REPORT OF THE
INDEPENDENT TECHNICAL
REVIEW
COMMITTEE EVALUATION
OF THE MOS-1 PORTION OF THE LOS ANGELES
METRO RAIL PROJECT

January 3, 1985 6

see attachment #8

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I. INTRODUCTION

The charge to the Independent Technical Review Committee was to undertake a review of the work design and safety of the MOS-1 portion of the Los Angeles Metro Rail Project with particular emphasis on methane gas, and that in this regard, review, but not be limited to consideration of existing engineering reports.

Because the charge to the Committee specifically designated that the Committee review the design and safety of MOS-1 with particular emphasis on methane gas, much of the Committee effort was spent on the construction portion of the tunnels (where exposure to methane is most likely), on tunnel ventilation, and on detecting methane gas once operations begin. All Committee deliberations were conducted in open, public sessions.

The Committee notes that experience from other tunneling projects shows that most danger to life and limb resulted from unexpected and unforeseen conditions or happenings. Expected conditions or foreseen conditions can be planned for and in this way the hazards can be reduced. Therefore, the Committee made every effort to identify all possible potentially hazardous conditions and then to ascertain if the SCRTD was prepared to handle them safely. The Committee feels that SCRTD identified and was

prepared for most of the likely hazards, but also believes there are some additional potential hazards that should be addressed by the SCRTD as well as additional precautions which should be taken.

Notwithstanding the limited time available to review this complicated Project and the mix of experience of the Committee members, it is the general consensus of the Independent Technical Review Committee that the MOS-1 portion of the L.A. Metro Rail Project is feasible to construct and operate if appropriate precautions are taken. The Committee concludes that the MOS-1 portion of the Project is not more complicated and does not pose greater hazards of construction or operation than some other tunneling projects that have been successfully completed for subways, highways, and pipelines in the United States and in other countries. However, the Committee recognizes that the MOS-1 portion of the Project does have some special features which pose difficulties, such as the possibility of encountering methane gas, the possibility of encountering old abandoned oil wells, and the possibility of encountering an unknown fault; and these special features must receive all necessary attention.

Ultimately, the safety of those building the Project and those who will operate and use the system will depend on adequate planning, designs, and construction management by the SCRTD; on construction techniques and procedures used by contractors yet to be selected; on adequate inspections; on knowledgeable, conscientious, and attentative workers, supervisors, and managers. The Independent Technical Review Committee notes that it cannot guarantee the safety of the Project on the basis of a review of plans, specifications, designs, and proposed construction techniques. But the recommendations in this report, and those contained in the Critchfield-King Report (an SCRTD Board of Review Report of the L.A. Metro Rail Project) will contribute to the reduction of worker and patron risk exposure.

The Committee, in the course of examining MOS-1 and, to a very limited extent, the portions of the route beyond this segment, especially the westerly extremities of the initial 18.6 mile route, were concerned about the adequacy of the geological data gathered to date and did not believe sufficient information was developed to adequately represent the geologic, seismic, and groundwater conditions there. The Committee therefore wishes to indicate that there will be the need for the SCRTD to augment existing geological information about those areas well in advance of the beginning of tunnel construction work in those areas.

The Committee wishes to express its thanks to the representatives of the SCRTD and their consultants for their patience and active cooperation in this review. Appreciation is also directed to the representatives from Cal-OSHA and the Los Angeles Fire Department for making presentations to the Committee.

ATTACHMENT No. 3

INDEPENDENT TECHNICAL REVIEW COMMITTEE
L.A. METRO RAIL AGENDA

MEETING 1 DATE: November 12, 1985

LOCATION: CITY HALL, ROOM 350

Time

9:00 * Charge by Pat Russell, President, Los Angeles City Council
9:10 * Statement of study (See Attachment 1)
9:15 * Acceptance of Committee Guidelines (See Attachment 2)
9:25 * Acceptance of existing published information - soils reports, route, plans for tunnel construction, reports and conclusion

Those individuals listed below will make their complete presentation first. Questions by Committee members will follow.

9:30 DESCRIPTION OF THE PROJECT BY J. MONSEES (10 Min.)

A. Alignment and Geology

1. Location
2. Geologic Deposits of Engineering Significance
3. Groundwater
4. Abandoned Oil Wells

B. Structures

1. Tunnels
2. Stations

C. Construction Approach

9:50 GAS OCCURRENCES BY D. FASPER (20 Min.)

A. Field Investigation Activities

1. Geotechnical Exploration
2. Gas Probes
   a) 1983
   b) 1985

B. History of Gas Occurrences

C. Wilshire/Fairfax Building Construction

10:10 BASIS FOR DESIGN BY J. MONSEES (40 Min.)

A. Gas Flow Conditions

1. Through Joints

2. By Diffusion
3. Through Cracks
4. Water Infiltration

B. Selection of Liners

1. Steel
2. Pre-Cast Concrete
3. Cast-in-Place Concrete

C. Membranes

1. Products Considered
2. Laboratory Tests
   a) Permeability
   b) Chemical Resistance
   c) Abrasion Resistance

11:15 VENTILATION BY A. DALE (15 Min.)

A. Gas Monitoring

11:30 SUMMARY OF DESIGN BY J. CRAWLEY (10 Min.)

A. Gas Sensing and Monitoring

B. Ventilation System

C. Liners and Membranes

11:45 LUNCH

1:00 CONSTRUCTION TECHNIQUES BY H. SCOTT (15 Min.)

A. Methods and Equipment

B. Gas Sensing and Monitoring

1:35 OPERATIONAL PROCEDURES BY A. DALE (15 Min.)

2:00 POSS CLOTHING STORE EXPERIENCE BY D. BARTLETT (10 Min.)

2:20 STATE REGULATORY REQUIREMENTS BY B. ISHKANIAN (30 Min.)

A. Cal-OSHA

1. Tunnel Safety Orders
2. Mine Safety Orders

3:00 TECHNICAL PRESENTATIONS BY PUBLIC

3:15 DISCUSSION BY COMMITTEE MEMBERS

*Request Additional Information
*Set Date of Second Meeting
*Adjournment

The Committee's specific concerns, issue statements, and recommendations are contained in the body of this report. A list of the Committee recommendations follow this page. We believe that these require the immediate attention of the SCRTD so that the results of the additional studies, revised designs, investigations, or possible project modifications can be incorporated in the project's plans, designs, bid documents, specifications, training and safety manuals, etc. The Committee also wishes to call attention to comments and additions made to the Critchfield-King recommendations. These are included in this Report as Attachment No. 8 and will be of some benefit to the SCRTD.

Richard W. Balcerzak

James E. Slosson

J. Davitt McAteer

Jay L. Smith

Terence G. McCusker

Eugene B. Waggoner

Jerome C. Neyer

John Witte

Robin Shepherd

George W. Housner, Chairman

II. Recommendations

1. The SCRTD should conduct additional studies and research to improve the method of locating uncharted oil and gas wells before they are encountered and ruptured by a tunnel excavator and establish a procedure to abandon any oil or gas well encountered.

1A. Audible and visual warning devices should be installed on tunnel excavating machines and in the tunnels to alert employees when detectors have identified the presence of methane gas.

1B. The SCRTD should provide all its available methane gas documentation and interpretations by qualified experts to those bidding on the construction contracts involving tunneling or stations construction, and the SCRTD should include in bid documents the requirement that the contractor provide all employees involved in underground construction work with at least 8 hours of training in dealing with the hazards created by methane gas, safety precautions and emergency procedures to be followed when working underground, prior to those employees commencing underground work. In addition, periodic emergency drills and simulated rescues should be staged to reinforce the training.

1C. Any tunnel excavating machine used to excavate the tunnels should be equipped with an enclosed cab and/or self-contained oxygen supply for the machine operator. In addition, all other workers in the immediate vicinity of the face should have, at all times and in immediate proximity of their working location, self-contained "self rescuers" with an independent oxygen supply. Catalytic type "self rescuers" should not be relied upon since they are not effective in a methane environment.

2. The SCRTD should undertake additional study to determine the effects that the geological environment surrounding the tunnel route will have on the amount of water and gas likely to penetrate the tunnels. A more thorough study of the characteristics of the oil and gas reservoirs in the vicinity of the route should also be undertaken.

3. The SCRTD should review its decision not to provide some automatic mechanism to "back-up" the control room operators activation of emergency ventilation fans. An automatic system should be designed for the control room so that if an alarm should warn of increasing levels of methane gas and the appropriate actions required of a human operator do not occur within a specific period of time, a preprogrammed computerized sequence of events will be initiated to activate the required fans, blowers, exhaust systems, etc.

4. The SCRTD should, if it has not already completed such a review, assemble its own review panel to examine if its construction designs incorporate sufficient planning to

accommodate adequately the special needs of the handicapped patron to use emergency accesses with as little assistance from employees or other patrons as can reasonably be expected.

5. The SCRTD should reevaluate its gas probe and monitoring system so as to ensure that the system will: 1) locate probes in such underground locations as stations, tunnels, cross passages, etc. where methane and hydrogen sulfide gases are likely to collect (in addition to those to be located in the exhaust ducts); 2) locate probes so that reasonably adequate diagnostic data can be generated to help locate the source of a gas intrusion should it occur.

6. The SCRTD should assign a certified engineering-geologist to be stationed at or near the working face of the tunnel at all times to inspect and log tunnel geology so as to obtain accurate information and interpretation in a timely manner about geologic conditions encountered such as methane pockets, groundwater, and changes in geologic conditions exposed during tunnel construction.

   In addition, the SCRTD, if it has not already done so, should develop a contingency plan that will establish the criteria against which faults encountered during construction will be judged as potentially active or inactive and establish a procedure whereby the concrete tunnel lining will be replaced by specially designed steel lining when a fault classified as active is encountered.

7. The SCRTD should better define the groundwater environment through which the Metro Rail will traverse by preparing a detailed profile along the tunnel alignments illustrating the position of the water levels. Estimates should be made of water inflow rates and these should be compared with the capacities of pumping units to be installed in the tunnels. Evacuation plans and tunnel walkway plans should also be examined to ensure that they will remain useful to evacuate patrons and employees should excessive inflow occur.

8. The SCRTD and its consultants should obtain a copy of the U.S.G.S. Professional Paper 1365 and verify the adequacy of the MOS-1 structural seismic design. Additional consideration of fault displacement and related damage to the tunnel should also be analyzed.

9. The SCRTD should review its plans for backup power supplies and utilize fixed or mobile generators to supply emergency power for the ventilation and dewatering pumps in critical areas.

10. The SCRTD should reexamine the use of membrane clamps, grout holes and grout pipes to insure that the membrane surrounding the tunnel lining will be properly sealed and closed off after grouting.

III. BACKGROUND

The design of the Los Angeles Metro Rail Project has been in process for several years. Recently, the 1986 Transportation Appropriations bill that would finance the first 4.4 mile segment of the 18.6 mile system proposed by the Southern California Rapid Transit District (SCRTD) was approved.

The House of Representatives, on September 12, 1985, approved H.R. 3244, which would authorize $117 million for the Minimum Operating Segment (MOS-1) of the Metro Rail Project. A floor amendment added to the bill prohibited the Metro Rail Project from penetrating certain areas in and adjacent to the La Brea Tar Pits in the Fairfax area of Los Angeles.

Congressional representatives and local officials have expressed concerns about the designs and safety of MOS-1. In a letter dated September 23, 1985, Congressmen Waxman and Dixon asked the City of Los Angeles to initiate an independent technical evaluation of the design and safety of the MOS-1. The evaluation was felt necessary because the MOS-1 will pass through ground known to contain methane gas and possible seismically active faults. The Waxman-Dixon letter is attached as Attachment No. 1.

It was requested that a committee of ten members be assembled (eight appointed by the President of the City Council and two by Congressman Waxman), with Committee deliberations open to the public.

On October 23, 1985, the City Council, in approving a Transportation and Traffic Committee Report in City Council File 85-1849, established the ten member Independent Technical Review Committee, approved a budget for the review of the Metro Rail Project, and authorized the President of the City Council to appoint eight technical experts to the Committee. The City Council action is noted in Attachment No. 2.

Shortly thereafter, the President of the City Council appointed the following individuals to the Independent Technical Review Committee:

-- Dr. George W. Housner: Dr. Housner has been on the faculty at Caltech since 1945, becoming Professor Emeritus in 1982. The author of three textbooks and more than 100 technical papers on seismology, earthquake analysis, and design of structures, Housner has an international reputation in earthquake engineering. He was a consultant to the Bay Area Rapid Transit System. He is a member of the National Academy of Engineering and the National Academy of Sciences. He was designated Chairman of the Committee.

-- Jay L. Smith: Mr. Smith is President of the Jay L. Smith Company, Inc. He is a registered geologist and engineering

geologist with over twenty five-years of experience in geotechnical investigations of the Los Angeles area.

-- Eugene B. Waggoner: Mr. Waggoner, an engineering geologist, is the former Chief Executive Officer of Woodward-Clyde & Associates, a national firm of consulting soil and foundation engineers and engineering geologists.

-- Dr. Robin Shepherd: A civil engineer, Dr. Shepherd has been on the faculty of the University of California, Irvine, since 1980 and is the author of many academic papers applying structural dynamics to earthquake-related structural loads.

-- John Witte: President of John Witte, Inc., a consulting firm, Mr. Witte has designed tunnel support systems for over 20 tunnels and has been engaged as a consultant for tunnels planned by the Los Angeles County Flood Control District, Los Angeles County Sanitation District, the City of Los Angeles, and served as a consultant on the subway system projects in Washington D.C. and Baltimore, Maryland.

-- Richard Walter Balcerzak: Mr. Balcerzak, a civil engineer, is the Assistant General Manager in charge of Operations, Engineering and Right of Way for the Metropolitan Water District of Southern California. He has been the principal engineer for various tunnel and pipeline projects for the MWD.

-- Jerome C. Neyer: President of the consulting engineering firm of Neyer, Tiseo and Hindo, Ltd., Mr. Neyer has specialized in geotechnical engineering for underground construction projects. He is the past president of the Southeastern Branch of the American Society of Civil Engineers.

-- Terence G. McCusker: Mr. McCusker is a tunnel construction consultant with an international practice, author of a number of technical articles on tunneling, and is the immediate past chairman of the American Society of Civil Engineering's Committee on Tunneling and Underground Construction.

The following two appointments were made by Congressman Henry Waxman:

-- Dr. James Edward Slosson: Dr. Slosson is a former California State Geologist and Chief of the State's Division of Mines and Geology and former commissioner on the State Seismic Safety Commission. Dr. Slosson has authorized more than ninety technical articles about geology, engineering geology, seismology, earthquakes, natural hazards and forensic engineering geology and has been associated with over one thousand construction projects including tunnels.

-- J. Davitt McAteer: A member of the American Bar Association, Mr. McAteer is currently the director of the Occupational Safety and Health Law Center in Washington D.C. and a former attorney for the United Mine Workers of America.

IV. First Meeting

The first meeting of the Independent Technical Review Committee was held in Room 340 of the Los Angeles City Hall on November 12, 1985. All members were present at this meeting. After Councilwoman Pat Russell thanked the members for agreeing to serve on the panel, the Committee, as its first order of business, accepted the following Statement of Study:

STATEMENT OF STUDY

Soil and geological conditions in the Los Angeles Basin and specifically along the alignment of the Metro Rail Project, have created concerns about the adequacy of the design and safety of constructing and operating the first 4.4 mile segment of the Metro Rail Project commonly referred to as the Minimum Operating Segment (MOS-1). Methane gas, crude oil and other hydrocarbon substances as well as the soils and seismic conditions in the Basin necessitate the evaluation of the designs, construction techniques, etc., by an independent committee.

It is the task of this Independent Technical Review Committee to examine relevant technical data supporting and justifying the proposed design, proposed construction techniques, and safety considerations incorporated into the Project, to judge the adequacy of the data and the resultant designs and to determine to the extent possible, if the Project, has been so designed that it can be safely constructed and operated. The Committee shall offer any recommendation it believes to be appropriate to enhance the design and safety of the project.

The Independent Technical Review Committee will establish its own rules and will accept testimony in open meetings. The Technical Committee report and recommendations will be made to the City Council Transportation Committee at a public hearing, so that the Transportation Committee can make findings or recommend other appropriate action based upon this report. The Technical Committee and the Transportation Committee action shall be completed by December 31, 1985.

The following Committee Guidelines were similarly accepted:

COMMITTEE GUIDELINES

> Proceedings shall be conducted as informally as possible. Proceedings of the committee shall be conducted by quorum. Approval of matters shall be by consensus.
>
> Testimony shall be restricted to acceptance of such technical matters as design criteria, designs, tunnel construction techniques, soil conditions, seismic evaluations, structural design requirements, methane gas control, safety standards, etc. Ridership, alternate transit concepts, costs, etc. are not within the scope of the Committee's consideration, and no testimony will be accepted about these or other non-technical issues.
>
> Presentation of all testimony shall be in public session.

After formal acceptance of the SCRTD's Board of Review Report on Methane Gas and the City Task Force Report on the Methane Fire and Explosion in the Fairfax Area of Los Angeles, the Committee proceeded to review the Metro Rail Project during the next five hours. A detailed outline of the subjects reviewed during this hearing is contained in Attachment No. 3. During the initial presentations by the SCRTD and its consultants, a detailed description of the overall route (including MOS-1) was presented, including generalized descriptions of geological deposits, groundwater conditions, uncharted oil wells and how these affected project engineering and design considerations for the Metro Rail tunnels and stations. Questions raised by the Committee were answered.

A more detailed presentation followed which identified the geotechnical investigations and gas probes used to evaluate the methane gas conditions along the proposed route. Additional background information was presented to describe the historic and recent occurrence of methane and current building construction practices used to keep methane gas from entering building foundations, basements and underground parking garages. Questions raised by the Committee were answered.

Based on the preceding geological and methane gas descriptions, SCRTD consultants outlined the design criteria used to determine when steel, cast-in-place concrete, or pre-cast concrete tunnel lining would be used, and the means by which the flow of water and methane gas could be reduced through tunnel linings, at joints, and cracks. In addition, the various types of coatings and membranes considered and tested for use on the tunnel and stations were described. Questions raised by the Committee were answered.

Additional testimony centered on the SCRTD's proposed system to detect and analyze for the presence of methane and other gases in

the tunnels during and after construction. In conjunction with this topic, the methods of ventilating the tunnels and other underground facilities were detailed. Extensive questioning by the Committee was centered on the means by which the presence and concentration of methane and hydrogen sulfide would be detected, analyzed, and what computer or human activated response would occur in the event of detection of increasing levels of gas.

The first day of the SCRTD presentation was concluded with SCRTD consultants' description of the methods and techniques to be used to construct the tunnels, the ventilation systems and air movement levels to be required during construction, and the anticipated ventilation procedures to be followed during revenue and non-revenue operation to insure passenger and employee safety. Questions raised by the Committee were answered.

Two regulatory agencies presented testimony about the role each would play to insure project and human safety. A representative of the Los Angeles Fire Department provided background information on its efforts to insure that the construction and operating plans of the project would meet the City's "fire-life" safety requirements. A brief overview of the methane gas explosion and fire at the Ross Clothing Store was also presented.

A representative of Cal-OSHA presented information that described the applicability of the State's rules governing mining and tunneling to the SCRTD project, as well as the on-going and cooperative relationship that has existed and exists between Cal-OSHA and the SCRTD.

Upon completion of the presentation of testimony by City and State regulatory agencies, the general public was invited to present comments and technical information. None was presented.

The Committee then proceeded to review extensively Appendix B-List of Studies and Reports Available to the Board of Review, contained in the SCRTD's Report on Construction and Operation in Gaseous Areas. Attachment No. 4 describes the material requested by each Committee member from Appendix B. The Committee directed staff to review the complete tape recording of the day's proceedings and present a written list of questions to the SCRTD representatives that were not or were not completely answered during the first day. The list of questions and SCRTD responses are noted in Attachments No. 5 and No. 6. The Committee set its second meeting for December 2, 1985 in City Hall.

V. Second Meeting

The Committee conducted its second meeting on December 2, 1985 in the Conference Room in Room 300 of City Hall East beginning at 9:00 a.m.. This meeting, like the first, was open to the public. All Committee members were present. The agenda for this meeting is Attachment No. 7. Information, including the SCRTD answers to

questions posed at the first meeting, was distributed. The SCRTD response generated additional questions from the Committee and were answered by SCRTD representatives.

The Committee members then proceeded to review the Critchfield, King, King, and Zeigler consultants' report (referred to as the Critchfield-King Report) on the SCRTD's study entitled "Design, Construction, and Operation in Gaseous Areas". This report is Attachment No. 8. After commenting on the completeness and appropriateness of each recommendation, staff was instructed to incorporate their comments on this report into the Committee's report. The Committee members then proceeded to discuss their individual concerns and issues that warranted additional attention and consideration by the SCRTD before construction of the project commenced or revenue operations begin.

VI. Committee Concerns, Issue Statements and Recommendations

By consensus of the Committee, the following important concerns and issues were determined to warrant additional SCRTD study, consideration, or action in order to meet the long and short term safety needs of the L.A. Metro Rail Project more completely.

The Committee noted that the SCRTD was very concerned about worker safety during construction as evidenced by the requirements specified in the Construction Safety and Security Manual, the draft specifications and the substantial involvement of Cal-OSHA and the Los Angeles Fire Department during project planning. However, the Committee had specific concerns about certain details associated with methane gas and other matters as indicated by the following.

1. Uncharted Oil and Gas Wells

The Los Angeles City Oil Field, discovered in the late 1890's, contains many wells that were drilled and later abandoned years before State regulations required location surveys and official abandonment procedures. The MOS-1 portion of the Metro Rail project will tunnel near this field and other portions of the route will pass near fields of similar age. Available maps that designate the location of these wells are not complete or accurate and are of limited reliability in finding them. If such wells contain gas under pressure, the gas would pose a threat to workmen in the tunnel, should the tunnel excavating machines unexpectedly rupture a well allowing an inrush of gas into the tunnel.

To eliminate the possibility of explosion or fire as a result of the presence of an explosive gas/air mixture, the SCRTD is proposing to introduce large volumes of ventilation air into the tunnels at relatively high velocities to dilute and flush out the gas. However, additional measures are required to deal with an inrush of gas under pressure in high volumes. Additional effort should be made to determine if the abandoned wells can be located

before being opened by a tunnel excavating machine even though the Committee is not certain that such techniques are available.

Procedures should be established by which any encountered oil or gas well will be properly abandoned.

Recommendation

The SCRTD should conduct additional studies and research to improve the method of locating uncharted oil and gas wells before they are encountered and ruptured by a tunnel excavator and establish a procedure to abandon any oil or gas well encountered.

1A. Audible and Visual Alarms to Alert Tunnel Construction Workers of a Methane Gas

Automatic methane gas detection systems and shut down devices are to be located on the motorized equipment at the working face of the tunnel to shut off motorized equipment should a sudden surge of methane gas invade the tunnel.

However, the automatic shut down of certain pieces of equipment may not be enough to warn workers of the emergency, particularly those workers not working at the face.

Recommendation

Audible and visual warning devices should be installed on tunnel excavating machines and in the tunnels to alert employees when detectors have identified the presence of methane gas.

1B. Training of Employees Working Underground

An extremely important element in an overall safety program of a tunneling project is to have the construction contractor and the work force knowledgeable of the hazards of methane gas and the procedures to be followed when tunneling through ground that may contain explosive gases.

It is anticipated that most employees on the construction crews may be unfamiliar with, and need training in, the nature of underground work, methane gas hazards, use of safety equipment, and safety and emergency procedures.

Recommendation

The SCRTD should provide all its available methane gas documentation and interpretations by qualified experts to those bidding on the construction contracts involving tunneling or station construction, and the SCRTD should include in bid documents the requirement that the contractor provide all employees involved in underground construction work with at least 8 hours of training in dealing with the hazards created by methane gas, safety precautions and emergency procedures to be followed

when working underground, prior to those employees commencing underground work. In addition, periodic emergency drills and simulated rescues should be staged to reinforce the training.

1C. Emergency Oxygen Supplies

There exists the possibility in any tunnel construction project that workers at the face or tunnel heading (the tunnel excavating machine operator and the miners), could be exposed to or enveloped by an asphyxiating gas atmosphere if a large volume of methane gas should suddenly enter the tunnel. Those workers in close proximity to the face could be exposed to a significant hazard for an indefinite period until the tunnel ventilation diluted the gas and restored breathable air. In the opinion of the Committee, the safety of those workers at the tunnel face needs to be enhanced.

Recommendation

Any tunnel excavating machine used to excavate the tunnels should be equipped with an enclosed cab and/or self-contained oxygen supply for the machine operator. In addition, all other workers in the immediate vicinity of the face should have, at all times and in immediate proximity of their working location, self-contained "self rescuers" with an independent oxygen supply. Catalytic type self rescuers should not be relied upon since they are not effective in a methane environment.

2. Permeability of Concrete Tunnel Lining and Ambient Geological Conditions Surrounding the Tunnels.

The SCRTD has presented a good deal of test information about the effectiveness of seals, coatings, and plastic barriers to prevent or inhibit the passage of gas and water through the tunnel lining. The test data were tied to the the known characteristic of concrete that allows the passage of some water through it. References and comparisons were made to the amount of leakage detected in other transit tunnels, but no information was presented about the geological conditions surrounding those tunnels. Nothing was said as to the effect of such things as permeability of the sediments surrounding the L.A. Metro Rail tunnels, their lenticularity, and the viscosity of the water, oil and gas in the earth materials or the effects that such geological factors as the dip, strike and faults would have on the leakage expected into the L.A. Metro Rail tunnels.

Recommendation

The SCRTD should undertake additional study to determine the effects that the geological environment surrounding the tunnel route will have on the amount of water and gas likely to penetrate the tunnels. A more thorough study of the characteristics of the oil and gas reservoirs in the vicinity of the route should also be undertaken.

3. Automatic/Manual Activation of Ventilation Equipment

As presently designed by the SCRTD, automatic gas monitoring and analyzing devices will detect and analyze for the presence of methane and other gas in the exhaust ducts of the completed Metro Rail ventilation systems. Once the level or concentration of gas exceeds a predetermined alert level, an alarm will be annunciated and recorded on Metro Rail control room equipment. Operators within the control room must then take action to activate manually a series of fans and ventilators to purge the tunnels. The Committee is concerned that the system does not have any automatic capability to activate the ventilation systems in case the human operator fails to act. The Committee was informed that there would be multiple operators on duty whenever passengers were being carried on the system and that more than one person will be at the control room at all times to initiate required action. The Committee believed that because of recent histories of inadequate human reaction to emergency situations, some form of preprogrammed computer back-up response is necessary even though it appears unlikely that levels of gas requiring a response will ever occur.

Recommendation

The SCRTD should review its decision not to provide some automatic mechanism to "back-up" the control room operators activation of emergency ventilation fans. An automatic system should be designed for the control room so that if an alarm should warn of increasing levels of methane gas and the appropriate actions required of a human operator do not occur within a specific period of time, a preprogrammed computerized sequence of events will be initiated to activate the required fans, blowers, exhaust systems, etc.

4. Patron Behavior Studies and Tunnel and Station Design

The Committee was concerned that the designs prepared by the SCRTD would adequately provide a procedure for those unanticipated emergencies (i.e. loss of power due to an earthquake, rupture or displacement of tunnel lining, etc.) that might require patrons to evacuate a subway car and walk to a station and/or exit to the surface. The Committee members recognize that their experience and expertise does not qualify them to recognize whether the present designs fully incorporate the needs of the handicapped. The Committee concern centers on whether the designs of the tunnels and passages will enable handicapped patrons to navigate through the tunnels or stations in an emergency with minimum assistance from other patrons or SCRTD employees. It should be assumed that an evacuation maybe required following damage to the tunnel due to a large earthquake and the possible increase in flow of gas and/or water into the tunnel.

Recommendation

The SCRTD should, if it has not already completed such a review, assemble its own review panel to examine if its construction designs incorporate sufficient planning to accommodate adequately the special needs of the handicapped patron to use emergency accesses with as little assistance from employees or other patrons as can reasonably be expected.

5. Gas Probes and Monitoring after Construction is Completed

The plans of the SCRTD now call for the installation of gas monitoring probes in the exhaust ducts that remove air from the tunnels and other underground areas. Probes are not proposed to be installed in tunnels or cross passages between tunnels.

After extensive discussion of this system with representatives of the SCRTD, the Committee feels that what is proposed is too passive and that reliance on detectors in the exhaust ducts will not give any indication of the zone from which the gas is emanating and in other ways is not reliable as a control method. If the ventilation system should not be operable or operating for any reason, the probes in the exhaust duct would not provide any information about the quality of the air in the tunnels. The proposed probe and monitoring system planned for installation in the L.A. Metro Rail System has been used primarily in industrial processing systems.

The SCRTD estimated that the proposed ventilation system would provide for a complete change of air in the underground areas once every 15 minutes. This, coupled with the planned "low threshold" settings of the methane gas analyzers, would provide more than adequate warning of changing methane levels far in advance of any critical level being reached.

Recommendation

The SCRTD should reevaluate its gas probe and monitoring system so as to ensure that the system will: 1) locate probes in such underground locations as stations, tunnels, cross passages, etc., where methane and hydrogen sulfide gases are likely to collect (in addition to those to be located in the exhaust ducts); 2) locate probes so that reasonably adequate diagnostic data can be generated to help locate the source of a gas intrusion should it occur.

6. Identification of Currently Unknown But Potentially Active Faults Uncovered During Tunnel Construction

The L.A. Metro Rail tunnels have the potential of intersecting unrecorded and potentially active faults. While this was not described in the documentation presented to the Committee, SCRTD indicated orally that geologists and technicians would be required to be at the working face of the tunnels to examine as much of the

exposed portion of tunnel as is possible during the tunneling process.

Much discussion centered on this topic due to the limited tunnel area likely to be exposed during construction, the criteria to be used by the SCRTD and its consultants in judging whether the fault was active or not, and the limited amount of time available to the geologists and engineers to make a decision to change the tunnel lining without unreasonably delaying construction progress.

Recommendation

The SCRTD should assign a certified engineering-geologist to be stationed at or near the working face of the tunnel at all times to inspect and log tunnel geology so as to obtain accurate information and interpretation in a timely manner about geologic conditions encountered such as methane pockets, groundwater, and changes in geologic conditions exposed during tunnel construction.

In addition, the SCRTD, if it has not already done so, should develop a contingency plan that will establish the criteria against which faults encountered during construction will be judged as potentially active or inactive and establish a procedure whereby the concrete tunnel lining will be replaced by specially designed steel lining when a fault classified as active is encountered.

7. Groundwater Conditions

The horizontal and vertical alignment of the tunnel along the MOS-1 (and other segments) will cause it to pass through and be located below current groundwater levels in some places. The location of the groundwater table, including the areal, vertical, and stratigraphic distribution, was described in very general terms. There is concern, although the chance is very small, that should a break occur in the tunnel lining and surrounding membrane from an earthquake or other cause, potentially significant volumes of water could flow into the tunnels. More information should be gathered to assure that sufficient information is known about the groundwater conditions to verify that emergency evacuation plans for workers and patrons, pumping equipment, and evacuation routes will be adequate and usable for a reasonably estimated rate of water inflow.

Recommendation

The SCRTD should better define the goundwater environment through which the Metro Rail will traverse by preparing a detailed profile along the tunnel alignments illustrating the position of the water levels. Estimates should be made of water inflow rates and these should be compared with the capacities of pumping units to be installed in the tunnels. Evacuation plans and tunnel walkway plans should also be examined to ensure that they will remain useful to evacuate patrons and employees should excessive inflow occur.

8. Earthquake Criteria

The Lindvall Richter and Associates Report dated May 3, 1983 appears to suggest that some tunnel collapse may occur if the lateral and/or vertical acceleration related to a seismic event exceeds 0.6g. This may result if a 6.5 to 7 magnitude earthquake should occur on the Newport-Inglewood Fault or the Hollywood-Santa Monica Fault.

A Committee member indicated that, after the seismic design of the Metro Rail was prepared, the United States Geological Survey published Professional Paper 1365 entitled "Evaluating Earthquake Hazards in the Los Angeles Region" which indicated that an earthquake with 0.6g acceleration was possible in the Los Angeles region.

Recommendation

The SCRTD and its consultants should obtain a copy of the U.S.G.S. Professional Paper 1365 and verify the adequacy of the MOS-1 structural seismic design. Additional consideration of fault displacement and related damage to the tunnel should also be analyzed.

9. Backup Power Supply for Emergency Ventilation and Pumping Systems

Underground installations must be provided with a continuous supply of fresh air by the operation of mechanical fans and blowers.

The SCRTD has described that the proposed power supply system for the L.A. Metro Rail is based on three primary feeders supplying electrical energy from three independent distributing stations. Two of the distributing stations will serve the L.A. Metro Rail Project, along with other commercial, industrial and residential customers. The third is totally dedicated to the Metro Rail Project. The SCRTD believes that this represents a sufficient diversity of supply to insure that, even after a major earthquake, power from the Department of Water and Power will be available.

The Committee, however, believes a major earthquake could interrupt all three power sources and that additional standby safeguards are necessary to assure that a sufficient supply of electricity will always be available to power the ventilation fans and to operate dewatering pumps in critical locations.

Recommendation

The SCRTD should review its plans for backup power supplies and utilize fixed or mobile generators to supply emergency power for the ventilation and dewatering pumps in critical areas.

10. Grouting Tunnel Lining

When placing concrete or steel linings in the tunnels, it is planned to fill any voids behind the rigid tunnel lining with grout. A solid backfill is necessary to preclude subsidence and to tightly bond the tunnel lining to the surrounding earth.

However, the grouting process requires that holes be made in the solid tunnel linings and in the plastic membrane that will surround the lining. If this membrane is not properly sealed after grouting is completed, it could allow some methane gas to penetrate the tunnels.

Consultants for the SCRTD recognize this problem and have proposed a clamp to seal the plastic membrane at grout holes. Additionally, the SCRTD proposes to install a "grout pipe" behind the membrane to reduce the number of penetrations through the plastic membrane. However, the Committee believes that additional review by the SCRTD is warranted to ensure, to the maximum extent possible, that the integrity of the membrane will be maintained.

Recommendation

The SCRTD should reexamine the use of membrane clamps, grout holes and grout pipes to insure that the membrane surrounding the tunnel lining will be properly sealed and closed off after grouting.

ATTACHMENT No. 1

Congress of the United States

House of Representatives

Washington, D.C. 20515

September 23, 1985

Honorable Pat Russell
Chairwoman
Committee on Transportation
and Traffic
Los Angeles City Council
City Hall - Room 260
200 N. Spring Street
Los Angeles, California 90012

Dear Chairwoman Russell:

On September 12, 1985 the House of Representatives approved H.R. 3244, the 1986 Transportation Appropriations bill. As you know, we amended this bill on the floor to ensure that the Metro Rail route beyond MOS-1 will not penetrate either the "potential risk zone" or "high potential risk zone" in the Fairfax area as identified by the City of Los Angeles Task Force.

Included in this legislation are key provisions related to Metro Rail funding and its future alignment. The following language has been included in the bill approved by the House:

> H.R. 3244, page 41
>
> Sec. 320. (a) Notwithstanding any other provision of law, the Secretary shall, with regard to the Discretionary Grants Program of the Urban Mass Transportation Administration, within 30 days after the enactment of this section, issue a letter of intent and enter into a full funding contract with the Southern California Rapid Transit District for $429,000,000 to complete the Minimum Operable Segment, MOS-1, of the Downtown Los Angeles to the San Fernando Valley Metro Rail Project: Provided, That the $429,000,000 shall include $11,800,000 earmarked for fiscal year 1984, $117,200,000 earmarked for fiscal year 1985, $117,000,000 in fiscal year 1986 and, subject to the availability of funds $170,000,000 in subsequent fiscal years.

(b) The Urban Mass Transportation Administration shall enter into a contract with the Southern California Rapid Transit District to conduct a study of the potential methane gas risks relating to the proposed alignment of the Metro Rail Project beyond the Minimum Operable Segment, MOS-1. None of the funds described in subsection (a) may be made available for any segment of the downtown Los Angeles to San Fernando Valley Metro Rail Project unless and until the Southern California Rapid Transit District officially notifies and commits to the Urban Mass Transportation Administration that no part of the Metro Rail project will tunnel into or through any zone designated as a potential risk zone or high potential risk zone in the report of the City of Los Angeles dated June 19, 1985 entitled "Task Force Report on the March 24, 1985 Methane Gas Explosion and Fire in the Fairfax area." Funds for this study, in an amount not to exceed $1,000,000, shall be made available from funds previously allocated for the MOS-1 project, commencing within 30 days of enactment.

We are pleased that this compromise adequately addresses the construction of the second phase of Metro Rail through the Fairfax-Wilshire area of Los Angeles. Under the bill, RTD must notify and commit to UMTA that Metro-Rail, beyond MOS-1, will not penetrate the risk zones identified by the City Task Force.

As you are aware concerns have also been expressed about the design and safety of MOS-1, the first 4.4 mile segment of the system. Because of its importance, we ask that your Committee on Transportation and Traffic undertake a review of the work design and safety of MOS-1 with particular emphasis on methane gas, and that in this regard you review, but not limit yourself to considering, existing engineering and safety reports.

We ask that you convene, to assist your review, a Technical Committee comprised of ten members, two of these members to be named by Congressman Waxman. The Committee Chair would be appointed by you, and the Technical Committee will establish its own rules and their deliberations should be open to the public. We are recommending that the Technical Committee report to the Council's Transportation Committee at a public hearing, so that the Transportation Committeee can adopt findings based upon this report, or take whatever action is deemed appropriate. We are requesting that the Technical Committee and the Transportation Committee complete their work by December 31, 1985.

As evidenced by the relevant sections of H.R. 3244, your Transportation Committee's review of the design and safety of MOS-1 does not impact the issuance of a full funding contract by UMTA or the release of funds for construction of the first segment of Metro Rail. However, we anticipate that construction will not begin on MOS-1 until your committee has completed its work and made the appropriate findings.

We appreciate your willingness and that of your Committee to review these important issues, and each Member of the Los Angeles Congressional Delegation stands ready to assist you in any way you feel appropriate. We look forward to receiving your findings.

Sincerely,

HENRY WAXMAN
Member of Congress

JULIAN C. DIXON
Member of Congress

cc: Councilman Howard Finn
Councilman Zev Yaroslavsky

ELIAS MARTINEZ
CITY CLERK

CITY OF LOS ANGELES
CALIFORNIA

OFFICE OF
CITY CLERK
ROOM 395, CITY HALL
LOS ANGELES, CA 90012
485-5705

Jeff D.

...MAKING INQUIRIES
...ATIVE TO THIS MATTER,
...ER TO FILE NO

85-1849

CD

TOM BRADLEY
MAYOR

ATTACHMENT NO. 2

November 4, 1985

Congressman Henry Waxman
House of Representatives
Washington, D.C. 20515

Congressman Julian C. Dixon
House of Representatives
Washington, D.C. 20515

City Administrative Officer
Chief Legislative Analyst
City Attorney
Data Service Bureau
Controller:
Accounting Division
Disbursement Division
Room 220

RE: TECHNICAL REVIEW COMMITTEE TO REVIEW AND EVALUATE THE WORK DESIGN AND SAFETY OF THE METRO RAIL PROJECT PROPOSED FOR LOS ANGELES

At the meeting of the Council held October 23, 1985, the following action was taken:

Attached report adopted	X
" motion " ( )	
" resolution " ( )	
Ordinance adopted	
Motion adopted to approve attached report	
" " " " " communication	
To the Mayor for concurrence	
To the Mayor FORTHWITH	
Mayor concurred	10-31-85
Appointment confirmed	
Appointee has/has not taken the Oath of Office	
Findings adopted	
Negative Declaration adopted	
Categorically exempt	
Generally exempt	
EIR certified	
Tract map approved for filing with the County Recorder	
Parcel " " " " " " "	
Bond approved	
Bond is No. ____ of Contract	
Resolution of acceptance of future street ____ to be known as ____ adopted	
Agreement mentioned therein is/are No. ____ ____ of Contracts	

Elias Martinez

City Clerk
ab

ATTACHMENT NO. 2 (CONT'D)

File No. 85-1849

TO THE COUNCIL OF THE
CITY OF LOS ANGELES

Your TRANSPORTATION AND TRAFFIC Committee

reports as follows:

RECOMMENDATIONS

In order to assemble the Technical Review Committee and provide for anticipated expenses of its operation to review and evaluate the work design and safety of the Metro Rail Project proposed for Los Angeles, the following actions be taken:

1. That an Independent Technical Review Committee be established to evaluate the work design and safety of the first 4.4 mile segment of the Metro Rail Project with particular emphasis given to the problems created by the methane gas expected to be encountered along the route; and that the President of the City Council be authorized to appoint eight technical experts to said Committee.

2. That, SUBJECT TO THE APPROVAL OF THE MAYOR, the Controller be requested to transfer, within the Proposition A Local Transit Assistance (PALTA) Fund No. 6920, $50,000 from the Projects to be Designated by Ordinance or Resolution (Account No. 084,700) to a new account entitled Independent Technical Review Committee Evaluation of Metro Rail.

3. That the Chief Legislative Analyst be authorized to expend these funds for the expenses associated with the Independent Technical Review Committee efforts; such expenses shall include but are not limited to food and lodging, travel, payment of consultant(s) services, and other reasonable costs.

4. That the Chief Legislative Analyst be authorized to execute personal services contracts or Authority for Expenditure (AFEs) to provide consulting services of an expert and technical nature that will be of very limited duration.

SUMMARY

The Chief Legislative Analyst reported that by letter dated September 23, 1985, Congressmen Waxmen and Dixon requested that the City of Los Angeles convene an Independent Technical Review Committee of ten members to publicly review and evaluate the work design and safety of the Metro Rail Project proposed for Los Angeles. The Committee will give particular emphasis to the concerns created by methane gas in and along the route of the Metro Rail Project. The Independent Technical Review Committee and the City Council Transportation and Traffic Committee reviews must be completed by December 31, 1985.

-continued-

ATTACHMENT No. 2 (CONT'D) File No. 85-1849

TO THE COUNCIL OF THE
CITY OF LOS ANGELES

Your TRANSPORTATION AND TRAFFIC Committee

reports as follows:

In order to assemble the Technical Review Committee and provide for anticipated expenses of its operation, funding must be provided. A proposed budget of $50,000 has been prepared and is attached as Exhibit 1. Since the Technical Review Committee's efforts are directly related to a major transportation project, is is appropriate to use Proposition A funds contained in the 1985-86 Budget.

Respectfully submitted,

TRANSPORTATION AND TRAFFIC COMMITTEE

CSK:ab
10-17-85

ATTACHMENT NO.2 (CONT'D)

EXHIPIT NO. 1
TECHNICAL REVIEW COMMITTEE
BUDGET*

Technical Consultants	$ 30,000
Travel, lodging, and associated expenses of Committee Members	10,000
Printing, Postage, and other Miscellaneous Expenses	5,000
Contingencies	5,000
	$ 50,000

*Budget categories and the amounts so listed shall not limit maximum expenditures.

ATTACHMENT NO. 4

APPENDIX B

LIST OF STUDIES AND REPORTS
AVAILABLE TO THE SCRTD
BOARD OF REVIEW

1. Geotechnical Investigation Report, Volumes 1 & 2, Converse Ward Davis Dixon, November 1981. SMITH, NEYER

2. Geotechnical Engineering Report for Design Unit A-250, Converse Consultants, May 1984. SMITH, McATEER,

3. Geotechnical Engineering Report for Design Unit A-140, Converse Consultants, October 1983. SMITH, SHEPHERD

4. Methane Transmission Rates Through Various Barrier Materials for Tunnel Construction, Miedema and Haxo, January 17, 1985. McCUSKER

5. Durability of Various Barrier Materials for Tunnel Construction, Miedema and Haxo, June 6, 1985. McATEER, McCUSKER

6. Swelling in Hexane of Various Barrier Materials for Tunnel Construction, Miedema and Haxo, February 28, 1985. McATEER, McCUSKER

7. Report of Subsurface Gas Investigation, Engineering-Science, January 1984. NEYER, BALCERZAK, SLOSSON, McCUSKER

8. Report of Subsurface Gas Investigation, Engineering-Science, May 1985. NEYER, BALCERZAK, WITTE, SLOSSON, McCUSKER

9. Title 8 Tunnel Safety Orders, Cal-OSHA, revised August 23, 1973. McATEER

10. Task Force Report on the Methane Gas Explosion and Fire, Department of Building and Safety of the City of Los Angeles, June 10, 1985. ALL MEMBERS

11. Map locating oil wells, Division of Oil and Gas, Department of Conservation, State of California, January 5, 1985. (INCLUDED IN NO. 10)

12. Construction Safety and Security Manual, PDCD, February, 1985. McATEER, WITTE, WAGGONER, McCUSKER

13. Feasibility of Tunneling in Gassy Ground, R. J. Proctor, June 28, 1985. McATEER, WITTE, WAGGONER, SLOSSON

14. Route Alignment Drawings, Contract A-250, Bechtel Civil & Minerals, Inc., April 8, 1985. WITTE

15. Route Alignment Drawings, Contract A-141, A-146, and A-147, DeLong Hampton & Associates, July 9, 1985. WITTE

ATTACHMENT NO. 4 (CONTINUED)

16. Gas Monitoring System Review and Design Recommendations, MRTC, January, 1985. MCATEER, WITTE, WAGGONER, MCCUSKER

17. Methane Control Program Theory of Operation (Draft). BALCERZAK, MCATEER, WITTE, WAGGONER, MCCUSKER

18. Shield Driven Tunnels, Specification Section 02311, July 5, 1985. NEYER, MCATEER, MCCUSKER

19. Hydrocarbon-Resistant Membrane for Cast-In-Place Concrete, Specification Section 07101, June 10, 1985. MCATEER

20. Hydrocarbon-Resistant Coating, Specification Section 07121, June 24, 1985. MCATEER

21. Summary letter, Hammond to Crawley, June 25, 1985. WITTE

22. Tunnel liner rationale, letter, Hammond to Murray, August 7, 1985. WITTE, MCCUSKER

23. Environmental Control System (Draft), PBQD, July 1, 1985. MCATEER, WITTE

24. Abandoned oil well casings, letter, Proctor to Crawley, September 17, 1984. SMITH, MCATEER, WITTE,

25. Cal-OSHA classification of Metro Rail tunnels, letter, Larson to Monsees, December 18, 1984. WAGGONER

NOT LISTED - LINDVAL RICKTER REPORT IDENTIFYING ACTIVE FAULTS & CRITERIA. SMITH, SHEPHERD, SLOSSON

ATTACHMENT No. 5

mav4-119

SPECIAL QUESTIONS PRESENTED TO SCRTD

1. QUESTION BY T. McCUSKER:

   RTD assumes a water flow rate into tunnel of 0.02 gal per square foot per day. What amount of natural gas is contained in this water?

2. QUESTION BY J. SLOSSON:

   What procedure during tunneling is to be used so geologic staff can view working face and side wall?

3. QUESTION BY UNKNOWN MEMBER OF COMMITTEE:

   How do you decide what part of tunnel gets the steel liner?

4. QUESTION BY D. McATEER:

   The RTD is not going to use the method of testing or sampling air in the tunnel and/or stations in common use in most coal mines. Is there a study that comments on this or recommend not using the coal mine systems?

5. QUESTION BY D. McATEER:

   Has the air monitoring system proposed to be used by the RTD been used in any other place for detection of and prevention of explosions?

6. QUESTION BY UNKNOWN MEMBER OF COMMITTEE:

   How do you know when you get near an uncharted oil well?

7. QUESTION BY JAY SMITH:

What criteria will your geologic staff use to identify or determine that a fault encountered during construction is active? Do you have some established or proposed plan to make a design decision to change the liner while construction continues?

8. REQUEST FOR ADDITIONAL INFORMATION BY DR. HOUSNER:

(A) Give a brief description of the ventilation system to be used in the tunnel during its construction. Make it clear what you will use (fans, ducts, blowers, etc.) during construction including source of back-up electrical power.

(B) The discussion before the Committee left some unresolved questions concerning the gas detection system, how employees will be alerted to changes in gas concentrations and what will occur automatically vs. that which will occur as the result of human intervention. Please give a brief description of the proposed system to sense for the presence of gas, location of gas monitors and analyzers, concentrations or levels at which warnings or alerts will be enunciated to control room attendants, manual or automatic responses that will take place to turn on ventilation fans, exhaust fans, etc.

(C) Please clarify the alerts to be given control room operators - clearly specify if multiple warnings or alerts will be sounded and describe the concentration levels of gas that will trigger the "low," "moderate" and "high" or other "warnings" or "alerts."

ATTACHMENT NO. 6

RESPONSES TO QUESTIONS BY THE CITY TECHNICAL REVIEW COMMITTEE TO EVALUATE SAFETY, DESIGN AND METHANE GAS ASSOCIATED WITH THE METRO RAIL PROJECT

Following are responses to specific questions raised by the Committee at their meeting of November 12, 1985. The questions were paraphrased by Jeffrey D. Druyen of the City Council Office of Chief Legislative Analyst from the tape of Committee proceedings.

1. QUESTION BY T. McCUSKER:

RTD assumes a water flow rate into tunnel of 0.02 gal per square foot per day. What amount of natural gas is contained in this water?

RESPONSE:

Using data from "Water Purification and Treatment, Vol. II", 1968, by Fair, Geyer, and Okum, it is found that one gallon of water in a pure methane atmosphere at 15 psi and 68°F contains 0.00894 cu ft of methane. Applying this information to the 7th/Flower to Wilshire/Alvarado tunnel (4960 ft) with an assumed water inflow of 0.02 gal/sq ft/day, the amount of methane transported into the tunnel by water is 0.034 cu ft/min, requiring 13.6 cfm of air to dilute to 1/20 of the lower explosive limit. This is approximately 0.1 percent of the ventilation previously calculated (11500 cfm) to dilute gas coming into this reach of tunnel by the means discussed at the briefing. Similar calculations for other reaches of tunnels lead to like results. Thus, it is concluded that transport of dissolved gas by water is negligible compared to the other possible sources.

2. QUESTION BY J. SLOSSON:

What procedure during tunneling is to be used so geologic staff can view working face and side wall?

RESPONSE:

For a cast-in-place concrete tunnel utilizing steel ribs and wood lagging, where an open face digger shield is used, the tunnel face can be mapped and the side wall examined when the ribs are expanded. In addition, sections of lagging can be omitted in questionable areas to permit further examination of the side wall. If a

closed face excavator is used, only the tunnel walls could be mapped unless the face is partially exposed after each shove.

A pre-cast tunnel, using an open face digger, would allow the face of the tunnel to be mapped. In the event a closed face excavator is used, the tunnel face only could be mapped by partially exposing the face after a shove.

In those instances where it is not practical to map geology inside the tunnel, cored holes could be used in advance of tunneling as shown in Figure 1 to pinpoint discontinuities.

3. QUESTION BY UNKNOWN MEMBER OF COMMITTEE:

How do you decide what part of tunnel gets the steel liner?

RESPONSE:

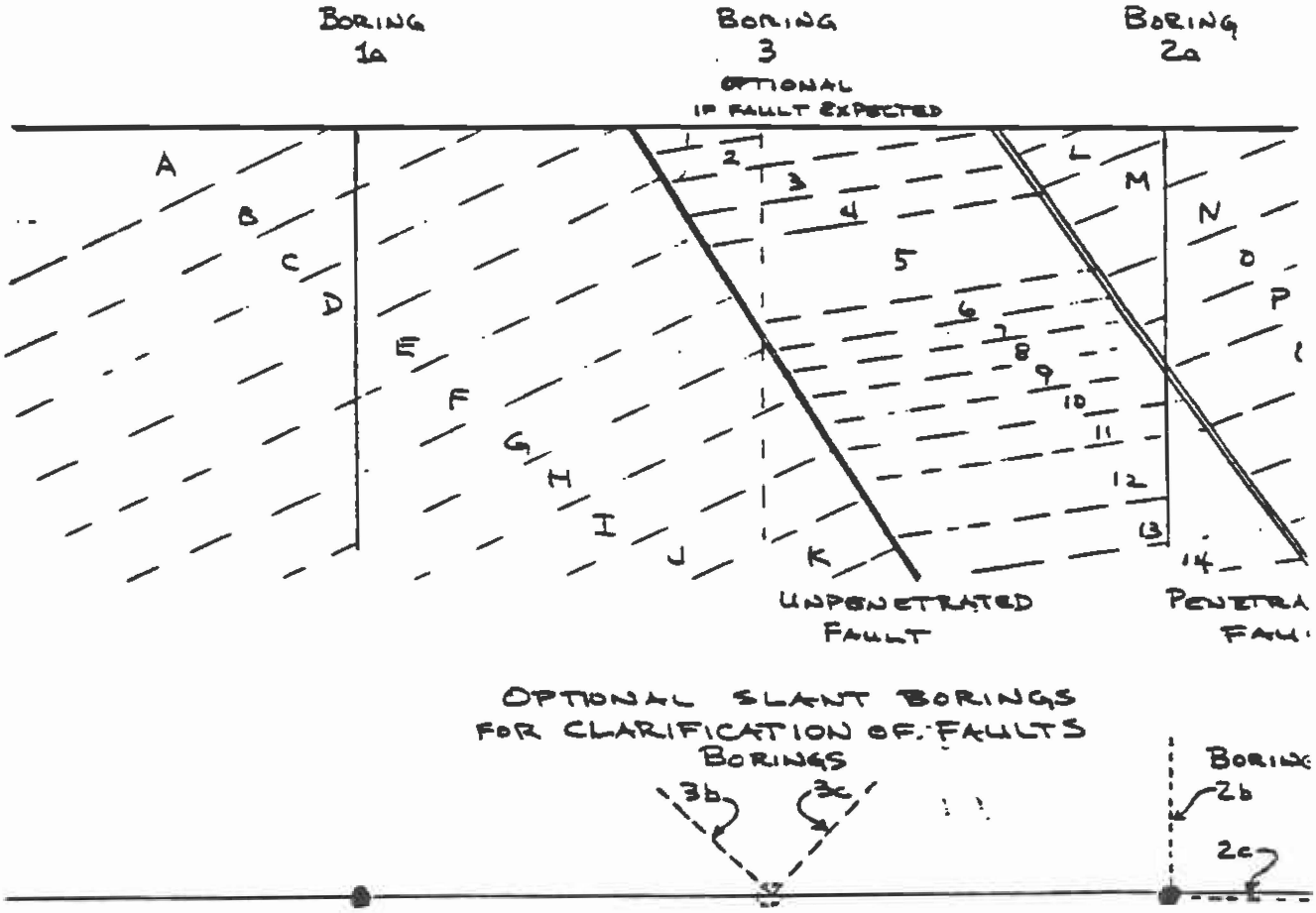
Fabricated steel linings have been recommended for use in sections of tunnel meeting any one of the following three criteria:

a. Fault Zones - Fabricated steel linings are recommended for use where the tunnel crosses potentially active fault(s) as defined by Converse Consultants, Inc., and Lindvall Richter and Associates.

Calculations indicate the fabricated steel to be approximately three to ten times more flexible than concrete, thus steel provides a higher measure of ductility than does concrete in those areas. In addition, it is usually easier to make repairs to or reinforce segmented steel linings than it is concrete linings.

b. Higher levels of Gas Pressure and Concentration - Where the field probes have indicated higher pressure and concentration of gas, fabricated steel linings have been recommended because they can be sealed tighter than concrete for the following reasons:

- The steel is impervious to gas diffusion,



BORINGS AND FAULTS

FIGURE 1

NOV. 22, 1985

- o the steel will not crack,

- o the steel permits tighter bolting at flanged joints,

- o the steel joints can be welded if necessary.

c. Construction Considerations - Steel was recommended for the tunnels through tar sands because, as in (a) above, the steel segments can be reinforced or repaired to adjust to difficult construction conditions by welding in additional struts, flanges, etc.

4. QUESTION BY D. McATEER:

The RTD is not going to use the method of testing or sampling air in the tunnel and/or stations in common use in most coal mines. Is there a study that comments on this or recommend not using the coal mine systems?

RESPONSE:

Yes, the Gas Monitoring System Review and Design Recommendations report referenced in appendix "B" of the Report on Construction and Operation in Gaseous Areas, distributed to the Committee, Section 3.2.C, provides a comparison with gassy mines.

In coal mines, gas concentrations are measured throughout each shift using hand held detectors, and continuous monitors are mounted on the mining equipment working at the face.

A major consideration in selecting the present gas monitoring system for the Metro Rail Project over the type used in coal mines is the high sensitivity of the equipment. The sensors used in coal mines have a sensitivity of approximately 1000 ppm of methane in air, while the system proposed for the Metro Rail Project has a sensitivity of approximately 1 ppm. The high sensitivity equipment will detect and annunciate abnormal gas intrusions at lower concentration levels, thereby notifying personnel of the gas presence earlier than would be expected from less sensitive equipment under similar conditions. The high sensitivity is also desirable due to the variability of possible infiltration locations and the possibility that airflow will dilute gas concentrations to low levels before the gas reaches the monitoring equipment.

There are also significant reliability and maintenance advantages to the presently designed gas monitoring system.

5. QUESTION BY D. McATEER:

Has the air monitoring system proposed to be used by the RTD been used in any other place for detection of and prevention of explosions?

RESPONSE:

Yes, this type of equipment has been used successfully to detect incipient fire and explosion conditions in coal handling processes for power generating stations, cement plants, and pulp/paper mills.

Some actual installation sites and contacts are as follows:

1.	Allegheny Power System Pittsburgh, Pennsylvania	Mr. Claude Frantz (412) 838-6155
2.	Riverside Cement 1500 Rubidoux Boulevard	Mr. Ken Latchum (714) 683-3660
3.	Weyerhauser Co. Columbus Pulp & Paper	Mr. C. H. Harris (601) 243-4513

6. QUESTION BY UNKNOWN MEMBER OF COMMITTEE:

How do you know when you get near an uncharted oil well?

RESPONSE:

Available maps and records of old oil wells have been obtained from state and local sources. These will be made available to contractors who will be cautioned to be alert to the wells shown on these documents as well as other possbile wells that may be in the area but not on these records.

A probe will be installed in front of the shield. This should help identify areas of significant pressure and concentration of gas that may indicate the presence of wells. Planned additional vertical probes along the alignment may also help identify such areas.

We are not aware of reliable electromagnetic or other device that permits remote location of old wells.

7. QUESTION BY JAY SMITH:

What criteria will your geologic staff use to identify or determine that a fault encountered during construction is active? Do you have some established or proposed plan to make a design decision to change the liner while construction continues?

RESPONSE:

In the opinion of the District's technical experts, the probability of encountering an unmapped fault of major concern is remote in light of the exploratory work done over the years by various organizations.

In regard to decisions on design change, the construction work will proceed, in other than emergency conditions while analysis for a need of a design change is completed. The affected tunnel section will then be modified when final conclusions are available.

The Construction Manager (CM) will have a team of geologists assigned to each tunnel. These geologists will monitor the face, record observations, and take samples. When it is apparent that a fault exists, the heading will be stopped until such time as the observations, samples, and measurements of the fault can be completed.

Consultants, including Converse Consultants, Inc., Lindvall Richter and Associates, and Professors Ralph Peck and Tor Brekke will be available to help evaluate the extent, condition, and possible activity of the fault.

Based on the results of this evaluation, several steps may be taken:

- no change may be required,
- the existing tunnel support system or a portion thereof may be removed and replaced by segmented steel linings to gain the increased flexibility and repairability offered by this type of lining, or
- a special design may be developed to handle a special condition. This latter case would also require removing a portion or all of the system first installed by the contractor.

Methods to determine the age and activity of faults are time consuming, difficult and speculative. However, a method of determining activity would be micro-seismicity readings over an extended time period or on a continuous basis at fault locations.

Seismic instrumentation would be provided though grout holes in pre-cast liners or embedded in cast-in-place lining at points of discontinuity. Cross hole seismic and ground-electrical readings may also be made from previously drilled holes.

8. REQUEST FOR ADDITIONAL INFORMATION BY DR. HOUSNER:

PART (A) Give a brief description of the ventilation system to be used in the tunnel during its construction. Make it clear what you will use (fans, ducts, blowers, etc.) during construction including source of back-up electrical power.

RESPONSE:

The specifications require that during normal operations, when gas inflows are minimal or non-existent, the ventilation will be in accordance with Cal-OSHA requirements. Considering the probable manpower and equipment that a contractor will use, it is estimated that ventilation requirements will be in the range of 35,000 cubic feet per minute. This quantity of air will be flowing through the tunnel from the portal to the face and be exhausted through a duct. The duct will most probably have inline fans.

In addition, the District is requiring the installation of duct work and fans so that the air quantity going into the tunnel may be boosted to a minimum of 100,000 CFM if gas inflows require the additional quantity for dilution to safe levels. This additional air volume will be provided at 5 percent of lower explosive limit (LEL). The specifications will also dictate the requirement to provide diesel stand-by generators capable of operating all of the installed fans required to boost the ventilation to 100,000 CFM.

PART (B) The discussion before the Committee left some unresolved questions concerning the gas detection system, how employees will be alerted to changes in gas concentrations and what will occur automatically vs. that which will occur as the result of human intervention. Please give a brief description of the proposed system to sense for the presence of gas, location of gas monitors and

analyzers, concentrations or levels at which warnings or alerts will be enunciated to control room attendants, manual or automatic responses that will take place to turn on ventilation fans, exhaust fans, etc.

PART (C) Please clarify the alerts to be given control room operators - clearly specify if multiple warnings or alerts will be sounded and describe the concentration levels of gas that will trigger the "low", "moderate" and "high" or other "warnings" or "alerts".

RESPONSE:

The gas monitoring system is made up of gas analysis instruments located at each passenger station, with sampling probes (tubes) extending from the centrally located instruments to the remote locations to be monitored. Air samples are extracted from the exhaust ventilation shafts and each end of each tunnel bore throughout the MOS-1 system for measurement of gas concentration levels. A sample stream switching operation allows the sample from one probe at a time to be routed to the gas measurement instruments for analysis. In this manner the gas analysis instruments at one location can be used to monitor the gas levels at multiple vent shafts and each tunnel entrance, as shown in Figure 2.

There are two annunciation points for elevated gas levels, called the warning and alarm set points. Gas concentrations above either the warning or alarm set points will automatically cause audible and visual annunciations at the Central Control Facility (CCF). In addition, actual gas concentration readings are reported to the Metro Rail computer for record keeping and trend analysis purposes, and the central control operator can view these readings on a CRT display, or cause a hard copy to be generated, on command.

Actions to be taken in the event of alarm level gas concentrations are displayed to the central control operator from the Metro Rail computer. The operator will review the proposed actions and initiate them by acknowledging to the computer that he is in agreement. The computer will then control the specific operations, i.e., starting fans, closing dampers, etc. If the central control operator does not agree with the proposed actions, he can modify those actions. Before the alarm level gas concentration is reached, plans include utilizing portable gas detection units to survey

TYPICAL TRAIN ROOM VENTILATION SYSTEM

GAS MONITORING SYSTEM SAMPLE PROBE LOCATIONS INDICATED BY ●

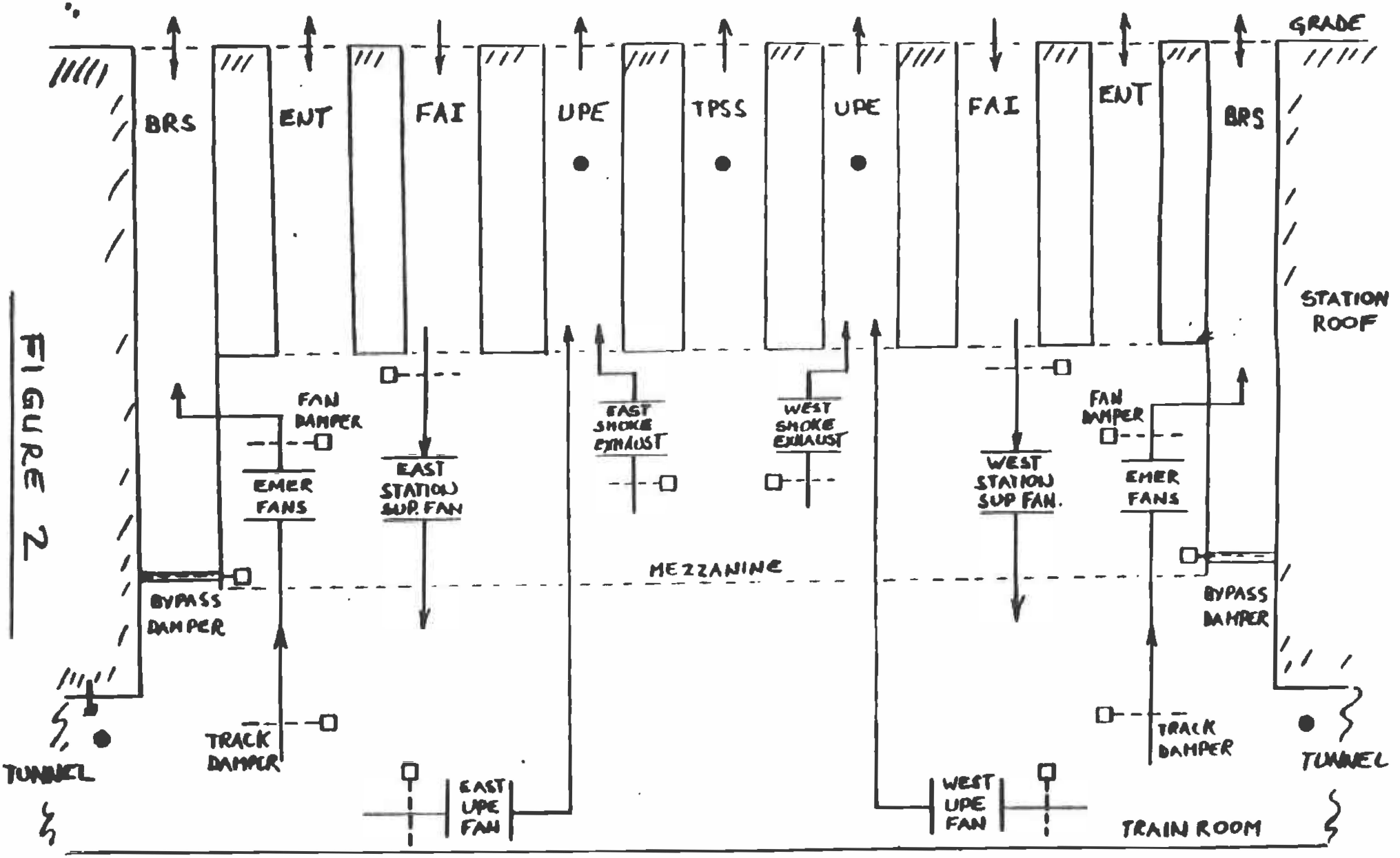


FIGURE 2

and locate the specific area/point of infiltration so that corrective measures can be taken.
If conditions warrant, system evacuation or other emergency measures will be implemented.

Backup to the main computer is provided in case of failure, and redundant power is provided to essential equipment such as computers and fans.

During the commissioning phase of Metro Rail prior to opening the system for operation, tests will be conducted to determine the actual ambient gas levels throughout the system. Each segment of the facility is expected to require different warning level set points, depending on the effectiveness of the membrane applied during construction, and the degree to which the ventilation system, in normal operation, dilutes any gas infiltration. Realistically, readings of 25 ppm or less of methane are anticipated, and warning set points will be set at approximately 20 percent higher than the normal ambient level determined during the testing period. Any segment of the facility with readings reaching the warning set point would be examined for cause of the increase using hand held detection equipment. Any change in source would be identified and repaired. Alarm set points would be established approximately 100 percent higher than normal ambient, depending on the normal ambient, but in all cases alarm levels will be well below the 2500 ppm level at which Cal-OSHA classifies an area as gassy.

ATTACHMENT No.7

INDEPENDENT
TECHNICAL COMMITTEE EVALUATION
OF THE L.A. METRO RAIL PROJECT
SECOND MEETING
MONDAY, DECEMBER 2, 1985
ROOM 300, CITY HALL EAST
9:00

SUBJECT

1. Consideration of SCRTD responses to Committee questions at November 12, 1985 meeting.

2. Additional SCRTD presentation as required.

3. Consideration of issues and recommendations including the following:

   A. Is it the opinion of the Committee that an underground Metro Rail System (MOS-1) necessarily possesses unacceptable hazards during tunnel construction and operation?

   B. Adequacy of proposed gas monitoring and detection systems to be used during construction and operation.

   C. Adequacy of automatic warning/alert system and proposed level of human intervention.

   D. Adequacy of ventilation system during construction and operation.

   E. Completeness of operating procedures.

   F. Adequacy of procedures to located uncharted oil wells.

   G. Other issues of concern to Committee members.

4. Instructions to Staff

5. Lunch (about 11:30 - 11:45)

6. Discussion of Report Formats and Signatures

ATTACHMENT NO. 8

REPORT

INDEPENDENT REVIEW BOARD

DESIGN, CONSTRUCTION, AND OPERATION IN GASEOUS AREAS

Prepared for
Southern California Rapid Transit District
Los Angeles, California

Prepared by

John W. Critchfield
John W. Critchfield

Roger L. King
Roger L. King

Robert H. King
Robert H. King

Edward J. Zeigler
Edward J. Zeigler

31 October 1985

REPORT

INDEPENDENT REVIEW BOARD

DESIGN, CONSTRUCTION, AND OPERATION IN GASEOUS AREAS

I. INTRODUCTION

On March 24, 1985, an explosion and fire occurred at the Ross Dress-for-Less Store located at 6298 West Third Street in Los Angeles. This event was attributed to the accumulation of methane gas in the store. The methane gas was conjectured to have migrated from an underground source into the store via natural fractures in the strata. Since this store was near the alignment proposed for the SCRTD Metro Rail Project, concern was raised as to the safety of tunneling in ground that was known to contain methane. To assist in addressing this specific concern and to obtain an independent evaluation of the overall Project's safety procedures with respect to gas, an independent review board was convened to review the District's proposed design, construction, and operation plans for the Project in gassy ground.

The Board members were selected by the SCRTD and letters of invitation to participate on this Board were extended by John A. Dyer, General Manager. The selected Board consisted of

John W. Critchfield
Hart-Crowser & Associates and
Chairman, Committee on Gassy Tunnels
Underground Technology Research Council
Seattle, Washington

Dr. Robert H. King
Associate Professor
Colorado School of Mines
Golden, Colorado

Roger L. King
Research Supervisor
U.S. Bureau of Mines
Pittsburgh, Pennsylvania

Edward J. Zeigler
Manager, Geotechnical Department
Rummel-Klepper-Kahl Consulting Engineers
Baltimore, Maryland

The Board's charge was to review the design, construction, and operation plans for the Metro Rail Project as they pertained to safety in gassy ground conditions. The scope of the review included:

1) Review of the current plans for tunneling through and operating in areas identified by the City of Los Angeles Task Force Report as a

"High Potential Risk Zone" and a "Potential Risk Zone", as well as other gaseous areas.

2) Review of the draft report prepared by the SCRTD In-house Board of Review, the City of Los Angeles Task Force Report, and other pertinent documents.

3) Preparation of a report summarizing the Board's findings with emphasis on the gas-related safety aspects of the Project.

The Board twice met formally as a group. At the first meeting on September 5, 1985, there was a presentation by staff members of the SCRTD on the Metro Rail Project and how it had planned to safely accomplish tunneling and operating in gassy ground. After this meeting the Board independently reviewed the In-house Board of Review Report of September 1985 and the documents listed in Appendix B. Finally, the Board reconvened on October 3, 1985, to discuss outstanding issues and questions and to review preliminary findings with members of the SCRTD before preparing this report.

Although this report suggests additional areas that may improve the overall safety of the Project, it was evident to every member of the Board that the SCRTD and its consultants have given careful and detailed consideration to the design, construction and operation of the subway in gassy ground. It was also evident that this work had been completed well before the Ross store explosion and fire. The Board recognizes that gassy ground exists along nearly all the tunnel alignment and that the recommendations that are made in this report apply anywhere gas may be encountered and not just the area that has recently garnered public attention in the Wilshire-Fairfax District.

II. ANALYSIS OF ISSUES AND RECOMMENDATIONS

This section will discuss the Board's review and analysis of the adequacy of the District's plans for the following elements of the Metro Rail Project:

- gas investigation
- design
- construction
- operation

Specific recommendations have been included which the Board believes will improve the overall safety of the Project.

1) GAS INVESTIGATIONS

a) Analysis

- Design, construction, and operation of a project in gassy ground requires an understanding of the gas reservoir. The degree of understanding that can be achieved is limited because of the extremely complex

nature of the gas reservoir and the many factors which cause changes in the reservoir over time. The SCRTD has done a very commendable job in recognizing the potential gas hazards and quantifying the hazard along the tunnel alignment where gassy ground was identified.

b) Recommendation

Although the SCRTD's investigations have been adequate for design purposes, the Board believes that the SCRTD Project will benefit from the additional study of potential methane gas risk mandated by Congress. Although extensive gas and geotechnical studies have been conducted, a further study should be made of existing gas data by qualified petroleum engineers to attempt to better relate gas concentrations and pressures with geologic structures, such as folds and faults. This information can be used by the SCRTD in providing a rationale for locating the additional vertical probe holes planned for the construction phase. This information would also contribute to a better understanding of the gas environment and would be useful in evaluating the feasibility of an area-wide gas dispersal system. However, in the opinion of the Board, an area-wide dispersal system is unlikely to be effective in mitigating gas hazards during construction and operation. Also, additional field investigations will assist in quantifying the hydrogen sulfide (H_2S) environment and to fill-in areas of "no data" in the vicinity of the Santa Monica Mountains.

In addition to the above, the Board recommends that the SCRTD provide gas monitoring of existing buildings both prior to and during construction, combined with monitoring of existing gas probes, and the ventilation air in the tunnel to aid in obtaining a comprehensive picture of the methane reservoir and the changes that may occur during construction. It is important to recognize that methane investigations must be of a continuing nature. This is particularly true for the MOS-1 construction, which will form an experience base for future work.

COMMITTEE CONCURS AS MODIFIED.

2) DESIGN

a) Analysis

The need to design the Metro Rail Project to accommodate the presence of gas is unavoidable in the Los Angeles area. In the opinion of the Board, the SCRTD has proposed a design for the subway that should provide a very safe environment for the passengers. The use of high density polyethylene (HDPE) as an external wrap for the cast-in-place tunnel liners is considered to be effective in limiting the gas inflow through the liner. Regardless of the sealing element, the amount of ventilation proposed appears adequate to dilute and render harmless any gases that may enter the tunnel. The proposed gas monitoring systems should be effective in providing warning of any significant changes in gas concentrations.

AND EXPERT INTERPRETATIONS ABOUT WHAT SHOULD BE ANTICIPATED OR

b) Recommendation

The Board recommends that the SCRTD provide prospective contractors with complete, detailed information on the gas environment expected in the tunnel during construction. This information should contain information on the types of gases anticipated (i.e., CH_4, H_2S, other hydrocarbons, etc.), and the minimum measures expected to be required by Cal-OSHA from the Tunnel Safety Orders (e.g., Section 7980 - Permissible Equipment, Section 7984 - Continuous Monitoring within 50 feet of the Face, Section 8427 - Horizontal Probe Holes).

COMMITTEE CONCURS AS MODIFIED.

3) CONSTRUCTION

a) Analysis

There is considerable experience with conventional tunneling that has been successful in the Los Angeles area. Other tunneling techniques (such as utilizing large amounts of compressed air) do not offer any particular advantages in handling gas hazards in this environment. Therefore, the Board agrees that conventional tunneling proposed by the District is the best construction method.

b) Recommendations

It is the conclusion of the Board that the construction can be accomplished in a safe manner. However, the Board would offer several recommendations for the SCRTD to take into consideration during construction. It is our understanding that the SCRTD has implemented or has plans to implement several of the recommended actions. The Board recommends the following:

1) Have a separate group, responsible to the construction manager, for collecting, reducing, and interpreting gas data. This would include measurements of gas concentrations in probes, surface monitoring, and measurements of gas concentrations in the tunnel. These readings should be obtained to enable the determination of the total amount of gas liberated by the ground. This will emphasize the importance of recognizing changes in the methane environment on a daily basis, and provide advance warning of any change in gas conditions as well as better information for planning future construction.
COMMITTEE CONCURS.

2) Provide diesel backup power for the electric power supply energizing the ventilation fans.
COMMITTEE CONCURS.

3) Request Cal-OSHA to provide fulltime inspection during construction start-up and frequently (weekly, if possible) afterwards. COMMITTEE BELIEVES THIS RECOMMENDATION IS NOT NECESSARY.

4) Continue and ensure ongoing coordination with the local fire departments. Invite key personnel underground during construction to familiarize them with the tunnel.
COMMITTEE CONCURS.

5) Do not permit the usage of an overhead trolley locomotive for construction. COMMITTEE INDICATED SUCH EQUIPMENT NOT USED IN 30 YEARS.

6) In addition to the use of belt-wearable self-rescuers (hopcalite type), provide for each person underground a self-contained self-rescuer (SCSR) which provides breathable oxygen. COMMITTEE BELIEVES HOPCALITE UNITS ARE UNUSEABLE IN A METHANE ENVIRONMENT. TBM OPERATOR MUST BE IN ENCLOSED CABIN WITH SELF CONTAINED OXYGEN SUPPLY. ALSO, OXYGEN SUPPLIES MUST BE READILY AVAILABLE TO WORKERS AT THE FACE.

7) Implement a detailed plan, similar to that required by MSHA, which outlines specialized safety training for the workers that deals with the additional safety problems manifested by working in a methane environment. COMMITTEE CONCURS.

8) Utilize horizontal probe holes in advance of the tunnel at least until construction procedures for dealing with methane have been fully proven and documented. A horizontal probe hole offers the best available means of pre-draining gas-bearing zones ahead of the face. Technology is available for probe drilling that will not greatly hinder excavation progress provided the contractor has been made aware of the requirement. COMMITTEE CONCURS WITH FIRST SENTENCE.

9) Implement a detailed ventilation plan similar to that required by MSHA. COMMITTEE CONCURS.

10) Perform an analysis of the applicability of using underground coal mine electrical equipment as outlined in Parts 18 and 75 of Title 30, Code of Federal Regulations. COMMITTEE CONCURS.

4) OPERATION

The detailed operational plan is not yet complete, however, the Board would recommend that the SCRTD take into account the following:

1) Contact the Washington Metro Area Transit Authority and ascertain from them what type of success they have had with gas monitoring during operations. NO COMMENT NECESSARY.

2) Locate all of the gas probes and abandon them in a safe manner. COMMITTEE CONCURS.

3) Ensure that the underplatform exhaust system is turned on if a train becomes stalled in a tunnel. COMMITTEE CONCURS.

4) Ensure that high and low points in the tunnel alignment are either monitored for accumulation of gas or are adequately ventilated. COMMITTEE CONCURS.

III. SUMMARY

It has been quite evident to this Board that the SCRTD has gone to a great deal of effort to ensure that the design, construction, and operation of the Metro Rail Project is accomplished in as safe a manner as possible. The Board feels that the construction and operation of MOS-1 can be safely accomplished by utilizing the safety procedures proposed by SCRTD and supplemented by this report. Because of the detail planning and design that has

gone into the Project, there is no doubt that this Project will be the model that other projects in gassy ground will emulate.