition, including removal of existing A.C. paving	--	L.S.	--	10,000.00
2	Relocation of existing facilities	--	L.S.	--	10,000.00
3	Excavation, including bracing and dewatering (measured two feet outside base slab)	2,441	cu.yd.	30.725	74,999.72
4	Rock mattress, as necessary, including allowance for excavation over and above Item 3	50	tons	6.50	325.00
5	Waterproofing membrane below base slab and enclosing structure to El. 5.0	5,770	sq.ft.	2.60	15,002.00

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
6	P.C.C. slab, 2000 psi, 3" thick over waterproofing membrane (measured net to outside of pump pit base slab)	1,952	sq.ft.	2.561	4,999.07
7	Backfill, selected native material stockpiled on site or other location at Contractor's option	711	cu.yd.	14.065	10,000.22
8	Backfill, imported, as necessary, including allowance for haulaway of equal amount of unsuitable native material	100	cu.yd.	30.00	3,000.00
9	Haulaway	1,730	cu.yd.	2.89	4,999.70
10	P.C.C., 4000 psi in base slab	188.8	cu.yd.	132.415	24,999.95
11	P.C.C., 4000 psi in walls and columns in pump pit	227.1	cu.yd.	450.463	99,999.90
12	P.C.C., 4000 psi in suspended slab and beams over transition	24.0	cu.yd.	416.667	10,000.01
13	P.C.C., 4000 psi in suspended slab and beams for floor at El. 12.50	50.2	cu.yd.	498.008	25,000.00
14	P.C.C., 4000 psi in stairway and wall below grade	7.0	cu.yd.	600.00	4,200.00

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
15	P.C.C., 4000 psi in cantilevers and beams at grade	9.5	cu.yd.	210.526	2,000.00
16	P.C.C., 4000 psi in floor slab at grade	12.0	cu.yd.	125.00	1,500.00
17	P.C.C., 4000 psi in stair bulkhead, mezzanine and crane corbels	6.6	cu.yd.	578.125	3,700.00
18	P.C.C., 4000 psi in roof construc- tion and topping	24.1	cu.yd.	127.527	3,100.00
19	P.C.C., 2000 psi in miscellaneous slabs and footings at grade	3.4	cu.yd.	176.471	600.00
20	P.C.C., 2000 psi in mattress under manifold	9.5	cu.yd.	84.211	800.00
21	Reinforcing steel and welded wire mesh in P.C.C.	90,600	lbs.	0.341	30,931.20
22	R.C.P. Inlet 75" diam., 2000-D	3.33	lin.ft.	450.45	1,500.00
23	Precast Pre- stressed Concrete Roof members, 8" deep	1,558	sq.ft.	2.567	3,999.39
24	Concrete block masonry, split face, 8" thick x 26' height above grade	4,106	sq.ft.	4.871	20,000.33
25	Concrete block ma- sonry, split face 8" x 8" around openings	204	lin.ft.	12.255	2,500.02

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
26	Concrete block masonry, precision 8" x 16" in pilasters x 23' height	322	lin.ft.	15.528	5,000.02
27	Concrete block masonry, extra labor at window openings, soldier course and miscellaneous	--	L.S.	--	500.00
28	Reinforcing steel in concrete block masonry	3,540	lbs.	0.169	598.26
29	Structural steel and miscellaneous metal in embedded items	9,359	lbs.	4.274	40,000.37
30	Structural steel in walkways, stairs, platforms, trash rack, pump pit and miscellaneous	26,156	lbs.	1.912	50,010.27
31	Structural steel in stairways and miscellaneous in engine room	3,422	lbs.	2.922	9,999.08
32	Doors, windows, louvers and roof scuttle	--	L.S.	--	12,000.00
33	General construction in office, toilet and pump pit	--	L.S.	--	2,000.00
34	Office and toilet ventilation	--	L.S.	--	650.00

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
35	Roofing	16.2	Squares	86.420	1,400.00
36	Flashing and miscellaneous sheet metal, including engine radiator exhaust closures	--	L.S.	--	2,200.00
37	Exterior waterproofing on concrete masonry	3,510	sq.ft.	0.541	1,898.91
38	Overhead crane, 5 ton, including rails and supporting steel	1	L.S.	--	20,000.00
39	Gas engines, with drive shafts and accessories complete	3	Each	51,666.66	155,000.00
40	Pumps, 51.33 cfs, with right-angle gear drives	3	Each	51,333.33	154,000.00
41	Pump, 27 cfs, with electric motor	1	Each	28,000.00	28,000.00
42	Check Valves, 36"	3	Each	30,000.00	90,000.00
43	Check Valve, 24"	1	Each	15,000.00	15,000.00
44	Sump pump with flexible hose and accessories, complete	1	Each	4,000.00	4,000.00
45	Check valve, 8" with discharge piping	1	Each	1,700.00	1,700.00
46	Discharge manifold, complete	1	Each	30,000.00	30,000.00
47	Dual Fuel Supply System, complete	1	L.S.	4,000.00	4,000.00

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
48	Advance deposit to Long Beach Gas Department	1	L.S.	500.00	500.00
49	Domestic and industrial water supplies, plumbing and fixtures, and connection to sewer, if required	1	L.S.	8,000.00	8,000.00
50	Advance deposit to Long Beach Harbor Department	--	L.S.	--	500.00
51	Air inlet and exhaust fans with sheet metal and concrete ducting	--	L.S.	--	3,500.00
52	Lube oil supply, drain tanks and piping	--	L.S.	--	3,000.00
53	Air valves, miscellaneous piping, supports and fixtures	--	L.S.	--	3,000.00
54	Electrical power and lighting, complete	--	L.S.	--	41,611.40
55	Instrumentation, pump control, water level recording and gas detection	--	L.S.	--	12,583.00
56	Telemetry system and telephone service, complete	--	L.S.	--	8,000.00
57	Protective coatings and tape	--	L.S.	--	12,000.00

<u>Item No.</u>	<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Total</u>
58	Chain-link fencing and gates	--	L.S.	--	2,300.00
59	Guard posts	14	Each	64.28	900.00
60	Base course, 6" thick generally and 8" thick as required, under paving	2,430	sq.ft.	.65	1,598.94
61	A.C. Paving, 3" thick generally and 6" thick as required	2,430	sq.ft.	1.44	3,499.20
62	Operational testing, including furnishing all water, fuel, power and lubricants	--	L.S.	--	3,000.00
					\$1,100,106.00

* * * * *

APPENDIX D

SPECIFICATIONS

To many engineers the writing of specifications presents more difficulty than computations and drawings related to the design. This is recognized by many government agencies such as the Corps of Engineers and the Department of the Navy, who make available outline specifications which can be edited to suit a particular project. State Transportation agencies will likewise have their own standard specifications which meet their usual types of construction.

However, it is unlikely that adequate pump station specifications are generally available and this Manual attempts to fill such a need by presenting complete specifications for all aspects of a recently constructed station. The subject station is of wet-pit type with rectangular sump. It is equipped with conventional vertical centrifugal pumps, three driven by natural gas engines and one by an electric motor. The station was designed for the City of Long Beach, California, to the elaborate standards of the Los Angeles County Flood Control District. It thus contains a comprehensive array of equipment and features and the specifications are correspondingly detailed. These specifications have been tested by actual use in control of construction of the station and were found to be entirely adequate for their purpose. A few discrepancies were found and these are pointed out in the comments which conclude this introduction.

These Specifications are intended to be used as a guide only, the individual designer being able to modify them to suit his conditions, the equipment he selects, and the like. The format is that developed by the Los Angeles County Flood Control District and has been utilized on the construction of a number of pump stations. Some minor adaptation to suit the format of the City of Long Beach was required and this was done.

It will also be noted that reference is made to Standard Specifications. That excellent publication is the Standard Specifications for Public Works Construction, developed by public agencies in Southern California in cooperation with the Associated General Contractors of California, and used very extensively. Any other standard specifications can be substituted, as desired.

Attention is drawn to some specific items which deserve comment, either due to the content as written or its impact on the control of the construction.

Section 1.6

A rock mattress was necessary and was installed over the bottom of the excavation, which was carried to necessary depth inside a close sheeted cofferdam constructed with H-pile soldier beams and timber lagging. Ground water infiltration was minimal.

Sections 2.1.3 and 2.4

The requirement that all shop drawings be properly coordinated and submitted together worked very effectively. It enabled the engineer's checking and resolution of problems to be expeditiously done without imposing any burden on the contractor.

Section 5

Waterproofing membrane was placed over the three-inch lean concrete slab and not beneath it as shown on the drawings. A heavy polyethylene film was placed over the top of the membrane for protection while the reinforcing of the base slab was placed.

Section 7

It was found to be impossible to secure deliveries of colored split face concrete masonry units in an acceptable uniformity of color and texture. A grey block was used in lieu of the color specified.

Section 9.3.3

Difficulty was experienced in avoiding distortion of the secondary trash rack members during galvanizing. This was apparently due to differing heat transfer through steel sections of greatly varying sizes. Special attention is required where fabrication is to be galvanized.

Section 15.1.2

The specifying of minimum efficiencies at both maximum and minimum total dynamic heads proved to be impractical and requirement for efficiency was limited to design point.

Section 15.2.2

A 10 horsepower motor was proved to be adequate for the sump pump and was accepted accordingly.

Section 20.2.1

Mild steel conforming to ASTM A 36 was used in lieu of ASTM A 283 Grade C due to delivery difficulties. In any case, the superior properties of A 283 do not appear in any way to have been necessary.

Section 20.4

The contractor submitted a slanting-disc check valve of foreign manufacture which met specifications and was accepted. However, the mounting of the dash-pot differed from that of the anticipated valve, and reduced clearance and access for maintenance. Where such choices are offered to the contractor, the drawings must clearly show dimensions as being "To suit equipment furnished" and some field adjustments may be required.

Section 22.10.4

A change in model was required since the item specified had been discontinued. Specifications should always be checked thoroughly to verify that specified items are available.

Section 25.3

The epoxy primer Engard 411 was incorrectly specified. This is not compatible with Engard 482. Consequently a two-coat application of Engard 482 to the required mil thickness was utilized.

Section 26.3.1

The office and toilet fans were intended to be roof-mounted and should have been specified as Model CRF 67 or equal. Duct size of eight-inch diameter was also omitted, and a clarification was necessary.

Apart from the foregoing, very few questions as to the content or intent of the Specifications were raised throughout the project.

* * * * *

CITY OF LONG BEACH, CALIFORNIA

WESTSIDE PUMP STATION

DESCRIPTION OF WORK TO BE DONE

The work to be done hereunder consists of constructing a complete pump station, including reinforced concrete pump pit, entirely below existing grade, below-grade transition structure connection from storm drain, manifold connection to discharge line, appurtenant excavation, shoring and backfill, concrete block masonry superstructure with concrete roof, and installation of all pumping machinery, electrical work, plumbing and related items.

The pump pit is approximately 27 feet deep and 41 feet by 32 feet on plan; the superstructure is approximately 26 feet high and 54 feet by 32 feet on plan.

All items of pumping machinery and electrical equipment shall be furnished by the Contractor under conditions as set forth in Special Provisions. No material will be furnished by the City.

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SECTION 1: GENERAL

1.1 Protecting the Worker from the Hazard of Caving Ground

Subsequent to approval by the Division of Industrial Safety, three sets of prints showing the design criteria, calculations and sketches indicating the sequence of the placement and removal of shoring, bracing, sloping or other provision made for worker protection shall be submitted to the Engineer for review.

The contractor shall be aware that if a requirement for shoring as specified by the State Construction Safety Orders is in conflict with the requirements specified by the Federal Occupational Safety and Health Standards, the most stringent requirement shall govern.

1.2 Backfill and Bedding

The soils report indicates that all the soils on this project can be easily excavated with conventional excavating equipment, and that the soils are suitable for use as backfill. However, the majority of the soil was found to be over their optimum moisture content and will require aeration prior to use as backfill. It is anticipated that some import fill will be required in lieu of native material to make first-class bedding and backfill around inlet pipes, and as floor slab subgrade. Groundwater was encountered and some of the soils approached saturation. It was also noted that sheeting will be required to maintain the vertical excavation, since open excavations are not feasible due to limitations of space. A combination of sheeting and open cut will be permitted provided all excavation is within the limits indicated on the plans.

At the beginning of compacted fill or backfill operations, test sections shall be made, unless otherwise ordered by the Engineer, as follows:

The test section may be any length or width sufficient, in the opinion of the Engineer, to conclusively demonstrate that the type of compacting equipment, thickness of fill or backfill layers and moisture content used will produce at least the specified relative compaction, which is 95% of

Sec. 1.2 contined.

maximum optimum density. A sufficient number of fill or backfill layers shall be placed in the test section to conclusively demonstrate that the required minimum relative compactions are being attained. The City will make the relative compaction tests, and if results are satisfactory, the equipment, thickness of layers, moisture content and compactive efforts used in the test section shall be used thereafter in the placing and compacting of fill and backfill material. However, when fill or backfill material different from that previously tested is used, or when relative compaction tests indicate that required minimum relative compactions are not being attained, then a new test section shall be made and equipment, thickness of layers, moisture content and compactive effort shall be adjusted or changed as necessary to attain the specified minimum relative compactions. Approval of equipment, thickness of layers, moisture content and compactive effort shall not be deemed to relieve the Contractor of the responsibility for attaining the specified minimum relative compactions. The Contractor, in planning his work, shall allow sufficient time to perform the work connected with the test sections, and to permit the City to make the tests for relative compactions.

The relative compaction test will be made by the City at no cost to the Contractor.

Each layer shall be evenly spread, moistened, and worked by means approved by the Engineer, and then mechanically compacted until a relative compaction for the fill or backfill of not less than the percentage specified has been attained.

If excavation materials with an excessive moisture content are used as backfill, the Contractor may find it necessary to do one of the following to attain the required relative compaction:

- (a) Suitably dry the wet material
- (b) Blend the wet material with dry material, such dry material being from the project excavation or imported from sources outside the project limits.

Sec. 1.2 continued.

- (c) Waste the wet material and use suitable excavation or imported material.

1.3 Contractor's Work Area

The Contractor is cautioned that his work will be in an area occupied by Harbor Department tenants in which cargos are stored and/or handled. He will be required to co-operate with these tenants to minimize inconvenience and avoid any conditions which might preclude these tenants from performing their normal operations.

The entire work area is on Long Beach Harbor Department property and the Contractor will be permitted to use only the area surrounding the pump station and adjoining the oil production area, as indicated on the drawings. The work area will be entirely within the fenced area surrounding the Long Beach Harbor Department Warehouse No. 6, and will be irregularly shaped, allowing at least seventy feet of clearance south of the warehouse building for Harbor Department tenants' truck access and passage. The work area may be used for job office, storage, stockpiling and conditioning of backfill, parking and other work-related reasons. No additional Harbor Department property whatsoever will be available to the Contractor for any purposes, and any auxiliary area which the contractor considers necessary for his operations shall be leased by him at his expense. Any damage to Harbor Department paving, fencing or existing facilities caused by the Contractor's operation shall be made good by him at his expense and to the satisfaction of the Long Beach Harbor Department.

1.4 Collateral Work

The Contractor is advised that the work of constructing the storm drain collecting system upstream of and leading to the pump station, together with the downstream discharge line from the pump station, will be in progress concurrently with his work. He will be required to co-operate with others performing the above-mentioned work and to schedule his work to take account of same and to facilitate the actual work of tie-ins.

Temporary bulkheads required to be installed by the Contractor in the inlet pipe and discharge manifold shall be capable of withstanding water pressure from either side so as to be of value in testing both upstream and downstream pipe conduits. Removal of the bulkheads and leaving the lines clear shall be the responsibility of the pump station Contractor unless due to prior completion of the pump station work the Engineer waives this requirement.

1.5 Removal and Restoration of Permanent Surfacing

The removal and replacement of existing pavement shall be accomplished in accordance with the notes and details shown on the drawings, the applicable provisions of the Standard Specifications, and the "General Specifications for Pavement Removal and Replacement Over Trench Excavations", a copy of which is on file in the office of the City Engineer.

The first and second paragraphs included under I. GENERAL of the "General Specifications for Pavement Removal and Replacement Over Trench Excavation" shall be deleted and the following substituted therefor:

"All work embraced herein shall be done in accordance with the applicable requirements provided in "STANDARD SPECIFICATIONS for PUBLIC WORKS CONSTRUCTION, 1973 Edition", adopted by the City Council of the City of Long Beach on July 24, 1973, together with City of Long Beach amendments to said document, included herewith, and in accordance with these Special Provisions.

Whenever reference is made to "Standard Specifications", it shall be deemed to mean STANDARD SPECIFICATIONS for PUBLIC WORKS CONSTRUCTION, 1973 Edition, together with "City of Long Beach, California Amendments to Standard Specifications for Public Works Construction, 1973 Edition".

Minimum replacement width for asphalt concrete paving shall be 36" measured from the edge of the excavation, whether shored or open cut. The outside 6" of paving on both sides of the excavation shall be saw cut and removed as the last order of work prior to final paving.

The surface course of asphalt concrete shall be a minimum of 1-1/2 inches thick and shall be Type 1-C-4000 asphalt concrete.

The base course of asphalt concrete shall vary in thickness as required to meet specified thickness called out on the drawing minus the thickness of the surface course and shall be Type 1-B-AR-4000 asphalt concrete.

Where restoration of permanent surfacing exceeds 12-feet or where it is deemed necessary by the City Engineer, the asphalt concrete shall be spread with a self-propelled, mechanical spreading and finishing machine.

Sec. 1.5 continued.

Existing surfacing within the fenced area south and west of Warehouse No. 6 is six inches of asphalt concrete on eight inches of base rock, and where removed outside the lease line for the new pump station shall be replaced in kind.

1.6 Rock Mattress

Where the ground or subgrade on which a conduit or the pump station structure is to be laid or constructed is soft or spongy or otherwise unsuitable for a foundation, the unstable material shall be removed and replaced to the depth specified by the City Engineer with crushed aggregate base conforming to the requirements of Section 200-2.2 of the Standard Specifications. The crushed aggregate base shall be tamped until firm and unyielding to form a rock mattress.

Payment for rock mattress will be made at the unit price of six dollars and fifty cents (\$6.50) per ton, for the actual number of tons, authorized by the City Engineer, which Contractor imports and uses as foundation material for structures, and for foundation and bedding material for pipe. An estimated tonnage is inserted by the City in the Contractor's bid form.

Said price shall include all costs necessary or incidental to furnishing and placing the rock mattress, including excavation and disposal of surplus excavated material. The quantity shown in "Estimated Quantities" is to be used only in determining the total bid. The City will not be liable for anticipated profits if the quantity required is less than the quantity shown in "Estimated Quantities."

1.7 Portland Cement

All portland cement to be used on this project shall be Type II and shall not contain any calcium chloride admixtures. The Contractor is cautioned to order pipe or other materials that will comply with this requirement.

1.8 Water Line Connection

Water line connection and/or appurtenant work as referred to in the Estimated Quantities will be accomplished by the Long Beach Harbor Department. The Contractor shall request the work to be performed and shall make payment to the Harbor Department of an advance deposit for the amount stated under Item 50 of the Bid Form.

The Contractor shall also be aware that the Harbor Department will require four months between the time that the work is performed and the time that the final billing can be computed. At the time of final billing, the Contractor will either be given a refund by the Harbor Department or will be charged for costs over the amount of the deposit. Upon presentation of the paid final invoice to the City Engineer, the Contractor will be reimbursed in due course of payments by the City for the real costs incurred.

1.9 Gas Line Connection

Gas line connection and/or appurtenant work as referred to in the Estimated Quantities will be accomplished by the Long Beach Gas Department. The Contractor shall request the work to be performed and shall make payment to the Gas Department of an advance deposit for the amount stated under Item 48 of the Bid Form.

The Contractor shall also be aware that the Gas Department will require four months between the time that the work is performed and the time that the final billing can be computed. At the time of final billing, the Contractor will either be given a refund by the Gas Department or will be charged for costs over the amount of the deposit. Upon presentation of the paid final invoice to the City Engineer, the Contractor will be reimbursed in due course of payments by the City for the real costs incurred.

1.10 Reinforced Concrete Pipe

Reinforced Concrete Pipe shall conform to the applicable provisions of Section 207-2 of the Standard Specifications. Installations shall be in accordance with Section 306 -- Underground Conduit Construction.

Payment for all costs for reinforced concrete pipe construction shall be included in the unit price bid for Item 22.

1.11 Protective and Security Fencing

The Contractor shall provide protective and security fencing in accordance with State of California Construction Safety Orders along the west side of the work site, maintaining a clear width of at least eighteen feet of existing roadway. Existing fence which is to be removed may be relocated and used as temporary protective fencing if complying with above-mentioned Safety Orders, and if acceptable to the Long Beach Harbor Department as providing adequate security for the enclosed warehouse area.

The entire warehouse area is fenced and secured and no other fencing of work area will be required, provided the Contractor makes satisfactory arrangements with the Harbor Department for ingress and egress and barricades all points of hazard. However, at his option, the Contractor may at his own expense fence his entire work area within or up to the maximum limit as shown on the plans and provide his own access to the existing roadway west of the pump station. Removal of fence and restoration of permanent surfacing shall be performed in accordance with paragraph 1.5 herein. All costs for protective and security fencing shall be included in the lump sum bid for Item 2.

1.12 Payment

Payment shall be made in accordance with Section 9 of the Standard Specifications.

SECTION 2: MATERIAL, TESTS AND GUARANTEE

2.1 Material and Equipment Furnished by the Contractor

2.1.1 General Construction

The Contractor is required to furnish at his expense all the materials of general construction for the pump station, including but not limited to concrete, reinforcing steel, structural steel, concrete block masonry, prestressed concrete roof members, plumbing, waterproof membrane, roofing, rock and fill material, paving and fencing, all as shown on the contract drawings and as described in these specifications.

The Contractor shall also furnish at his expense all materials required for shoring excavations and for forming concrete and for any other incidental work of general construction.

2.1.2 Mechanical and Electrical Construction

The Contractor is required to furnish at his expense all the machinery, equipment and materials for mechanical and electrical construction of the pump station, all as shown on the contract drawings and as described in these specifications.

2.1.3 Shop Drawings for General Construction

Within 30 days after award of contract, the Contractor shall submit to the City Engineer, City of Long Beach, one complete package containing all required shop drawings for general construction as set forth below. The submittal shall consist of six copies of all shop drawings of the following items to be furnished, fabricated or manufactured by the Contractor under the contract:

Reinforcing Steel for concrete and masonry.
Stainless Steel Anchor Bolts for embedment in pump pit base slab.
Reinforced Concrete Pipe.
Prestressed Concrete Roof Members.

Sec. 2.1 continued.

Included with the package shall be six copies of Specification Data, which may be in bulletin form, of the following materials to be used or furnished by the Contractor under the contract:

Concrete Mixes.
Waterproofing Membrane.
Surface Hardener for engine room floor.
Concrete Block Masonry Units.
Louvers, Doors and Frames, Windows and Roof Scuttle.
Glazing
Roofing
Paint and Protective Coatings.

All Shop Drawing and Specification Data shall be clearly marked or stamped "City of Long Beach, West Side Pump Station -- Project 07-01-01426".

The Contractor will not be permitted to commence work on the site until all the above-listed shop drawings and data for general construction of the entire pump station have been approved by the Engineer.

Six samples of concrete block not exceeding eight inches square shall be submitted with the package to show color and texture of block proposed to be used.

If any major changes are required after checking the Contractor will be required to resubmit six copies. If minor changes are required, such required changes will be indicated on the two copies which will be returned to the Contractor and which shall be used for construction.

Structural Steel shop drawings shall be submitted as described herein under paragraph 2.4.

Review of shop drawings and data by the City will be general and shall not relieve the Contractor of the entire responsibility for the correctness of details and dimensions, and from furnishing materials and performing work required by the contract regardless of omissions from the shop drawings. Review of the shop drawings shall in no way operate to waive or modify any requirements of these specifications or the guarantee bond.

2.2 Payment

Payment will be made on the basis of percentage completion each month of each of the items as listed in the Bid Form. No payment will be made for materials or equipment received and on site, but not installed.

2.3 Guarantee

2.3.1 General Construction

Before the contract work is accepted by the City, the Contractor shall furnish the City or its assignees a written guarantee stating that he will guarantee all workmanship and materials becoming a part of the completed construction for the period of 12 months from the date of final acceptance by the City.

During this 12-month period, when in the opinion of the Engineer there is evidence to indicate defective materials or workmanship, the Contractor shall repair or replace the defective materials or workmanship at his own expense and to the full satisfaction of the Engineer.

The mechanical and electrical equipment shall not be covered by this guarantee but shall be guaranteed as specified in subsection 2.3.2 hereinbelow. The roofing shall be guaranteed as specified in section 11.3.

2.3.2 Mechanical and Electrical Equipment

Before the final start-up and testing of the pump station, the Contractor shall furnish a bond from a Surety Company acceptable to the City for an amount of five hundred fifty thousand dollars (\$550,000.00) guaranteeing the satisfactory performance of the mechanical and electrical equipment furnished and installed under the contract to the extent that performance under actual operating conditions may be affected by the workmanship or defective materials.

The Bond shall guarantee the replacement or making acceptable of any materials, equipment or parts of equipment found to be inferior in workmanship or defective in materials or improperly installed. The terms of this guarantee bond shall extend for two years from the date of final acceptance of the entire work by the City, and all costs of the bond shall be included in the prices bid for applicable items of mechanical and electrical work.

2.4 Equipment Working Drawings and Specification Data

Within 60 days after award of contract, the Contractor shall submit in one complete package all required equipment working drawings as set forth below. The submittal shall consist of eight copies of all Working Drawings of the following items to be furnished, fabricated or manufactured by the Contractor under the contract:

- A. * Pump Detailed Cutaway Assembly Drawings for Pumps Nos. 1 through 4, including Electric Motor for Pump No. 1 showing internal construction. Separate drawings are required for each item, with a minimum scale of 1" = 1'0".
- B. * Pump Detailed Cutaway Assembly Drawings for Sump Pump, including Electric Motor showing internal construction. Separate drawings are required for each item, with a minimum scale of 1" = 1'-0".
- C. * Right Angle Gear Detail Cutaway Assembly, including details of Tachometer Generator Drive Gearing, with a minimum scale of 1" = 1'-0".
- D. * Natural Gas Engines Detail Drawings.
- E. * Natural Gas Engine Installation Drawing, including Flexible Drive Shaft, Shaft Guard, Right Angle Gear, Pump Base and Right Angle Gear Pedestal, Electric Starting System, Exhaust System with Piping and Supports, and Engine Foundation Plan.
- F. * Torsional Analysis for Engine, Drive Shaft, Right Angle Gear and Pump System.
- G. * Engine Instrument Panel Detail Drawing.
- H. * Electrical Switchboard.
- I. * Pump Plant Electrical Wiring Diagrams, including Engine Control Panel.
- J. * Recording Instrument Panels.

Sec. 2.4 continued.

- K. *Water Level Recorder Panel.
- L. *Telemetry System.
- M. *Discharge Manifold and Piping, including Couplings.
- N. *Bridge Crane.
- O. *L.P.G. Tank, Piping and Fittings.

For the convenience of the Contractor and to allow more time for preparation, the following item of shop drawings is included herein in lieu of a requirement that it be submitted as an item under paragraph 2.3.1 of General Construction. Six copies are required of which two will be returned as provided for in Paragraph 2.1.

- P. Structural Steel, Miscellaneous Metal Work and Fabricated Item, except stainless steel anchor bolts as referred to under Subsection 2.1.3 herein.

The Contractor shall prepare and submit eight copies of Specification Data, which may be in bulletin form or catalog cuts, of the following items to be manufactured or equipment to be used by the Contractor under the contract:

1. Pumps (including Pump Performance Curves marked with design points as specified).
2. Pump Motors.
3. Right Angle Gear Drives.
4. Gas Engines, including all accessory items specified.
5. Drive Shafts.
6. Check Valves.
7. Air and Vacuum Valves.
8. Discharge Manifold Flexible Couplings.

Sec. 2.4 continued.

9. Discharge Manifold Cam-Lock Doors.
10. Electrical Switchboard.
11. Electrical Fixtures, Equipment and Materials.
12. Pressure Switches.
13. Water Level Recorder.
14. Recording Tachometers.
15. Recording Wattmeter.
16. Telemetry Components.
17. Gas Detector and Accessories.
18. Bridge Crane.

All bulletins or catalog cuts shall be properly edited and marked with the reference to the exact item or model which the Contractor proposes to furnish.

All Working Drawings and Specification Data shall be clearly marked or stamped "City of Long Beach, West Side Pump Station, Project 07-01-01426."

The eight copies of Working Drawings and Specification Data shall be sent to the City Engineer, City of Long Beach, who will process the drawings and instruct the Contractor regarding same.

The working drawings shall indicate all the detail, dimensions, clearances, types of finishes, types of materials, and other pertinent data.

If any major changes are required after checking, the Contractor will be required to resubmit eight copies. If minor changes are required, such required changes will be indicated on all the working drawings.

Sec. 2.4 continued.

When review is completed, two sets of drawings and data will be returned to the Contractor with the Engineer's instructions. No work shall be done or shipments made until the City's instructions have been received. The remainder of the drawings shall become the property of the City, and shall not be subject to recall by the Contractor.

The Contractor shall allow a total of 30 calendar days for checking the submittal of working drawings or specification data, unless extended by the necessity for resubmittals. Such time shall start when drawings are officially received by the City Engineer. No checking or review whatsoever will begin until it has been verified to the satisfaction of the Engineer that the submittal of the required drawings and data is complete and includes all items listed herein. The 30-day period for checking and review will begin from date of such verification and will be extended by any necessity for resubmittals. Approval will be only for the entire package of all equipment. No prior approval of individual items will be granted.

In addition, after the working drawings have been finalized, the Contractor shall furnish one set of reproducible tracings or "sepias" for each of the working drawings designated with an asterisk (*) in this section, all being stamped or marked "As-Built."

The cost of preparing all required working drawings and "as-built" reproducible tracings or sepias shall be absorbed in the price bid for each applicable item.

The Contractor shall certify to each and every item of electrical and mechanical equipment being in strict accordance and compliance with these specifications by stamping each page as follows: "CERTIFIED TO BE IN ACCORDANCE WITH THE REQUIREMENTS OF SPECIFICATIONS NO. R-4786." Structural steel is not included in this certification requirement.

The Contractor's certifier shall be the signatory to the Bid Form for this contract, or other qualified person acceptable to the Engineer, who shall sign and date each page of the submittal under the above specified stamp.

Sec. 2.4 continued.

Review of working drawings by the City will be general and shall not relieve the Contractor of the entire responsibility for the correctness of details and dimensions, and from furnishing materials and performing work required by the contract, regardless of omissions on the working drawings. Review of the working drawings shall in no way operate to waive or modify any requirements of these specifications or the guarantee bond.

2.5 Material Furnished by the City

No material will be furnished by the City.

2.6 Inspection

The Contractor shall provide the Engineer access to all testing, manufacturing and assembly sites of the engines, right angle gear drives, pumps and accessories, and any other manufactured or fabricated items under the contract. Inspections will be made at the discretion of the City.

The Contractor shall notify the City sufficiently in advance of the time the equipment and accessories and other items are to be fabricated, to permit scheduling the inspections.

2.7 Substitution of Materials

Reference is made to Section 4-1.5 of the Standard Specifications.

During the preparation of the working drawings for the equipment to be fabricated and furnished by the Contractor, the Contractor may if he so desires, offer for approval, by the Engineer, substitutions in materials, designs, or method of fabrication from that specified. Necessary material specifications, data, and detail drawings must be furnished with request for substitution in order for Engineer to evaluate the substitution. If such substitutions are considered equivalent to or better than those specified, in the opinion of the Engineer, the Contractor will be allowed to incorporate the changes in the working drawings. The Contractor may be required at his own expense, to furnish evidence, perform tests, or provide other proof to the Engineer, in order that any substitution offered may be properly evaluated.

Sec. 2.7 continued.

All such requests for substitutions by the Contractor must be made as part of the working drawing submittal within 60 days after award of contract and shall have adequate attention drawn thereto by the Contractor when certifying the submittal, who shall add the words "Except as Noted", and state the substitution requested and request its acceptance over his signature.

2.8 Permits and Code Requirements

All operations in connection with the construction of the proposed pump station buildings shall be done in a manner to conform with the Building, Mechanical, Electrical, and Plumbing regulations of the City of Long Beach Municipal Code, and other laws and ordinances specified herein.

The Contractor's attention is directed to the fact that if any building, electrical, or plumbing permits are required to be issued by the City for this project, the various required permits will be provided at no cost to the Contractor. Inspection of all phases of construction to insure compliance with these specifications will be performed by the City Engineer.

The Contractor shall secure at his expense and prior to start of work any permits required by the State of California and the Division of Industrial Safety.

The Contractor's responsibilities regarding utility services to the buildings are specified in Section 12.

2.9 Instruction Manuals and Parts Catalogs

Before final inspection and performance testing of the pump station and appurtenant facilities, the Contractor shall furnish eight complete bound together sets of instruction manuals and parts catalogs of the following items:

2.9.1 Main Pumps, including electric motor for Pump No. 1.

2.9.2 Right Angle Gear Drives.

Sec. 2.9 continued.

- 2.9.3 Natural Gas Engines and All Auxiliary Equipment.
- 2.9.4 Drive Shafts.
- 2.9.5 Check Valves.
- 2.9.6 Sump Pump and Motor.
- 2.9.7 Bridge Crane.
- 2.9.8 Roll-up Entrance Door.
- 2.9.9 Inlet and Exhaust Fans.
- 2.9.10 All Measuring and Recording Instruments.
- 2.9.11 Telemetering Equipment
- 2.9.12 Gas Detector.

The binders shall be Wilson Jones Catalog Cover No. 564-64LH or equal as manufactured by Coast Book Cover Company, or a City-approved equal.

2.10 Installation of Equipment

The Contractor shall have the installation of pumps, engines, and right angle gear drives, specified in Sections 15, 16, 17, 18 and 19 hereinafter, supervised by the equipment manufacturer or his authorized distributors or dealers. It is the intent of the City to have only experienced installers in responsible charge of work on the project. Any inexperienced personnel permitted on the job shall be adequately supervised. The piping and electrical connections to this equipment performed by other trades, shall have final connections supervised and installation approved by equipment manufacturer or his authorized distributors or dealers.

The Contractor is responsible for all work of any subcontractor as outlined in Section 2-3 of the Standard Specifications.

2.11 Operational Tests (After Installation in the Pumping Plant)

2.11.1 Notification

The Contractor shall notify the Engineer one week in advance of the time he wishes to start the operational tests. Such notification shall not be given until the pump station and discharge manifold are completed, and the discharge line to Channel 2 is completed by others.

2.11.2 General Requirements

The Contractor shall operate and test all equipment, engines, pumps, electrical work, controls, and instrumentation in the manner directed by the Engineer.

The engines, and pumps, are specified to be tested prior to installation. However, this further testing will be required to insure adequacy of installation, and the acceptability of the permanently installed recording devices. All equipment and devices for the tests shall be furnished by the Contractor.

All necessary repairs, replacements, or adjustments shall be made, if required, until all equipment, pumps, engines, electrical work, controls, and instrumentation are operating properly and are satisfactory to the Engineer.

2.11.3 Tests

The Contractor shall furnish all water required for the operational tests and shall fill the sump and inlet transition structure to an elevation of 0.00 feet, prior to the tests. A temporary bulkhead shall be constructed at the upstream end, inside the 75-inch inside diameter storm drain pipe and capable of withstanding the specified head of water from either upstream or downstream side. The short spool of discharge piping and the flexible couplings between each check valve and the manifold shall be removed during pump tests. The spigot ends of manifold branches for discharge lines Nos. 1, 2, 3 and 4 shall be fitted with tight-fitting covers during the pump tests to prevent loss of water.

In event any equipment does not operate properly, or any other water is lost, the Contractor will be required to refill the sump and the

Sec. 2.11 continued.

transition structure to the above-stated elevation for rechecking of any equipment after it has been repaired, replaced, or adjusted until all equipment operates properly and is satisfactory to the Engineer.

The Contractor shall first test the electric motor driven pump which is labeled Number 1 on the plans. The operational test for this pump shall be performed with pump discharging the pumped water back into the sump. The minimum operational time shall be one hour for each pump.

The three engine-driven pumps Nos. 2, 3 and 4 shall be tested while completely assembled and installed in place by recirculating water in the sump. Each engine shall be run for one hour. The engine shall be run at speeds up to 1200 rpm as designated by the Engineer. The satisfactory operation of solenoid valves and recording devices shall be demonstrated during this test.

Measurement for the capacity of the pumps will not be required. However, the Contractor may be required to perform other measurements, such as pump and engine speeds, and the checking of the accuracy of controls and permanently installed recording devices.

All equipment and devices for the tests and measurements shall be furnished by the Contractor.

On completion of main pump operational tests, the sump pump shall then be operated to lower the water level in the sump. It shall be tested by running continuously to discharge until stopped automatically by low-level cut-off. The temporary bulkhead shall then be removed by the Contractor. Covers over manifold branches shall also be removed and discharge piping spools and flexible coupling shall be installed complete.

2.11.4 Payment

All costs of the operational tests including, but not limited to, providing water, natural gas, LPG, electric power, lubricants, repairs, replacements, adjustments, or subsequent re-testing, shall be included in the lump sum amount bid for Item 62.

SECTION 3: DEMOLITION

3.1 Removal of Existing A.C. Paving

The Contractor shall remove all existing A.C. paving over the entire area of construction. Refer to Section 1, paragraph 1.5, Removal and Restoration of Permanent Surfacing, and comply with same.

3.2 Removal of Existing Fence and Protective Devices

The Contractor shall remove existing fence within the limits indicated on the plans. No existing fence material may be re-used in the permanent work, but at the Contractor's option it may be used for protective and security fencing as provided for in Section 1, paragraph 1.11, to which reference is made. The existing guard post which is to be removed shall become the property of the Contractor, but shall not be reused in the permanent work.

3.3 Relocation of Existing Facilities

The existing light pole shall be relocated as shown on the plans. Depth of embedment of the pole shall be the same as existing. Conduit run and wiring shall be shortened or extended to suit ensuring that any routing is outside the fenced area of the new construction. Relocation of the light pole shall be effected immediately following removal of existing A.C. paving from the construction area and service shall not be interrupted during hours of darkness. Long Beach Harbor Department will arrange for power to be cut off as necessary for performance of the work and shall be advised by the Contractor 48 hours in advance of his scheduling of the work.

3.4 Payment

The cost of all work of demolition shall be included in the lump sum price bid for Item 1 and the cost of all work of relocation of existing facilities shall be included in the lump sum price bid for Item 2.

SECTION 4: EARTHWORK AND SURFACING

4.1 Earthwork

4.1.1 General

The Contractor shall perform all earthwork required to construct the pump station and appurtenances, all as shown on the drawings and as described in these specifications.

The earthwork, in general, shall consist of excavation, control and diversion of water and dewatering excavations, backfill, removal and disposal of excess excavated materials and fine grading.

The removal of existing improvements of any nature required as a result of the construction of the pump station and discharge lines, is considered a part of the work Under Item 1. The restoration of all existing improvements, except base course and A.C. paving, shall be as specified in Section 1.3 and shall be included in the lump sum amount bid for Item 2.

4.1.2 Shoring of Excavations

Shoring of excavations shall be in accordance with the requirements of subsection 306-1.1.6, as amended, Standard Drawing 2-D 466 and other applicable provisions of these specifications and project drawings. The required lateral pressure to be used in the design of sheeting is shown on Sheet 2.

On request, the Contractor will be provided by the Engineer with a copy of the foundation investigation tests.

The unit price bid for Item 3 shall include all costs relating to shoring and dewatering of excavations as described hereinabove.

No change will be made in the amount to be paid under Item 3 as a result of required revisions in the shoring details as mentioned in subsection 306-1.1.6.

4.2 Backfill and Fill

Backfill material (including imported material, if the Contractor so elects or the City directs the use thereof) and placement shall be in accordance with the applicable provisions of sections 300 and 306.

Unless otherwise specified, the project excavation material is suitable for use as backfill. A sufficient quantity may be stockpiled on site within the area allowed as working area for the Contractor.

The Contractor's attention is directed to the fact that some of the material to be encountered may have a high moisture content and he is referred to subsection 306-1.3.1, for methods of obtaining the required relative compaction specified hereinafter.

All backfill and fill shall be mechanically compacted to a minimum relative compaction of 90 per cent, except for the topmost 12" which shall be compacted to a minimum relative compaction of 95 per cent.

4.3 Densification

Backfill shall be placed and densified in accordance with the provisions of section 300 and subsection 306-1.3.

4.4 Grading

Perform all grading around and adjacent to pump station as detailed on Sheet 2. Grading shall include grading required for subgrade for paving work as described in Section 4.5, hereinafter.

4.5 Paving

4.5.1 Yard and Surrounding Area

The Contractor shall pave the enclosed yard and surrounding area around the pump station building as shown on Sheet 2 with three inches of asphalt concrete over six inches of crushed aggregate base over compacted subgrade, except that any pavement removed outside the lease line shall be replaced in kind, six inches of asphalt concrete over eight inches of base rock. Refer to and comply with Subsection 1.5 herein.

Sec. 4.5 continued.

4.5.2 Materials

4.5.2.1 Aggregate Base Material

The aggregate base material shall conform to Section 200-2.2 of the Public Works Specifications. Base material shall not be less than six inches thick after compaction.

The relative density of aggregate base shall be determined by the method described in Section 211-2 of the Public Works Specifications.

4.5.2.2 Surfacing Material

Grade and base compaction work shall be completed and compaction test data approved by the Engineer before the work required for asphalt paving shall be started. The placing of hot-mix asphalt shall be performed only when weather conditions are suitable and atmospheric temperature is fifty degrees F. or higher. No paving shall be placed on wet base.

Asphalt concrete shall be as specified in Subsection 1.5 herein.

4.5.2.3 Soil Sterilization

Areas to be surfaced with asphaltic concrete pavement shall be treated with a non-toxic soil sterilizer such as Fenamine as manufactured by the American Chemical Company, Pramitol 25E as manufactured by Geigy Agricultural Chemicals, or a City-approved equal.

The Fenamine shall be diluted with water at the rate of 1 gallon of sterilant to 9 gallons of water. The Pramitol 25E shall be diluted at the rate of 1 gallon of sterilant to 5 gallons of water.

The soil sterilant solution shall be applied at the minimum rate of 3 gallons per 1000 square feet by means of spray equipment which provides good agitation and even coverage of the soil.

The soil sterilizer shall be applied after the preparation of the subgrade has been completed and just prior to constructing the pavement. The pavement shall not be constructed on the treated area until it has thoroughly dried.

Sec. 4.5 continued.

The Contractor shall provide all necessary protection to prevent injury to life and damage to property (including plants and other vegetation) occasioned by the application of the soil sterilizers.

The mixing and application of the soil sterilizing solution shall be performed only in the presence of the City inspector. After a reasonable drying period for the applied sterilant, the Contractor shall proceed with the paving operation.

4.6 Dewatering

Refer to subsection 306-3.2 of Standard Specifications. Substitute the words "pump station" in lieu of the word "tunnel" where the latter occurs.

4.7 Rock Mattress

Refer to paragraph 1.4 for use of rock to form mattress as required to stabilize bottom of excavation.

4.8 Payment

All costs involved in the excavation, including shoring and dewatering, shall be included in the unit price bid for Item 3.

All costs for backfill using native material shall be included in the unit price bid for Item 7.

All costs for imported backfill shall be included in the unit price bid for Item 8.

All costs for haulaway of excess excavated or unsuitable material shall be included in the unit price bid for Item 9.

All costs for rock mattress shall be included in the unit price bid for Item 4.

Sec. 4.8 continued.

All costs for base course shall be included in the unit price bid for Item 60.

All costs for A.C. paving shall be included in the unit price bid for Item 61.

SECTION 5: WATERPROOFING MEMBRANE

5.1 General

It is the intent of this specification that the reinforced concrete pump station sump wall and floor below El. 5.00 shall be completely sealed and protected with the specified bentonite waterproofing membrane and that all joints between individual sections of the waterproofing membrane shall be continuously sealed by overlapping joints or hydrobar tubes. Bentonite joint seal jelly shall be applied around any pipes, sleeves, conduit or other projections from the exterior concrete surface.

All work for and in connection with the installation of the waterproofing membrane and the field sealing of joints, shall be done in strict conformity with all applicable specifications, instructions, and recommendations of the manufacturer. Personnel installing and sealing waterproofing membrane shall be required to demonstrate to the satisfaction of the Engineer their ability to perform these functions in accordance with these specifications.

The bottom membrane shall be protected by a concrete slab with a mix containing 1 part of portland cement, 2 parts of sand and 2 parts of #4 aggregate, or similar proportions, adjusted to produce a minimum ultimate strength of 2000 psi at 28 days. The concrete shall be poured to a thickness of 3 inches and shall be screeded to grade and raked to a rough surface. The purpose of this concrete pad is to prevent the puncture of the bottom waterproofing membrane during construction before the pouring of the pump pit floor concrete.

5.2 Materials

5.2.1 The bulk and panel material shall be high-swelling Wyoming-type granular bentonite, containing a minimum of 90 per cent of montmorillonite and a maximum of 10 per cent of unaltered volcanic ash or other native sediments, in the form of "Volclay" panels manufactured by American Colloid Company, delivered to site in original unbroken packages bearing manufacturers label. Panels shall be stored at site in a dry location, raised above ground and protected from physical damage and moisture.

5.2.2 Bentonite material shall meet the following requirements:

Sec. 5.2 continued.

5.2.2.1 Swelling of two grams of bentonite, when reduced to 100 per cent passing a 100 mesh screen, shall be a minimum of 25 cubic centimeters when gradually added to a 100 ml graduate of distilled water. A minimum free swelling of 20 cubic centimeters shall be created with water samples taken from soil borings.

5.2.2.2 Active ingredient: Hydrous silicate of alumina with approximate percentage of chemical analysis:

Silica	60.0
Alumina	20.0
Iron Oxide	5.0
Magnesia	3.0
Soda and Potash Oxides	3.0
Calcium Oxide	0.5
Molecular Water	5.5
Minor	3.0

5.2.2.3 Board type panels shall contain bentonite material sealed between two layers of absorbent material. Each panel shall contain a minimum of one pound of bentonite per square foot evenly distributed, and shall be 48-inches square by minimum 3/16-inch thick.

5.2.2.4 "Hydro Bar" Bentonite tubes shall be water soluble polyvinyl alcohol containers filled with dry granular bentonite. Tubes shall be approximately 2'-0" long x 2" diameter x pounds weight.

5.2.2.5 Bentonite mineral-base jelly shall meet requirements of ASTM D 217 for a Worked Penetration Range of 225 to 275 and shall contain 10 per cent of controlled hydrated Wyoming-type high-swelling Bentonite by weight. Bentonite mineral-base jelly shall have a minimum pH of 8.8; contain no free water, and have a maximum of 5 per cent residual swell.

5.3 Surface Preparation

The bottom of the excavation shall be accurately sloped to grade as shown on the drawings, including the depression for the sump pump sump.

Sec. 5.3 continued.

Excavation shall be completely dewatered and the entire area shall be covered with polyethylene film .040 inches minimum thickness, lapped six inches at joints.

Concrete surfaces to receive bentonite waterproofing treatment shall be free from irregularities. Remove loose and foreign material, and remove form tie rods. Point cracks and honeycombs in concrete surfaces with cement mortar flush with adjacent concrete surfaces. Allow cement mortar to dry for 72 hours minimum prior to application of bentonite panels.

5.4 Installation

5.4.1 Apply waterproofing in accordance with manufacturer's detailed instructions, lap adjoining panels below structure 1-1/2" minimum on sides and ends. Do not install panels during wet or damp weather.

5.4.2 Fold panels at wall base and bend around corners with corrugations extending vertically. Attach panels with 3/4" masonry nails (6 per panel), joint seal or mastic. Install flat panels at walls with corrugations running horizontal. Lap adjoining panel edges and ends 1-1/2" as marked. Stagger vertical joints of succeeding courses. When trimming, cut panels longitudinally with corrugations, to prevent loss of clay granules. Lay tubes along and against base of first panel course at wall footing joint. Abut edges of tubes. Cut panels to fit around pipes and penetrations. Keep panels horizontal. Tape all cut edges, or wipe with wet sponge before handling to prevent bentonite loss. Securely fasten panels over all construction joints and all expansion joints. Thoroughly pack all through-wall openings and penetrations with bentonite joint seal jelly or granular bentonite, or both, prior to the placement of bentonite panels.

5.5 Backfilling

Provide protection to the bentonite panels during backfilling operations as recommended by the manufacturer of bentonite materials. Do not puncture or damage panels during backfilling operations. Minimum protection is fiberboard, 1/2" thickness over entire wall area. Backfill against first panel as soon as possible. Protect panels from moisture with temporary plastic sheets.

5.6 Responsibility

Waterproofed walls shall not develop leaks before final acceptance of the work. Remedy leaks and all defective areas to produce a watertight installation.

5.7 Payment

All costs for waterproofing membrane and PVC underlay as described hereinabove shall be included in the unit price bid for Item 5.

All costs for the concrete protecting slab over membrane as described hereinabove shall be included in the unit price bid for Item 6.

SECTION 6: REINFORCED CONCRETE CONSTRUCTION

6.1 General

All portland cement concrete work for the pump station and other improvements adjacent to the pump station shall conform to the applicable provisions of sections 201 and 303 of the Standard Specifications, except as hereinafter specified.

6.2 Forms

Wherever reinforced concrete construction is exposed to view inside or outside of pump station, the Contractor shall use metal, masonite, overlaid plywood forms, or a City-approved equal form which will attain a smooth architectural finish. No walls shall be poured against the ground but shall be formed on both sides. Grade beams, cantilevers and mattress under manifold may be contact poured.

The Contractor shall submit for approval the type of forms he proposes to use in the construction prior to starting the concrete construction.

6.3 Concrete

All concrete used in reinforced concrete construction for the pump station shall be 4000 p.s.i. concrete, except for prestressed units which shall be 5000 p.s.i. concrete. The combined aggregate grading for the pump plant shall be Grading C, except for the 2-1/2-inch minimum thickness concrete topping which shall be Grading D.

6.4 Reinforcing Steel

Reinforcing steel, size #5 and larger, shall be deformed bars complying with ASTM A 615, Grade 60. Bars #4 and smaller shall comply with ASTM A 615, Grade 40. Welded wire fabric shall comply with ASTM A 185.

6.5 Surface Hardener

The entire pump room floor area shall be hardened by the application of a floor hardener. The manner of application and the concentration shall be in accordance with the manufacturer's printed instructions.

Sec. 6.5 continued.

The hardening material shall be a factory-mixed solution of approximately 80 per cent Magnesium Fluosilicate and 20 per cent Zinc Fluosilicate with a penetrating agent and water. Material shall be brought to the site in unopened containers.

The Contractor shall submit manufacturer's certificate of materials compliance and application directions for approval before starting application.

Two manufacturers of the hardener material are as follows:

1. Grace Manufacturing Co., "Hornolith"
2. Sonneborn Building Products, "Lapidolith"

Curing of the floor must be performed by a method that will not leave residue or compounds that are not compatible with the hardener material and the concrete floor must be clean before and during application.

6.6 Embedded Metal and Conduit

All metal surfaces to be embedded in concrete shall be clean and free from rust, scale, paints, oil, or other foreign matter before concrete is placed.

Electrical conduit embedded in concrete shall be so located as not to reduce the strength of the structure, and where the outside diameter of conduit is in excess of 30 per cent of the thickness of a concrete also, said conduit shall not be embedded therein. Under no circumstances shall conduit be placed between the bottom of slabs and adjacent reinforcing provided therein.

Conduit embedded in a slab, running parallel to a beam or girder, shall not be placed closer than one foot to the nearest face of the beam or girder. Parallel embedded conduit shall be placed three inches clear (minimum) from adjacent conduit, and shall be spaced along a single horizontal plane only. Not more than one conduit will be permitted to cross over another at any one intersection.

Sec. 6.6 continued.

Pipe or conduit which is not shown on the drawings will not be permitted in structural concrete, except as approved by the Engineer.

6.7 Precast Prestressed Concrete Roof Units

6.7.1 General

The work included is the furnishing, delivery and erection of the precast prestressed concrete roof slabs directly on teflon bearing pads.

Shop drawings with calculations shall be submitted to Engineer for approval, showing setting plan, reinforcing and details, and including accurately located cored or formed holes. Each slab shall be identified by a standard mark to be listed in the schedule shown on the manufacturer's erection plan and placed legibly on each unit at time of manufacture.

The units shall be slabs with round or oval voids running lengthwise as fabricated by Spancrete of California, or City-approved equivalent.

Deck units are to be designed in accordance with ACI Standard Building Code Requirements for Reinforced Concrete (ACI 318-63).

6.7.2 Material and Fabrication

All concrete materials shall be clean and properly graded and the resulting concrete shall have a minimum compressive strength of 3500 psi at time of initial prestress and 5000 psi at 28 days.

Prestressing steel shall be uncoated seven-wire, stress-relieved strand equivalent of ASTM A 416, or shall be strand having physical properties as set forth in Section 304.3 of the Tentative Recommendations for Prestressed Concrete by ACI-ASCE Joint Committee 323, 1958, shall have an actual ultimate tensile strength of not less than 250,000 psi and shall have bonding properties that are equal or better than that of a seven (round) wire strand of comparable area.

Portland cement shall be ASTM C 150, Type II, Low Alkali.

Sec. 6.7 continued.

The manufacturer shall cure the slabs by the steam or other suitable methods to secure 3500 psi minimum compressive strength at time of initial prestress and 5000 psi minimum at 28 days, as indicated by 6" x 12" compression cylinder tests (ASTM C 39).

6.7.3 Erection and Installation

Installation of the precast units is to be made by leveling the roof slabs in a workmanlike manner keeping the units tight and at right angles to the bearing walls. A mortar pad approximating three-eighths of an inch in thickness shall be placed on top of the masonry immediately prior to placing each unit.

Slabs shall be aligned and leveled by the method approved by the manufacturer using equipment recommended or supplied by the manufacturer.

Slabs shall be grouted by a mixture of not less than one part cement to three parts fine sand, care being taken to see that the joints are filled. Any grout that may have seeped through to the ceiling below shall be removed before it hardens.

Cutting holes into the Deck Units in the field will not be permitted. All required anchors, hangers, electrical outlets, conduits, and other fixtures shall be cast into the units.

All work shall be neatly and fully finished and all surplus materials and rubbish shall be removed from the premises.

6.8 Construction Joints

Construction joints in the pump station structure shall have keys as indicated on the drawings.

6.9 Non-Skid, Tread Treatment

Carborundum grits shall be applied on exposed concrete stairtreads and landings as recommended by manufacturer.

6.10 Payment

All costs for poured-in-place concrete work as described hereinabove shall be included in the unit prices bid for Items 10 through 20.

All costs for reinforcing steel bars and welded wire mesh shall be included in the unit prices bid for Item 21.

All costs for precast prestressed concrete work as described hereinabove shall be included in the unit price bid for Item 23.

SECTION 7: CONCRETE UNIT MASONRY

7.1 Scope of Work

Provide all labor, materials, and services necessary to complete the concrete masonry work required by the drawings and as specified herein:

1. Adequate bracing, forming and shoring required in conjunction with and in the course of constructing the concrete masonry.
2. Furnishing and placing of all reinforcing steel for concrete masonry.

7.2 Materials

All masonry units shall be hollow load bearing units. Masonry units, mortar, grout, water and other materials shall be as specified in Standard Specifications, Section 202-2, except as noted on drawings and specified herein.

Hollow load bearing masonry units shall be Grade N-I, conforming to ASTM Designation C 90-70 and, in addition, to the requirements of the Quality Control Standards of the Concrete Masonry Association. Units shall be closed end, split-faced, presenting a stone-like texture on the exposed face and shall be Orco Block brown color. The Contractor shall submit color samples of the units for approval, and shall insure that all units used for construction conform to samples, and when laid up present a completely uniform texture and color. Returns forming jamb's shall be precision faced. Special sill or other units and any portions of precision faced units visible on the exterior or interior of the building shall be factory stained to match the color of the split-faced units.

Mortar shall be Type M in accordance with the Uniform Building Code, 1973 Edition, Table No. 24-A, and grout shall be f'c - 2000 psi minimum. Mortar shall be colored to match block, using mineral pigments only.

Reinforcing steel, size #5 and larger, shall be deformed bars complying with ASTM A 615, Grade 60. Bars #4 and smaller shall be ASTM A 615, Grade 40.

7.3 Workmanship

The concrete unit masonry shall be constructed in accordance with the requirements specified in Standard Specifications, section 303-4.1. Horizontal joints shall be pointed to present a weather-tight surface. Masonry walls above eight feet high shall be braced during erection.

7.4 Clean Up

At the conclusion of the masonry work, the masonry contractor shall clean all masonry, remove scaffolding and equipment used in the work, and remove all debris, refuse, and surplus masonry material from the site.

7.5 Payment

All costs for concrete masonry work as described hereinabove shall be included in the unit prices bid for Items 24 through 26 and 28, and the lump sum price bid for Item 27.

SECTION 8: GENERAL CONSTRUCTION IN OFFICE,
TOILET AND PUMP PIT

8.1 General

The work of general construction specified herein is limited to metal studs, gypsum board and plaster skim coat, cement plaster, sound attenuation material, rough and finish carpentry and acoustic ceiling as required in the areas noted. All materials and workmanship shall be first-class.

8.2 Metal Studs

Studs shall be of sizes or weights as shown on the drawings and shall be the product of Western Metal Stud Company or City-approved equal. Bottom track and end studs shall be securely attached to floor and concrete masonry with powder-actuated studs. All material shall be accurately cut to length and properly framed and shall be welded at all intersections and joints.

8.3 Gypsum Board and Plaster Skim Coat

Gypsum board shall be of thickness shown on the drawings and shall be "Gold Bond" as manufactured by National Gypsum Company or City-approved equal, securely attached to studs in accordance with provisions of Long Beach Municipal Code Section 8109. Corners shall be protected by corner beads, joints shall be taped, and the entire surface inside and outside shall be covered with a plastic skim coat, smooth finish.

8.4 Cement Plaster

Cement plaster dado shall be constructed over metal lath to 42 inch height above floor on interior and exterior of toilet walls. Thickness of plaster, number of coats, and method of application shall be in accordance with Long Beach Municipal Code, Section 8100. Surface shall be trowelled to a smooth finish without blemishes.

8.5 Sound Attenuation

Sound attenuation blanket 1-1/2" thick with a minimum sound transmission loss rating of 38 decibels shall be applied to entire area of walls

Sec. 8.5 continued.

and ceiling as shown on the drawings. Batts shall be as manufactured by Johns-Manville Company or City-approved equal.

8.6 Carpentry

Materials shall be Douglas Fir, No. 1 or better, Douglas Fir Plywood Grade CD and Redwood, No. 1 or better. Fascia boards shall be in one piece on each face, neatly mitered at corner.

Plywood deck shall be cut to fit accurately to radius of concrete masonry and shall be butt jointed without gaps.

Redwood brackets shall be accurately cut and grooved, and doors shall be accurately cut and assembled with ledges and braces, allowing one-half inch gap between individual boards and between door and jambs to allow for swell under service conditions. Jambs shall be planted on interior of concrete forms prior to pour.

Bolts, nails and hardware shall all be galvanized and shall be of correct length to suit lumber.

8.7 Acoustic Ceiling

Acoustic ceiling shall be perforated fiber tile attached to underside of metal framing with clips, adhesive or T-bar system. Tile shall be as manufactured by Armstrong or City-approved equal.

8.8 Payment

All costs for the work of general construction as described herein shall be included in the lump sum bid for Item 33.

SECTION 9: METAL WORK

9.1 General

Section 9 includes all of the miscellaneous ferrous and nonferrous metal work required for the construction of the pump station including, but not limited to, the following items: step-irons, stairways and landings, checker plates, welded grating, ladders, railings, exhaust piping supports, trash rack, miscellaneous brackets and supports, concrete expansion anchors, hoisting anchors, bridge crane beams, floor opening frames, pipe sleeves, flashing, metal closure for radiator, and all bolts and other connections shown or required for complete installation.

All ferrous metal work other than stainless steel (including fasteners) below the Engine Room Floor which is not specified to be painted or coated shall be galvanized in accordance with Standard Specifications paragraph 206-7. Unless otherwise specified, all metal work above the Engine Room Floor shall be painted as specified in Section 25 of these specifications.

Some fasteners are specified to be stainless steel or other corrosion-resistant metals. See Section 9.2.6. These are to remain uncoated.

9.2 Materials

9.2.1 Structural Steel

All structural steel shapes shall conform to ASTM Designation A 36, "Structural Steel." Steel plates and bars shall also conform to ASTM Designation A 36.

9.2.2 Sheet Metal

All sheet metal such as building louvers and duct work shall conform to ASTM Designation A 569, "Steel, Carbon (0.15 Maximum Per cent), Hot-Rolled Sheet and Strip, Commercial Quality", galvanized per ASTM A 123.

9.2.3 Bolts, Nuts and Steel Washers

Materials for bolts, nuts and plain steel washers shall conform to ASTM Designation A 325, "Carbon Steel Externally and Internally Threaded Standard Fasteners", except as specified in Section 9.2.6 herein.

Sec. 9.2 continued.

9.2.4 Washers

Plate washers shall be fabricated from structural steel plate ASTM A 36. Washers for timber contact fastening shall be cast malleable iron.

9.2.5 Pipe

Pipe for use in hand railings, structural items and utility purposes shall be standard steel pipe conforming to ASTM A 120, for "Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses", or American Water Works Association Specification C202, as applicable.

9.2.6 Corrosion Resistant Bolts and Nuts

Corrosion resistant bolts and nuts embedded in pump pit slab for attachment of trash rack shall be fabricated from stainless steel alloys in the 300 series.

9.3 Workmanship

9.3.1 General

All fabrication and assembly methods used shall be in accordance with the latest AISC Specifications unless otherwise noted or shown on the drawings.

Before laying out or working in any way, materials shall be thoroughly straightened by methods that will not result in injury; however, sharp kinks or bends in members will be cause for rejection. Finished members shall be free from kinks, bends or winds. Shearing shall be accurately done, and all portions of the work neatly finished. Re-entrant cuts shall be made in a workmanlike manner and, where they cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filleted unless otherwise approved by the Engineer. Corners shall be square and true unless otherwise shown on the drawings. All bends, except for minor details, shall be made by approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the

Sec. 9.3 continued.

metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted, except where welding is definitely specified or called for on the drawings. All bolts, nuts, and screws shall be tight.

Details on sheet metal work not explicitly shown or specified shall conform to the latest trade standards.

9.3.2 Welding

All welding shall be done by the electric arc welding process using certified welders, arc welding machines, and approved electrodes, conforming in all respects to the standard specifications of the "American Welding Society" for applicable type work, as specified in Section D2.0-69 of said code, titled "Arc and Gas Welding in Building Construction".

9.3.3 Galvanizing

All metal fabricated items specified in these specifications or on the drawings to be galvanized shall be galvanized in conformance with the requirements specified in Standard Specifications Subsection 206-7. All galvanizing shall be performed after fabrication.

Wherever galvanized metal items are welded, abraded, or cut in the field, all such surfaces or welds shall be coated with "Galvicon" as manufactured by the Galvicon Corp., Brooklyn, N.Y., or "Galvalloy" as manufactured by the Metalloy Products Co. of Los Angeles, California, or a City-approved equal coating.

9.3.4 Bolted Connections

Bolt holes for fitted bolts shall be truly cylindrical throughout. Holes for unfinished bolts, unless otherwise specified on the drawings, shall be drilled and shall not be more than 1/16-inch larger than the nominal diameter of the bolts.

All high strength bolts shall be installed in accordance with Section 5 of the current Specification for Structural Joints using ASTM A325 or A490 Bolts, as endorsed by the American Institute of Steel Construction. Tightening shall be in accordance with paragraph 5e, "Tightening by use of a Direct Tension Indicator." Load Indicator Washers (L.I.), as manufactured

Sec. 9.3 continued.

or licensed by Cooper & Turner, Inc., shall be used as the approved direct tension indicator. The L.I. shall be sheardized and shall not be modified in any way after receipt from the manufacturer.

9.4 Metal Work Items

9.4.1 Bar Grating

The Contractor shall furnish and install hot-dip galvanized welded steel bar grating as indicated on the plans. Grating shall be capable of withstanding a uniformly distributed live load of 100 psf or a concentrated live load of 172 psf and shall have a minimum bearing bar size of 3/4" x 3/16" at 1-3/16" on center with cross bars at 4" spacing maximum. Grating shall be securely bolted or welded into place. Steel shall meet the criteria of ASTM A 36 specifications. Grating shall be Irving welded rectangular design, Type IWA, as manufactured by IKG Industries, Division of Harsco Corporation, or a City-approved equal.

9.4.2 Steel Grating Stairway Treads

The Contractor shall furnish and install welded, hot-dip galvanized steel grating stairway treads as indicated on the plans. Treads shall be capable of withstanding a uniformly distributed live load of 100 psf or a concentrated live load of 172 psf and shall have a minimum bearing bar size of 3/4" x 3/16" at 1-3/16" on center with cross bars at 4" spacing maximum. Treads shall have a cast abrasive nosing. Treads shall be securely bolted in place. Steel shall meet the criteria of ASTM A 36 specifications. Stairway tread grating shall be Irving welded rectangular design, Type IWA, as manufactured by IKG Industries, Division of Harsco Corporation, or a City-approved equal.

9.4.3 Steel Trash Racks

The trash racks shall be fabricated of steel angles, beams and bar stock. The racks shall be arranged in removable sections and shall be installed by use of bolted fasteners as shown on the drawings.

The steel trash racks shall be galvanized after fabrication.

Bolts and nuts and other fasteners at base shall be stainless steel.

9.4.4 Pipe Sleeves

Pipe sleeves shall be provided for all pipes and conduits passing through floors and walls of the pump station. The sleeves shall be cut from standard weight steel pipe, galvanized after sizing to proper lengths.

Sec. 9.4 continued.

9.4.5 Pipe Railing

Pipe used for hand railings shall be standard steel pipe conforming to ASTM A 120, for " Black and Hot - Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses."

The pipe railings shall be two rail, vertical post type, with removable sections where required.

Railing shall have flush joints coped or mitered to suit the angle of the work and shall be welded solid. Welded joints shall be dressed smooth. The posts of the railing shall be set in pipe sleeves. Pipe sleeves shall be lengths of standard weight steel pipe, galvanized after cutting to length, cast in concrete.

9.4.6 Hoisting Anchors

Hoisting anchors shall be imbedded in the sump at locations indicated on the drawings.

The hoisting anchors shall be round steel bars, shaped as shown on the drawings. Bars shall be galvanized after fabrication. The anchors shall be fabricated from ASTM Designation A 108, Grade 1040.

9.4.7 Concrete Expansion Anchors

Concrete expansion anchors shall be similar and equal to the Red Head self-drilling anchors as manufactured by Phillips Drill Company, Los Angeles, or the Type 2 threaded ring wedge cinch anchor as manufactured by National Lead Company, or a City-approved equal. Size shall be as indicated or required.

In general it will be required that the anchor system provide load capacity (pull out strength) at least equal in strength to that of the concrete in which it is set.

9.4.8 Flashings and Downspouts

Roofing and wall openings shall be flashed with 24 gauge galvanized steel.

Sec. 9.4 continued.

Downspouts and appurtenances shall be a minimum of 24 gauge galvanized steel.

9.4.9 Stairways and Landings

Steel stairways and landings shall be constructed of standard structural steel shapes with welded grating landings and stair tread member sizes as indicated on the drawings. Structural frames, landings and treads shall be galvanized after fabrication.

9.4.10 Ladders

Ladders shall be fabricated from structural steel shapes and sections all as shown and detailed on the drawings. Openings at heads of ladders shall be protected by safety-chains with harness snaps. All ladders shall be galvanized after fabrication.

9.4.11 Crane Rails and Beams

The running rails and steelwork for the bridge crane shall be fabricated and installed as shown on the drawings. Rubber bumper stops shall be provided as shown.

9.4.12 Floor Opening Frames

Floor opening frames shall be fabricated of angles and bar stock of the sizes and weights as shown and detailed on the drawings. The frames shall be galvanized after fabrication.

9.4.13 Miscellaneous Items

All miscellaneous metal items required and not specified or shown on the drawings shall be furnished and installed. Where anchors, straps, clips, angles, dowels, connections, metal weather-proofing items, or other details of miscellaneous metal items are not definitely shown or specified, their materials, size, form, attachment and location shall conform to the best trace practice. Details and specifications of items for which standard manufactured products are available are representative guides for the requirements of these items. Anchor bolts shall be properly located and built into connecting work prior to pouring of concrete.

9.5 Engine Radiator Exhaust Metal Closure

The front of the engine radiator shall be attached to the louvered opening in the station wall by means of a galvanized sheet metal closure. The metal closure shall be fabricated from sheet metal of a gage thickness not less than 18.

All seams of the metal fabrication shall be riveted and soldered. Reinforcing ribs shall be provided to insure a durable installation.

A flexible connection shall be prefabricated to extend from the radiator to the metal closure. The flexible connection shall consist of three-inch wide 24 gage galvanized metal strips each and a six-inch width of exposed fabric. The fabric shall be clenched to the metal strips by means of double lock seams. The fabric in the connectors shall weigh not less than 24 ounces per square yard, and shall be of a material that has good strength and durability. At least one inch of slack shall be allowed in the fabric when installing the connectors to assure that no vibration is transmitted from radiator to metal closure. The flexible connector shall be fastened to the radiator duct adaptor and to the metal closure by corrosion resistant metal screws.

9.6 Payment

All costs of items specified in this section shall be included in the unit prices bid for Items 29 through 31 and the lump sum bid for Item 36.

SECTION 10: DOORS, WINDOWS, LOUVERS AND ROOF SCUTTLE

10.1 Doors, Flush Panel, Metal

Doors D-1, D-2 and D-4 shall be 3'-0" by 7'-0" metal, flush panel, industrial hollow steel doors, Type 3070, 1-3/4" thick, as manufactured by Armco, Soule, Republic or a City-approved equal.

10.1.1 Frames

Frames shall be a commercial steel product as manufactured by Manufacturing Division of Republic Steel Corporation or equivalent, by Steelcraft Manufacturing Company, or a City-approved equal, and compatible with flush panel door selected, and as detailed.

10.1.2 Coating

All doors, windows, louvers and collateral steel items shall be bonderized and primed with one coat of light gray (phenol resin) paint, oven baked for one hour at 350 degrees Fahrenheit. Final painting shall be as specified in Section 25.

10.1.3 Reinforcement

Hinge reinforcement shall be not less than 10 gage steel. All other hardware reinforcement shall be of not less than 12 gage steel.

10.2 Doors, Sound Retardant

Doors D-5 and D-6 shall be sound retardant doors with a minimum sound transmission loss rating of 38 decibels similar and equal to that as manufactured by Bob Lynch Company, 5146 West 104th Street, Inglewood, California, Krieger Company, or a City-approved equal. Doors D-5 and D-6 shall be 2'-8" by 7'-0", flush panel, metal doors. The doors shall be furnished with a utility grade finish suitable for painting and with all special stops, stop adjusters, gaskets, and automatic threshold sealing devices. The door, metal frame, and seals shall be the product of one manufacturer.

Sec. 10.2 continued.

The doors shall be guaranteed against manufacturing defects and for performance for one year, in accordance with the terms of manufacturer's guarantee. The Contractor shall submit a certification from the manufacturer substantiating the sound transmission loss based on Riverbank Acoustical Laboratories tests, run in accordance with ASTM E 90. Riverbank Acoustical Laboratories is the official testing laboratory for the Acoustical Door Institute.

10.3 Door, Roll-Up, Metal

Roll-up door D-3 shall be a motor operated overhead rolling door. Motor operator shall be wall mounted and operate from 208 volt, 1 phase power.

Roll-up door shall have a curtain of interlocking slats roll-formed in easy curves from open-hearth galvanized steel. Slats shall be of section sufficiently large to resist a wind load of twenty (20) pounds per square foot without possibility of displacement from side guides. Each alternate slat shall be fitted with malleable endlocks three-eighths (3/8) of an inch thick. Bottom bar shall be two angles placed back-to-back, and shall be complete with slide bolt arranged for padlocking on inside of door. In addition to motor drive, door shall be hand-chain operated from inside with chain of sufficient length to reach to within six inches of finished floor.

Curtain shall be coiled on a pipe of size sufficient to carry the door load with a deflection not exceeding one-quarter (1/4) inch, and shall be evenly balanced by helical springs contained in the pipe, all springs being anchored to the same tension rod and held in position by the same adjusting wheel, accessible from the outside.

Complete door shall be galvanized with high grade, pure zinc coating, not less than one and one-quarter (1-1/4) ounces per square foot of flat metal in accordance with applicable ASTM Standard. Galvanized surfaces shall be phosphate coated for paint adhesion. Finish painting of door shall be in accordance with Section 25 of these specifications. A neoprene weatherstrip shall be fitted to the bottom of the door.

Sec. 10.3 continued.

Coil brackets shall be of high grade iron and coil shall be housed in sheet metal hood not less than twenty-four (24) gauge thickness. Guides shall be hot-rolled structural steel sections. Gears shall be best grade gray iron, cast teeth machine-molded from machine cut patterns.

10.4 Windows

10.4.1 Soundproof Windows (W-1 and W-2)

Soundproof windows shall be as shown on the drawings. Neoprene seals shall be installed to insure an effective seal between stop and frame. Glass shall be set in a bed of elastic glazing putty. All trim and framing members shall be primed before installation. Glazing shall be 1/4-inch thick, Grade B sheet glass similar and equal to that manufactured by the Libbey-Owens-Ford Glass Company, Toledo, Ohio, or equivalent by Pittsburgh Plate Glass Company, or a City-approved equal.

10.4.2 Vision Panels

Vision panels (W-3 through W-6) shall be aluminum store-front frame with fixed bronze glazing.

10.5 Hardware

Hardware for the various doors shall be as follows and shall be in addition to that furnished with the doors.

10.5.1 Doors D-1 and D-2

Locks - "Yale" mortise, #33, heavy duty with knob cylinder and wide sectional escutcheon, 3" x 8-1/4", as manufactured by Eaton Security Products and Systems, or City-approved equal.

All locks shall be furnished complete with cores and two keys. Panic Hardware shall be Yale Mortise Lock device 1533 series or City-approved equal to match lock furnished.

Sec. 10.5 continued.

Weatherstrip shall be installed at the bottom of outside doors.

10.5.2 Doors D-3, D-4 and D-5

Cylindrical lock, push button locking with outside emergency key, set number 5K0L3 as manufactured by Best Universal Lock Co., Lockwood "S" Series 120-SD Bronze Privacy Lock as manufactured by Lockwood Hardware Manufacturing Co., or City-approved equal.

Butt - full mortise, bronze, similar and equal to 4-1/2-inch x 4-1/2-inch Model TA 3313-1/2, as manufactured by McKinney Hardware, Pittsburgh 33, Pennsylvania, Model FBB 193 as manufactured by Stanley Hardware, New Britain, Connecticut, or a City-approved equal, and furnished with one-half wood screws. Three (3) required for each door.

10.6 Manually Operated Intake Louvers

The wall louvers shall be constructed of galvanized steel sheets. Frame and mullions shall be 16 gage. Louvers shall be of 16 gage.

Inside of louvers shall be covered with removable 1/2-inch mesh 16 gage galvanized insect screens.

The louvers shall be hand chain operated with the catch claw mounted four feet above the floor elevation.

Louvers shall be Series 200 as manufactured by Air Louvers, Ltd., Los Angeles, California, or Series 136-7 as manufactured by Ventilouvre Company, Inc., Marietta, Ohio, equivalent by Armco, or a City-approved equal.

10.7 Automatic Exhaust Louvers

Louvers shall be normally closed and shall be as equally resistant to vandalism as the manual louvers described in Section 10.6. Provide hand chain and catch claw as these louvers shall also be manually operable.

Sec. 10.7 continued.

These louvers shall operate automatically when the engine starts by admitting engine lube oil under pressure into hydraulic cylinder which opens spring loaded louvers against spring pressure. When the engine shuts off, the spring shall return the louver to closed position.

The front of the engine radiators shall be attached to the louvered openings by means of metal closures as described in Section 9.

10.8 Roof Scuttle

The Contractor shall provide a 2'-6" x 3'-0" roof scuttle for ladder access from inside the motor room to the top of the roof. The metal roof scuttle cover shall be 14 gauge with 3" beaded flange, neatly welded. Insulation shall be glass fiber 1" thickness, fully covered and protected by a 22 gauge metal liner.

The curb shall be 12" in height and of 14 gauge steel. It shall be formed with a 3-1/2" flange with holes provided for securing to the roof deck. The curb shall be equipped with an integral metal capflashing of the same gauge and material as the curb, full welded at the corners for absolute weathertightness. Insulation on the exterior of the curb shall be rigid fiber board 1" in thickness.

The scuttle shall be completely assembled with heavy pintle hinges, compression spring operators enclosed in telescopic tubes, positive snap latch with turn handles and padlock hasps inside and outside, and neoprene draft seal. The cover shall be equipped with an automatic hold-open arm complete with handle to permit easy, one hand release. All hardware shall be galvanized, treated to bond with paint and primed with red oxide primer. The manufacturer shall guarantee proper operation and against defects in material or workmanship for a period of five years. The outside shall be painted with two coats of paint to match doors, window frames and louvers per Section 25 of the Specifications. The scuttle shall be type No. S-20 as manufactured by the Bilco Company or a City-approved equal.

10.9 Payment

The cost of all doors, windows, louvers, roof scuttle and related items as specified in this section shall be included in the lump sum price bid for Item 32.

SECTION 11: ROOFING

11.1 General

Furnish all labor, materials, appliances, services, and equipment required to install roofing work as indicated on the drawings and as described herein, including, but not limited to the following:

1. Composition roofing over concrete roof slab.
2. Composition flashing of all roof fixtures.
3. Cant strips.

11.2 Built-Up Roofing

Over all concrete topping roof areas, the Contractor shall apply a Johns-Manville specification No. 601-P Gravel-Surface Asbestos built-up roof, or a City-approved equal roof. The roof preparation, materials, and application specifications shall conform in all respects to the latest edition of aforementioned manufacturer's specifications, or City-approved equal. Roofing shall be applied by a roofing contractor approved by the manufacturer of the roofing materials.

11.3 Guarantee

The Contractor shall issue a written guarantee to the City which states that he will maintain the roof flashing and counterflashings in a watertight condition for a period of two years after acceptance by the City.

11.4 Cant Strips

Cant strips shall be asphalt impregnated cant fiber board.

11.5 Payment

The cost of all roofing as specified in this section shall be included in the unit price bid for Item 35.

SECTION 12: UTILITY SERVICES

12.1 General

All utility service connections to the pump station shall be made as hereinafter specified. The Contractor shall make all arrangements and pay all costs attendant to obtaining the services unless otherwise excepted hereinbelow. The Contractor shall install the service lines to the depths and lines and grades shown on the drawings or as otherwise specified or required. All costs of materials, labor and equipment required for the utility services, as specified hereinbelow, shall be included in the lump sum amount bid for applicable items of work.

12.2 Water Service and Meter

The Contractor shall notify the Long Beach Harbor Department at least 30 days in advance of the date on which he requires the meter installed. The Long Beach Harbor Department will make the connection to the water main, and will furnish and install the meter and enclosure. However, the Contractor shall bear the cost of the service from main to meter, the meter and enclosure, and shall also pay all charges required by the Harbor Department for the installation thereof, as provided for under Subsection 1.8 herein.

The meter shall be 2-inch size.

12.3 Sewer Service

The Contractor shall construct the sewer line from the pump station to a point two feet outside the building as shown on Sheet 24 of the drawings.

At this point, sewer shall be connected to the new four-inch sewer which is to be constructed by others.

12.4 Electrical Service

The Contractor shall furnish all necessary materials, labor, and equipment required for the installation of conduit for electrical service to

Sec. 12.4 continued.

the pump station from the relocated service pole, as shown on Sheet 26. Installation of primary transformer and primary cable, and connections to power and lighting service heads, will be by Southern California Edison Company.

The bidder will be informed of the extent and cost of the labor, equipment and materials that will be furnished by the utility company and will be held responsible for determining what labor, equipment and materials will have to be furnished by himself for complete services.

The bidder shall include in his bid price for Item 54, all costs required for furnishing and installing complete in place the three-phase and single-phase services from the service pole to the pump station; including therein all charges levied by the utility company.

The Contractor shall notify Southern California Edison Company immediately after award of contract furnishing information as to the total lighting and power loads, and the estimated schedule for completion of the project so they may schedule their work.

12.5 Gas Service Line and Meter

The Contractor shall notify the City of Long Beach Gas Department at least 30 days in advance of the date on which he requires the meter and regulator set-up installed.

The gas service line, meter, and regulator set-up for the pump station will be furnished and installed by the City of Long Beach Gas Department as shown on Sheet 22 of the drawings. The Contractor will be required to furnish and install a fuel line to the natural gas engines as specified in Section 14 and also as shown on Sheet 22. However, the Contractor shall bear the cost of the service from the gas main to the meter and of the regulator set-up, and shall also pay all charges required by the Gas Department for the installation thereof, as provided for under Subsection 1.9 herein.

The bidder shall include in his bid price for Item 47, all costs required for furnishing and installing complete in place the gas service from the Gas Department regulator set-up to the pump station.

12.6 Telephone Service

The Contractor shall make all arrangements and shall coordinate with the General Telephone Company to provide a telephone service to the pump station. The bidder shall be responsible for determining the extent of the labor, equipment and material that will be furnished by the Telephone Company and what labor, equipment and materials will have to be furnished by himself for the service.

The bidder shall include in his bid price for Item 56, all costs required for furnishing and installing complete in place the telephone service from the telephone company facilities to the pump station, including all charges levied by the Telephone Company.

12.7 Drawings

During the contract period, the City will furnish upon request from the Contractor blue line prints or reproducible copies of the original contract drawing sheets showing the utility services for the Contractor's use in coordinating his work with the utility companies.

SECTION 13: CHAIN LINK FENCING

13.1 Scope

The Contractor shall furnish all labor, materials and equipment to construct fencing and gates complete in place. Some minor changes to existing fencing are required and are to be done in accordance with standards specified hereinunder.

13.2 Materials

13.2.1 Fencing

Materials shall comply with the notes and details shown on Standard Drawing No. 2-D 178, section 206-6 of the Standard Specifications for Public Works Construction and the modifications shown on the project drawings. Fencing installed shall be 6 feet high as shown on the drawings.

13.2.2 Gates

The Contractor shall furnish and install two 6-foot high by 14-foot wide sliding gates at the locations shown on Drawing Sheet 3. The gates shall comply with all details per Standard Drawing No. 2-D 178, Section 206-6 of the Standard Specifications for Public Works Construction and the modifications shown on the project drawings.

13.2.3 Guard Posts

The Contractor shall furnish and install protective guard posts adjacent to the entrance door and the LPG tank as shown on the drawings. Posts shall be steel pipe of size and weight as filled with and embedded in concrete as shown on the drawings.

13.3 Installation

Install fence, gates and guard posts as specified in section 304-3 of the Standard Specifications for Public Works Construction and in accordance with the drawings.

13.4 Payment

The cost of all fencing and gates shall be included in the lump sum price bid for Item 58 and the cost of all guard posts in the lump sum price bid for Item 59.

SECTION 14: BUILDING PLUMBING AND SANITARY FACILITIES

14.1 General

All miscellaneous plumbing work required for the pump station building, mechanical equipment, fixtures, hose bibbs, and utilities within the buildings shall be furnished and installed by the Contractor. Liquefied petroleum gas (LPG) storage and connection to engines shall also be included.

Miscellaneous plumbing work shall include all water and sewer piping, including waste and vent lines, valves, plumbing fixtures, hose bibbs and risers, and all connection to utility services. Connection to sewer will be required under this contract if new sewer being constructed as collateral work is completed prior to completion of pump station.

14.2 Water Piping and Fittings

14.2.1 Water Piping

Water piping downstream of the meter shall be constructed on the alignments shown on the drawings.

Water piping outside the building and in the engine room shall be galvanized pipe Schedule 40 with threaded couplings. Piping inside the building shall be Schedule 40 copper pipe, with threaded coupling ends, 85 per cent brass or Type L copper tubing.

PVC pipe Schedule 80 with solvent weld fittings shall be used where shown.

14.2.2 Fittings

Fittings for the copper pipe shall be wrought or cast type, screw ends equal in strength to the copper pipe. If Type L copper is used, wrought copper fittings or cast bronze, solder sweet type fittings shall be used.

14.2.3 Backflow Preventers

The industrial water backflow preventer shall be a 2" reduced pressure principle device, with two independently acting toggle lever check

Sec. 14.2 continued.

valves and a pressure differential relief valve. It shall have no more than 6.5 psi drop across the checks at 80 gpm flow, and no more than 11 psi drop at 200 gpm. The backflow preventer shall be a Clayton Model RP-1 or City-approved equal.

The domestic water backflow preventer shall be a 3/4" reduced pressure principle device, with two independently acting spring-loaded check valves and a pressure differential relief valve. It shall have no more than 12 psi drop across the checks at 10 gpm flow and no more than 17 psi drop at 40 gpm. The backflow preventer shall be a Clayton Model RP or City-approved equal.

Gate valves shall be installed on the upstream and downstream ends of the backflow preventers and shall be non-rising stem, screwed, 125 ANSI, Crane No. 438, equivalent by Walworth, or a City-approved equal.

14.3 Sanitary Sewer Stub-out

14.3.1 Soil, Waste, and Vent Piping

Soil, waste, and vent piping below floors and to two (2) feet outside of structure, as indicated on drawings, shall be coated service weight cast iron soil pipe and fittings, lead caulked, furnished in compliance with Commercial Standard 188.

Soil, waste and vent piping above floors shall be Schedule 40 weight, galvanized steel pipe, ASTM A 120, with cast iron drainage pattern fittings, CS-188, except that main building vent may be cast iron as in above paragraph.

Vent stack flashing sleeve for two-inch vent pipe, similar and equal to Figure 1721 Smith, or Z-195-5 Zum, or a City-approved equal, shall be provided and installed in roof of the pump station. Vent stack flashing sleeve shall be watertight and secured to roof with underdeck clamp.

14.4 Valves

14.4.1 Gate Valves

Gate valves shall be 125 pound class, all bronze, wedge disc, Crane No. 438, Walworth No. 4, or a City-approved equal.

Sec. 14.4 continued.

14.4.2 Globe Valves

Globe valves shall be 125 pound class, all bronze, swivel disc, Crane No. 1, Walworth No. 58, or a City-approved equal.

14.4.3 Hose Bibb

3/4-inch hose bibbs shall be Crane No. 58, bronze without cap or chain, or Walworth No. 24, or a City-approved equal.

14.4.4 Check Valve

Check valve shall be 125 pound class, bronze disc, swing check valve, Crane No. 34, Lunkenheimer No. 2144, or a City-approved equal.

14.5 Plumbing Fixtures

14.5.1 Water Closet

Water closet shall be Crane Santon 3-300 with Crane 10 CC black solid plastic open front seat with check hinge and 110 Sloan Royal flush valve, an equivalent water closet by American Standard, or a City-approved equal.

14.5.2 Lavatory

Lavatory shall be provided and installed at the pump station and shall be acid-resistant vitreous china wall hung lavatory, Crane Company Norwich 1-195 modified for cold water, with concealed wall carrier; 8-2201 Capri self-closing lavatory faucet; 8-5222 1-1/4" tailpiece; 8-5022 3/8 angle supply valve; L.A. Pattern "P" trap with wall flange, or equivalent lavatory by American Standard, or a City-approved equal.

14.5.3 Toilet Paper Dispenser

One toilet paper dispenser shall be furnished and installed. The dispenser shall be a single roll Model No. 964, as manufactured by Scott Paper Company, Model B-273 by Bobrick Dispensers, Inc., or a City-approved equal.

Sec. 14.5 continued.

14.5.4 Towel Holder

One towel holder shall be furnished and installed. The towel holder shall be "Public Service" No. 101, as manufactured by Crown Zellerbach Company, Model No. 983 by Scott Paper Company, or a City-approved equal.

14.6 Pipe Hangers and Supports

The Contractor shall furnish all brackets, hangers and supports or other approved devices for all piping to be supported from the pump station structures.

Items shall be as manufactured by Carpenter and Patterson, Inc., Grinnell, or a City-approved equal.

14.7 Water Hammer Arrestors

Water hammer arrestors shall be furnished and installed on all branch water lines to fixtures and to locations in the pipe system near the solenoid valves.

The water hammer arrestors shall be "Hydrotrol", as manufactured by Jay R. Smith Mfg. Co., Shoktrol by Zurn Industries, Inc., or a City-approved equal.

14.8 Natural Gas Fuel System

14.8.1 General

The natural gas delivery pressure from Long Beach Gas Department is variable, but 2 to 5 psi is the range. This pressure shall be reduced to the value required by the carburetor. The Contractor shall furnish and install all necessary piping, components and accessories to insure reliable natural gas service at correct pressure and volume recommended by engine manufacturer.

Sec. 14.8 continued.

14.8.2 Regulation

Regulation shall be accomplished in two stages. A primary regulator shall reduce delivery pressure (2 to 5 psi) to 10" to 15" of water column and shall be located outside of the engine room as shown on the drawings. A secondary regulator at each engine shall reduce the 10" to 15" of water column pressure supplied by the primary regulator to the 4" to 10" water column required by the engine carburetor. A commercial dry type gas filter shall be installed immediately upstream of the primary regulator.

14.8.3 Shut Off and Bypass Valves.

A manually operated shut-off valve cutting gas supply to all engines shall be located outside the engine room.

14.8.4 Piping

Pipe shall be schedule 40 black steel conforming to ASTM A 53 with black malleable iron screwed fittings between meter assembly and engine. Underground pipe shall be primed and wrapped in accordance with Section 25. Piping above the Pump Room floor shall be painted in accordance with Section 25.

The use of metallic flexible connectors to the engine is required for protection against damage caused by vibrations and expansion.

14.9 Liquefied Petroleum Gas (LPG) Fuel System

14.9.1 General

The Contractor shall furnish the LPG tank, fittings and piping and install the system in accordance with Unfired Pressure Vessel Safety Orders. The installation shall also comply with the City of Long Beach Fire Department regulations.

Sec. 14.9 continued.

The Contractor shall obtain operating permits for the LPG installation from the State of California Division of Industrial Safety and the City of Long Beach Fire Department. The Contractor shall perform the test specified in Section 14.9.5 in the presence of the State and City inspectors before operating permits will be issued. After operating permits have been obtained, the Contractor shall fill the LPG tank. The Contractor shall pay all costs for obtaining permits and for filling the LPG tank.

14.9.2 LPG Tank

LPG Tank shall be 499 gallon water capacity, 250 PSI design pressure constructed in accordance with the A.S.M.E. Code for Unfired Pressure Vessels and complete with required tank fittings. All materials, fittings construction and installation shall conform to the requirements of the State Division of Industrial Safety and the City of Long Beach Fire Department. The tank shall be radiographed in accordance with paragraph UW-52-Section VIII, A.S.M.E. Code for Unfired Pressure Vessels. The tank shall have lifting lugs and support feet or pedestals to anchor the tank to the slab. The tank exterior shall be primed with an epoxy primer (2 mil thickness) and given a coat of epoxy coating (15 mil thickness) as specified in Section 25. Shop drawings of the tank shall be submitted as specified in Section 2. Tank fittings shall be suitable for LPG service, 250 pound rated working pressure and shall not be of cast iron materials. The tank shall have the word "FLAMMABLE" and the words "NO SMOKING OR OPEN FLAME PERMITTED WITHIN 25 FEET" painted on two sides in letters 5 inches in height.

14.9.2.1 Filling Level Indicator

Filling level indicator shall be a manually operated orifice set at the 13-1/2 per cent outage line in the tank wall.

14.9.2.2 Vapor Equalizing Valve

Install to open to the tank vapor space above the liquid level.

Sec. 14.9 continued.

14.9.2.3 Filler Valve

Filler valve shall open to the tank vapor space and shall be a double back pressure check valve or combination back-pressure check valve and excess flow check valve.

14.9.2.4 Safety Valve

Safety valve shall be a spring loaded valve communicating directly with the vapor space, discharging vertically upward with the discharge terminal protected from the entry of all foreign material with a loose raincap. Return pipe bends or restrictive fittings will not be permitted.

14.9.2.5 Liquid Level Gauge

Liquid level gauge shall be direct reading magnetic fuel gauge.

14.9.2.6 Liquid Fuel Supply Valve

Liquid fuel supply valve shall permit withdrawal of liquid fuel and be connected to the fuel delivery line. Valve assembly shall be complete with an excess flow valve which shuts off automatically in the event of delivery line breakage or excessive flow through the vapor equalizing valve. The excess flow valve shall open automatically when the discharge line pressure is restored to normal or the vapor equalizing valve is shut off.

14.9.2.7 Locking Cover

Locking cover with a hasp for padlock shall be provided over all the tank fittings.

14.9.3 Emergency Shutdown Valve

Emergency shutoff valve shall be 250 pound, flanged, steel body shutoff valve with integral relief valve, U.L. approved for use with L.P.G. in the liquid or vapor phase.

Sec. 14.9 continued.

14.9.4 Piping

Piping between tank and engine shall be schedule 80 black steel pipe complying with ASTM A 53, of the type and grade suitable for flanging and welding. Piping from tank to engine shall be socket welded with the exception of flanged connections inside building for convenience in assembly, and short sections of metallic flexible hoses and connectors at the engine equipment.

All pipe fittings shall be steel socket weld type 3000 pounds W.O.G. Flanges shall be 150 pound ANSI steel socket welding flanges.

Hoses and metallic flexible connectors shall be approved for LPG service. Piping shall be installed, inspected and tested to comply with the safety regulations of the Los Angeles County Fire Department and the State Division of Industrial Safety.

Underground piping shall be tape-wrapped as specified in Section 25.

14.9.5 Tests

After installation of LPG tank and piping, the Contractor shall test the piping in the presence of the Fire Department inspector and the Division of Industrial Safety inspector. Piping shall be tested at 125 psi with no leaks allowed. After satisfactory completion of pressure tests, the LPG piping shall be backfilled.

14.10 Solenoid Valves

14.10.1 Agitator Piping Solenoid Valve

A 1-1/2-inch solenoid valve shall be furnished and installed on the water line to the sump pump agitator system. The solenoid shall be all brass 125 pounds screwed type with positive opening and closing action, and with 120 volts AC, single phase molded Class A coil. Solenoid valve shall be Asco Catalog No. 8210 C22, or equivalent as manufactured by Gould, or a City-approved equal.

Sec. 14.10 continued.

14.10.2 Right Angle Gear Water Piping Solenoid Valve

The 24 Volts, D.C., 3/4-inch solenoid valve for gear oil cooler waterline shall be Catalog No. 8210 D 3 as manufactured by ASCO, equivalent by Gould or City-approved equal.

14.11 Lube Oil System

Storage tanks shall be fabricated from steel plate conforming to ASTM A 36 or A 283. Piping shall be galvanized steel, Schedule 40, with threaded connections.

14.12 Payment

The cost of all piping, fittings, valves, plumbing and sanitary fixtures specified in this section shall be included in the lump sum price bid for Item 49.

The cost of all tanks and piping for lube oil storage and drain shall be included in the lump sum price bid for Item 52.

The cost of dual fuel supply system as specified in this section shall be included in the lump sum price bid for Item 47.

SECTION 15: PUMPS

15.1 Main Pumps

15.1.1 General

The Contractor shall furnish and install in the pump station at the locations indicated on the drawings four (4) main pumps and their separate drives, consisting of one (1) electric motor, three (3) natural gas engines with right angle gear drives and appurtenances.

The pumps shall be of the single stage vertical submerged mixed flow type, and shall be constructed so as to be suspended from a heavy steel base plate. All pumps shall be underground discharge, that is, with elbow below the steel base plate. The pumping element is to be suspended below the necessary length of discharge column and elbow. Each pump shall have a suction umbrella securely bolted to the underside of the bell. The pump assembly shall be so constructed that dismantling and repairing may be accomplished without difficulty. The design and workmanship on the component parts of the pumps and columns shall be such that they are completely interchangeable with like parts in other pumps to insure maximum potential usage of any single repair part. Each complete unit shall operate free of excessive vibration and noise and shall operate over the specified range without cavitating or vortexing with noise and vibration limits as set forth by the "Hydraulic Institute."

All pumps shall be the products of a single manufacturer.

The pumps shall be subjected to the Operational Tests after installation in Pumping Plant according to Section 2.

The pumps and related auxiliaries shall be guaranteed as specified in Section 2.

15.1.2 Pump Data

Pump No. 1 shall be a single stage pump with a capacity of 12,118 gallons per minute at a laboratory or bowl assembly total dynamic head of 24.5 feet, and shall operate satisfactorily between laboratory or bowl assembly total dynamic heads of 14 feet and 26.5 feet.

Pumps Nos. 2, 3 and 4 shall be single stage pumps with a capacity of 23,038 gallons per minute at a laboratory or bowl assembly total dynamic head of 24.5 feet, and shall operate satisfactorily between laboratory or bowl assembly total dynamic heads of 14.0 feet and 26.5 feet.

Sec. 15.1 continued.

See Sheet 21 of the drawings for required minimum efficiencies of all main pumps at design points, and at maximum and minimum total dynamic heads. Shut-off heads and horse-powers shall not exceed values shown.

15.1.3 Pump Manufacturing Requirements

15.1.3.1 General

All Pumps shall conform to the following specifications. The materials specified are a guide to the minimum quality required in the pumps. The Contractor is referred to Section 2 concerning substitutions of materials.

15.1.3.2 Bowl Assembly

The bowl assembly shall consist basically of a suction bowl, discharge bowl, impeller, pump shaft, pump shaft bearings, and necessary parts to secure the impeller to the shaft. Heavy duty lifting lugs shall be provided on the bowl assembly.

15.1.3.2.1 Suction and Discharge Bowls

The suction and discharge bowls shall be made from close grain "Meehanite" cast iron, or Class 30 cast iron conforming with ASTM Designation A 48. The bowls shall be cast with smooth interior and exterior surfaces. The bowls shall be separate units, provided with heavy flanges accurately faced and drilled for connection to each other and to the discharge column.

The suction bowl shall be designed to permit proper distribution of the liquid to the impeller and shall have a bell shape designed to reduce entrance losses. Maximum 34-inch bell diameter is permissible for Pump No. 1 and 48-inch for Pumps Nos. 2, 3 and 4. Larger bells cannot be installed through the floor openings. The bell diameters shall be increased by the use of suction umbrellas as described in Section 15.1.3.2.2.

All bowls must be so designed that they will withstand not less than twice the maximum operating pressure of the pump, when operating at the specified speed. In no case shall the wall thickness of the bowls be less than that of the column.

Sec. 15.1 continued.

Diffuser vanes shall be integrally cast into the bowls above and below the impellers. The number of vanes shall be sufficient to support the lower guide bearings as well as to sustain the weight of impellers and pump shaft when dismantling the pump.

15.1.3.2.2 Suction Umbrellas

Suction umbrellas in two (or four) sections shall be fastened on to the suction bowl with threaded fasteners such that they can easily be installed or removed. The plates shall be of adequate thickness with gussets and ribs as required to make them stiff and rugged members capable of withstanding all the forces caused by the turbulence of pumping operations. The vortex plates shall be fabricated from ASTM A 283 steel and shall have outside diameter of 48 inches for Pump No. 1 and outside diameters of 72 inches for Pumps Nos. 2, 3 and 4.

15.1.3.2.3 Impellers

Whenever the term impeller is used in these pump specifications, it shall also mean propeller, whichever is applicable.

The impellers shall be cast in one piece from high grade bronze, ASTM B 143, Alloy 923, and finished all over to a smooth surface, correct in shape and contour. The impellers shall be firmly secured to the shaft by means of a key and thrust collar. Collars and keys shall be stainless steel ASTM A 276, of the type most suited for this purpose.

The thrust collars shall be the split type allowing the impellers to be removed from the bottom of the pump. The thrust collar retainer shall be bronze ASTM B 143, Alloy 923. The impellers shall be balanced statically and dynamically to minimize vibration and wear. The top of impeller hub shall be equipped with a special seal ring to prevent rope, rags and other fibrous debris from wrapping around shaft above the impeller. Seal ring shall be made of high grade bronze, ASTM B 143, Alloy 923.

15.1.3.2.4 Pump Shaft

The pump shaft shall be considered that section of shafting which supports the impellers in the bowl assembly and extends to

Sec. 15.1 continued.

a point immediately above the discharge bowl bearing and connects to the line shafting. The shaft dimensions shall be of ample size to transmit maximum driver horsepower and shall operate without vibration or distortion. The pump shaft shall be accurately turned, ground and polished precision shafting of stainless steel, ASTM A 276, Type No. 410, annealed, or a City-approved equal stainless steel alloy.

15.1.3.2.5 Pump Bearings

The pump shall have bronze bearings immediately above and below the impeller. The lower-most bearings shall be protected by a sand collar covering the locking collar, preventing sand or grit from entering.

The suction bowl bearing shall be packed with waterproof grease.

A shaft seal shall be provided immediately above the impeller. Bypass ports to drain excess oil from the shaft enclosing tube shall be provided above the seal.

The bearings shall be cast from ASTM B 144, Alloy No. 937, or a City-approved equal alloy. The sand collar shall be bronze ASTM B 143, Alloy 923.

15.1.3.3 Discharge Column Assembly

The discharge column assembly shall consist of the elbow, necessary section of column, base plate, drive support, flanges, shaft enclosing tube, enclosing tube adaptor, line shafting, line shaft couplings, line shaft bearings, and enclosing tube tension device.

15.1.3.3.1 Column and Elbow

The column shall be designed for suspension from the pump base plate, and the elbow shall be below the base plate. The column base plate and elbow shall be so proportioned as to safely support the bowl assembly and withstand the hydraulic pressure, dynamic forces, thrust, and any other load that it may be subjected to during transportation, erection or operation, including lateral bracing as required. The outside diameter of the column and discharge elbow shall be not less than twenty-four inches for Pump No. 1, and not less than thirty-six inches for Pumps Nos. 2, 3 and 4.

Sec. 15.1 continued.

If more than one section of column is used to connect the bowl assembly to the discharge elbow, the diameter of any intermediate section shall be the same as the diameter of the discharge end of the elbow. Connections shall be 125-lb. flanged. The lowest section of column or the lower end of elbow (if it is connected directly to the discharge bowl) may be tapered to make proper connection to the discharge bowl. The section of column connecting the discharge elbow to the base plate may not be less than one nominal size smaller in diameter than the diameter of the elbow at the discharge end. The thickness of the material used in that portion of the column above the elbow shall be equal in thickness to the material used for the elbow.

The elbow and column shall be fabricated from standard weight pipe per ASTM A 120 or from ASTM A 283 steel of a thickness no less than one-quarter (1/4) inch. After fabrication, including attachment of flanges and the completion of all welding, each assembly shall be heated and stress relieved. After stress relieving, the columns and elbows shall be machined between centers for perfect alignment and concentricity.

The elbow and each of the column pipes shall be provided with lifting lugs or lifting eyes to facilitate the handling of these parts during installation. Thrust restraining brackets shall also be welded to upper portions of columns.

The pump discharge elbows shall be short elbows with at least three mitered intermediate sections, and shall have standard steel ring flanges, Class D, complying with AWWA Standard C207-55 electrically-welded to the elbows. The flanged ends shall be suitably finished for attachment to the check valves to be furnished.

There shall be no guide or diffusion vanes except in the pump bowl.

The pump column sections shall not be fabricated in lengths exceeding ten feet. Total lengths shall be computed from elevations shown on the drawings.

The supporting column and elbow shall be coated inside and outside with the coating material specified in the paint section, Section 25.

Sec. 15.1 continued.

15.1.3.3.2 Base Plate and Drive Support

The base plate shall be fabricated from ASTM A 283 steel plate, Grade D, of the thickness shown on the drawings. Each base plate shall be set in recesses in the concrete floor slab with the top of plate set flush with finish floor and with continuous even bearing to concrete supporting surface, and shall allow for above base servicing of the oil tube connection. Base plates shall be drilled to accommodate hold-down bolts.

The right angle gear pump drive and electric motor drive shall be mounted on heavy fabricated steel pedestals. These shall be designed and fabricated by the Contractor or pump manufacturer so as to conform to the following requirements.

- a. Fabricate using heavy steel plates, top, bottom, and vertical, with reinforcing members and ribs as required by the equipment loads. Heavy steel castings of equal strength will be acceptable.
- b. Provide two (2) access holes at least 9" wide by 12" long, located at front and back.
- c. Purpose of pedestal is to provide access to the pump head shaft coupling and enclosing tube tension device.
- d. Details of the pedestal to be fabricated and furnished shall be submitted for City approval with shop drawings, see Section 2.
- e. Pedestal shall be integrally welded to base plate. A short section of pump column shall be welded to bottom of base plate and shall be provided with a flange for connection to pump extension above discharge elbow.
- f. The pedestal shall be fitted with lifting lugs of sufficient strength to support the weight of the complete pumping unit.

Sec. 15.1 continued.

- g. Provide stainless steel heavy gage screen over each opening, and fasten with stainless steel screws.

15.1.3.3.3 Shaft Enclosing Tubes

The shaft enclosing tubes shall be designed to support the line shaft bearings and prevent leakage of the fluid flowing into the shaft assembly. The tube may be threaded internally to receive a combination tube coupling and line shaft bearing. The shaft enclosing tubes shall be extra strong steel pipe ASTM Designation A 120, or steel tubing, of commensurate strength. The tube shall be fabricated in lengths not over five feet. The shaft enclosing tube may connect directly to the bowl assembly or may be connected by means of an adaptor or diffuser cone. The enclosing tube adaptor, or diffuser cone, shall be fabricated from steel castings or steel plate.

15.1.3.3.4 Line Shafting

Line shafting shall be precision turned, ground, and polished from AISI, C1045 steel, ASTM A 108. The shaft shall be furnished in lengths not exceeding 10 feet. The shaft shall be tested for straightness to .005-inch accuracy (total indicator reading for a 10-foot long section). The shaft diameter shall be such that no excessive deflection or whip will occur and shall be designed to transmit the maximum torque required to operate the pumps. Calculations shall be submitted with shop drawings substantiating the selection of the shaft size and couplings.

15.1.3.3.5 Line Shaft Couplings

Line shaft couplings shall be AISI, C1045 steel, ASTM A 108. The couplings shall be of the threaded type designed to transmit the full load torque required to operate the pump, and shall be equal to the shaft strength. They shall be designed also to maintain alignment between adjacent sections of shafting, and shall be interchangeable so match marking is not necessary on installation or subsequent disassembly.

15.1.3.3.6 Line Shaft Bearings

All line shaft bearings shall be bronze ASTM B 145, Alloy 836, of the removable type so they can be readily replaced in the

Sec. 15.1 continued.

field. They shall be grooved to allow oil to pass from one bearing to the next in the line shaft assembly to insure adequate lubrication for each line bearing. The bearing spacing shall be such that the shaft operates at not more than 80 per cent of the first critical speed. (Bearing spacing of more than five feet will not be permitted.) The bearings shall be of sufficient length to insure permanent shaft alignment and prevent shaft whip and vibration.

15.1.3.3.7 Enclosing Tube Tension Device

Means shall be provided at pump base plates for tension loading of the enclosing tube. If special wrenches or tools are required for subsequent adjustment or manipulation of this connection they shall be furnished by the Contractor.

15.1.3.4 Lubrication

Each pump shall be equipped with a solenoid valve operated lubrication system which shall supply lubricant to the line shaft bearings. The solenoid valve operated oilers shall have metal oil reservoirs with a capacity of not less than one gallon. Each system shall be equipped with a main sight feed valve, solenoid valve and bypass sight feed valve. Solenoid valve for engine driven pumps shall be a one-half inch, 24 volts D.C. valve, ASCO Catalog No. 8210 D 2 or a City-approved equal. Solenoid valve for electric motor driven pump shall be one-half inch, 480 volts A.C. valve, ASCO Catalog No. 8210 D 2 or a City-approved equal.

15.1.3.5 Dynamic and Static Balance

All moving parts shall be statically and dynamically balanced.

15.1.3.6 Bolting

All bolts necessary to assemble pump, and column shall be stainless steel ASTM A 320, Austentic, grade B8, or City-approved equal.

15.1.4 Shop Drawings

The Contractor shall submit detail drawings of the pump and pump assembly, including base pedestal for drive gear mounting, as specified

Sec. 15.1 continued.

in Section 2. However, in addition, after City review of shop drawings, the Contractor shall furnish one set of reproducible tracings or "sepias", all marked "As-Built."

The Contractor shall include the following data on the shop drawings: Total pump assembly weight, including pedestal; pump thrust; thrust factor; and impeller pitch; shaft diameter; impeller weight and material designation.

15.1.5 Painting

Pump shall be painted as specified in Section 25.

15.1.6 Installation

Reference is made to Section 3, concerning responsibility for installation of pumps.

15.1.7 Data for Torsional Analysis

The Contractor must obtain from the pump manufacturer the necessary mass elastic data such as moments of inertia and stiffness factors on all rotative parts of pumps to make a torsional analysis of complete system of pump, right angle gear, drive shaft assembly, and gas engine. Pumps shall not be shipped to job site until torsional analysis has been reviewed by City; therefore, expeditious submittal of mass elastic data is required in order to facilitate the Contractor's torsional analysis as specified in Section 18.

15.1.8 Operation and Maintenance Manuals

Eight complete sets of operating and maintenance instructions and eight sets of parts list shall be furnished as specified in Section 2.

15.2 Sump Pump

15.2.1 General

The Contractor shall furnish and install at the location indicated on the drawings one sump pump, including submersible electric motor drive

Sec. 15.2 continued.

and appurtenances. The pump shall be Wemco Model 4S3 or a City-approved equal.

The pump will encounter mainly storm drain water with sand in suspension, but will be required to pass varying amounts of trash, including rocks, fibrous materials and other solids, without fracturing impeller or clogging the pump.

The pump shall be of the vertical, non-clogging, vortex or delta type for submersion in a "wet" pit, and shall be constructed so as to stand on its own legs with discharge vertically through a flexible hose.

The pump shall be so constructed that dismantling and repairing may be accomplished without difficulty. The design and workmanship on the component parts of the pump shall be such that they are completely interchangeable with like parts in other pumps to insure maximum potential usage of any single repair part. The complete unit shall operate free of excessive vibration and noise and shall operate over the specified range without cavitating.

Pump and motor shall be equipped with lifting harness to facilitate handling during installation and maintenance. Harness shall consist of 1/4" neoprene coated stainless steel cable of minimum 6,300 pounds tensile strength, looped through motor lifting lugs and secured to eyebolt in pump room floor slab.

15.2.2 Pump Data

Sump pump shall have a capacity of 600 gallons per minute at a total dynamic head of 27.0 feet operating at a speed of 1735 RPM and shall operate satisfactorily between total heads of 19 feet and 30 feet without exceeding the rated 15 horsepower of the drive.

The shutoff head on pump shall be at least 20 per cent higher than the maximum operating head required by the system. The pump shall have a maximum speed of not over seventeen hundred and fifty (1750) revolutions per minute. Pump impeller shall not overload the motor when operating at any point on its curve. Suction and discharge size shall be not less than

Sec. 15.2 continued.

4 inches. The pump shall be directly mounted on a vertical solid shaft submersible type electric motor as specified in Section 16.

15.2.3 Pump Manufacturing Requirements

15.2.3.1 General

Sump pump shall conform to the following specifications. The materials specified are a guide to the minimum quality required in the pumps. The Contractor is referred to Section 2 concerning substitutions of materials.

15.2.3.2 Pump Assembly

The pump assembly shall consist basically of a pump casing with integral legs, backplate, impeller and necessary parts to secure the impeller to the shaft of the electric motor.

15.2.3.2.1 Pump Casing

The pump casing shall be made from close grain "Meehanite" cast iron, or Class 30 cast iron conforming with ASTM Designation A 48, and shall be cast with smooth interior and exterior surfaces. Pump casing shall be open from suction to discharge with no wearing rings or impeller face plates. All internal case clearances shall be such that a 3-7/8-inch sphere will pass through the pump.

Pump casing must be so designed that it will withstand not less than twice the maximum operating pressure of the pump, when operating at the specified speed.

The suction opening shall be in the bottom of the casing and shall be designed to permit proper distribution of the liquid to the impeller. The suction opening shall have a circular shape designed to reduce entrance losses, and may be cast integral with pump casing or be a separate flanged assembly bolted to pump casing.

Supporting legs shall be cast integrally with the pump casing or may be of fabricated steel plate bolted to the casing, and shall

Sec. 15.2 continued.

be of sufficient length to raise the suction opening to at least four inches above the bottom of the sump pit.

15.2.3.2.2 Backplate

The backplate shall be made from close grain "Meehanite" cast iron, or Class 30 cast iron conforming with ASTM Designation A 48. The backplate shall be accurately machined to register with the pump casing and shall be flanged for bolting to pump casing.

15.2.3.2.3 Impeller

The impeller shall be recessed of the portless non-clog design vortex or delta type, and shall be cast in one piece from close grain "Meehanite" cast iron, of Class 30 cast iron conforming with ASTM Designation A 48. The impeller shall be designed such that it will pass a 3-7/8-inch sphere through the pump. The impeller shall be keyed to the motor shaft and secured by an impeller lockscrew. The impeller shall be balanced statically and dynamically to minimize vibration and wear.

15.2.3.2.4 Fasteners

All bolts and nuts necessary to assemble pump components shall be stainless steel ASTM A 320 bolts, Austenitic, Grade B8, or City-approved equal.

15.2.3.3 Dynamic and Static Balance

All moving parts shall be statically and dynamically balanced.

15.2.4 Shop Drawings

The Contractor shall submit detail drawings of the pump and motor assembly as specified in Section 2. However, in addition, after City's approval of shop drawings, the Contractor shall furnish one set of reproducible tracings or "sepias", all marked "As-Built."

Sec. 15.2 continued.

15.2.5 Painting

The pump casing, impeller and discharge pipe shall be epoxy coated, except for mating surfaces, as specified in Section 25, with 2 mils dry film thickness of epoxy primer and 15 mils dry film thickness of epoxy coating for a total of 17 mils dry film thickness.

The pump motor shall be epoxy coated on exterior, including lower mounting flange, except for mating surface, as specified for pump components.

The epoxy coating shall conform to and be applied according to all requirements as specified in Section 25.

15.2.6 Installation

Reference is made to Section 2, concerning responsibility for installation of pumps.

15.2.7 Operations and Maintenance Manuals

Eight complete sets of operating and maintenance instructions and eight sets of parts lists shall be furnished as specified in Section 2.

15.3 Pump Performance Tests

15.3.1 General

Each pump to be furnished under the contract shall be performance tested by the Contractor at the pump manufacturer's test stand or test laboratory before shipping to the pump station. The testing facilities must be approved by the City as being suitable for the prescribed tests, prior to the performance of any tests. All costs for pump performance testing of pumps 2, 3 and 4 shall be included in the price bid for Item 40 and for pump 1 in Item 41. Performance testing for the sump pump shall be included in the price bid for Item 44. No model testing will be permitted.

Sec. 15.3 continued.

15.3.2 Test Requirements

All pumps shall be tested using the motor to be furnished with each respective pump, except that in the case of Pumps Nos. 2, 3 and 4, which are to be engine-driven, an electric motor of 300 horsepower may be substituted. Pump impeller test speed must be the same as pump impeller design speed.

Each pump shall be tested at its specified minimum, design and maximum laboratory or bowl assembly total dynamic heads and enough points in between such that a smooth performance curve can be plotted describing each pump's performance throughout the entire range. Pump No. 1 shall also be tested at shut-off head. A suitable throttling device such as a butterfly valve or gate valve may be used to simulate the total head conditions. No test of pumps at other than design speed will be required but manufacturer will be required to certify that operation above or below the design speed will be satisfactory and vibration-free, and within the specific speed capacity of the impeller, and that delivery heads and capacities will conform to the affinity laws. This requirement does not apply for sump pump.

Prior to the tests, the pump serial number shall be painted on the outside of the impeller bowl and stamped into the metal on the impeller shaft just below the lowest coupling and on a nameplate to be fastened to the motor pedestal or right angle gear pedestal.

15.3.3 Measurements Required

General:

The Contractor shall submit for review eight copies of the manufacturer's anticipated pump performance curves, or standard published performance curves for each pump he proposes to furnish under the contract. The curves shall accompany the pump working drawing submittal required under Section 2.4 of these specifications.

The City will review the curve data, and if acceptable in accordance with specification requirements will so designate on all copies of the curves.

Sec. 15.3 continued.

The actual laboratory pump performance tests required under the contract shall not be performed until the City has reviewed the preliminary performance curves.

The following measurements shall be made by the Contractor:

15.3.3.1 Capacity Measurement - by orifice meter, venturi meter, or other suitable means approved by the City.

15.3.3.2 Head Measurement - by manometers of suitable range and scale.

15.3.3.3 Speed Measurements - motor R.P.M. by electronic or other suitable means approved by the City.

15.3.3.4 Electrical Measurements

Amperes - 3 phases
Voltage - 3 phases
Motor KW (or P.F.)

15.3.4 Test Code Requirements

All of the Contractor's test stand facilities shall conform with recommendations of the Hydraulic Institute and ASME - Power Test Code.

15.3.5 Results Required

The results of the tests above performed when plotted on the certified pump performance curves furnished by the Contractor shall in all respects meet the specification requirements. Pumps and motors not meeting the specification requirements shall be altered or replaced and retested by the Contractor until approved by the Engineer.

The testing shall include the minimum, design, and maximum total dynamic heads and enough points in between such that a smooth curve can be plotted describing each pump's performance throughout the entire range. Pump performance results shall be such that the pump shall have only one definite discharge capacity for one corresponding total dynamic head.

Sec. 15.3 continued.

All pump test results and performance curves as determined from the test stand shall be within the following tolerances to be considered as meeting the specification requirements:

1. At design head, capacity shall not exceed five per cent above or zero per cent below design capacities as specified in Section 15.1.2 for main pumps and in Section 15.2.2 for sump pump.
2. At minimum, design and maximum heads, engine horsepower ratings and electric motor horsepower ratings shall not be exceeded.
3. At shut-off head for Pump No. 1, electric motor horsepower shall not exceed value shown on Sheet 21 of the drawings.

Upon completion of witnessed laboratory test, eight copies of certifications, test data and performance curves plotted from test data shall be submitted for review. No pumps shall be shipped to the pump station until test data and performance curves have been reviewed by the City and found to meet the specification requirements.

15.3.6 Notification

The Contractor shall notify the City two weeks in advance of pump performance tests. All performance tests will be witnessed by the City.

15.4 Payment

All costs for furnishing the engine driven pumps Nos. 2, 3 and 4 shall be included in the price bid for Item 40. All costs for the motor driven pump No. 1 shall be included in the price bid for Item 41.

All costs for the sump pump with 15 h.p. electric motor shall be included in the price bid for Item 44.

SECTION 16: ELECTRIC MOTOR DRIVES

16.1 General

Pump No. 1 shall be directly connected to 480 volt, 60 hertz, three phase vertical hollow shaft, ball bearing, across the line start (NEMA Code F or better), normal starting torque induction motor. Motor shall conform to AIEE and NEMA Standards and shall be of drip-proof construction. The thrust bearings shall be selected for a minimum B-10 life of 20,000 hours as per AFBMA Standards. The thrust bearings shall have ample capacity to carry the weight of all rotating parts plus the hydraulic thrust of the impeller and shall have an ample safety factor. Thrust bearing shall be removable without disassembly of the motor. Motor shall be of proper size to provide the horsepower specified with a temperature rise of not more than 70 degrees Centigrade above a 40 degrees Centigrade ambient temperature, while running at 115 per cent of the nameplate rated load, with NEMA Class B insulation. Motor shall be capable of full plant operation without exceeding any nameplate ratings (without considering the service factor) of the motor or overloading the electrical equipment.

The stator frame and end brackets shall be of normalized cast iron. The stator frame shall be accurately machined and drilled to receive the end brackets and bearing supports.

The motor shall be balanced after assembly to an overall vibration amplitude peak to peak of not more than .001 inches.

Rodent guards shall be provided.

A non-reverse ratchet shall be incorporated in the motor design to prevent the pump from turning in a reverse direction. The maximum reversal of shaft rotation shall be limited to 4.5 degrees. Provision shall be made for pump impeller adjustment, in the top of the motor assembly, with a positive device for locking the rotor to facilitate the pump shaft adjustment.

16.2 Motor Sizes

16.2.1 Pump No. 1

The motor for Pump No. 1 shall be 150 horsepower with a synchronous speed of not more than ~~500~~ R.P.M. Motor shall have a 1.15

Sec. 16.2 continued.

service factor with the thrust and lower guide bearing oil lubricated. A visible means shall be provided for checking the oil level.

Power factor at full load shall be .77 minimum, at 3/4 load .69 minimum, and at 1/2 load .58 minimum. Full load current at 480 volts shall not exceed 200 amps.

16.2.2 Sump Pump

The motor for sump pump shall be submersible, meet NEMA Standards, have a synchronous speed of not more than 1750 R.P.M., operate on 480 volt, 60 hertz, three phase, have a 15 horsepower nominal rating and be mounted on a sealed oil filled chamber. The motor shaft shall also serve as pump shaft and be stainless steel.

The motor shall be supplied with 30 continuous feet of multi-conductor cables with 3 power leads, one ground lead in one cable and 4 sensing leads in the other cable. The motor shall have a thermal sensing unit mounted in it and a moisture sensing unit mounted in the oil filled chamber to warn of moisture before it reaches the inner motor chamber. Seals shall be provided at all locations where moisture might enter the submersible pump bearings, motor, or wiring. Hardware shall be stainless steel.

The motor shall be mounted on the pump and shall be provided with thrust and radial bearings to carry the entire load which may be imposed upon it under all operating conditions. Motor shall be of nationally known manufacturer and shall be approved by the Underwriters for an explosion-proof atmosphere.

The motor shall have two mechanical seals--the lower one outside the motor and protecting the upper one which is in an oil filled chamber. Moisture detector probes in the oil filled seal chamber shall be connected to an alarm to indicate the presence of moisture in the seal chamber. Thermal overload protectors shall be imbedded in the motor windings and connected to the starter to disconnect the motor in the event of overload.

16.3 Heaters and Electrical Connections

The motor for Pump No. 1 shall be equipped with two (2) space heaters rated 240 volts each and shall be connected in series on

Sec. 16.3 continued.

240 AC Panel A power as indicated on the drawings. The heater elements shall raise the motor temperature above the ambient temperature by a minimum of 10 degrees Fahrenheit. The heater elements shall be easily replaceable without requiring dismantling of equipment and shall be insulated electrically from the frame. A junction box shall be provided to allow for easy connection to the heaters.

The motor feed, heaters, and the heater junction boxes shall be oriented on the motor exactly as shown on the drawings. No variations will be accepted. The motor feed junction box shall be of sufficient size as to accommodate the wiring shown on the plans.

16.4 Commercial Test per NEMA Standards

Contractor shall, after the completion of the standard commercial test, submit eight (8) copies of the test results along with eight (8) copies of the latest complete dynamometer test of a duplicate motor to the City for approval prior to shipping motors to pump manufacturer for pump performance tests.

Standard commercial test shall consist of the following checks:

- a. No load current
- b. No load speed
- c. Locked rotor current
- d. Winding resistance
- e. High potential test
- f. Bearing inspection-vibration test

Complete dynamometer test shall consist of the following checks in addition to those of the standard commercial test:

- g. Torque-speed characteristics
- h. Heat run-temperature rise
- i. Efficiency and power factor at 1/2, 3/4, and full load

16.5 Working Drawings

The Contractor shall submit certified dimensional working drawings of the motor, base pedestal for motor mounting, and a cross sectional drawing showing internal construction and motor specification data as specified in Section 2. Included on the working drawings shall be the non-reverse ratchet, bearings and pump impeller adjustment and coupling details.

16.6 Installation

Reference is made to pump specifications concerning responsibility for installation of electric motor drives.

16.7 Operations and Maintenance Manuals

Eight complete sets of operating and maintenance instructions and eight sets of parts lists shall be furnished as specified in Section 2.

16.8 Payment

All costs for the 150 horsepower electric motor as specified herein-above shall be included in the price bid for Item 41.

All costs for the 15 horsepower electric motor which is a part of the sump pump shall be included in the price bid for Item 44.

SECTION 17: RIGHT ANGLE GEAR DRIVES

17.1 General

The Contractor shall furnish and install for Pumps Nos. 2, 3, and 4 a right angle gear drive between the pump and the natural gas engine. The unit shall be a standard product of a reputable gear manufacturer, and shall be manufactured in accordance with the applicable requirements of the standard practices of the American Gear Manufacturer's Association. The gear unit manufacturer must be a firm regularly engaged in the production of right angle gear drives and the model submitted for City approval shall have been proven by at least two years of successful commercial use.

The drive shall be a spiral bevel gear speed reducer unit capable of transmitting a minimum of 400 continuous brake horsepower and shall be properly sized model as manufactured by Western Gear Corporation, Amarillo Gear, Philadelphia Gear Corporation, Johnson Gear and Manufacturing Co., or a City-approved equal. The gear ratio shall be computed by the Contractor when he has determined the speed of the pump and the gas engine to be furnished. Equipment selected by ratings and service factors not set forth in published catalogs of the manufacturer will not be acceptable.

17.2 Manufacturing Requirements

The right angle gear drive shall incorporate the following features and appurtenant items.

17.2.1 Housing

The housing shall be of rugged proportions specifically designed to provide a rigid, strong, and sealed construction. The material shall be cast iron or cast steel. The interior of the housing shall be thoroughly cleaned and protected with a rust-resisting oil-proof paint.

The right angle gear drive shall be subjected to an operational test after installation in Pumping Plant according to Section 2.

The right angle gear drive and its appurtenant items shall be guaranteed according to Section 3.

Sec. 17.2 continued.

17.2.2 Bearings

Ample capacity precision bearings shall be used throughout, the proportions and type being consistent with best modern practices for the loads and speeds of this application. The bearings shall be selected for a minimum B-10 life of 20,000 hours as per AFBMA Standards, and a minimum vertical down thrust equal to the weight of the rotating parts plus hydraulic thrust based on a pumping head of 40 feet.

17.2.3 Gears and Shafts

All gears shall be manufactured from alloy steel forgings properly heat treated and hardened. Gears shall be finished lapped in matched pairs.

The vertical output shaft of the gear unit shall be hollow type made from heat treated alloy steel forging.

17.2.4 No-back

A no-back or non-reverse ratchet shall be provided.

The Contractor shall submit for approval to the City calculations and metallurgical data on the non-reverse ratchet substantiating his design. This shall be included in the shop drawing submittal of the right angle gear units.

17.2.5 Lubrication

A positive lubrication system shall be incorporated into the drive. The system shall supply an adequate supply of oil to all gear teeth in mesh and to all bearings. A self-priming positive displacement pump shall be connected directly to the lower end of the vertical shaft, giving positive pumping action at all times. To provide protection from ferrous metallic particles in the oil, the suction line shall be screened and the housing drain supplied with a magnetic plug.

17.2.6 Lubricating Oil Heat Exchanger

The lubricating oil shall be cooled by a heat exchanger connected to the water service supply line. The heat exchanger may be a type that is installed inside or outside of the gear drive.

Sec. 17.2 continued.

17.2.7 Oil Pressure and Temperature Gauge Connections

A plugged tapped opening shall be provided on the right angle gear in lubrication system for the connection of an oil pressure gauge and oil temperature gauge. The oil pressure and oil temperature gauges shall be furnished and mounted on the right angle gear assembly. The Contractor shall furnish and install a 3/8-inch copper tubing between tapped opening on right angle gear and oil pressure gauge and a capillary tube for the oil temperature gauge. The tapped openings shall be made during manufacture of unit. Field tapping will not be permitted.

17.2.8 Oil Fill Sight Gauge

The oil reservoir in right angle gear housing shall be provided with a sight level oil gauge to provide a visual check of the oil level and condition.

17.2.9 Tachometer Generator Connection

The gear drive manufacturer shall furnish a positive gear drive connection from tachometer generator to the head shaft of the pump through specially designed gears of the proper ratio to accommodate the tachometer generator. A suitable bracket shall be furnished to mount the tachometer generator in a horizontal position on the side of the right angle gear drive and shall be direct connected to the generator drive provided with a flexible coupling. The exposed shaft and coupling shall be guarded in accordance with requirements of the State of California Industrial Safety Regulations.

17.3 Tachometer Generator

An Esterline-Angus, Bristol, or City-approved equal tachometer generator for the natural gas engine driven pump shall be supplied, installed and coupled to the gear reducer tachometer connection.

The speed indicator must indicate the actual pump RPM with the tachometer generator driven at the takeoff speed provided on the right angle

Sec. 17.3 continued.

gear. The speed indicator, tachometer generator, and recording D.C. voltmeter must be calibrated in the shop for the correct reading. No resistors or other devices will be permitted to be added to the system in the field. The Contractor shall submit certification that the proper RPM was recorded at shop testing.

The tachometer generator must be installed and tested in the plant of the right angle gear manufacturer. Test results consisting of speed curves within operating range of the engines shall be submitted for approval to the City along with the shop drawings prior to shipment of the right angle gear units to the pump station site. Test curves submitted shall also show speeds 10 per cent above and below operating range of engines.

17.4 Water Connections to Drive Unit Heat Exchangers

The Contractor shall make a proper water connection to the right angle gear drive heat exchangers from the water service line. A 3/4-inch riser shall be brought up from the water supply line below motor room floor, and a 3/4-inch globe valve shall be installed upstream and bypassing the solenoid operated valve. A 3/4-inch water hammer arrester shall be installed upstream from the solenoid valve. A 3/4-inch waste water line shall be installed from the right angle gear drive and shall discharge into pump sump below motor room floor. Reference is made to Section 14 for specification on the globe valves, the water hammer arresters, and the solenoid valves. Schematic of water piping is shown on Sheet 24 of the drawings.

17.5 Installation

Reference is made to Section 2 concerning responsibility for installation of right angle gear drives.

17.6 Data for Torsional Analysis

The Contractor must obtain from the right angle gear manufacturer the necessary mass elastic data such as moments of inertia and stiffness factors

Sec. 17.6 continued.

on all rotative parts of gears to make a torsional analysis on complete system of pump, right angle gear, drive shaft assembly, and gas engine. Right angle gear shall not be shipped to job site until torsional analysis has been reviewed by the City; therefor, expeditious submittal of mass elastic data shall be made in order to facilitate the Contractor's torsional analysis as specified in Section 18.

17.7 Working Drawings

The Contractor shall submit certified dimensional working drawings of the right angle gear drive showing attachment to base pedestal for mounting, with a cross sectional drawing showing internal construction, parts list, gear ratio and drive specification data as specified in Section 3. In addition, the details of the tachometer generator take off shall be shown on the working drawings.

In addition, after City review of working drawings, the Contractor shall furnish one set of reproducible tracings or sepias, all marked "As-Built."

17.8 Payment

All costs for the right angle gear units and tachometer generators as specified hereinabove shall be included in the price bid for Item 40.

SECTION 18: NATURAL GAS ENGINE DRIVES AND
AUXILIARY EQUIPMENT

18.1 General

The Contractor shall furnish and install three self-contained, stationary open-type, naturally aspirated natural gas engine power units to drive Pumps Nos. 2, 3 and 4. Each engine shall be equipped with proper cooling system, ignition system, exhaust system, fuel system, starting system, lubrication system, engine control, power takeoff, and all other necessary appurtenances to provide a complete power unit for the proposed application.

The engines shall be identical and shall be single "open type" units of not less than 6 cylinders, four cycle type and shall operate under design conditions at a speed of not more than 1200 R.P.M., with a maximum brake mean effective pressure of 78 psi sea level elevation. Each engine shall be capable of a minimum of 225 brake horsepower continuous output at 1200 R.P.M. at 78 BMEP.

The engines shall have not less than 1900 cubic inch displacement. Engines of lesser cubic inch displacement will not be acceptable to the City.

The engines shall be the product of a manufacturer regularly engaged in the building of natural gas engines and shall be a model which has been regular production by the manufacturer for at least two years.

The engines described shall be heavy duty, industrial type natural gas with overhead valves, exhaust valve inserts, alloy steel valves, renewable wet sleeve cylinder liners, main bearings, crankshaft vibration damper, full pressure lubrication, and other features common to heavy duty engine design. There shall be no critical torsional vibrations in the operating speed range.

The natural gas engines and their auxiliary equipment shall be guaranteed as specified in Section 2.

18.2 Detailed Requirements for Engine Drive and Auxiliary Equipment

18.2.1 General

The following list of engine auxiliary equipment shall be furnished and installed by the Contractor on the engine. It shall be understood by the Contractor that it will be his responsibility to furnish and install any other items not specifically listed, to provide the complete power unit for the proposed application. Guards for all belts shall be furnished by the Contractor in accordance with State Division of Industrial Safety requirements.

18.2.2 Cooling System

18.2.2.1 Radiator

The engine shall be furnished with a radiator cooling system having sufficient capacity for cooling the engine when delivering maximum horsepower of engine at 1200 R.P.M. and with an ambient temperature of 100 degrees F. at sea level elevation.

The radiator cooling system shall be furnished complete with pusher fan, fan driving belts, belt guard, fan guard, fan shroud, belt driven water pump, thermostats, and quick warm-up bypass line. The radiator shall be heavy duty model with removable cores and shall be integrally mounted with the engine on a steel skid for proper alignment. A liquid level indicator shall be provided on each radiator, of sturdy construction and mounted for easy viewing.

An air duct adaptor flange shall be mounted to the face of the radiator to receive flexible connector between radiator and metal closure duct to louver in building exterior. The flexible connector and metal closure duct are specified in Section 9.

The radiator drain shall be equipped with a manual shut-off valve and a pipe in the outlet of the valve terminating over the two inch sleeved hole in the floor to drain radiator into pump pit. The manual shut-off valve shall be a gate valve as specified in Section 14.

The engine shall be equipped with a water cooled exhaust manifold (one on each bank if Vee-Type engine).

Sec. 18.2 continued.

18.2.2.2 Engine Preheater

An engine immersion preheater, 3000 watt for 480 volt single phase AC power supply shall be placed in the cooling system. Heater shall be equipped with a thermostatic control to maintain engine jacket water temperature between 120 degrees F. to 160 degrees F.

The contacts of thermostat shall be rated 20 amps, 480 volts. A terminalized strip junction box shall be furnished with engine heater and thermostat wired to it. Terminal strip shall be Square D, Type S, or Buchanan Type TC, or a City-approved equal. If a Vee-type engine is furnished, it must be equipped with 3000 watt heaters on each bank. The heater water lines shall be connected to engine block with the inlet taken low from one end and the outlet from heater going into engine block low at opposite end. The heater shall have manual shut-off valves at the engine block inlet and outlet to allow for heater line change without draining engine water. The water lines shall be flexible metal.

18.2.2.3 Filter Conditioner

Engine cooling system shall be equipped with a filter conditioner unit which will filter the water, chemically treat the water to maintain ph factor, chemically treat the water to maintain corrosion protection, and have a sacrificial plate to control electrolysis. The filter conditioner unit shall be installed with shut-off valves on water inlet and outlet to allow for element change without draining engine water and shall have a sight glass installed in water line for visual check on water condition.

18.2.2.4 Automatic Louver Operation System

The engine fan exhaust louvers shall be normally closed and shall be of automatic design to open when the engine starts by means of proper-sized hydraulic cylinder operating from the engine oil pressure. These shall automatically close after the engine shuts off. Engine manufacturer shall provide for and furnish necessary devices as described above so as to coordinate the installation with the louvers as described under Section 10.

Sec. 18.2 continued.

18.2.3 Fuel System

18.2.3.1 Carburetion System

Carburetion system shall be for combination natural gas - LPG complete with carburetor, gas regulator at the engine to reduce the 10-15 inches water gauge supply pressure to the low pressure in inches required by the carburetor, heat exchanger-regulator unit to vaporize LPG, dry type air cleaner, compound pressure gauge with push button valve.

The gauge shall be mounted on a panel attached to the building wall in a location adjacent to the engine. If a Vee-type engine is supplied, a dual carburetion system shall be furnished.

A fuel transfer switch (toggle) shall be installed on engine instrument panel to permit selection and use of either the natural gas fuel system or the liquefied petroleum gas system at any given time.

18.2.3.2 Converter

Converter shall be a combined pressure reducing valve and heat exchanger to vaporize the liquid petroleum gas using engine jacket water. It shall have two stages of regulation, reducing gas pressure from tank pressure to approximately one inch of water column vacuum. A commercial liquid stage filter shall be installed upstream of the converter. A load adjuster shall be placed between converter and carburetor to adjust converter outlet pressure to match engine actual load.

18.2.3.3 Air Cleaner

All air to the carburetor shall be filtered by properly-sized dry type air cleaner.

18.2.3.4 Shut Down Device

24 volt D.C. solenoid operated shut-off valves shall be furnished and installed on the engine to shut down engine by cutting off the natural gas or LPG fuel supply in the event of engine overspeed, high water temperature, low oil pressure or low water level in the pump pit. Solenoid valves shall be actuated from circuits in the engine control panel as specified hereinafter. Solenoid valve shall have a coil for operation

Sec. 18.2 continued.

on battery voltage. The setting of the transfer switch specified under Subsection 18.2.3.1 determines whether the engine control is connected to the solenoid valve for natural gas or for LPG at any given time.

The 24 Volts D.C. Natural Gas 3-inch solenoid valve shall be Catalog No. 821541 as manufactured by ASCO, equivalent by Gould or City-approved equal.

The 24 Volts D.C. LPG one-half-inch solenoid valve shall be Catalog No. 8215 B21 as manufactured by ASCO, equivalent by Gould or City-approved equal.

Manually operated natural gas shut-off valves shall be furnished. One valve shall be installed upstream of the natural gas automatic shut-off solenoid valve and one in a bypass line around the natural gas automatic shut-off solenoid valve. The valves shall be ball valves with teflon seats, Pacific Valves, Figure No. CS400 P5, or equivalent by Lunkenheimer or a City-approved equal.

Shutoff and bypass valves for the LPG line shall be Clayton Mark 150 pound, No. 772TTU flanged ends carbon steel body ball valve with teflon seals, gasket and packing, U.S. listed for shutoff valves in LPG service in either liquid or gas phase, equivalent by Hills-McCanna or City-approved equal.

18.2.4 Lubrication and Lubricants

18.2.4.1 Lubrication

Each engine shall be equipped with gear type lubricating oil pump which will supply oil under pressure to main bearings, crank pin bearings, pistons, timing gears, camshaft bearings, and valve rocker mechanism. Lubrication system shall have full-flow lubricating oil filters which filter all oil prior to entering main bearing gallery and other lubricated surfaces. The filters shall be equipped with a spring loaded bypass valve as assurance against stoppage of lubricating oil circulation in the event filters become clogged. Oil pressure shall be controlled by an externally adjustable pressure regulating valve.

Sec. 18.2 continued.

The engine oil pan shall be the box base type with oil reservoir equipped with a visible column oil level gauge, dip stick, and an oil drain out pipe with a valve and cap provided. The drain valve shall be easily accessible for engine maintenance.

18.2.4.2 Lubricants

Lubricants for the engine shall be furnished by the Contractor. The initial application of these lubricants shall be performed by the Contractor prior to plant test, in accordance with engine manufacturer's recommendation. Prior to initial lubrication and testing of engine, the Contractor shall submit for approval to the City a list of manufacturer's recommended lubricants to be used.

18.2.5 Engine Speed Control

18.2.5.1 Governor

An adjustable speed, mechanical, flyball governor shall be mounted on the engine for operating speed control, variable from idle to top speed. Governor shall be fully enclosed, self-lubricating, and capable of providing speed control with 10 per cent of rated speed from no load to full load conditions.

18.2.5.2 Two Element Speed Switch

A two-element speed sensitive switch with an automatic reset shall be furnished and installed. The underspeed element shall be set at a speed between cranking and idle speed to indicate when engine is running, and high speed element shall be set to stop engine at 10 per cent over covered speed.

18.2.5.3 Throttle Control

A 24 volt DC reversible throttle motor shall be provided to control the engine throttle in conjunction with the automatic engine control. Motor shall provide an adjustment of from zero to three minutes in the time required to open the throttle from idle to full design speed and shall have limit switches to stop at the full design and the idle speeds. When the control panel selector switch is in the automatic position, the engine is started and warmed up at idle speed, the throttle motor being energized to accelerate the engine to full design speed in up to three minutes according to setting. When the engine is at full design speed, the throttle motor will be de-energized by the limit switch. A disconnect and a friction-type hand throttle shall be provided for manual control.

Sec. 18.2 continued.

On signal from the control panel the throttle motor will be energized to run in the opposite direction and return the engine to idle speed. The throttle motor will be de-energized by another limit switch.

18.2.6 Exhaust System

18.2.6.1 General

The Contractor shall furnish a complete exhaust system for the gas engine. The exhaust system will follow the general scheme shown on the drawings, and shall be mounted above and be integral with the engine. The Contractor shall submit full details of the exhaust system with the working drawings required in Section 2.

The maximum back pressure allowable in the exhaust piping will be 10 inches water column, measured at the manifold exhaust header. Header shall be provided with a plugged tapped connection for the attachment of a test manometer to check back pressure after installation of exhaust system in field. The engine shall have a single exhaust outlet connected to the silencer. The exhaust system shall be sized in accordance with the engine manufacturer's recommendations.

18.2.6.2 Exhaust Piping

The exhaust piping shall be fabricated from standard black pipe, ASTM A 120 or A 53. The exhaust piping shall be supported in such a manner as to relieve the flexible connection and engine exhaust manifold from any loads, and shall be sloped slightly towards outlet to drain condensate.

Where a V-type engine is used having two exhaust manifolds, a "Y" connection can be utilized, made with two branches entering a single pipe at approximately 60 degrees single confluence angle. The use of "T" connections or multiple exhaust connections to a common header will not be permitted.

18.2.6.3 Muffler

The muffler shall be a critical residential class silencer (four chambers) Model TRS as manufactured by Kittell Muffler and Engineering,

Sec. 18.2 continued.

or an equivalent by Maxim Silencer Company, or a City-approved equal. The muffler shall be sized for maximum of 10-inch water column friction loss on complete exhaust piping. The muffler shall have a size inlet located as close to the muffler inlet end as possible, and an end outlet. An outlet drain with waste piping shall be provided at the low end of muffler to drain condensate. The waste piping shall extend through floor to discharge condensate into pump pit.

18.2.6.4 Flexible Connection

There shall be installed in the exhaust piping an 18-inch long section of Type 321 Stainless Steel accordion pleated flexible connection. The flexible connection shall be flanged both ends with carbon steel plate flanges. The Type 321 Stainless Steel shall conform to ASTM A 269.

18.2.6.5 Safety Guard and Insulation

The exhaust piping beyond engine manifold to the building wall including muffler, except for the flexible connection, shall be insulated with a City-approved type of insulation suitable for temperature of 1300 degrees Fahrenheit. The exterior of insulation shall be protected with a stainless steel sheet metal cover, Type 321 per ASTM A 167 and to be minimum of 24 gage. The insulation maximum exterior temperature allowed shall be 150 degrees Fahrenheit.

The flexible connection shall be provided with an approved type safety guard. The safety guard must be mounted so as not to interfere with the functional operation of the flexible connection.

18.2.7 Starting System

18.2.7.1 General

A complete self-contained electrical starting system shall be furnished and installed for each engine.

18.2.7.2 Starting Motor

Each engine shall be equipped with a 24 volt direct current electric starter complete with a magnetic contactor. A pushbutton switch shall be provided in engine control panel for energizing starter.

Sec. 18.2 continued.

18.2.7.3 Alternator

Each engine shall be equipped with an alternator for charging the battery system. The alternator shall have a minimum charge rate of 35 amps and shall be complete with drive and regulator. Engine shall be equipped with a relay to transfer battery to alternator when engine starts and to trickle charge when engine stops, and to energize the totalizing type hour meter.

18.2.7.4 Battery System

Each engine shall have four (4) twelve volt Group 8D heavy duty batteries rated at 200 ampere-hour capacity at 20 hour rate, mounted in battery racks. The batteries shall be series and parallel connected for 24 volt 400 ampere-hour system. A set of 4/0 battery cables shall be furnished to connect battery system to starting motor. A 35 ampere fuse shall be furnished and installed in feed line to engine control pane.

18.2.7.5 Battery Charger

A solid state battery charger shall be provided for each engine which shall be automatic, self-regulating, and have no moving parts. The D.C. output shall be rated 10 amperes at 24 volts and shall have a D.C. ammeter. The amount of loading and the state of charge of the battery shall determine the charger's current output. The charger shall use a magnetic amplifier for D.C. voltage regulation and sealed silicon diodes for full wave rectifier. Charger shall not discharge battery if A.C. power goes off. Unit shall have U.L. Listing and an isolation transformer to completely separate the A.C. line from the charging circuit. The unit shall have automatic surge suppressors and current limiting overload protection, and fused A.C. input and D.C. output.

18.2.8 Clutch Power Take-Off

Each engine shall be equipped with a heavy duty clutch power takeoff. The clutch mechanism shall be enclosed, and a hand lever shall be provided to manually engage and disconnect engine from pump during testing or servicing engine. The clutch power take-off shaft shall have a diameter

Sec. 18.2 continued.

not less than the required to transmit full engine rated horsepower with an adequate safety factor. The clutch take-off shaft shall be cross drilled to permit lubrication of fly-wheel pilot bearing without removing the connecting drive shaft.

Clutch shall be equipped with a positive action switch which when clutch handle is in disengaged position will open circuit to water coolant valve and oiler on right angle gear. Tilting type mercury switches are not acceptable due to failure resulting from engine vibrations.

18.2.9 Instrument Panel

An engine instrument panel, engine mounted and vibration isolated, shall be provided for each engine, complete with water temperature gauge, oil temperature and pressure gauge, manifold vacuum gauge, ammeter, electric tachometer with momentary push button, fuel transfer switch, starter pushbutton, and a 24 volt D.C. totalizing-type hour meter for the engine.

All gauges and switches shall be furnished with black bakelite engraved nameplates.

18.2.10 Engine Control Panel

18.2.10.1 Control Panel

An engine control panel unit for each engine shall be furnished and mounted on the interior of the engine room wall. The control unit shall provide for manual, automatic, and test operation. The mode of operation shall be selected by a four position switch located on the control panel. All indicating lights and switches on control panel shall be plainly labeled. The control shall conform to Standard Drawing 2-ML 227.

18.2.10.2 Control Panel Selector Switch

The selector switch shall have Manual, Off, Automatic, and Test positions.

Manual Position - Power shall be supplied to starter switch and fuel solenoid valve.

Sec. 18.2 continued.

- Off Position - All power to unit shall be off except to water indicator lights.
- Automatic Position - The engine shall be automatically started at a predetermined water level with a predetermined low R.P.M. After an adjustable time delay, the engine throttle is opened to its operating speed. When the sump water level reaches shutdown level, the throttle is closed to the idle position and remains in this position for a predetermined time before shutting off the fuel solenoid valve.
- Test Position - The engine starts and runs until the switch position is changed. There are no water level or throttle controls in this position. The throttle is controlled manually.

18.2.10.3 Control Panel Operation on a Failure

In the automatic and test positions, low oil pressure, high water temperature, or over speed switches will shut down the engine when trouble occurs. In addition, the throttle will be closed in the automatic position.

The control panel lights shall indicate the cause of shutdown with yellow for oil, white for high engine water temperature, and red for overspeed.

In the automatic and test position, a failure will result in the correct indicating light coming on and remaining on until the selector switch is manually turned to the off position. The alarm bell will ring until the engine stops or alarm silence switch on panel is turned off.

The manual position has no safety devices in operation, no operation of alarm bell and no safety indicating lights.

Sec. 18.2 continued.

18.2.10.4 Water Level Lights

The red and green water level lights shall operate in the following way:

1. Water level below automatic stop level will result in both red and green lights on dim.
2. Water level in pumping range will result in red light off and green light bright.
3. Water level at the automatic start level and the selector switch in the automatic position will result in both red and green lights being on bright. The engine should be in operation.

18.2.10.5 Sensing Switches

The engine shall be equipped with a low oil pressure safety switch, high water temperature safety switch, and a two-element speed switch with underspeed switch to indicate engine running and an overspeed switch for the overspeed safety switch to operate with engine control panel.

18.2.11 Junction Box

The engine shall be equipped with a terminalized strip junction box with all engine safety accessories shop wired to it. All wiring shall be standard and clearly identified. Terminal strips shall be Square D Type S, or Buchanan Type TC, or City-approved equal.

18.2.12 Structural Steel Base

The Contractor shall furnish and install a separate welded structural steel skid frame, and shall mount the engine with radiator on this frame in such a manner as to provide clearance below engine for maintenance and to allow clearance on oil and water drain lines. The entire

Sec. 18.2 continued.

unit shall be placed on the reinforced concrete foundation shown on the drawings and solidly anchored in place with anchor bolts screwed into cast-in-place anchor bolt sleeves. The frame and anchor bolt layout for the frame shall be designed by the Contractor. Working drawings shall be submitted for City approval, as specified in Section 2.

18.2.13 Painting

The natural gas engine shall be painted with machinery gray enamel in accordance with manufacturer's standard practice.

18.2.14 Spare Parts

The following spare parts shall be included with engine:

1 set of spark plugs.

6 sets of lubricating oil filter elements and gaskets
for six complete changes of all oil filters if
engine equipped with more than one filter.

6 sets of replacement elements and sacrificial plates
for water filter conditioner.

1 set valve cover gaskets.

1 set side door inspection gaskets.

18.2.15 Operations and Maintenance Instruction Manuals

Eight complete sets of operating and maintenance instructions and eight sets of parts lists shall be furnished by the Contractor for all equipment furnished under this contract. The operating and maintenance instructions and parts lists shall be bound together in sets and delivered to the City prior to shipment of engine and auxiliary equipment to pump station.

Sec. 18.2 continued.

18.2.16 Instruction of Operating Personnel

The engine manufacturer or his authorized representative shall, upon completion of installation, instruct City operating personnel in care and operation of the engines and all accessories furnished, and shall demonstrate the operation to the satisfaction of the Engineer.

18.2.17 Working Drawings

The Contractor shall submit detail drawings of the engines and accessories as specified in Section 2. However, in addition, after fabrication of equipment, the Contractor shall furnish reproducible tracings or sepias marked "As-Built."

18.3 Torsional Analysis

To insure that no harmful critical torsional vibrations exist in the operating range, a torsional analysis shall be made on the complete rotative system of pump, right angle gear, drive shaft assembly, and natural gas engine.

Eight certified copies of torsional analysis showing no harmful critical torsional vibration existing in the operating range shall be submitted to City for approval prior to shipment of any of the equipment involved to the jobsite.

18.4 Installation

Reference is made to Section 2, concerning responsibility for the installation of natural gas engines.

The crankshaft of each engine shall be horizontal and in exact longitudinal alignment with the input shaft of the right angle gear drive. The crankshaft elevation shall be 2-1/2" above elevation of the input shaft of the right angle gear drive.

18.5 Natural Gas Engine Performance Tests

18.5.1 General

The engine to be furnished under the contract shall be performance tested by the Contractor on a dynamometer at the engine manufacturer's test facility or test laboratory before shipping to the pump station. All costs for engine performance testing shall be included in the price bid for Item 39.

18.5.2 Measurements Required

The following measurements shall be recorded during the test:

18.5.2.1 Load Measurement - by dynamometer, or other suitable means approved by City.

18.5.2.2 Speed Measurement - by electronic or other suitable means approved by City.

18.5.2.3 Barometric Pressure Measurement

18.5.2.4 Combustion Air Inlet Temperature Measurement - by calibrated temperature gauge.

18.5.2.5 Fuel Consumption Measurement - by calibrated meter.

18.5.2.6 Exhaust Back Pressure Measurement - by water manometer.

18.5.2.7 Intake Manifold Vacuum - by mercury manometer.

18.5.2.8 Oil Pressure Measurement - by calibrated pressure gauge.

18.5.2.9 Outlet Jacket Water Temperature - by calibrated temperature gauge.

18.5.2.10 Inlet Jacket Water Temperature - by calibrated temperature gauge.

Sec. 18.5 continued.

18.5.2.11 Radiator Inlet Air Temperature Measurement - by calibrated temperature gauge.

18.5.2.12 Radiator Outlet Air Temperature Measurement - by calibrated temperature gauge.

18.5.3 Test Code Requirements

All of the Contractor's dynamometer test facilities shall conform with recommendation of the Internal Combustion Engine Institute.

18.5.4 Results Required

The results of the tests above performed when plotted on the certified published engine performance curves furnished by the Contractor shall fall within the following tolerances to be considered as meeting the specifications:

- A. Maximum horsepower shall not be more than five per cent below the manufacturer's certified published performance curve.
- B. Natural gas consumption shall not be more than five per cent above the manufacturer's certified published performance curve.

Engines not meeting the specification requirements shall be altered or replaced and retested by the Contractor until approved by the Engineer.

Upon completion and acceptance of the engine dynamometer performance tests, the Contractor shall furnish the City with reproducible tracing or sepia of the actual test performance curve of the engine plotted from the witnessed dynamometer test data.

18.5.5 Notification

The Contractor shall notify the City two weeks in advance of engine performance tests. All performance tests will be witnessed by the

Sec. 18.5 continued.

City, unless specifically waived by the City at the time notification is given.

18.6 Certified Engine Published Performance Curve

The Contractor shall submit for review eight certified copies of the manufacturer's published engine performance curves for the engine he proposes to furnish under the contract. The curves shall accompany the engine shop drawing submittal required under Section 2 of these specifications.

The City will review the curve data and if acceptable in accordance with specifications requirements will so designate on all copies of the curves.

The actual dynamometer engine performance tests required under the contract shall not be performed until the City has reviewed the certified published engine performance curves.

18.7 Payment

All costs for the engines with accessories as specified in this section shall be included in the price bid for Item 39.

SECTION 19: CONNECTING DRIVE SHAFTS

19.1 Drive Shaft Assembly

Each clutch shaft shall be connected to the right angle gear input shaft with a Model J-490 "Twin Disc" or Model WL-90 Watson flexible Shaft, or a City-approved equal drive shaft assembly.

Shaft shall consist of two flexible joints and a center section which includes shaft flexibility features, and two special flanges; one for the clutch power take-off shaft at the engine and one for the right angle gear drive input shaft. Overall length shall suit 48" clear between ends of shafts.

The torque rating of the coupling selected must exceed by a minimum of 1.5 to 1, the maximum torque of the engine, when transmitting maximum horsepower at 1200 RPM. The drive shaft bearings shall have a B-10 minimum life of 16,000 hours. Data supporting selection criteria shall be included with Working Drawings for Natural Gas Engines to be submitted for City approval. Applicable data shall be included in the Contractor's torsional analysis.

19.2 Drive Shaft Guard

A suitable drive shaft guard shall be furnished and installed for each shaft. The guard supports shall be anchored to the motor room floor and engine foundation. The upper portion of the guard shall be hinged and shall be provided with a padlock hasp. The guard arrangement shall be such that service and lubrication can be readily accomplished. A working drawing shall be furnished as part of the Natural Gas Engine submittal required by Section 2.

Guard shall be designed in conformance with the "State of California Industrial Safety Orders." Guard shall be painted as specified in Section 25.

19.3 Payment

All costs for the Connecting Drive Shafts and guards as specified in this section shall be included in the price bid for Item 39.

SECTION 20: PUMP DISCHARGE MANIFOLD AND RELATED ITEMS

20.1 General

The discharge lines from all pumps, extending from the pumps inside the pump station to the downstream end of the discharge manifold outside the station, shall be constructed as shown on the drawings and as specified herein.

All costs for the installation of discharge manifold and related items as described in this section, except for shoring of excavation, shall be included in the price bid for Item 46. Shoring of excavation shall be paid for under Item 3.

20.2 Discharge Piping - Main Pumps

The discharge for each main pump shall consist of a check valve bolted to the pump discharge elbow, followed by a steel pipe spool connecting the check valve to a steel pipe fabricated manifold extending through the pump station wall, the manifold then terminating downstream in an adaptor for connection to concrete pipe.

20.2.1 Steel Pipe and Fittings

A steel pipe section shown on Sheet 23 shall extend from the pump check valve to a point inside the pump station wall and shall be flanged at the upstream end. The steel pipe section shall have a minimum wall thickness of 1/4 inch, and shall be fabricated from steel plate ASTM A 283 Grade C. Pipe size shall be as required to match pump elbow and check valve.

The steel pipe section shall be connected to the pump discharge valve by a flanged connection and to the manifold using a flexible coupling so as to be readily removable.

The coupling shall be of such a design that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation or other adjustments of the discharge line, and shall be assembled with stainless steel bolts and nuts.

The coupling shall be Dresser Style 38, equivalent by Baker or a City-approved equal.

Sec. 20.2 continued.

Flanges shall be standard steel ring flanges, Class D, complying with AWWA Standard C207-55, electrically welded to the pipe. Bolts and nuts both upstream and downstream of the check valves shall be carbon steel complying with AWWA Standard C 207-55 and ASTM A307. All gaskets shall be cloth impregnated neoprene.

The steel pipe section shall be epoxy lined and coated as specified in Section 25.

20.2.2 Manifold and Steel-to-Concrete Pipe Adaptor

Manifold shall be designed to withstand external design loads equivalent to 2250 D. and 18 psi internal pressure and shall consist of steel plate of diameters varying from 24" and 36" at inlet elbows to 54" at downstream end. Plate shall be ASTM A 283, Grade C, of 1/4-inch minimum wall thickness, and fabrication shall be in accordance with AWWA Standard C201-66 for electrically welded steel water pipe. Exterior shall have cement mortar protective coating in accordance with AWWA Standard C205-62 and interior shall be epoxy coated in accordance with Section 25.

Adaptor shall consist of a steel pipe section, 61-1/2-inch outside diameter and 1/4-inch minimum wall thickness with standard steel sized bell ring one end, reducing at opposite end to steel cylinder with cement-mortar lining and coating, 54-inch inside diameter, suitable to receive spigot-end reinforced concrete pipe with rubber-gasket joint.

Adaptor shall be welded to and integral with manifold and shall be fabricated from steel plate as described in 20.2.1 above. Cement-mortar lining and coating shall be Type II cement, with welded wire fabric reinforcing complying with ASTM A-185.

20.2.3 Cam-Locked Closures

Cam-locked closures shall be thirty-inch diameter, designed to A.S.M.E. Code specifications. Code stamp is not required. Covers shall be ductile iron and weld ring stubs shall be steel plate with a minimum wall thickness of 1/4 inch, conforming to ASTM A285 Grade C. Ten cam-locks shall be equally spaced around the circumference of the cover. Cams shall be standard type with integral handle and shall have cadmium-plated fittings. A neoprene gasket shall be inserted into the cover so as to maintain watertightness when the cover is locked and shall remain securely embedded in the cover when the latter is opened. Closures shall be epoxy coated as specified in Section 25.

Sec. 20.2 continued.

Closures shall be welded to the manifold and shall be subjected to shop hydrostatic pressure test as specified in Subsection 20.6.1.

Closures shall be Part No. 3036-1-E-C-4-2-ST-1-N as manufactured by West Coast Engineered Products, or City-approved equal.

20.3 Discharge Piping - Sump Pump

The sump pump discharge line, as shown on the drawings, shall consist of a 6-inch steel pipe portion, and 8-inch steel pipe portion, a flexible hose section and fittings.

The steel pipe shall be ASTM A 120 Schedule 40, black, with flanges ASTM A 181 Grade 1, 150 pound ANSI. Eight-inch steel pipe in the sump shall be fabricated in a maximum of 10 foot lengths. Eight-inch pipe outside the pump station shall be fabricated integral with manifold. Pipe inside sump room shall be supported by split clamp pipe hangers except where welded steel brackets are shown. Hangers and brackets shall be galvanized. Bolts and nuts shall be stainless steel.

All steel pipe and fittings shall be epoxy coated inside and outside as specified in Section 25. All bolts and nuts shall be stainless steel. Gaskets shall be cloth impregnated neoprene.

Flexible discharge hose shall be 6-inch I.D. SBR-2, 5 ply rubber impregnated duck with abrasion-resistant synthetic rubber cover. Hose shall withstand a minimum working pressure of 55 psi. Hose shall be fastened to adaptors by stainless steel clamps.

20.4 Check Valves and Air Valves

The Contractor shall furnish and install one 24-inch and three 36-inch diameter slanting disc check valves for the main pumps as shown on the drawings. For both sizes, the body of check valve shall be two (2) piece construction, bolted together through the center section, in a manner to capture the seat on an angle. The seat ring and disc ring must be replaceable in the field without need for machining. The area throughout the valve body must be equal to full pipe area. The body and disc of the check valve shall be made of cast ductile iron or carbon steel with flanged ends. The valve shall have stainless steel internal trim, stainless steel fasteners, inspection hand hole, a hydraulic closing damper (oil dashpot), and a

Sec. 20.4 continued.

position indicator. The closing damper shall provide for a free opening and a positive non-slam closing. The hydraulic damper shall be designed to contact the disc during the last ten (10) per cent of the closure and control the final closing of the valve to prevent slamming. The rate of closure shall be externally adjustable.

The ductile iron or carbon steel components of the body and disc of valve, the exterior of closing damper and the internal parts of closing damper exposed to the water shall be epoxy coated completely. The epoxy coating to be as specified under the painting section and to be a thickness of .012-inch plus or minus .002-inch.

The cast ductile iron if used for the body, disc and damper housing shall conform to ASTM A-536, Grade 65-45-12. The cast carbon steel if used for the body, disc, and damper housing shall conform to ASTM A-27, Grade 70-40. The stainless steel for the internal trim such as disc seat ring, seat, pivot pin, bushing and damper internals shall be a 300 series stainless steel conforming to ASTM A-276. All stainless steel bolting shall conform to ASTM A-320, Grade B8M.

The ~~36~~-inch slanting disc check valve shall be a Series 800, as manufactured by Valve and Primer Corporation or a List 23 as manufactured by Chapman Division of Crane Company or a City-approved equal.

The check valve for the sump pump shall be an eight-inch diameter swing check valve, ferrosteeel body, bronze trim, flanged, 125-pound, with leather-faced disc. Valve shall be Crane No. 373 or City-approved equal.

Air-release valves shall be air and vacuum type designed to release air from pump columns and from the discharge manifold and to prevent vacuum conditions. Valves shall be in accordance with the following schedule:

Pump No. 1:	4" Apco No. 1604/152 with slow-closing attachment or City-approved equal.
Pumps Nos. 2, 3 & 4:	6" Apco No. 1606/153 with slow-closing attachment or City-approved equal.
Manifold Vent:	4" Apco No. 152 with screwed top outlet or City-approved equal.
Sump Pump:	1" Apco No. 142 or City-approved equal.

20.5 Installation of Discharge Manifold and Piping

20.5.1 Excavation

The excavation for the discharge manifold shall be carried out, and any necessary shoring shall be designed and placed in accordance with Section 4.

20.5.2 Concrete Mattress

After the manifold is secured in place true to line and elevation, the concrete mattress shall be placed under the entire length of the manifold which is 48" or larger steel pipe diameter. Concrete strength shall be a minimum of 2000 psi at 28 days and shall be as specified in Section 6.

20.5.3 Backfill

All backfill shall be placed as specified in Section 4.2

20.6 Testing of Discharge Piping and Manifold

20.6.1 Shop Hydrostatic Test

The 24-inch and 36-inch pipe spools and the 54-inch discharge manifold shall be subjected to a hydrostatic pressure test as specified in sub-section 207-2.9.5, as amended. The test pressure shall be forty pounds per square inch (40 psi).

20.6.2 Field Pressure Test

The discharge manifold shall be pressure tested after installation in the field. Prior to testing the pipe, the Contractor shall advise the Engineer of the planned scheme of testing, the details of the test bulk heads, the size and location of the pump and location of metering devices and pressure gauges. The Contractor shall provide calibrated meters or tanks for measurement of leakage, the necessary pipe, calibrated recording pressure gauges, water, pump, power, labor and other apparatus necessary for obtaining and maintaining the required water pressure.

Sec. 20.6 continued.

The manifold shall be slowly filled with water and placed under slight pressure for a minimum of 48 hours. During the filling of the pipe and before applying the specified test pressure, all air shall be purged from the pipe line. To accomplish this, taps may be made as necessary at the point of highest elevation and after completion of the test; the taps shall be tightly plugged to the satisfaction of the Engineer. The duration of the test shall be not less than 4 hours during which the recording pressure gauges shall be in operation. The test pressure (P) shall be equal to forty pounds per square inch (40 psi).

If the leakage exceeds the amount determined by the formula in subsection 306-1.4.4, the manifold being tested will be considered defective. The Contractor shall determine the points of leakage, make the necessary repairs and make another test. This procedure shall be continued until the leakage falls within the allowable maximum. However, regardless of the test results, all detectable leaks shall be repaired by the Contractor. Leakage shall be determined by a calibrated meter device to measure the water coming into the pipe line while under the required pressure or by suitable calibrated tanks used for measurement of leakage. The Contractor shall assume all responsibility for any damage to the manifold as a result of pressure imposed during the operations of filling the pipe with water and conducting the tests.

The 8-inch steel discharge line is not to be field pressure tested.

20.7 Working Drawings

Detail working drawings shall be furnished on the pump discharge manifold and piping as specified in Section 2.

20.8 Payment

All costs for Discharge Manifold and Related Items as specified in this section shall be included in the price bid for Item 46.

All costs for Air Valves and related piping as specified in this section shall be included in the price bid for Item 53.

All costs for Check Valves and related piping as specified in this section shall be included in the prices bid for Items 42, 43 and 45.

SECTION 21: BRIDGE CRANE

21.1 General Requirements

A complete single trolley, single girder top-riding bridge crane shall be furnished and installed by the Contractor in the pump station engine room. Crane shall be equipped with electrically-powered longitudinal and lateral travel and shall have an electrically-powered hoist of 5-ton capacity, low-headroom type. Pendant pushbutton control shall be operable from engine room floor level.

All equipment shall be products of nationally recognized equipment manufacturers. Hoist shall be a model which has been in operation for a period of at least five years.

21.2 Manufacturer's Qualifications

Equipment provided shall be designed, fabricated and installed in accordance with best industry standards and be of standard design of manufacturer. The Contractor shall provide evidence of having made other satisfactory installations of equipment of the size and type proposed.

21.3 Working Drawings

The Contractor shall submit 8 copies of working drawings showing general arrangement and control wiring diagrams to the City for approval. The Contractor shall also submit 8 copies of structural calculations, load ratings, and manufacturer's data clearly defining the equipment. After completion of the work, he shall submit 8 copies of as-built drawings, parts list, printed description of operation and maintenance procedures.

21.4 Codes and Standards

Where applicable, work shall conform to the following:

- A. California Admin. Code, Title 8, Division of Industrial Safety.

Sec. 21.4 continued.

- B. American Safety Code for Cranes, Derricks and Hoists, ANSI B 30.2 - 1943 (R 1952), latest revision.
- C. Specifications for Electric Overhead Traveling Cranes published by the Crane Manufacturer's Associates of America, Inc. (Specification #70).

21.5 Materials

Material not definitely specified shall be the best quality used for the purpose in commercial practice. Material shall be free from all defects and imperfections that may affect the finished product. Structural steel shall conform to ASTM A-36.

21.6 Specific Requirements

21.6.1 Hoisting and Traveling Speeds

The crane hoist shall be single-speed with a minimum of twelve (12) feet per minute and a maximum of fifteen (15) feet per minute. Bridge and trolley travel speed shall be a minimum of 45 feet per minute.

21.6.2 Hook Heights and Limits of Travel

The required upper and lower limits of hook heights and the required limits of travel longitudinally and laterally are shown on the drawings. All equipment proposed to be furnished and installed shall be capable of operating at full capacity within the limits shown. The maximum lift shall not be less than that capable of handling equipment through the floor openings from the bottom of the sump.

21.6.3 Service Rating

All equipment shall be of type suitable for Class A-1 service (standby).

21.7 Manufacturing Requirements

21.7.1 Design Safety Factors and Other Requirements

- A. Calculations of all structural members shall include allowance for vertical impact of 25% of live load and for lateral impact of 20% of combined weight of hoist, trolley and live load.
- B. Live load deflection of bridge girder shall not exceed $1/600$ of the span.
- C. The design of the hoist cables shall be based upon a safety factor of 5 to 1 throughout, based on the ultimate strength of materials.
- D. All equipment utilizing structural steel or supporting structures shall be designed in accordance with the specifications of the American Institute of Steel Construction, current edition, and where welding is employed, such work shall be designed in accordance with the standards of the American Welding Society.

21.8 Bridge Structure

The bridge structure shall be designed and fabricated as a complete integral structure comprised of girder, outrigger channel, bracing, end trucks and drive unit, with only such parts removable as required to facilitate the erection or maintenance of equipment.

21.9 Wheels, Axles, Gears and Bearings

All wheels and gears shall be mounted so that they may be removed without disassembling any major part of the crane.

The bridge drive wheels shall be connected by a squaring shaft through intermediate gearing.

21.9.1 Wheels

Wheels shall be of the double flanged type made from steel. The wheels shall have deeply treated (chilled) treads and shall be ground to equal diameters in matched pairs to fit the rails on which they are to operate.

Sec. 21.9 continued.

21.9.2 Axles

Wheel axles may be of the stationary or rotating type, and shall be made from high carbon steel. Where rotating type axles are used, wheels shall be pressed on their axles and the driving wheels keyed to their axle. The axle bearing assemblies shall be supported in diagonally split bearings. Where stationary axles are used, they shall be machined to receive the roller bearings.

Axles shall be prevented from turning or rotating endwise by means of a key plate fitting into a milled slot in the end of the axle and bolted to the end trucks.

21.9.3 Gears

All gear teeth shall be machine cut from solid stock.

Spur gears and pinions shall be made from high carbon steel forgings and shall have 14-1/2 or 20 degree stub teeth, heat treated, as required.

Worm gear sets shall consist of a forged steel worm with ball bearing thrust and a bronze worm wheel made from special gear bronze.

All gears in the hoist gear train shall be made from steel.

21.9.4 Bearings

Bearings shall be high grade, heavy duty, ball or roller bearings as the location may require. All bearing housings shall be equipped with grease fittings.

21.10 Bridge Drive

21.10.1 General

Bridge movement shall be single-speed with electric motor drive.

Sec. 21.10 continued.

21.10.2 Bridge Motor and Machinery

Bridge drive shall consist of an electric motor driving a cross shaft through a fluid coupling and a self-contained spur or worm gear speed reducer unit and including a bridge brake. The cross shaft shall be supported at not less than 7'-0" centers by anti-friction bearings with grease fittings.

The bridge motor, fluid coupling, speed reducer unit, and bridge brake shall be independently mounted on a common base in a horizontal plane with cross shaft. Driving pinions and gears shall be mounted on short shafts to facilitate handling when replacements are necessary. The bridge brake shall be mounted so that the bridge motor armature may be removed without dismantling the brake.

The bridge motor shall be as specified in Subsection 21.11.2 hereinafter.

21.11 Hoist and Trolley

21.11.1 General

The hoist machinery shall consist of an electrically-driven train of spur gears, electrical and mechanical load brake, and a right- and left-hand grooved drum lapping. The trolley shall be integral with the hoist, but with a separate electric drive motor.

21.11.2 Hoist Motor

The hoist shall be powered by a single speed, 480 volt 3-phase, A.C., 60-hertz motor, totally enclosed type, for crane and hoist service, 30 minute duty, 55 degrees centigrade temperature rise.

21.11.3 Trolley Motor

The trolley shall be powered by a motor as specified under Subsection 21.11.2 above.

Sec. 21.11 continued.

21.11.4 Brakes

The hoisting mechanism shall be equipped with quick acting, positive, electrical and mechanical load brakes, to hold and control the load.

The electric brake shall be spring set and released by a solenoid magnet whenever current is flowing to the motor. Brake shall be of the shoe or disc type and easily adjusted for wear.

The automatic load brake shall be of the double disc type with large friction surfaces and shall operate in oil.

21.11.5 Switches

The hoist shall be equipped with an upper limit switch to prevent over travel of the hook block.

The hoist shall be furnished with an adjustable lower limit cut-out switch, set to prevent unreeling of the entire cable from the drum.

21.11.6 Drum

The hoisting drum shall be a right and left hand grooved drum. The hoisting motor shall be geared to the drum with suitable reduction gearing.

The hoist cable shall be securely attached to the drum by means approved by the State Industrial Safety Commission.

Enough cable and drum capacity shall be provided so that when the full specified length of cable (hook touching sump floor) is unravelled, at least 3 laps of rope remain on drum.

21.11.7 Hoisting Rope

The hoisting rope shall be of an extra flexible construction and of a proper size to give a safety factor of at least five when fully loaded.

Sec. 21.11 continued.

21.11.8 Hoisting Tackle and Hook

The hoisting tackle shall consist of a safety type lower block and hook with necessary sheaves and hoisting rope. The lower block shall be a heavy steel housing to support the sheaves and hook. The hook shall be forged steel and shall be supported on a ball bearing thrust. The hook shall have a safety clasp, spring loaded, to protect the load from being released from the hook when the tension on the cables are released.

Sheaves shall be of a heavy pattern and shall have deep flanges and shall be properly grooved to fit the rope and properly guarded.

21.11.9 Trolley Stops

To prevent any part of the crane trolley projecting beyond the end of the crane bridge, rubber bumper trolley stops are to be provided on the bridge.

21.12 Power Supply and Control

21.12.1 Power Supply

Power supply shall be 480 volt, 3-phase A.C., 60 hertz, delivered to a junction box mounted at the southwest corner inside of the wall of the building, at an elevation of twenty feet above floor level.

Supply from junction box to the bridge crane may be by reel or by tagline and suspended conductor cable, but in either case the conductor cable shall not sag below the underside of the crane rail support beams when the bridge crane is at the easterly limit of its travel. A reel or tagline and suspended conductor cable of identical type to the above shall also be mounted on the bridge to supply power to the hoist and trolley motor. Conductor shall not sag below level of bottom of hoist reel when hoist is at limit of travel in either direction.

21.12.2 Control

Control of hoist, trolley and bridge movement shall be from a pendant push button station with 110 volt circuits and with bottom of station four feet above engine room floor. The pendant shall be grounded and shall be shock-proof, and control shall be suitable for 1/8 inch increment inching

Sec. 21.12 continued.

movement. The pendant station shall also incorporate a strain chain running parallel to the cable, and shall be fully-floating, suspended from a track under the outrigger channel.

All electrical work shall be installed according to the National Electrical Code, the State Building Standards, Basic Electrical Regulations and all local regulations.

21.13 Measurements and Clearances

Provision must be made to provide suitable clearances overhead and at each end of the crane so there will be no interferences between the crane and any parts of the building or building obstructions, except that hoist hook in highest position may be permitted to lay on office roof with hoist over office.

21.14 Operating Tests and Adjustments

Upon completion of installation, the entire system shall be thoroughly lubricated, aligned, and adjusted. The bridge crane installation shall be tested by an agency approved by the State of California. The crane shall be tested according to the provisions of Sections 5021 through 5023 of the State Industrial Safety Orders. The testing agency shall certify the bridge crane installation after satisfactory completion of all tests.

21.15 Painting

Refer to and comply with Section 25: Protective Coatings and Tape. All exposed ferrous metal surfaces except those in rolling or sliding contact shall be thoroughly cleaned and be given one coat of primer followed by two coats of machinery enamel. The rails, bridge structure, hoist, hook and the supporting load block shall be painted OSHA yellow. Rail beams shall be painted Long Beach blue. All painted surfaces shall be touched up as necessary after installation.

21.16 Name Plates

Name plates shall be permanently attached to the bridge and load block showing capacity in short tons of 2,000 lbs.

21.17 Maintenance and Operations Manuals

The Contractor shall furnish eight operating manuals, repair and parts catalogs bound together as specified in Section 2.

21.18 Payment

All costs for the bridge crane and related items including all costs for testing and certification as specified in this section shall be included in the price bid for Item 38.

SECTION 22: ELECTRICAL WORK

22.1 General

The electrical work shall include the furnishing of all electrical equipment, apparatus, fixtures, and accessories shown or specified, the furnishing of all labor and equipment required to make installation of same, and the complete wiring, connecting testing, and making the electrical systems for use (except as specifically modified on the drawings and specifications). Furnishing of pump motors is not included in this section. All electrical equipment shall be the latest production model of a manufacturer who has produced this type of equipment for at least three (3) years.

22.2 Work Included In This Section

The work of this section includes, but is not limited to, the following major items and all work relatively incidental thereto:

- 22.2.1 Two electric underground services, 120/240 volt single phase, three wire, for lighting and receptacles and 480 volt, three phase, four wire, for power. Contractor shall pay established costs for electrical services to be furnished by utility company.
- 22.2.2 Underground telephone service and conduit system.
- 22.2.3 Complete interior and exterior lighting including lamps and ballasts.
- 22.2.4 Complete receptacle system.
- 22.2.5 Complete main switchboard assembly, including motor control units.
- 22.2.6 Connections to electric pumps, natural gas engines and their associated controls.
- 22.2.7 Connections to recording instrument panel.

Sec. 22.2 continued.

22.2.8 Furnish and install intrusion alarm system.

22.2.9 Furnish and install heating equipment.

22.2.10 Connect all electrical equipment.

22.2.11 Tests.

22.3 Work Not Included in This Section

22.3.1 Electric motors for pumps.

22.3.2 Recording instrument panel.

22.3.3 Water level recording system.

22.3.4 Gas detection system.

22.3.5 Telemetry system.

22.4 Special Provisions

22.4.1 General

The Contractor shall make all necessary provisions throughout the building for the installation of proper backings, supports, inserts, anchors, and bolts for the hanging and support of all electrical fixtures, conduit, panelboards, and switches, also all provisions required for coordination of the work.

22.4.2 Regulations and Codes

Work and materials shall conform to the latest rules of the National Board of Fire Underwriters, wherever standards have been established and label service is regularly furnished, all local and state ordinances, electrical regulations from Long Beach Municipal Code,

Sec. 22.4 continued.

the State of California Administrative Code (including Title 24, Part 3 Electrical Regulations), the State Fire Marshal and all prevailing rules and regulations. Nothing in these specifications shall be construed to permit work not conforming to the most stringent of applicable codes.

Should any changes be necessary in the drawings or specifications to make the work comply with these requirements, the Contractor shall notify the Engineer at once and cease work on all parts of the contract which are affected.

22.4.3 Drawings and Intention

Accompanying drawings and schedules are for the convenience of the Contractor and indicate minimum requirements. Locations shown on the drawings are reasonably correct but their absolute accuracy cannot be implied or assumed. The exact locations, levels, and distances shall be governed by the actual construction and field measurements made by the Contractor.

It is the intention of these specifications and drawings to secure an electrical installation complete in every detail. The Contractor shall not omit or fail to furnish any necessary or required element or part because of failure of City to specify or name such element or part.

Interpretations as made by the City shall govern the work and the Contractor's bid shall include all work and costs incidental to the carrying out of such interpretations.

22.4.4 Record Drawings

Provide and maintain in good order a complete set of electrical contract prints. All changes to the contract shall be clearly recorded on this set of prints. At the end of the project, the Contractor shall transfer all changes, in ink, to two sets of prints for submission to the Engineer. The first sheet of each set shall be signed by the Contractor and Inspector as being a correct and accurate record of the installation. Prints will be furnished to the Contractor by the City when requested.

Sec. 22.4 continued.

22.4.5 Shop Drawings

The electrical drawings shown are diagrammatic only. The Contractor shall submit complete electrical working drawings (shop drawings) as required in Section 2, prior to starting any electrical work.

22.4.6 Coordination

The electrical work hereinunder shall be coordinated by the Contractor with the work specified under other parts of these specifications and with the serving utility company's requirements.

If any project work must be altered due to lack of coordination by the Contractor, he shall be responsible to correct any such work at his own expense to the full satisfaction of the Engineer.

22.4.7 Guarantee

All materials and equipment provided and installed under this part shall be guaranteed by the Contractor for a period of two years from the date of acceptance of the work by the City, as specified in Section 2.

22.5 Materials

22.5.1 General

All materials, including equipment, accessories, fixtures fittings, and all elements and parts shall be new.

Manufacturer's names and trade names identified with certain materials are mentioned on the drawings and in the specifications. Products of other manufacture may be permitted on an "or equal" basis provided that such approval is first obtained from the City. Reference is made to Section 2.

Approved materials shall be selected from those listed in the publications of the Underwriters Laboratories, Inc., entitled "Electrical Equipment List." The materials shall bear the labels where labels are

Sec. 22.5 continued.

indicated to be used in said publications. Any materials not listed shall have specified approval by the City before they are to be used in this work. Materials not having this approval shall not be kept at the construction site. All material for the same purpose shall be of the same make and quality throughout the work and as hereinafter specified. Capacities, sizes, and dimensions given are minimum unless otherwise indicated. In addition, where maximum dimensions are indicated, due to space requirements these maximums shall be maintained. All manufactured materials shall be delivered and stored in their original containers which shall indicate clearly the manufacturer's name, the brand, and identifying number. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.

As a part of his submittal for mechanical and electrical work, the Contractor shall furnish the Engineer within sixty (60) days after award of contract, eight (8) copies of a complete list of the materials showing the manufacturers of the equipment designated to be installed. Materials which have not received the approval of the Engineer shall not be incorporated into the work.

The Contractor shall be entirely responsible for all electrical materials, appliances, fittings, fixtures, assemblages, and parts delivered to the site of the work to be installed by him and shall provide for their storage and protection during storage and during construction. Damaged materials shall be removed and replaced at the Contractor's expense before the final inspection and approval.

22.5.2 Conduit

Conduit shall comply with the requirements of the Underwriters Laboratories, and shall be delivered to the site in standard lengths, with each length bearing manufacturer's trademark or stamp and Underwriters label. Rigid conduit shall be used throughout except for connections to equipment and shall be standard weight, rigid steel, hot-dipped galvanized, whether inside or outside the building, under floor, in concrete, in contact with earth or in damp location.

Sec. 22.5 continued.

Couplings and connectors shall be galvanized and shall not be the indent type, set screw type or similar, but shall be of the screw thread type. Conduit ells shall be of the same material and make as the conduit. The radius of the curvature must not be less than six (6) times the internal diameter of the conduit and the enclosed angle not less than ninety (90) degrees. Minimum conduit size shall be 3/4 inch. Conduit underground shall be installed a minimum of 18 inches below the finished surface and encased in concrete.

Conduit fittings shall be used in place of bends on all 1-inch or larger conduit runs exposed in the engine room. Use of conduit bends in lieu of fittings will be permitted only at inaccessible locations.

Conduit and fittings exposed in the pump pit shall be epoxy coated.

Flexible conduit shall be liquid-tight neoprene jacketed "Sealtight" flexible conduit with liquid-tight compression type connectors, and bonding grounding conductors.

22.5.3 Wire and Cable

All wire shall be delivered to the site in unbroken packages and packages shall be inspected and approved by the Engineer before opening. Packages shall be plainly marked or tagged as follows:

- 22.5.3.1 Underwriters labels.
- 22.5.3.2 Kind, size and insulation.
- 22.5.3.3 Name of manufacturing company and trade name.
- 22.5.3.4 Month and year when manufactured, which date shall not exceed eight (8) months prior to the date of delivery at the site.

Sec. 22.5 continued.

Wire and cable operating at 480 volts and less shall be insulated for 600 volts, National Electrical Code standard of type specified below and shall comply with the requirements of the Underwriters Laboratories standard for wire and cable rated 600 volt.

Conductors shall be copper and sizes larger than #8 shall be stranded. Conductors of the following types shall be used in the following locations:

22.5.3.5 Light and power circuits:

Conductors shall be Underwriters type THHN or THWN. Minimum size of conductors shall be #12 AWG, except control wiring which can be #14 AWG, and where specifically noted otherwise.

22.5.3.6 Line voltage control circuits for mechanical equipment shall be 600 volt, Underwriters type THWN conductors.

22.5.4 Bushings and Locknuts

Bushings and locknuts and similar devices shall be galvanized up to 1-inch conduit. Aluminum die-cast or pot metal fittings will not be accepted. Insulating bushings shall be used for conduits over one inch.

22.5.5 Splices in Wire and Cable

Make joints, splices, taps, and connections for 600 volt conductors with solderless connectors approved by the Engineer. Approved connectors are:

22.5.5.1 For wire #10 AWG and smaller:

22.5.5.1.1 "Scotchlok"

22.5.5.1.2 Ideal (set screw type) connectors

22.5.5.1.3 Buchanan connectors

Sec. 22.5 continued.

- 22.5.5.1.4 Marr connectors
- 22.5.5.2 For wire #8 AWG and larger:
 - 22.5.5.2.1 T & B "Lock-Tite" connectors
 - 22.5.5.2.2 Brandy Versitaps and heavy duty connectors
 - 22.5.5.2.3 O.A. solderless connectors
 - 22.5.5.2.4 Trumbull solderless connectors

Tape all connections with Scotch Tape #33 or a City-approved equal.

22.5.6 Outlet Boxes

Outlet boxes and covers shall be pressed steel knockout type for concealed mounting and shall be hot-dipped galvanized. All boxes shall be of proper code size for the number of wires or conduits passing through or terminating therein, but in no case shall any pressed steel box be less than 4 inches square unless specifically noted as smaller on the drawings. Boxes at end run and containing a single device may be of the handy box type. Covers for flush outlets shall finish flush with the finished surface. Approved factory-made knockout seals shall be used in all boxes where knockouts are not intact. Boxes in concrete shall be a type which will allow the placing of conduit without displacing the reinforcing bars. Outlet boxes shall be used as pull boxes wherever practicable.

Light outlet boxes shall be equipped with fixture supporting devices as required by unit to be installed. Fixture weights in excess of 6 pounds shall not be supported by outlet box cover screws.

Switch outlet boxes shall be solid gang boxes. Where two switches are installed in one box, 4-11/16 inch square by 2-1/8 inch deep boxes will be minimum size allowed.

Outlets for exterior mounting shall have weatherproof connections all around; boxes shall have suitable gaskets.

Sec. 22.5 continued.

22.5.7 Junction and Pull Boxes

Pull boxes shall be installed in all conduit runs wherever indicated and/or where necessary, in order to facilitate the pulling of wires or cables. Boxes shall be provided with removable covers, secured with machine screws. Where more than one junction box is used in any room, the junction box covers shall be identified. All surfaces of boxes and covers, inside and out, shall be given a primer coat and one coat of gray paint. Conduit shall enter the boxes through tight fitting, bored or punched holes, and shall be secured to the boxes with double locknuts and bushings.

22.5.8 Wiring Devices

Duplex convenience outlets shall be grounding type, ivory, and shall have two current-carrying parallel contacts and one "U" shaped grounding contact which is internally connected to the receptacle frame, and shall be rated 20 amperes, 125 volts. The duplex convenience outlets shall meet Federal Specification W-C-596 (D4 and D8).

Receptacle shall be one of the following:

<u>Manufacturer</u>	<u>Catalog Number</u>
Hubbell	5352-1
Arrow-Hart	5735-S1
Bryant	5352-1
General Electric	GE-4108-2
Sierra	1462

Local switches shall be AC "T" rated specification grade, "Quiet", ivory, totally enclosed, of bakelite base toggle type and shall meet Federal Specification W-S-896. Switch ratings shall be in accordance with the following table of loads:

<u>Watts</u>	<u>Rating</u>
0 to 1400 W @ 120 V	15A, 120-277 V AC
1400 to 1920 W @ 120 V	20A, 120-277 V AC

Sec. 22.5 continued.

Local switches shall be as manufactured by one of the following:

Hubbell, Arrow-hart, General Electric, Bryant or
Sierra.

22.5.9 Plates

Plates shall be supplied for every local switch, receptacle, telephone outlet, and similar items. All switch plates shall be furnished with engraved or etched designations under any one of the following conditions:

22.5.9.1 Switches at which the equipment or circuit controlled cannot readily be seen at the switch location.

22.5.9.2 Where so indicated on the drawings.

Plates shall be of the best quality molded bakelite, of ivory color, equal to Sierra "P-line", or Bryant Uniline, or a City-approved equal, in all finished locations, and .040" satin-finish stainless steel plates in motor room. Install weatherproof plates where exposed to weather or called for on drawings.

22.5.10 Name Plates

Provide engraved laminated plastic (black-white-black) name-plates for switchboard, motor starters, panelboards, transformers, and all other fabricated equipment. Size of engraved letters shall be 1/4 inch high minimum. Letters shall be vertical and shall be upper case. Submit shop drawings for proper size and nomenclature.

22.5.11 Gutter

Gutter shall be of the lay-in duct flangeless or concealed flange type and shall be furnished as a complete and continuous raceway. Gutter shall be sized as indicated and shall be equipped with hinged cover. All fittings and hanger facilities shall be furnished and installed

Sec. 22.5 continued.

to provide a completed raceway, including connectors at terminations. Threaded screws shall be used at each connection so that complete electrical continuity will exist.

22.6 Electrical Devices

22.6.1 Motor Starters

Motor starters shall be Allen Bradley Bulletin 713 (or Cutler-Hammer, Square-D, Westinghouse, or General Electric equivalent), Type I, across-the-line combination circuit-breaker, magnetic starter with three overload elements. Circuit-breakers shall be as described herein. Selector switches and "push-to-test" 6 volt pilot lights in the covers as shown shall be Bulletin 800T.

22.6.2 Circuit-Breakers

Circuit-breakers shall be automatic trip-free, quick make, quick break, thermal-magnetic type, bolt on type, with handle clearly indicating tripped position. Breakers shall be of sizes and arrangements shown with voltage rating as required. All breakers shall be rated to interrupt maximum short circuit amperes. Breakers shall meet with the Underwriters requirements concerning harmless momentary overloads, and all breakers shall be provided with accessories for locking the handle in the "off" position.

Motor starter for the submersible pump shall meet additional requirements for ambient compensated quick trip overloads on all three phases. Provisions shall be made for connecting the internal motor thermal units into the holding coil circuit. A moisture sensing warning light shall be provided on the starter.

22.6.3 Control Relays

Control relays shall be machine tool type with contacts rated 10 amperes at 600 volts open type. Provide contacts and coil voltages as indicated. The relays shall be General Electric Class CR2811A, Square-D Class 8501 Type D, or equivalent by Cutler-Hammer or Westinghouse.

Sec. 22.6 continued.

A Warrick relay Type 2800 shall be provided for submersible pump motor moisture sensing circuit.

22.6.4 Sequence of Start Timers

Timers shall be equivalent to Microflex Reset Timer No. HA43-D6-C221, as manufactured by Eagle Signal Co., or equivalent by Paragon, or a District-approved equal.

Timing intervals shall be set as follows:

Pump #1 - 0 seconds

22.6.5 Time Delay Relay

Time delay relay shall have poles as indicated on plans and contacts rated 10 amperes at 480 volts. Coil voltage shall be as required. Timing range shall be 0 to 3 minutes with "on" delay. Square-D Class 9050, Type B, General Electric No. CR 2820B, or City-approved equal.

22.6.6 Dry Type Transformer

Transformers shall be indoor, dry type, self-cooled, with Class B insulation, 80 degrees C. rise. KVA and voltage rating shall be as indicated. Transformers shall be switchboard mounted as shown and shall be mounted on Korfund, or Vibra-Check, or City-approved equal vibration mounting pads.

22.7 Switchboard

The design of all current-carrying devices and parts of switchboard shall conform to the latest standards specified in the related sections of NEMA and IEEE Standards except as these characteristics may be modified herein. The switchboard shall include all items shown or listed on the drawings for the switchboard, including internal wiring and connections. Switchboard shall meet requirements of serving utility.

Sec. 22.7 continued.

The standard test for all switching and control apparatus systems 60 to 600 volts shall be 1500 volts, for one minute. Where standards on devices used on this equipment call for a lower test voltage, such devices may be disconnected during the test. Voltage tests shall be made in accordance with American National Standards.

All switchboard sections shall be constructed of stretcher leveled code gauge steel. All holes, supports, studs, and openings shall be standardized to enable interchange of interior and front cover units. All sections shall be fabricated with right angle corners, and plumb edges and surfaces. Each section shall be formed steel construction welded together to form a rigid, self-supporting, floor standing unit. Switchboard shall be NEMA 1 indoor construction.

Circuit-breakers shall be as described on the drawings. Circuit-breakers shall have an interrupting capacity of not less than 12,000 RMS amperes, symmetrical, at 480 volts.

The enclosure shall be parkerized or bonderized as a unit after all welding has been completed, then painted with a rust-resisting primer coat of paint. The back of the enclosure and the interior shall be finished with a coat of light gray baked enamel, and the front, top, and exposed sides shall be finished with a scratch-resistant silver-gray hammerstone finish.

All wiring gutters shall extend the full depth of the switchboard from front to back.

Watt-hour meter socket, RKVA meter socket, current transformer area, switchboard layout and equipment shall conform to the serving utilities requirements.

The service shall be three phase four wire with 50 per cent neutral. The neutral shall be grounded in the metering section of the switchboard. A ground fault relay with shunt trip on main breaker shall be provided for main switchboard ground fault protection.

Bus bars, connection bars, and wiring on the back of the switchboard shall be arranged so that maximum accessibility is provided for cable

Sec. 22.7 continued.

connections. Bus bars shall be copper and rated to carry not less than the ampere rating of the main breaker. Bus bars shall be braced to carry not less than 12,000 amperes. Bus shall be three phase, 4 wire, in metering section and 3 wire in other sections of switchboard.

Consideration shall be given to the arrangement of cables so they may be connected to the switchboard in an orderly manner. Electrical clearance between parts of opposite polarity and between live parts and ground shall conform to the National Electric Code. Provide a minimum vertical clearance of 12 inches between the terminals and the bottom of the switchboard enclosure.

A ground bus with a capacity equal to at least 1/3 of the capacity of the largest circuit shall extend throughout the entire length of the switchboard assembly. Each housing of the assembly shall be grounded directly to this bus.

All connections between bus bars shall be made by drilling and tapping the bus bars and attaching the breaker jumper bars with cap screws. Connections shall be arranged so that individual breakers from fifteen (15) to eight hundred (800) amperes may be removed and/or added without interference to the continuous operation of the entire switchboard section or the individual adjacent breaker units in the same panel. Switchboard shall be Square-D Type CBs, Cutler-Hammer Type CBN, General Electric AV line, or City-approved equal.

22.8 Panelboards

Panelboards shall be dead-front, safety type, equipped with circuit-breakers and shall be mounted as indicated. Bus bars shall have lugs for connection to 3 wire, 1 phase, 120-240 volt feeder, and provided with the number and size of single or double pole, branch circuit-breakers, as required by the panelboard schedule and diagrams on the drawings. Plug in circuit-breakers are also acceptable. Circuit-breakers shall have an interrupting capacity of not less than 10,000 RMS amperes at 120/240 volts.

Furnish and install in the space provided on the back of the panelboard door, a neatly typewritten list of all circuits. Lists shall be under clear glass or 1/32-inch Lucite, a minimum of 6 inches wide and shall clearly indicate the equipment supplied by each circuit.

22.9 Meters

22.9.1 Elapsed Time Indicator

Indicator shall have 3-1/2-inch commercial case reading to 99,999 hours plus tenths of hours and rated 480-volts, 60 hertz. General Electric No. 50-236302ACAA1, or equivalent by Hobbs.

22.9.2 Ammeter

An ammeter shall be furnished and installed on the switchboard for each electric motor driven pump as indicated on the drawings. Ammeters shall be 4-1/2 inches square panel mounting type and shall be equipped with necessary transformers and accessories required to provide readings as indicated below. Ammeters shall have an accuracy of one per cent or better, and a 250 degree scale.

The ammeter ranges shall be :

- 0 - 300 amps for 150 HP motor
- 0 - 30 amps for 15 HP motor

22.9.3 Voltmeter

A voltmeter and voltmeter switch shall be furnished and installed on the switchboard to check line voltage. Voltmeter shall be a 4-1/2" square panel mounting type with an accuracy of one per cent or better, and a 250 degree scale. The voltmeter range shall be 0-600 volts.

22.10 Electrical Equipment

22.10.1 Lighting Fixtures

The type of fixture for each location is denoted on the drawings. Fixtures shall be as shown in the fixture schedule and all fixtures of each type shall be by one manufacturer. A fixture shall be installed on each lighting outlet. Fixtures shall be inspected, approved, and labeled by Underwriters' Laboratories, Inc.

Sec. 22.10 continued.

22.10.2 Lamps

22.10.2.1 Fluorescent Lamps

Fluorescent lamps shall be standard cool white, rapid start lamps, manufactured by General Electric, Sylvania, or Westinghouse, in accordance with fixture requirements of those fixtures shown in the fixture schedule.

22.10.2.2 Incandescent Lamps

Incandescent lamps shall be of highest quality and shall be General Electric Type "G.E.", Westinghouse, marked "K"; Westinghouse, marked "W", or Sylvania Long Life series. Faulty lamps shall be removed and new lamps installed leaving fixtures properly operating.

22.10.3 Fluorescent Ballasts

Ballasts shall be rapid start, high power factor, with ETL and CBM labels. They shall be selected for quiet operation and those which prove to be noticeably noisy shall be replaced at the Contractor's expense. Ballasts shall be equipped with internally mounted automatic resetting thermal device.

22.10.4 Wall Heater

Heater shall be rated 3000 watts, 480 volts, 3 phase, 60 hertz and shall be surface mounted wall type. Heater shall be General Electric No. 2A375G32 or equivalent by Federal Pacific or City-approved equal. Provide thermostat, 3-pole contactor, and control transformer for heater.

22.10.5 Time Switches

Time switches for lights shall be DPST rated 40 ampere, 120 volt, with skip-a-day dial and shall be Tork Model No. 7200, Paragon 4003-0S, or a City-approved equal. Time switches for fans shall be SPDT rated 40 ampere, 120 volt and shall be Tork Model No. 8001, or a City-approved equal.

Sec. 22.10 continued.

22.10.6 Strip Heaters

Strip heaters in motors and switchboard shall be General Electric, Chromalox, or a City-approved equal with steel sheath mounted on brackets under the coils and connected with two similar 240 volt units in series on 240 volts.

22.10.7 Inlet and Exhaust Fans

The inlet and exhaust fans shall be as specified under Section 24 and shall be connected to their control switches as indicated on the drawings.

22.10.8 Contact Closures

Dry contact closures for approximately thirteen telemetry functions shall be provided as part of the electrical work. Interface to the telemetry equipment shall be made by wiring brought to the telemetry cabinet through conduit or CMT as shown on the drawings.

22.10.9 Intrusion Alarm System

The intrusion alarm system shall consist of a microwave (10.525 GHz) transceiver capable of detecting the motion of a man-sized object moving at a rate of from three inches per second (0.1705 miles per hour) to ten miles per hour. It shall be capable of protecting a maximum area of approximately 24 feet by 75 feet and be capable of having its range extended to approximately 24 feet by 100 feet by utilization of an antenna adapter. The range control shall be adjustable from zero to full range. A walk test light system shall be provided to aid in proper range adjustment with provision to disable circuit. Three units are required to cover the total area to be protected and there shall be compatibility among the units so that, if there is an overlap in the protected areas, the proper operation of all units will not be adversely affected by the simultaneous operation of the other unit. The total area to be protected is indicated on the plans, and an isolating switch shall be provided and located in the office to enable the system to be deactivated by authorized persons.

The transceiver shall have tamper-proof circuitry to provide protection against unauthorized opening of unit. It shall also have circuitry

Sec. 22.10 continued.

which monitors all electronics so if any component should malfunction or fail, the system goes into alarm. It shall have ability to discriminate against electrical noise, random motion and transients that can cause false alarms. All electronics shall be within the transceiver and shall operate from the output of separate 12 volt transformer supplied with 115 volts $\pm 15\%$, 50/60 hertz, single phase. A standby power supply shall be installed as a part of the system. The standby unit, in the event of primary power failure, shall be capable of maintaining normal operation of the system for a minimum of four hours. The standby unit shall be automatically recharged when primary power is restored. The alarm output from the transceiver shall be a set of single pole double throw contacts. All parts of the alarm system shall be by the same manufacturer and purchased as a system. The system shall be a product of Advanced Devices Laboratory, Inc., Model 2202 Transceiver, 2230 standby battery and T-503 Transformer or a City-approved equivalent.

(Section 22 continued on next page)

22.11 Installation

22.11.1 Conduit

Horizontal conduit runs in the building shall be embedded in the concrete structure throughout. Stub-ups shall be accurately located to ensure flush concealed mounting of outlet boxes in concrete block walls. Vertical conduit runs in the building shall be exposed on the inside of concrete block walls. No exposed conduit will be permitted on outside walls.

Conduit runs shall be parallel with supporting walls, beams, or ceilings and with each other. Right-angle turns shall consist of cast metal fittings or symmetrical bends. All runs of conduit shall be installed in a manner to avoid trapped condensation. Liquid-tight flexible conduit shall be used for motor connections or other equipment subject to vibration.

All control apparatus, outlet boxes, junction or pull boxes, and other similar equipment shall be installed and maintained in accessible positions and locations.

Conduit shall not be run closer than 6 inches to any source of heat.

Conduit ends shall be reamed and shall be made to butt in the center of the coupling. The use of running threads is prohibited.

Telephone conduit runs shall have not more than 2-90 degree bends. All other conduit runs shall have not more than three 90 degree bends between pull boxes.

A nylon pull cord shall be installed in all wiring conduit including stub-outs which will not have conductors installed under this section of the specifications and which sections or lengths are five feet or longer.

Conduit shall be installed as a complete system, continuous from outlet to outlet, cabinet, box, or fittings and shall be so mechanically and electrically connected that adequate electrical continuity from one conduit to another and from box to box is obtained.

Where rigid conduit is supported from building members, supports shall be installed as follows:

Sec. 22.11 continued.

Supports shall be installed within 18 inches of each outlet box and on each side of each coupling or connector and at a spacing not to exceed 8 feet.

Nails, perforated strap, or plumbers tape shall not be used for support of conduit. Wooden plugs inserted in masonry or concrete shall not be used as a base to fasten supports.

Separate conduits shall be used for each home run indicated.

22.11.2 Wire and Cable

All wire and cable shall be installed in hot-dipped galvanized rigid conduit.

All single phase equipment and lighting shall be wired so that there is a minimum of unbalance between phases. Conductors shall be continuous and the lengths such that no splice will occur except within outlet or junction or pull boxes, panelboards, switches, motor starters, or other similar devices or equipment. Neutral conductors of each circuit shall run directly to the panel and shall not be connected to other neutral conductors.

All lighting and power circuits shall be identified by panel letter and circuit number with wrap-around self-adhesive cloth wire markers at all terminations and junctions. The wire markers shall be "Brady", "E-Z-Code" by Westline or a City-approved equal.

Feeders shall be identified by number and phase with wrap-around self-adhesive cloth wire markers in pull boxes and at all terminations and junctions.

22.11.3 Fixtures

Fixtures shall be properly and securely installed, level, plumb, and in line, on outlets, and connected to the wiring, ready for operation.

Sec. 22.11 continued.

Each fixture shall be completely and properly assembled, with screws and nuts tight, and parts securely mounted. Any missing or necessary additional parts, wire, screws, nuts, washers, locknuts, bushings, or similar items shall be furnished and installed by the Contractor to make the fixtures and the installation complete, safe and substantial. Parts, including paint and finish, shall be clean and undamaged, and the entire installation shall be satisfactory to the Engineer.

22.11.4 Mounting Height of Equipment

Unless specified elsewhere or shown on the plans, the following mounting heights shall apply:

Receptacles (convenience)

Office 12" finished floor to centerline

Pump Room 48" finished floor to centerline

Switches (wall) 50" finished floor to centerline

Telephone 12" finished floor to centerline

22.11.5 Sleeves, Inserts and Openings

Provide and install all sleeves, inserts, anchor bolts, and similar items required for the installation of the work as the general construction work proceeds and at sufficient time in advance of needs, advise the other trades of any required provisions to accommodate the work. Insofar as possible the work shall be installed without cutting, boring, or notching any part of the structure, but should cutting, boring or notching of the structure be required, due to failure to install the work at the proper time, the necessary operation shall be carried out under the direction of the Engineer and made good to his satisfaction, at no cost to the City. Conduits which pass through slabs on grade shall be placed before the concrete is poured.

Sec. 22.11 continued.

22.11.6 Grounding

Make good contact at all panel boxes, outlet boxes, and junction or pull boxes to the conduit system. Use approved bonding materials. Service neutrals shall be grounded by a ground conductor to metallic cold water mains. Ground rods shall be used where non-metallic water mains are installed or dielectric couplings are utilized and also shall be bonded to the cold water piping system within the Building. All equipment, including switchboards, conduit systems, motors, and other applicable apparatus, shall be grounded by a conduit or insulated conductor to grounding system as indicated. Wiring to ground rods shall be routed to avoid damage to pump station water-proofing.

Ground rods, where used, shall as far as practicable, be embedded below permanent moisture level. Ground tests shall be made with a "megger" type instrument. Should ground resistance exceed 25 ohms. Additional rods shall be driven until a reading of 25 ohms or less is achieved. Driven rod electrodes, except where a rock bottom is encountered, shall be driven a minimum depth of 10 feet regardless of the size and number of electrodes used. Ground rods shall be of copper clad steel not less than 8 feet in length and not less than 3/4 inch diameter.

22.11.7 Tests

Upon completion of the work and adjustment of all equipment, all systems shall be tested under the direction of the Engineer to demonstrate that all equipment furnished and installed and connected under the provisions of these specifications shall function electrically in the manner required.

All systems shall test free from short circuit and grounds, shall be free from mechanical and electrical defects, and shall show an insulation resistance between phase conductors and between phase conductors and ground, not less than the requirements of the National Electrical Code. All circuits shall be tested for proper neutral connection.

Contractor shall check the service voltage under maximum load and no load and shall, if voltages and regulations are not within acceptable

22.11 continued.

limits, arrange with the utility company for proper voltage. Contractor shall submit to the Engineer a report showing service voltages at full load and no load.

22.12 Payment

All costs for electrical work as specified herein shall be included in the lump sum bid for Item 54.

SECTION 23: INSTRUMENTATION

23.1 General

Pump control and water level recording systems shall be furnished and installed as shown on the drawings. The water level control system shall consist of a nitrogen storage cylinder, high pressure regulator, constant flow regulator with sight feed bubbler, recorder, pressure gauge, needle valves and a sensing line into sump complete with watertight sleeve at floor. The main pump and sump pump controls (on-off) shall be a separate system using entrapped air tubes as shown on Sheet 21 of the drawings.

Recording instrument panels shall be furnished and installed consisting of three recording tachometers and one recording wattmeter complete with indicating lights, alarm bell, bell silence pushbutton, bell silence relay, light control relays, and wattmeter disconnect switch.

Location of panels and equipment shall be as shown on the drawings.

23.2 Water Level Recording System

23.2.1 Water Level Recorder

The recorder shall be a Model 1 G 500-15-ELAX-Z131X with 400-20 milliamp output signal as manufactured by Bristol or equivalent by Fischer Porter Co., or a City-approved equal. The recorder shall be for 12-inch size charts, and case shall be black enameled, cast aluminum, dust and moisture proof for wall mounting with bottom connections. Recorder shall be 110 Volt A.C. operated seven (7) day chart drive. The measuring system shall be gas-bubbler type and pressure element shall be capsular N1 Span C. Range on instrument shall be 0-15 feet. The instrument shall have 2 high and 2 low alarm contacts for telemetering signals to central control station. The recorder shall be wall mounted as shown on the drawing on a 3/4" waterproof plywood panel. The Contractor shall submit a working drawing showing layout of components on plywood panel.

23.2.2 Nitrogen Storage Cylinder

Nitrogen cylinder shall be 220 cubic foot standard oil pumped nitrogen cylinders, 2200 p.s.i. pressure full with a CGA 580 valve for tank

Sec. 23.2 continued.

connection. The nitrogen cylinder shall have a safety chain as shown on the drawings to prevent cylinder from accidentally being knocked over.

23.2.3 High Pressure Cylinder Regulator

Cylinder regulator shall be single stage, low flow for oil pumped nitrogen to deliver 50 standard cubic feet per hour at 45 p.s.i. Regulators shall be equipped with an integral relief valve, 2-inch 0-4000 p.s.i. cylinder pressure gauge and a 2-inch 0-100 p.s.i. delivery pressure gauge. Tank connection to be CGA 584. Body to be machined from solid brass bar stock. Regulators are to be Millaflow Series No. IR 301B-584CGA-GR, or City-approved equivalent.

23.2.4 Constant Flow Regulator

The constant flow gas regulator with constant differential sight feed bubble chamber and needle valve. Regulator to maintain 1-1/2 p.s.i. drop across needle valve. Regulator shall be Conoflow Model DH-41-1088 or a City-approved equal. The bubbler chamber shall be pyrex glass and enough Dow-Corning 200 silicone fluid with a viscosity of 50 centistokes shall be furnished to fill the glass bowl of bubbler 1/2 full. The fluid is to be furnished only by the Contractor and will be installed by the City at the time installation is to be operationally tested. The constant flow regulator and sight feed bubbler assembly shall be mounted on plywood panel below the level recorder.

23.2.5 Tubing

The sensing line into sump pit shall be thermoplastic polyethylene tubing, 1/4-inch outside diameter, .040-inch wall thickness and natural color with material conforming to ASTM D 1248, Type I, Class A, Category 4. The tubing fittings shall be of brass. Tubing shall be strapped to sump walls by stainless steel clamps at 2 foot intervals.

23.2.6 Needle Valves

Needle valves shall be forged brass of the size and configuration shown on the drawings and shall be suitable for use with nitrogen.

Sec. 23.2 continued.

Valves shall be Imperial Eastman Corporation 394 or equivalent by Dragon Valve Incorporated, or a City-approved equal.

23.2.7 Pressure Test Gauge

A pressure test gauge shall be furnished and installed as shown on the drawings. Gauge shall be surface mounted, phenol case, adjustable pointer, 6 inch diameter with black figures at intervals of 1 foot and intermediate graduations at 1/4 foot. Full scale reading shall be 15 feet of water. Gauge shall have an accuracy of 1 per cent over the scale range and shall be Robertshaw Catalog No. 771, equal by Marsh, or a City-approved equal.

23.3 Pump Control System

23.3.1 Pressure Switches

Pressure switches shall be diaphragm-actuated type, adjustable from .4 to 17.8 p.s.i. in a weatherproof enclosure with surge damper and dual double-throw snap-action switching elements rated 10 amperes, 125 volts. Unit shall withstand a test pressure of 60 p.s.i. Unit shall be Barksdale No. D 2T-H18 with 40801 surge damper.

23.3.2 Pressure Switch Risers

Pressure switch risers shall be Type II schedule 80 PVC pipe with solvent cement welded fittings as indicated on the drawings. Pipe size shall be 2" for Pumps Nos. 1, 2, 3 and 4 and 1" for sump pump. The complete riser installations shall all be air-tight. After installation, the risers shall be checked for air-tightness by an air pressure test. The bottom end of the riser shall be capped and a pressure of 7 p.s.i. shall be held for 24 hours.

23.4 Recording Instrument Panel

23.4.1 Recording D.C. Voltmeters (Tachometers)

Speed recorders for the natural gas engine driven Pumps Nos. 2, 3 and 4 shall be Esterline-Angus Model A, or equivalent by

Sec. 23.4 continued.

Bristol Company, or a City-approved equal, and two shall be mounted in a twin flush switchboard case. One shall be mounted in a similar twin case with the recording electric wattmeter. Chart drives shall be Esterline Angus No. 4 synchronous motor chart drive, hour and minute feed, 3/4-inch per hour speed, with 120 volt, 60 cycle power supply. The meters shall be coordinated with and connected to the tachometer generator which is mounted on the right angle gear drive as specified in Section 17 to indicate pump RPM. The charts shall have a 3/4-inch per hour speed calibration; the divisions shall be so selected that pump RPM will be not less than 75 per cent of full chart reading. Six extra charts shall be furnished for each speed recorder.

23.4.2 Recording Electric Wattmeter

A recording wattmeter shall be provided for the 150 horsepower electric motor driven pump. The wattmeter shall be mounted in a twin flush switchboard case, together with one recording tachometer. The recording wattmeter shall have two current inputs and three potential inputs rated 5 amps and 500 volts respectively. Frequency is 60 Hertz and accuracy shall be 1% of full scale. Response time shall be 1-1/4 seconds maximum. Chart drive shall be synchronous motor 3/4 inch per hour speed with 120 volt, 60 cycle power supply. Six extra paper charts shall be furnished for the meter. Wattmeter range shall be 0-300 KW for 150 HP motor.

Recording wattmeter shall be Esterline-Angus Model A, or equivalent by Bristol Company, or a City-approved equal.

23.4.3 Disconnect Switch for Wattmeter

A disconnect switch shall be furnished and installed directly under each meter to manually disconnect each recording wattmeter. In the "on" position the wattmeter is connected. In the "off" position the circuit to the wattmeter potential input is open circuited and the current transformers are short circuited. Disconnect switch shall be General Electric Type SB, or equivalent by Westinghouse, or a City-approved equal.

Sec. 23.4 continued.

23.4.4 Indicator Lights

Red and green indicator lights shall be furnished and installed on the recording instrument panel as called for on the drawings. The lights shall have screw terminals and screw-in caps. Indicator lights shall be 24 volt, D.C. Indicator lights shall be by Dialco 80-3114-1231-301, or equivalent by Drake, or City-approved equal.

23.4.5 Bell Silence Pushbutton

A momentary closed contact bell silence pushbutton shall be furnished and installed where shown on the drawing of the recording instrument panel. The bell silence pushbutton shall be Cutler Hammer Catalog No. 8817K5, or Arrow Hart No. 1020, or a City-approved equal.

23.4.6 Control Relays (Bell Silence and Light)

Control relays shall be machine tool type with contacts rated 10 amperes at 600 volts open type. Provide contacts and coil voltages as indicated. The relays shall be General Electric Class CR2811A, Square D Class 8501 Type D, or equivalent by Cutler-Hammer or Westinghouse.

23.4.7 Terminal Strips

Terminal strips for recording instrument panel shall be Square D Type S, or Buchanan Type TC, or a City-approved equal.

23.4.8 Instrument Panels

Instrument panels shall be code gage stretcher levelled sheet steel cabinets with formed or angle reinforcing and hinged lockable front panels. Steel shall be bonderized or equal and finished light grey with baked enamel. The recording instruments, lights, and pushbuttons as specified in the above paragraphs shall be mounted in the front panels, as shown on the drawings. Each meter, recorder light and pushbutton shall be clearly identified by nameplates as shown on the drawings.

Sec. 23.4 continued.

The Contractor shall furnish and install all required conduits, wires, sleeves, and other materials and devices for the proper operation of all instruments mounted in the instrument panel in the office. All wire must be adequately marked for easy identification.

A 3/4-inch thick overlaid plywood panel shall be used to insulate the panel from the wall. The plywood shall be high density type, overlaid both sides.

23.4.9 Nameplates

Provide engraved laminated plastic (black-white-black) nameplates for the recording instrument panel as shown on the drawings. Size of engraved letters shall be 1/4-inch high minimum. Letters shall be vertical and shall be capital. A working drawing shall be submitted for verification of proper size and nomenclature.

23.4.10 Bell

Bell shall be six-inch diameter industrial type UL approved with an output of 83 db at 10 feet. Unit shall operate on 24 volts D.C. input. Alarm bell shall be Edwards No. 343-6, or equivalent by Federal Electric, or City-approved equal.

23.5 Gas Detector

A fuel presence alarm device shall be provided for detecting and indicating the presence of fuel gases or other combustible gas mixtures.

23.5.1 General Requirements

The gas detector is to be an eight-channel unit with the eight sample points located as follows:

- Main sump room - 4 sample points
- Engine room - 4 sample points

Sec. 23.5 continued.

The unit shall contain indicator lights, indicating meter, alarm lights, flowmeter, pump, motor, and all other components necessary for operation. Unit shall have Amphenol M5-301-16S-IS connector for telemetry connection.

An explosion-proof, motor driven howler shall be furnished and installed. The howler shall be connected to the 115 V alarm circuit of the gas detector unit. Howler shall be Benjamin Type EXH No. 8130-115V.

The gas detector unit shall be similar to Gastech Model 1070 as manufactured by Gastech Incorporated of Mountain View, California, equivalent by Bacharach Instrument Company, Mine Safety Appliance Company, or City-approved equivalent. Unit shall have Factory Mutual or equal, approval based on State Division of Industrial Safety Article 4, Section 1532, Title 8.

23.5.2 Operating Requirements

The combustible gas detector unit shall be capable of sequentially sampling the atmosphere at a minimum of eight points, drawing the samples to a single detector unit and determining in each sample the quantity of combustible gas present in terms of a percentage of the lower explosive limit (L.E.L.). Sample sequencing shall be automatic and shall be an integral feature of the detector unit. The detection technique shall be by means of catalytic combustion of the sample on a platinum element which forms one leg of a Wheatstone bridge.

The gas detector unit shall be factory calibrated for natural gas and shall be adjusted for the following conditions:

- a. Low alarm circuit shall be actuated at 5% LEL. The low alarm light shall light and the external alarm circuits shall be energized. The alarm circuit shall latch on until manually reset.

Sec. 23.5 continued.

- b. High alarm circuit shall be actuated at 15% LEL. The high alarm light shall light and the external alarm circuits shall be energized. The cycling sequence shall stop and hold on the sample point causing the alarm. The high alarm circuit shall latch on until manually reset.

- c. A trouble alarm circuit shall energize a trouble light and de-energize external alarm circuits in the event of failure of current in the power supply or detection circuits.

23.6 Payment

All costs for furnishing and installing instrumentation as described herein shall be included in the lump sum bid for Item 55.

SECTION 24: TELEMETERING

24.1 General

The condition and functioning of the pump station shall be continuously monitored and all resulting information shall be transmitted by telemetry link to the Port Security Office, Berth 11, Pier A, Port of Long Beach. The Contractor shall furnish and install complete all required equipment as specified herein for the pump station. The Contractor shall also furnish complete and test the telemetering panel as specified herein for installation at the remote station by others. By definition, the telemetry equipment to be installed in the pump station is so referred to and described in this section, and the telemetry panel to be installed at the Port is referred to as the remote station. The remote station displays status and gives audible alarms only, enabling suitable response to be made by Harbor Department personnel. No capability for actual control of the pump station or its machinery is included in the remote station panel.

Equipment for both pump station and remote station shall be compatible with the existing Los Angeles County Flood Control District Pump Plant Telemetering System.

24.2 Monitoring and Display Details

Equipment and connections to telephone line shall be provided at the pump station to transmit the following information to the remote station:

<u>Pump Station Function</u>	<u>Equipment Display at Remote Station</u>
1. Signal Failure	Light and Audible Alarm (Horn #3)
2. Power Failure	Light and Audible Alarm (Horn #3)
3. Low Gas Hazard	Light and Audible Alarm (Horn #3)
4. High Gas Hazard	Light and Audible Alarm (Horn #3)
5. Recording Instrument Fault	Light and Audible Alarm (Horn #3)
6. Operator in Building (disarms burglar alarm after entry)	Light and Audible Alarm (Horn #1)
7. Sump Pump Start Level	Light Only
8. Sump Pump Running	Light Only
9. Pump 1 (Electric) Running	Light Only
10. Pump 2 (Gas Engine) Running	Light Only
11. Pump 3 (Gas Engine) Running	Light Only
12. Pump 4 (Gas Engine) Running	Light Only
13. High Water Level & Burglar Alarm	Light and Audible Alarm (Horn #2)
14. Water Level in Pump Pit	Two Digit Nixie, 0-19 read-out

Sec. 24.2 continued.

Dry contact closures for functions 3 to 13 are to be provided under Section 22, Electrical Work.

24.3 Equipment at Pump Station

24.3.1 Encoder

The encoder shall be a 16-function encoder complete with tone transmitter, power supply and line surge protector. The encoder shall scan 13 contacts and transmit their status (opened or closed). It shall also transmit one analog input.

Encoder and accessories shall be Automation Associates, Inc. Model DS90T encoder and Model FS/LAM 170T tone transmitter, power supply series PS and line surge protector Model LPA-31, or City-approved equals, and shall all be mounted in the telemetering panel enclosure.

24.3.2 Scanner Transmitter

The transmitter shall be digital multiplex type designed for use in telemetry systems to transmit the status of up to 16 electronic or mechanical switch contact chassis or 16 bit digitized analog information, over a single FSK tone telemetry channel for transmission over voice grade communication link. The transmitter shall be contained in an enclosed module for noise immunity and ease of maintenance. Additional scanners shall be operable sequentially through the same tone channel by address coding. Scanner transmitter shall be Automation Associates, DS-90T series, or City-approved equal.

24.3.3 Tone Transmitter

The tone transmitter shall be the frequency shift type with a frequency of 595 Hz, channel spacing of 170 Hz and a shift of ± 35 Hz. Transmitted signal output shall be front panel adjustable via a multi-turn potentiometer. Minimum adjustment range shall be +5 dbm to -30 dbm. Transmitter output shall be transformer isolated from electronic potentials, and shall be AC coupled so resistive continuity cannot be obtained across the output wires. Output shall match 600-900 ohm telephone lines and have rising off-channel impedance characteristic. Line termination shall be maintained with power turned off or in the event of power failure. The

Sec. 24.3 continued.

connections to this module shall be made through a contact, gold over nickel plated printed circuit board edge connector. Test signal shall be available at the module front panel through a twenty contact test connector. Modulation and signal level potentiometers shall be accessible through the module front panel. The tone transmitter shall be Automation Associates, FS/LAM170T or City-approved equal.

24.3.4 Analog to Digital Converter

The analog to digital converter shall accept an input voltage, scale the voltage to proper engineering with, and convert this voltage to an equivalent binary or binary coded decimal number. Up to 3 decades or 12 binary bits of converted information shall be available with conversion accuracy better than $\pm 0.1\% \pm 1/2$ LSB. Load potentiometers shall allow zero, span, offset and conversion note adjustment. The converter shall be contained in an enclosed module for noise immunity and ease of maintenance. Unit shall be Automation Associates ADC-90 series, or City-approved equal.

24.3.5 Power Supply

The power supply for the telemetry modules shall be plug-in type and provide regulated power +24 VDC, ± 15 VDC and +5 VDC as required by the module. Each supply shall have a full load rating of 250% of actual full load requirement. Unit shall be Automation Associates series PS, or City approved equal. Back-up battery power shall be supplied with capability of telemetering a line power-failure for a minimum of four hours.

24.3.6 Pressure Transducer

The pressure for telemetry shall be measured by electronic pressure transmitter. Output signal from the transmitter shall be variable frequency with frequency proportional to pressure. The operating circuits connecting to pressure transmitter unit shall be protected against line surges and transients by low voltage spark gaps, zener diodes, and replaceable fuses. Circuits shall be designed so that the connecting wires to the receiver can be interchanged, and the polarity reversed, without causing damage to the transmitter. Each transmitter shall be capable of operating with interconnecting line resistance of 1000 ohms maximum, or when multiple transmitters are connected to one line, the maximum series resistance shall be divided by the number of the transmitters used. Conversion of level/pressure to motion and then to frequency, shall be accomplished without friction producing parts.

Sec. 24.3 continued.

Transmitter output frequency shall be linearly proportional to pressure with $\pm 1\%$ of span without accuracy reduction due to hysteresis or stiction caused by mechanical friction. Unit shall cover the range from 0 to 15 pounds per square inch gage air pressure. Electrical output of transducer shall be 4-20 ma dc which shall vary directly with applied pressure. Pressure transmitter shall be furnished in a NEMA XII enclosure. Pressure supply and drain lines shall be mounted in the bottom of the cabinet via bulkhead fitting, suitable for 1/8" NPT connection of a male fitting. Plumbing between the bulkhead cabinet fittings and the diaphragm seal shall be via an electrical insulator tubing to protect against electrolysis or corrosion. Pressure transducer shall be Automation Associates PT-1250 series, or City-approved equal.

24.3.9 Telemetry Panel Enclosure

The telemetry panel enclosure shall be as shown on Plate P-30 and shall be NEMA Type 12 with single door, designed for wall mounting. Enclosure size shall be 42" high x 30" wide x 10" deep. Door shall have neoprene gasket, continuous hinge, and 3-point key lock. Panels shall be made of 14 gauge steel and have all seams welded. Interior finish shall be baked white enamel and exterior finish grey prime coat with all surfaces phosphatized before painting. Pump indicator lights shall be mounted in door panel. Enclosure shall be Hoffman Engineering A-423010LP, Boss N12S-423010, or City-approved equal, as illustrated on L.A.C.F.C.D. Pump Station Manual Plate P-30, but with rack mounting frame omitted.

24.4 Equipment for Remote Station

24.4.1 Remote Telemetry Panel

The remote telemetry panel shall consist of tone receiver, scanner receiver, display panel, and alarm modules assembled in an enclosure designed for wall mounting.

24.4.2 Tone Receiver

The tone receiver shall be frequency shift type with a frequency of 595 Hz., channel spacing of 170 Hz. and a shift of ± 35 Hz. to match the corresponding tone transmitter at the pump station. The tone receiver shall be Automation Associates, FS/170R series, or City-approved equal.

Sec. 24.4 continued.

24.4.3 Scanner Receiver

The digit multiplex receiver shall be designed for use in telemetry system to receive up to 16 discrete status information bits from the scanner transmitter. The receiver shall operate with the transmitter through frequency shift keyed audio tone telemetry channels. True double scan protection shall assure that two 16 bit status words must agree exactly before status is transferred to the output relay driver storage register. Additional scanners shall be operable sequentially through the same tone channel by address coding. A 20 position front connector shall permit examination of receiver operation without removal from the module rack. The scanner receiver shall be Automation Associates, DS90-R series, or City-approved equal.

24.4.4 Display Panel

Display panel layout shall be as shown on the drawings. The open-closed contact status is indicated by flashing indicating lights. These lights incorporate a dim glow feature that allows the operator to identify any defective lamp. The complete arrangement shall consist of twenty-eight (28) lights arranged in three rows of nine lights each, surmounted by one single light located centrally. Thirteen (13) lights only are to be utilized in the present installation; the remainder will serve as spares. All lights to be utilized are so indicated on the drawings and shall be identified on the panel by phenolic nameplates inscribed as shown on the drawings. No nameplates shall be furnished for lights which are spares. The analog read-out is a two digit Nixie display unit, reading 5 bit liquid level signal, unit reading range: 0-19, with similar phenolic nameplate identification.

24.4.5 Alarm Modules

Alarm and annunciation signals shall be processed by a modular annunciator. Each module shall be capable of at least 6 alarms. The flasher rate shall be adjustable from 2 Hz to 10 Hz with an internal resistor. The module shall be equipped for horn and reset button functions. Operation sequence shall be as follows:

- a. Close input.
- b. Corresponding alarm light shall flash and the audible alarm shall sound.

Sec. 24.4 continued.

- c. Upon pushing silencer button, alarm light shall remain steady on, with audible alarm off.
- d. Alarm lights shall remain on until the alarm condition is removed.

All three horns shall each sound with a different and distinctive tone. Relay module shall be Automation Associates, RA-06 series, or City-approved equal.

24.4.6 Telemetry Panel Enclosure

The telemetry panel enclosure shall be NEMA Type 12 designed for wall mounting. Enclosure size shall be approximately 30" high x 23" wide x 18" deep. The front shall be composed of four components as shown on the drawings. One component shall be power supply, another telemetry modules, another display devices and the fourth alarm horns. Each component shall be mounted on a standard 19" rack space and shall be removable. Construction and finish of enclosure shall be same as specified hereinabove for pump station.

24.4.7 Testing

The remote station panel shall be temporarily installed by the Contractor at the pump station and shall be demonstrated by the use of outside telephone lines to function satisfactorily. It will then be accepted by the City for installation at the Port Security Office by others.

24.5 Payment

All costs of the telemetry equipment to be installed or to be furnished only as specified herein are to be included in the lump sum price bid for Item 56.

SECTION 25: PROTECTIVE COATINGS AND TAPE

25.1 General

All painting, the application of epoxy coatings and protective tapes shall be included in this section. Except as otherwise specified herein, all steel, gypsum board, and wood surfaces shall be painted or epoxy coated. Concrete surfaces shall not be painted. Exterior of concrete masonry shall be water-proofed, interior shall be painted.

All colors shall be as hereinafter specified or as directed by the Engineer.

25.2 Painting

25.2.1 Paint Primers

25.2.1.1 Iron and Steel Primer

Iron and steel primer shall be "Kromik Metal Primer", as manufactured by Sherwin-Williams Company, X-60 Red Bare Metal Primer as manufactured by Rust-Oleum Corporation or an equivalent City-approved industrial primer.

25.2.1.2 Wood Primer

Wood primer shall be Exterior Wood Undercoater No. A2W5, as manufactured by Sherwin-Williams Company, 500 White Undercoater manufactured by Rust-Oleum Corporation, or a City-approved equal.

25.2.1.3 Galvanized Metal Primer

Galvanized metal primer shall be "Galvanized Iron Primer" as manufactured by Sherwin-Williams Company "Galvinoleum 3202 Undercoat" as manufactured by Rust-Oleum Corporation, or a City-approved equal.

Galvanized metal surfaces shall first be treated with a prepared metal bonderizer before applying metal primer.

Sec. 25.2 continued.

25.2.2 Paint Finish Coats

25.2.2.1 Interior and Exterior Metal Paint

Interior and exterior metal paint shall be "Metalastic", as manufactured by Sherwin-Williams Company, and equivalent industrial finish as manufactured by Reliance Universal, Inc., or a City-approved equal.

25.2.2.2 Wood Surface Paint

Wood surface paint shall be "Exterior Gloss Paint" as manufactured by Sherwin-Williams Company, an equivalent industrial finish as manufactured by Rust-Oleum Corporation, or a City-approved equal.

25.2.2.3 Enamel

Enamel shall be "Kem-Glo" as manufactured by Sherwin-Williams Company, an equivalent industrial finish as manufactured by Rust-Oleum Corporation or a City-approved equal.

25.2.2.4 Concrete Surface Paint

Concrete surface paint shall be acrylic vinyl water-based paint as manufactured by Sherwin-Williams Company, or City-approved equal.

25.2.3 Paint Schedule (Inside and Outside)

In general all exposed metal items of pump station above engine-room floor level shall be primed and painted with two coats of finish paint. All exposed wood items shall first be primed and then painted two coats of finish paint. Concrete masonry shall be painted two coats.

Bridge crane bridge, beams and rails, except bearing surfaces, shall be painted one coat primer and two coats finish paint.

Metal door frames and doors, door operator, louvers, column, stairway and handrails shall be primed and painted two coats of finish paint.

Sec. 25.2 continued.

Galvanized floor plates and seat angles shall be primed and painted two coats of finish paint.

Engines need not be repainted, except where coatings have been damaged or abraded in shipping or installation.

Right-angle drives and other manufactured items above engine-room floor level which have received manufacturer's factory coatings shall not be repainted.

25.2.4 Clean-Up

All clothes and waste materials which might constitute a fire hazard shall be placed in closed containers and disposed of at the end of each day. Upon completion of the painting work, all staging and scaffolding shall be removed from the site of the work. Paint spots, oil, or stains upon adjacent surfaces shall be removed and the entire job left clean and acceptable to the Engineer.

25.3 Epoxy Coating - Liquid Applied

25.3.1 Epoxy Primers

1. Engard 411 as manufactured by Engard Coatings Corporation. (2 mil thickness)
2. Koppers No. 654 as manufactured by Koppers Co., Inc. (2 mil thickness)

25.3.2 Epoxy Coatings

1. Engard 482 (gray) as manufactured by Engard Coatings Corporation. (15 mil thickness)
2. Glamorglaze (Light Gray) as manufactured by Koppers Co., Inc. (15 mil thickness)

Sec. 25.3 continued.

25.3.3 Preparation for Epoxy Coatings

All metal surfaces to receive epoxy coatings shall be cleaned to bright metal by sandblasting, using clean, dry, sharp sand in accordance with SSPC-SP5. After cleaning, all accumulated dust shall be removed. The primer coat shall be applied immediately after cleaning. Coating on pipes to be field welded, shall be held back from the weld joints approximately 2 inches. In held-back area, pipe and fittings shall be wire brushed or ground to bright metal, cleaned with solvent, then coated as specified.

25.3.4 Epoxy Coating Schedule

The steel pump columns, base plates, pedestals, bowls, elbows, and the discharge piping and fittings inside the pump station shall be coated inside and outside. The pump shaft enclosing tube and adaptor shall be coated outside only. The discharge manifold shall be coated inside only except for end returns to exterior as shown on the drawings.

Sump pump supports, pump casings, impellers and suction inlets shall be epoxy coated on the inside and outside. Sump pump motor and adaptor plate shall be epoxy coated on the outside with a liquid applied epoxy.

Exterior of LPG Tank shall be epoxy coated.

All gas and LPG piping inside the pump station, above or below the engine-room floor, shall be epoxy coated on the outside.

All air release valves and the vent pipes on the discharge lines shall be epoxy coated inside and outside.

All epoxy coatings except for field touch-ups, and coating of small utility pipes in pump pit shall be shop-applied by skilled applicators, in a shop approved in advance by the City. Field sandblasting and application of coatings will not be permitted.

Sec. 25.3 continued.

Upon completion of coatings, a Holiday Detector of suitable high frequency shall be used to test the coatings. Any imperfect spots shall be recoated to the satisfaction of the Engineer. Low Frequency detectors of wet wipe type are not approved.

Mating faces and bolt holes on the pump column flanges and bowls shall be protected from the above coatings.

Impellers shall not be painted.

25.3.5 Epoxy Applicators

The epoxy coatings shall be applied by an approved applicator. The following applicators are currently approved by the City:

Parker Brothers, Inc.
7044 Bandini Boulevard
Los Angeles, California 90022
Phone (213) 723-8701

Soc-co Plastic Coating Co.
13216 Laureldale
Paramount, California 90723
Phone (213) 636-9173

Alternate applicators must be approved in advance by the City.

Epoxy coated items shall not be shipped until the epoxy coating has been permitted to dry and age a minimum of 72 hours.

25.3.6 Field Touch-Up of Epoxy Coatings

Any epoxy coatings damaged in shipment or subsequent handling shall be patched by the Contractor at his own expense, in full conformance with the recommendation of the manufacturer of the epoxy used.

25.3.7 Field Testing of Coating Applications

All epoxy coating applications will be subject to field testing for compliance with these specifications. Any coating found not to be strictly in accordance with requirements shall be immediately remedied to the full satisfaction of the Engineer.

25.4 Epoxy Coating - Fused Powdered

25.4.1 Epoxy Coating

As an alternate to liquid applied epoxy coatings, the Contractor may, at his option, substitute a fused powdered epoxy coating electrostatically applied (12 mil minimum thickness) as manufactured by 3M Company, Armstrong Products of Warsaw, Indiana, or a City-approved equal.

25.4.2 Preparation for Fused Epoxy Coating

All metal surfaces to receive epoxy coatings shall be cleaned to bright metal by sandblasting as specified in Section 25.3.3.

25.4.3 Epoxy Application

The epoxy coating shall be applied by a City-approved applicator in accordance with the manufacturer's recommendations and applicable provisions of Sections 25.3.4; 25.3.6 and 25.3.7. The following applicators of fused powdered epoxy coatings are currently approved by the City:

Fusecote Company, Inc.
9703 Alpaca
South El Monte, California 91733
Phone (213) 443-6760

Ekco Products, Inc.
2717 Tanager
Commerce, California 90022
Phone (213) 723-9101

25.5 Protective Tapes

The corrosion protection tapes shall consist of a polyvinyl chloride backing and an inner layer of butyl rubber or other high tack adhesive.

The tape shall be applied to pipes using a primer to obtain a superior bond between metal and tape.

25.5.1 Thickness of Tape

The total laminated thickness of the backing material shall be a minimum of 20 mils. The butyl layer or other adhesive shall be 12 mils and plastic film 8 mils.

Sec. 25.5 continued.

25.5.2 Application Requirements

The tapes shall be applied to the pipe over the specified primer in all instances, and shall be covered with 1/2 lap for double thickness throughout the entire wrap.

25.5.3 Testing of Coating

The tape covering, after wrapping is completed, shall be tested with a "Holiday" detector of adequate capacity.

If "Holidays" are detected the pipe shall be wrapped at that location with additional tape, and then rechecked with the "Holiday" detector until satisfactory to the Engineer.

25.6 Galvanizing

All exposed metal surfaces in the sump below the Engine-Room Floor shall be galvanized unless epoxy coatings, copper, or stainless steel components are specified. The galvanized items in the sump need not be painted.

25.7 Waterproofing of Concrete Masonry

Apply two coats of Thompson's Water-Seal or City-approved equal in accordance with manufacturer's instructions.

25.8 Color Schedule

Concrete masonry walls	- Light Cream
Metal work and machinery, except handrails	- Long Beach Blue
Handrails and bridge crane	- OSHA Yellow

25.9 Payment

All costs for waterproofing concrete masonry shall be included in the price bid for Item 37.

All costs for epoxy coating, painting, protective tapes, galvanizing and all other items as specified hereinabove, shall be included in the price bid for each applicable item where clearly identifiable. All other costs for work as described herein shall be included in the price bid for Item 57.

SECTION 26: MISCELLANEOUS ITEMS

26.1 General

All miscellaneous items are covered in this section.

26.2 Fire Extinguishers

Three dry chemical fire extinguishers shall be provided on the engine room walls at locations as shown. The dry chemical extinguishers shall be of the portable type suitable for use in Class B and Class C fires (electrical equipment, flammable liquids, liquefied petroleum gas and other hazards). The units shall be UL rated, and shall be 20 pound size, and shall be wall mounted on heavy-duty wall brackets.

26.3 Ventilating Equipment

26.3.1 Office Exhaust Fan and Toilet Exhaust Fan

The toilet exhaust fan and office fan shall each be wall mounted, centrifugal type with direct drive and shall be rated for 150 CFM at 1/4 inch static pressure. Fan motor shall operate on 120 V., 60 Hz., single phase power. The fan shall be Model CWF 67 or manufactured by ILG Industries, Inc. or an equal by Penn Ventilator Co. or a City-approved equivalent.

26.3.2 Sump Inlet and Exhaust Fans

Pump pit inlet and exhaust fans shall be belted vent sets which shall be installed inside the engine room as shown on Sheet 25. Capacity of each fan shall be a minimum of 3000 CFM at one inch static pressure. Fan motors shall be explosion-proof 2 h.p., 1750 R.P.M., 480 volt, three phase, 60 Hertz. Fan speed shall be limited to avoid motor overload. Fans shall be epoxy coated and shall be Model 300G as manufactured by Buffalo Forge Company or a City-approved equivalent. Both fans shall be the product of one manufacturer and shall be of size suitable to fit space available.

26.4 Payment

All costs of office, toilet and pump pit inlet and exhaust ventilation as specified herein shall be included in lump sum prices bid for Items 34 and 51.

APPENDIX E

ENERGY ECONOMICS

1. General

Electrical power is furnished by public utilities, each serving its own defined geographical area. Power is furnished at rates in accordance with various published schedules for different types of usage. Many utilities have rate schedules specifically applicable to pumping. Samples are included in the text and numerical examples have been developed to show billings which would be payable under certain hypothetical circumstances.

Natural gas is also furnished through public utility companies, sometimes the same company which provides electrical power for the area. Service for gas engines is usually charged at the rates for commercial and industrial service, and is interruptable at times of high domestic demand.

LPG is usually furnished by private companies or distributors who set rates for their localities. A tabulation of rates typical for California has been compiled and is used in this Appendix.

The cost of gasoline or diesel fuel is not considered, since there will be very few applications of engines using these fuels. Where the situation does occur, it will be relatively straightforward to adapt data given herein in order to make comparisons.

Readers should note that the rate schedules published herein are typical of those generally prevailing in 1981 or 1982. In the past, rate schedules used to reflect the policy then in effect to offer discounts for larger quantities consumed. With current emphasis on energy conservation, this policy is changing. Also, rates are constantly being escalated or surcharged, so that to be valid, any study must use the latest possible data, obtained in the locality of the pump station.

2. Electrical Power

Electrical utility charges are made on either the connected load basis or on the demand basis and are the sum of two separate charges, the service or demand charge and the energy charge. The service or demand charge represents the cost of the utility company building and maintaining enough capacity to serve its customers. It is a fixed cost of the pump station, as it is the minimum charge for

electricity whether the motors are run or not. The energy charge is based on kilowatt-hour usage and depends on the hours of motor operation.

For a pump station which has large capacity pumps with high horsepower motors which are seldom run, the fixed cost of the demand charge becomes the larger element of the utility billing, even over 95% of the total.

The connected load basis service charge is simply a monthly or annual service charge for each horsepower of connected load. Referring to E-4, Schedule No. PA-1, for 2 HP and greater connected loads, the charge is \$1.00 per horsepower per month. Therefore, it would cost \$1,200.00 per year just for a 100 HP motor to be connected.

Each hour that a 100 HP motor runs at full load, it consumes 74.6 kilowatt-hours or KWh. (To convert HP to Kw, multiply by .746). The energy charge would therefore be $74.6 \times 2.044\text{¢}$, or \$1.52 per hour. The energy charge for 100 hours of running in a year would be \$152, and the total of both service and energy charges would be \$1,352 for the year. By contrast, for a 5 HP motor running 2,000 hours to perform equivalent work, the service and energy charges would be \$60 + \$152 for an annual total of \$212. The connected load basis is therefore seen to be favorable to motors of small horsepower running for long periods. For single motors of higher horsepower, the demand basis may be even more costly than the connected load basis. Using the 100 HP motor in the preceding example, referring to E-5, Schedule PA-2, the demand charge would be \$281.25 per month, while the energy charge would be $74.6 \times 1.120\text{¢}$ per hour, for an annual total of \$3,459. The lower of the two schedules, connected load basis or demand basis, is used for computation of the charges to be made by the supplying utility.

Where there are multiple large horse-power motors and a consequent diversity of load with infrequent peaks, the demand basis becomes much less expensive than the connected load basis. Again referring to E-5, Schedule No. PA-2, the demand basis demand charge uses the peak load during a peak month to establish the demand charge for that month and to establish the minimum demand charge for the next 11 months. For example, if the peak month storms required 3-300 HP motors to operate fully-loaded simultaneously, the peak load of 671.4 Kw would result in the peak month demand charge of \$2,517.75. During the next 11 months, a minimum of 50% of the peak load, or 335.7 Kw will result in at least a \$1,258.88 demand charge each month, for a total demand charge for the year of \$16,365. However, the demand charge on a connected load basis would amount to \$30,375. From a later example, the energy charge on a demand basis will be found to be only about 3% of total demand charges for electricity.

The fact that demand charges are so great should lead designers to consider increasing storage and using smaller pumps, possibly at

greater capital cost, in order to reduce the demand charges of large electric motors. This policy can be seen in Chapter 7. - Dry Pit Design, where the storage box allows smaller capacity pumps and motors.

3. Natural Gas

Natural gas is a fuel with a nominal value of 1,000 British Thermal Units (BTU's) per standard cubic foot. The rates for natural gas are normally a minimum monthly purchase, plus a charge per 1,000 cu. ft. in excess of the minimum purchase. The rates vary throughout the nation, depending on the availability of indigenous production, transportation costs, and interstate and intrastate regulation. In general, current prices for natural gas represent a lower cost per BTU than now prevails for crude oil, but possible decontrol may greatly increase gas prices.

Compared with electricity, natural gas often appears to be a substantially cheaper source of power. This is because natural gas is purchased as a fuel, not as power. The fuel must be converted into power by the engines installed at the pump station.

Examples 7.2 and 7.4 show a comparison of costs of electric motor drives and gas engine drives. Example 7.2 shows that the utility charges are reduced by using the gas fuel. Example 7.4 shows that the costs of the additional investment in engines and the additional maintenance required will outweigh the savings in utility charges unless a low interest rate can be used. This applies for the level of usage anticipated for a stormwater pump station. For pumping of water for irrigation, the reverse is often the case. Gas engines running for a much larger number of hours could be expected to be more economical than electric motors.

4. Liquefied Petroleum Gas

LPG is a fuel interchangeable with natural gas. It is supplied as a liquid under pressure, which is converted into a gaseous state at the engine carburetor. LPG has a value of 92,000 to 95,000 BTU per gallon.

LPG rates are per gallon charges in various annual usage categories. LPG costs more per gallon for low usage than it does for high usage. Pump stations are normally in the lowest annual usage categories where LPG costs 73 to 80 cents per gallon, depending on the transportation and indigenous production.

Example 7.3 shows a hypothetical pump station run on LPG only. For stormwater pumping the overall life-cycle cost of driving

pumps with LPG is probably the highest of all three power sources considered, but the benefit of LPG reliability may be considered to outweigh its cost.

5. Decision between Motors and Engines

The demand charge of the electrical utility represents the cost of having the utility invest in and maintain the power generators for the user at the utility's central stations, and provide transmission facilities to the user's site. The demand charge can be eliminated by the user assuming the additional capital costs of on-site engines, but in either case, fuel must be converted into power at some point. Electrical utility power is generally cheaper and more convenient for stormwater pumping, but demand charges have escalated to a point where engines burning gas or LPG fuel may show an economic advantage, depending upon the interest rate. An evaluation must use local utility rates and the motor-versus engine decision must be based not only on cost, but on all factors, including reliability, convenience and maintenance. Some stations, of course, have both motor and engine-driven pumps.

6. Synopsis of Rate Schedules

Published utility rate schedules are reproduced herein in edited form, as examples intended to show rates and conditions of service. Some of the detail appearing in the published documents is not relevant to this work and has been deleted. Other data can be related to Chapter 10. - Electric Motors, and to Chapter 12. - Electrical Systems and Controls. The rates quoted for electrical power, natural gas and LPG are used in the numerical examples 7.1 through 7.4.

A. SOUTHERN CALIFORNIA EDISON COMPANY SCHEDULE NO. PA-1 (Effective August 6, 1981)

Applicable to power service for pumping on connected load basis

<u>RATES</u>	<u>Per Meter</u> <u>Per Month</u>
Service Charge:	
Two horsepower and over of connected load, per horsepower.....	\$ 1.00
Energy Charge: (to be added to Service Charge)	
All kWh, per kWh.....	2.044¢
Minimum Charge: The minimum charge shall be the monthly Service Charge.	

1. Service will be supplied at one standard power voltage.

2. Connected load is the sum of the rated capacities of all of the customer's equipment that it is possible to connect to the Company's lines at the same time, determined to the nearest 1/10 hp. In no case will charges be based on less than 2 hp for single-phase service or on less than 3 hp for three-phase service. Normally such ratings will be based on the manufacturer's rating as shown on the nameplate or elsewhere but may, at the option of the Company, be based on tests or other reliable information.
3. Whenever, upon test, any motor under normal operating conditions is found to be delivering more than 115 per cent of its capacity as indicated by its nameplate rating, the Company may disregard the nameplate rating and base its charges upon the output as calculated from test.

B. SOUTHERN CALIFORNIA EDISON COMPANY SCHEDULE NO. PA-2
 (Effective August 1, 1981)

Applicable to power service for pumping on demand basis

RATES

Per Meter
Per Month

Demand Charge:

First 75 kW or less of billing demand.....	\$281.25
All excess kW of billing demand, per kW.....	3.75
(Subject to minimum demand charge. See Special Condition No. 5)	

Energy Charges (to be added to Demand Charge):

All kWh, per kWh.....	1.120¢
-----------------------	--------

1. Service will be supplied at one standard voltage.
2. The billing demand shall be the kilowatts of maximum demand but not less than 50% of the highest maximum demand established in the preceding eleven months, however, in no case shall the billing demand be less than 75 kw. Billing demand shall be determined to the nearest 1/10 kw.
3. The maximum demand in any month shall be measured maximum average kilowatt input, indicated or recorded by instruments to be supplied by the Company, during any 15-minute metered interval in the month. Where demand is intermittent or subject to violent fluctuations, a 5-minute interval may be used.

4. Minimum Demand Charge: Where no contract demand is involved, the monthly minimum demand charge shall be computed by multiplying the billing demand by the demand charge per kilowatt. Where a contract demand is involved, the monthly minimum demand charge shall be the greater of:
- a. The charge as computed by multiplying the billing demand by the demand charge per kilowatt; or
 - b. A facilities charge of 1.00 per kilowatt of contract demand.

C. LONG BEACH GAS DEPARTMENT GAS RATE SCHEDULE B
Commercial and Industrial Service
 (Effective October 28, 1981)

RATES

Meter charge per day\$.33

Usage charge per 100 cu. ft.\$.3918

A minimum charge of \$72.00 per meter per month shall be made for service under this schedule.

Consumers served under this schedule shall have priority in the use of gas over consumers served under any other rate schedule other than Schedule A, and said consumers shall be subject to a discontinuance of service in case of necessity due to shortage of gas in favor of consumers under Schedule A.

D. LPG RATES (FURNISHED BY MAJOR CALIFORNIA DISTRIBUTORS)
 (Effective April 1, 1982)

<u>Annual Usage Category</u>	<u>Price per Gallon</u>
0 - 2,500 gallons	79.8¢
2,501 - 3,500	76.5¢
3,501 - 6,000	75.1¢
6,001 - 10,000	73.2¢
10,001 - 25,000	71.4¢
25,001 - 40,000	70.4¢
Over 40,000	69.3¢

7. Numerical Examples

Examples 1 (Electricity), 2 (Natural Gas), and 3 (LPG) show an annual 212 hours of pump operation for a station under identical

conditions, with the cost of power or fuel for the three different sources. Example 4 allows for capital cost and maintenance and shows the reduction in cost for natural gas compared with electricity under the same conditions.

Example 1

A pump station has three vertical pumps each with a 300 HP motor. The motors are fully loaded at design conditions. Assume that all three pumps run simultaneously at design conditions for four hours during the first month of the year (12 hrs.); that two pumps run simultaneously for fifty hours during parts of three months (100 hrs.); and that one pump runs alone for one hundred hours during the year (100 hrs.). Total running time equals 212 hours. Using the Southern California Edison Company rate schedules, determine the total annual cost of electricity for the pumps under these conditions.

Demand Basis of Determining Demand Charge

<u>Demand Charge</u>	<u>Per Month</u>	<u>Total</u>
<u>Maximum Peak Load Month</u>		
(900 HP x 1 kW/1.3405 HP = 671.4 kW)		
First 75 kW (or less).....	\$ 281.25	
Excess 596.4 kW @ \$3.75/kW.....	2,236.50	
Demand charge for 671.4 kW load.....	<u>\$2,517.75</u>	\$2,517.75
 <u>3 - 600 HP Peak Load Months</u>		
(600 HP x 1 kW/1.3405 HP = 447.6 kW)		
First 75 kW.....	281.25	
Excess 372.6 kW @ \$3.75/kW.....	1,397.25	
Demand charge for 447.6 kW load.....	<u>1,678.50</u>	
3 months @ \$1,678.50.....		5,035.50
 <u>8 - 300 HP Peak Load Months</u>		
(50% of 671.4 kW (peak load during previous 11 months) = 335.7 kW)		
First 75 kW.....	281.25	
Excess 260.7 kW @ \$3.75/kW.....	977.63	
Demand charge per month.....	<u>1,258.88</u>	
8 months @ \$1,258.88.....		<u>10,071.04</u>
Total Demand Charge		\$17,624.29
Forward		\$17,624.29

Total Demand Charge (forward) \$17,624.29

Energy Charge

3 motors on:	3 x 300 HP x 1 kW/1.3405 HP x 4 hrs. 2685.56 kW hr. @ \$.01120.....	30.08
2 motors on:	2 x 300 HP x 1 kW/1.3405 HP x 50 hrs. 22380 kW hr. @ \$.01120	250.65
1 motor on:	1 x 300 HP x 1 kW/1.3405 HP x 100 hrs. 22380 kW hr. @ \$.01120	250.65
		Total Energy Charge \$ 531.38

Total Annual Cost of Electricity \$18,155.67

Demand Charge as % of Total Charge = 97.07%

Example 2

Assume the station in Example 1 uses three natural gas engines in lieu of the electric motors, each of 300 HP. Each engine has a gas consumption rate of 3,000 cu. ft./hr. (10,000 BTU/HP/hr.). Assume the station operates 62 engine hours in one month, 40 engine hours a month for two months, 10 engine hours a month for two months, and 2 engine hours a month for five months for the same 212 total engine hours a year of pumping as in Example 1. Find the total annual cost of gas fuel for the station utilizing the Long Beach Gas Department Rate Schedule.

Meter Charge 365 days x \$.33/day/12 = \$10.04/month average

<u>Maximum Month - Heaviest Use</u>	<u>Per Month</u>	<u>Total</u>
-------------------------------------	------------------	--------------

(62 engine hrs. at consumption rate of 3 MCF/hr. = 186 MCF)

Meter Charge	\$ 10.04	
Usage - 186 MCF x \$.3918/100CF.....	728.75	
62 engine hours operation cost.....		\$ 738.79

Forward \$ 738.79

	<u>Per Month</u>	<u>Total</u>
Forward		\$ 738.79
 <u>2 Months - Heavy Use</u>		
(40 engine hrs./mo. at consumption rate of 3 MCF/hour = 120 MCF/mo.)		
Meter Charge	\$ 10.04	
Usage - 120 MCF x \$.3918/100CF	470.16	
40 engine hours/mo. operation cost	\$ 480.20	
2 months @ 40 hours operation cost		960.40
 <u>2 Months - Moderate Use</u>		
(20 engine hrs./mo. at consumption rate of 3 MCF/hr. = 60 MCF/mo.)		
Meter Charge	10.04	
Usage - 60 MCF x \$.3918/100CF	235.08	
20 engine hrs./mo. operation cost	245.12	
2 months @ 20 hrs. operation cost		490.24
 <u>2 Months - Light Use</u>		
(10 engine hrs./mo. at consumption rate of 3 MCF/hr. = 30 MCF/mo.)		
Meter Charge	10.04	
Usage - 30 MCF x \$.3918/100CF	117.54	
10 engine hrs./mo. operation cost	127.58	
2 months @ 10 hrs. operation cost		255.16
 <u>5 Months - Lightest Use</u>		
(2 engine hrs./mo. at consumption rate of 3 MCF/hr. = 6 MCF/mo.)		
Meter Charge	10.04	
Usage - 6 MCF x \$.3918/100CF	23.51	
2 engine hrs./mo. operation cost	33.55	
5 months @ 2 hrs. operation cost	72.00 min.	360.00
Total Annual Cost of Natural Gas		<u><u>\$2,804.59</u></u>

Example 3

Assume the station in Example 1 uses 3 LPG engines, each with an LPG consumption rate of 30 gallons per hour (1/10 gallon per HP per hour). Calculate the fuel cost of the station.

Hours of one-engine operation = 100 x 1 =	100
Hours of two-engine operation = 50 x 2 =	100
Hours of three-engine operation = 4 x 3 =	<u>12</u>
Total hours of engine operation	212
Gallons used per hour	x 30
Total gallons used	6,320
Price per gallon in 6,000 - 10,000 gallon annual usage range	\$ <u>.732</u>
Annual Cost for LPG =	\$4,626.24

Example 4

Compare the total relevant costs of electricity and gas in Examples 7.1 and 7.2. Assume that each 300 HP engine, accessories and installation costs \$50,000 more than a motor. Also assume additional maintenance for three engines to be one man day per month at \$25.00 per hour (includes materials). Assume the public agency borrows capital expenditure money at 15% interest rate and the equipment has a 30-year life. The annual cost factor at 15% for 30 years is .15230.

<u>Costs</u>	<u>Electricity</u>	<u>Gas</u>	<u>+Saving of Gas -Extra Cost of Gas</u>
Initial capital cost of engines in excess of motors - radiators, pedestals, shafts, right angle gears, lubrication, gas supply and interest. (\$50,000 x 3 x .15230 annual cost factor)		\$22,845.00	\$-22,845.00
Utility Cost	\$18,155.67	\$ 2,804.59	\$+15,351.08
Maintenance		\$ 2,400.00	\$ -2,400.00
Additional Cost of Natural Gas			\$ -9,893.92

LPG, (Example 3) costing more annually than natural gas (\$4,626.24 vs. \$2,804.59) would be even less economical than natural gas, assuming the same capital and maintenance costs.

8. Summary

The examples used in the foregoing text are based on a hypothetical number of operating hours in each case. Naturally, the actual number of operating hours will vary from year and the numbers used in the examples are intended to be illustrative only and not an average for any particular locality. Study of rainfall records and hydrographs should be used to determine the anticipated annual average operating hours for any proposed new station.

It is also instructive to consider the electrical energy cost for a small station, reducing the three 300 HP motors by a factor of 10, to three 30 HP motors, with the same number of hours of operation. On the connected load basis, the demand charge is \$1,080.00 and the energy charge is \$96.95 for a total annual cost of electricity of \$1,176.95. On the demand basis, the demand charge would be \$3,375.00 and the energy charge \$53.12 for an annual total cost of \$3,428.12. The connected load basis would be used. If a large storage volume was provided, and pumping was needed for over 1,000 hours, the connected load basis would still be applicable.

* * * * *

APPENDIX F

PUMP AND ENGINE TESTING

It has by custom been the privilege of the purchaser of a machine to witness the testing of that machine at the manufacturer's factory, and to accept or reject the product according to the results of the test.

Although in our daily lives, it is impractical to witness tests of automobiles or other machines which we purchase, the witness testing of pumps, engines and even electric motors still prevails to a large extent. It will be noted from Appendix D - Specifications, that witness testing has been called for, but locations of manufacturing facilities in relation to the design office or jobsite often makes it impractical that tests be witnessed, hence a waiving of this requirement is provided for. Nonetheless, testing is important and is a routine function performed by the manufacturer. Therefore, test results can always be made available and are submitted as part of the shop drawings or as documentation accompanying delivery of equipment.

Engine testing is conducted with a dynamometer to which the engine is connected. A range of loadings is simulated and horsepower developed can be measured at various rpms. Fuel consumption, temperatures, and manifold pressures are all monitored and recorded. The extent of the information will be understood by reference to the figures in Chapter 11. - Engines and Accessories.

A pump manufacturer's test facility is set up so that pump speed in rpm can be measured, together with electrical power utilized. Flow is measured with an orifice or venturi meter and a valve can be opened or closed to simulate discharge head. See Figure F-3.

When testing a pump, a series of eight or ten conditions are set up and the resulting data is recorded. From this data, the head capacity curve of the pump is drawn and is then compared with the design point or points which have been specified. The exact manner in which the data is set forth requires a little study and interpretation. Figure F-1 shows the tabulated data, and Figure F-2 shows the plotted curves for head capacity, bowl efficiency and brake horsepower. The specified design point of 23,038 gpm at 24.5 tdh is seen to be well exceeded, a discharge of about 25,700 resulting at that head, with above equal excess performance at the maximum and minimum heads specified. The buyer will thus receive a little more than specified in this case, which is satisfactory since there is no motor overload involved. The Hydraulic Institute criteria allow zero to ten per cent excess discharge so that the pump in question is at the upper limit of allowable variation.

* * * * *

COPY OF CERTIFIED TEST DATA

COURTESY OF AURORA PUMPS

TYPE 3QLM STAGES 1 IMPELLER 3QLM-5A-37.5° COLUMN 30" HEAD 30'
 VENTURI 30 VENTURI K-FACTOR 10975 MOTOR 400HP-12 POLE DISCH. GAGE — SER. NO. —
 DYNAMOMETER LEVER ARM 26.53" DYNO. SCALE 2000 LB. K-FACTOR .0004209

<u>PUMP RATING</u>	
GPM -	24500
TDH -	265
EFF -	87
BHP -	188
RPM -	590

F-2

LAB RPM	SPEED	597	597	597	598	598	597	597	597
CAPACITY	H2O inches								
	Hg inches	5.10	5.55	6.85	7.40	6.20	4.15	3.25	2.45
	<u>30"</u> VENT.	24785	25855	28724	29855	27327	22357	19785	17178
GPM	— VENT.								
	— VENT.								
	TOTAL CAP.	24785	25855	28724	29855	27327	22357	19785	17178
HEAD FEET (WATER)	PST								
	VEL. HD.	2.25	2.30	2.82	3.25	2.79	1.86	1.39	1.00
	HD. TO GA.	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
	GAGE HD.	24.00	21.50	10.75	7.00	16.75	30.25	33.75	37.00
	TOTAL HD.	28.43	25.98	15.75	12.43	21.72	34.29	37.32	40.18
POWER	DYN./CORR.	804/	775/	650/	605/	725/	895/	957/	960/
	K x # x N = HP	202.02	194.73	163.33	152.27	182.48	224.89	240.47	241.22
	KILOWATTS								
	MOTOR EFF.								
	BHP								
	WHP								
BOWL EFFICIENCY %		88.00	87.10	69.90	61.50	82.10	86.00	77.50	72.20
GPM		24454	25552	28387	29455	26961	22095	19553	16976
JOB RPM <u>590</u> TDH		27.76	25.37	15.38	12.09	21.14	33.49	36.44	39.24
BHP		19500	187.96	157.65	146.24	175.25	217.07	232.11	232.83

FIGURE F-1. LABORATORY PUMP TEST DATA

COPY OF CERTIFIED TEST

COURTESY OF AURORA PUMPS

PUMP SIZE 30 PUMP TYPE LM RPM 590

STAGE ONE SPECIFIC GRAVITY 1.0 IMPELLER DIA. 5A-37.5°

F-3

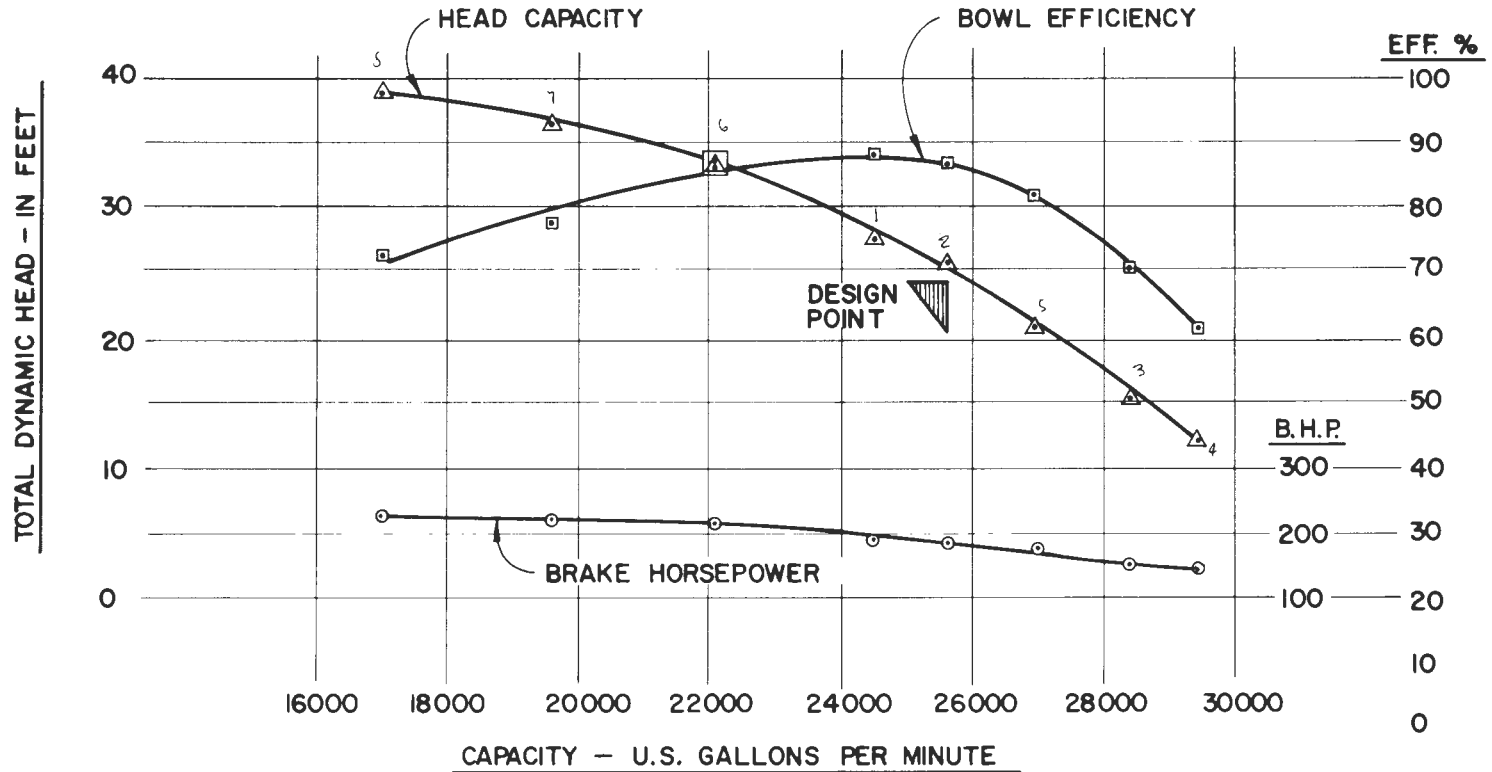


FIGURE F-2. CURVES BASED ON TEST DATA

F-4

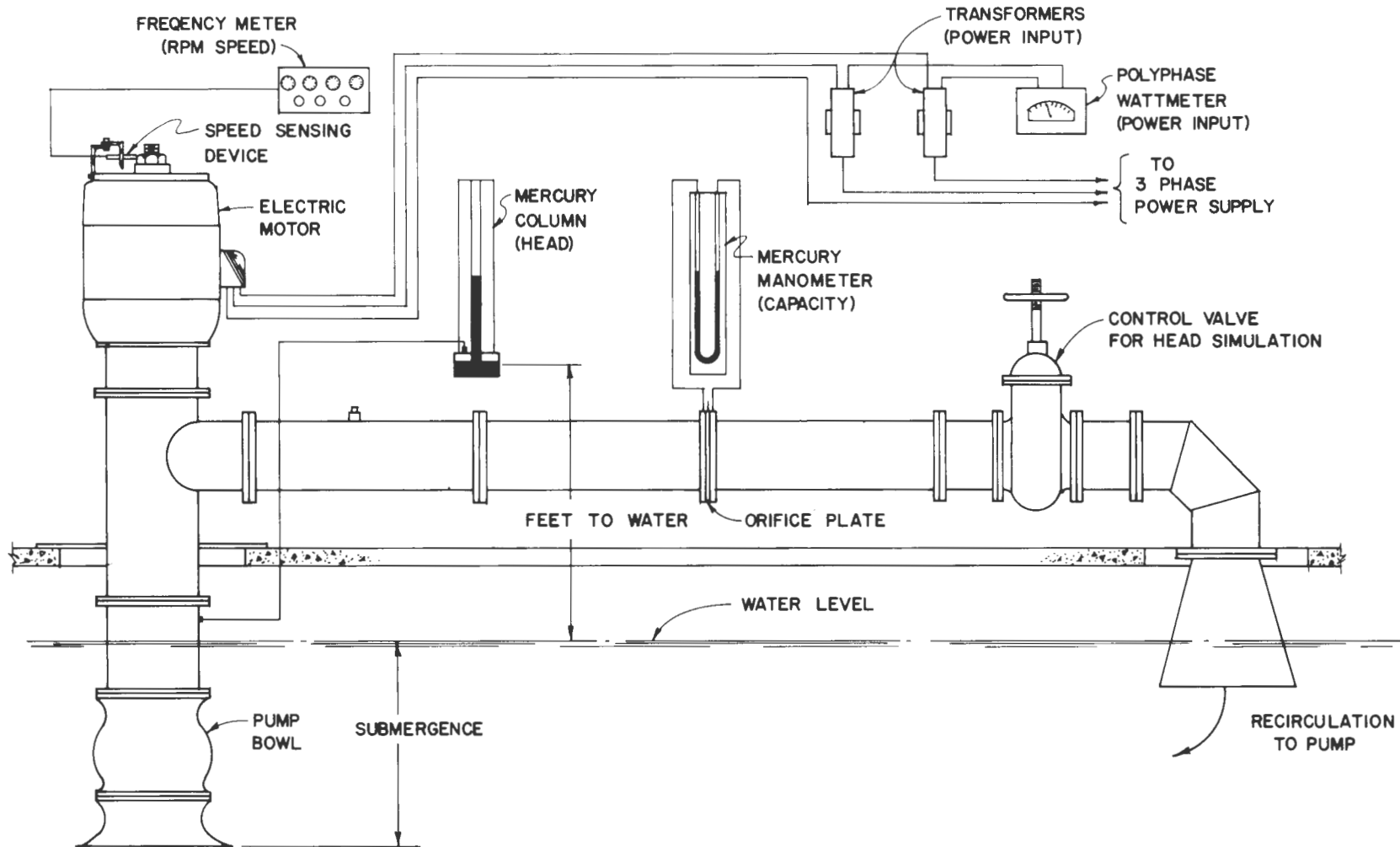


FIGURE F-3. TYPICAL PUMP TEST FACILITY

APPENDIX G

MAINTENANCE MANAGEMENT

The operation of a facility such as a stormwater pump station requires constant surveillance of plant and equipment. This is defined as continual inspection, rebuilding and repair as necessary.

To reduce the extent of this continual work, it is important that the design of a pump station be as simple and straight-forward as possible and that the use of elaborate equipment and accessories be avoided, unless need can be clearly justified. Complications and the added capital expenditure they involve are unlikely to reduce the cost of maintenance because there is simply more equipment to look after.

A preventive maintenance program should be established by every agency responsible for pump station operations and should be an integral part of start-up operations for new facilities. By adequate care, lubrication and replacement of worn parts of machinery, the program will ensure maximum availability of all equipment for use when needed.

To develop a comprehensive preventive maintenance program, the adoption of three major objectives is recommended. The objectives should be to provide against equipment failures, to provide for maximum continuous service of equipment, and to provide for maximum economy of operation and maintenance.

To accomplish these goals, it is first desirable to consult the manufacturer's representatives concerning the equipment they furnish. Individual equipment representatives should be requested to furnish the best advice available for the preventive maintenance of their equipment. A detailed schedule of planned maintenance and inspection can then be developed. Sometimes a contracted service for periodical maintenance by a manufacturer may be the most cost-effective solution.

One significant point which should be made at this time is that all personnel involved with the preventive maintenance program should have a thorough understanding of its objectives and full knowledge of the terminology used. For example, preventive maintenance, corrective maintenance and maintenance of structures should be defined in writing at the outset of the program. Terms such as "inspection", "rebuilding", and "repair", should be distinctly clear to everyone. For example, it is suggested that the following definitions be implemented:

Preventive maintenance is that specifically scheduled in the program and which is necessary for continued operation.

Inspection is the visual examination or other suitable examination of equipment which is specifically scheduled into the preventive maintenance program. A checklist should be provided for each pump or piece of equipment which should be operated or "exercised" at specified intervals.

Maintenance of structures should be defined as maintenance to buildings which includes doors, windows, floors, walls, roofs, ceilings, columns or supports, concrete basins, tanks, roadways, curbs, grating, and stairways.

Rebuilding is the major scheduled repair or replacement of component parts of a pump or piece of equipment that shows signs of wear or deterioration.

Repair is nonscheduled corrective work on any pump or piece of equipment, intended to keep the unit on-line and operating until it is rebuilt or replaced.

In order to ensure an adequate history for each piece of equipment, a separate file should be maintained. The file should include an account of all preventive maintenance and corrective maintenance performed. It should also include the time and material costs associated with the care and maintenance of each piece of equipment.

Maintenance personnel should receive proper training for the equipment which they will be responsible for maintaining, and the design engineer and each manufacturer of each piece of equipment should be consulted about specific maintenance requirements. It is essential that all appropriate shop drawings and parts-breakdown catalogs be available and remain on file for reference.

Another important maintenance factor, wholly different from the care of machinery and building plant, is the periodic removal of mud and other debris from every station. Various illustrations in the text show hoists and buckets in use for this purpose, but this mode of operation is giving way to the use of mobile vacuum equipment, operated in the liquids mode. This type of truck-mounted machine can be brought to the station and operated as needed in an environmentally acceptable manner, exhaust air being thoroughly cleaned by triple filtration. The resultant waste can be hauled to a sanitary landfill for disposal.

* * * * *

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