



U.S. DEPARTMENT OF LABOR MSHA



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IMPROVED FIRE PROTECTION SYSTEM

FOR

UNDERGROUND FUELING AREAS

PREPARED FOR

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

BY



THE ANSUL COMPANY, MARINETTE, WISCONSIN 54143

FINAL REPORT, VOLUME I
ON
CONTRACT NUMBER H0262023
IMPROVED FIRE PROTECTION SYSTEM
FOR UNDERGROUND FUELING AREAS

SEPTEMBER 30, 1977

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16. Abstract The contract objectives are (1) to develop safe practice guidelines which will minimize the chance of fires in underground fueling areas and (2) to develop a low-cost, reliable, automatic fire protection system for underground fueling areas. The effort described by this report covers the period from 21 June 1976 to 30 September 1977 and accomplished the following tasks: • Preparation of Data Plan and Data Acquisition, mainly through visits to sixteen mine sites and a literature survey. • Analysis of the accumulated data, providing design inputs for (a) evaluation of the fire problem; (b) development of safe practice guidelines; and (c) development of recommended design concepts for automatic fire protection systems. • Preparation of safe practice guidelines for underground fueling areas. • Preparation of recommended design concepts for automatic fire protection systems for underground fueling areas. • Design and fabrication of fire protection system for installation at Pine Creek Mine, Bishop, California. • Install system and perform underground fire tests at Pine Creek Mine.					
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FOREWORD

This report was prepared by The Ansul Company of Marinette, Wisconsin, under USBM Contract No. H0262023. The contract was initiated under the Metal and Non-Metal Health and Safety Research Program. It was administered under the technical direction of TCMRC, with Mr. Guy Johnson acting as the Technical Project Officer. Mr. B. G. Horton was the Contract Administrator for the Bureau of Mines.

This report is a summary of the work recently completed on a part of this contract June 21, 1976 to September 30, 1977. This report was submitted by the authors on September 30, 1977.

The program was performed at The Ansul Company under the direction of Mr. Gene R. Reid, Program Manager; Mr. Bruce C. Christensen, Systems Project Engineer; and Mr. Richard J. Plog, Electronics Engineer. Special acknowledgement should be given to the efforts of the following groups for their efforts towards the successful completion of this program:

- The coordination and performance of the data acquisition and data analysis phases by Midwest Research Institute of Kansas City, Missouri, under the direction of Mr. James Reinert and Dr. L. B. McDonald.
- The cooperation and assistance of the Union Carbide Corporation during the performance of the underground fire test demonstration, particularly Mr. Rod Philbrick, Mine Engineer at Pine Creek Mine.
- The assistance of Dr. Robert W. Heins, acting as a program consultant, in the planning of the data acquisition and review of data.
- The efforts of Marilyn Noonan in the preparation of this and other formal reports of this program.

DISCLAIMER NOTICE

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or of the U.S. Government.

EXECUTIVE SUMMARY
OF
FINAL REPORT, VOLUME I

U.S. BUREAU OF MINES CONTRACT H0262023
"IMPROVED FIRE PROTECTION SYSTEM FOR UNDERGROUND FUELING AREAS"

THE ANSUL COMPANY
MARINETTE, WISCONSIN 54143

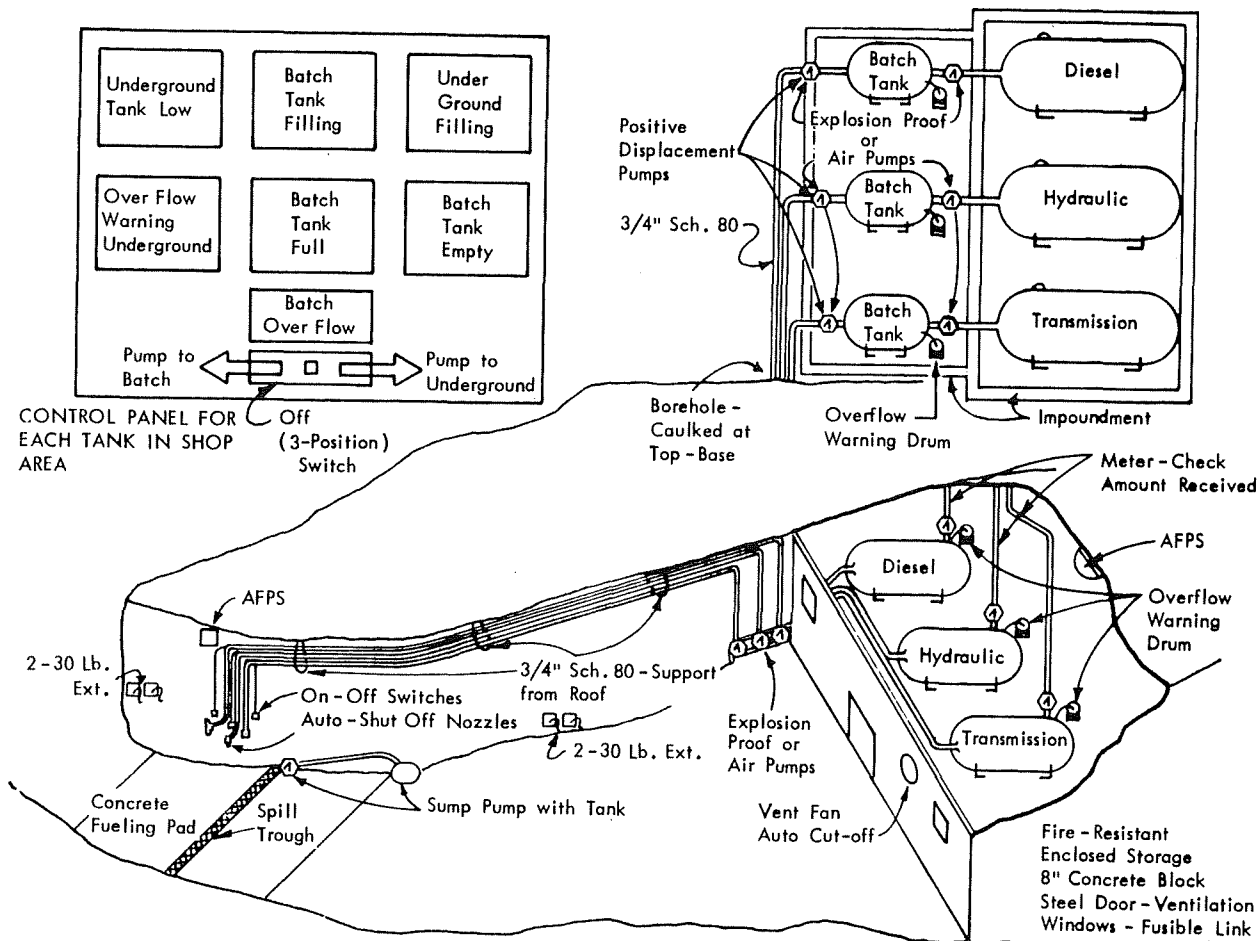
INTRODUCTION

The objectives of the Bureau of Mines research contract H0262023 were to develop safe practice guidelines which minimize the chances of fire in underground fueling areas and to develop a low cost, reliable, automatic fire protection system for underground fueling areas. Underground fire tests were performed to demonstrate the performance of a prototype system installed at an underground fueling area in a mine. The contract started on 21 June 1976 and extended through 30 September 1977.

The existing underground fueling areas were created by the mine operators, based on their experience and the specific needs of their individual operations, with little or no general guidance from existing standards. Thus, there is little uniformity in the design approach of existing fueling areas. The establishment of recommended or mandatory standards for design of the fueling system and fire protection should be an aid to the mine operator in design of the fueling system and should provide improved assurance of safe operation. The wide scope of mine conditions and the special fuel area requirements preclude the establishment of one optimum fire protection system for all mines. We can only attempt to provide guidance for the proper selection of equipment.

GENERAL DESIGN CRITERIA FOR FUELING SYSTEM

The figure on the following page is a recommended configuration for a fueling system, but does not represent the minimum acceptable design. The above-ground fuels may be stored in large storage tanks, but the transfer to an underground storage area should be done from a batch tank with less capacity than the underground tank being filled. The report gives detailed design recommendations for the protection of property in case of leaks in the tanks or piping, above ground or during the transfer to the underground area.



Recommended Fueling System

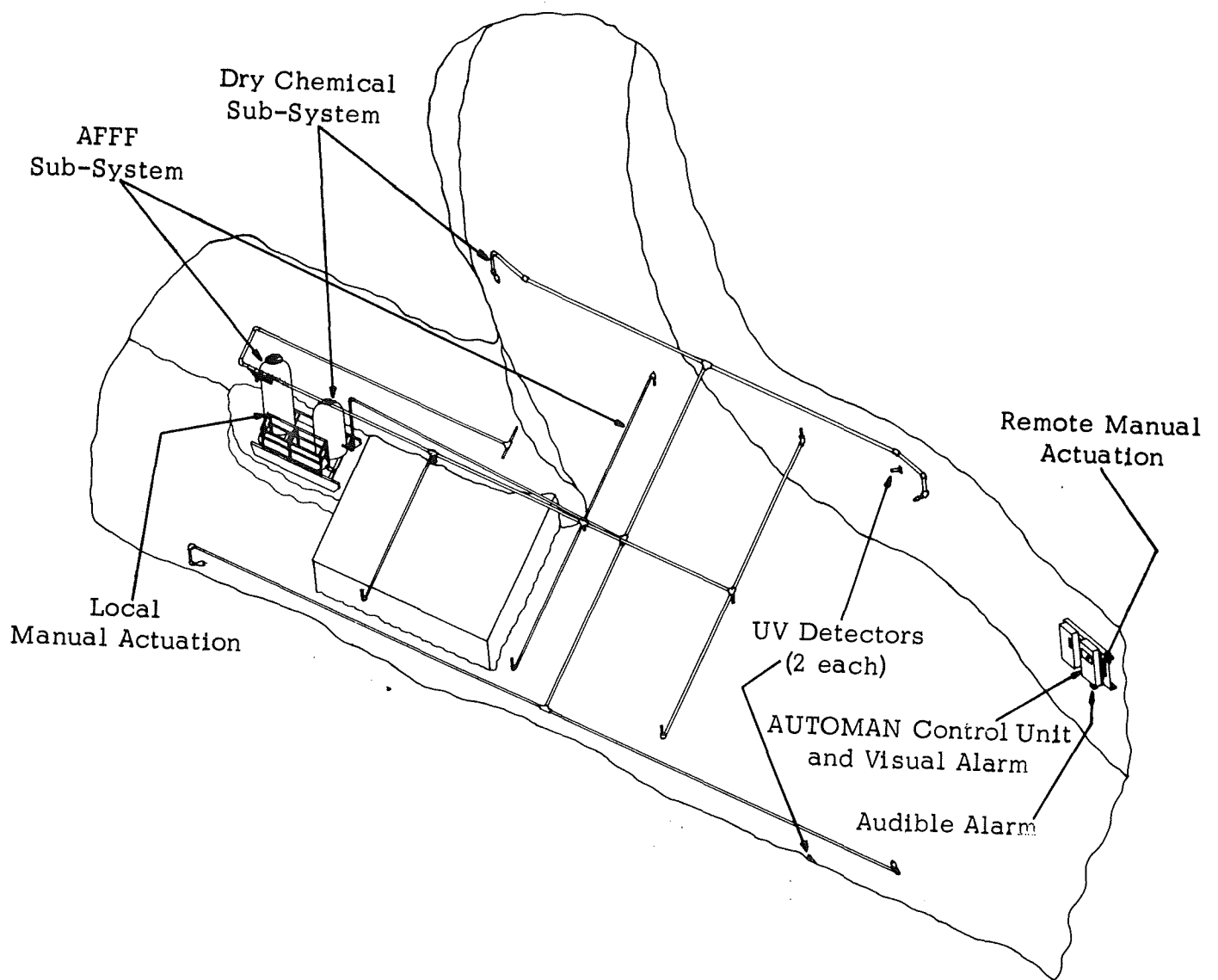
The major hazard occurs during the transfer of fuel to a vehicle from the storage area. Thus, the transfer area should be separated from the storage area and considerable attention is devoted to design practice and procedures in the transfer process. The underground storage area should be fully enclosed with the purpose of isolating this area from the mine ventilation system in the event of a fire. There are extreme variations in the fueling system conditions for the many types of underground mines. Thus, the recommended system in its precise form can only be a design guide. Alternate systems are discussed in detail.

FIRE PROTECTION SYSTEM DESIGN CONCEPT

The greatest hazard exists during the transfer of fuel from the storage container to the vehicle because fuel, heat sources, and personnel are present in close proximity. The underground storage area is the next most hazardous because, although likelihood of fire is low, the consequences of the release of heat energy and toxic gases from the large amounts of stored fuels are great. Thus far there has been no appreciable history of fire problems in fueling areas. However, the concern for the problem is great because of the potential for disaster.

A fire is more easily controlled when detected in its early stages. As the burn time lengthens, the extent of involvement of the combustibles increases and the fire grows in magnitude. In addition, the heated surfaces become a source of reignition and flashback after the discharge of portable extinguishers or a manual system. The fuel storage area is normally unattended. Thus, early detection can only be assured with an automatic system. There will be personnel present during the fuel transfer operation. However, because of the tensions involved when confronted with a fire situation and questionable training in the operation of a manual system, we believe that only an automatic system will ensure a rapid release of the fire suppression agent. The disadvantages of an automatic system are the possibilities of a system discharge due to a false alarm and the added cost of the detection and control system. We recommend the automatic system to provide optimum protection for personnel and property.

In order to describe the concept for fire protection which is applicable to the many various configurations of underground fueling areas, it is necessary to describe two concepts. Where the fuels are stored in a closed room the fire protection problem is simplified. Personnel are normally not present and the ventilation can be controlled to isolate the fire and smoke from the rest of the mine. In the fuel transfer area the fire protection problem is more complex. Personnel are always present during the actual transfer of fuel to the vehicle and the ventilation through this area cannot normally be isolated from the rest of the mine. In addition, the air velocity affects the dispersion of the fire suppression agent.



Schematic of Fire Protection System in the Mine

For the enclosed storage area, AFFF, dry chemical, Halon 1301, and high expansion foam are all recommended as acceptable fire suppression agents. However, for the more critical open fuel transfer area, the combined AFFF and dry chemical system is recommended. The recommended detection for both areas is ultraviolet with the option of optical integrity monitoring.

PROTOTYPE SYSTEM FIELD DEMONSTRATION

A prototype system was designed to protect a combination fuel transfer and storage area at the Union Carbide Corporation Pine Creek Mine at Bishop, California. A fueling area configuration of this type, where the storage area is not isolated from the transfer area, represents the most severe test for a fire protection system. The prototype system is a combined AFFF and dry chemical system with ultraviolet cross-zoned detectors. The dry chemical system provides a rapid suppression of the flames which is particularly important near and under the vehicle. The AFFF system is particularly effective in securing the fire, preventing reflash.

On July 31, fire test demonstrations were performed in the Pine Creek Mine. Pan fires were set on the concrete fuel storage pad and under a mock-up of a load-haul-dump vehicle. In both cases the system demonstrated its ability to detect and extinguish the fire.

RECOMMENDATION

The underground fire test demonstration must be supplemented by long-term validation tests in the mine environment to demonstrate system reliability.

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1.0 RESULTS AND RECOMMENDATIONS

1.1 Results

- General criteria for the design of underground fueling systems were prepared for use as a guideline to the mining industry.
- Design concepts of automatic fire protection systems for underground fueling areas were prepared.
- A prototype system for an open fuel transfer and storage area was designed and fabricated.
- The prototype system was installed in an underground fueling area and system performance was demonstrated by underground fire tests.

1.2 Recommendations

- Long-term testing of the prototype system in the mine environment is needed to demonstrate system reliability.
- Installation and long-term testing of systems in two additional mines is recommended to further demonstrate reliability.
- Additional development work is needed for a compact, all environment control console.
- Validation testing of the Brunswick ionization detector is recommended to determine its suitability to the mine environment.
- An AFFF environmental impact study's recommended to gain an understanding of the effect of a system discharge on the environment, particularly the water streams near the mine.

1.3 Subject Inventions

There are no inventions created under this program. The developed system incorporates state-of-the-art hardware with modifications only as needed to adapt to the underground mine environment.

2.0

DATA ACQUISITION

The overall objective of this task was to gather data for conducting a hazard analysis of underground fueling areas (areas for storage, transport and the fueling operation). The most direct approach would have been to utilize reports on leaks and small fires as indications of the potential types of larger fires. However, a preliminary check of accident reports indicated that insufficient data were available for drawing valid conclusions. A decision was made to collect information on fueling system leaks and fires during mine visits but not to depend on the accident data as the primary basis for the hazard analysis.

Primary emphasis was given to collecting fueling system design and operations data in order to conduct an engineering hazard analysis. The basic approach was to compare the capabilities (operating pressure specifications, ruggedness, reliability, etc.) of the various components of currently operational fueling systems to the requirement (pressure, shock, maintenance, etc.), placed on them during operation.

2.1

Data Sources

During the data gathering portion of the project, the following twelve (12) major sources of information were consulted.

- Bureau of Mines and MESA Staff
- Bureau of Mines and MESA Publications
- Ansul Company
- MRI Staff
- Project Consultants
- MESA Reports
- General Literature
- Mine Company Management Staff
- Mine Safety Directors
- Mine Maintenance Staff
- Equipment Manufacturers
- Insurance Industry

2.2

Mines Sample Description

This section describes the mines visited during the data acquisition task. An attempt was made to obtain a sample

representative of the metal and nonmetal mining industry in terms of size, mining method and ore extracted.

2.2.1 Mine Size (Tons Per Day, TPD)

• 5,000 TPD or less	8 (50%)
• 5,001 to 10,000 TPD	5 (31%)
• 10,001 TPD or more	3 (19%)

2.2.2 Mining Techniques

• Room and pillar	7 (37%)
• Open stopping	7 (37%)
• Caving	4 (21%)
• Cut and fill	1 (5%)

Note: More than one method used at some mines.

2.2.3 Haulage Methods

• Load-haul-dumps	8 (30%)
• Rail	8 (30%)
• Truck	5 (18%)
• Belt	3 (11%)
• Bobcats	3 (11%)

Note: More than one method used in some mines.

2.2.4 Number of Diesel Vehicles Underground

• 0 - 15	5 (30%)
• 16 - 25	3 (21%)
• 26 - 50	3 (21%)
• 51 - 75	1 (7%)
• 76 - 100	1 (7%)
• 101 - 300	1 (7%)
• 301 - 500	1 (7%)

Note: Data unavailable at one mine.

2.2.5 Average Working Depth

Above Entry	3 (21%)
500 - 750 ft	2 (13%)
751 - 1,000 ft	2 (13%)
1,001 - 1,500 ft	3 (21%)

1,501 - 2,000 ft	3 (13%)
2,001 - 3,000 ft	2 (13%)

Note: Data unavailable at one mine.

2.2.6 Number of Years in Production

• 0 - 5	3 (21%)
• 6 - 15	3 (21%)
• 16 - 25	4 (30%)
• 26 - 35	0 (0%)
• 36 - 45	1 (7%)
• 46 - 55	3 (21%)

Note: Data unavailable at two mines.

2.2.7 Number of Employees Underground

<u>Number</u>	<u>Shift</u>		
	<u>1</u>	<u>2</u>	<u>3</u>
0 - 25	3 (21%)	3 (21%)	7 (50%)
26 - 50	2 (14%)	3 (21%)	0 (0%)
51 - 100	2 (14%)	3 (21%)	3 (21%)
101 - 150	2 (14%)	0 (0%)	0 (0%)
151 - 300	3 (21%)	4 (29%)	2 (14%)
301 - 800	2 (14%)	1 (7%)	2 (14%)

Note: Data unavailable at two mines.

2.2.8 Ores Extracted

• Copper	6 (23%)
• Molybdenum	4 (15%)
• Uranium	3 (11%)
• Zinc	3 (11%)
• Lead	2 (8%)
• Salt	2 (8%)
• Tungsten	2 (8%)
• Nickel	1 (4%)
• Iron	1 (4%)
• Gypsum	1 (4%)
• Tin	1 (4%)

Note: More than one ore extracted at some mines.

2.2.9

States Represented

Figure 1 indicates the states in which sample mines were located.

2.3

Mine Visit Procedures

During a typical mine site visit, two research team members would arrive at the mine head office at the beginning of a working day and would report to the individual (mine manager or safety director) who had helped arrange their visit. Because most mines conduct blasting operations in the afternoon, the tour of the mine would begin as early as possible in the morning to allow 3 to 4 hour underground.

The two team members went underground in order to inspect the fuel piping, underground storage areas and vehicle transfer areas. If possible, fueling procedures were observed. Drawings of each underground storage area and vehicle transfer area were made and photographs were taken when permitted. The maintenance foreman in charge of the system was interviewed concerning leak and fire incidents as well as maintenance procedures.

After the tour, the next step typically involved interviewing the mine's safety director or maintenance manager about any fire incidents involving underground fueling equipment at the mine over the last 5 years. Since few actual incidents were expected, they were also asked to subjectively rate the relative fire hazard potential of various types of underground fueling equipment regardless of whether actual fires had occurred involving those types.

Mine executives with authority to approve major equipment purchases were also interviewed briefly to determine acceptable purchase price and maintenance costs for an automatic fire protection system. The desirability of various design features for such a system was also discussed and the executives' opinions recorded.

All interviews were conducted using an interview summary sheet, to help focus and standardize the questions, as well as to help simplify data recording. Following field

interviews, team members would fill in appropriate portions of the data collection forms, based upon their observations and conversations during the day.

2.4

Data Instruments

Six different data instruments were used in collecting the information needed to meet project data requirements. These instruments were used to summarize information obtained from appropriate data sources cited in Section 2.1.

These instruments, copies of which are provided in Appendix A, were:

- Mine Description Form
- Operator Comments on Proposed Standards
- Market Factor Ratings
- Fire Hazard Factor Ratings
- Leak Incident Description
- Maintenance Procedures Description
- Volatile Fluids System Description
- Existing Fuel Storage Area Fire Control Systems

2.5

Literature Review Procedures

An extensive literature review was conducted in the areas of fire safety, NFPA standards, mine fires, Bureau of Mines fire studies, petroleum pumping systems design, petroleum fuels flammability characteristics, MESA standards, and vehicle transfer equipment. The initial objective was to familiarize the project team with the possible fueling system components and to determine what data were most likely to be useful in the engineering hazard analysis.

The first finding of the literature search was that no fueling systems for underground mines were available as a complete package. Each mine had to design its system from a number of components, none of which were designed for underground use.

Data on flammability of diesel fuel and oils were located and saved for use in the hazard analysis. Results of laboratory studies on conditions affecting flammability of fuel and oil were also located. Specifications for a large number of fueling system components were also collected. Selected references appear in Appendix B.

During the literature search we located an Environmental Protection Agency regulation concerning oil pollution prevention. While pollution was outside the scope of the current contract, we felt that the mining community should be made aware of the regulation.

The regulation states that anyone who stores oil on their facility must have a Spill Prevention Control and Countermeasure Plan (SPCC Plan) indicating how an oil spill will be prevented from entering any navigable waterway, which includes any waterway utilized for recreation by out-of-state boaters. The plan must be signed by a registered professional engineer. Failure to have the plan on file at the mine for review by an EPA inspector will result in stiff fines. A copy of the regulation appears in Appendix C.

2.6

Description of Data Analysis Base

As a result of the literature search and mine visits, acquired data included the following:

- Literature on fire hazards and fueling systems
- Specifications on fueling system components
- Drawings, photographs and descriptions of fueling systems. Copies of drawings appear in Appendix D.
- Descriptions of previous leaks and fires
- Operator opinions on fire hazards, proposed standards and fire protection systems
- Fueling system operation and maintenance practices

3.0 ANALYSIS OF DATA

3.1 Overall Results

As a result of the hazard analysis, the vehicle transfer area (where fueling operation occurs) was selected as the most hazardous subsystem of the fueling system. The most hazardous vehicle transfer area design was one in which the fueling operation occurs in close proximity to the fuel and oil tanks with drums of oil present and no enclosure separating the tanks from the fueling operation. The most hazardous module of a vehicle transfer area was the fueling operation.

3.2 Fueling System Configuration Data

The typical fueling system consists of the following subsystems:

- Surface Storage
- Surface Transport
- Shaft or Bore-Hole Transport
- Haulageway Transport
- Underground Storage Area
- Vehicle Transfer Area

The following paragraphs describe the configurations observed in the mines visited.

3.2.1 Surface Storage

Diesel fuel (No. 1) may be stored in surface tanks or piped directly below from the delivery truck. Tank sizes range from 250 to 10,000 gal. with quantities from 750 to 75,000 gal. Oils (lubrication, transmission, rock, hydraulic) may be stored in surface tanks or drums or piped directly below. Tank sizes range from 500 to 5,000 gal. with quantities from 500 to 40,000 gal. Drums are 30 and 55 gal.

3.2.2 Surface Transport

Fuels and oils are transported on the surface in pipes (exposed or buried), in drums on pallets, in 5-gal. cans, in mobile tanks on wheels, in tanks carried by forklift, and by self-propelled tankers. Tanks are 250, 375 and 500 gal. capacity and the one tanker observed carried 800 gal. of diesel and 300 gal. of oil.

3.2.3

Shaft or Bore-Hole Transport

Fuel and oil are transported down the shaft on the cage using the mobile tanks and tankers described under surface transport. They are also piped down the shaft or a bore-hole in schedule 40 or 80, black or stainless steel pipe, 3/4 to 2 in. in diameter using welded, cast, forged or victaulic couplings.

Some mines have a wet line in which fuel and oil flow by gravity down the pipe and is stopped by a valve underground. Thus, the pipe is under static pressure from the column of fuel or oil between fueling operations and a hammer effect occurs when the valve closes and the end of a fueling operation. Most mines pipe the fuel down in batches with the line left empty (dry line) between operations. Some of these mines use an intermediate batch tank smaller than the underground tank to make certain no more fuel is sent down than can be held in the underground tank. Some mines pump the fuel from the surface tank and others utilize only gravity.

3.2.4

Haulageway Transport

Fuel and oil are transported in the haulageway in the same manner as described in shaft or bore-hole transport except that some drums and tanks are transported by LHD or truck.

3.2.5

Underground Storage Area

Diesel fuel is stored in tanks ranging in size from 250- to 5,000 gal. capacity with total volumes from 550 gal. to 5,000 gal. Oils are stored in 30- to 55-gal. drums and tanks ranging in size from 275- to 5,000-gal. capacity with total volumes from 1,000 to 44,000 gal. Tables I and II indicate the quantities and types of storage observed during our mine visits, Table III indicates dimensions of these underground storage areas and Table IV contains the piping.

3.2.6

Vehicle Transfer Area

Some vehicle transfer areas consist of only the piping, hose and nozzle with the fuel supply located more than 50 ft away or enclosed in a fire-resistant structure. Others have the fuel tanks in the immediate area and still others include oil tanks.

TABLE I

UNDERGROUND STORAGE AREAS

<u>Mine No.</u>	<u>No. Underground Storage Areas</u>	<u>No. Tanks Per Storage Area</u>	<u>Size Tanks and Type Fluid at Storage Area</u>	<u>Total Volume Each Fluid</u>
1	1	11	2-1,200 gal., diesel oil 2-5,000, delvac oil 5-5,000, hydraulic 2-5,000, rock oil	2,400 diesel 10,000 delvac 25,000 hydraulic 10,000 rock
2	None			
3	None			
4	1	4	2-2,500, diesel 2-1,500, hydraulic	5,000 diesel 3,000 hydraulic
5	1	4 (see note)	1-5,000, diesel 1-3,000, rock drill oil 1-3,000, hydraulic 1-2,000, 30-wt oil	5,000 diesel 3,000 rock drill 3,000 hydraulic 2,000 30-wt
6	1	3	1-3,500, diesel 2-2,500, hydraulic	3,500 diesel 5,000 hydraulic
7	2	3 (cans) in Area 1 3 (cans) in Area 2	3-5 gal. cans in Area 1 3-5 gal. cans in Area 2	15 diesel (Area 1) 15 diesel (Area 2)
8	None			
9	None			
10	1	7	7-250, diesel	1,750 diesel
11	None			
12	1	5	2-275, diesel 3-275, hydraulic	550 diesel 825 hydraulic
13	None			
14	5	None in Area 1 1 in Area 2 1 in Area 3 1 in Area 4 1 in Area 5	1-200, hydraulic (Area 2) 1-500, hydraulic (Area 3) 1-200, diesel (Area 4) 1-1,000, diesel (Area 5)	200 hydraulic 500 hydraulic 200 diesel 1,000 diesel
15	None			
16	None			

Note: One 300-gal. tank for used oil was located immediately outside of the room used as the underground storage area at Mine No. 5.

TABLE II

GENERAL INFORMATION ON FUEL DRUMS IN UNDERGROUND
STORAGE AREAS

<u>Mine*</u> <u>(Area)</u>	<u>No. of</u> <u>Drums</u>	<u>Total Volume</u>	<u>Type of Fluid in Drum</u>
1	0	--	--
4	0	--	--
5	0	--	--
6	0	--	--
7 (1)	0	--	--
7 (2)	0	--	--
10	40	2,200 gal.	Hydraulic oil
	4	220 gal.	Transmission oil
12	2	110 gal.	Solvent
	12	660 gal.	Texmatic fluid-cyl. oil
	6	180 gal.	Texaco Motor Oil SAE 30
	8	440 gal.	Transmission oil
14 (1)	4	220 gal.	Standard solvent
	3	90 gal.	Regal oil
14 (2)	0	--	--
14 (3)	6	330 gal.	Texaco lube
	1	200 gal.	Torque fluid
14 (4)	0	--	--
14 (5)	0	--	--

* Mine Nos. 2, 3, 8, 9, 11, 13, 15, and 16 have no underground storage areas.

TABLE III

DIMENSIONS OF UNDERGROUND STORAGE AREAS AND THEIR
TYPE (OPEN OR ENCLOSED)

<u>Mine No.</u>	<u>Length of Area</u> <u>(ft)</u>	<u>Width of</u> <u>Area</u> <u>(ft)</u>	<u>Height of</u> <u>Area</u> <u>(ft)</u>	<u>Volume of</u> <u>Area</u> <u>(cu ft)</u>	<u>Area Open or</u> <u>Enclosed</u>
1	200	30	15	90,000	Enclosed
2	No Area				
3	No Area				
4	30	15	12	5,400	Enclosed
5	30	30	15	13,500	Enclosed
6	30	15	20	9,000	Enclosed
7					
Area 1	5	8	8	320	Open
Area 2	5	10	8	400	Open
8	No Area				
9	No Area				
10	Estimated 50 (see note)	Est. 30	Est. 40		Open
11	No Area				
12	30	30	9	8,100	Enclosed
13	No Area				
14					
Area 1	30	15	10	4,500	Enclosed
Area 2	15	15	10	2,250	Open
Area 3	15	6	10	900	Open
Area 4	10	15	10	1,500	Open
Area 5	(see note 2)				Enclosed
15	No Area				
16	No Area				

Note: Storage area in main haulageway.

Note 2: Storage consists of one buried tank.

TABLE IV

PIPING TO UNDERGROUND STORAGE AREAS

<u>Mine No.</u>	<u>Type of Pipe</u>	<u>Vertical Piping Distance (ft)</u>	<u>Horizontal Piping Distance (ft)</u>
1			
Diesel tanks	3/4 in. stainless steel	550	20
Delvac tanks	Same	Same	85
Hydraulic tanks	Same	Same	85
Rock oil tanks	Same	Same	85
2	No area		
3	No area		
4			
(same pipe for all tanks)	2 in. schedule 40	1,800	30
5			
(same pipe for all tanks)	2 in. galvanized	810	1,200
6			
(same pipe for all tanks)	1-1/4 in. galvanized inside 6 in. pipe	1,000	50
7	No piping		
8	No area		
9	No area		
10	No piping		
11	No area		
12			
Diesel tanks	1-1/4 in. schedule 80	600	380
Hydraulic tanks	1-1/2 in. PVC fiber	600	380
13	No area		
14			
(no piping to areas 1 and 2)			
Area 3 (1 tank)	2 in. schedule 40	None	150
Area 4 (1 tank)	2 in. schedule 40	None	300
Area 5 (1 tank)	Unknown	15	300
15	No area		
16	No area		

Some vehicle transfer areas have tanks of fuel and oil as well as drums of oil in the immediate area. Other combinations of these possibilities exist. Tables V and VI indicate the quantities and types of storage, Table VII, the dimensions and Table VIII, the piping to vehicle transfer areas observed during the study. Table IX indicates the locations of vehicle transfer areas relative to the shop as well as water and power supplies.

3.2.7 Fuel and Oil Storage in Shop Areas

Tables X and XI indicate the extent of fuel storage in the shop areas and the dimensions of these areas observed during our mine visits. Table XII indicates the distance between shop areas and underground storage areas.

3.3 Hazard Analysis of Fueling System

3.3.1 Overall Results

Table XIII contains the results of the hazard analysis on the fueling system. The most hazardous subsystem is the vehicle transfer area because the area contains fuel, heat sources and personnel in close proximity. The underground storage area is the next most hazardous because the likelihood of a fire is very low but the consequences very great.

The relative hazard of various vehicle transfer area types appears in Table XIV. The most hazardous type has tanks of fuel and oil and drums of oil in the immediate vicinity of the fueling operation. The hazard steadily decreases as the system is simplified until only piping, hose and nozzles remain. The least hazardous vehicle transfer area is one in which the nozzles are separated from the fuel and oil tanks by a distance of 50 ft or the tanks are enclosed in a fire-resistant structure.

Table XV demonstrates that the most hazardous module of a vehicle transfer area is the fueling operation. This high rating is due to the close proximity of fuel, heat source (vehicle) and personnel. The next most hazardous modules are large fuel tanks because of the large quantities of fuel. For vehicle transfer areas with small tanks, piping and pumps are the next most hazardous because the fuel is under pressure.

TABLE V

VEHICLE TRANSFER AREA

<u>Mine No.</u>	<u>No. Transfer Areas</u>	<u>No. Tanks/and Nozzles/ Transfer Area</u>	<u>Tank Size-Type Fluid at Transfer Area</u>	<u>Total Volume of Each Fluid (gal.)</u>
1	4	Area 1-(2)	1-500 gal., diesel 1-500 gal., hydraulic oil 1-500 gal., diesel 1-250 gal., hydraulic oil	500 diesel 500 hydraulic 500 diesel 350 hydraulic
		Area 2-(5)	1-100 gal., hydraulic oil 1-150 gal., motor oil 1-150 gal., rock drill oil 1-2,500 gal., diesel 1-200 gal., diesel	150 motor oil 150 rock drill 2,700 diesel
		Area 3-(5)	1-1,500 gal., hydraulic oil 1-500 gal., hydraulic oil 1-200 gal., delvac oil	2,000 hydraulic 200 delvac
		Area 4-Nozzles-(4)	1 diesel 1-hydraulic oil 1-rock drill oil 1-delvac oil	
2	1	(3)	1-275 gal., hydraulic oil 1-100 gal., lubricating oil 1-375 gal., diesel	275 hydraulic 100 lubricating 375 diesel
3	2	Area 1-(3)	2-600 gal., diesel 1-550 gal., diesel	1,750 diesel
		Area 2		
		(1)	1-1,200 gal., diesel	1,200 diesel
4	1	(1)	1-100 gal., No. 3 oil	100 No. 3 oil
		2-Nozzles	2-nozzles, diesel	--
5	3		1-150 gal., diesel	150 diesel
		Area 1-(4)	1-150 gal., hydraulic oil 1-55 gal., 30-wt. oil 1-30 gal., grease	150 hydraulic 55 30-wt. oil 30 grease
		Area 2		
		1-Nozzle	1-Nozzle, diesel	--
		Area 3		
		1-Nozzle	1-Nozzle, diesel	--
6	2	Area 1		
		2-Nozzles	2-diesel	--
		Area 2		
		2-Nozzles	2-diesel	--
7	2	Area 1	3-5 gal., cans-diesel	15 diesel
		Cans-(3)		
		Area 2	3-5 gal., cans-diesel	15 diesel
		Cans-(3)		
8	2	Area 1-(1)	1-500 gal., diesel	500 diesel
		Area 2-(1)	1-500 gal., diesel	500 diesel
9 Section 19	2	Area 1		
		1-Nozzle	1-diesel	--
		Area 2		
		1-Nozzle	1-diesel	--
Section 30	1	Area 1		
		1-Nozzle	1-diesel	--
10	1		4-250 gal., diesel 3-250 gal., motor oil 1-100 gal., motor oil	1,000 diesel 850 motor oil
		(8)		
11	Unknown			
12	None			
13	1	1-Nozzle	1-diesel	--
14	1	(1)	1-135 gal., diesel	135 diesel
15	1	(2)	1-800 gal., diesel 1-300 gal., hydraulic oil	800 diesel 300 hydraulic oil
16	1	(1)	1-500 gal., diesel	500 diesel

TABLE VI

DRUMS IN VEHICLE TRANSFER AREA

<u>Mine No.</u>	<u>Size of Drums</u> <u>Quantity</u>	<u>Total Volume</u>	<u>Type of Fluid</u>
1 - Area No. 1	2-55 gal.	110 gal.	Motor oil
Area No. 2	None		
Area No. 3			
Area No. 4			
2	5-55 gal.	110 gal. 165 gal.	Hydraulic oil Transmission oil
3	None		
4	None		
5	None		
6 Area No. 1	None	385 gal.	Transmission oil
Area No. 2	10-55 gal. 385 gal. 165 gal.	165 gal.	Diesel motor oil
7	None		
8 Area No. 1	15-55 gal.	330 gal. 495 gal.	Hydraulic oil Transmission oil
9	None		
10	8-55 gal.	440 gal.	Motor oil
11	Unknown		
12	No fueling area		
13	3-55 gal.	110 gal. 55 gal.	Torque fluid Motor oil
14	2-55 gal.	110 gal.	Mobile oil
15	36-55 gal.	1,210 gal. 385 gal. 385 gal.	10 wt. motor oil No. 200 motor oil Grease
16	5-55 gal. 102-5 gal. 2-30 gal.	275 gal. 510 gal. 60 gal.	No. 1 grease Motor oil Hydraulic oil

TABLE VII
VEHICLE TRANSFER AREA DIMENSIONS

<u>Mine No.</u>		<u>Length of Area (ft)</u>	<u>Width of Area (ft)</u>	<u>Height of Area (ft)</u>	<u>Volume of Area (cu ft)</u>	<u>Area Open or Enclosed</u>
1	Area No. 1	40	29	20	23,200	Open
	Area No. 2	25	15	10	3,750	Open
	Area No. 3	50	30	10	15,000	Open
	Area No. 4	40	25	10	10,000	Open
2		35	60	15	31,500	Open
3	Area No. 1	25	25	12	7,200	Open
	Area No. 2 (see note 1)					Enclosed
4		40	40	20	32,000	Open
5	Area No. 1 } Area No. 2 } (see note 2) Area No. 3 }					Open
6	Area No. 1 } Area No. 2 } (see note 3)					Open
7	(see note 4)					Open
8	Area No. 1	30	20	15	9,000	Open
	Area No. 2	105	25	15	41,375	Open
9	Area No. 1	15	10	8	1,200	Open
	Area No. 2	15	10	8	1,200	Open
	Area No. 3	15	10	8	1,200	Open
10		50	30	40	60,000	Open
11	No area					
12	No area					
13		10	5	10	500	Open
14		10	6	10	600	Open
15		25	15	15	5,625	Open
16		15	12	15	2,700	Enclosed

Note 1 - Circular room - 75 ft diameter - 60 ft ceiling.

Note 2 - On rib in haulageway.

Note 3 - On rib in haulageway.

Note 4 - Use 5-gal. cans - hand carry down.

TABLE VIII

PIPING TO VEHICLE TRANSFER AREA

<u>Mine No.</u>	<u>Type of Pipe</u>	<u>Vertical Piping Distance (ft)</u>	<u>Horizontal Piping Distance (ft)</u>
1 Area No. 1	2 in. sch. 40	--	5
	4 in. sch. 40		5
2	None		
3 Area No. 1	1-1/2 in. sch. 40	400	
	1-1/2 in. sch. 80		1,000
	1 in. rubber		1,400
4 Nozzle -1	2 in. sch. 40		100
Nozzle -2	2 in. sch. 40		150
5 Nozzle -1	2 in. galvanized		50
Nozzle -2	2 in. galvanized		200
6 Nozzle -1	1-1/4 in. galvanized		40
Nozzle -2	1-1/4 in. galvanized		115
7	None		
8 Area No. 1	2 in. sch. 40	805	40
Area No. 2	2 in. sch. 40	1,305	40
9 Area No. 1	3/4 in. sch. 40	705	
Area No. 2	3/4 in. sch. 40	785	
Area No. 3	3/4 in. sch. 40	650	
10	None		
11	None		
12	None		
13 Area No. 1	1-1/2 in. sch. 40		
14	None		
15	None		
16	None		

TABLE IX

DISTANCE FROM VEHICLE TRANSFER AREA TO
SHOP, WATER AND POWER SUPPLIES

	<u>Quantity</u> <u>(Water)</u>	<u>Quantity</u> <u>(Power)</u>	<u>Quantity</u> <u>(Shop)</u>
Vehicle Transfer Areas- within 10 ft of above	13 (76%)	16 (88%)	1 (6%)
Vehicle Transfer Areas- 25 ft away from above	1 (6%)	1 (6%)	1 (6%)
Vehicle Transfer Areas- 75 ft away from above	1 (6%)		7 (38%)
Fueling Areas-125 ft or greater from above	2 (12%)	1 (6%)	9 (50%)
Totals	17* (100%)	18 (100%)	18 (100%)

* Note: One mine has no water underground in lines.

TABLE X

FUEL STORAGE IN SHOP AREA

<u>Mine*</u>	<u>Number</u> <u>of Drums</u>	<u>Number</u> <u>of Tanks</u>	<u>Size of Tank</u> <u>or Drum</u>	<u>Total</u> <u>Volume</u>	<u>Type of Fluid</u>
1	--	1	400 gal.	400 gal.	DELVAC
	11	--	55 gal.	605 gal.	Lub. hd. 80-90
	5	--	55 gal.	275 gal.	1 Lux. ed. 402
3	61	--	55 gal.	3,355 gal.	Assorted oils
5	--	1	685 gal.	685 gal.	Diesel & hyd.
	11	--	55 gal.	605 gal.	Trans. oil
	4	--	55 gal.	220 gal.	Motor oil
6	--	1	3,500 gal.	3,500 gal.	Diesel
		2	2,500 gal.	5,000 gal.	Hyd. oil
9	2	--	55 gal.	110 gal.	Motor oil
	2	--	55 gal.	110 gal.	Hyd. oil
	2	--	55 gal.	110 gal.	Rock drill
	2	--	55 gal.	110 gal.	Grease
14	8	--	55 gal.	440 gal.	Trans. oil

* Only mines storing fluids in shop area.

TABLE XI

DIMENSIONS OF FUEL STORAGE AREAS IN SHOP

<u>Mine*</u>	<u>Length of Area (ft)</u>	<u>Width of Area (ft)</u>	<u>Height of Area (ft)</u>	<u>Volume of Area (cu ft)</u>	<u>Area Open or Enclosed</u>
1	75	45	25	84,375	Open
3	30	30	15	13,500	Enclosed
5	Very large open area				
6	30	15	20	9,000	Enclosed
9	15	10	10	1,500	Open
14	30	5	12	1,800	Open

* Only mines with storage areas in shop area.

TABLE XII

DISTANCE OF UNDERGROUND STORAGE AREAS FROM SHOP AREAS

	<u>No.</u>	<u>Percent</u>
0-50 ft	2	15%
51-100 ft	1	8%
101-150 ft	1	8%
151-200 ft	1	8%
201-250 ft	1	8%
>> 250 ft		
(or no shop area)	7	53%

TABLE XIII

HAZARD INDICES OF SUBSYSTEMS OF FUELING SYSTEM

<u>Subsystem</u>	<u>Hazard Index</u>	Rank
		<u>1 = Most Hazardous</u>
Vehicle transfer area	278	1
Underground storage area	217	2
Surface storage	101	3
Shaft transport	77	4
Surface transport	59	5
Bore-hole transport	50	6
Transport to vehicle transfer area	48	7
Transport to underground storage area	43	8

TABLE XIV

HAZARD INDICES OF VEHICLE TRANSFER AREAS

<u>Type</u>	<u>Hazard Index</u>	Rank
		<u>1 = Most Hazardous</u>
Tanks and drums present	449	1
Fuel and oil tanks present	363	2
Fuel tanks present	292	3
Nozzles and drums	266	4
Nozzles only	212	5

TABLE XV

MOST HAZARDOUS MODULES OF VEHICLE TRANSFER AREA

<u>Module</u>	<u>Hazard Index</u>	Rank 1 = Highest	
		<u>With Large Tanks</u>	<u>With Small Tanks</u>
Fueling operation	53	1	1
2-500 gal. tanks diesel	49	2	--
1-500 gal. tank diesel	48	3	--
Piping	44	4	2
Pump	43	5	3
1-250 gal. tank diesel	43	6	4
Hose	42	7	5
1-75 gal. tank diesel	38	8	6

The most hazardous modules of underground storage areas are exhibited in Table XVI. Overflow vents are the most hazardous because human error leads to overfilling the tanks. Pumps and piping are the next most hazardous because the fuel is under pressure.

TABLE XVI

MOST HAZARDOUS MODULES OF UNDERGROUND STORAGE AREA

<u>Module</u>	<u>Hazard Index</u>	Rank 1 = Highest
		<u>With Large Tanks</u>
Overflow vent	44.7	1
Pumps	40.6	2
Piping	36.1	3
5,000 gal. tank	35.3	4
1,000 gal. tank	35.1	5
500 gal. tank	34.8	6
18-55 gal. drums	32.3	7
9-55 gal. drums	28.7	8
1-55 gal. drum	24.5	9
1-30 gal. drum	23.2	10

3.3.2 Hazard Analysis Procedure

3.3.2.1 Panel Ratings of Hazards

This section will discuss the engineering hazard analysis conducted as part of the study. The basic approach was to gather data on how the fueling systems were designed and operated and to compare this to the capabilities (such as bursting pressure) of the equipment. A list of the hardware observed in the mines was compiled and the capabilities of the hardware were determined from engineering reference manuals, literature from the manufacturer or engineering estimates based on similar hardware. The configuration of the various fueling systems was also recorded and the requirements (such as static and dynamic pressure) placed on the system were calculated.

An expert panel was then convened in order to rate the hazard of the various parts of fueling systems. The panel consisted of (1) a hazard analysis expert who had experience on a previous mining fire hazard study and who had visited six of the mines in the study, (2) an engineer who visited all of the mines in the study, (3) a mining engineering consultant, (4) a petroleum systems design consultant, and (5) a research engineer with hydraulic system design experience.

The fueling system was divided into the subsystems listed in Table XIII. Then all hardware observed in each subsystem at the mines was listed. Table XVII contains the modules of the vehicle transfer area. Each panel member received a stack of cards with the name of one module on each card.

The fire hazard of a piece of hardware consists of three factors: (1) probability of a leak or spill; (2) size of the leak or spill; and (3) probability of ignition. The total fire hazard is the sum of these three factors.

The panel of experts were first asked to rank the modules in order of probability that a leak or spill would occur. Before the ranking, each panel member was asked to comment on any considerations that he felt might affect the rankings. For example, the hydraulic system design consultant and research engineer would discuss the pressures and flow rates involved as compared to the operating specifications of the modules. The mining engineer consultant would

TABLE XVII

HAZARD RATING COMPUTATION PROCEDURE-VEHICLE TRANSFER AREA

Module	Probability of Leak						Extent of Leak					Probability of Ignition						
	Mean Rank	SD	R	FR=10	R	H=10+(10-FR)	Mean Rank	SD	R	FR=10	R	H=10+(10-FR)	Mean Rank	SD	R	FR=10	R	H=10+(10-FR)
	(M)			Total	(M)		Total			(M)	Total							
1. 1-75-gal. tank	13.4	4.10	16	9.4		10.6	6.4	3.13	5	2.9		17.1	12.2	3.42	17	9.99		10.1
2. 1-150-gal. tank	13.2	4.15	15	8.8		11.2	5.0	2.24	4	2.4		17.6	10.4	4.39	10	5.9		14.1
3. 1-250-gal. tank	15.0	0.00	17	9.99		10.1	3.6	1.34	3	1.8		18.2	10.2	4.44	9	5.3		14.7
4. 2-250-gal. tanks	12.8	5.02	14	8.2		11.8	2.6	1.34	2	1.2		18.8	9.0	5.52	5	2.9		17.1
5. 2-500-gal. tanks	12.6	5.73	13	7.6		12.4	1.2	0.45	1	0.6		19.4	8.4	6.19	4	2.4		17.6
6. 1-30-gal. drum	7.6	2.88	6	3.5		16.5	13.8	3.11	17	9.99		10.1	11.8	4.71	15	8.8		11.2
7. 1-55-gal. drum	7.0	2.55	4	2.4		17.6	13.2	3.11	16	9.4		10.6	11.2	3.90	14	8.2		11.8
8. 5-55-gal. drums	7.2	3.27	5	2.9		17.1	10.2	3.70	10	5.9		14.1	9.8	3.35	8	4.7		15.3
9. 10-55-gal. drums	6.6	3.36	3	1.8		18.2	11.0	3.32	11	6.5		13.5	9.2	2.86	6	3.5		16.5
10. Piping to pumps	9.6	2.19	9	5.3		14.7	9.0	3.81	7	4.1		15.9	10.6	4.51	11.5	6.8		13.2
11. Screened couplings-cast	8.2	3.27	7	4.1		15.9	7.8	1.64	6	3.5		16.5	10.6	3.91	11.5	6.8		13.2
12. Screened couplings-forged	10.0	4.00	10.5	6.2		17.8	9.6	2.07	8	4.7		15.3	12.0	4.00	16	9.4		10.6
13. Valves	8.6	4.16	8	4.7		15.3	12.0	2.55	13	7.6		12.4	10.8	2.28	13	7.6		12.4
14. Pump	10.0	4.18	10.5	6.2		13.8	13.0	1.87	15	8.8		11.2	3.8	2.59	3	1.8		18.2
15. Hose	10.2	5.36	12	7.1		12.9	11.8	5.54	12	7.1		12.9	9.6	6.77	7	4.1		15.9
16. Fueling vehicle	1.6	0.55	2	1.2		18.8	10.0	6.93	9	5.3		14.7	1.4	0.55	1	0.6		19.4
17. Fueling from tanker	1.4	0.55	1	0.6		19.4	12.8	4.97	14	2.4		17.6	2.0	0.71	2	1.2		18.8

comment on pertinent mining operations and mine environmental considerations. The two engineers who had visited the mines would mention their personal observations and comments by mine operators.

Each panel member would stack the cards in rank order from most hazardous to least hazardous module. The rankings were then copied on the board for comparison. If the rankings exhibited good agreement they were allowed to stand and the panel went on to the next ranking. If considerable disagreement occurred, then the members were asked to explain their logic. After the explanations, each panel member was given the opportunity to change his rankings if he had been persuaded by another panel member's discussion. The final rankings were then recorded for later use.

This procedure was followed for each of the three fire hazard factors on each of the eight fueling subsystems. Shaft transport, bore-hole transport and transport to underground storage were ranked assuming both a dry line and a wet line as defined in Section 3.2.3.

The fire hazard of a module is due partly to the characteristics of the module itself and partly to its location in the mine. For example, the same type of pipe is more hazardous in the shaft than on the surface because the operating conditions are more severe and the consequences of a fire are greater in the shaft. A decision was made to rate the fire hazard of each fueling system component and add this rating to the module hazard rating to obtain an overall fire hazard rating for each module based on both its specific characteristics and location in the mine.

The panel was asked to rate the fire hazard of each of the eight fueling subsystems on a scale from one to 10. After some discussion, a consensus was reached and the values in Table XVIII were recorded for later use.

At the end of the hazard rating session described above, each module observed in the mines had been ranked relative to the other modules in that subsystem in terms of the three factors of fire hazard. Also, the subsystems had been rated on a scale from one to ten on how hazardous a fire occurring in that subsystem would be to the underground miners.

TABLE XVIII

HAZARD RATING OF EACH COMPONENT BASED ON
EFFECT OF FIRE ON UNDERGROUND MINES

Component	Rating 1 = Most Hazardous
Vehicle Transfer Area	1
Underground Storage Area	3
Surface Storage	10
Shaft Transport	1
Surface Transport	7
Bore-Hole Transport	6.5
Transport to Vehicle Transfer Area	4
Transport to Underground Storage Area	5

3.3.2.2 Hazard Index Calculations

3.3.2.2.1 Module Hazard Indices

The expert panel had ranked the modules by relative hazard within subsystem and had rated the hazard of each subsystem. The next task was to convert these rankings into a usable hazard index.

First the mean rank assigned to the module by the five experts was calculated. Table XVII exhibits the hazard index calculation procedure for vehicle transfer areas. This rank was then converted to a scale of one to ten. For example, the rank 10th out of 10 received a final rank of 10 while the rank 10th out of 20 received a final rank of 5. The final ranks were then inverted such that the highest ranking module (1 = most hazardous) received the largest hazard index (10 = most hazardous). This was done in order to be able to add hazard indices and obtain a larger hazard index. The hazard index for the subsystem (10 in this example) was then added to each module hazard index to obtain the overall hazard index for each module.

3.3.2.2.2 Subsystem Hazard Indices

The hazard index for each subsystem was calculated by listing the major modules observed in each mine for each subsystem. The hazard index for each of the three fire hazard factors were then recorded for each module. Table XIX exhibits the subsystem hazard index calculation procedure of the vehicle transfer area for one mine.

The fire hazard for oils was calculated differently than for diesel fuel. Due to the high flash point (450°F) of oils, they are unlikely to start a fire unless ignited by burning diesel fuel. Therefore, oils were included in the hazard analysis as fuel supply for a secondary fire instead of as an ignition source. Oil stored in drums was assigned a probability of ignition hazard index of 10 because any fire around the drum will produce pressure that cannot be relieved without rupturing the drum and releasing the oil into the fire. The probability of ignition was assigned a hazard index of 1.0 if the oil was contained in a vented tank because the fire around this type of tank will, at worst, ignite a flame at the vent. The size of spill hazard index was the same as that for a diesel fuel container of the same type.

After the hazard indices for each module were recorded in the table they were added together to obtain a hazard index for each subsystem of each mine. Then the average hazard index was calculated for each subsystem. The hazard analyses appearing in Table XIII were calculated by the above procedure.

3.3.2.2.3 Hazard Indices for Various Types of Vehicle Transfer Areas

The hazard index for the various types of vehicle transfer areas listed in Table XIV were calculated by first classifying the areas by type and then finding the mean hazard index for each type. The same procedure was followed to obtain the mean hazard indices for modules of underground storage areas (Table XV) and vehicle transfer areas (Table XVI).

TABLE XIX

HAZARD INDEX CALCULATION PROCEDURE—VEHICLE TRANSFER AREA

<u>Mine No.</u>	<u>Area No.</u>	<u>Module</u>	<u>Fluid</u>	<u>Prob. of Spill</u>	<u>Size of Spill</u>	<u>Prob. of Ignition</u>	<u>Prob. of Sec. Fire</u>	<u>Size of Sec. Fire</u>	<u>Fire Hazard</u>
49	1	Piping		14.7	15.9	13.2			
		Screw couplings		15.9	16.5	13.2			
		Hose		12.9	12.9	15.9			
	2	Fueling operation		18.8	14.7	19.4			184.0
		1-500 gal. tank	D	11.8	18.8	17.1			
		1-500 gal. tank	H				1.0	18.8	
		Piping		14.7	15.9	13.2			
		Screw couplings		15.9	16.5	13.2			
		Pump		13.8	11.2	18.2			
		Hose		12.9	12.9	15.9			
		Fueling operations		18.8	14.7	19.4			294.7
	3	1-500 gal. tank	D	11.8	18.8	17.1			
		1-250 gal. tank	H				1.0	10.1	
		1-100 gal. tank	H				1.0	17.3	
		1-150 gal. tank	O				1.0	17.6	
		1-150 gal. tank	R				1.0	17.6	
		Piping		14.7	15.9	13.2			
		Screw couplings		15.9	16.5	13.2			
		Pump		13.8	11.2	18.2			
		Hose		12.9	12.9	15.9			
		Fueling Operation		18.8	14.7	19.4			341.5
	4	1-200 gal. tank	D	11.7	17.9	14.4			
		1-200 gal. tank	O				1.0	17.9	
		1-500 gal. tank	H				1.0	18.8	
		1-2,500 gal. mobile tanker	D	31.0	48.5	44.0			
		1-1,500 gal. tank on above	H				1.0	29.1	
		Piping		14.7	15.9	13.2			
		Screw couplings		15.9	16.5	13.2			
		Pump		13.8	11.2	18.2			
		Hose		12.9	12.9	15.9			
		Fueling Operation		18.8	14.7	19.4			463.5

3.3.2.2.4 Dry Versus Wet Line

A major area of concern in underground fueling system design is wet versus dry line. The wet line (with fuel in the line at all times) has the advantage of no underground storage of fuel but the piping is more hazardous. The dry line (line empty between filling operations) places less stress on the piping but has the disadvantage of underground fuel storage.

A hazard analysis was conducted to determine whether a dry line or a wet line system delivers the fuel with the least overall hazard. Table XX contains the calculations utilized to conduct the hazard analysis. Two mines (numbers 9 and 13) with wet line systems were used as the test case.

The hazard of each component of the wet line system as presently designed and operated was calculated. Then the hazard for each component was calculated again assuming a dry line system with the same fuel delivery capacity. Hazard for the dry line system was calculated under two assumptions. The first one was that no more than 24 hour of fuel supply could be stored underground and the second one was that a week's supply (6 operating days) could be stored.

Note that the hazard index for the piping is low but repeated transfers and effects of static and dynamic pressure make the hazard per day many times higher for the wet line than for the dry line. Since no fuel is stored underground with the wet line system, the dry line system is more hazardous in the underground storage area. The hazard for the vehicle transfer area is the same for both systems.

When all of the hazard indices were summed, the overall hazard to underground personnel was higher for the wet line than the dry line. The safest system was one that stored larger quantities of fuel underground (enclosed in a fire-resistant structure) and reduced the frequency of fuel transfers as well as pressure and shock in the piping. The results of this hazard analysis agreed with a well known statement--that "transfer of fuel is more hazardous than storage of fuel."

TABLE XX

HAZARD CALCULATION PROCEDURE--WET VS DRY LINE

Mine No.	Subsystem	Units	Dry Line--One Transfer/Day			Wet Line			Dry Line--One Transfer/Week		
			Hazard Per Transfer	No. Transfers Per Day	Total Hazard Per Day	Hazard Per Transfer	No. Transfers Per Day	Total Hazard Per Day	Hazard Per Transfer	No. Transfer Per Day	Total Hazard Per Day
9	Bore-Hole Transport	BH Piping Screw Couplings	34.9	1	34.9	41.9	9	377.1	34.9	1/6	5.8
13	Bore-Hole Transport	BH Piping Screw Couplings	34.9	1	34.9	41.9	6	251.4	34.9	1/6	5.8
9	Haulageway Transport to Transfer Area	Piping Screw Couplings	53.6	1	53.6	64.0	9	576.0	53.6	1/6	8.9
13	Haulageway Transport to Transfer Area	Piping Screw Couplings	53.6	1	53.6	64.0	6	384.0	53.6	1/6	8.9
9	Haulageway Transport to U.G. Storage Area	Piping Screw Couplings	24.1	1	24.1	0		0	24.1	1/6	4.0
13	Haulageway Transport to U.G. Storage Area	Piping Screw Couplings	24.1	1	24.1	0		0	24.1	1/6	4.0
9	U.G. Storage Area	Tank (150 gal.) Piping Screw Couplings Valves Overflow	35.0 36.1 40.2 37.4 <u>38.1</u>	1 1 1 1 1	186.8	0		0	36.2 36.1 40.2 37.4 <u>38.1</u>	1 1 1 1 1/6	36.2 36.1 40.2 37.4 <u>6.4</u>
			186.8	1							156.3
13	U.G. Storage Area	Tank (250 gal) Piping Screw Couplings Valves Overflow	35.5 36.1 40.2 37.4 <u>38.1</u>	1 1 1 1 1	187.4	0		0	37.4 36.1 40.2 37.4 <u>38.1</u>	1 1 1 1 1/6	37.4 36.1 40.2 37.4 <u>6.4</u>
			187.4								157.5
9	Vehicle Transfer Area	Piping Screw Couplings Valve Hose Pump Fueling Operation	43.8 45.6 40.1 41.7 43.2 <u>52.9</u>			43.8 45.6 40.1 41.7					
			267.3	9	2,405.7	224.1	9	2,016.9	267.3	9	2,405.7
13	Vehicle Transfer Area		267.3	6	1,603.8	224.1	6	1,344.6	267.3	6	1,603.8
9	Total				2,705.1			2,970.0			2,580.7
13	Total				<u>1,903.8</u>			<u>1,980.0</u>			<u>1,780.0</u>
	Total Both Mines				4,608.9			4,950.0			4,360.7

3.3.2.3

Hazard Index Calculation Summary

The subsystem of a fueling system were rated in terms of hazard to underground personnel by a panel of experts. The experts also ranked the modules within a subsystem in terms of relative hazard. These rankings were converted to hazard indices. The modules of each subsystem as observed in each mine were listed and the appropriate hazard indices were summed to determine the mean hazard index for each subsystem. Similar analyses were conducted to determine the hazard of various modules and types of subsystems.

The vehicle transfer area was selected as the most hazardous subsystem with the most hazardous module being the fueling operation. The most hazardous type of vehicle transfer area has fuel and oil tanks as well as drums of oil in close proximity with the fueling operation. Dry line systems were found to be less hazardous than wet line systems.

3.4

Mine Management Opinion Data

3.4.1

Fire Hazards

Another source of fire hazard information is the mine managers who live with the problem everyday. During the mine visits, a number of mine managers were asked for their opinions concerning fueling system fire hazards. Table XXI indicates the source of these ratings. These managers rated diesel fuel as the greatest fire hazard (see Table XXII) and the most likely fueling system modules to leak as the vehicle transfer area hose, pump and piping (see Table XXIII). The most hazardous ignition sources were listed as sparks and heat from the vehicle and sparks from the vehicle transfer area (see Table XXIV). Operator error was selected as the highest ranking cause of fires (see Table XXV). Overall, these rankings by mine managers agree very well with the hazard analysis results in pointing to the vehicle transfer area as the most hazardous subsystem.

3.4.2

Automatic Fire Protection System Design Inputs

Mine managers were also asked to rank the relative importance of various automatic fire protection systems (AFPS) design considerations. Table XXVI indicates the source of these rankings.

TABLE XXI

SOURCE OF FIRE HAZARD RATINGS

1. Mine safety directors	12	(60%)
2. Mine engineers	3	(15%)
3. Mine maintenance staff	1	(5%)
4. Fire inspector	1	(5%)
5. Other mine executives	<u>3</u>	<u>(15%)</u>
	20	(100%)

TABLE XXII

ITEM RANKING ACCORDING TO POTENTIAL FIRE HAZARD

	<u>Mean Ranking</u>	<u>Standard Deviation</u>
1. Diesel fuel	1.861	0.801
2. Hydraulic fluid	2.861	1.082
3. Solvents	2.917	1.396
4. Lubricants	3.639	0.936
5. Electrical equipment	6.306	2.685
6. Wiring on vehicles	7.361	1.607
7. Lunchroom	7.361	1.607
8. Powder and waste materials	7.528	0.915
9. Tires	7.583	0.619
10. Class A material	7.583	0.619

Note: Low standard deviation of ranking indicates high agreement between judges.

TABLE XXIII

ITEM RANKING OF UNDERGROUND FUELING EQUIPMENT MOST LIKELY TO LEAK
(1 = Most Hazardous)

	<u>Mean Rank</u>	<u>Standard Deviation</u>
1. Hose to vehicle	2.389	2.253
2. Underground pumps to vehicle	4.583	3.817
3. Piping to fueling pump	5.167	3.447
4. Shaft piping valves	6.556	2.817
5. Haulageway piping	6.750	2.439
6. Haulageway valves	6.833	3.020
7. Surface transfer pump	7.056	2.514
8. Shaft piping	7.194	2.951
9. Underground storage tanks	7.333	3.249
10. Surface storage tanks	8.389	2.731
11. Surface piping	8.472	2.506
12. Haulageway pumps	8.500	2.607
13. Nozzles end	12.861	2.711
14. Filter discharge side	12.917	2.475

TABLE XXIV

ITEM RANKING ACCORDING TO POTENTIAL SOURCE OF IGNITION
(1 = Most Hazardous)

	<u>Mean Rank</u>	<u>Standard Deviation</u>
1. Electrical sparks (vehicle)	2.263	0.033
2. Vehicle engine heat	2.605	1.845
3. Electrical sparks (fueling area)	3.658	1.700
4. Smoking	4.421	2.529
5. Impact sparks (vehicle to rib)	5.316	1.773
6. Welding	7.526	2.860
7. Vehicle exhaust	8.658	1.930
8. Human error	8.658	1.930
9. Hot hydraulic pumps	8.684	1.701
10. Drive shaft brakes	8.789	1.273
11. Unusual occurrences	8.789	1.273
12. Trash build-up	8.842	1.068
13. Spontaneous combustion	8.868	0.847

TABLE XXV

ITEM RANKING OF FUEL SYSTEM FIRE CAUSES
(1 = Most Important)

	<u>Mean Rank</u>	<u>Standard Deviation</u>
1. Operator error	1.700	1.174
2. Improper maintenance	2.725	1.094
3. Fuel system design	3.175	1.139
4. Infrequent maintenance	3.250	1.362
5. Groundfall or similar incidents	4.650	0.796
6. Breakdown of lines	6.750	1.362
7. Housekeeping	6.800	1.140
8. Welding and cutting	6.950	0.484

TABLE XXVI

SOURCES OF MARKET FACTOR RATINGS

1. Mine safety directors	10	(55%)
2. Mine maintenance staff	1	(6%)
3. Mine engineer	1	(6%)
4. Other mine executives	6	<u>(33%)</u>
		(100%)

In deciding whether or not to install an automatic fire protection system on a fueling subsystem, the most important consideration was personnel safety and the least important was AFPS cost (see Table XXVII). The most important characteristic of an AFPS was system reliability followed by system cost (see Table XXVIII).

Figure 2 indicates what percent of the mine managers would be willing to pay various prices for an AFPS and Figure 3 indicates how much they would be willing to spend on system maintenance. The number of years a vehicle transfer area is expected to last appears in Figure 4 and the number of years an AFPS should last appears in Figure 5. Figure 6 indicates how long a vehicle transfer area is expected to remain in one place.

In summary, mine managers are concerned more with personnel safety and mine shutdown time than with saving the equipment on fire. They are more concerned that the system work when needed than that it be inexpensive.

The system should be designed to last as long as possible because the vehicle transfer area and underground storage area are not likely to be moved or replaced for a considerable time.

3.4.3 Opinions on Proposed MESA Standards

During the mine visits, mine managers were asked their opinions of the proposed MESA standards on fueling systems. Table XXIX contains their comments by section.

3.4.4 Leak Incident Descriptions

Mine managers were asked to describe fueling system leaks and fire that had occurred in their mines over the last 5 years. Pertinent aspects of the incident descriptions appear in Table XXX. Fueling systems fire incidents, as expected, are too rare to be of use in determining hazards.

TABLE XXVII

RANKED FACTORS BY IMPORTANCE IN DECIDING WHETHER OR NOT AN
AUTOMATIC FIRE PROTECTION SYSTEM SHOULD BE INSTALLED
(1 = Most Important)

	<u>Mean Ranking</u>	<u>Standard Deviation</u>
1. Personnel safety	1.000	0
2. Mine shutdown time	2.147	0.343
3. Damage to fueling area	3.235	0.687
4. Insurance rates	3.735	0.437
5. Production losses	5.882	0.761
6. Equipment damage	6.000	0.306
7. Initial cost	6.000	0.306

TABLE XXVIII

IMPORTANCE RANKINGS FOR CHARACTERISTICS OF ANY
AUTOMATIC FIRE PROTECTION SYSTEM
(1 = Most Important)

	<u>Mean Ranking</u>	<u>Standard Deviation</u>
1. Control system reliability	1.781	1.888
2. Control system purchase price	4.594	2.208
3. Frequency of maintenance	5.813	2.664
4. Maintenance cost	5.906	2.538
5. Control system life	5.906	2.882
6. Ease of maintenance	6.000	2.983
7. Adaptability to current system	6.188	3.016
8. Ease of installation	6.719	2.145
9. Operator training (e.g., override procedures)	7.031	2.766
10. Effectiveness	8.063	1.887
11. Determination of need	8.063	1.887

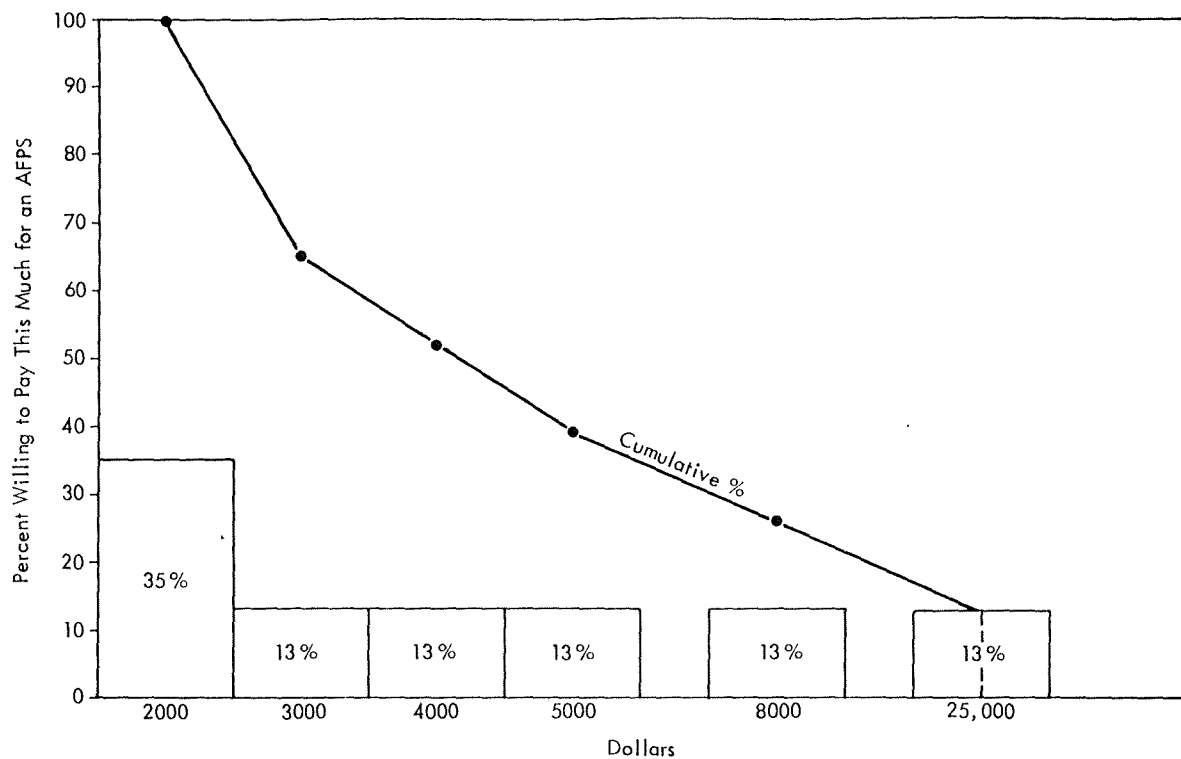


Figure 2 - AFPS Cost Data Inputs

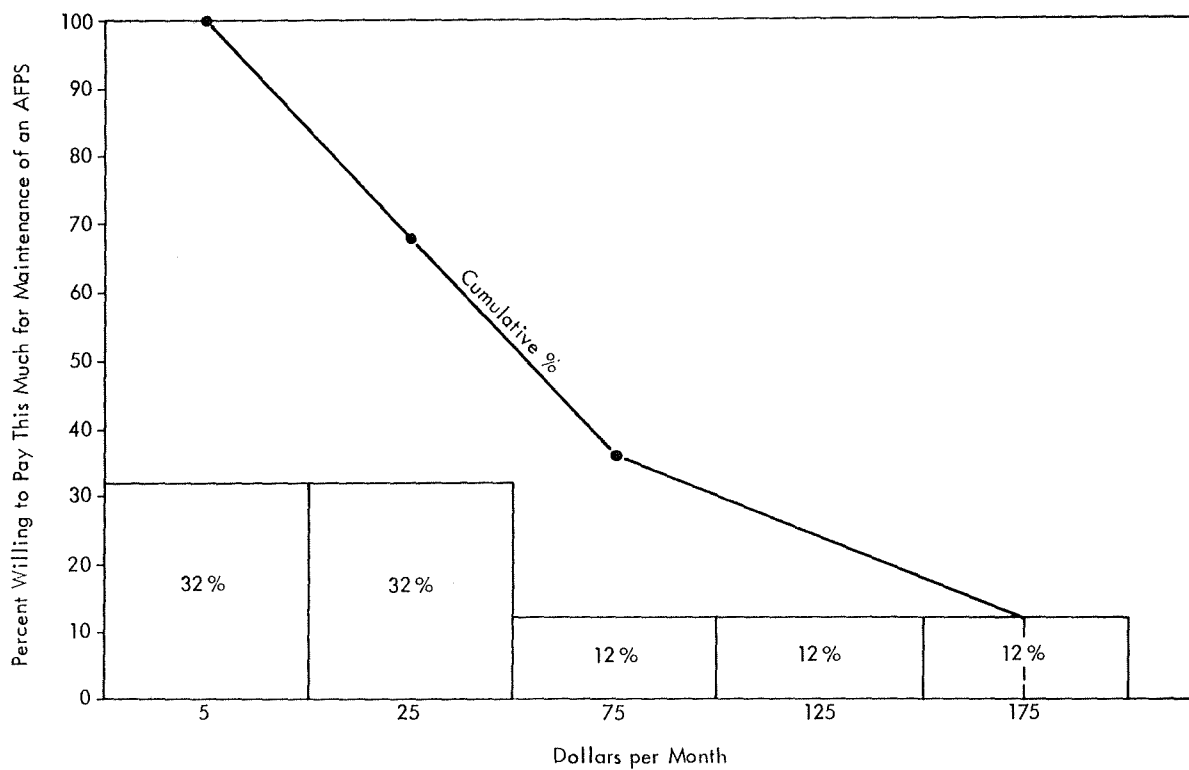


Figure 3 - AFPS Maintenance Cost Data Inputs

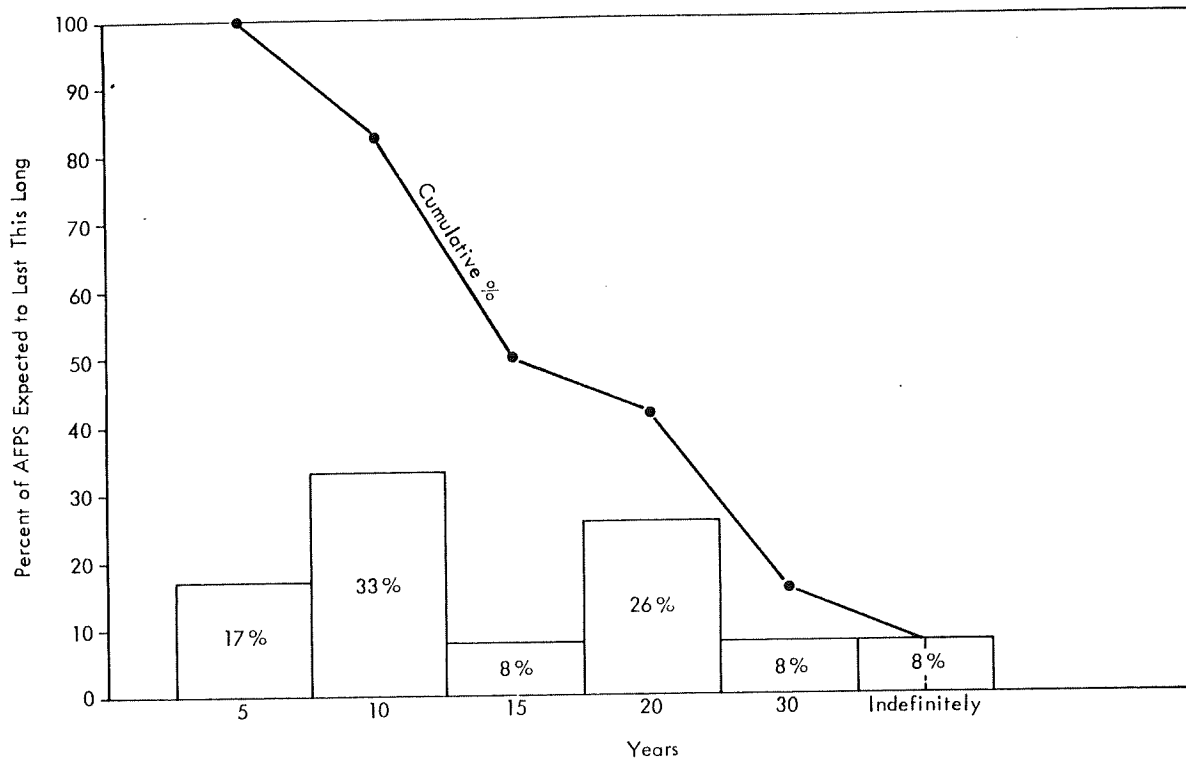


Figure 4 - Fueling System Expected Life

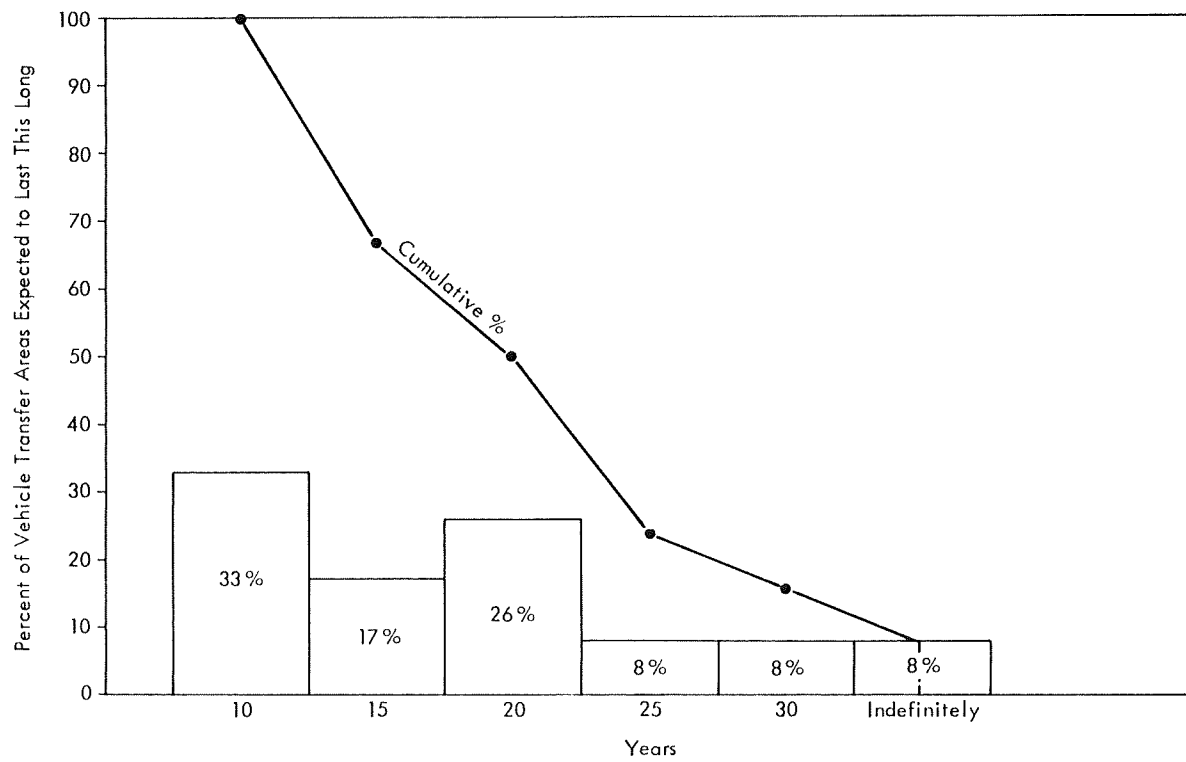


Figure 5 - AFPS Expected Life

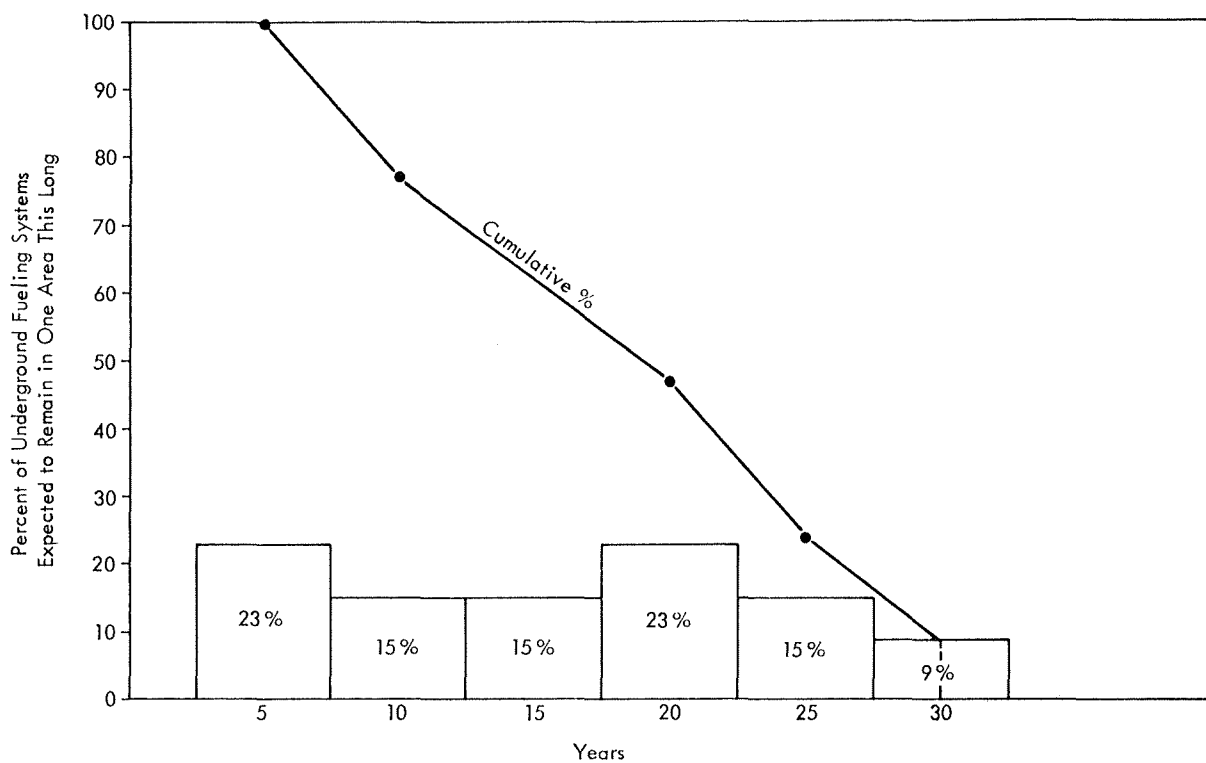


Figure 6 - Period of Time Before Fueling Area Moved

Table XXIX

OPERATOR COMMENTS ON PROPOSED STANDARDS

Permanent Storage

Section 2. Definitions

"Permanent type combustible liquid storage depot' means a depot where more than 2 days operating supply of any combustible liquid used is stored or the total quantity of combustible liquids stored exceeds 1,000 gal. The 2 days supply is determined according to the mine area served."

Section 4. - 57.4FP30 - "Permanent Type Combustible Liquid Storage" Shall be:

"a. Located at least 100 ft from shafts, slopes, raises, U G hoist rooms, shops, explosive magazines, ventilation fans and working places; at least 50 ft from electrical equipment, wooden bulkheads, other hazardous underground fire areas; and at least 25 ft from haulageway."

Those mines commenting on Section a 12

Those agreeing with Section a 8

Definitions

Felt electrical equipment should be defined better.	2
If approved, electrical equipment by NFPA should be allowed.	2
Felt term haulageway vague--should say main or primary.	2
How is the 100 ft distance measured--either through rib or by walking distance.	2
Felt provisions should be made for placement of systems which have fire control systems not just an alarm.	2
Define type of fan--primary, secondary, intake, exhaust.	1
Define working place--can a fuel area be one?	1
Other hazards could be anything in a mine.	1

General Comments

Should be able to fuel next to shop due to convenience.
Will effect production more than safety.
What if fuel area is next to exhaust.
Should look at reality and not just theory.

Table XXIX (Continued)

"b. Totally enclosed by construction and materials having at least a 2 hour fire resistance rating."

Total mines commenting on Section b	11
Those agreeing with Section b	8

General Comments

Fire suppression system negates long time need.
Should depend on where fuel area is located. In some areas a need may be there in other areas no.
Should not be a blanket policy since each mine is different and should be treated as such.

"c. Provided with access door(s) which shall be kept closed except when the door(s) are in use."

Total mines commenting on Section c	12
Those agreeing with Section c	9

General Comments

Should also depend on where system is located.
Should not be blanket policy--same reason as "b."
Depends on design of doors as to how they are to be used and their purpose.

"d. Ventilation openings shall be provided with heat-activated or equivalent sensing devices to automatically close the openings in case of fire."

Total mines commenting on Section d	11
Those agreeing with Section d	9
Those disagreeing with Section d	1

General Comments

Depends on whether system, if really needs ventilation fine, if not forget it.

Table XXIX (Continued)

"e. Provided with floors constructed of concrete or other impermeable, noncombustible material."

Total mines commenting on Section e	11
Those agreeing with Section e	11

Temporary Storage

Section 2. Definitions

"Temporary type combustible liquid storage depot' means a depot containing not more than 2 days supply of each liquid stored, but not less than 55 gal. nor more than 1,000 gal. total quantity of combustible liquid. The 2 days supply is determined according to the mine area served."

Section 4.57.4-FP31 - "Temporary Type Combustible Liquid Storage Depots" Shall Be:

"a. Located at least 100 ft from shaft, slopes, raises, explosives magazines; at least 50 ft from wooden bulkheads, other hazardous underground fire areas; and at least 25 ft from haulageways."

Total mines commenting on Section a	14
Those agreeing with Section a	1
Those disagreeing with Section a	0

Definitions

- 3 - Dislike definition of combustible liquids to include those with flashpoint of 400°F, which includes greases. Should be same as NFPA Code.
- 1 - Vague definition as to what constitutes a temporary storage area.

General Comments

Insurance rates may be affected.	1
Temporary structures at face may not withstand blasting	1
Rock drill and hydraulic oil, need to be near face since face equipment not easily withdrawn.	3
Twenty-five feet might cause problems.	3
Two-day supply prevents effective operation	3
Not feasible for storing small quantities--should change 55-gal to 250-gal.	2

Table XXIX (Continued)

Cannot have temporary by permanent even if by exhaust shaft.	2
Must be able to keep 30 gal. oil in shop areas just for lubrication purposes, very disruptive if cannot have.	1
Have single drift, have to mine off special section.	1
"b. Totally enclosed by construction and materials meeting the Standard Method of Tests, ASTM E-136-1973."	
Total mines commenting on Section b	10
Those agreeing with Section b	2
Those disagreeing with Section b	2

General Comments

Unreasonable for temporary, since moved every 1 to 6 months--high construction cost.	3
Unenforceable standard since most oils are moved in 55 gal. drums.	3
Build tank inside tank then store.	1
Would be acceptable if were storing 250 gal. or more.	1
"c. Of materials having a strength of at least equal to 1/8 in. thick steel plate or 4 in. thick cinder block."	
Total mines commenting on Section c	8
Those agreeing with Section c	2
Those disagreeing with Section c	3

General Comments

Would be okay if were able to store in 250 gal. or more.	1
"d. Provided with access doors meeting the requirements of (b) and (c) above which shall be kept closed except when the door is in use. Ventilation openings shall be provided with heat-actuated or equivalent sensing devices to automatically close the openings in case of fire."	
Total mines commenting on Section d	9
Those agreeing with Section d	2
Those disagreeing with Section d	4

Table XXIX (Continued)

General Comments

Might be good idea but way to costly.	2
Okay if you were able to store 250 gal. at a time	1
"e. Equipped with at least two portable fire extinguishers."	
Total mines commenting on Section e	10
Those agreeing with Section e	7

General Comments

Might be good except for cost.	2
Size of extinguishers should be known.	1

TABLE XXX

LEAK INCIDENT DESCRIPTION

<u>Mine No.</u>	<u>Information</u>	<u>Approximate Date</u>	<u>Part System</u>	<u>Fluid Invol.</u>	<u>Describe Leak</u>	<u>Cause of Failure</u>	<u>Fuel Spread</u>	<u>Response to Leak</u>	<u>Damage</u>	<u>Lost Prod</u>	<u>Fire</u>
1	--	--	--	--	--	--	--	--	--	--	--
2	Industrial Engineer	--	--	Hydraulic Oil	Leak at nozzle	Binding in thread	No	Used tylon tape	None	None	No
	Industrial Engineer	--	--	Hydraulic Oil	Leak at elbow	Pressure at threads	No	Tylon tape	None	None	No
3	--	--	--	Diesel	Spillage at miner's-nozzle	Human error	--	--	--	--	--
	Observation	--	--	Diesel	Nozzle	Abuse	No	Wrapped rag around nozzle	None	None	No
4	Maintenance Dept.	--	Piping to Fueling System	Diesel	When pump activated valve leaked	Threads	Only in fuel storage area	None--till room was inspected	None	None	No
	Safety	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--
7	Shift superintendent	--	Fueling area	Diesel	Spills while refueling	Human error	No	Put dry up compound on it	--	None	No
8	Maintenance Dept.	--	Fueling area	Diesel	Spillage while fueling	Human error	No	Daily clean up	None	None	No
9	Electrical Main.	--	Valve gate	Diesel	Pressure valve wore out	If forget to shut valve off human error	No	Replaced valve	None	None	No
	Maintenance Dept.	--	Fueling area	Diesel	Spillage refueling	Human error	No	Wash off with water	None	None	No
10	Mine superintendent	12 years ago	Storage tank	Diesel	Tank fell off skid and ruptured		Went down haulage way	Poured compound on it	None	None	No

TABLE XXX (Concluded)

<u>Mine No.</u>	<u>Information</u>	<u>Approximate Date</u>	<u>Part System</u>	<u>Fluid Invol.</u>	<u>Describe leak</u>	<u>Cause of Failure</u>	<u>Fuel Spread</u>	<u>Response to Leak</u>	<u>Damage</u>	<u>Lost Prod</u>	<u>Fire</u>
11	Unknown										
12	Maintenance Department	Jan. 76	Piping to Fuel System in Haulage-way	Hydraulic	Punctured oil line	Hot oil too much pressure punctured pipe	Bottom shaft	About 10 min. drain line shut valve off	None	None	No
	Observation	Sept. 76	Fuel storage area	Diesel	Ran-out overflow pipe into fueling area	Forgot to inform operator above that U.C. tank was full	Covered fueling area	Call operator above to shut-off valve	None	None	No
13	Safety	Oct. 75	Piping to fueling area	Diesel	Did not have pipe screwed together	Human error	Came down Two men 1-bore-hole day screw spread in pipe back fueling together area		None	None	No
14	Maintenance Department	--	--	--	--	--	--	--	--	--	--
15	Safety Director	--	Fueling area	Diesel	Blocked nozzle open	Human error	All around vehicle	Pulled block out of nozzle	None	None	No
	Maintenance	Aug. 76	Mobile tanker	Diesel	Pumps on tanker leak	Pumps needed to be replaced	Around fueling area maintenance	About 3 months	None	None	No
16	Maintenance	--	--	--	--	--	--	--	--	--	--

TABLE XXXI
CURRENTLY EMPLOYED FUEL AREA FIRE PROTECTION SYSTEMS

System Type	Mine No.	No. Observed	Operation Mode	Detection	System Operated Accessories	Special Equipment	Storage Area Characteristics	System Age (Months)	Actual Costs (Dollars)			
									Equip-ment	Instal-lation	Mtnce	Opera-tion
Water Sprinkler	15	1	Automatic	Fusible link sprinkler heads	None	None	Open	Not available	600	200	---	---
Water Deluge	2	1	Manual	N/A	None	Air Injection	Partial Dike	60 months	500	200	---	---
High Expansion Foam	4 6	2	Automatic	Heat detecting wire	4 - light, siren 6 - none	4 - fuse link, door closers 6 - normally closed fire doors	Enclosed closeable openings	4 - 18 mo.	2,200	250	300	200
								6 - 30 mo.	1,200	150	300	200
Halon 1301	16	1	Automatic	HAD	Pneumatic door closers, siren	Primary and reserve capability, pneumatic door closers	Enclosed closeable openings	8 months	5,000	600	---	1,000
Dry Chemical	3	1	Automatic	HAD	None	Normally closed fire doors	Enclosed closeable openings	24 months	10,000	600	200	500

3.5 Currently Employed Fuel Area Fire Protection Systems

During the course of the sixteen mine visits, five different types of fire systems were observed in the fuel areas of six of the mines. All six systems were designed to protect only the storage area, leaving the transfer area (the highest hazard area) unprotected except for hand-operated extinguishing equipment.

None of the six systems had ever experienced an actual fire, nor had any discharged inadvertently; consequently, performance history is non-existent.

Table XXXI summarizes the five types of systems and general characteristics of each.

A brief description of each system follows:

3.6 Water Sprinkler System (Mine No. 15)

3.6.1 Sprinkler Design (Figure No. 7)

The water sprinkler system is designed identical to an above-ground installation consisting of fusible link sprinkler heads installed on balanced piping. The water supply for the wet pipe system is simply the mine water line with a ball valve for control in shutting down the water flow.

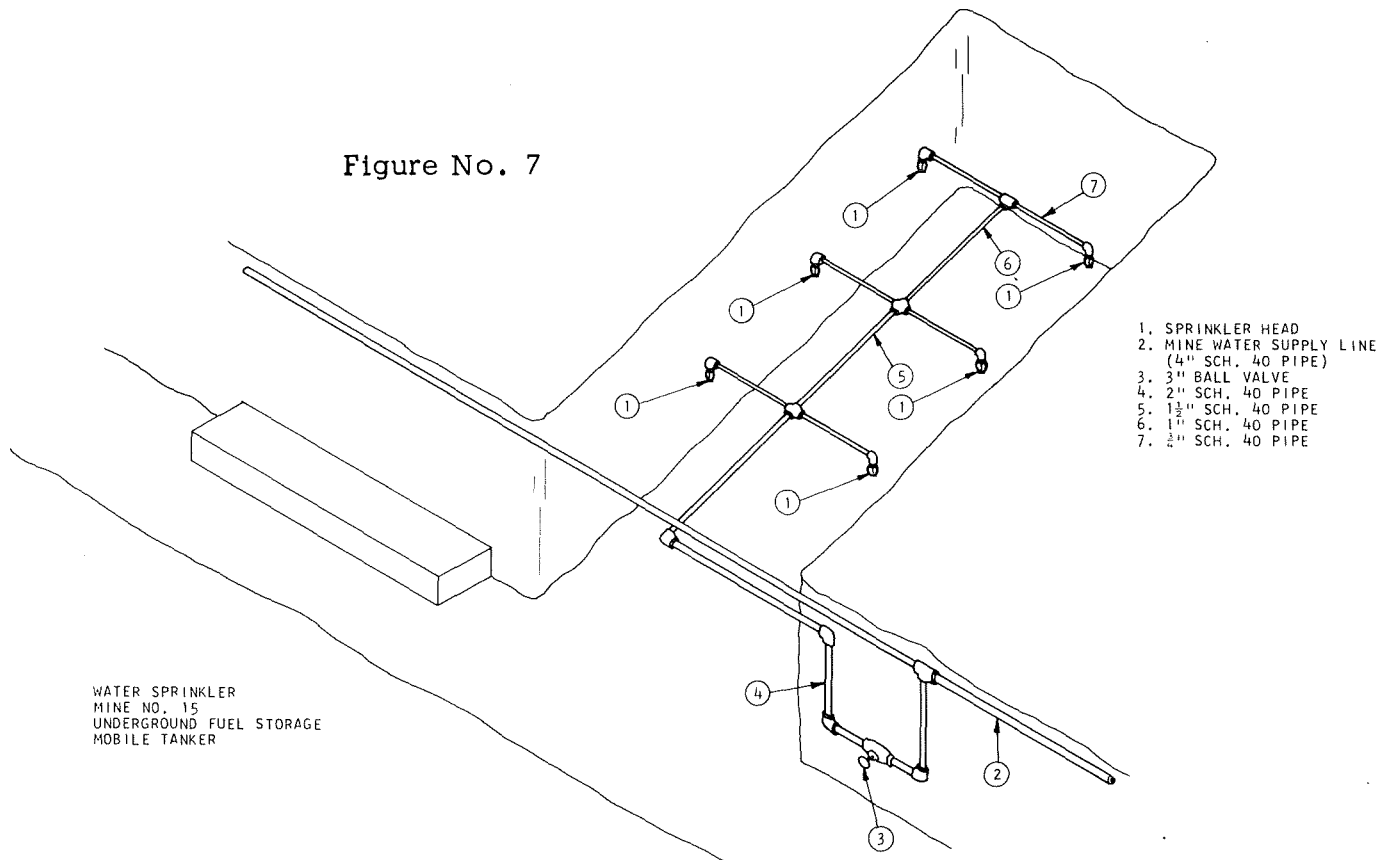
3.6.1.1 Sprinkler Heads (Item No. 1)

Standard sprinkler heads are utilized containing fusible links set for approximately 200°F. As the link melts, the spring-loaded mechanism opens the orifice and water flow is initiated by line pressure. A deflector after the orifice causes a break-up of the water stream, giving the "sprinkler" effect.

3.6.1.2 Piping (Item No. 2)

Standard Schedule 40 black iron pipe is being used for the system. Sizes range from 4" at the water main to 3/4" at the farthest sprinkler heads.

Figure No. 7



3.6.1.3 Ball Control Valve (Item No. 3)

A 3" ball valve, pinned in the normally open position, is used as the flow control. After system discharge and extinguishment, the valve can be closed to allow replacement of the fusible links.

3.6.2 Overall Operation

Upon fire outbreak, the heat generated melts the fusible link and opens the system's sprinkler heads in the vicinity of the actual fire. Fire spread will actuate more sprinklers, supplying more water spray for cooling and fire control. After extinguishment, either by the system or by mine personnel with hand-operated equipment, the valve is closed manually to stop water flow for replacement of the fusible links on the opened heads.

3.6.3 Storage Area Characteristics Relating to System Performance

This storage area was situated back in a dead-end drift and contained a mobile tanker for fueling the vehicles. Upon fire outbreak, with the low velocity ventilation, any Class A material or any small fuel spill would allow detection and, in all probability, would be extinguished. A large spill, a pressure fire, or a burst tank could, with the addition of enough water, be forced to flow out of the area away from sprinkler protection and increase the fire danger.

In most cases the system would cool and control enough in its own area of protection to allow extinguishment and securement by mine personnel. If the sprinkler system covered the entire area enclosed by the manually-actuated fire doors (independent system operation), smoke control could also be an advantage. Containment of the smoke and fire by these doors will assure the escape and safety of mine personnel in adjacent areas.

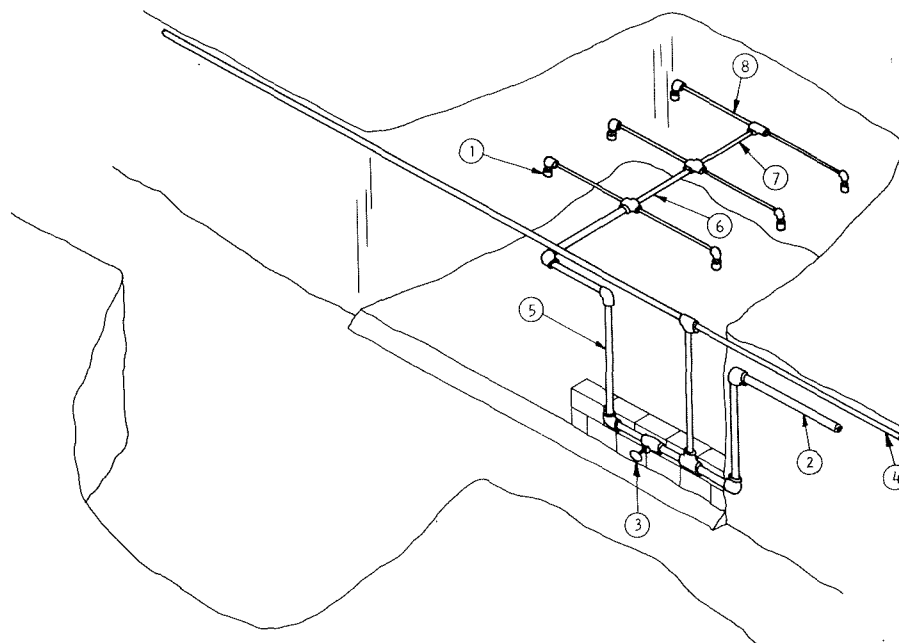
3.6.4 Maintenance

Being self-equipped, mine personnel had no maintenance procedure for their system; therefore, none was conducted. The system did appear to be in operating condition, having few components to cause reliability problems.

3.7 Water Deluge System (Mine No. 2)

3.7.1 System Design (Figure No. 8)

In contrast to the water sprinkler system, this water deluge system is a dry pipe system activated by a manually-operated globe valve. The balanced piping carries the water to straight-through orifice nozzles which in turn flood the entire storage area. A unique addition to the system is the capability for air injection to "gasify" the water, forming a softer, finer stream instead of the straight, hard stream. The water supply and the air supply come from the mine water and air lines.



1. NOZZLE
2. MINE WATER SUPPLY LINE
(4" SCH. 80 PIPE)
3. GLOBE VALVE
4. MINE AIR SUPPLY
(1 1/2" SCH. 80 PIPE)
5. 2 1/2" SCH. 80 PIPE
6. 1 1/2" SCH. 80 PIPE
7. 1" SCH. 80 PIPE
8. 1/2" SCH. 80 PIPE

Figure No. 8

WATER DELUGE
MINE NO. 2
UNDERGROUND FUEL STORAGE
MOBILE TANK

3.7.1.1 Nozzles (Item No. 1)

The nozzles utilized are straight-through, straight-stream nozzles. Water flow is greater than from a sprinkler head and is not broken up after discharge, although the air injection will give an effect similar to a sprinkler.

3.7.1.2 Piping (Item No. 2)

Piping in this system is Schedule 80 black iron and ranges in size from 2-1/2" to 1/2" at the nozzles.

3.7.1.2 Globe Valve (Item No. 3)

This valve is normally closed, controlling both water and air lines. Upon visual detection of fire, the system is actuated by opening this valve.

3.7.2 Overall Operation

Upon detection by personnel, the manual globe valve is opened and, utilizing the cooling and control effects of the water, mine personnel can extinguish and secure the area. The system is deactivated by closing the valve.

3.7.3 Storage Area Characteristics Relating to System Performance

This storage area was set back in the side of a drift and partially diked by a cement block wall. An opening was needed in the dike to allow the removal of the mobile tank for refill on the surface. This opening would also allow water flooded fuel to flow to a storage tank on the opposite side of the drift, outside the protection of the system, increasing the fire danger.

Again, Class A material and small spills probably would be extinguished, however, large spills would be a problem from the standpoint of smoke and escape of personnel. Escape would require going through the storage area to get from the working face to the shaft. These problems are negated somewhat by the small quantities of fuel stored, however, the factor of personnel danger is evident.

3.7.4 Maintenance

As in the case of the sprinkler system, the lack of maintenance was evident, however, the simplicity of the system will tend to maintain the reliability.

3.8 High Expansion Foam (Mines No. 4 and 6)

3.8.1 System Design (Figure No. 9)

Both mines use the same high expansion foam generator, yielding approximately 700 cu.ft./min. of foam. Heat-sensing wire is used for detection and nitrogen is utilized to open the water valve and power the generator. The mine water line is used for supply, regulated to 20 psi, with eductors picking up the foam concentrate. The control box in Mine No. 4 is also used to turn on an auxiliary light and siren. Mine No. 6 has six high expansion foam systems, all of which are identical.

3.8.1.1 Detection (Item No. 1)

The basic operation of the detection wire is to provide a switch closure type of contact. Two wires are held apart in the same manner as standard television antenna lead-in

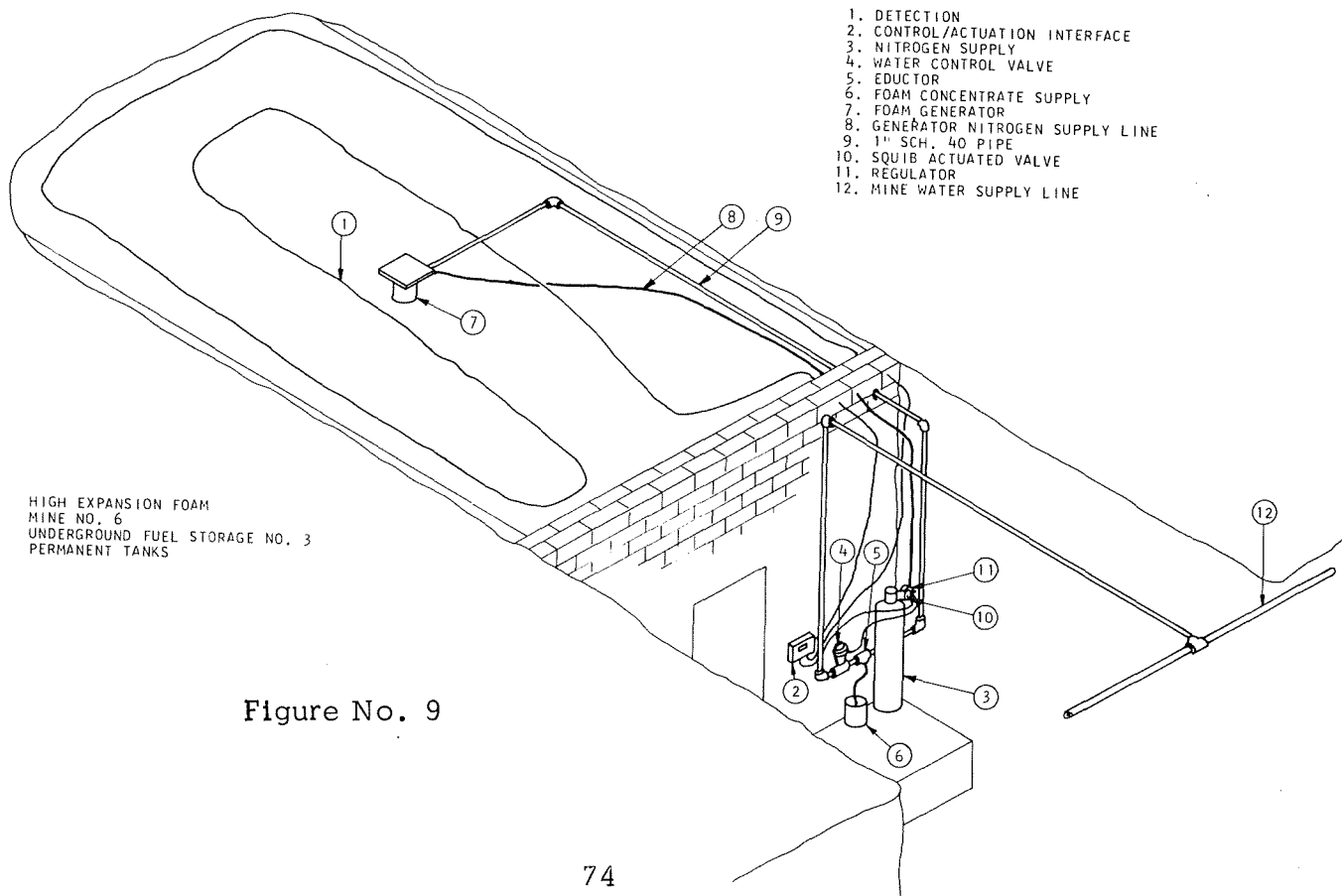
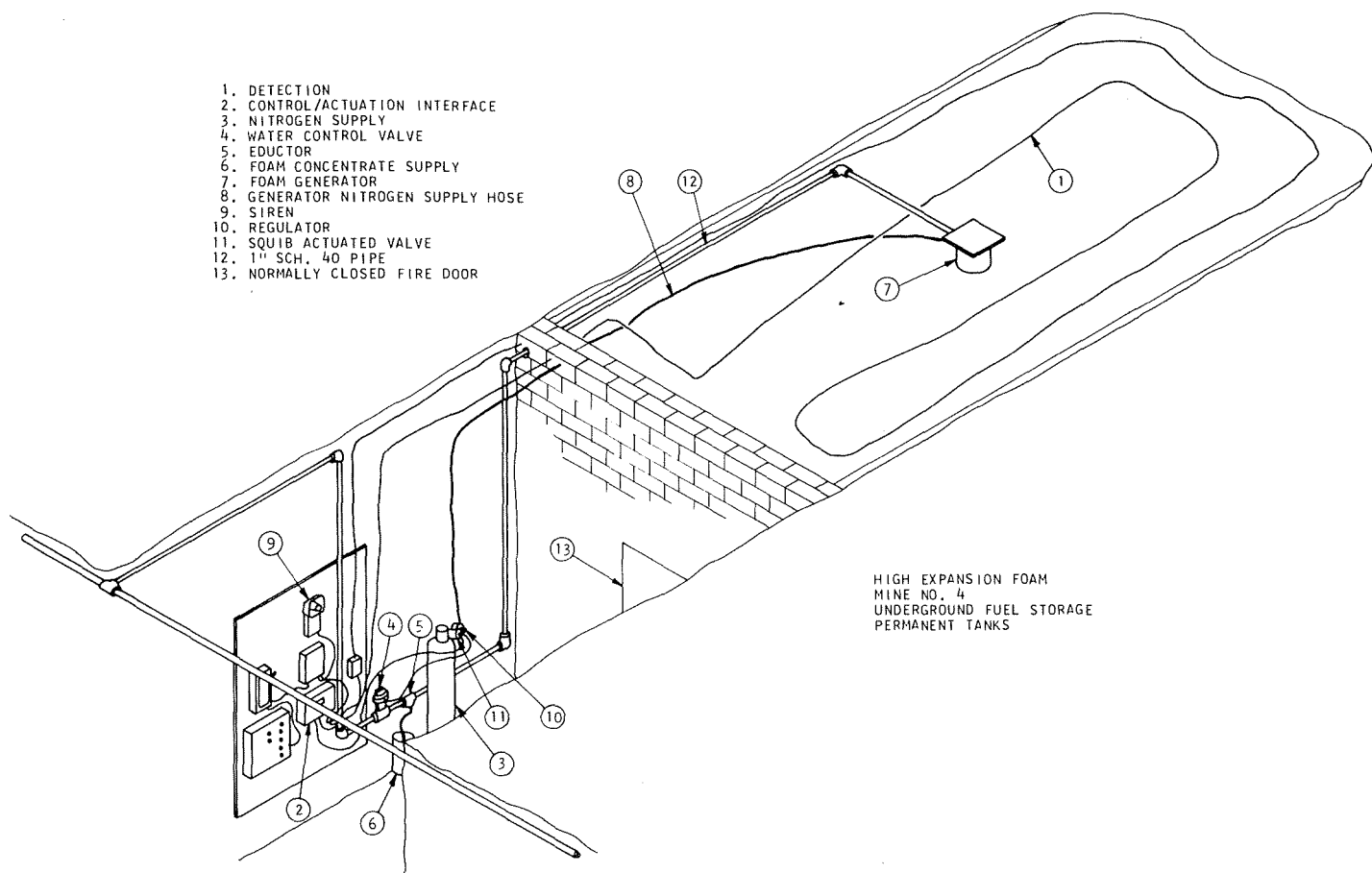


Figure No. 9

wire. These wires are generally installed under tension by twisting them as they are strung through the hazard area. When sufficient heat is generated by a fire condition, the material holding the wires apart softens and allows the two wires to come together and provide a short circuit or signal path. This type of detection is slow compared to ultra-violet and ionization forms of detection and generally will allow a fairly large fire to develop before the materials can soften enough to allow the wires to contact each other.

3.8.1.2 Control/Actuation Interface (Item No. 2)

The control box accepts the signal from the detecting wire and in turn, using its own power supply (two alkaline manganese batteries), provides current to explode the squib, opening the nitrogen valve. Power is also available for auxiliary equipment.

3.8.1.3 Nitrogen Supply (Item No. 3)

Nitrogen is supplied from one 220 cu.ft. DOT cylinder at 2400 psi at 70°F. Control for the nitrogen is available from a standard handwheel valve, including a gauge.

3.8.1.4 Water Control Valve (Item No. 4)

The water control valve is a regulating pilot-operated globe valve actuated by nitrogen pressure. The valve is normally closed and will remain open only as long as the nitrogen pressure is available. When the cylinder is depleted, the valve will close, shutting the water supply.

3.8.1.5 Eductor (Item No. 5)

Downstream of the water valve an eductor utilizes a pressure differential to draw the foam concentrate into the water in the desired proportion. The mixture then continues downstream and enters the foam generator.

3.8.1.6 Foam Concentrate Supply (Item No. 6)

Foam concentrate is available from a 5-gallon plastic container. The eductor line is simply inserted into the open container.

3.8.1.7 Foam Generator (Item No. 7)

The foam generator consists of a fan powered by compressed nitrogen. The mixture of water and foam concentrate enters the generator and is expanded by the action of the fan on a screen. The resulting foam is discharged into the enclosed storage area.

3.8.2 Overall Operation

In the case of Mine No. 4, a fire breakout would cause two things to happen. At 150°F, fusible links holding two ventilation windows open would melt, enclosing the entire area. At 180°F, the detection wire would sense fire and signal the control box which, in turn, would sound the siren and actuate the explosive squib. In Mine No. 6, the detection wire would only actuate the squib.

The nitrogen valve opens, and pressure regulated to 100 psi simultaneously opens the water line regulating valve and starts the foam generator. Water flowing through the eductor at 20 gpm is injected with the foam concentrate and the mixture enters the generator where it is transformed into foam at an expansion ratio of 500 to 1000:1. An approximate time of two minutes is required to submerge the tanks, with five minutes to fill the entire volume.

If the nitrogen cylinder and foam concentrate supply are sized correctly, when the volume is full, both supplies will be depleted and the water valve will close, stopping the system. At this point, control and/or extinguishment should have taken place and personnel can cautiously enter the space and initiate full securement and clean-up.

3.8.3 Storage Area Characteristics Relating to System Performance

As mentioned previously, in Mine No. 4 the two ventilation windows will close (independent of the system) and if the main fire door is closed, the storage area is completely enclosed and able to be flooded with foam. Ground-mounted tanks will be completely covered in approximately two minutes and the danger after that should be minimal.

In Mine No. 6, one main fire door is normally closed and no other action is required for containment. Tanks mounted on steel framework are installed at varying heights with one tank requiring the entire volume to be filled before being covered.

In both mines the foam generators are mounted inside at the top center of the storage area, and are required to use the air in the space, which may contain products of combustion, for manufacturing the foam. In some instances this may have an effect on the quality of the foam generated with undesirable results.

All types of fires can be controlled, with the exception of pressure fires, although with the fuel transfer techniques utilized, pressure fire danger is minimal. A burst tank, giving a flowing fuel fire, could be a problem, however, the fuel volume is finite and will be contained by the storage area.

3.8.4

Maintenance

Maintenance procedures have been outlined in both mines, consisting of a weekly electrical continuity test and a check of the foam generator. Nitrogen cylinder pressure is also checked. According to mine personnel, there is no requirement for actual actuation of the system, although spare parts include explosive squibs and extra agent.

Mine No. 4 did have a defective squib-operated nitrogen valve; consequently, the cylinder handwheel valve had been shut off, rendering the system inoperative except for the siren. Mine No. 6 conducted the electrical check in our presence and the system appeared to be in complete operating condition.

The 12-volt alkaline manganese batteries had a stated life of two years, with recommended replacement annually. Mine No. 6 conducted a battery voltage check periodically and replaced batteries at seven to thirteen month intervals.

3.9 Halon 1301 (Mine No. 16)

3.9.1 System Design (Figure No. 10)

The Halon 1301 system is a 360 psi total flooding application. It is protecting a volume of approximately 13,000 cu.ft., with a main system including a reserve back-up. Four heat-actuated detectors are utilized for system actuation, along with optional manual actuation inside the area. The system pressure during discharge is also tapped for pneumatic door closers and a pneumatic siren within the enclosed storage area. After discharge, an electric siren outside the space is actuated to alert mine personnel of the discharge of the system. The system utilizes unbalanced piping with three nozzles of two different types in the enclosure.

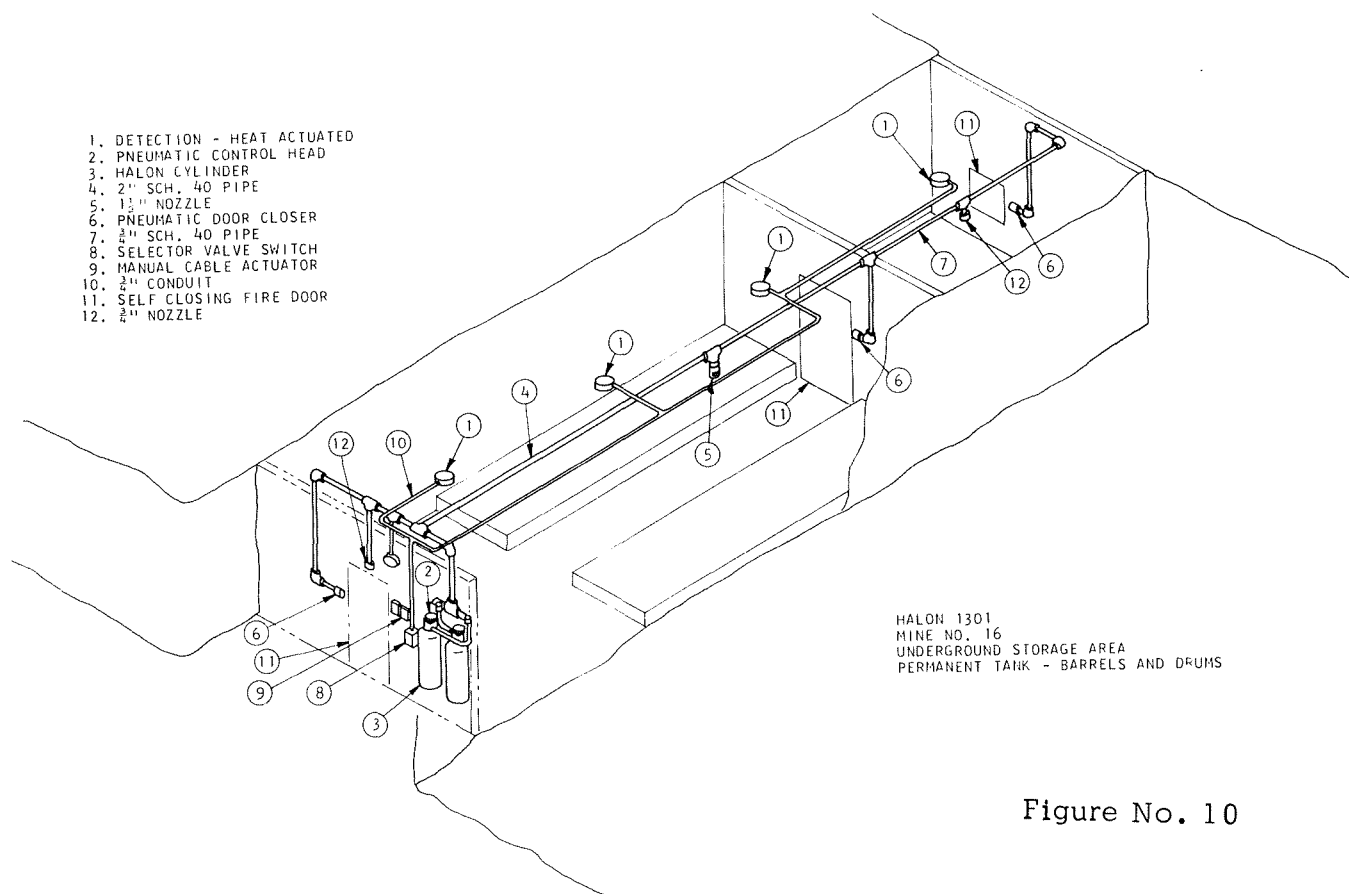


Figure No. 10

3.9.1.1

Detection (Item No. 1)

The pneumatic HAD (Heat Actuated Device) detection system offers a relatively slow response to a fire condition, but allows freedom from nuisance alarms and freedom from any electrical dependency. Since this system operates on an increased pressure due to increased air temperature caused by convected thermal energy, the source of the energy must be fairly large and in well developed stages of an actual fire. For this system to operate, the fire must generally develop to a life-threatening condition which will include the generation of toxic gases and smoke. As compared to ultraviolet, infrared, or even ionization types of detection, the pneumatic HAD system is extremely slow.

Operation of this form of detection is to develop a pressure in a sealed line and operate a pressure sensitive mechanical trip mechanism which in turn allows the discharge to occur.

3.9.1.2

Pneumatic Control Head (Item No. 2)

The pneumatic control head is mounted on the halon valve and by means of three separate methods, will actuate and open the valve. Pneumatic pressure from the detection will react on a diaphragm which in turn releases a spring-loaded actuator. The actuator can also be released by local manual means or by use of a cable for remote manual means. All three capabilities are being used in Mine No. 16.

3.9.1.3

Halon Cylinder (Item No. 3)

One hundred seventy-five (175) pounds of halon is contained in each of the two cylinders used respectively in the main and reserve system. The cylinders are built to DOT 4BA 500 specification, with a fully charged weight of 313 pounds. Each cylinder is fitted with a valve that is controlled by the pneumatic control head. The valve outlet is connected to a manifold by a 1-1/2" flexible discharge hose.

3.9.1.4 Piping (Item No. 4)

All piping utilized is Schedule 40 stainless steel pipe with size ranging from 2" to 1/2". Thin-wall conduit is utilized to enclose the 1/8" tubing used on the HAD.

3.9.1.5 Nozzles (Items No. 5 and 12)

Two sizes of nozzles are used and include a 1-1/2" double fan spray and two 3/4" single fan spray. All nozzles contain pipe thread ends and connect directly to distribution piping.

3.9.1.6 Pneumatic Door Closers (Item No. 6)

The storage area is fitted with two fire doors and one closeable window. All are normally open and close by the action of gravity on a weight. The weight is suspended by a chain which in turn is held by the pneumatic door closer. At the moment of system discharge, halon pressure acting within the door closer will release the chain, allowing the door to swing closed.

As a safety measure, the connecting chains are fitted with fusible links which will also release the drop weights at 180°F.

3.9.1.7 Selector Valve Switch (Item No. 8)

A selector valve switch is installed in the system to allow the detection to be alternated between the main and reserve system. Detection pressure is simply averted from one pneumatic control head to the opposite pneumatic control head.

3.9.2 Overall Operation

As stated in the description of the pneumatic control head, three modes of actuation are available for the system. Fire condition will be observed by the detection, manual actuation can be done locally at the control head, and manual cable pull can be done adjacent to the cylinders. Note that

all manual actuators are inside the storage area. All three modes will open the halon valve mounted on the cylinder. Halon discharge will begin and simultaneously close all fire doors and sound the pneumatic siren. A five percent halon concentration should result, with extinguishment of all types of flammable liquids in storage. At the completion of the discharge, the pneumatic siren will stop, with the electric siren external to the storage area alerting mine personnel.

3.9.3 Fueling Area Characteristics Relating to System Performance

The halon total flooding system requires an enclosed space. Self-closing or system closed doors accomplish that requirement in this mine. This feature will also reduce the effects of smoke throughout the rest of the mine, assuring personnel safety.

3.9.4 Maintenance

According to mine personnel, system maintenance procedures were not supplied by the manufacturer of the system; consequently, none was being done. The system did appear to be in operating condition, with cylinder pressures registering correctly on the gauges. The system, at the time of the visit, was eight months old, however, failure to perform periodic inspections could cause future problems.

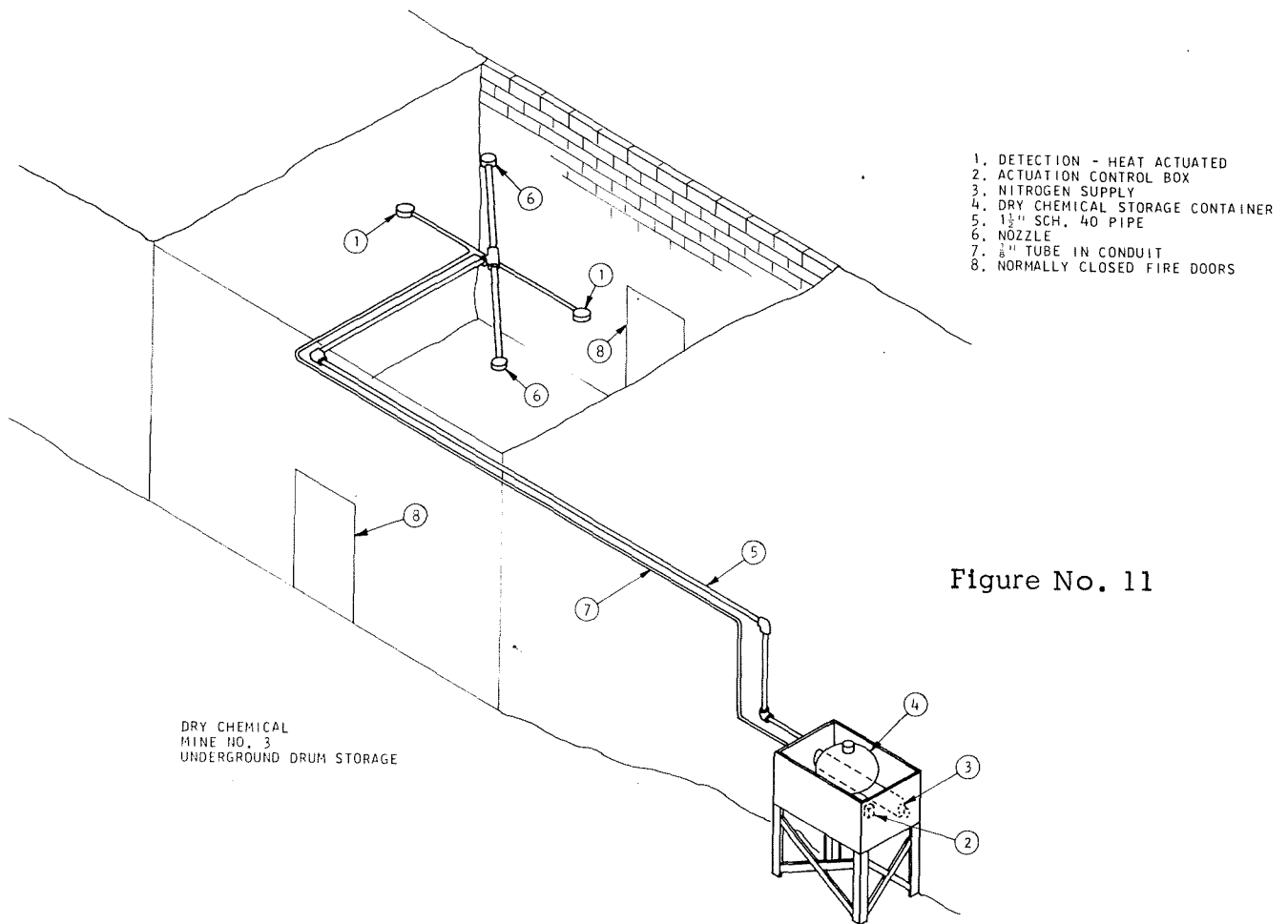
3.10 Dry Chemical (Mine No. 3)

3.10.1 System Design (Figure No.11)

The dry chemical system is designed as a total flood system with HAD detection identical to the Halon 1301 system. The discharge is done in an enclosed area containing 55-gallon drums of oils and grease. Five hundred (500) pounds of dry chemical are utilized and the storage container and operating mechanism are external to the space.

3.10.1.1 Detection (Item No. 1)

Reference Paragraph 3.9.1.1.



3.10.1.2 Actuation (Item No. 2)

The pressure obtained from the HAD is utilized similar to that in the pneumatic control head of the Halon 1301 system. The control box suspends a weight which, when released, mechanically opens a ball valve on the nitrogen supply line. Mechanical actuation is also available with a cable pull reacting on the control box.

3.10.1.3 Nitrogen Supply (Item No. 3)

Nitrogen is stored in a 300 cu.ft. DOT cylinder containing a standard normally open nitrogen handwheel valve. The nitrogen is utilized to invert the storage container and fluidize and expel the dry chemical.

3.10.1.4 Dry Chemical Storage Container (Item No. 4)

The dry chemical storage container is a spherical tank

approved by the Ontario Department of Labour. It is mounted on a swivel fitting on one end and connected to an air cylinder on the opposite end. The air cylinder utilizes nitrogen pressure to invert the tank while, simultaneously, regulated nitrogen is entering the tank and fluidizing the dry chemical. At a predetermined pressure a burst disc on the outlet of the tank will burst and the dry chemical/nitrogen mixture will flow into the pipeline.

3.10.1.5 Piping (Item No. 5)

The distribution piping for the dry chemical is 1-1/2" Schedule 40 black iron pipe. From the outlet the pipe runs approximately 90 feet, tees off and goes to two nozzles.

3.10.1.6 Nozzles (Item No. 6)

The nozzles of the dry chemical system distribute the dry chemical in a full 360° total flood pattern. Two "spinner" nozzles are utilized, each containing a frangible disc which ruptures prior to discharge.

3.10.2 Overall Operation

When the HAD picks up the presence of fire or the system is manually actuated, the dry chemical storage container is simultaneously inverted and pressurized. After pressure build-up, the main disc is burst and the nitrogen/chemical mixture flows through the piping, breaking the frangible disc at each nozzle. The mechanical action of the nozzle disperses the dry chemical throughout the storage area.

3.10.3 Storage Area Characteristics Relating to System Performance

The storage area is completely enclosed by use of two normally closed fire doors. Both doors were open at the time of the visit, a situation which may decrease the effectiveness of the system discharge in case of fire. With the doors closed, personnel danger in adjacent areas is drastically reduced.

With no surface piping into the storage area, pressure fire situations are almost non-existent, and if the dry chemical

system contained an all purpose dry chemical (information not available) Class A hazards in the area would be no problem.

If the storage area doors are open, burning oil flowing from the room will not be extinguished and a hazardous situation could exist.

3.10.4

Maintenance

A definite maintenance procedure was supplied to mine personnel by the manufacturer and included a weekly visual check of components and a semi-annual actuation test, in which the storage container was inverted without pressurization. A safety valve for this inspection and maintenance purpose was supplied as part of the system. Mine personnel were also supplied with a complete manual on the system and component parts.

4.0 GENERAL DESIGN CRITERIA FOR FUELING SYSTEM

4.1 Recommended System

Figure 12 is a drawing of the recommended (but not minimum acceptable) configuration for fueling systems. Surface storage of fuel and oil is recommended because fuel truck drivers should not be trusted to deliver the exact quantity ordered without overfilling underground tanks.

4.1.1 Surface Storage and Transport

In mines where the quantity of fuel necessitates the use of above ground storage tanks with capacities of 200 gal. and above, consideration should be given to protecting the property in case of leaks in either the tank or piping. The best practice would be enclosing the tanks in a dike area capable of holding all of the fuel in the tanks in the event of a tank rupture. The tanks should be equipped with the proper size relief valve openings which would open and allow the tank to vent in the event of a fire surrounding the tank. Fire codes specify the size of these openings in relation to the size of the tanks. Another protection device easily installed is an excess flow valve in the bottom connection to the tank. In the event that a pipe were broken, this excess flow valve would shut off the flow of diesel fuel. The excess flow valves are commonly used throughout the petroleum industry, particularly on propane tanks.

Support for tanks, if unprotected from any fire beneath the tanks, sometimes can add to the intensity of the fire by collapsing. For this reason, reinforced concrete saddles are preferable to steel saddles. If the amount of fuel stored in the tank is large, this becomes even more important.

In the event any electrical equipment is installed near the tanks, it should be explosion-proof, Class I, Group D with "T" rating of 5 or 6. If the temperature of the storage tank exceeds 100°F, then the vapors within the tank will be in the explosive range. For this reason, it is imperative that ignition sources are eliminated from coming in contact with any vapors released from the storage tank.

Fuel and oil should not be pumped below from a large storage tank but should come from a batch tank with less capacity than the underground tank being filled. One possibility is to have a batch tank with one-half the capacity of the

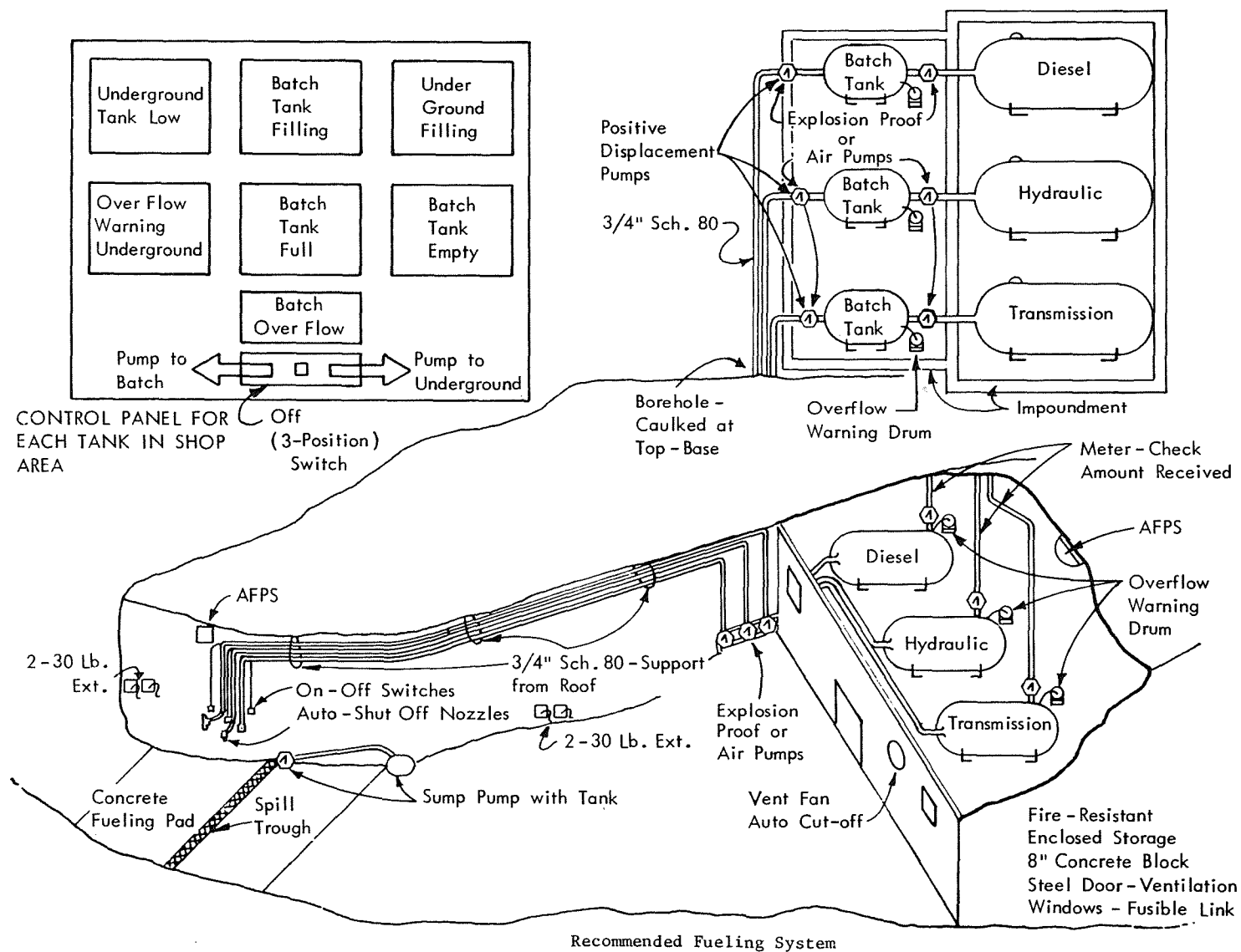


Figure 12

underground tank and to refill the underground tank when it is one-third full. The batch tank should be filled with a pump instead of by gravity feed because pump failure will stop the flow and valve failure might maintain flow.

The batch tank should have an overflow vent pipe which empties into a container with a float that activates an alarm. Figure 13 is an example of an inexpensive overflow alarm.

The batch tank should remain empty until the underground tank needs fuel. Then the batch tank pump should be actuated to fill the tank and shut off automatically. Next, the underground tank pump should be actuated to pump the contents of the batch tank below. Venting of the batch tank will be required to prevent siphoning fuel out of the surface tank through the batch tank. One three-position switch to control the two pumps will prevent running them simultaneously and overfilling the underground tank.

4.1.2

Bore-Hole Piping

The pressures developed in the piping system for the diesel fuel varies according to the depth of the mine. The following values have been calculated:

<u>Depth (Ft)</u>	<u>Pressure (psi)</u>
500	178
1,000	356
1,500	533
2,000	711
4,000	1,423

It is apparent from this table that except for shallow mines, heavy piping Schedule 80 should be employed. Pipe fittings with a minimum rating of 300 psi should be used.

To eliminate leaks as much as possible, it may be desirable to use welded fittings throughout the system. Only a small 3/4 in. pipe would be needed for transfer between tanks. This reduces pipe costs and the hazard in the event of a line rupture. This line should be protected with excess flow valves which would sharply reduce the hazard in the event of a ruptured line.

4.1.3 Underground Storage Area

The underground storage area should be fully enclosed and constructed of materials with a 2 hour fire resistance rating. Windows should close automatically with fusible links and the door should remain closed when not in use. An automatic fire protection system is recommended. The floor should be impermeable (rock or concrete) and have a sump for holding spilled fuel. Lights and wiring should be explosion proof.

The tanks should be of good quality and supported on concrete saddles. An overflow vent pipe should be large enough to release fuel at the maximum possible delivery rate to avoid rupture during a possible overfill. This vent will also release pressure in the event of a fire. The overflow vent should feed into an overflow alarm tank. Tanks should have a float or sight glass with the refill level clearly marked to reduce human error.

4.1.4 Vehicle Transfer Area

The vehicle transfer area would have no fuel, oil tanks, or drums within 50 ft (by shortest accessible route) unless those tanks are enclosed in a fire resistant structure. Emergency pump controls should be located such that they can be reached in the event of fire at the vehicle transfer area. The area should be well lighted with explosion proof lamps.

Diking or some other form of drainage control should be provided to collect spilled fuel into a container with minimum surface area. Oil dry or a similar substance for absorbing spilled fuel should be located near the nozzles. Vehicle transfer areas should not be located such that spills will drain toward an underground storage area or the shop.

Pumps should be located outside the underground storage area (see Figure 14) to remove that heat source from the large fuel quantities. The pump should not keep constant pressure in the fuel lines but should be actuated by the operator during the fueling operation. Automatic shut-off nozzles are recommended to reduce the incidence of overfills. An excess flow valve should be installed downstream of the pump.

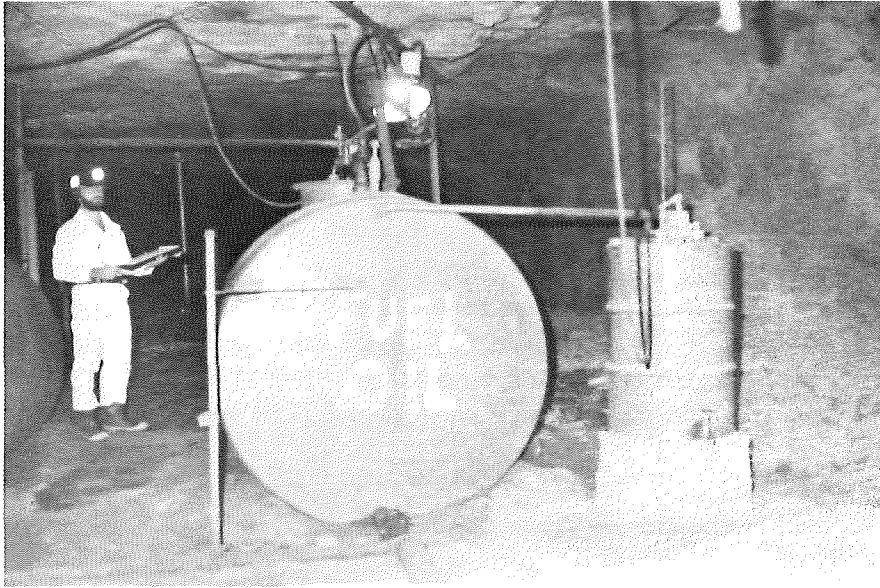


Figure 13 - Overflow Alarm

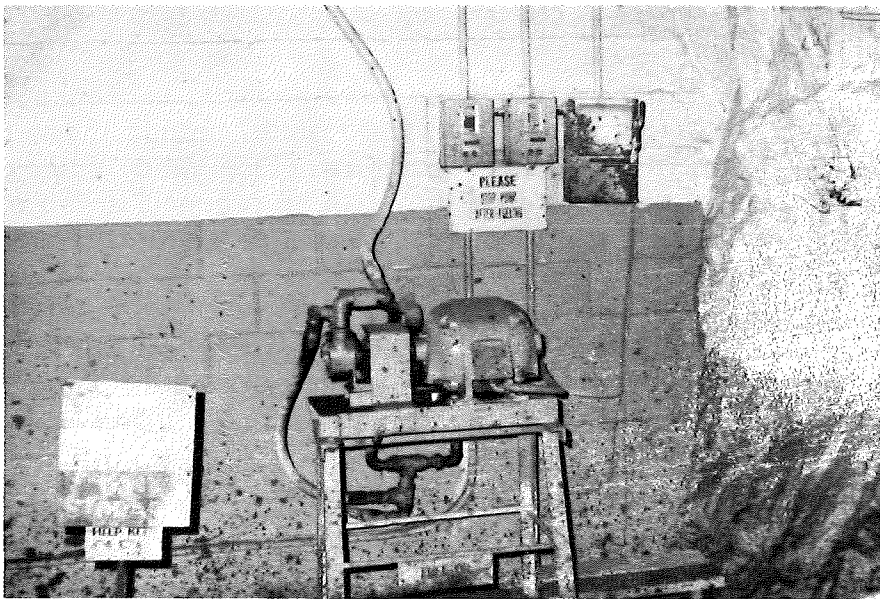


Figure 14 - Pumps Outside Underground
Storage Area

Several mines visited during the study had experimented with high speed fueling equipment and abandoned their use. They were unable to keep the nozzles clean enough to prevent high pressure leaks. We recommend against the use of high speed fueling equipment.

Each vehicle transfer area should have an automatic fire protection system. In addition, two 30 lb. extinguishers should be located between 20 and 30 ft from the nozzles. These hand extinguishers may be sufficient to handle small fires before they become large enough to trigger the AFPS.

Maintenance and housekeeping are serious problems in fueling system operations. One individual should be assigned clear responsibility to clean and maintain the system. We recommend that a man be assigned to each vehicle transfer area during peak refueling times to fuel the vehicles, prevent abuse of the equipment, report leaks and repair needs and clean up daily.

4.2 Alternative Systems

Alternative systems to the one recommended would produce an acceptable level of safety. These possible systems are discussed below by subsystem.

4.2.1 Surface Storage and Transport

Some mine operators may have some compelling reason not to store fuel or oil on the surface. Direct transfer to underground tanks would be acceptable only if the tanks being filled can accept more than a full tanker load at a time.

Not all mines consume sufficient quantities of fuel and oil to warrant a piping system. The use of good quality portable tanks would be acceptable for fuel consumption rates under 100 gal. per day. Oils should be transported in tanks up through 200 gal. capacity instead of drums.

4.2.2 Shaft or Bore-Hold Transport

A hazard analysis was conducted to determine whether bore-hole piping or tank transport was the safest method for handling small fuel consumption rates. Even though the piping system is more complicated it is still the least hazardous method of handling even small quantities of fuel. However, because of the economics, a portable tank system would be acceptable for low fuel consumption rates (100 gal/day or less).

In comparing shaft and bore hole piping, the latter is clearly safer because any leaks would collect in the underground storage area which is diked and protected from heat sources. In addition, a fire in the bore-hole will not eliminate the shaft as an escape route.

The largest leak from the piping between the surface and underground storage tanks would result if the break in piping occurred at the bottom of the shaft. Under these conditions, 1½ in. Schedule 80 pipe would permit a flow rate of 82 gpm, while a ¾ in. line would offer only 28 gpm. Neither of these would theoretically produce lethal amounts of carbon monoxide in an inby ventilation shaft. However, convection currents could produce sufficient back pressure to reduce the air flow, thus lowering the excess air supply and producing carbon monoxide.

4.2.3

Haulageway Transport

Fuel may be transported by piping, tank or tanker. With piping the hazards lie in ruptures, leaks and high pressure sprays. A rupture or leak would produce a large pool of fuel. In most mines fuel would be at 65°F and well below its flash point. A substantial heat source would be required to raise the fuel to its flash point. Laboratory studies (Murad, 1970) show that heat applied to a pool of fuel is transmitted quickly throughout that pool. Thus, the entire pool must be heated to near the flash point before the fuel at the heat source is above the flash point. The same study showed that fuel at its flash point that is swept by a 3 fps air flow will produce an ignitable vapor less than 1 in. above its surface. Most haulageways have ventilation well in excess of 6 fps.

A high pressure spray would produce a mist in the haulageway air. Any open flame (other than a cigarette) or an arc would ignite the mist. The mist would probably drift down the haulageway less than 180 ft. This type of fire would probably produce a flash but no sustained fire.

The use of tankers to haul fuel underground is not recommended. Close proximity between the large fuel quantities and engine heat creates too great a hazard. The primary advantage of tankers is that they are able to supply vehicle transfer areas that are moved periodically to remain near the advancing face. We recommend instead that haulage vehicles be brought out to more permanent vehicle

transfer areas located by underground storage areas supplied by piping. Since face working vehicles have lower fuel consumption rates, infrequent withdrawal to the vehicle transfer area will not have a serious effect on production. For vehicles that cannot be withdrawn from the face, a tanker with no more than 100 gal. of fuel could refuel the vehicle. Captive vehicles (such as in cut and fill operations) will still require fueling by tanker hose or cans.

Since oils have a flash point of approximately 450°F, they can be delivered safely to "near the face" transfer areas by tanker. However, tankers should not carry fuel and oil at the same time.

One overall impression developed from observing tankers was that they were not dented or scarred like the haulage vehicles. This would indicate that tankers are driven more carefully. We recommend that tanker deliveries be scheduled such that they do not share a haulageway with production haulage vehicles. The tanker should utilize a rotating yellow beacon and be driven by older, more mature drivers for added safety.

4.2.4

Underground Storage Areas

Due to the high flash point of oils, they are unlikely to burn without being ignited by diesel fuel. If stored in tanks instead of drums the oil is less likely to leak and a rupture should not occur in the event of a fire. Consequently, we recommend that oils stored in good quality vented tanks, and with a total volume of under 500 gal. in one area, need not be stored in enclosed areas. These unenclosed tanks should not be located within 50 ft (by shortest accessible route) of a vehicle transfer area or shop, and muck or mud should be used to form an impoundment. This recommendation will allow rock, hydraulic and lubrication oils to be stored close to the working face to serve the face vehicles. Since drums of oil are more likely to leak and to rupture in a fire, quantities of oil in drums over 110 gal. should be enclosed. The drums should be 25 ft from shop areas and 50 ft from vehicle transfer areas. Any oils stored near underground fuel storage areas should be included in the enclosure and treated the same as fuel.

4.2.5

Vehicle Transfer Area

In order to determine the hazard of a spill, a number of calculations were performed concerning the extent of a possible fire. Fuel used underground in mines is generally No. 1 diesel. In considering the hazards involved, the following properties of No. 1 diesel were used:

Gravity	40.9% API
Density	0.821 gm/ml
Boiling Point	344 to 576°F
Flash Point	100°F (Min. lower limit)
Viscosity at 100°F	1.6 centipoise
Mol Wt	170
Latent Heat	115 Btu/lb
Heat Combustion	19,700 Btu/lb

Spills of diesel fuel may occur at different points in an underground mine. Regardless of where the spill occurs, it will present a hazard depending upon the size of the leak and the spill area. In general, for a spill fire of this type the rate of heat release and the rate of air consumption are functions of the exposed area of the spill, and, thus it is important to restrict the spill area.

To appreciate the extent of the hazard involved, calculations were made on leaks involving 30, 250 and 1,000 gal. in size. If these leaks are confined in areas of 6 ft x 6 ft, 30 ft x 20 ft and 100 ft x 100 ft, the hazard resulting from a fire will vary greatly. An open fire resulting from a spill of diesel fuel may be expected to burn at the rate of 8 in. of depth per hour. Confining the leak to a smaller area lengthens the burning time, but also reduces the heat release quantity and therefore the rate at which the oxygen is consumed as shown in Table XXXII. The heat release rates for various common heat sources are shown for comparison in Table XXXIII.

Since there is a limit on the amount of available air in any given mine, lowering the combustion rate reduces the chance of incomplete combustion producing carbon monoxide. If we consider a 20 ft x 30 ft haulageway and a spill area of 20 ft x 30 ft floor area, covered by 1,000 gal, then a 5-mile/hr ventilation rate through this area will supply 300% excess air. The carbon monoxide content remains below the lethal toxic level if enough oxygen is present during combustion.

TABLE XXXII

HEAT RELEASE AND AIR CONSUMPTION FOR VARIOUS SPILL SIZES

<u>Area (ft)</u>	<u>Heat Release (Btu/hr)</u>	<u>Air Consumption Rate (cfm)</u>
6 x 6	24,200,000	3,890
30 x 30	403,000,000	64,843
100 x 100	6,718,000,000	1,080,718

TABLE XXXIII

HEAT RELEASE FOR VARIOUS COMMON HEAT SOURCES

<u>Heat Source</u>	<u>Heat Release (Btu/hr)</u>
Hot Water Heater	30,000
Home Furnace	120,000
Steam Boiler-Commercial Bldg.	500,000
Process Furnace in Refinery	125,000,000

The combustion gas temperature is directly related to the amount of excess air provided during combustion. Assuming complete combustion and neglecting disassociation, the actual flame temperature with 0% excess air will be near 3600°F. With 100% excess air, this temperature will drop to 2340°F. With 200% excess air, the temperature will be 1650°F. At 1,000% excess air, the temperature is 565°F. Heat transfer from the combustion gases to the rock walls will reduce the gas temperature. Theoretical calculations cannot adequately define this problem as pointed out by 1973 Edition of the Mining Engineering Handbook.

Calculations emphasize the necessity of limiting the amount of the spill. The size of the spill will determine the air requirements. If it approaches 1,000 gal, it will be difficult to maintain carbon dioxide and carbon monoxide below lethal concentrations.

The calculations assume perfect ventilation conditions. In an actual mine fire, back pressure from the fire and changes in ventilation would produce more carbon monoxide than calculated. However, it is clear that a fire involving 100 gal. in a well ventilated haulageway is unlikely to produce lethal amounts of carbon monoxide.

Based on these calculations, we recommend that mines with fuel consumption rates below 50 gal/day, be allowed to store 100 gal. (total) underground, unenclosed, and in good quality vented tanks. Also, large mines should be allowed to refuel face vehicles from 100-gal. tankers if the face vehicles are withdrawn to a well ventilated area.

Figure 15 contains an example of a vehicle transfer area with fuel tanks present. We recommend that no fuel or oil tanks, nor drums be located within 50 ft of a vehicle transfer area.

One long standing question is whether or not the engine of a refueling vehicle should be turned off. Since diesel engines have no ignition system, that heat source is not eliminated when turned off. The greatest heat source in a haulage vehicle is the diesel engine which by law has an operating skin temperature below 400°F, but is typically below 300°F. However, when the engine is turned off the temperature will rise because the cooling system is also off. We were unable to determine the extent of this temperature rise but it should be below 444°F which is the autoignition temperature of diesel No. 1.

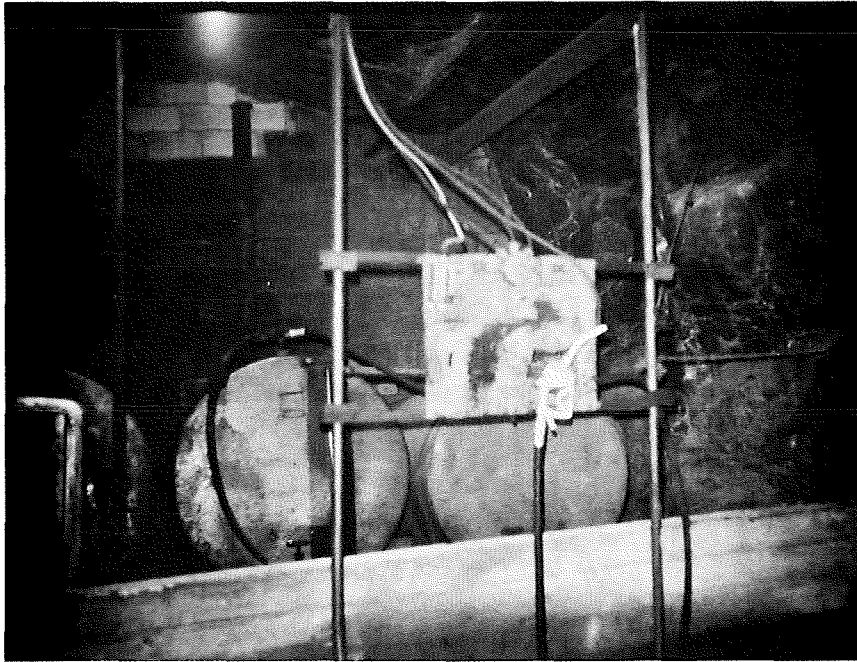


Figure 15 - Vehicle Transfer Area (Tanks Present)

A spill of diesel fuel on a hot, stopped engine should not ignite but will produce ignitable vapors. The fuel will run into the sump under the engine and continue to generate the vapors. These vapors will drift out of the engine compartment and any spark or flame will ignite them.

A spill of diesel fuel on a hot, running engine should not ignite but will produce ignitable vapors. However, the cooling fan should dilute these vapors below the ignitable range.

We recommend that diesel engines be left running during refueling operations. The vehicle transfer area should be well lighted so that the vehicle lights can be turned off. Drivers should be warned not to utilize the hydraulic system (turn steering wheel, raise bucket) during refueling operations because ruptured hoses are a leading cause of vehicle fires.

4.2.6 Locations of Fueling Areas

The location of fueling areas greatly affect their associated hazard, primarily because of their location in the ventilation system. Underground storage areas are generally located near shops which are normally near the shaft. If that shaft is an air intake, the underground storage areas are in the main ventilation supply for most of the mine. Consequently, it is important that a storage area be designed to reduce the chance of fire to a minimum and to contain the smoke and extinguish the flame. This is why an enclosure with automatic ventilation control, and an AFPS are recommended. We also recommend that no fuels or oils be stored in close proximity to the refueling operation unless enclosed. We also recommend an AFPS for vehicle transfer areas.

Some mines have the underground storage and vehicle transfer areas located near an exhaust ventilation shaft that is not used for man-trips. These areas are unlikely to be a hazard to underground personnel and no enclosures or AFPS's are recommended.

5.0

SYSTEM DESIGN CONCEPT

As indicated by the variety of systems currently utilized in underground fuel areas, a large number of possibilities exist for fire protection systems when considering the overall general hazard of underground fuel areas. Due to the many variations in configuration and design parameters of fuel areas, there is no single system that is most cost effective for all applications. Each hazard will require its own analysis and a design concept developed to meet the particular needs of each. This section will present various fire protection systems and attempt to show the advantages and disadvantages of each as a guideline for mine operators. In some cases the fuel area will require modifications to accept a certain type of system, however, these requirements will become obvious through the discussion.

5.1

Type of Suppressant

Knowing the general type of hazard and application, a determination of the types of agents to be considered for analysis can be made. Four types of systems were observed in the mines and are automatically included. These systems include high expansion foam, multipurpose dry chemical, water, and Halon 1301. The remaining agent types that could be considered are carbon dioxide, Halon 1211, other types of foams, such as protein foam or aqueous film forming foam (AFFF), and other types of dry chemicals.

CO₂ and Halon 1211 were eliminated from consideration because of possible health effects, a factor enhanced by the underground application. Any personnel without breathing apparatus, caught in a discharge of either agent, could be seriously affected.

Aqueous film forming foam (AFFF) is included because of its excellent securing ability. When discharged, the AFFF will form a fast spreading film over the fuel, preventing the escape of flammable vapors and virtually eliminating the possibility of flashback. AFFF is compatible with dry chemical agents and will not be broken down when used simultaneously with or when dry chemical is applied after a system discharge. AFFF does not require special discharge devices and can be distributed by standard sprinkler heads.

The protein foams and other synthetic foams are not as compatible with dry chemical and require blanketing of an entire spill before providing the securing ability; consequently, higher discharge rates are required. The protein foams do require special air-aspirating equipment for foam manufacture. Synthetic foams are normally not as stable as AFFF. In view of the disadvantages of these foams, and the fact that AFFF and high expansion foam are considered, the protein and synthetic foams will be eliminated from the trade-off analysis.

The other types of dry chemicals were not considered because the specific application requirements called for multipurpose dry chemical.

5.2

Types of Fires

Determination of the particular type of suppressant to be used is directly related to the type of fire to be encountered in any one particular hazard. The primary objective of the system in an underground fuel area is to protect against a Class B fire comprised of diesel fuel, hydraulic fluid, motor oil, transmission fluid, and various other combustible liquids. The Class B fire can occur in three different ways:

- The Class B spill fire will be the most prominent, consisting of fuel spills by personnel, fuel system component leaks, tank overfills or a burst tank.
- The Class B pressure fire could occur from a break in a wet transfer line from the surface to an underground tank or a vehicle fueling line between the fuel pump and a self-closing nozzle.
- A Class B running fire, fuel flowing from an unpressurized source, may also occur from a burst tank. In the majority of cases, a finite fuel volume will be depleted, leaving only the spill fire to contend with.

A Class A fire, although a secondary fire hazard, is also a possibility in most underground fuel areas. The Class A hazard would consist of paper or cardboard boxes, clothing inadvertently left in the area, rags used for cleaning, wooden timbers or tank supports, and electrical wiring harnesses.

Electrical equipment utilized in the area will constitute a Class C hazard, however, the unique problem associated with agent conductivity is not a major consideration in an automatic system discharge, especially if electrical service is shut down on system actuation.

Table XXXIV rates the five agents against the anticipated types of fires and considers the effectiveness of each agent when applied under ideal conditions from a system installed with current hardware and technology. Examination of the table will reveal:

- Halon 1301 is very effective when applied in an enclosed space under the total flooding principle. A higher rating can be achieved for the Class A fire considering a possible soaking period, but more agent and higher costs will result.
- Dry chemical has excellent extinguishing but no securing ability on Class B fires.
- Pressure and running fires can be controlled but are difficult to extinguish with water based agents.

TABLE XXXIV
AGENT EFFECTIVENESS ON VARIOUS FIRE TYPES

<u>Type Fire</u>	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
Class B Spill	5	3	5	5	4
Class B Pressure	2	1	1	5	4
Class B Running	3	1	2	5	4
Class A	<u>5</u>	<u>5</u>	<u>5</u>	<u>3</u>	<u>5</u>
Average	3.75	2.50	3.25	4.50	4.25

Rating System: 5 = Extinguish and Secure
 4 = Extinguish; No Securement
 3 = Control w/Possible Extinguishment
 2 = Control; No Extinguishment
 1 = No Control

5.3

Fuel Area Configurations

Observing fuel areas throughout the mining industry, one is afforded a wide view of design and installation parameters. Fuel areas can be enclosed, open with diked or buried tanks, or completely open to main ventilation. Air velocities can vary from zero to 20 mph. These factors will all have an effect on the design and installation of the fire protection system. Table XXXV can be used to obtain an indication of the best overall agent, rating them with respect to effectiveness under varying application environments. Each agent will be applied to a Class B spill fire containing diesel fuel. As well as indicating no control, rating Number 1 means a system application is not recommended or feasible.

Examination of the table will reveal:

- The excellent securing ability of AFFF is clearly indicated.
- Halon 1301 is the only agent to obtain a no application rating.
- In some cases, fuel area configuration can drastically effect agent extinguishing ability.

TABLE XXXV
AGENT EFFECTIVENESS UNDER VARYING APPLICATION ENVIRONMENTS
CLASS B SPILL FIRE

<u>Fuel Area Configuration</u>	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
High Ventilation - Open	5	2	2	1	3
- Diked	5	2	3	1	4
Low Ventilation - Open	5	2	3	1	4
- Diked	5	2	4	3	4
- Enclosed	5	3	4	4	4
No Ventilation - Enclosed	<u>5</u>	<u>3</u>	<u>5</u>	<u>5</u>	<u>4</u>
Average	5.00	2.33	3.50	2.50	3.83

Rating System: 5 = Extinguish and Secure
 4 = Extinguish; No Securement
 3 = Control w/Possible Extinguishment
 2 = Control; No Extinguishment
 1 = No Control

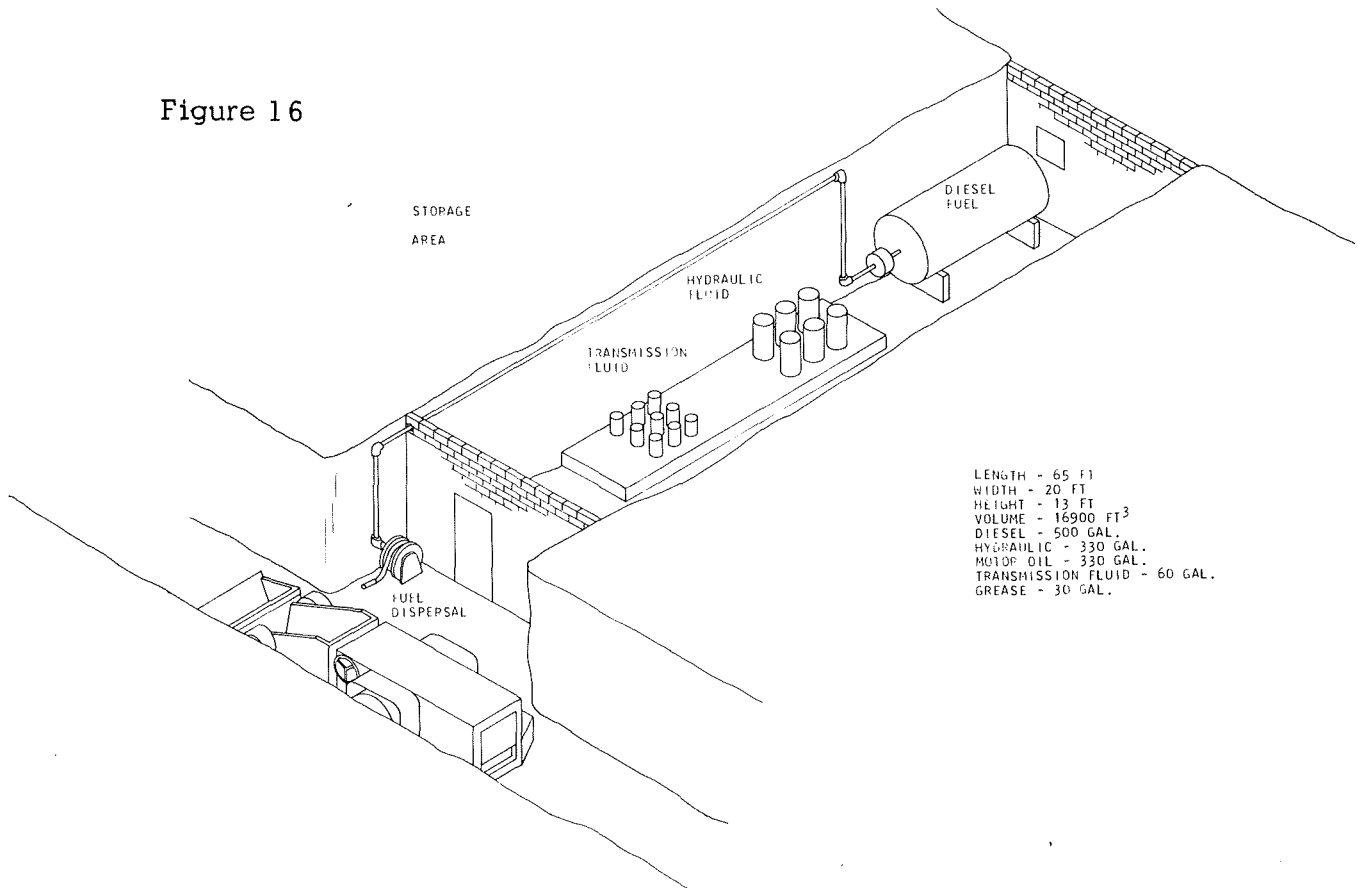
5.4

Basic System Design

To obtain a basis for agent/system comparison, a representative fuel area was developed. From the data of all sixteen mine visits average values were obtained for fuel area volumes, diesel fuel tank sizes, and quantities of other flammable liquids stored in the area. These average values were combined with the most prevalent methods of storage and transfer to develop the fuel area of Figure 16.

Although this area proved to be representative of the actual areas observed in the mines, variations on it could change the hazard analysis and greatly affect the optimum system design. As indicated by the data analysis, a combining of storage and transfer area would greatly increase the hazard index, resulting in more danger for personnel and increasing the need for an automatic system. As indicated by Table XXXV, combining would also require that the area not be enclosed, a factor virtually eliminating total flooding, the design parameter required for Halon 1301. Elimina-

Figure 16



tion of the total flooding possibility would greatly increase system costs of high expansion foam, due mainly to increased application rates required. Combining the two areas and including high ventilation effects would increase the agent requirements for high expansion foam and dry chemical, due to the turbulence and dispersing effect of the high velocity air.

To retain the five types of systems for consideration, the enclosed storage area was set up as the basis for system design and eventually cost comparison.

A basic system of each type, excluding detection, was designed and installed in the storage area. Detection will be considered a separate sub-system and will be discussed independently.

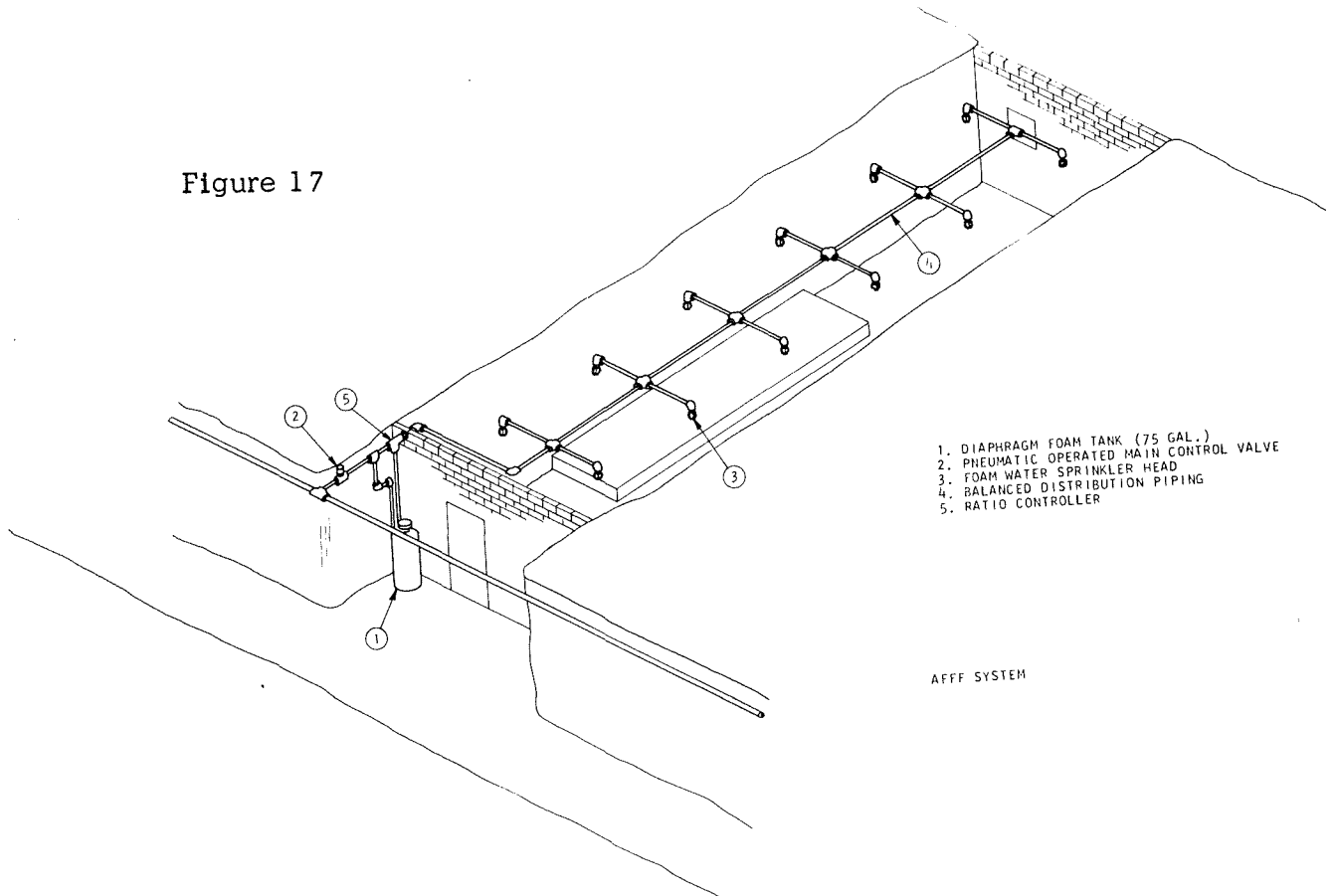
5.4.1

AFFF

The AFFF proportioning system is shown in Figure 17. The system utilizes the mine water supply, restrained by the pneumatically-operated main control valve (Item 2). The detection control box will accept a signal from the detector and respond by opening the valve. Water flowing into the diaphragm foam tank and through the proportioner will automatically mix with the foam concentrate and flow into the distribution piping. Discharge from the 12 nozzles will aspirate the mixture, creating the foam, which in turn will be evenly distributed over the entire area, simultaneously extinguishing and securing. The 75-gallon concentrate tank will supply foam for a minimum of 10 minutes, at which time pure water will be discharged unless provision is made for manual or automatic shutdown.

The foam expansion ratio will be approximately 6:1. This ratio yields a foam heavy enough to be distributed, even with a relatively high ventilation rate, yet maintains a vapor sealing barrier over the fuel to prevent combustion. In an open storage or transfer area with a slight incline, the AFFF will have a tendency to follow a flowing fuel spill and maintain its extinguishing effectiveness.

Figure 17



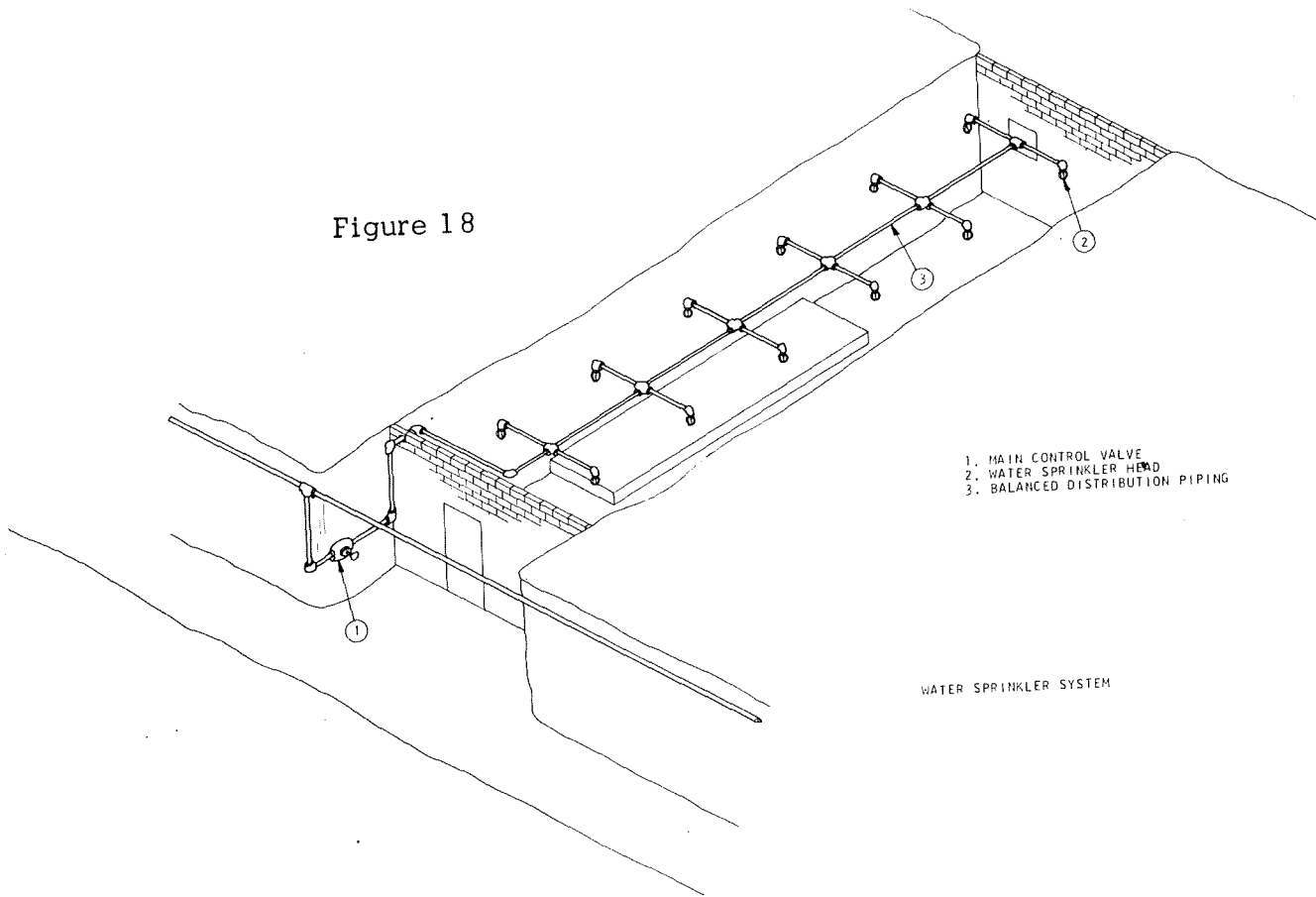
The disadvantage of the AFFF system is its relatively low effectiveness against a pressure fire. It will provide a cooling effect and control of the fire, allowing extinguishment by mine personnel with hand-operated extinguishing equipment.

5.4.2

Water

The water sprinkler system operation of Figure 18 is identical to the foam system except that the diaphragm foam tank and proportioner are not required. The control box will again operate the main control valve, allowing water to flow through the hydraulically balanced distribution piping and out the nozzles. If enough water is available, the water spray system will cool and control a fire. On the other hand, if too much water is introduced into an open or diked area, the burning fuel could be raised above any restraining boundaries and carried to other parts of the mine, creating a greater personnel hazard.

Figure 18



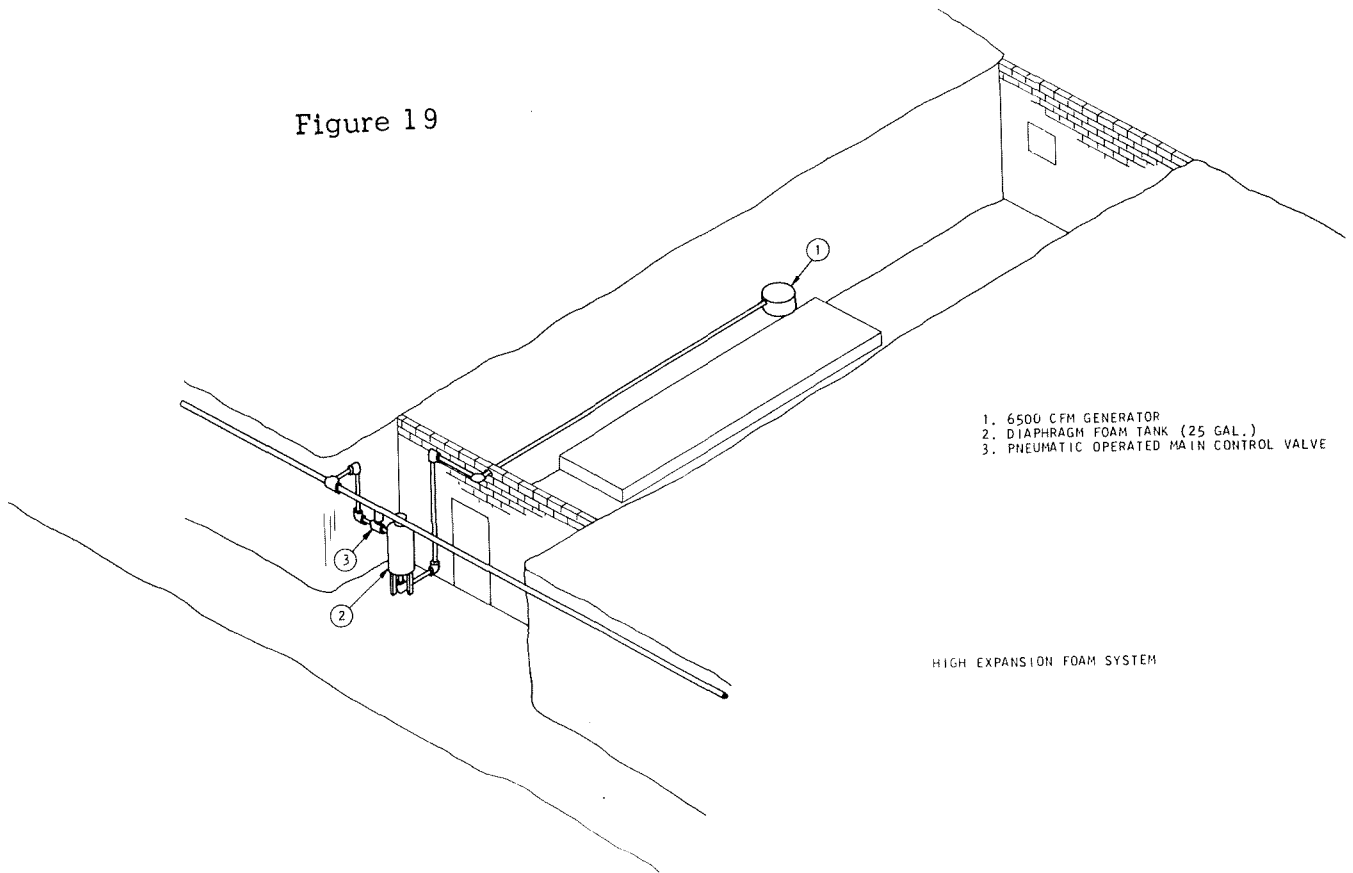
5.4.3

High Expansion Foam

The high expansion foam system also utilizes the mine water supply line and consists of a main control valve, a foam concentrate supply, and distribution piping to a water-powered foam generator, as shown in Figure 19. The concentrate can be mixed with the water through an eductor or a diaphragm tank, although the manufacturer consulted recommended the diaphragm tank to prevent concentrate contamination through an open supply or accidental removal of the eductor hose.

A 25-gallon concentrate tank is utilized with a minimum of 15-minute discharge time of approximately 800:1 expanded foam. The water-powered generator is situated in the top center of the protected area, allowing the foam to flow systematically throughout the space. With a high expansion ratio, the light foam created is especially affected by ventilation rates in open areas.

Figure 19



Being similar to the other water based agents, AFFF and water sprinkler, high expansion foam can only cool and control a pressure fire. Due to its lightness, it will be forced away from the actual pressure fire area, and cooling effects will be lessened. Total flooding of an enclosed space is the ideal application, although local applications are possible in areas with low ventilation rates.

Another consideration for the foam generator is to duct in outside fresh air for the manufacture of the foam. Products of combustion within the space will cause a reduction in the foam produced. If outside ducting is impossible, an increase in generator size is necessary to allow for decreased foam production.

5.4.4

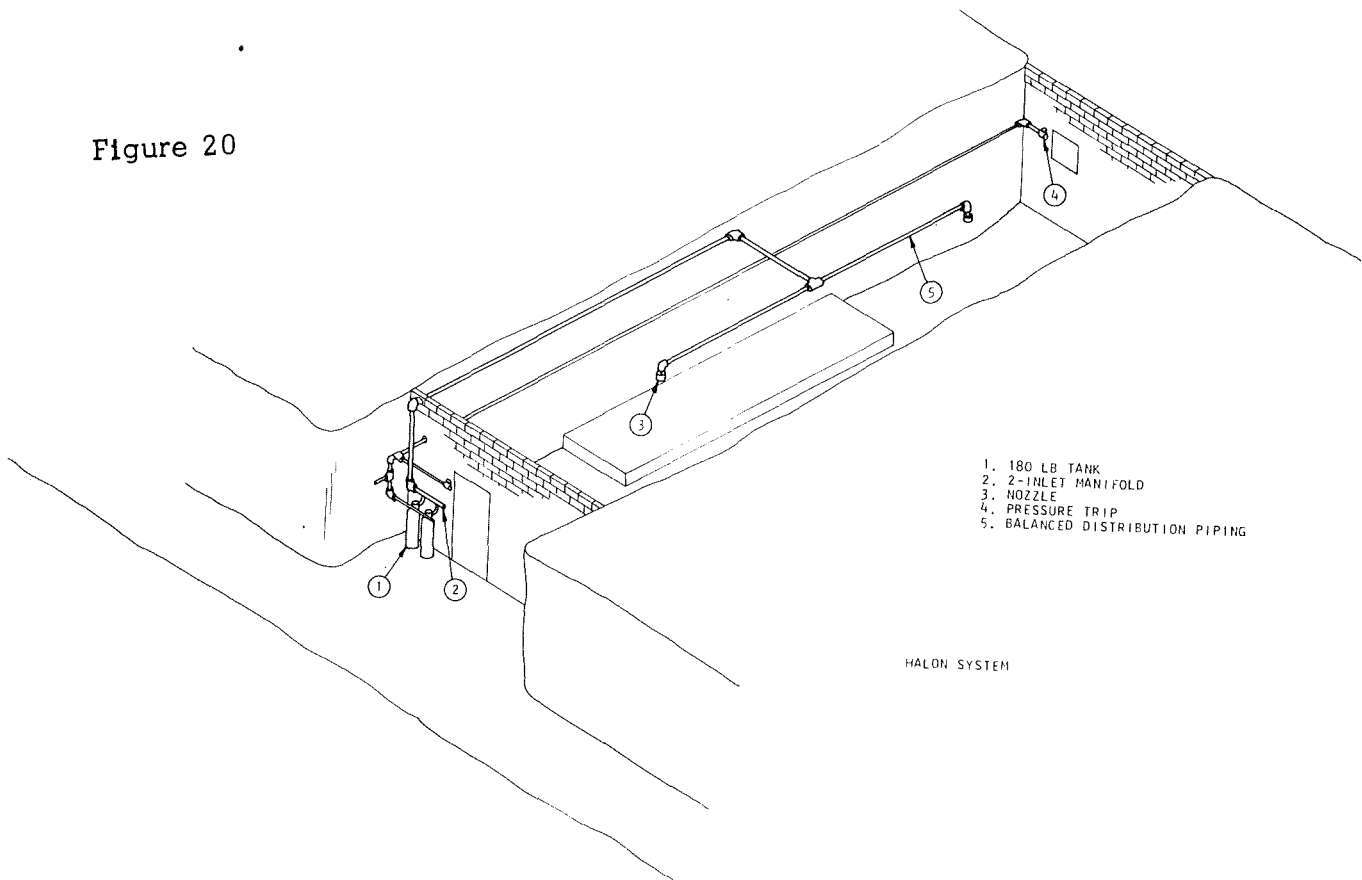
Halon 1301

Halon 1301, Figure 20, is strictly for total flooding of an enclosed space, although spaces with low ventilation rates can be accommodated by extra agent discharge to maintain concentration. All doors require closing, which is accomplished by pressure trips operated pneumatically from the detection control box. This control box will also

actuate the halon cylinder valves and allow the agent, superpressurized with nitrogen to 360 psi, to flow through the balanced distribution piping and be distributed throughout the space by the nozzles.

When applied in an enclosed area in a concentration of 5% the agent is very effective against all anticipated types of Class B fires. Local application of Halon 1301 is not presently being done in any environment. Maintaining the concentration of Halon 1301 within the space will give assurance that the area is secure and personnel with breathing apparatus can enter safely. With the gaseous agent, no clean-up is required and any equipment within the area will not be damaged.

Figure 20



5.4.5

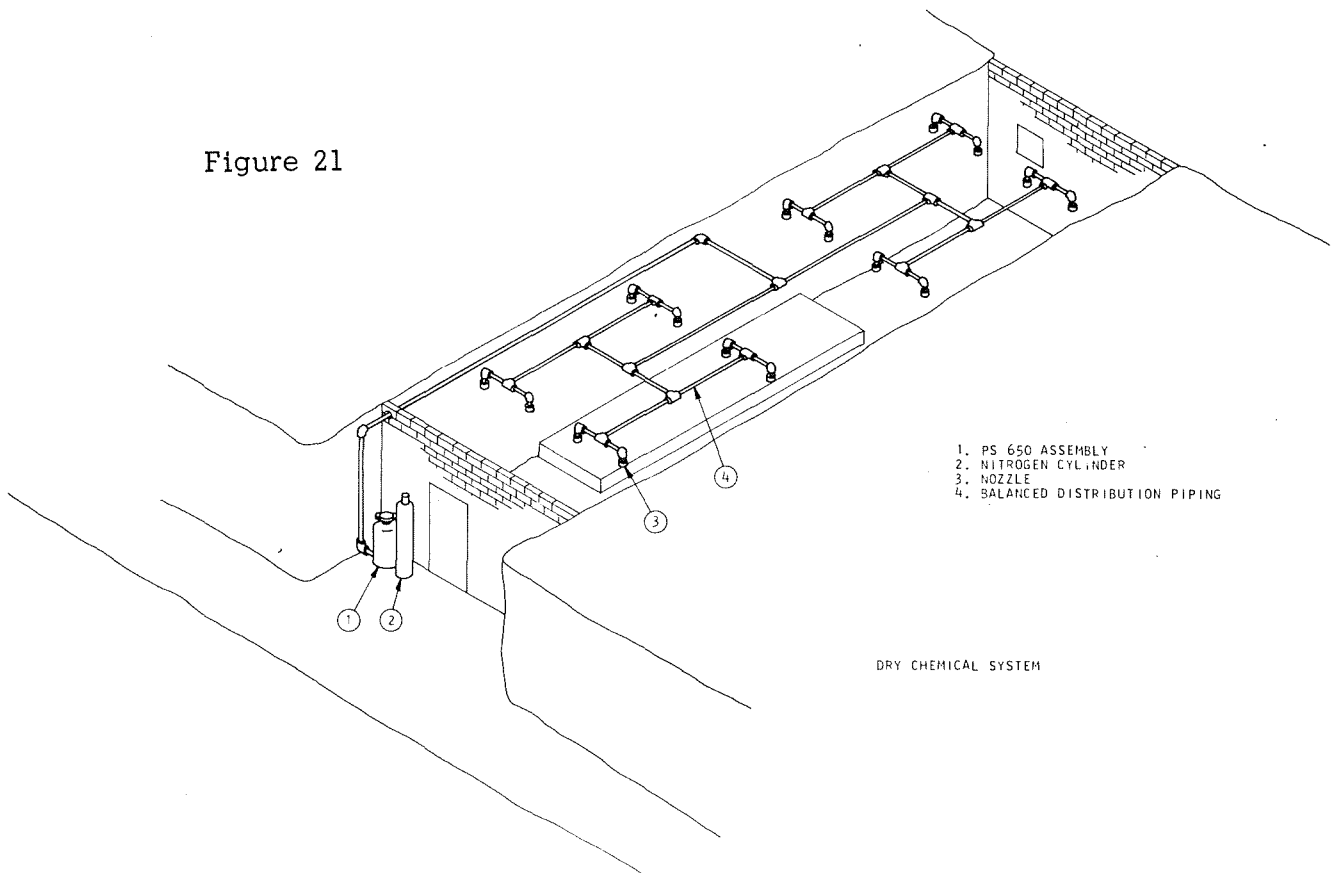
Dry Chemical

The dry chemical system pictured in Figure 21 is a total flooding application, however, local application is also permitted. The enclosed storage area required a 650-

pound dry chemical supply tank with a compressed nitrogen cylinder as a pressurizing and power source. The nitrogen cylinder valve is the main system control valve, actuated by the detection control box. Nitrogen flows into the dry chemical storage container, fluidizing and pressurizing the dry chemical. When system flow begins, the nitrogen/chemical mixture is distributed to the nozzles by balanced piping and discharged into the space.

Dry chemical is a very quick-reacting agent, but it does not possess any securing ability on the Class B fires.

Figure 21



5.5

Automatic vs. Semi-Automatic vs. Manual

When selecting and designing a fire protection system, the detection method is of utmost importance. Automatic systems have the definite advantage of eliminating the possibility of a fire going completely undetected and out of control with the system never having been discharged. Having the fire detected by personnel without training in the actuation and operation of the system, or even with training, having personnel panic when confronted with a fire, could have a disastrous effect.

When the time and money have been invested in the design and installation of a fire protection system, introducing the factor of relying on human detection negates a large portion of the "insurance" obtained from the installation.

Considering the added cost against the rapid detection obtained, a safety factor, although difficult to define, is undeniably present. A fire is much more easily controlled and extinguished when detected in its early stages than if given an amount of preburn time in which all involved surfaces are heated above fuel flash point temperatures. All preheated surfaces are a potential ignition source for reignition and flashback at the end of a system discharge. At the point of fire reflash after a system discharge, no benefit whatsoever would have been realized in the case of non-securing agents. Semi-automatic systems are another consideration, but also require the human element for complete system operation. If the cost of detection for a semi-automatic system is spent, it is simply a matter of interconnection to control the fire protection system actuation with the detection system and eliminate the need for manual actuation and reliance on personnel. Although the possibility of false alarms is present, in view of the above disadvantages of manually actuated systems, an automatic system, including detection, will be recommended.

5.6 Detection

5.6.1 Basic Overview

There have been numerous studies and research evaluations to establish the various advantages and disadvantages associated with the several forms of fire detection available for use in a mining environment. Basically, the forms available are heat or thermal detection, aerosol or smoke detection, and flame detection. Thermal or heat sensitive detectors have a history of high reliability due to simplicity and a low maintenance characteristic also due to simplicity, but are very slow in response time. They depend on convected thermal energy and typically respond in one-half to five minutes depending on the distance from and the size of the fire source. Aerosol or smoke detectors are much faster since they normally respond to the products of combustion associated with one ignition. However, due to the nature of the environment,

aerosol detectors have a high rate of nuisance alarms and require frequent maintenance for cleaning and testing. Most smoke detectors also exhibit a strong dependency on air velocities, humidity and temperature for proper operation. Flame detectors are ultra-fast in response to an open flame, but also require frequent maintenance to keep the optical lenses clean, and can also be sources of nuisance alarms. Typically, arc welding will affect the ultraviolet detectors and hot gases and surfaces will affect the infrared detectors.

5.6.2 Detection vs. Hazard

5.6.2.1 Fuel Transfer Area

In the fuel transfer area the vehicle being loaded should be protected with a fairly fast response detection system because of the possibility of a flash fire situation since several hot ignition sources exist. Assuming the vehicle does not have an automatic thermal detection and suppression system already installed, it would not be practical to use a heat sensitive thermal detection system for protecting the vehicle while in the transfer area. Such a thermal system could not be installed close enough to the vehicle to detect a fire in a reasonable amount of time, yet be out of the way of normal traffic and be unaffected by the heat crescendo from a parked vehicle. Since it would take a fairly large fire (vehicle engulfed in flames) to operate a thermal system within a minute when mounted directly over the transfer area, thermal detection must be ruled out. Due to air velocities, particulates in the mine air, and the low probability of a smoldering combustion in the fuel transfer area as opposed to a flash fire situation, photoelectric and ionization types of smoke detectors would be impractical as forms of fire detection. In a flash fire situation these detectors cannot react fast enough or reliably enough due to the large size of the particulates given off to prevent serious damage or a large fire. Therefore, a flame detector should be used as the form of detection for the fuel transfer area. Of the open flame detectors available, ultraviolet detectors would be highly desirable over infrared since the UV detector will respond only to the fire. Some infrared detectors can respond to hot gases and, in general, any high energy heat source, and hence, have a high nuisance alarm rate. One possible cause of nuisance alarms for the

UV detector will be arc welding, particularly if the fuel transfer area is close to the shop maintenance area. In this case, some form of shielding will be required.

5.6.2.2 Fuel Storage Area

In the fuel storage area it would be impractical to place thermal detectors close enough to the fuels to allow fairly rapid detection. To prevent damage to the detection system in the storage area it must be mounted high on the side walls or on the ceiling and not directly at the storage containers. This would limit the convected energy thermal detectors to a relatively slow response to a fire condition and would allow a large fire to develop before detection could be achieved. For this reason, a faster reacting detection system is required. Since smoke detectors of various kinds are susceptible to air velocity, smoke entry into the chamber, contamination build-up, and nuisance alarms due to particulates in the air, detectors sensitive to the incipient stages of a fire would not be suitable for an underground mining environment. Detectors that respond to a visual flame source can detect fires during the early ignition stages and provide a fast, reliable detection of a fire situation with a minimum of nuisance alarms.

5.6.3 Recommended Detection

Therefore, based on the criteria that the fire be detected as early as possible to prevent a very large fire from developing, the detector be insensitive to hot gases, fluctuation of temperature, humidity and air velocity, and be capable of operating in a hazardous environment without affecting the detection characteristics and capabilities, ultraviolet detection should be used. Most studies also recommend that ultraviolet detection be seriously considered for the fuel transfer and storage area hazard in an underground mine. Provided a proper maintenance schedule is established, this type of detection can be kept in an operational state at all times. In addition, present state-of-the-art in UV detection can provide an "optical integrity" feature of monitoring the detector lens for paint, oil film, and dirt build-up. This also checks the operation of the UV tube and can provide a trouble indication, allowing unscheduled maintenance and lense cleaning at much longer intervals on the average than a strict scheduled maintenance.

5.6.4

Alternative Detection System

The only alternative to a UV detection system would be a completely thermal detection system, whether it is pneumatic, heat-actuated, continuous thermistor wire, or point source rate-of-rise detectors. The advantages to this alternative system are higher overall reliability, lower cost, and minimal maintenance. The disadvantage is the response time to detect a fire condition and the size of the fire when left to grow during this time lag.

5.7

Estimated System Costs

For comparative purposes, approximate system costs were developed for systems to protect a large closed-in storage area as illustrated by Figure 16. A manufacturer of each type system was consulted to develop the component costs. The cost of each system includes a \$3,000 allowance for detection and control. Thus, each estimated total cost represents the estimate of total system cost to the mine operator. The system costs may vary considerably depending on the size of the fueling area and other special mine conditions.

TABLE XXXVI
ESTIMATED SYSTEM COSTS

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
Equipment	\$ 7,200	\$5,000	\$ 7,400	\$ 7,000	\$ 7,000
Installation	3,000	3,000	2,000	2,000	3,500
Operation	1,000	400	800	1,800	1,000
Maintenance/Yr.	<u>200</u>	<u>100</u>	<u>200</u>	<u>250</u>	<u>250</u>
Est. Total Cost	\$11,400	\$8,500	\$10,400	\$11,050	\$11,750

Installation costs are based on systems being installed by fire protection personnel. Savings to mine operators can be realized through self-installation, provided the manufacturer is in agreement and supplies installation drawings to the operator, along with the equipment.

- Operation costs reflect agent and/or actuating device replacements, refill of nitrogen cylinders and an estimate of time required for clean-up and reinstatement of system ready status.
- Maintenance costs are estimated mainly on man-hours required to maintain the system integrity.
- Detection system costs are based on the best and most reliable UV detectors and any variation from this type will decrease the cost.

5.8

Cost Effectiveness Index

Utilizing the agent effectiveness rating and the equipment costs, some means was required to combine the two and form an indication of cost effectiveness relating to the best overall automatic fire suppression system.

Table XXXVII is an average rating of the agents, combining the fire type effectiveness and configuration effectiveness. Utilizing this rating, dividing by five, the maximum rating, and multiplying the result by 100, yields a percentage effectiveness rating. Dividing equipment costs by 100 and dividing this quotient into the percentage rating yields an effectiveness per unit dollar index, indicative of cost effectiveness.

Assuming a maximum rating of 5.00 for 100% effectiveness and utilizing the lowest equipment cost of \$5000, the maximum index attainable is 2.00.

$$\frac{5.00}{5.00} \times 100 = 100\%$$

$$\frac{100\%}{\$5000/\$100} = 2.00 \frac{\% \text{ Effectiveness}}{\text{Unit Cost}}$$

Using the minimum rating of 1.00 and the maximum system cost of \$8800, the minimum index is 0.23.

TABLE XXXVII
AVERAGE EFFECTIVENESS RATING

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
Fire Type Effectiveness	3.75	2.50	3.25	4.50	4.25
Area Configuration Effectiveness	<u>5.00</u>	<u>2.33</u>	<u>3.50</u>	<u>2.50</u>	<u>3.83</u>
Average	4.38	2.42	3.38	3.50	4.00

Table XXXVIII shows the relative closeness of the system indexes when considering the various types of applications that can be encountered. This fact reinforces the opinion that each particular hazard must be analyzed for its own design parameters and protection objectives.

AFFF, with the highest index, indicates this system as being appropriate in the majority of applications, although it may not be the best system in any one particular case.

TABLE XXXVIII
EQUIPMENT COST EFFECTIVENESS

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
Average Effectiveness Rating	4.4	2.4	3.4	3.5	4.0
Percentage Effectiveness Average Rating/5.00 x 100	88	48	68	70	80
Equipment Cost/\$100	72	50	68	70	70
Cost Effectiveness Index (% Rating/Cost/\$100)	1.22	.96	1.00	1.00	1.14

Extinguishing Response Time

Extinguishing response time of a system is another important factor to consider relative to personnel and equipment safety. Again, the longer preburn time a fire is allowed, the more difficult that fire will be to extinguish. Although system response time is more directly related to detection, actual extinguishing response time can also be a factor and can be rated as such.

Table XXXIX indicates relative response times to the various agents under consideration.

TABLE XXXIX
EXTINGUISHING RESPONSE TIME

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
Relative Rating	Good	None	Good	Excellent	Excellent
Comments	Relates to discharge time	Control thru cooling may not extinguish	Relates to discharge time	Secure while concentration is maintained	No securing on Class B fires
Est. Ext. Time	2 minutes	---	3 minutes	10 seconds	20 seconds
Numerical Rating	4.0	1.0	4.0	5.0	5.0

Rating System: 1 = None
2 = Poor
3 = Fair
4 = Good
5 = Excellent

The quick knockdown effects of Halon 1301 and dry chemical are desirable, however, slow knockdown of the foams will be compensated for somewhat by instantaneous detection, initiating system discharge while the fire is small.

Personnel Safety

Personnel safety is another consideration when selecting a system for fire protection. With the most hazardous area indicated as the transfer area and the major ignition source being the vehicle, the assumption can be made that someone will be present in or adjacent to the area. The effects a system discharge will have on him or others attempting to escape through the transfer area is definitely a factor to consider.

Rating of each agent can be done with an established system (Table XL). Five (5) is least hazardous, with one (1) being undesirable. Safety factors to consider are visual obscurity, difficulty in breathing, effects on ability to function, i.e., walk, run, etc., and any possible after effects due to toxicity.

The ratings consist of giving each agent a five and subtracting one point for each of the unsatisfactory characteristics the agent will display during and after discharge. For example, during discharge a total flood dry chemical system will obstruct vision and irritate the eyes, consequently, a rating of 3. After discharge there is no effect on personnel, and a rating of 5.

TABLE XL
SYSTEM DISCHARGE EFFECTS ON PERSONNEL

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
During Discharge	4	5	4	4	3
After Discharge	<u>4</u>	<u>4</u>	<u>2</u>	<u>3</u>	<u>5</u>
Average	4.0	4.5	3.0	3.5	4.0

Maintenance and Reliability

Reliability of any system is directly proportional to the maintenance performed, consequently, they will be discussed coincidentally. Both depend somewhat on the simplicity of the system. The more major components, the more inspection and maintenance required and the greater the possibility of component failure. Maintenance of the systems will require checking the main control valve for operation and will consist of an actual or simulated actuation test. Pressurized components will require checking, i.e., nitrogen cylinders, Halon 1301 cylinders. Operating components, high expansion foam generators, will require inspection for freedom of movement, and all pipelines should be kept clear of obstructions. Full maintenance inspections on all systems should be performed semi-annually, with visual examinations done at least bi-weekly.

When maintenance inspections are performed according to pre-planned schedules, the system will maintain its integrity and reliability.

Utilizing UV detectors with the optical integrity feature will give the detection system an added reliability factor, however, manual actuation is possible on all systems concerned. In addition to manual actuation, the dry chemical and halon systems can be installed with reserve back-up. System costs will reflect the increase in agent and component parts, however, the halon system cannot normally be recharged by mine personnel, and a back-up reserve may be required for continuous protection after a discharge when the primary system is being reinstated by a distributor.

For an increased degree of reliability, most of the systems recommended can be purchased with approvals of various regulatory agencies, assuring that they meet rigorous environmental and operational requirements.

The five systems will be assigned a numerical rating considering overall operating components.

Overall Cost Effectiveness Analysis

Table XLI contains the overall analysis for the five system designs. The four ratings were all combined into one average (line 5) and the appropriate costs were added together to form two separate indexes. The first, line 8, is an installed system index, utilizing the equipment and installation costs combined with the overall rating in the same manner as Table XXXVIII.

The total cost effectiveness index (line 12) utilizes the same rating, but includes maintenance costs. Operation costs were not included because if a system has operated successfully in a fire situation, cost of the fire protection is not significant compared to the savings in lives and equipment.

TABLE XLI

OVERALL COST/EFFECTIVENESS ANALYSIS

	<u>AFFF</u>	<u>Water</u>	<u>High Expansion Foam</u>	<u>Halon 1301</u>	<u>Dry Chemical</u>
1 Personnel Safety	4.0	4.5	3.0	3.5	4.0
2 Ext. Response Time	4.0	1.0	4.0	5.0	5.0
3 Mtnce. & Reliability	4.0	4.0	4.0	2.0	3.0
4 Agent Effectiveness	<u>4.4</u>	<u>2.4</u>	<u>3.4</u>	<u>3.5</u>	<u>4.0</u>
5 Numerical Average	4.1	3.0	3.6	3.5	4.0
6 Percent Effectiveness Numerical Avg./5 x 100	82	60	72	70	80
7 Est. System Installed Cost	10200	8000	9400	9000	10500
8 Installed Cost/ Effectiveness Index (% Effectiveness/ Cost/\$100)	.80	.75	.77	.78	.76
9 Est. Mtnce. Cost	200	100	200	250	250
10 Est. Operation Cost	1000	400	800	1800	900
11 Total Installed & Mtnce. Cost	10400	8100	9600	9250	10750
12 Total Cost Effective- ness Index	.79	.74	.75	.77	.75

When considering the various cost effectiveness indices of Table XLI, whether it is equipment cost, installed cost, or total cost, there is no single agent that presents itself as being more adapted to the full scale of mining environments and applications than any other particular agent presented. All the agents will provide a certain amount of protection and will provide the protection with a quality almost directly proportional to the cost involved. Consequently, system/agent choice should depend on other parameters.

Upon reviewing the trade-off study, the single parameter which has the greatest impact on agent effectiveness appears to be the ventilation variations (Table XXXV). Ventilation in the enclosed storage area can be completely controlled by system operation and is not a major factor in that application. Ventilation in the transfer area will be a part of or all of the main ventilation and, in most cases, cannot be stopped or varied in any way.

As indicated by the data analysis, the vehicle transfer area is the most hazardous sub-system with the most hazardous module of that sub-system being the fueling operation. Personnel will be present in the transfer area much more than in the storage area, and more importantly, will be present during the fueling operation. Consequently, the greatest personnel and property danger is in the transfer area and a system installed in the area is a much more critical and required application than that of the storage area.

To accomplish the objective of optimum protection for the total fuel area, the enclosed storage area and the vehicle transfer area must be separated from each other with respect to fire suppression systems. Each fire suppression sub-system will be independent of the other and will be actuated and controlled by separate detection devices.

The procedure of separating the fuel area into two components will allow the flexibility of recommending a choice of fire suppression sub-systems for the enclosed storage area. Each agent, as presented in the trade-off study, does have an application possibility in an enclosed

storage area; consequently, the minor design parameters and the most cost effective choice can be left to the mine operators.

The transfer area will have the major design parameters to consider and does require a somewhat more sophisticated system. A single recommended design concept will be proposed for the transfer area.

5.13.1 Storage Area

The storage area, as defined for the design concepts, will be completely enclosed or outfitted with closeable openings. This area will contain some or all of the fuels that are permissible for underground storage and can contain them in tanks, drums and/or cans. The representative fuel storage area of Figure 16 will be used as an example for the recommended suppression sub-system design concepts.

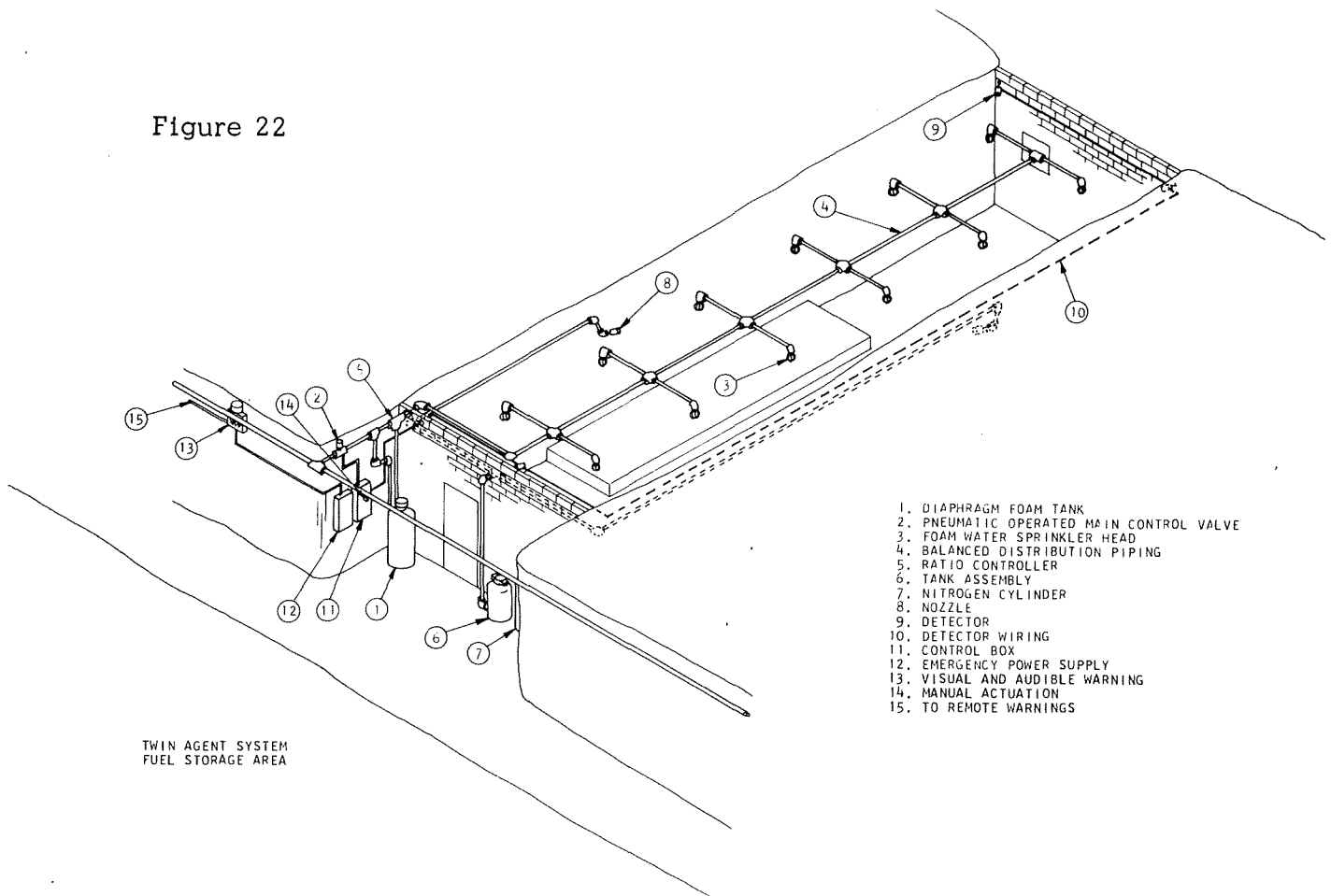
5.13.1.1 Detection Sub-System

The recommended detection for the fuel storage area is ultraviolet with the option of optical integrity for maintaining the detection integrity. Since the typical field of view of most UV detectors is maximum through the forward 90° , with useful vision on some units to 180° , a minimum of two detectors should be used to protect the storage area. However, for the representative storage area shown with a large storage tank and many smaller drums, three or four detectors should be used to properly overlap each other's vision and "see" around the drums (Figure 22). Cross-zoning would not be recommended since the two sources of nuisance alarms, sunlight and arc welding, would not be present in the storage area.

5.13.1.2 Control Sub-System

The control sub-system for the enclosed storage area will provide detection/actuation interface for the automatic fire suppression sub-system (Figure 22). It will also provide means for manual actuation or manual abort of system actuation. It will be capable of using mine electrical supply and emergency battery power. Upon a signal from

Figure 22



the detection system or manual actuation, the control unit will provide for automatic shutdown of electrical power and will also supply a means of closing automatic fire doors if not normally closed.

As a safety measure, both audible and visual alarms will be actuated locally outside the storage area and also remotely at a normally occupied control station.

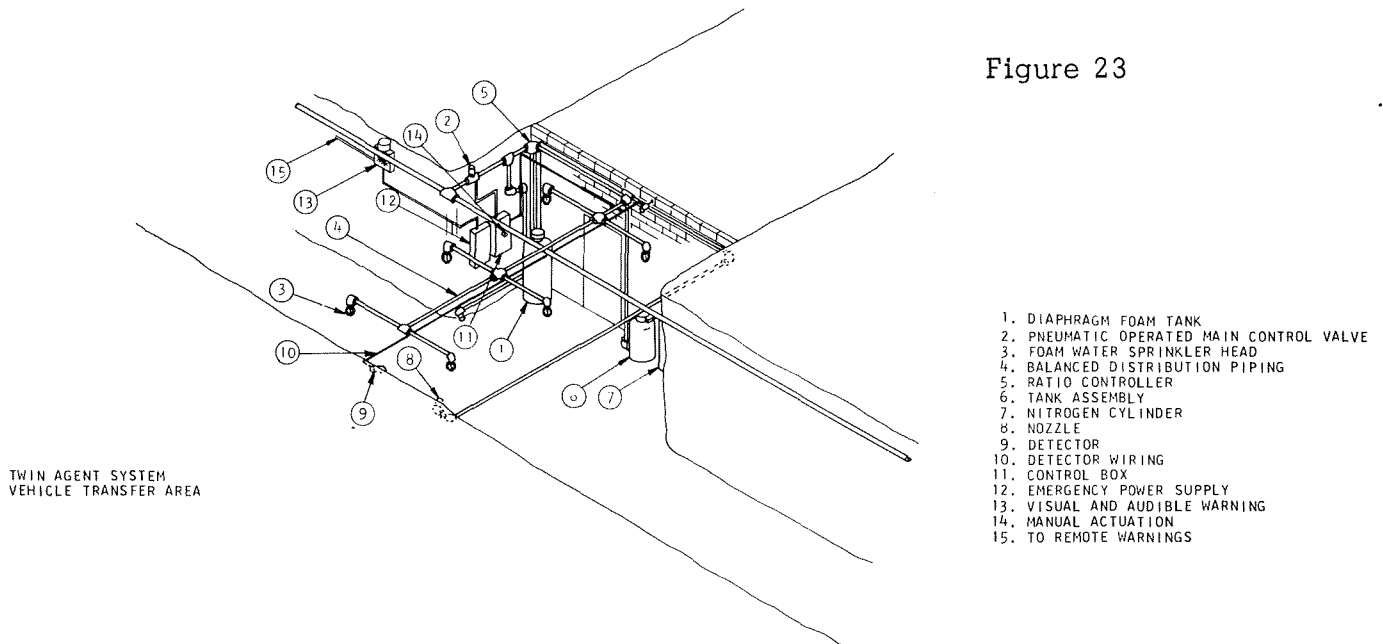
5.13.1.3 Fire Suppression Sub-System

The actual fire suppression sub-systems recommended for the enclosed storage area will include the systems used in the trade-off study with the exception of the water sprinkler. This system is not recommended as a design concept because of the low effectiveness rating it did receive. A water sprinkler system will usually extinguish a burning combustible liquid with a flash point above 200°F, however, only control can be expected when a system is operating on burning fuels with lower flash points.

Sub-systems utilizing AFFF (Figure 17), high expansion foam (Figure 19), Halon 1301 (Figure 20), and dry chemical (Figure 21), will all be alternate design concepts for the enclosed storage area. A fifth sub-system (Figure 22) will be a twin agent concept combining AFFF and dry chemical. The twin agent system will be the most effective of all the design concepts, combining the rapid flame knockdown of the dry chemical with the excellent securing ability of the AFFF.

5.13.2 Vehicle Transfer Area

The vehicle transfer area will include the area in which fuel is placed in the vehicles, as well as any adjacent open area that contains tanks, drums, or cans of combustible liquids. The transfer area will not include any area with storage of combustible liquids that is separated from it by a wall or rib. More efficient fire suppression will be obtained and the hazard in the vehicle transfer area decreased if all combustible liquid storage is eliminated from the area.



5.13.2.1 Detection Sub-System

To properly protect the fuel transfer area (Figure 23), a minimum of two UV detectors should be installed, one on either side of the vehicle parking area. These detectors should be mounted at the roof and aimed downward toward the vehicle parking area and would be considered a single zone of detection. The two units could be cross-zoned to minimize the chances of a nuisance alarm which could prematurely cause the suppression system to operate. If the transfer area is near a maintenance area, shielding from radiation due to arc welding must be provided.

5.13.2.2 Control Sub-System

The control sub-system should be similar to that of the storage area, incorporating manual actuation, shutdown of electrical power in the fuel area, the ability to operate off normal mine and battery power, and the actuation of local and remote, visual and audible warning devices (Figure 23).

This control unit will provide the means for automatic actuation of the fire suppression sub-system when given a signal by the detectors.

5.13.2.3 Fire Suppression Sub-System

The recommended design concept for the vehicle transfer area will be the twin agent unit utilizing the quick flame knockdown of dry chemical combined with the securing ability of AFFF (Figure 23). Because of the high hazard area and the presence of personnel, the most effective and quickest reacting system is required. The dry chemical will be applied with a local application principle, aimed primarily at any possible sources of pressure fires in the fueling equipment and to sweep top and bottom of the vehicle. The AFFF system will be actuated simultaneously and will blanket the entire area and equipment to prevent reflash after extinguishment with dry chemical.

6.0

DESIGN OF A PROTOTYPE SYSTEM FOR A MINE INSTALLATION

The prototype system design was based on the following design concept as developed in Section 5.0:

- A closed storage room system shall utilize multiple, ultraviolet (UV) fire sensors and one of the following fire suppressant agents: aqueous film-forming foam (AFFF), Halon 1301, high expansion foam, ABC dry chemical, or a twin agent system (dry chemical plus AFFF).
- An open fuel transfer area system shall utilize multiple UV fire sensors and a twin agent suppressant.

The prototype system was designed to protect an underground fueling and storage area at the Union Carbide Corporation Pine Creek Mine in Bishop, California. The site, with no separation between the storage and fueling areas, represented the most severe test for a fire extinguishing system and required a twin agent system design in accordance with the design concept.

6.1

General Description of Fueling Area

The installation site, known as the 1576 fuel dock, consists of a combined fuel storage and transfer area (Figure 24). The site is located at approximately 9400 feet above sea level, 7000 feet horizontally from the portal. A pipe storage area is located immediately adjacent to the fuel storage area and both are located in the main haulageway on that level. The area is generally wet and muddy and does not contain any major amounts of Class A flammable material.

The fuel is stored approximately two feet above floor level on a 10' x 12' concrete pad. Normal storage consists of a single 135-gallon portable diesel fuel tank and from two to four 55-gallon drums containing motor oil and hydraulic fluid. The fueling operation is accomplished by a hand pump at the tank which forces the diesel fuel through a flexible hose to the vehicle fuel tank. When the fuel supply is depleted, the tank is transported to the surface for refilling.

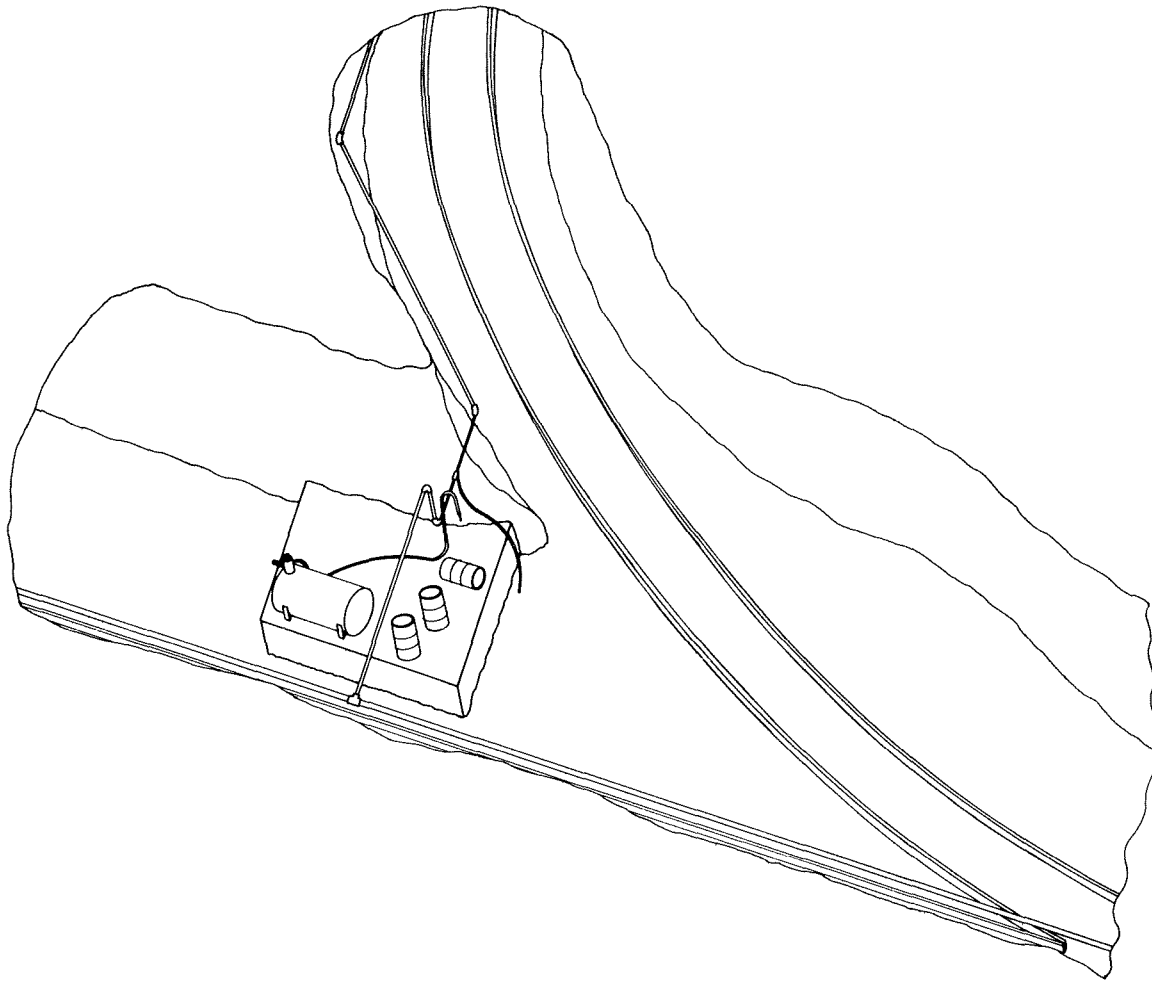


Figure 24 - Schematic of Fuel Storage Area

The general design parameters for the area are tabulated below:

- Environmental

Ventilation Rate:	1 mph
Temperature:	40 - 45°F
Humidity:	90 - 100%

- Physical Dimensions

Approximate Area of Protection: 750 - 800 Sq.Ft.
Overhead Clearance: 10 Ft.

- Approximate Amounts of Combustible Liquids

Diesel Fuel: 135 Gallons
Motor Oil: 110 Gallons
Hydraulic Fluid: 110 Gallons

- Water Supply

4" Main Supply: 200 psi Static Pressure
2" Side Tap (Used for AFFF Water Supply)
Valve and Hose Line Available for Cleaning
Total Hardness: 28.0 mg/L (APHA Standard Method)
pH: 7.1

- Electrical Supply

110 Volt, 20 Amp Lighting Circuit
3 - 200 Watt Explosion-Proof Bulbs Illuminate the Area

6.2 Design of Detection and Control Sub-System

6.2.1 Description

The detection and control sub-system contains ultraviolet detectors monitored by a control panel which provides a pneumatic output to the suppression sub-system when flames are present within the cone of vision of the detectors. A block diagram of the detection and control sub-system is shown in Figure 25.

The detectors are self-contained units that accept 24 VDC and provide both instantaneous and time-delayed Form C contacts as outputs (Figure 26). The control system utilizes the 5-second delay contacts as a zone alarm input, leaving the instantaneous contacts available for additional remote annunciation on a per detector basis if required. The detectors respond to ultraviolet radiation as opposed to heat or smoke and include an "optical integrity" feature allowing

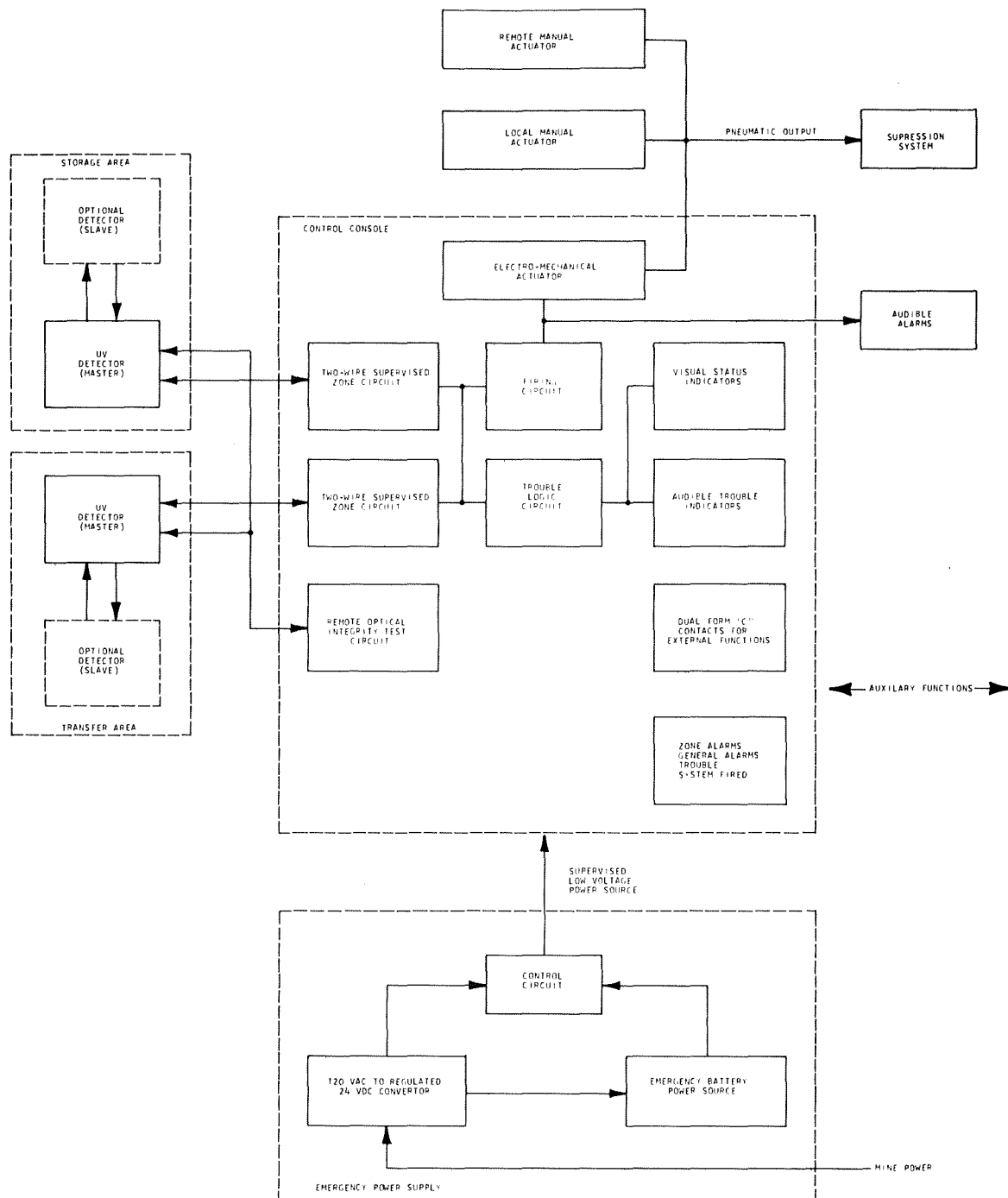


Figure 25 - Detection and Control Sub-System

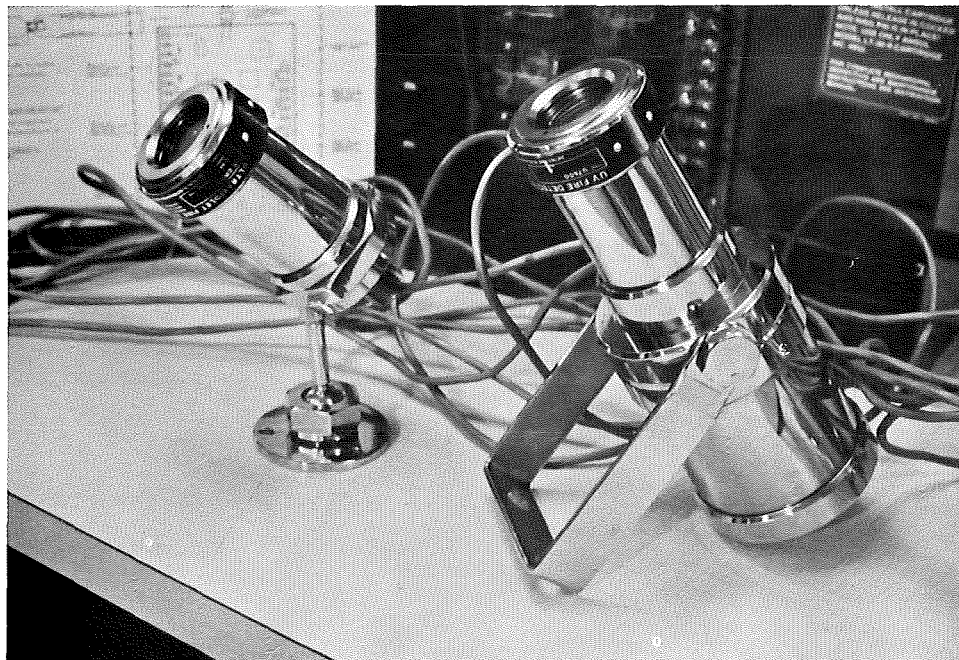


Figure 26 - Ultra-Violet Detectors

remote testing of the condition of their optical lenses. The detectors are housed in an explosion-proof enclosure and are easily installed with integral swivel mounts and brackets. Two detectors are required for this system. They are placed in the fueling area where the 90° fields of vision overlap and each covers the complete area.

The two detectors are cross-zoned within the control unit to minimize false alarms (Figure 27). This means that both detectors must sense the fire before the fire signal passes to the actuation device. The fire signal operates a mechanical releasing device which releases an internally stored pressurized gas to operate the suppression system. The control unit has an internal adjustable time delay to delay actuation of the suppression system a pre-determined time after the alarm input is received. This allows the use of an ABORT function through

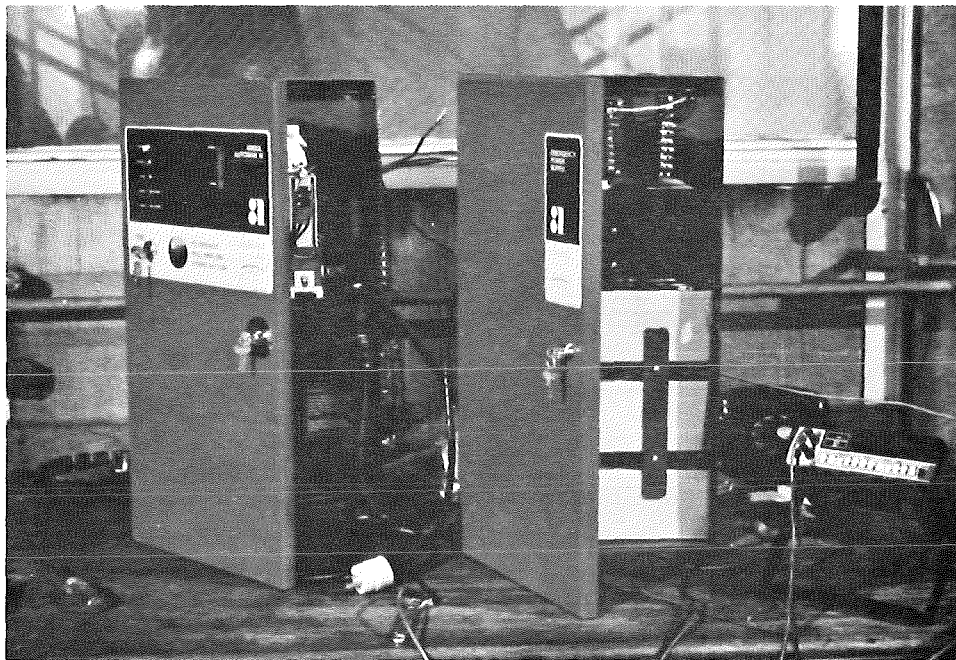


Figure 27 - AUTOMAN III and Emergency Power Supply

the control unit to prevent system discharge in the vent of a false or nuisance alarm, and also provides the capability to use pre-discharge alarms. The control unit also provides additional isolated Form C contacts for common alarm, common trouble, zone alarm, and system fired conditions to accomplish external ancillary functions and remote annunciations. The prototype system will include only local alarms. However, the control unit provides signal outputs which could be wired to a mine control panel.

The control unit is powered directly from an emergency power source which converts primary AC input power to a low voltage DC for the control unit and maintains a float charged secondary standby battery source in the event primary AC is interrupted. The batteries are gelled electrolyte, rechargeable batteries with sufficient energy storage capability to operate the entire system, including alarms and actuation for a period of at least 24 hours.

The control unit also contains a test panel to allow checking the condition of the optical lenses in each of the detectors without having to disarm the suppression system and perform optical tests in the hazardous area.

6.2.2 Specification

The detection and control sub-system requires a single phase, 120 VAC, 47-63 Hz, 1.5 amp input power. It provides two sets of isolated Form C contacts for system alarm, system trouble, system fired, Zone 1 alarm and Zone 2 alarm, with contacts rated 1/10 H.P. 120 VAC, 1/4 H.P. 240 VAC, 5 amps at 28 VDC, or 240 VAC at 80% power factor. It also provides 0.7 amps at 24 VDC for polarized alarm bells or horns and has the capability to provide an ABORT and auxiliary trouble inputs as well as a remote release test input.

Detailed specification sheets for the various components can be found in Appendix E.

6.3 Design of Dry Chemical Sub-System

6.3.1 Description

The dry chemical sub-system consists of three major components. They are the nitrogen power supply, the dry chemical storage container and the distribution system composed of piping and nozzles (see Figure 28). Pneumatic pressure from the control unit cartridge will open all nitrogen cylinders simultaneously, releasing the nitrogen through pressure regulators to pressurize the

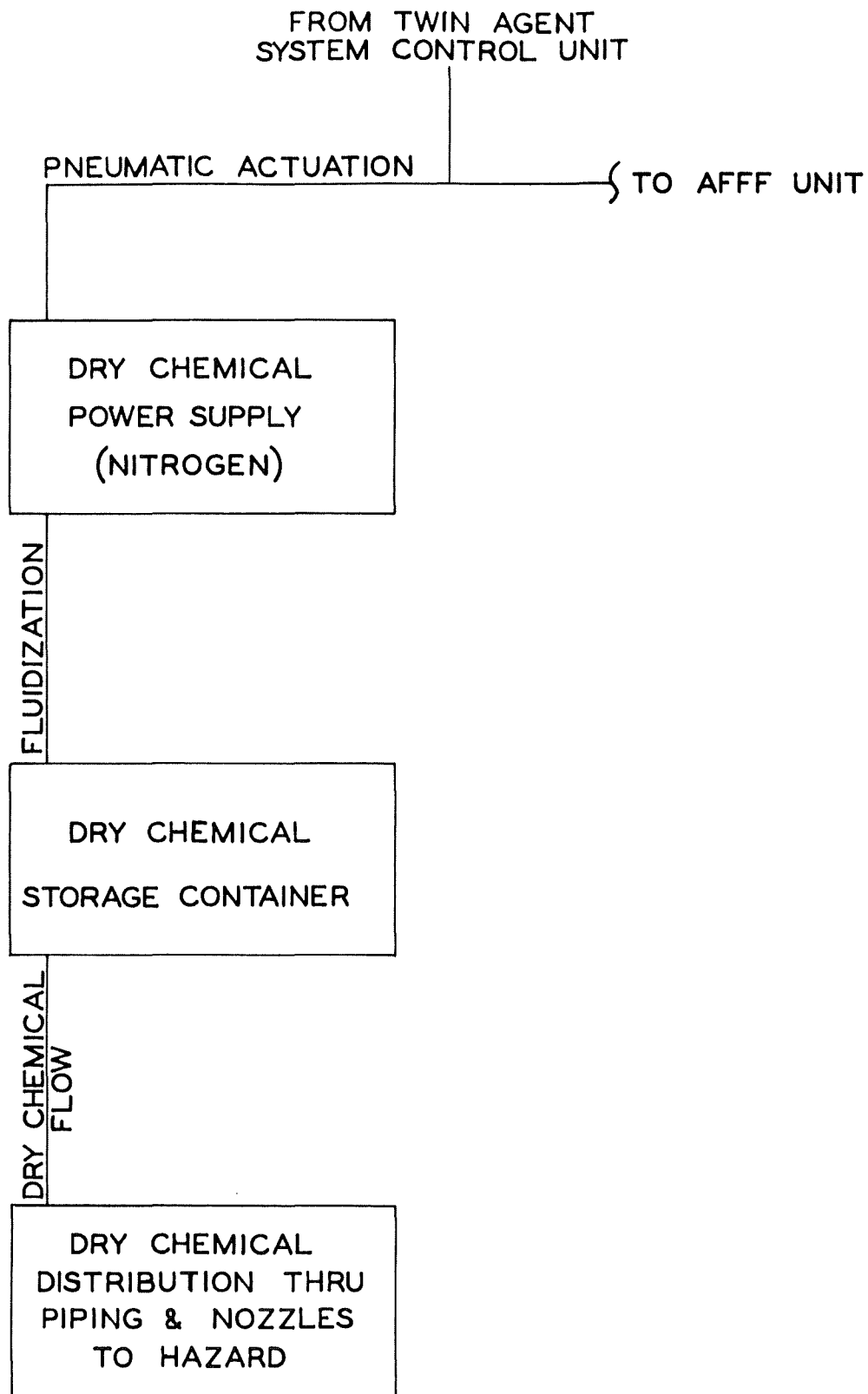


Figure 28

DRY CHEMICAL SUBSYSTEM SCHEMATIC

storage container and fluidize the dry chemical. When the storage container reaches a predetermined pressure, a frangible disc in the outlet piping will burst, releasing the dry chemical into the piping. Pre-aimed stationary nozzles will discharge the dry chemical onto the hazard. Detailed specification sheets for components are included in Appendix E.

6.3.2

Specifications

- Nitrogen Supply

Two pneumatically operated quick-opening nitrogen valves are fitted on DOT 3AA 2400 specification cylinders to provide a high pressure nitrogen supply for fluidizing and expelling the dry chemical. The nitrogen supply is directed through two regulators designed for an inlet pressure of 3000 psi and set to deliver nitrogen at a reduced pressure of 210 to 230 psi to the dry chemical storage container.

- Dry Chemical Storage Container

The dry chemical storage container is of welded steel construction, designed and manufactured to the latest ASME Unfired Pressure Vessel Code with a working pressure of 250 psi.

The tank is fitted with an internal piping arrangement to adequately fluidize the multipurpose (ABC) dry chemical.

The dry chemical tank is fitted with one 4" I.D. fill opening in the top head and is provided with a discharge outlet containing a flanged connection external to the tank. The mating flange in turn secures the bursting disc which will allow pressure to build internally in the tank before allowing the dry chemical to discharge.

The dry chemical tank provides for the storage of 425 pounds of ABC dry chemical.

Dry Chemical Agent

The dry chemical fire extinguishing agent used in this system is multipurpose dry chemical. This agent is suitable for use on fires involving cellulosic type fuels such as wood, paper, plastics, etc. as well as flammable and combustible gases and liquids. Federal Specification O-D-1380A, July 12, 1968, details the composition and physiochemical properties of this type of agent. The agent is a finely divided solid consisting of about 90% by weight monoammonium phosphate. Materials to improve the flow and packing characteristics and reduce the hygroscopicity such as clays, colloidal silicas and polymeric siloxanes constitutes the remaining 10% of the agent formulation. This type of agent is also compatible with AFFF type foam agents in a separate or simultaneous application.

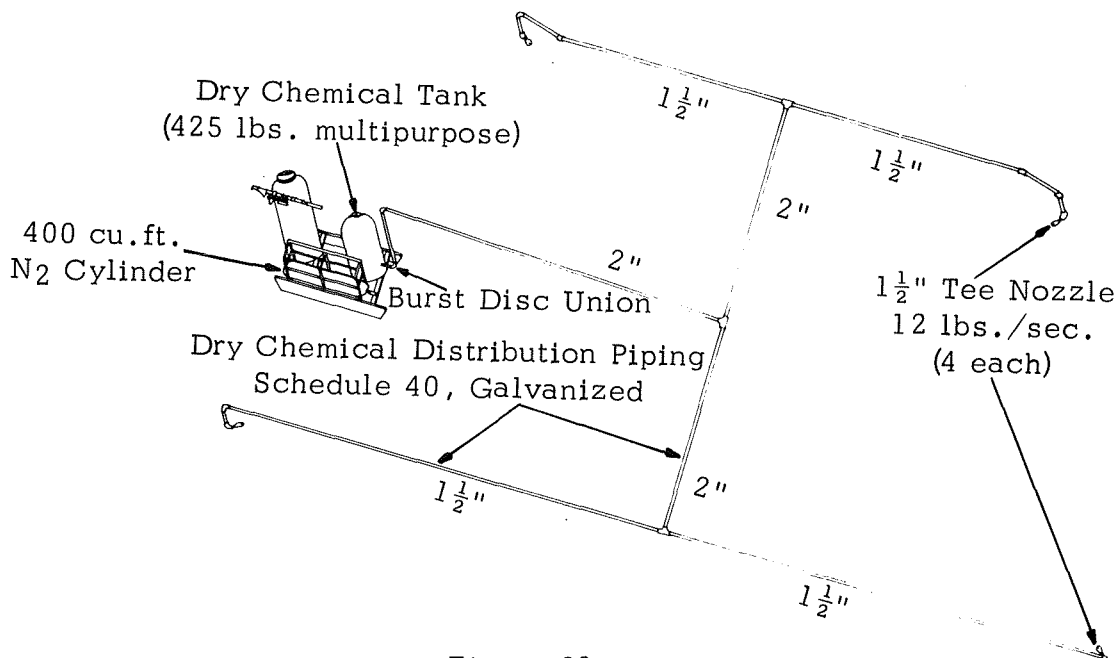


Figure 29
Dry Chemical System Design Schematic

Distribution Piping and Nozzles

The distribution piping for the dry chemical is Schedule 40 hot-dipped galvanized pipe. A balanced piping arrangement is used to distribute the dry chemical evenly to each of four nozzles (see Figure 29).

The four 1½" dry chemical nozzles (see Figure 30) provide a fan-shaped pattern for a large area sweep and will distribute the dry chemical at a flow rate of about 12 pounds per second.



Figure 30 - Dry Chemical Nozzle

- Environmental

The dry chemical sub-system is designed for and can be operated in the temperature range of -40°F to 120°F.

Highly humid or corrosive atmospheres are dealt with by an external epoxy coating on all components. A completely sealed system offers protection against moisture and corrosion internally on tanks, cylinders and piping.

6.4

AFFF Sub-System

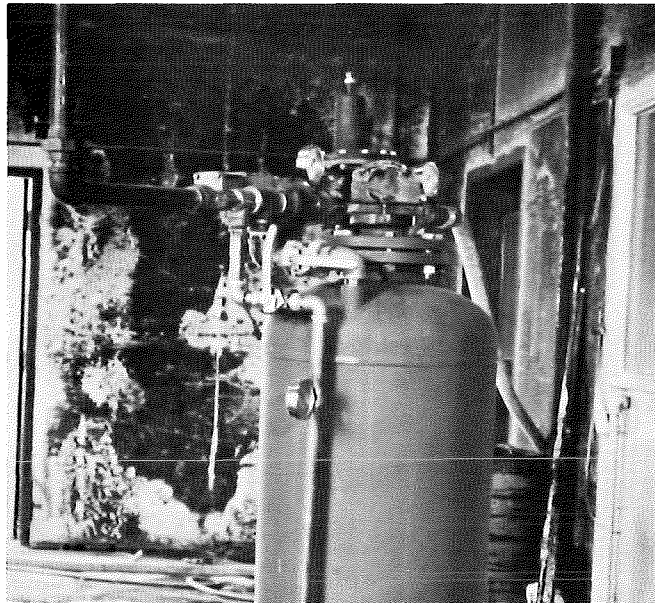


Figure 31 - AFFF Sub-System

6.4.1

Description

The AFFF sub-system contains a main control valve, a water pressure and flow control unit, a concentrate bladder tank, a water-concentrate proportioner and a distribution system of pipe and nozzles (see Figure 32).

The pneumatic pressure from the control unit, while opening the nitrogen cylinders of the dry chemical unit, also reacts on the main control valve of the AFFF sub-system, beginning water flow from the mine water supply line. The flow and pressure of this line are maintained at constant levels through the use of a pressure reducing valve. Actual values depend upon the area coverage and number of foam water nozzles required. This flow of water is

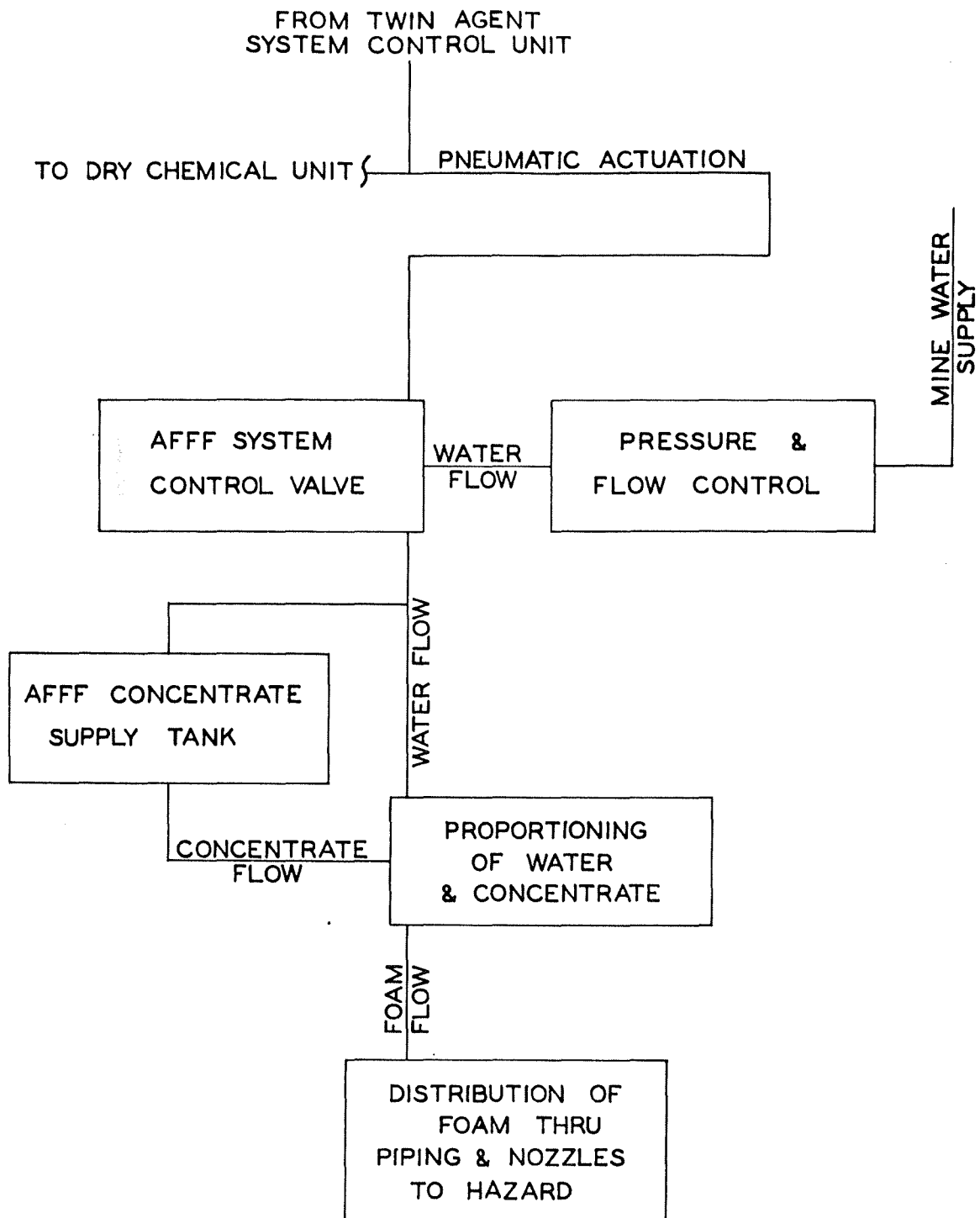


Figure 32
AFFF SUB-SYSTEM SCHEMATIC

used to fill the volume of the bladder tank between the bladder and the tank wall, pressurizing the concentrate inside the bladder. The concentrate is then forced out of the tank and into the proportioner where it is mixed with the main water flow into a solution containing 3% concentrate. The solution then flows through the piping to the nozzles where the air is drawn into it to form the foam which is discharged onto the hazard.

Eight nozzles, each with the standard 100 sq.ft. coverage, are required to cover the fuel area. At the required minimum delivery rate of .1 gpm/sq.ft. of protected area, the 800 sq.ft. fuel storage area requires 80 gpm of foam discharge. A minimum of a 10-minute discharge would require a 24-gallon AFFF concentrate tank. Increasing foam water sprinkler nozzle pressure to 30 psi to provide a higher quality foam would yield 16 gpm/nozzle or .16 gpm/sq.ft. of area. The 800 sq.ft. area would then require 128 gpm and a 40-gallon AFFF concentrate tank for a 10-minute discharge. Utilizing the 70-gallon concentrate tank and operating eight nozzles at 16 gpm/nozzle, the actual foam flow time will be 18.2 minutes. The distribution piping was hydraulically calculated and sized to provide nearly equal nozzle pressures to all eight nozzles. Detailed specification sheets for components are included in Appendix E.

6.4.2

Specifications

- Main Control Valve

The main control valve (Figure 33) is a standard 2" screwed-end Class 600, 1/4-turn ball valve with reinforced teflon seats and stem seals. It is provided with a piston type actuator for pneumatic operation at 300 psi.

- Pressure Reducing Valve

The pressure reducing valve (Figure 34) is utilized to provide constant pressure and flow from the normally high and widely fluctuating pressure of the mine water supply.

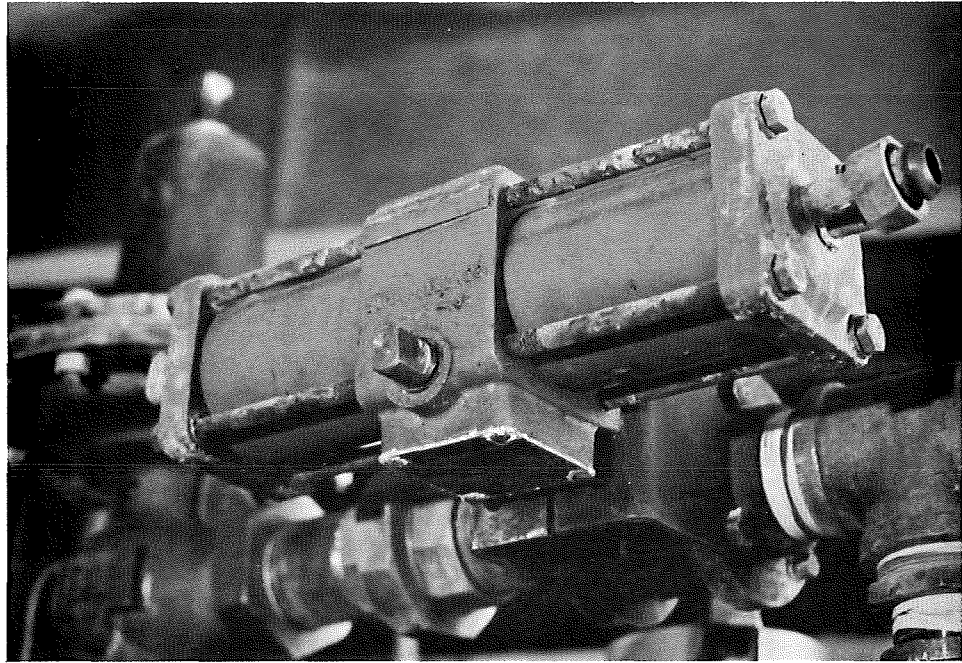


Figure 33 - AFFF Sub-System - Main Control Valve

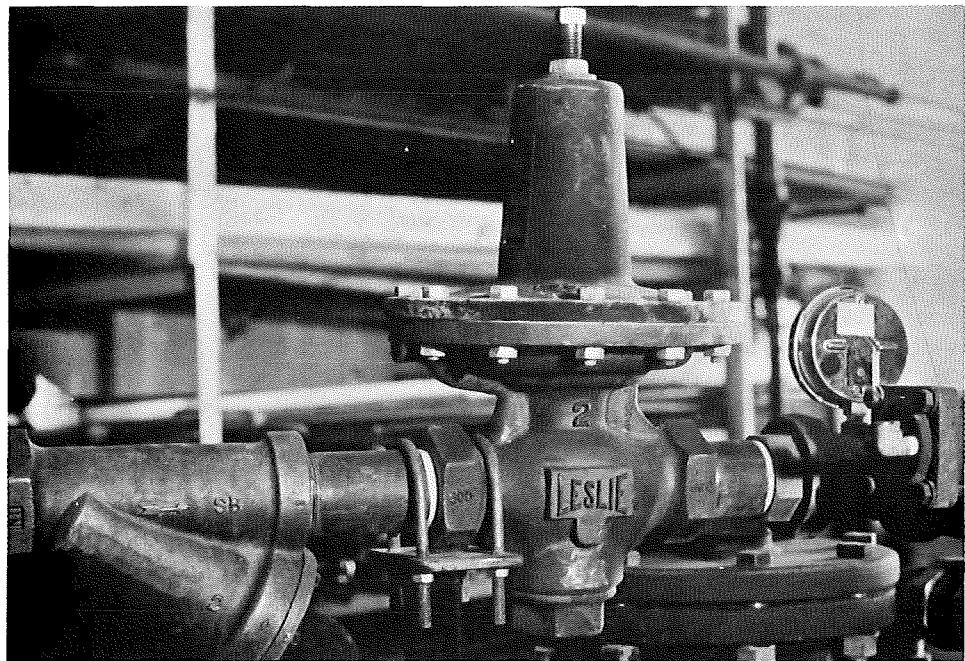


Figure 34 - AFFF Sub-System - Pressure Reducing Valve

The pressure reducing valve is a 2" screwed-end balancing diaphragm type globe valve of cast bronze construction. Maximum inlet pressure is 300 psig with a reduced downstream pressure range of 25-80 psig. The downstream pressure is adjustable and, once set for flow and pressure, can be locked into position. A bronze 2" screwed-end strainer with a stainless screen is incorporated into the line prior to the pressure reducing valve to prevent large particles from jamming or damaging the operating parts. The strainer is fitted with its own valve for purging or the screen can be removed for cleaning with standard wrenches.

AFFF Concentrate Bladder Tank

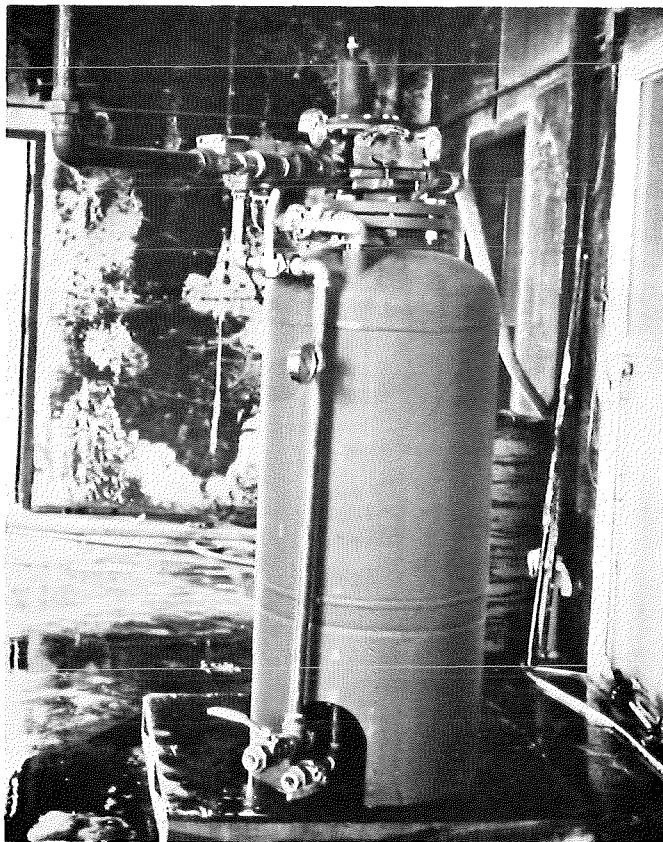


Figure 35 - AFFF Concentrate Bladder Tank

The AFFF concentrate tank (Figure 35) is constructed to the latest Section VIII of the ASME Code for Unfired Pressure Vessels. It has a working pressure of 150 psig and is fitted with flanges at both ends for installation and removal of the bladder. A 4" I.D. fill opening at the top of the vertical tank allows for filling of the bladder with concentrate. The bladder is constructed of nylon reinforced buna-N rubber and is flanged on both ends for fastening of the bladder within the tank.

• Proportioner

The proportioner (Figure 36) consists of a venturi for water flow and an orifice for concentrate flow. The same pressure on the two media forces water to flow through the venturi, creating a pressure drop which allows the correct amount of concentrate to be introduced into the stream depending on the orifice size. Any pressure variations affect both media and the proportion of concentrate will remain constant, in this system at 3%.

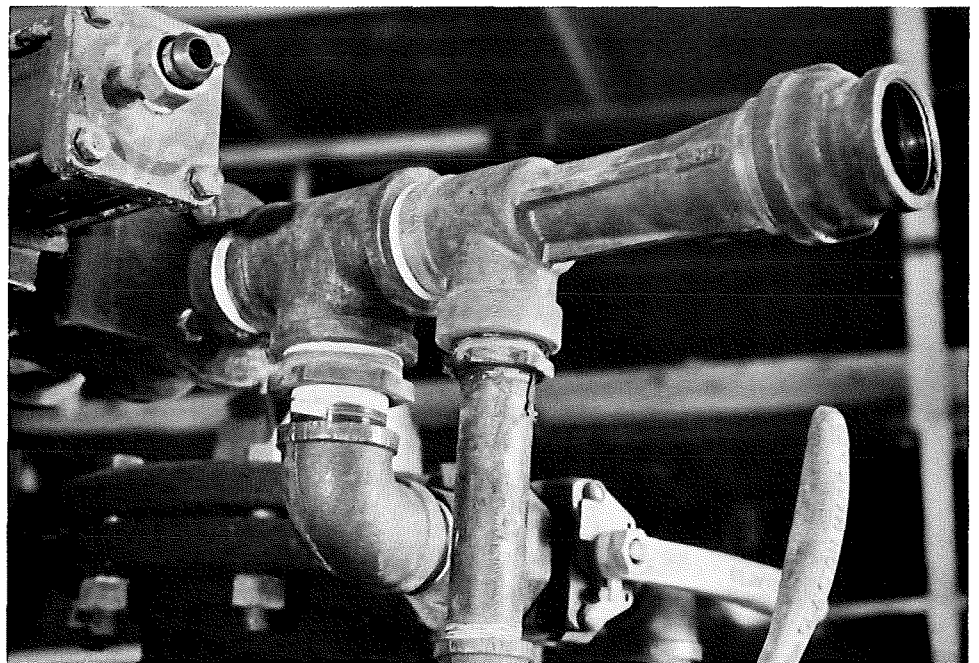


Figure 36 - 3% Foam Proportioner

- AFFF (Aqueous Film Forming Foam) Agent

The AFFF agent used in this system is a 3% type concentrate. It is intended for use by dilution or proportioning at the 3 to 97 volume ratio with water. At present, there are no federal or military specifications covering this type of concentrate. MIL-F-24385A, 2 May, 1977 (U.S. Navy), covers 6% AFFF concentrates and requires performance at 3%, 6%, and 50% concentration before and after aging for 10 days at 150°F of both the concentrate and premixed fresh and salt water solutions.

The 3% AFFF concentrate used in this system meets all of the fire performance requirements of MIL-F-24385A. It also has been tested and found to perform equally well in water having a hardness (Ca & Mg) of 500 ppm. The AFFF concentrate is a mixture of fluorochemical surfactants, hydrocarbon surfactants and solvents. It has been specifically formulated to have low corrosion characteristics on most common metals and low environmental impact (BOD, COD and fish toxicity). This agent is also listed by Underwriters Laboratories for use in foam hardware including aspirating foam sprinkler heads. Proportioning of the AFFF concentrate with water containing sediments such as dirt or rust will not affect the agent adversely but may interfere with proportioning equipment and discharge nozzles.

- Distribution Piping and Nozzles

The nozzles will be aspirating type, upright foam water sprinkler nozzles with 1/2" NPT connections and a 3/8" throat that will provide good quality foam during discharge (Figure 37).



Figure 37 - AFFF Nozzle

The distribution piping for the AFFF sub-system will be Schedule 40 hot-dipped galvanized pipe. The piping arrangement is hydraulically balanced to provide approximately the same pressure and flow at each of the nozzles (Figure 38).

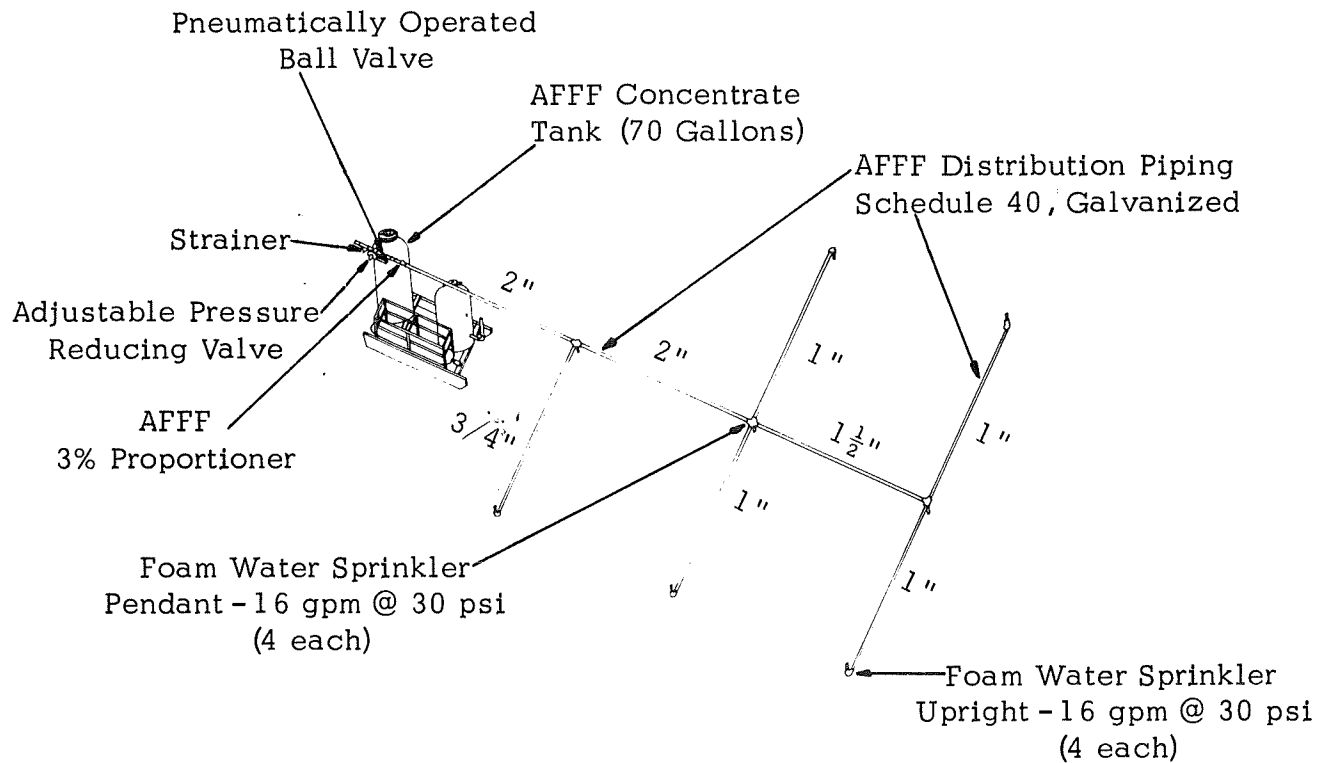


Figure 38
AFFF System Design Schematic

- Environmental

The AFFF system is designed for an operating temperature range of 32°F to 120°F. Because the AFFF solution will freeze, the minimum temperature cannot go below 32°F.

Corrosion protection is accomplished with bronze valves and fittings and brass piping, and the entire unit will be furnished with a special epoxy coating.

6.5

Total System Parts List and Cost

The following equipment is required for the twin agent piped system. The system consists of a two-detector control sub-system with optical integrity feature and back-up power source. The AFFF sub-system is a 70-gallon concentrate tank with pressure and flow control equipment and aspirating nozzles, and the dry chemical sub-system is a 425-lb. multi-purpose (ABC) unit independent of any external power or media supply.

6.5.1

Detection and Control Sub-System

<u>Qty.</u>	<u>Manufacturer</u>	<u>Mfgr.'s P/N</u>	<u>Description</u>
1	Ansul	26408	AUTOMAN III Control Unit
2	Ansul	25946	End-of-Line Module
2	Ansul	17818	3-Wire Zone Card
1	Ansul	28421	Actuation Line Orifice Vent Plug
1	Ansul	5873	Nitrogen Cartridge
1	Ansul	-----	OI Test Sub-Panel
1	Ansul	25977	Emergency Power Supply
3	Ansul	26300	Battery Pack
1	Detronics	U7600B3201	UV Detector, 24 VDC, w/OI
1	Detronics	C7050B3002	UV Detector w/OI
1	Detronics	Q9001B1007	Swivel Mount Assembly
2	Ansul	33051	Flush-Mount Alarm Horn

In addition to the above-listed equipment, proper rigid steel conduit and fittings suitable for hazardous locations, as well as interconnecting wire and shielded twisted pairs, will be required for the installation. Additional accessories, remote indicators, etc., can be added to the system as required for the given installation.

The total cost to mine operator of the detection and control sub-system will be approximately \$2900.

6.5.2

Dry Chemical Sub-System

<u>Qty.</u>	<u>Manufacturer</u>	<u>Mfgr.'s P/N</u>	<u>Description</u>
1	Ansul	19901	Tank
1	Ansul	3116	3" Safety Head
2	Ansul	28592	400 Cu.Ft. N ₂ Cylinder
1	Ansul	X-31975	Skid
2	Ansul	14798	Pressure Regulator
4	Ansul	X-32051	1½" Tee Nozzles
			Misc. Piping, Valves and Fittings

The dry chemical sub-system will require 2" and 1½" pipe from unit to nozzles, with accompanying hangers and supports. Total cost to the mine operator for the dry chemical sub-system will be approximately \$2620.

6.5.3

AFFF Sub-System

<u>Qty.</u>	<u>Manufacturer</u>	<u>Mfgr.'s P/N</u>	<u>Description</u>
1	Ansul	X-31946	75-Gal. Diaphragm Tank
1	Ansul	X-31945	Diaphragm
1	Leslie	Model W2	Pressure Reducing Valve
1	Leslie	Type S	Strainer
1	Contromatics	C-1611-AA	Pneumatic Ball Valve
1	Feecon	Model C 79202520	Proportioner
12	Grinnell	Issue B-1	Foam Water Sprinkler
			Misc. Piping, Valves and Fittings

Additional piping, ranging in size from 2" to ¾", will be required during installation. The total mine operator cost for the AFFF sub-system will be approximately \$4620.

6.5.4

Total System Cost

The total mine operator equipment cost for the automatic twin agent piped system will be approximately \$10,140.

Installation costs may be estimated at approximately \$3,000. However, this will vary widely with location and installer.

Again, this particular unit size has been designed to protect an above average size fueling area; therefore, the majority of such installations should result in a lower than stated cost.

7.0 SYSTEM EVALUATION

Where deemed necessary by insufficient history related to performance in an underground mine environment, component and system tests were performed. The initial system tests were performed prior to the selection of Pine Creek Mine as the field demonstration site. After the selection of Pine Creek Mine, the actual system piping was assembled as it would be in the mine and fire tests were performed duplicating the mine test sequence.

The component and system tests are described in detail in Laboratory Test Reports T-3608 and T-3683, which are included as Appendices F and G.

7.1 Detection and Control Sub-System

7.1.1 Component Testing

All of the component parts of the detection and control sub-system have been extensively tested and are listed by Underwriters Laboratories, Inc. The ratings and limitations of the UV detection system and the capabilities of the emergency power supply and control equipment are pre-defined by UL.

7.1.2 Sub-System Testing

The entire sub-system has been assembled and limited operational tests have been performed to ensure proper operation. In addition, the detection and control sub-system was used as the detection, control and actuating system during full-scale fire tests of the suppression system at Ansul.

7.2 Dry Chemical Sub-System

Due to previous testing and past history on installations, the dry chemical unit is considered to be rugged and corrosion-resistant enough to withstand the atmosphere and hard usage that it will encounter underground. Components of the system such as cylinder, valves, hoses, gauges and other equipment have all undergone salt-spray, shock, vibration and operational tests to obtain Underwriters Laboratories approval, along with Coast Guard marine listing. Dry chemical installa-

tions on offshore platforms have been exposed to severely corrosive environments and the units have functioned for extended periods in these environments.

7.2.1

Component Testing

The nozzle was the only component which required testing as a component. This particular nozzle, although tested on larger equipment, has not been coupled with this particular dry chemical unit; consequently, flow rates, range and nozzle pattern had to be determined.

The test set-up of Figure 39 was assembled and instrumented to measure weight loss (for determination of flow rate) and pressures throughout the length of the piping from unit outlet to the nozzle. During discharge the nozzle range and pattern were observed to be a minimum of 36' and approximately 180° fan pattern.

7.2.2

Sub-System Testing

The twin agent system tests in Section 7.4.1 were run with 850 pounds of ABC dry chemical. These tests indicated that for the smaller demonstration test site, which has a low ventilation rate, a smaller dry chemical unit would be suitable. Consequently, the test set-up of Figure 40 was assembled using the dry chemical tank which stores up to 425 pounds of ABC dry chemical.

A 50 sq.ft. pan was used with 2" of heptane for fuel and the mine vehicle mock-up set on top of the pan to simulate a spill during fueling. Only two of the four nozzles were situated to bear on the fire.

Preburn time was approximately 20 seconds, with extinguishment being accomplished within 4.2 seconds of the beginning of dry chemical discharge. Total discharge time was approximately 15 seconds.

The unit performed satisfactorily and could be used if the vehicle transfer and storage area were of such size to require only a 425-lb. unit.

7.3

AFFF Sub-System

The AFFF sub-system was designed with new updated hardware and improved components with corrosion resistance

as the major consideration. The basic system principle is current state-of-the-art in use and available through many manufacturers.

The special components selected, such as the main control valve and the pressure reducing valve, were selected mainly by materials of construction and simplicity of operation. As far as could be determined, none of these components had ever been subjected to the recommended testing of the approval agencies; therefore, the test program on each was carefully selected.

7.3.1

Component Testing

- Pneumatic Ball Control Valve with Actuator

Operational testing on the pneumatically operated control valve consisted of obtaining the torque output from the actuator at varying inlet actuation pressures (Figure 41). The valve was operated 26 times while measuring the torque outputs.

The results of the salt spray brought a decrease in torque output significant enough to cause concern. Therefore, a new actuator was obtained, with a few minor additions, to prevent corrosive atmospheres from affecting the internal parts of the actuator. Gaskets and plugs were used to seal joints and "O" rings were added to the actuator shaft to eliminate seepage between the shaft and body.

A second salt-spray test on the redesigned actuator gave satisfactory results.

- Pressure Reducing Valve

The objective of the pressure reducing valve testing was to determine pressure setting vs. flow and pressure of the reducing valve. The data, as shown in Appendix F, can be used as a guide in presetting the valve before installation, knowing the mine water supply pressure and the flow required. Operational tests after installation should require a minimum of adjustment.

No problems were encountered with operation during any of the tests and the pressure reducing valve provided leak free operation and consistent reduced pressures downstream (Figure 42).

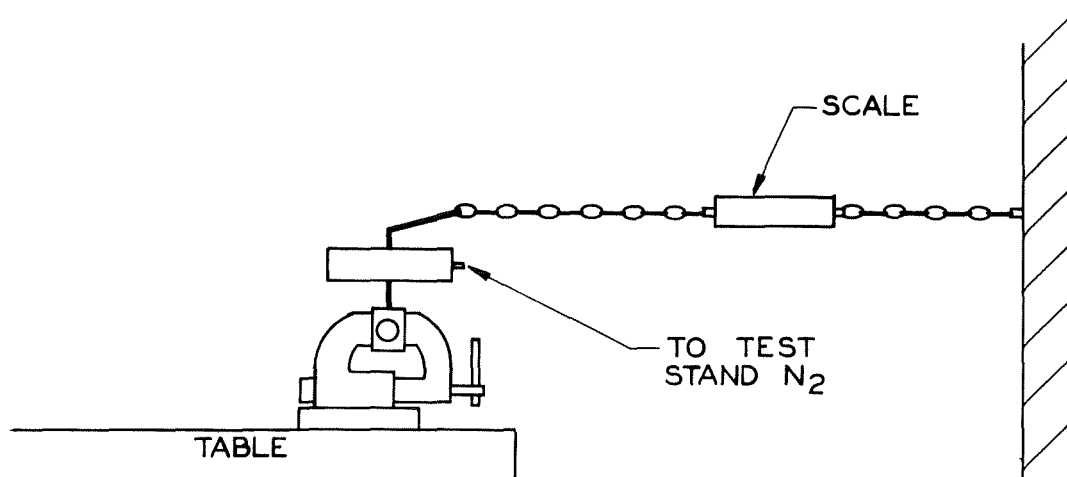


Figure 41

TEST SET-UP PNEUMATICALLY OPERATED CONTROL VALVE AFFF UNIT (TORQUE OUTPUT)

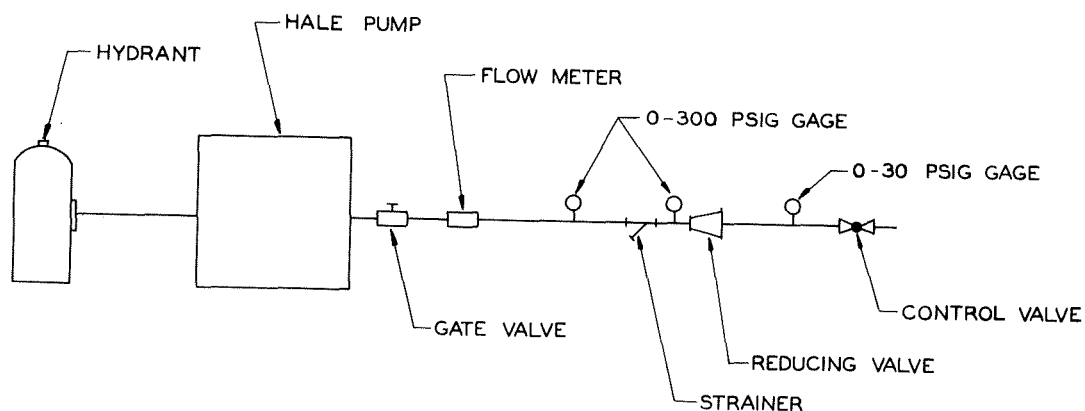


Figure 42

TEST SET-UP LESLIE PRESSURE REDUCING VALVE AFFF UNIT FLOW, PRESSURE SETTING RELATIONSHIP

- AFFF Nozzles

A series of nozzles were tested with regard to foam quality, range and pattern, and pressure vs. flow. Standard upright and pendant sprinkler heads were used, as well as upright and pendant foam water sprinklers (aspirating nozzles).

As the data indicated, the aspirating nozzles did not have quite as much coverage as did the standard sprinkler heads, however, that coverage loss was compensated for by the greatly increased foam quality observed. Coverage on all nozzles was more than the 100 sq.ft. advertised and, on average, expansion and drain time were almost doubled with the aspirating nozzles.

Selection of the upright aspirating nozzle was based on this data as well as sub-system testing.

7.3.2

Sub-System Testing

The AFFF sub-system testing consisted of the complete sub-system set up for manual actuation, as shown in Figure 43. Three nozzles were selected and each one was tested per the UL test procedure for foam water sprinklers.

A 50 sq.ft. pan with 1" of heptane and 8" of freeboard was used for the fire. Foam was discharged for ten minutes from four nozzles, with extinguishing time as one of the comparable variables.

Following the foam discharge, water was discharged on the foam blanket for a period of 20 minutes, at which time a reflash test was conducted.

As indicated by the data, the foam water (aspirating) sprinkler was far superior, completely re-extinguishing the one sq.ft. fire ignited in the foam-covered pan. Operation of the valving and bladder tank was completely satisfactory so the final phase of the initial test plan was initiated.

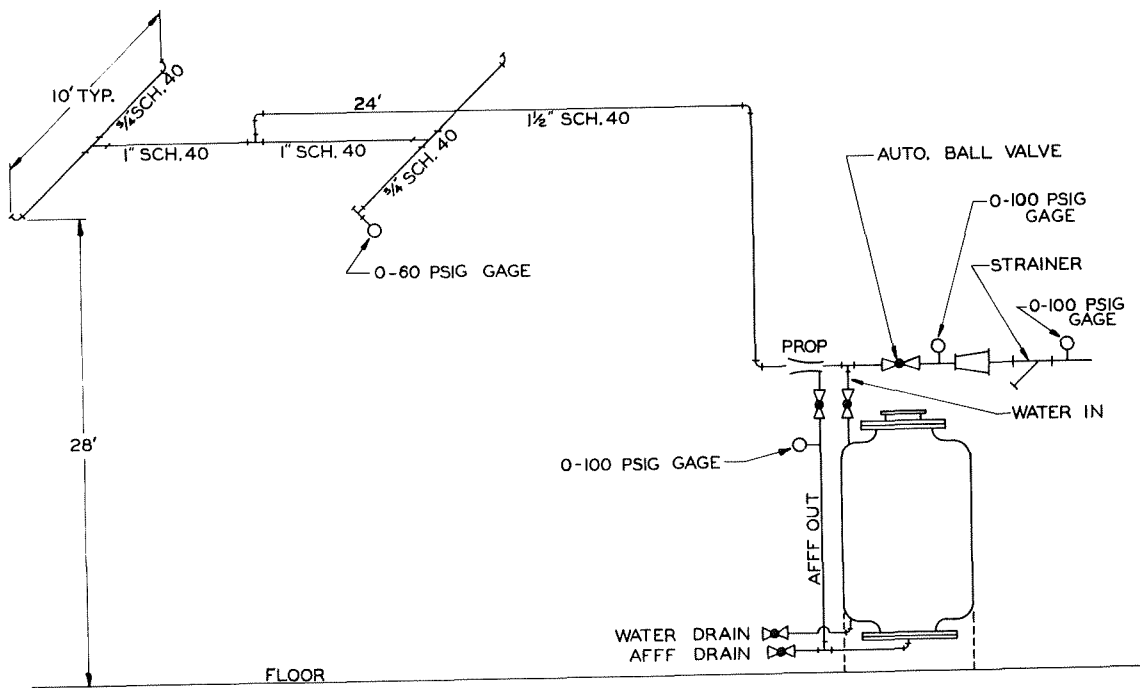
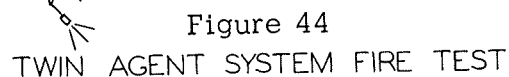


Figure 43
AFFF FIRE TESTING (NOZZLE PERFORMANCE)

7.4 Total System Fire Tests

7.4.1 Preliminary System Tests

This series of tests was performed prior to the selection of the field demonstration test site. Thus, the general piping configuration and the size of the dry chemical unit differ from the final design of the prototype system. The test configuration is illustrated by Figure 44.



The fire hazard consisted of a 50 sq.ft. pan fueled with 2" of heptane with 6" of freeboard. A vehicle mock-up was situated directly over the pan to simulate a fire under a vehicle during the fueling operation. The mock-up also provided an obstacle, a definite disadvantage for the system. Prior to system actuation, the heptane was ignited and allowed approximately a 15-second preburn which gave total involvement. Heptane was used instead of diesel

fuel for ease of ignition and also because of higher volatility, giving a much hotter flame and increasing extinguishing difficulty.

The AFFF sub-system was installed with four nozzles in a grid spaced 10' apart and suspended 10' directly over the hazard. The system operating pressures and water flow rates were recorded. Information relating to nozzle pressure vs. flow was used to set the required nozzle pressure by selecting the desired flow. The entire unit was set in the automatic mode with the actuation line connected to the ball valve.

The dry chemical unit was installed with two nozzles aimed at the hazard and two additional nozzles aimed elsewhere for a total system effect. Data obtained on the dry chemical unit included weight loss measurements (for determination of flow rate), pipe pressure readings, and nozzle pressures. All were recorded on a continuous read-out strip chart recorder. Range was obtained and photographed on one of the extra nozzles. The dry chemical sub-system was also in the automatic mode for pneumatic actuation.

System actuation was provided by pneumatic actuation lines run from the AFFF and dry chemical sub-systems to the control unit.

7.4.1.2

Fire Test

The fire was ignited and allowed a 15-second preburn. At 15 seconds one detector was aimed at the fire and instantaneously actuated the control unit. The AFFF flow began immediately with pure water for the first five seconds and, once stabilized, foam flow thereafter. The cooling effect of the foam was noticed shortly thereafter with a slight decrease in flame intensity.

When the AFFF control valve was opened, the nitrogen cylinder valves on the dry chemical unit simultaneously opened, beginning pressurization of the dry chemical tank. A 12-second delay is built into the dry chemical unit by use of the burst disc, allowing the pressure to build in the tank and

fluidize the dry chemical. This will delay the discharge and allow personnel to vacate the area, as the dry chemical discharge will completely obscure vision. Therefore, the 12-second delay during the sounding of the audible and visual alarms should alert personnel to the fire condition and the pending discharge.

The time span between the bursting of the disc and complete extinguishment was approximately three seconds. Total time from detection to extinguishment, during which time foam flow was already starting control, was approximately 15 seconds.

The fire test sequence is illustrated by Figures 45-52.

The successful total system test concluded the initial test program for the twin agent system.

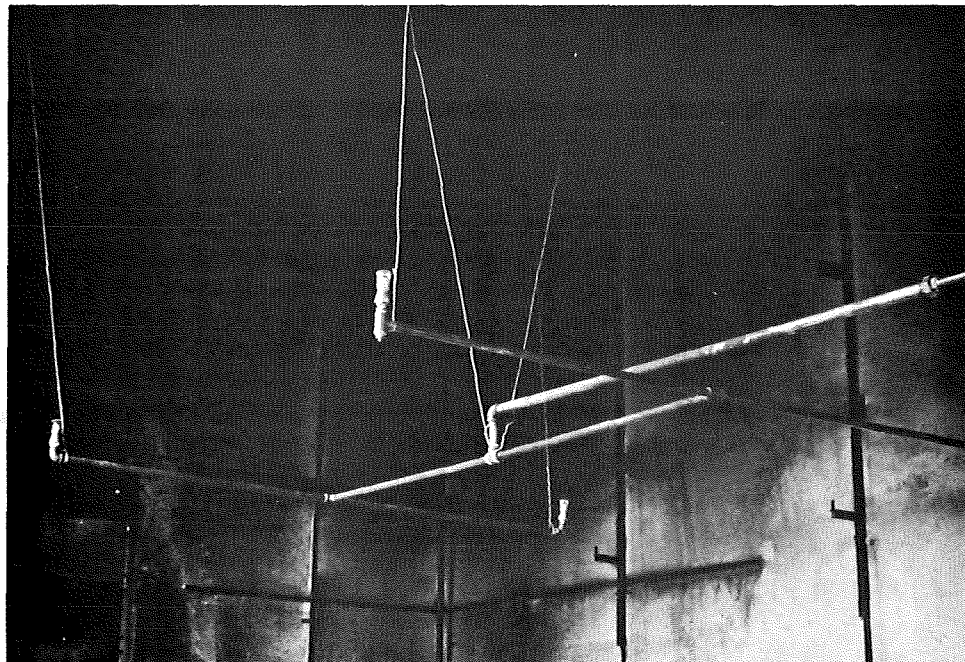


Figure 45 - AFFF Piping

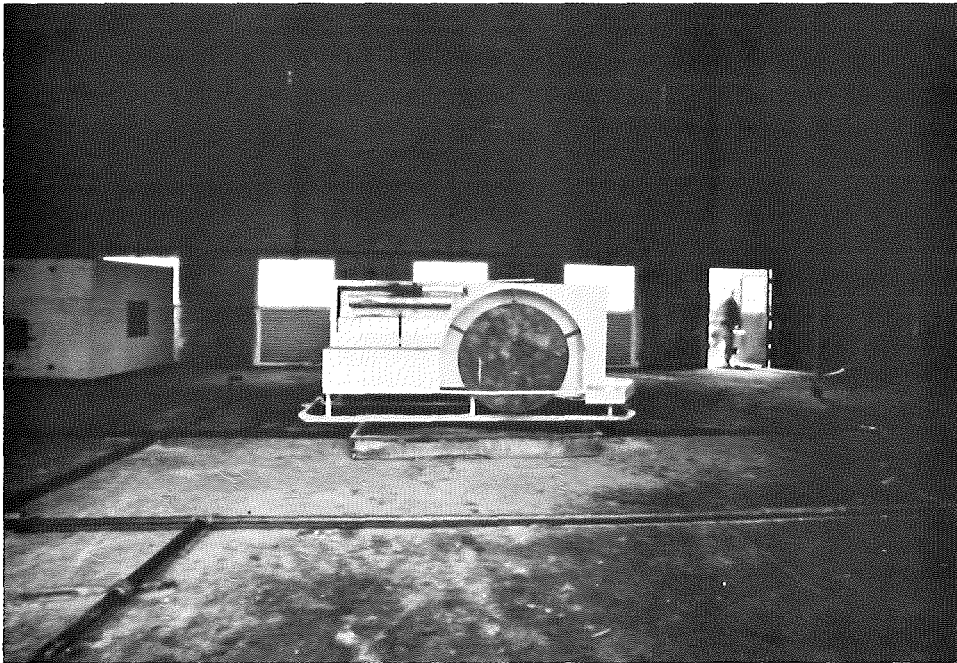


Figure 46 - Dry Chemical Piping and Mock-Up

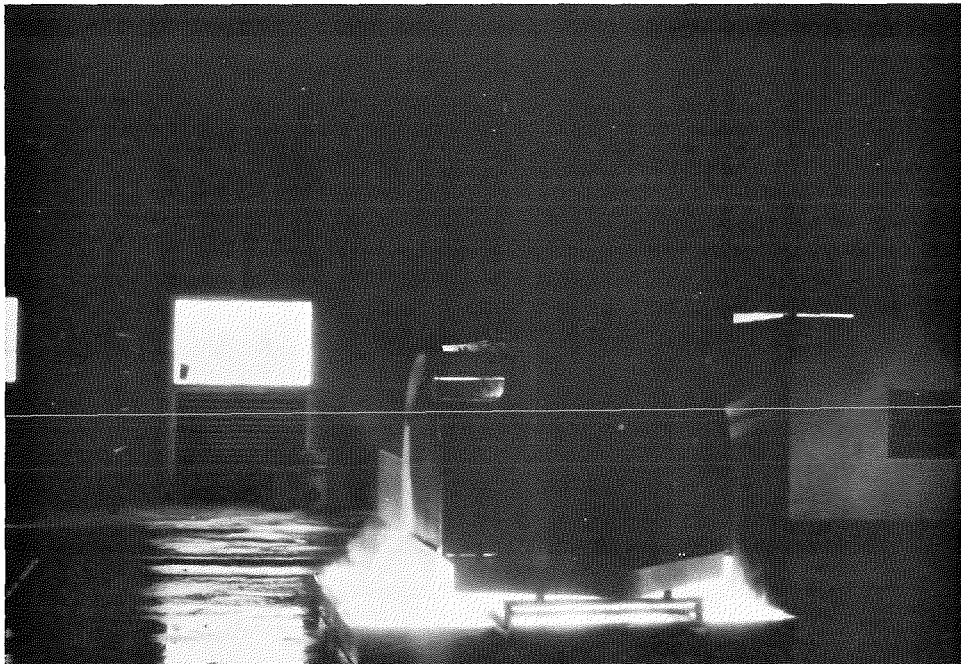


Figure 47 - Fire Ignition

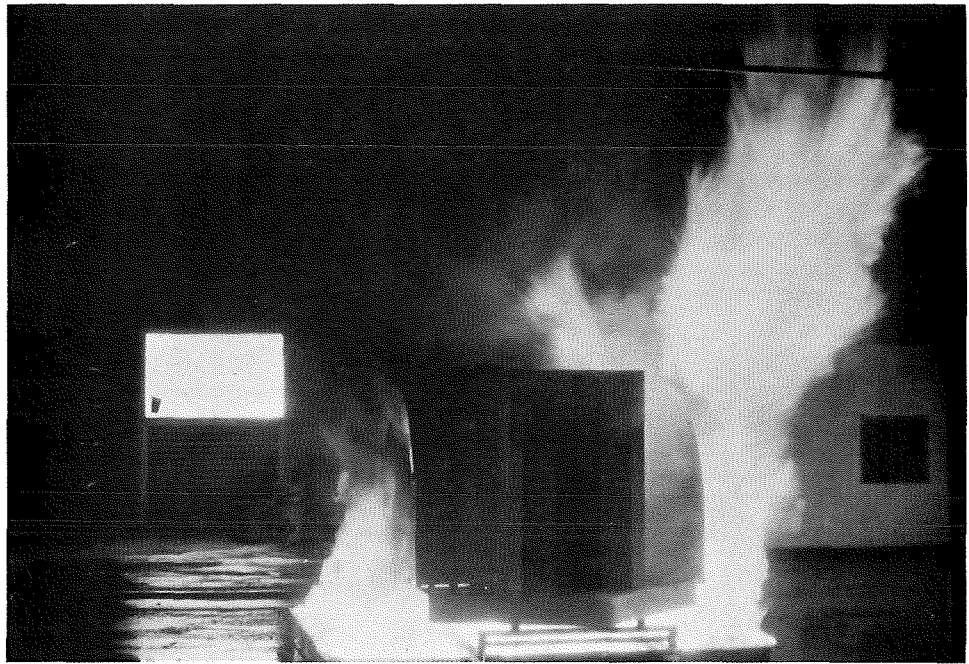


Figure 48 - Preburn

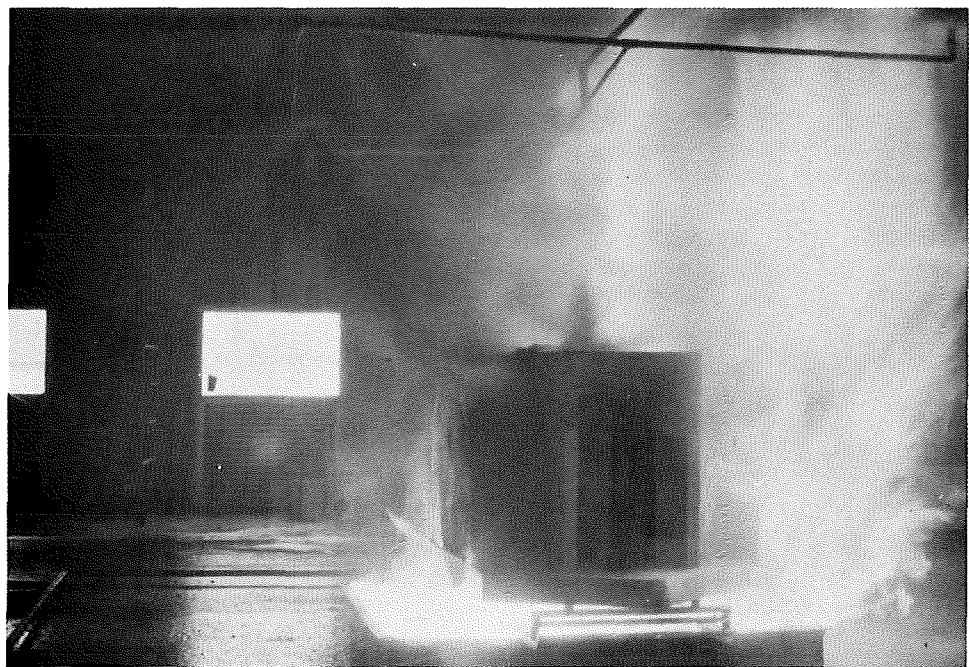


Figure 49 - Actuation

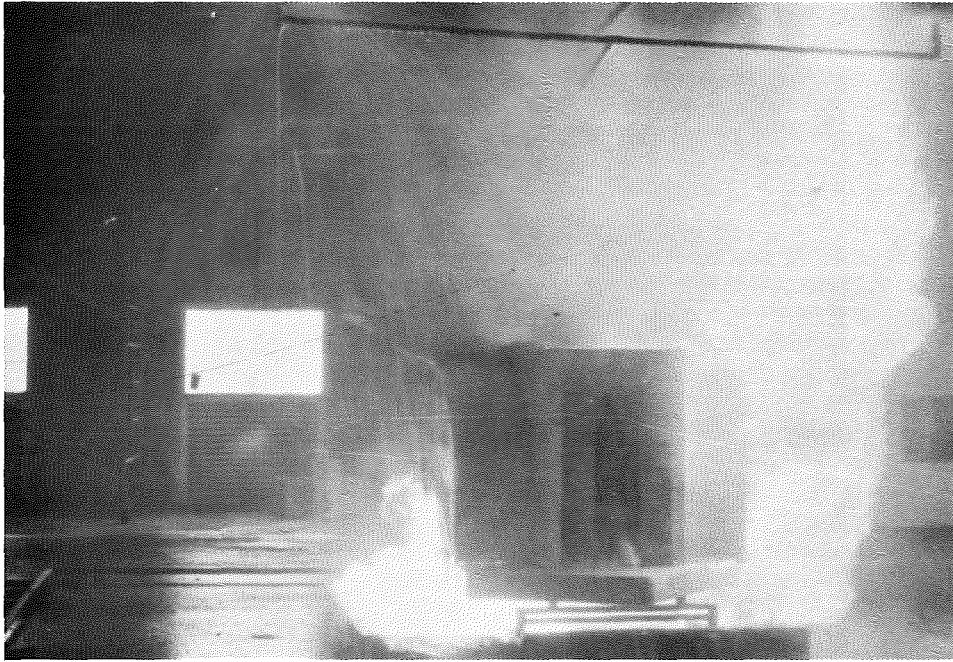


Figure 50 - Foam Discharge , Initial Securement



Figure 51 - Dry Chemical Discharge , Extinguishment



Figure 52 - Foam Securement After Extinguishment

7.4.2 Tests of Prototype System

After the selection of Pine Creek Mine for the field demonstration, a series of fire tests were performed which included the specific tests to be performed underground and using the precise distribution piping layout of the mine installation.

7.4.2.1 Test Configuration

Testing of the system was accomplished outdoors, with one objective being to obtain some indication of wind or ventilation effects on the system. The actual system piping layout as it would be installed underground was assembled and supported at approximately a 10' height. All galvanized piping was utilized and, following the testing, was dismantled and used in the actual installation underground. Actuation of the system was manual and the supply water for the foam system was obtained from the local City water supply. The test configuration is illustrated by Figure 53.

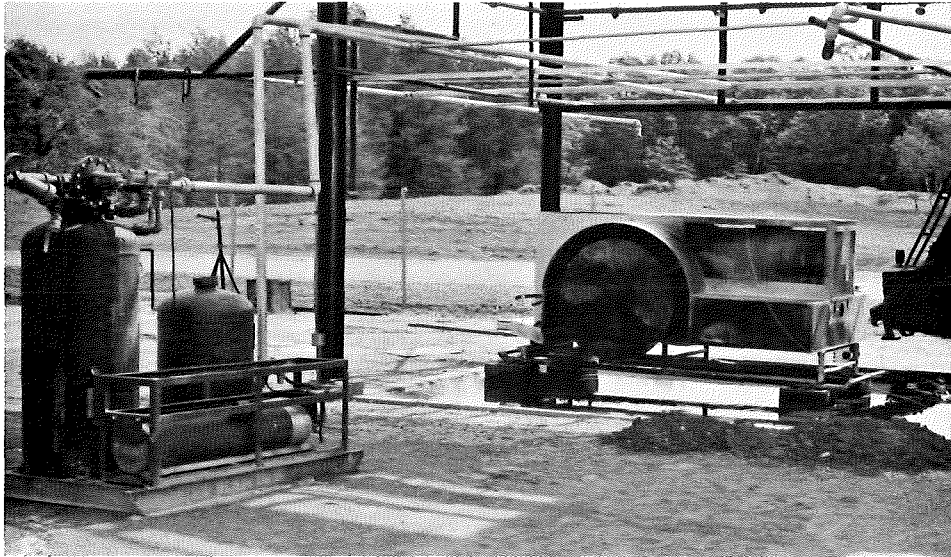


Figure 53 - Prototype System Test Configuration

7.4.2.2

Fire Testing

The testing consisted of a complete rehearsal of the proposed underground testing. In addition, a more stringent fire test was conducted utilizing a full 10' x 15' gasoline spill and during which the wind conditions were monitored. Refer to Laboratory Test Report T-3683, Appendix G, for specific test parameters and results.

- Fire Test No. 1

During Fire Test No. 1 only foam was applied. The fire consisted of a 2' x 3' pan containing water and two gallons of diesel fuel. Following full involvement of the flame, the foam system was actuated and extinguishment was effected in approximately three seconds.

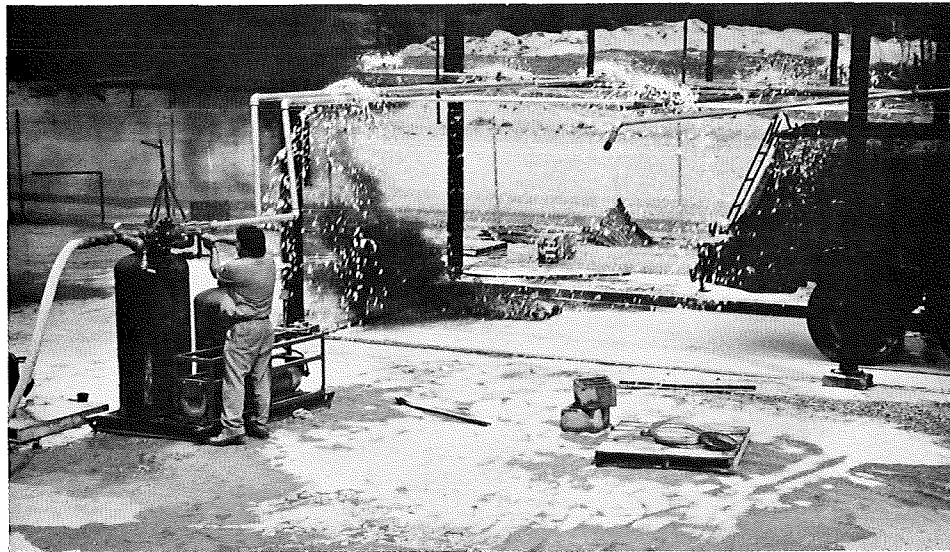


Figure 54 - Fire Test No. 1

- Fire Test No. 2

For the second test the mine vehicle mock-up was placed over the fuel pan and both dry chemical and foam systems were armed. Full involvement of the fire was followed by actuation of the foam system.

Actuation of the dry chemical system was delayed to determine whether foam alone would extinguish the fire obstructed from the overhead nozzles by the mock-up.

Extinguishment with foam alone was not accomplished and the dry chemical system was actuated. Initial dry chemical discharge extinguished the fire while foam blanketed and secured the area.

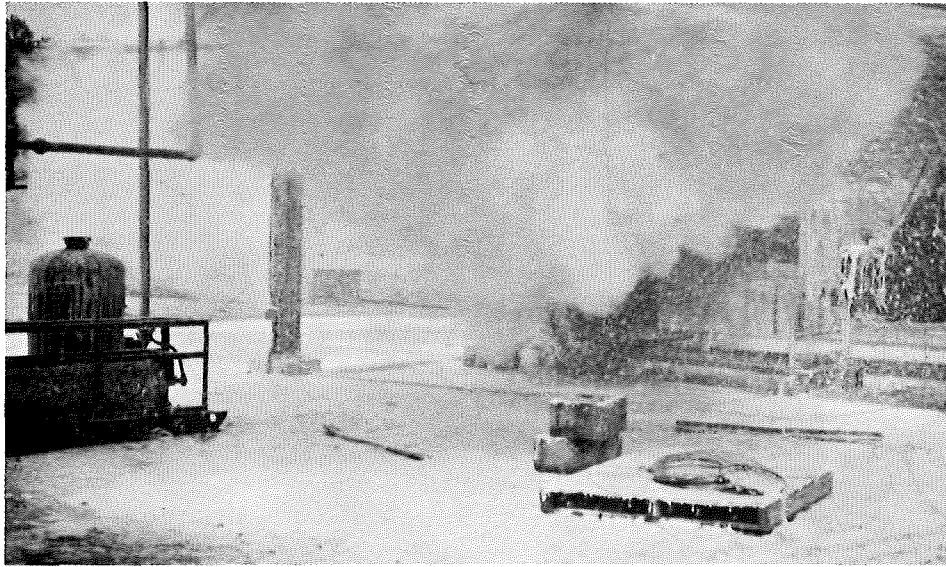


Figure 55 - Fire Test No. 2

- Fire Test No. 3

This test was designed to provide some indication of the actual extinguishing ability of the unit incorporated with the effects of higher wind conditions.

Approximately five gallons of gasoline were used because of the higher volatility, and wind velocity was measured at 15 mph. The unit was actuated when the fire became fully involved. The foam discharge began immediately, with dry chemical discharge following 13 seconds thereafter.

Wind affected the nozzle pattern to prevent complete coverage of the protected area, indicating that nozzle installation in a mine will depend on ventilation velocities. The nozzles can be directed slightly upstream to allow for pattern variation from ventilation rates over 15 mph.

Approximately 10 percent of the flame remained following the dry chemical discharge. However, the foam quickly controlled and extinguished the remaining fire. This demonstrated an advantage of the twin agent system.



Figure 56
Fire Test No. 3 Configuration - Preburn



Figure 57
Fire Test No. 3 - Twin Agent System Discharge



Figure 58
Union Carbide Corporation
Pine Creek Mine

8.0 FIELD DEMONSTRATION

8.1 Planning for Field Demonstration

The field demonstration involved underground fire tests demonstrating the performance of an automatic fire protection system installed in an underground fueling area.

The Ansul Company and the Union Carbide Corporation, Metals Division, at Bishop, California, began planning early in April 1977 towards a cooperative effort to perform the required field demonstration. An agreement between the two companies (see Appendix H) determined that the field demonstration would be performed at the Pine Creek Mine. The automatic fire protection system was installed at the 1576 Fuel Dock on the 1500 Level. The system protected an open fuel storage and fuel transfer area with no separation between them.

Since Federal Standard 574-58 prohibits the lighting of fires underground, it was necessary to obtain a variance to the standard in order to perform the field demonstration. Variance No. 277 was issued through the Western Office of the Mining Enforcement and Safety Administration (see Appendix J). In addition, the Department of Industrial Relations of the State of California granted a temporary variance from the Mine Safety Order, Section 7061.a (see Appendix K). The field demonstration was performed in accordance with these variances.

The test plan was prepared and, after receiving approval signatures from representatives of Ansul and Union Carbide, it became Exhibit "C" of the agreement (see Appendix I).

The field demonstration was performed on July 31 and was witnessed by representatives of the Bureau of Mines Twin Cities Mining Research Center, Mining Enforcement and Safety Administration, the California Department of Industrial Relations, and participating representatives of the Pine Creek Mine and The Ansul Company. The underground rescue team was provided by the Pine Creek Mine and the back-up (above-ground) rescue team was provided by MESA.

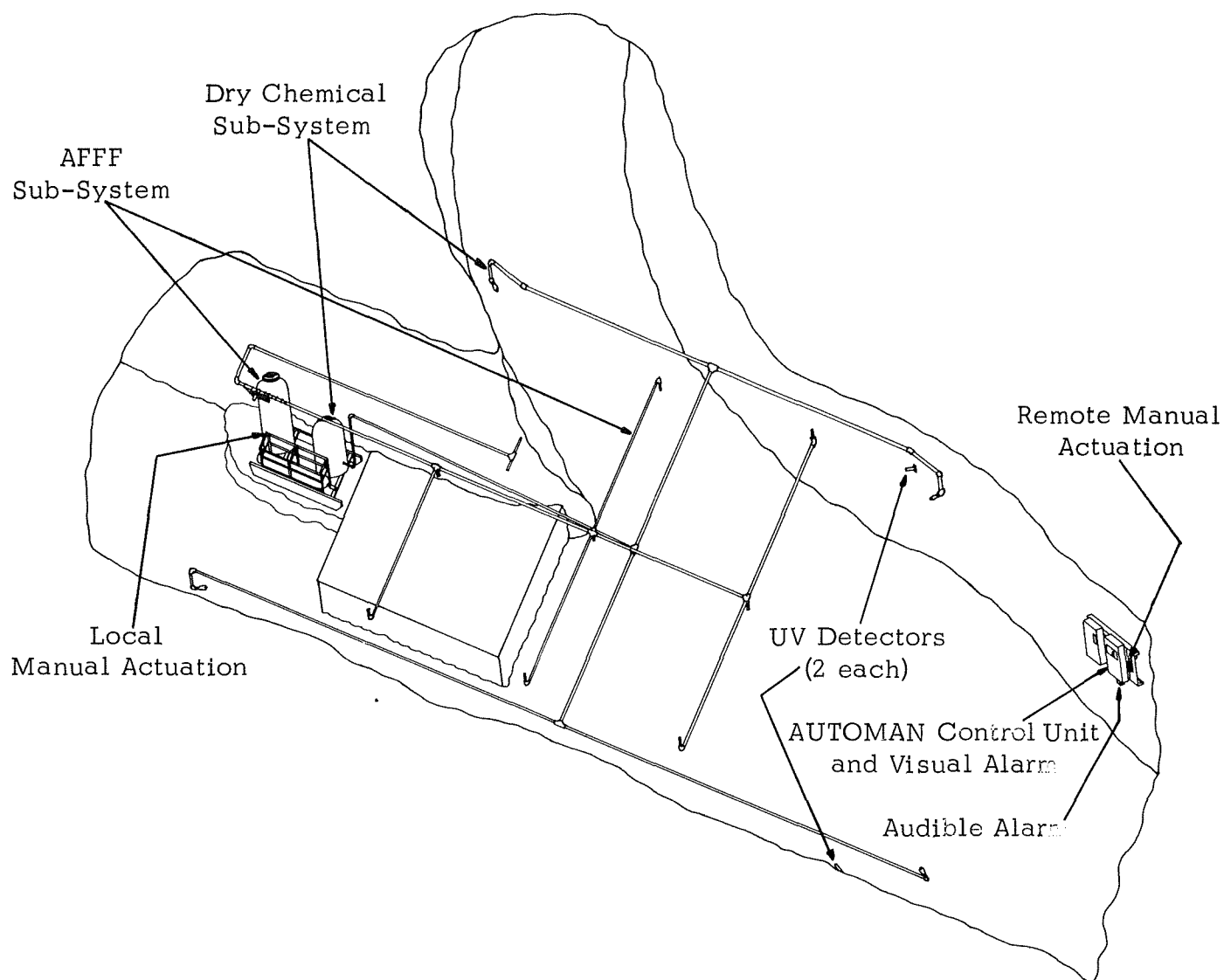


Figure 59
Twin Agent System Installation
1576 Fuel Dock
Union Carbide Corporation
Pine Creek Mine

Underground installation took five days and proceeded as planned with no major difficulties. The installation of the detection and control sub-system was completed first and the detector performance was monitored for several days before the demonstration.

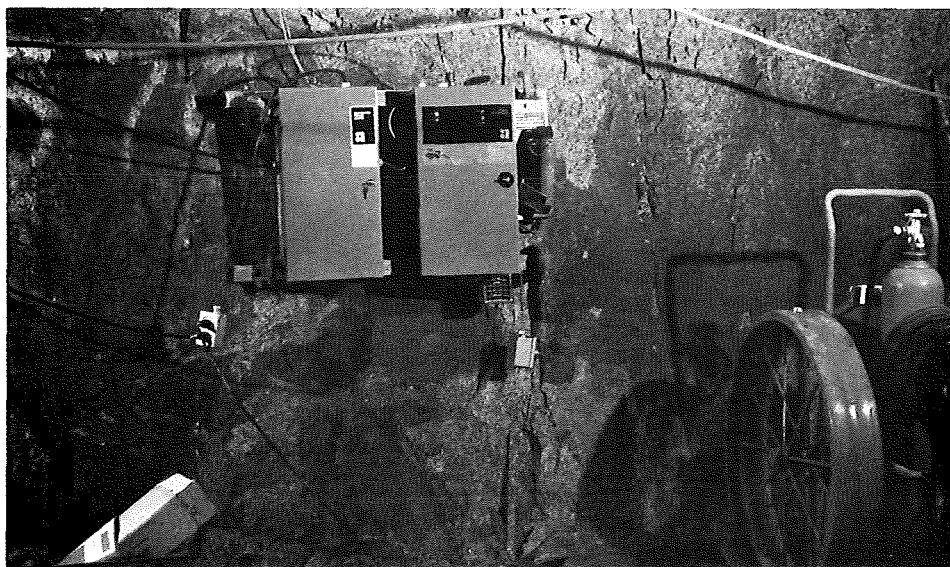


Figure 60
Control Unit and Emergency Power Supply

During three days of monitoring, no false alarms or other problems occurred. On the fourth day a malfunction was discovered in the unused portion of the time delay circuit. The cause was determined to be the temperature/humidity effect of the underground atmosphere. A simple by-pass of the circuit solved the problem; however, a new circuit board containing a permanent fix will be installed in the unit.

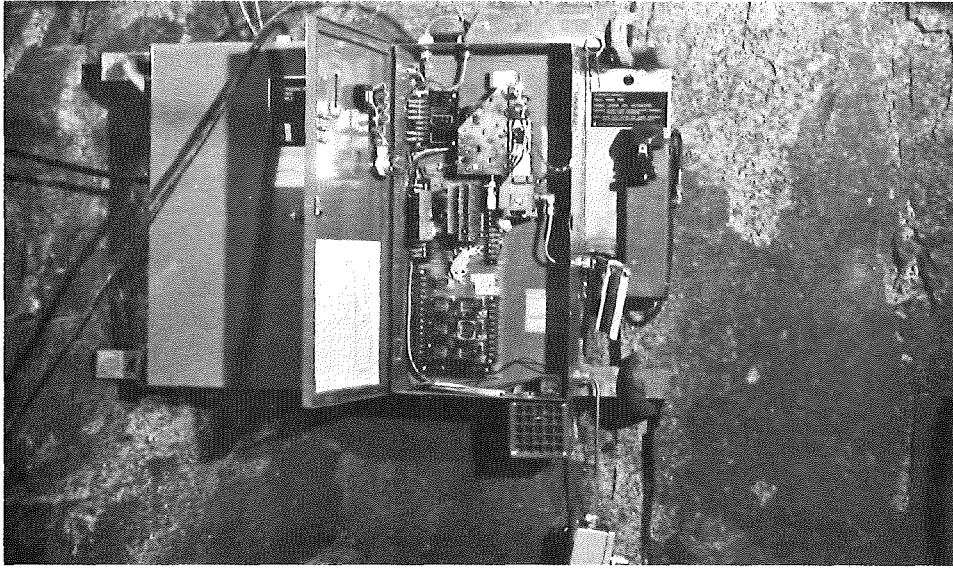


Figure 61 - Internal Control Unit

Dry chemical and foam piping networks were cabled to roof bolts and/or J-bolts, with stationary mounts at each dry chemical nozzle. The dry chemical nozzles were welded to pins wedged in the rock walls to prevent recoil during the discharge.

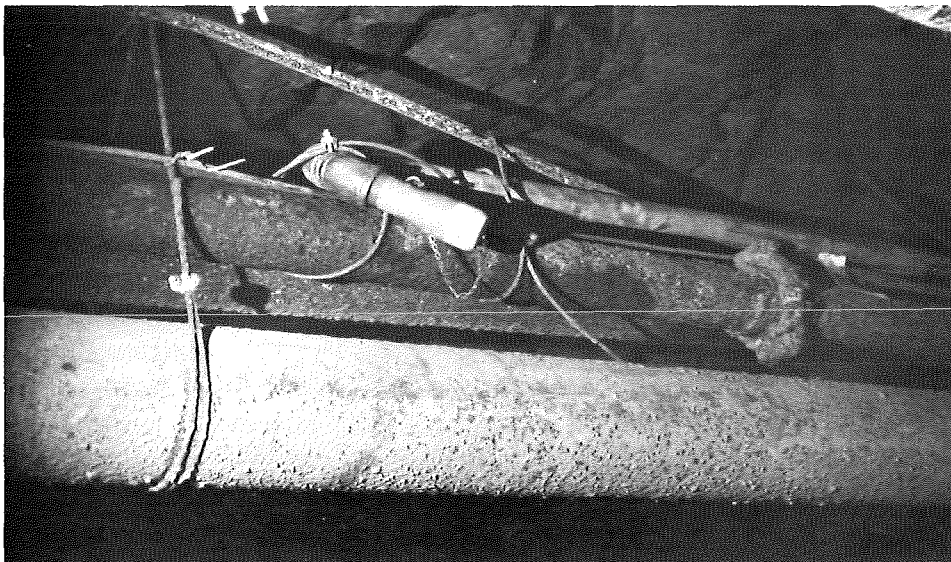


Figure 62 - 1-1/2" Dry Chemical Tee Nozzle

The mine water supply was connected to the foam system inlet.

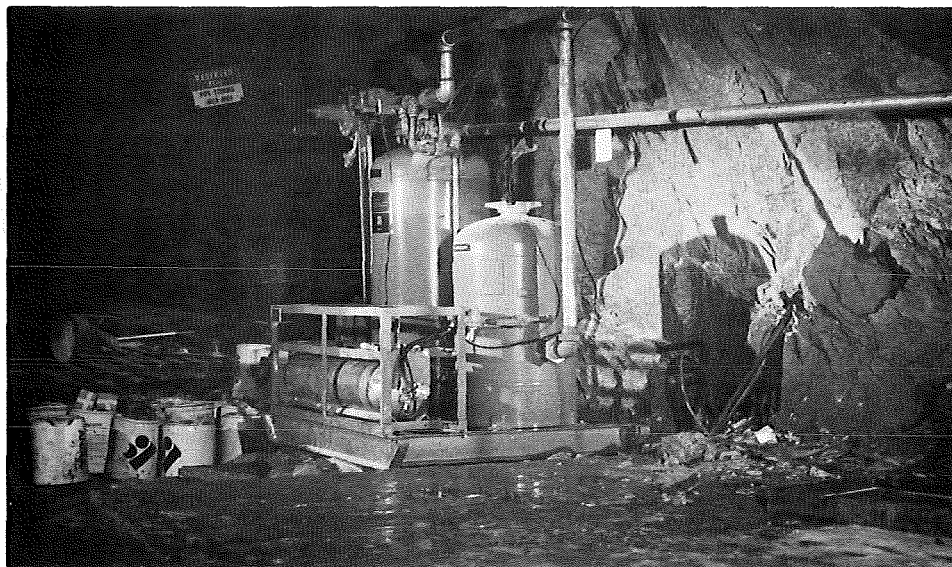


Figure 63 - Skid Unit Installation

Temporary equipment installed included an abort switch to prevent premature firing of the system while the fires were being ignited.

Following installation, the system was checked out by means of scheduled pretests.

8.3

System Pretest

Prior to the actual fire tests, the system was given a complete maintenance inspection, including discharge. The detectors were checked via the test panel and also a cigarette lighter flame. All cartridge actuators were operated, assuring leak-free tubing and normal actuation. Fifty pounds of FORAY multipurpose dry chemical was discharged from the unit to assure proper fluidization of dry chemical, proper burst disc rupture, and proper nozzle location and aim.

During the last actuation sequence, gauges were installed at the unit water inlet and one nozzle. The pressure regulating valve setting was increased to attempt to obtain the desired nozzle pressure of 30 psi.

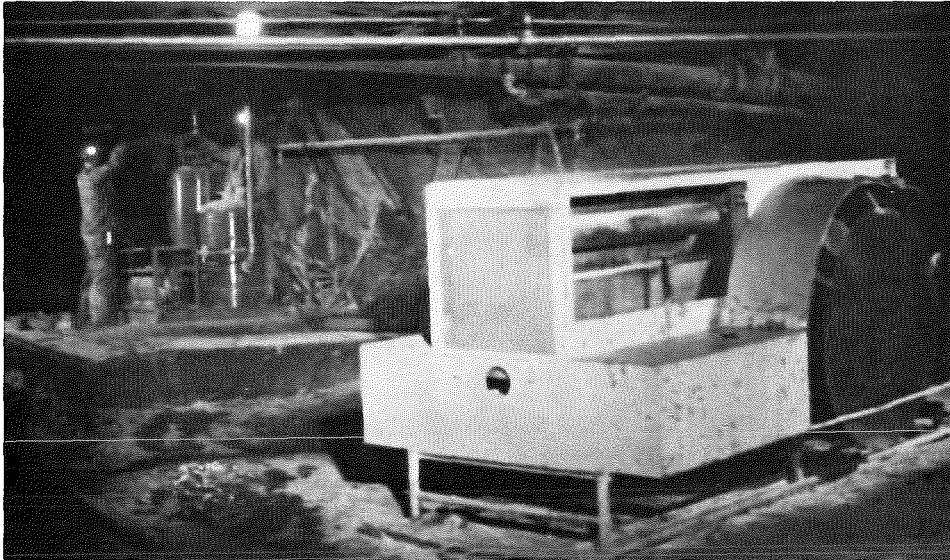


Figure 64 - Setting AFFF Nozzle Pressure

Static unit inlet pressure was 210 psi from the 4" mine water supply line. Flow pressure at the unit inlet dropped to 55 psi and pressure drop in the distribution piping lowered the nozzle pressure to 12 psi. This was maximum nozzle pressure attained during stabilized flow.

Examination of the piping revealed an upstream reduction in pipe size to 2" pipe which was continued upstream throughout other mine levels. Considering a nozzle pressure of 12 psi, a check of the nozzle pressure/flow curve indicates a flow rate of 10.5 gpm. This pressure is enough to maintain the minimum required flow rate of .1 gpm/sq.ft.

Following recharging, the system was ready for fire testing.

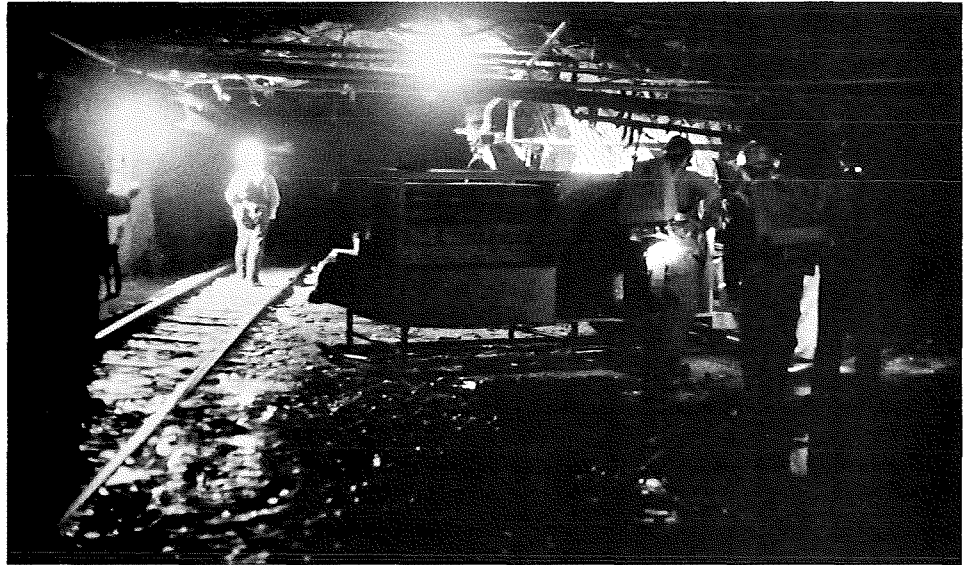


Figure 65 - Preparation for Fire Testing

8.4

Environmental Impact of AFFF

Since aqueous film-forming foam (AFFF) is a relatively new fire suppression agent which has not previously been used in underground mining applications, a discussion of the environmental considerations is provided. None of the environmental considerations involve any danger to human life or well being.

The environmental impact of AFFF type agents can be broken down into the following parameters:

- BOD (Biological Oxygen Demand) - a measure of the amount of oxygen needed by bacteria to oxidize the organic matter. Generally expressed as 5-, 10-, 15-, 20- or 30-day value in mg./liter.
- COD (Chemical Oxygen Demand) - a measure of the amount of oxygen needed to convert all of the organic material into CO_2 and H_2O . Generally expressed in mg./liter.
- TOC (Total Organic Carbon) - a measure of the amount of organic carbon in a sample. Generally expressed in mg./liter.

- Fish Toxicity - the concentration of material required to produce mortality in 50% of a population of a given species. This quantity depends both on the species and the age of the species. Expressed as an LC₅₀ value in ppm at 96 hours exposure.

Unfortunately, most of the studies conducted to date involve determination of BOD, COD and Fish Toxicity of AFFF concentrates. This is acceptable if one is interested in comparing these characteristics for different brands of AFFF concentrates. It does not, however, reflect the lesser environmental effect of this material in either a 6% or 3% dilute aqueous solution. Since the various manufacturers' brands of AFFF differ in formulation, it is difficult to generalize on their environmental characteristics.

If we assume the concentrations of AFFF expressed in ppm (as used for fish toxicity) can be directly related to a dilute solution entering a flowing stream or other body of water, we can make some observations with regard to the system installation at the Pine Creek Mine.

As a simple example, the LC₅₀ value for a flathead minnow with 48-hour exposure is 4000 ppm. Using a direct relationship which reflects a worst case condition, the 70 gallons of AFFF concentrate utilized at the Pine Creek Mine would require 17,500 gallons of water to reach the above mentioned LC₅₀ value. However, during the period of least flow, drainage from the Pine Creek Mine main portal is approximately 4000 gpm. Assuming no further dilution effects due to stream flow, 70 gallons of concentrate would have to be injected at the portal in approximately $4\frac{1}{2}$ minutes to attain 4000 ppm. Considering dilution of the solution in the mine, filtering action during flow through the mine, stream water flow, and AFFF system flow, a concentration lethal to fish at the mine outlet does not seem possible.

8.5 Underground Fire Tests

8.5.1 Fire Test No. 1

The first underground fire test was the extinguishment of the 2' x 3' pan placed on the fuel storage pad. The pan contained approximately two gallons of water supporting one gallon of diesel fuel. For the first test, the dry chemical sub-system was rendered inoperable and only the foam system was actuated.

With the detectors operating and the control system in the abort mode, the following sequence was observed:

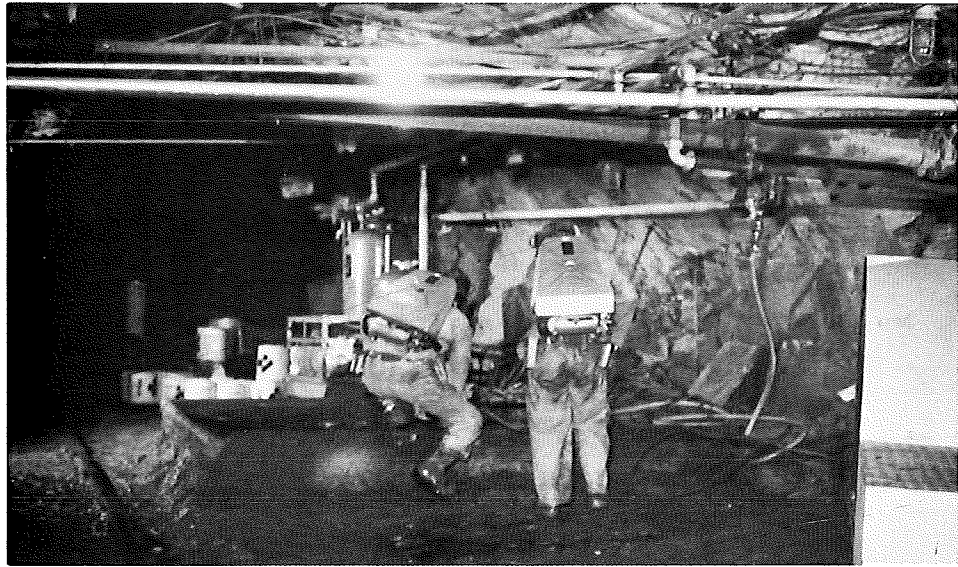


Figure 66 - Fire Test No. 1 - Igniting the Pan

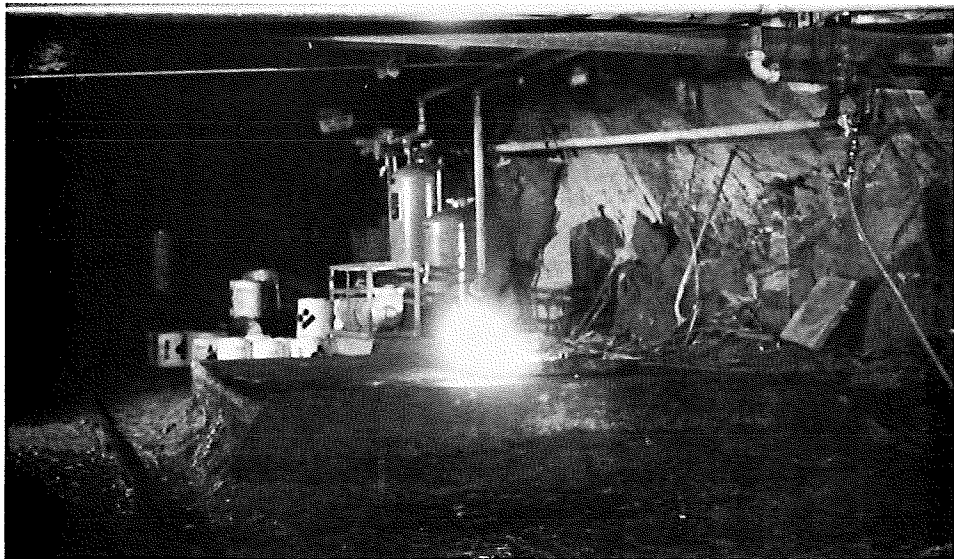


Figure 67 - Fire Test No. 1 - Preburn (-15 Seconds)



Figure 68 - Fire Test No: 1 - Full Involvement (-5 Seconds)



Figure 69 - Fire Test No. 1 - Release Abort Mode, Actuation
(0 Seconds)



Figure 70 - Fire Test No. 1 - Foam Discharge (5 Seconds)



Figure 71 - Fire Test No. 1 - Extinguishment (10 Seconds)



Figure 72 - Fire Test No. 1 - Unit Shutdown

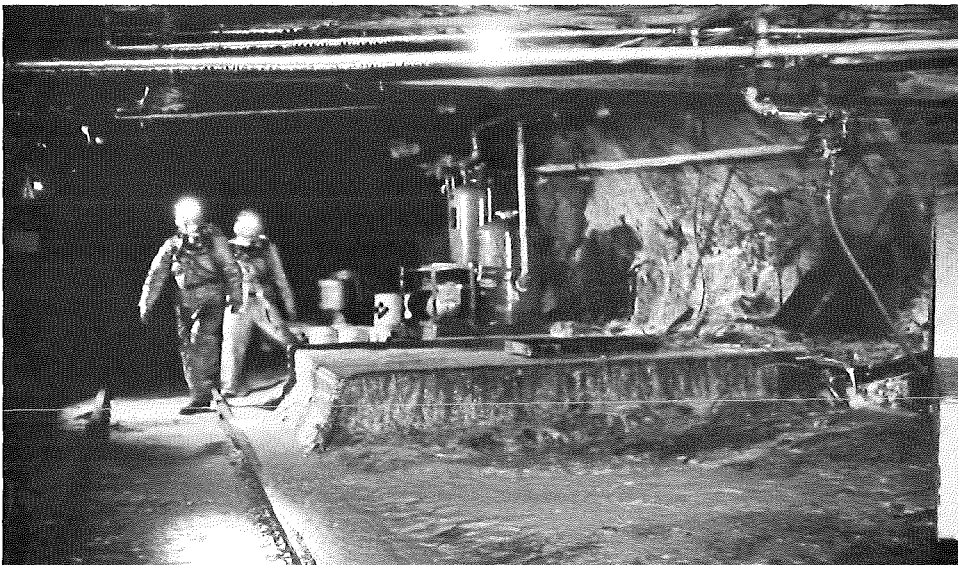


Figure 73 - Fire Test No. 1 - Foam Blanket

8.5.2

Fire Test No. 2

The second fire test was conducted utilizing the same pan and amounts of water and fuel. The pan was placed under a vehicle mock-up to provide an obstruction against the foam discharge and simulate a spill under a vehicle.

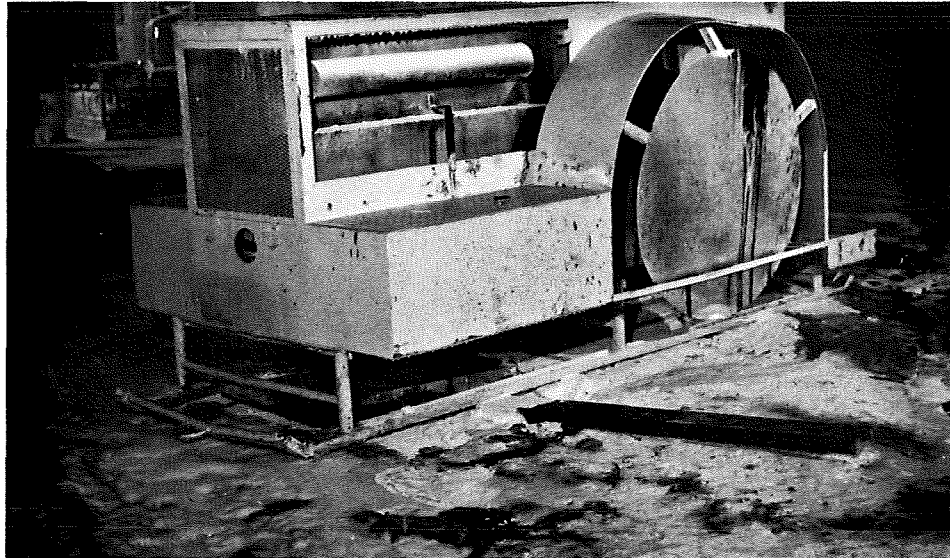


Figure 74 - LHD Mock-Up

The control unit was again placed in the abort mode and the unit was actuated manually with the remote manual actuator.

Fire Test No. 2 sequence is as follows:

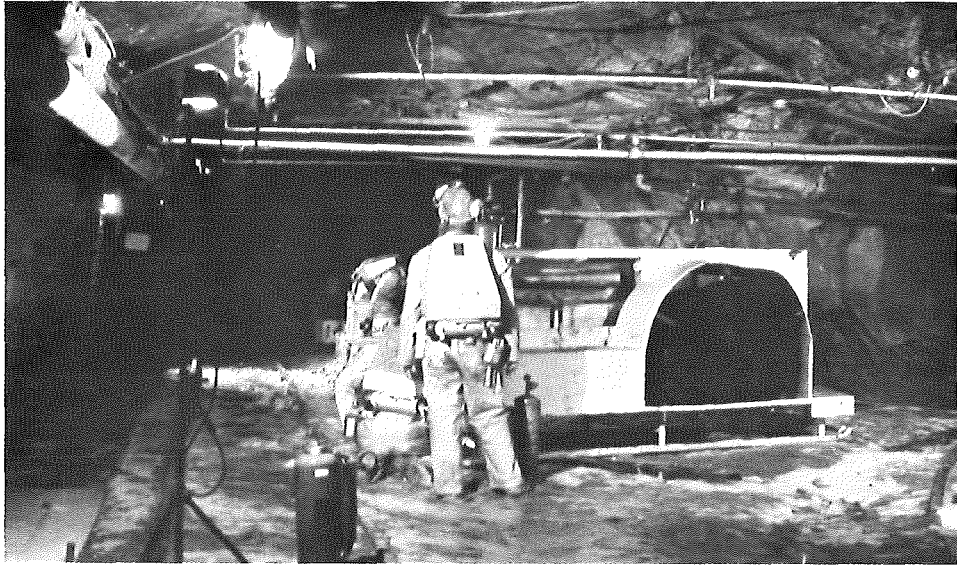


Figure 75 - Fire Test No. 2 - Igniting the Pan

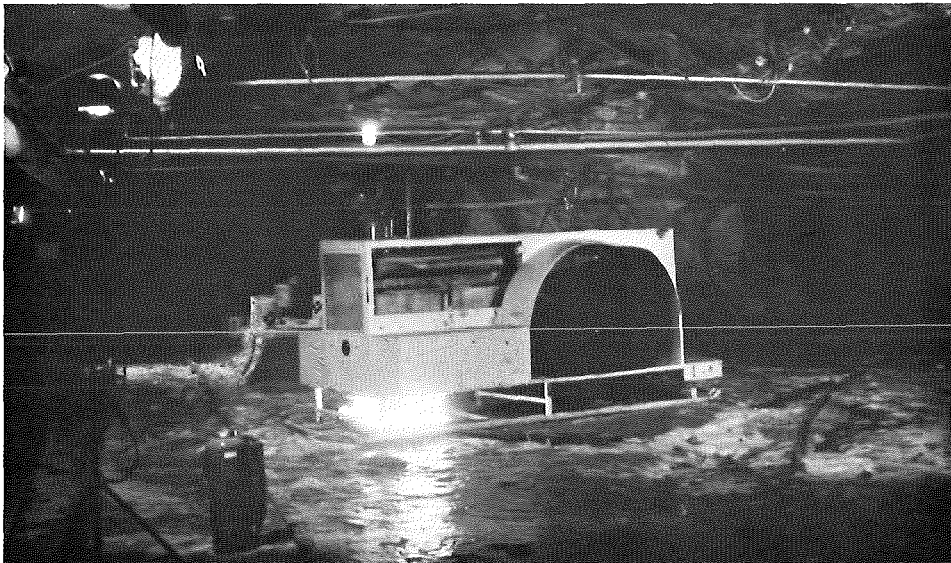


Figure 76 - Fire Test No. 2 - Preburn (~10 Seconds)

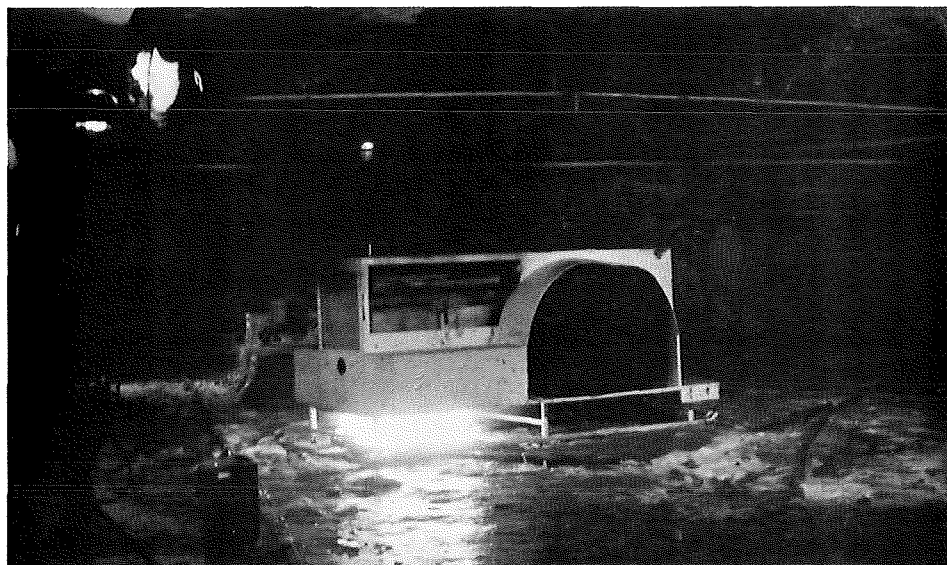


Figure 77 - Fire Test No. 2 - Full Involvement (-5 Seconds)



Figure 78 - Fire Test No. 2 - Manual Actuation (0 Seconds)

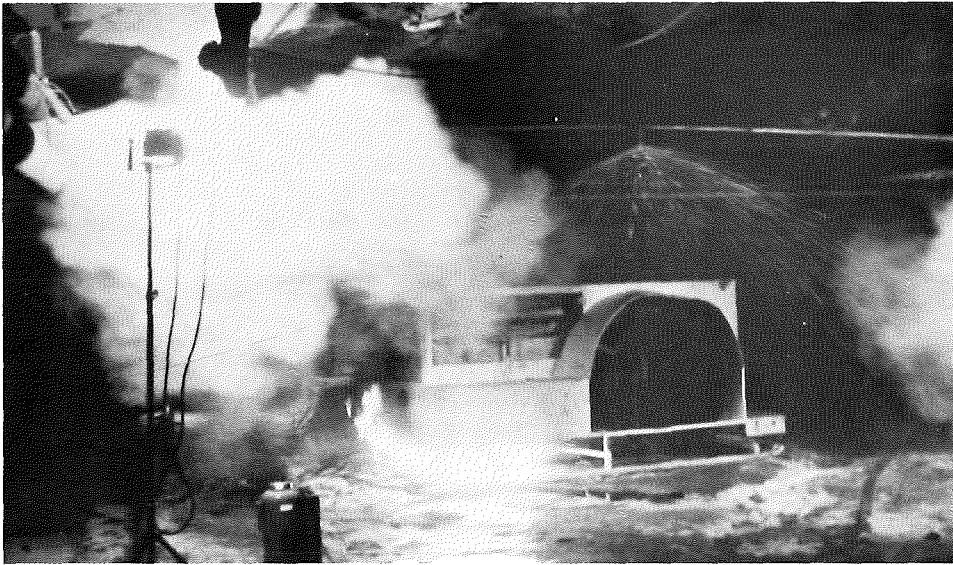


Figure 79 - Fire Test No. 2 - Dry Chemical Burst Disc Ruptures
(13 Seconds)



Figure 80 - Fire Test No. 2
Dry Chemical Discharge, Extinguishment (16 Seconds)

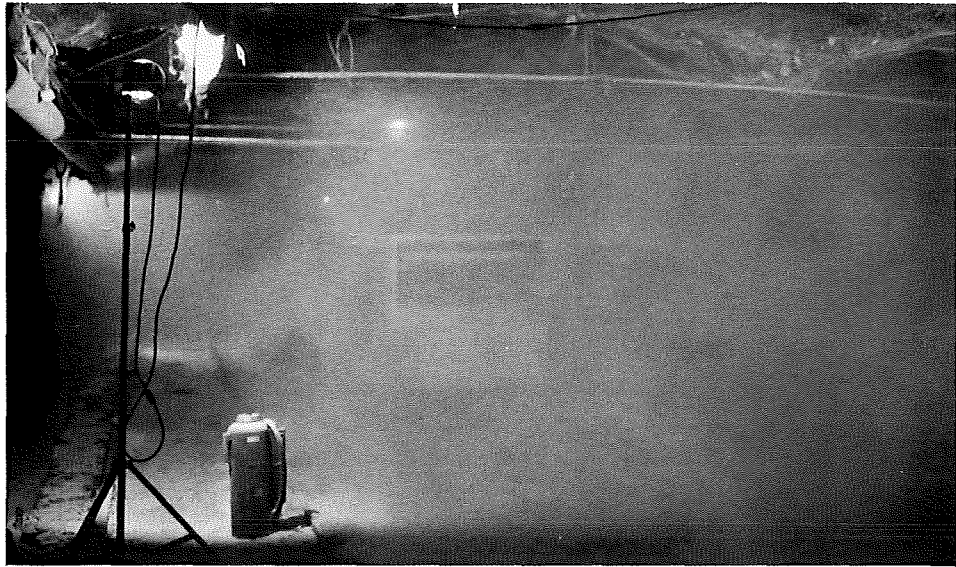


Figure 81 - Fire Test No. 2 - Unit Shutdown

Carbon monoxide sampling was done following both fire tests with no traces being found.



Figure 82 - Carbon Monoxide Sampling

Summary of Fire Test Results

Operation of the twin agent piped system was completely satisfactory. The size of the fire in both tests did not show the full extinguishing ability of the system; however, the ability of the twin agent system to extinguish the size fire that could be possible in the fueling area was evident.

Measurements were not taken to determine the effects of the fire protection system discharge on the water quality leaving the mine. However, as discussed in section 8.4 we do not expect that there is an environmental problem.

The control unit can be ruggedized to handle the underground environment by incorporating a weather-proof box and redesigning the time delay circuit.

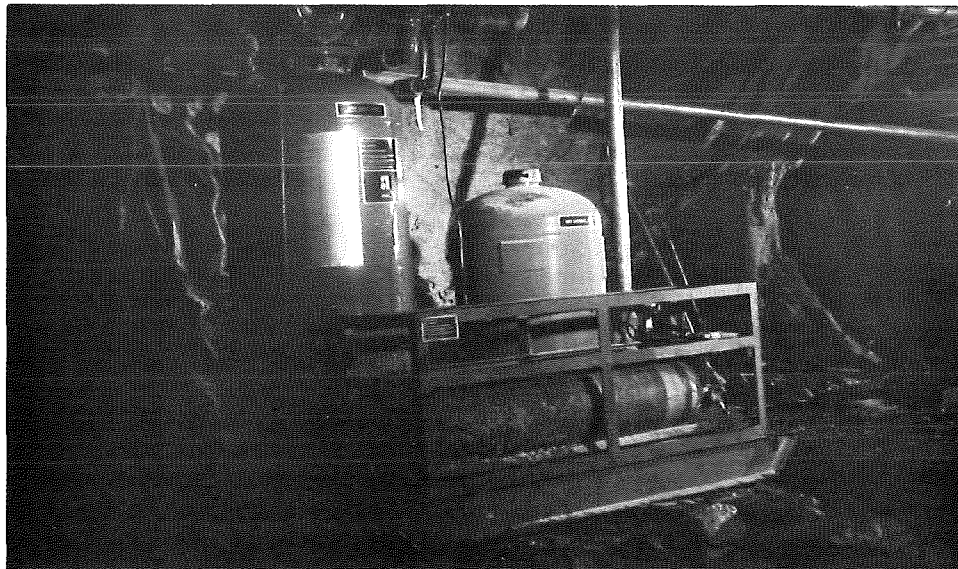


Figure 83 - Twin Agent Piped System

The system remains installed and armed in the Pine Creek Mine and will be periodically inspected for any sign of deterioration or malfunction due to exposure to the mine environment.

APPENDIX A
DATA INSTRUMENTS

MINE DESCRIPTION FORM

1. Name of company and mine:

2. Ores mined (check all that apply):

___ a. copper
___ b. Fluorspar
___ c. gold
___ d. gypsum
___ e. iron
___ f. lead
___ g. molybdenum
___ h. nickel

___ i. potash
___ j. salt
___ k. silver
___ l. trona
___ m. tungsten
___ n. uranium
___ o. zinc
___ p. other: _____

3. Tons mined per day: _____

4. Ambient temperature: _____

5. Humidity: _____

6. # Diesel Vehicles: _____

7. Methods of hauling and mucking
used (check all that apply):

___ a. LHD's
___ b. rail
___ c. truck
___ d. belt
___ e. other _____

8. Approximate dollar value of one
day's production: \$_____

9. Average working depth of mine:
_____ ft

10. Corrosive water? _____

11. Stopping methods used:

___ a. room and pillar
___ b. cut and fill
___ c. caving (sublevel,
block)
___ d. open stoping
___ e. other: _____

12. Production age of mine: _____ years

13. Employees underground:

a. 1st shift: _____
b. 2nd shift: _____
c. 3rd shift: _____
d. others: _____

OPERATOR COMMENTS ON PROPOSED STANDARDS

Permanent storage > 1,000 gal.

- a. Located at least 100 ft from shafts, slopes, raises, U G hoist rooms, shops, explosive magazines, ventilation fans and working places; at least 50 ft from electrical equipment, wooden bulkheads, other hazardous underground fire areas; and at least 25 ft from haulageway.
- b. Totally enclosed by construction and materials having at least a 2-hour fire resistance rating.
- c. Provided with access door(s) which shall be kept closed except when the door(s) are in use.

d. Ventilation openings shall be provided with heat-actuated or equivalent sensing devices to automatically close the openings in case of fire.

e. Provided with floors constructed of concrete or other impermeable, noncombustible material.

Temporary storage--55 to 1,000 gal.

- a. Located at least 100 ft from shaft, slopes, raises, explosives magazines; at least 50 ft from wooden bulkheads, other hazardous underground fire areas; and at least 25 ft from haulageways.

- b. Totally enclosed by construction and materials meeting the Standard Method of Tests, ASTM E-136-1973.

- c. Of materials having a strength of at least equal to 1/8-inch thick steel plate or 4-inch thick cinder block.

d. Provided with access doors meeting the requirements of (b) and (c) above which shall be kept closed except when the door is in use. Ventilation openings shall be provided with heat-actuated or equivalent sensing devices to automatically close the openings in case of fire.

e. Equipped with at least two portable fire extinguishers.

MARKET FACTOR RATINGS

1. Source of rating information:
 - ___ a. mine safety director
 - ___ b. mine maintenance staff
 - ___ c. mine purchasing staff
 - ___ d. other mine executive
 - ___ e. other: _____
2. Rank the relative importance of each of the following in deciding whether an automatic fire control system should be installed in your fueling system:
 - ___ a. personnel safety
 - ___ b. damage to fueling area
 - ___ c. mine shutdown time
 - ___ d. insurance rates
 - ___ e. other: _____
3. Pick the five characteristics considered most important for any automatic fire control system which might become available to the industry as a result of this study. Rank these in order from (1) most important, to (5):
 - ___ a. control system purchase price
 - ___ b. ease of installation
 - ___ c. control system life
 - ___ d. operator training (e.g., override procedures)
 - ___ e. frequency of maintenance
 - ___ f. ease of maintenance
 - ___ g. maintenance cost
 - ___ h. control system reliability
 - ___ i. adaptability to current system
 - ___ j. other: _____
4. What would you consider a realistic price for a reliable automatic fire control system that protects the fueling area and the fuel storage area?
\$ _____
5. What would be an acceptable cost for maintaining the automatic fire control system in working order? \$ _____ per _____ mos./years
6. How long would you expect an automatic fire control system to last?
_____ mos./years
7. How long do you usually expect an underground fueling system to last?
_____ mos./years
8. How long does a fueling area remain in one location: _____ mos./years

FIRE HAZARD FACTOR RATINGS

1. Information source:
 - ___ a. mine safety director
 - ___ b. mine maintenance staff
 - ___ c. other mine executive
 - ___ d. other: _____
2. Select and rank in order from (1) most hazardous, to (12) least hazardous, the 12 types of underground fueling equipment most likely to have leaks in the metal and non-metal mining industry:
 - ___ a. surface storage tanks
 - ___ b. surface transfer pump
 - ___ c. surface piping
 - ___ d. shaft piping
 - ___ e. shaft piping valves
 - ___ f. haulageway piping
 - ___ g. haulageway pumps
 - ___ h. haulageway valves
 - ___ i. underground storage tanks
 - ___ j. underground pumps to vehicle
 - ___ k. piping to fueling pumps
 - ___ l. hose to vehicle
 - ___ m. other _____
 - ___ n. other _____
3. Rank in order from most (1) to least (5) fire hazard:
 - ___ a. diesel fuel
 - ___ b. hydraulic fluid
 - ___ c. lubricant
 - ___ d. solvents
 - ___ e. other: _____
4. Rank ignition sources in order from (1) most to (7) least fire hazard:
 - ___ a. vehicle engine heat
 - ___ b. electrical sparks (vehicle)
 - ___ c. electrical sparks (fueling area)
 - ___ d. impact sparks (vehicle to rib)
 - ___ e. smoking
 - ___ f. other _____
 - ___ g. other _____
5. Please rank fuel system fire cause from (1) most important to (6) least important:
 - ___ a. operator error
 - ___ b. infrequent maintenance
 - ___ c. groundfall or similar incidents
 - ___ d. fuel system design
 - ___ e. improper maintenance
 - ___ f. other: _____

____ Mine #
____ Incident #

LEAK INCIDENT DESCRIPTION

1. Source of information:
 - ____ a. MESA report
 - ____ b. Mine records/report
 - ____ c. Other literature
 - ____ d. Maintenance department
 - ____ e. Safety
 - ____ f. Other mine executive
 - ____ g. Other: _____
2. Approximate date of incident: _____
3. Part of System:
 - ____ a. Surface storage
 - ____ b. Piping to fuel area
 - ____ c. Tanker to fuel area
 - ____ d. Fuel area
 - ____ e. Piping to fueling area
 - ____ f. Tanker to fueling area
 - ____ g. Fueling area
 - ____ h. Vehicle
4. Fluid involved:
 - ____ a. Diesel
 - ____ b. Hydraulic
 - ____ c. Lube oil
 - ____ d. Solvents
 - ____ e. Other: _____
5. Describe leak: _____

6. Cause (equipment failure, corrosion, human error, etc.): _____

7. Did fuel spread? (where): _____

8. Response to leak (detection time): _____

9. Damage, cost and injuries: _____

10. Lost production: _____
11. Any fire? Describe (duration and magnitude): _____

12. Heat source: _____
13. Secondary fires: _____

14. Response to fire (mechanical and human): _____

15. Type agents used and effectiveness: _____

____ Mine #

MAINTENANCE PROCEDURES DESCRIPTION

INTERVIEW SUMMARY FORM

1. Source of information (if other than mine maintenance staff): _____ 3. Interval between inspections: _____ 4. Interval between preventative maintenance efforts: _____ 5. Cleaning practices: a. compound or substance used: _____ b. cleaning interval: _____ 7. General cleanup interval: _____ 9. Replacement criteria: _____ _____ _____ _____	2. Types of equipment involved (check all types comprising maintenance group at mine): ____ a. surface storage ____ b. surface transfer ____ c. shaft piping ____ d. haulageway piping ____ e. fuel area ____ f. underground tanker ____ g. fueling area ____ h. detection system ____ i. other _____ 6. Describe any corrosive chemicals or byproducts which collect on equipment: _____ _____ _____ 8. Inspection procedure: _____ _____ _____ _____

_____ Mine #

VOLATILE FLUIDS SYSTEM DESCRIPTION

Surface to Fuel Area

Pipe transport (size, thickness, metal type, seams)

Surface tank (specs & I.D.): _____

Valves: _____

Pumps: _____

Piping (length, elbows, sealant): _____

Venting: _____

Pipe Support: _____

Malfunction Detectors: _____

Shock Protection: _____

Dynamic Pressure Allowance: _____

Entry Portal: _____

Containment: _____

_____ Mine #

Surface to Fuel Area

Mobile Tanker Transport (specs & I.D., steel & thickness, baffles): _____

Valves: _____

Pumps: _____

Venting: _____

Shock Protection: _____

Entry Portal: _____

Motive Power: _____

Spill Prevention Devices: _____

Tank Subdivisions: _____

_____ Mine #

Fuel Areas

Tank Capacities: _____

Tank Spec. and I.D.: _____

Tank Support: _____

Venting: _____

Level Indication: _____

Protection From Shock: _____

Ventilation Control (normal and emergency): _____

Water Supply (how clean): _____

Power Supply: _____

Isolation: _____

Drainage: _____

Impoundment (capacity): _____

Access and Egress: _____

Location of Other Flammables: _____

Location of Heat Sources: _____

Lighting in Area: _____

Number and Locations of Fuel Areas (show ventilation shafts and haulageways):

Drawing of Fuel Area (plan & perspective). Show walls, ribs, ventilation (inby or outby), piping, tanks, doors, FX, impoundment, drainage, materials, detectors, lighting, impact protection, standing water, coatings on surface, spills, power cables.

_____ Mine #

Fueling Area

Transfer system-fuel area to fueling area (specs and I.D. and distance):

Transfer system fueling area to vehicle (specs and I.D.): _____

Drainage: _____

Impoundment (capacity): _____

Safety Devices: _____

Water supply (how clean): _____

Power supply: _____

Ventilation normal and emergency (effect of back pressure 2 in. H₂O):

Access and Egress: _____

Location of other flammables: _____

Location of heat sources: _____

Lighting in area: _____

Drawing of area (show piping, pumps, ventilation (inby or outby), walls, vehicle location, personnel locations, FX systems, access and egress, impact protection, standing water, coatings on surface, spills, power cables.)

EXISTING FUEL STORAGE AREA FIRE CONTROL SYSTEMS
DATA SHEET

1. Mining company no.: _____ (See list)

2. Name of company and mine: _____

3. Date form completed: _____

4. Person completing form: _____

5. General System Information:

Manufacturer: _____

System model: _____

Cost of system: _____

Equipment: _____

Installation: _____

Type-of fire control system:

High Expansion Foam _____

AFFF _____

Dry Chemical _____

Water Sprinkler _____

Other _____

Period in service: _____

Any available manual or spec. sheets _____

6. Detection

	Ultraviolet	Infrared	Ionization	Other (Specify)
Quantity	_____	_____	_____	_____
Manufacturer	_____	_____	_____	_____
Model	_____	_____	_____	_____
Explosion-Proof Housing	_____	_____	_____	_____
Location and Mounting (Ceiling, Wall, Etc.)	_____	_____	_____	_____
Supervised (i.e. Lens)	_____	_____	_____	_____
Interconnection (Wire Type and Size)	_____	_____	_____	_____
Special Protection (Conduit, etc.)	_____	_____	_____	_____

Local Control

Manufacturers and Models: _____

Quantity and Location: _____

Actuation of System (Automatic, Manual, Both, None): _____

Special Functions (Time Delay, Cross-Zoning, Abort, Etc.) - Specify for each control system: _____

Remote

Capability (Control, Warning, Other): _____

Length and Type of Interconnection (i.e. Coaxil, Twisted-Pair): _____

Location and Distance from Local Control:

1. _____
2. _____
3. _____
4. _____

7. Detection/System Interface:

Control Tradename: _____

Actuation:

Electric _____

Pneumatic _____

Mechanical _____

Manual _____

Actual Operation Taking Place

Open Cylinder Valve _____

Open Water Valve _____

Start Motor _____

Open Storage Container Valve _____

Other _____

8. Extinguishing Agent

Agent Manufacturer _____

Agent Type and/or Tradename _____

(i.e. Ansul Foray, ABC Dry Chemical, or 3M 6% AFFF concentrate)

Agent Amount (pounds, gallons, etc.) _____

Storage Container _____

On Hand _____

9. External Power Requirements

Nitrogen _____
Cylinder size _____ ft³
Pressure _____ psi
Water _____
Approximate Volume Required _____ GPM
Water Line Pressure _____ PSI
Electrical _____
Voltage _____
Power Draw _____
Compressed Air _____
Line pressure _____
Other _____

10. Storage Container

General Description _____
Container Size _____
Internal Operating Pressure _____
Pressure Vessel Specification _____
ASME _____
DOT _____
Other _____

11. Distribution Method

Flexible Tube _____	Hoseline _____
Material _____	Size _____
Other _____	Type _____
	Chemical Engine Hose _____
	Water Hose _____

Piping _____
Size _____ inch, Schedule _____
Maximum Run _____ feet
Balanced Yes _____ No _____

12. Agent Dispersion

Nozzle _____
Size _____
Opening Configuration _____
Discharge Pattern _____
Open Tube or Pipe _____
Size _____
Sprinkler _____
Brand name or type _____
Other _____

13. Approximate Output of System

_____ GPM

_____ lb/sec

_____ ft³/min

Output per nozzle, pipe, or unit _____

Foam expansion ratio _____:1

Volume or area covered _____

14. System Maintenance

Maintenance Period _____

Problem History _____

On Hand Repair Parts _____

15. Sketch of System and Area Covered

16. Brief step by step system operation.

APPENDIX B

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APPENDIX C
SPCC PLAN LAW

TUESDAY, DECEMBER 11, 1973
WASHINGTON, D.C.

Volume 38 ■ Number 237

PART II



ENVIRONMENTAL PROTECTION AGENCY

OIL POLLUTION PREVENTION

Non-Transportation Related Onshore
and Offshore Facilities

Title 40—Protection of the Environment

CHAPTER I—ENVIRONMENTAL
PROTECTION AGENCY

SUBCHAPTER D—WATER PROGRAMS

PART 112—OIL POLLUTION PREVENTION

Non-transportation Related Onshore and
Offshore Facilities

Notice of proposed rule making was published on July 19, 1973, containing proposed regulations, required by an pursuant to section 311(j)(1)(C) of the Federal Water Pollution Control Act, as amended (86 Stat. 868, 33 U.S.C. 1251 et seq.), (FWPCA), to prevent discharges of oil into the navigable waters of the United States and to contain such discharges if they occur. The proposed regulations endeavor to prevent such spills by establishing procedures, methods and equipment requirements of owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, distributing, or consuming oil.

Written comments on the proposed regulations were solicited and received from interested parties. In addition, a number of verbal comments on the proposal were also received. The written comments are on file at the Division of Oil and Hazardous Materials, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C.

All of the comments have been given careful consideration and a number of changes have been made in the regulation. These changes incorporate either suggestions made in the comments or ideas initiated by the suggestions.

Some comments reflected a misunderstanding of the fundamental principles of the regulation, specifically as they applied to older facilities and marginal operations. During the development of the regulation it was recognized that no single design or operational standard can be prescribed for all non-transportation related facilities, since the equipment and operational procedures appropriate for one facility may not be appropriate for another because of factors such as function, location, and age of each facility. Also, new facilities could achieve a higher level of spill prevention than older facilities by the use of fail-safe design concepts and innovative spill prevention methods and procedures. It was concluded that older facilities and marginal operations could develop strong spill contingency plans and commit manpower, oil containment devices and removal equipment to compensate for inherent weaknesses in the spill prevention plan.

Appropriate changes were made in the regulation to simplify, clarify or correct deficiencies in the proposal.

A discussion of these changes, section by section follows:

A. *Section 112.1—General applicability.* Section 112.1(b), the "foreseeability provision", contained in 112.1(d)(4) was added to paragraph 112.1(b). As modified, the regulation applies to non-transportation-related onshore and offshore facilities which, due to their loca-

tion, could reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines.

Sections 112.1(b), 112.1(d)(4) and 112.3 are now consistent.

Section 112.1(d)(1) was expanded to further clarify the respective authorities of the Department of Transportation and the Environmental Protection Agency by referring to the Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency (Appendix).

Section 112.1(d)(2), the figure for barrels was converted to gallons, a unit of measure more familiar to the public, and now reads "42000 gallons."

Section 112.1(d)(3), exemption for facilities with nonburied tankage was extended to 1320 gallons in aggregate with no single tank larger than 660 gallons and applies to all oils, not just heating oil and motor fuel. Tanks of 660 gallons are the normal domestic code size for nonburied heating oil tanks. Buildings may have two such tanks. Facilities containing small quantities of oil other than motor fuel or heating oil would also be exempt, thus making this consistent with the definition of oil in § 112.2.

B. *Section 112.2—Definitions.* Section 112.2(1), the term "navigable waters" was expanded to the more descriptive definition used by the National Pollutant Discharge Elimination System.

Section 112.2(m), the U.S. Coast Guard definition of the term "vessel" was included. This term is used in the regulation and the definition is consistent with the Department of Transportation regulations.

C. *Section 112.3—Requirements for the preparation and implementation of spill prevention control and countermeasure plans.* A new paragraph (c) was added to § 112.3 which applies to mobile or portable facilities subject to the regulation. These facilities need not prepare a new Spill Prevention Control and Countermeasure Plan (SPCC Plan) each time the facility is moved to a new site, but may prepare a general plan, identifying good spill prevention engineering practices (as outlined in the guidelines, § 112.7), and implement these practices at each new location.

Section 112.3(a), (b) and (f) (which was § 112.3(e) in the proposed rule making) have been modified to allow extensions of time beyond the normally specified periods to apply to the preparation of plans as well as to their implementation and to remove the time limitation of one year for extensions. Extensions may be allowed for whatever period of time considered reasonable by the Regional Administrator.

Section 112.3(e) (which was § 112.3(d) in the proposed rule making) was modified to require the maintenance of the SPCC Plan for inspection at the facility only if the facility was normally manned. If the facility is unmanned, the Plan may be kept at the nearest field office.

Section 112.3(f)(1) (§ 112.3(e)(1) in the proposed regulation) was changed to include the nonavailability of qualified personnel as a reason for the Regional Administrator granting an extension of time.

D. *Section 112.4—Amendment of spill prevention control and countermeasure plans by Regional Administrator.* Section 112.4(a)(11), permits the Regional Administrator to require that the owner or operator furnish additional information to EPA after one or more spill event has occurred. The change limits the request for additional information to that pertinent to the SPCC Plan or to the pollution incident.

Section 112.4(b) now reads "Section 112.4 * * *", not "This subsection * * *"

Section 112.4(e) allowed the Regional Administrator to require amendments to SPCC Plans and specifies that the amendment must be incorporated in the Plan within 30 days unless the Regional Administrator specifies an earlier effective date. The change allows the Regional Administrator to specify any appropriate date that is reasonable.

Section 112.4(f). A new § 112.4(f) has been added which provides for an appeal by an owner or operator from a decision rendered by the Regional Administrator on an amendment to an SPCC Plan. The appeal is made to the Administrator of EPA and the paragraph outlines the procedures for making such an appeal.

E. *Section 112.5—Amendment of spill prevention control and countermeasure plans by owners or operators.* Section 112.5(b) required the owner or operator to amend the SPCC Plan every three years. The amendment required the incorporation of any new, field-proven technology and had to be certified by a Professional Engineer.

The change requires that the owner or operator review the Plan every three years to see if it needs amendment. New technology need be incorporated only if it will significantly reduce the likelihood of a spill. The change will prevent frivolous retrofitting of equipment to facilities whose prevention plans are working successfully, and will not require engineering certification unless an amendment is necessary.

Section 112.5(c), this paragraph required that the owner or operator amend his SPCC Plan when his facility became subject to § 112.4 (amendment by the Regional Administrator). This paragraph has been removed. It is inconsistent to require the owner or operator to independently amend the Plan while the Regional Administrator is reviewing it for possible amendment.

F. *Section 112.6—Civil penalties.* There are no changes in this section.

G. *Section 112.7—Guidelines for the preparation and implementation of a spill prevention control and countermeasure plan.* Numerous changes have been made in the guidelines section; the changes have been primarily:

1. To correct the use of language inconsistent with guidelines. For example, the word "shall" has been changed to "should" in § 112.7(a) through (e).

2. To give the engineer preparing the Plan greater latitude to use alternative methods better suited to a given facility or local conditions.

3. To cover facilities subject to the regulation, but for which no guidelines were previously given. This category includes such things as mobile facilities, and drilling and workover rigs.

In addition, wording was changed to differentiate between periodic observations by operating personnel and formal inspections with attendant record keeping.

These regulations shall become effective January 10, 1974.

Dated: November 27, 1973.

JOHN QUARLES,
Acting Administrator.

A new Part 112 would be added to subchapter D, Chapter I of Title 40, Code of Federal Regulations as follows:

- Sec.
- 112.1 General applicability.
 - 112.2 Definitions.
 - 112.3 Requirements for preparation and implementation of Spill Prevention Control and Countermeasure plans.
 - 112.4 Amendment of Spill Prevention Control and Countermeasure Plans by Regional Administrator.
 - 112.5 Amendment of Spill Prevention Control and Countermeasure Plans by owners or operators.
 - 112.6 Civil penalties.
 - 112.7 Guidelines for the preparation and implementation of a Spill Prevention Control and Countermeasure Plan.
- Appendix Memorandum of Understanding Between the Secretary of the Department of Transportation and the Administrator of the Environmental Protection Agency. Section II—Definitions.

AUTHORITY: Secs. 311(j) (1) (C), 311(j) (2), 501(a), Federal Water Pollution Control Act (Sec. 2, Pub. L. 92-500, 86 Stat. 816 et seq. (33 U.S.C. 1251 et seq.)); Sec. 4(b), Pub. L. 92-500, 86 Stat. 897; 5 U.S.C. Reorg. Plan of 1970 No. 3 (1970), 35 FR 15623, 3 CFR 1966-1970 Comp.; E.O. 11735, 38 FR 21243, 3 CFR.

§ 112.1 General applicability.

(a) This part establishes procedures, methods and equipment and other requirements for equipment to prevent the discharge of oil from non-transportation-related onshore and offshore facilities into or upon the navigable waters of the United States or adjoining shorelines.

(b) Except as provided in paragraph (d) of this section, this part applies to owners or operators of non-transportation-related onshore and offshore facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, distributing or consuming oil and oil products, and which, due to their location, could reasonably be expected to discharge oil in harmful quantities, as defined in Part 110 of this chapter, into or upon the navigable waters of the United States or adjoining shorelines.

(c) As provided in sec. 313 (86 Stat. 875) departments, agencies, and instrumentalities of the Federal government

are subject to these regulations to the same extent as any person, except for the provisions of § 112.6.

(d) This part does not apply to:

(1) Equipment or operations of vessels or transportation-related onshore and offshore facilities which are subject to authority and control of the Department of Transportation, as defined in the Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency, dated November 24, 1971, 36 FR 24000.

(2) Facilities which have an aggregate storage of 1320 gallons or less of oil, provided no single container has a capacity in excess of 660 gallons.

(3) Facilities which have a total storage capacity of 42000 gallons or less of oil and such total storage capacity is buried underground.

(4) Non-transportation-related onshore and offshore facilities, which, due to their location, could not reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines.

(e) This part provides for the preparation and implementation of Spill Prevention Control and Countermeasure Plans prepared in accordance with § 112.7, designed to complement existing laws, regulations, rules, standards, policies and procedures pertaining to safety standards, fire prevention and pollution prevention rules, so as to form a comprehensive balanced Federal/State spill prevention program to minimize the potential for oil discharges. Compliance with this part does not in any way relieve the owner or operator of an onshore or an offshore facility from compliance with other Federal, State or local laws.

§ 112.2 Definitions.

For the purposes of this part:

(a) "Oil" means oil of any kind or in any form, including, but not limited to petroleum, fuel oil, sludge, oil refuse and oil mixed with wastes other than dredged spoil.

(b) "Discharge" includes but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying or dumping. For purposes of this part, the term "discharge" shall not include any discharge of oil which is authorized by a permit issued pursuant to Section 13 of the River and Harbor Act of 1899 (30 Stat. 1121, 33 U.S.C. 407), or Sections 402 or 405 of the FWPCA Amendments of 1972 (86 Stat. 816 et seq., 33 U.S.C. 1251 et seq.).

(c) "Onshore facility" means any facility of any kind located in, on, or under any land within the United States, other than submerged lands, which is not a transportation-related facility.

(d) "Offshore facility" means any facility of any kind located in, on, or under any of the navigable waters of the United States, which is not a transportation-related facility.

(e) "Owner or operator" means any person owning or operating an onshore facility or an offshore facility, and in the

case of any abandoned offshore facility, the person who owned or operated such facility immediately prior to such abandonment.

(f) "Person" includes an individual, firm, corporation, association, and a partnership.

(g) "Regional Administrator", means the Regional Administrator of the Environmental Protection Agency, or his designee, in and for the Region in which the facility is located.

(h) "Transportation-related" and "non-transportation-related" as applied to an onshore or offshore facility, are defined in the Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency, dated November 24, 1971, 36 FR 24080.

(i) "Spill event" means a discharge of oil into or upon the navigable waters of the United States or adjoining shorelines in harmful quantities, as defined at 40 CFR Part 110.

(j) "United States" means the States, the District of Columbia, the Commonwealth of Puerto Rico, the Canal Zone, Guam, American Samoa, the Virgin Islands, and the Trust Territory of the Pacific Islands.

(k) The term "navigable waters" of the United States means "navigable waters" as defined in section 502(7) of the FWPCA, and includes:

(1) all navigable waters of the United States, as defined in judicial decisions prior to passage of the 1972 Amendments to the FWPCA (Pub. L. 92-500), and tributaries of such waters;

(2) interstate waters;

(3) intrastate lakes, rivers, and streams which are utilized by interstate travelers for recreational or other purposes; and

(4) intrastate lakes, rivers, and streams from which fish or shellfish are taken and sold in interstate commerce.

(l) "Vessel" means every description of watercraft or other artificial contrivance used, or capable of being used as a means of transportation on water, other than a public vessel.

§ 112.3 Requirements for preparation and implementation of Spill Prevention Control and Countermeasure Plans.

(a) Owners or operators of onshore and offshore facilities in operation on or before the effective date of this part that have discharged or could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines, shall prepare a Spill Prevention Control and Countermeasure Plan (hereinafter "SPCC Plan"), in accordance with § 112.7. Except as provided for in paragraph (f) of this section, such SPCC Plan shall be prepared within six months after the effective date of this part and shall be fully implemented as soon as possible, but not later than one year after the effective date of this part.

(b) Owners or operators of onshore and offshore facilities that become operational after the effective date of this part, and that have discharged or could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines, shall prepare an SPCC Plan in accordance with § 112.7. Except as provided for in paragraph (f) of this section, such SPCC Plan shall be prepared within six months after the date such facility begins operations and shall be fully implemented as soon as possible, but not later than one year after such facility begins operations.

(c) Onshore and offshore mobile or portable facilities such as onshore drilling or workover rigs, barge mounted offshore drilling or workover rigs, and portable fueling facilities shall prepare and implement an SPCC Plan as required by paragraphs (a), (b) and (d) of this section. The owner or operator of such facility need not prepare and implement a new SPCC Plan each time the facility is moved to a new site. The SPCC Plan for mobile facilities should be prepared in accordance with § 112.7, using good engineering practice, and when the mobile facility is moved it should be located and installed using spill prevention practices outlined in the SPCC Plan for the facility. The SPCC Plan shall only apply while the facility is in a fixed (non transportation) operating mode.

(d) No SPCC Plan shall be effective to satisfy the requirements of this part unless it has been reviewed by a Registered Professional Engineer and certified to by such Professional Engineer. By means of this certification the engineer, having examined the facility and being familiar with the provisions of this part, shall attest that the SPCC Plan has been prepared in accordance with good engineering practices. Such certification shall in no way relieve the owner or operator of an onshore or offshore facility of his duty to prepare and fully implement such Plan in accordance with § 112.7, as required by paragraphs (a), (b) and (c) of this section.

(e) Owners or operators of a facility for which an SPCC Plan is required pursuant to paragraphs (a), (b) or (c) of this section shall maintain a complete copy of the Plan at such facility if the facility is normally attended at least 8 hours per day, or at the nearest field office if the facility is not so attended, and shall make such Plan available to the Regional Administrator for on-site review during normal working hours.

(f) Extensions of time.

(1) The Regional Administrator may authorize an extension of time for the preparation and full implementation of an SPCC Plan beyond the time permitted for the preparation and implementation of an SPCC Plan pursuant to paragraphs (a), (b) or (c) of this section where he finds that the owner or operator of a facility subject to paragraphs (a), (b) or (c) of this section cannot fully com-

ply with the requirements of this part as a result of either nonavailability of qualified personnel, or delays in construction or equipment delivery beyond the control and without the fault of such owner or operator or their respective agents or employees.

(2) Any owner or operator seeking an extension of time pursuant to paragraph (f) (1) of this section may submit a letter of request to the Regional Administrator. Such letter shall include:

(i) A complete copy of the SPCC Plan, if completed;

(ii) A full explanation of the cause for any such delay and the specific aspects of the SPCC Plan affected by the delay;

(iii) A full discussion of actions being taken or contemplated to minimize or mitigate such delay;

(iv) A proposed time schedule for the implementation of any corrective actions being taken or contemplated, including interim dates for completion of tests or studies, installation and operation of any necessary equipment or other preventive measures.

In addition, such owner or operator may present additional oral or written statements in support of his letter of request.

(3) The submission of a letter of request for extension of time pursuant to paragraph (f) (2) of this section shall in no way relieve the owner or operator from his obligation to comply with the requirements of § 112.3 (a), (b) or (c). Where an extension of time is authorized by the Regional Administrator for particular equipment or other specific aspects of the SPCC Plan, such extension shall in no way affect the owner's or operator's obligation to comply with the requirements of § 112.3 (a), (b) or (c) with respect to other equipment or other specific aspects of the SPCC Plan for which an extension of time has not been expressly authorized.

§ 112.4 Amendment of SPCC Plans by Regional Administrator.

(a) Notwithstanding compliance with § 112.3, whenever a facility subject to § 112.3 (a), (b) or (c) has: Discharged more than 1,000 U.S. gallons of oil into or upon the navigable waters of the United States or adjoining shorelines in a single spill event, or discharged oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines in two spill events, reportable under section 311(b) (5) of the FWPCA, occurring within any twelve month period, the owner or operator of such facility shall submit to the Regional Administrator, within 60 days from the time such facility becomes subject to this section, the following:

(1) Name of the facility;

(2) Name(s) of the owner or operator of the facility;

(3) Location of the facility;

(4) Date and year of initial facility operation;

(5) Maximum storage or handling capacity of the facility and normal daily throughput;

(6) Description of the facility, including maps, flow diagrams, and topographical maps;

(7) A complete copy of the SPCC Plan with any amendments;

(8) The cause(s) of such spill, including a failure analysis of system or subsystem in which the failure occurred;

(9) The corrective actions and/or countermeasures taken, including an adequate description of equipment repairs and/or replacements;

(10) Additional preventive measures taken or contemplated to minimize the possibility of recurrence;

(11) Such other information as the Regional Administrator may reasonably require pertinent to the Plan or spill event.

(b) Section 112.4 shall not apply until the expiration of the time permitted for the preparation and implementation of an SPCC Plan pursuant to § 112.3 (a), (b), (c) and (f).

(c) A complete copy of all information provided to the Regional Administrator pursuant to paragraph (a) of this section shall be sent at the same time to the State agency in charge of water pollution control activities in and for the State in which the facility is located. Upon receipt of such information such State agency may conduct a review and make recommendations to the Regional Administrator as to further procedures, methods, equipment and other requirements for equipment necessary to prevent and to contain discharges of oil from such facility.

(d) After review of the SPCC Plan for a facility subject to paragraph (a) of this section, together with all other information submitted by the owner or operator of such facility, and by the State agency under paragraph (c) of this section, the Regional Administrator may require the owner or operator of such facility to amend the SPCC Plan if he finds that the Plan does not meet the requirements of this part or that the amendment of the Plan is necessary to prevent and to contain discharges of oil from such facility.

(e) When the Regional Administrator proposes to require an amendment to the SPCC Plan, he shall notify the facility operator by certified mail addressed to, or by personal delivery to, the facility owner or operator, that he proposes to require an amendment to the Plan, and shall specify the terms of such amendment. If the facility owner or operator is a corporation, a copy of such notice shall also be mailed to the registered agent, if any, of such corporation in the State where such facility is located. Within 30 days from receipt of such notice, the facility owner or operator may submit written information, views, and arguments on the amendment. After considering all relevant material presented, the Regional Administrator shall notify the facility owner or operator of any amendment required or shall rescind the notice. The amendment required by the Regional Administrator shall become part of the Plan 30 days

after such notice, unless the Regional Administrator, for good cause, shall specify another effective date. The owner or operator of the facility shall implement the amendment of the Plan as soon as possible, but not later than six months after the amendment becomes part of the Plan, unless the Regional Administrator specifies another date.

(f) An owner or operator may appeal a decision made by the Regional Administrator requiring an amendment to an SPCC Plan. The appeal shall be made to the Administrator of the United States Environmental Protection Agency and must be made in writing within 30 days of receipt of the notice from the Regional Administrator requiring the amendment. A complete copy of the appeal must be sent to the Regional Administrator at the time the appeal is made. The appeal shall contain a clear and concise statement of the issues and points of fact in the case. It may also contain additional information which the owner or operator wishes to present in support of his argument. The Administrator or his designee may request additional information from the owner or operator, or from any other person. The Administrator or his designee may request additional information from the owner or operator, or from any other person. The Administrator or his designee shall render a decision within 60 days of receiving the appeal and shall notify the owner or operator of his decision.

§ 112.5 Amendment of Spill Prevention Control and Countermeasure Plans by owners or operators.

(a) Owners or operators of facilities subject to § 112.3 (a), (b) or (c) shall amend the SPCC Plan for such facility in accordance with § 112.7 whenever there is a change in facility design, construction, operation or maintenance which materially affects the facility's potential for the discharge of oil into or upon the navigable waters of the United States or adjoining shorelines. Such amendments shall be fully implemented as soon as possible, but not later than six months after such change occurs.

(b) Notwithstanding compliance with paragraph (a) of this section, owners and operators of facilities subject to § 112.3 (a), (b) or (c) shall complete a review and evaluation of the SPCC Plan at least once every three years from the date such facility becomes subject to this part. As a result of this review and evaluation, the owner or operator shall amend the SPCC Plan within six months of the review to include more effective prevention and control technology if:

- (1) Such technology will significantly reduce the likelihood of a spill event from the facility, and
- (2) if such technology has been field-proven at the time of the review.

(c) No amendment to an SPCC Plan shall be effective to satisfy the requirements of this section unless it has been certified by a Professional Engineer in accordance with § 112.3(d).

§ 112.6 Civil penalties.

Owners or operators of facilities subject to § 112.3 (a), (b) or (c) who violate the requirements of this part by failing or refusing to comply with any of the provisions of § 112.3, § 112.4, or § 112.5 shall be liable for a civil penalty of not more than \$5,000 for each day that such violation continues. The Regional Administrator may assess and compromise such civil penalty. No penalty shall be assessed until the owner or operator shall have been given notice and an opportunity for hearing.

§ 112.7 Guidelines for the preparation and implementation of a Spill Prevention Control and Countermeasure Plan.

The SPCC Plan shall be a carefully thought-out plan, prepared in accordance with good engineering practices, and which has the full approval of management at a level with authority to commit the necessary resources. If the plan calls for additional facilities or procedures, methods, or equipment not yet fully operational, these items should be discussed in separate paragraphs, and the details of installation and operational start-up should be explained separately. The complete SPCC Plan shall follow the sequence outlined below, and include a discussion of the facility's conformance with the appropriate guidelines listed:

(a) A facility which has experienced one or more spill events within twelve months prior to the effective date of this part should include a written description of each such spill, corrective action taken and plans for preventing recurrence.

(b) Where experience indicates a reasonable potential for equipment failure (such as tank overflow, rupture, or leakage), the plan should include a prediction of the direction, rate of flow, and total quantity of oil which could be discharged from the facility as a result of each major type of failure.

(c) Appropriate containment and/or diversionary structures or equipment to prevent discharged oil from reaching a navigable water course should be provided. One of the following preventive systems or its equivalent should be used as a minimum:

- (1) Onshore facilities.
 - (i) Dikes, berms or retaining walls sufficiently impervious to contain spilled oil
 - (ii) Curbing
 - (iii) Culverting, gutters or other drainage systems
 - (iv) Weirs, booms or other barriers
 - (v) Spill diversion ponds
 - (vi) Retention ponds
 - (vii) Sorbent materials
 - (2) Offshore facilities.
 - (i) Curbing, drip pans
 - (ii) Sumps and collection systems
 - (d) When it is determined that the installation of structures or equipment listed in § 112.7(c) to prevent discharged oil from reaching the navigable waters

is not practicable from any onshore or offshore facility, the owner or operator should clearly demonstrate such impracticability and provide the following:

(1) A strong oil spill contingency plan following the provision of 40 CFR Part 109.

(2) A written commitment of manpower, equipment and materials required to expeditiously control and remove any harmful quantity of oil discharged.

(e) In addition to the minimal prevention standards listed under § 112.7 (c), sections of the Plan should include a complete discussion of conformance with the following applicable guidelines, other effective spill prevention and containment procedures (or, if more stringent, with State rules, regulations and guidelines):

(1) *Facility drainage (onshore); (excluding production facilities)*. (i) Drainage from diked storage areas should be restrained by valves or other positive means to prevent a spill or other excessive leakage of oil into the drainage system or implant effluent treatment system, except where plan systems are designed to handle such leakage. Diked areas may be emptied by pumps or ejectors; however, these should be manually activated and the condition of the accumulation should be examined before starting to be sure no oil will be discharged into the water.

(ii) Flapper-type drain valves should not be used to drain diked areas. Valves used for the drainage of diked areas should, as far as practical, be of manual, open-and-closed design. When plant drainage drains directly into water courses and not into wastewater treatment plants, retained storm water should be inspected as provided in paragraph (e) (2) (iii) (B, C and D) before drainage.

(iii) Plant drainage systems from undiked areas should, if possible, flow into ponds, lagoons or catchment basins, designed to retain oil or return it to the facility. Catchment basins should not be located in areas subject to periodic flooding.

(iv) If plant drainage is not engineered as above, the final discharge of all in-plant ditches should be equipped with a diversion system that could, in the event of an uncontrolled spill, return the oil to the plant.

(v) Where drainage waters are treated in more than one treatment unit, natural hydraulic flow should be used. If pump transfer is needed, two "lift" pumps should be provided, and at least one of the pumps should be permanently installed when such treatment is continuous. In any event, whatever techniques are used facility drainage systems should be adequately engineered to prevent oil from reaching navigable waters in the event of equipment failure or human error at the facility.

(2) *Bulk storage tanks (onshore); (excluding production facilities)*. (i) No

tank should be used for the storage of oil unless its material and construction are compatible with the material stored and conditions of storage such as pressure and temperature, etc.

(ii) All bulk storage tank installations should be constructed so that a secondary means of containment is provided for the entire contents of the largest single tank plus sufficient freeboard to allow for precipitation. Diked areas should be sufficiently impervious to contain spilled oil. Dikes, containment curbs, and pits are commonly employed for this purpose, but they may not always be appropriate. An alternative system could consist of a complete drainage trench enclosure arranged so that a spill could terminate and be safely confined in an in-plant catchment basin or holding pond.

(iii) Drainage of rainwater from the diked area into a storm drain or an effluent discharge that empties into an open water course, lake, or pond, and bypassing the in-plant treatment system may be acceptable if:

(A) The bypass valve is normally sealed closed.

(B) Inspection of the run-off rain water ensures compliance with applicable water quality standards and will not cause a harmful discharge as defined in 40 CFR 110.

(C) The bypass valve is opened, and resealed following drainage under responsible supervision.

(D) Adequate records are kept of such events.

(iv) Buried metallic storage tanks represent a potential for undetected spills. A new buried installation should be protected from corrosion by coatings, cathodic protection or other effective methods compatible with local soil conditions. Such buried tanks should at least be subjected to regular pressure testing.

(v) Partially buried metallic tanks for the storage of oil should be avoided, unless the buried section of the shell is adequately coated, since partial burial in damp earth can cause rapid corrosion of metallic surfaces, especially at the earth/air interface.

(vi) Aboveground tanks should be subject to periodic integrity testing, taking into account tank design (floating roof, etc.) and using such techniques as hydrostatic testing, visual inspection or a system of non-destructive shell thickness testing. Comparison records should be kept where appropriate, and tank supports and foundations should be included in these inspections. In addition, the outside of the tank should frequently be observed by operating personnel for signs of deterioration, leaks which might cause a spill, or accumulation of oil inside diked areas.

(vii) To control leakage through defective internal heating coils, the following factors should be considered and applied, as appropriate.

(A) The steam return or exhaust lines from internal heating coils which discharge into an open water course should be monitored for contamination or passed through a settling tank, skimmer, or other separation or retention system.

(B) The feasibility of installing an external heating system should also be considered.

(viii) New and old tank installations should, as far as practical, be fail-safe engineered or updated into a fail-safe engineered installation to avoid spills. Consideration should be given to providing one or more of the following devices:

(A) High liquid level alarms with an audible or visual signal at a constantly manned operation or surveillance station; in smaller plants an audible air vent may suffice.

(B) Considering size and complexity of the facility, high liquid level pump cutoff devices set to stop flow at a predetermined tank content level.

(C) Direct audible or code signal communication between the tank gauger and the pumping station.

(D) A fast response system for determining the liquid level of each bulk storage tank such as digital computers, telepulse, or direct vision gauges or their equivalent.

(E) Liquid level sensing devices should be regularly tested to insure proper operation.

(ix) Plant effluents which are discharged into navigable waters should have disposal facilities observed frequently enough to detect possible system upsets that could cause an oil spill event.

(x) Visible oil leaks which result in a loss of oil from tank seams, gaskets, rivets and bolts sufficiently large to cause the accumulation of oil in diked areas should be promptly corrected.

(xi) Mobile or portable oil storage tanks (onshore) should be positioned or located so as to prevent spilled oil from reaching navigable waters. A secondary means of containment, such as dikes or catchment basins, should be furnished for the largest single compartment or tank. These facilities should be located where they will not be subject to periodic flooding or washout.

(3) *Facility transfer operations, pumping, and in-plant process (onshore); (excluding production facilities)*. (i) Buried piping installations should have a protective wrapping and coating and should be cathodically protected if soil conditions warrant. If a section of buried line is exposed for any reason, it should be carefully examined for deterioration. If corrosion damage is found, additional examination and corrective action should be taken as indicated by the magnitude of the damage. An alternative would be the more frequent use of exposed pipe corridors or galleries.

(ii) When a pipeline is not in service, or in standby service for an extended time the terminal connection at the transfer point should be capped or blank-flanged, and marked as to origin.

(iii) Pipe supports should be properly designed to minimize abrasion and corrosion and allow for expansion and contraction.

(iv) All aboveground valves and pipelines should be subjected to regular examinations by operating personnel at which time the general condition of items, such as flange joints, expansion

joints, valve glands and bodies, catch pans, pipeline supports, locking of valves, and metal surfaces should be assessed. In addition, periodic pressure testing may be warranted for piping in areas where facility drainage is such that a failure might lead to a spill event.

(v) Vehicular traffic granted entry into the facility should be warned verbally or by appropriate signs to be sure that the vehicle, because of its size, will not endanger above ground piping.

(4) *Facility tank car and tank truck loading/unloading rack (onshore)*. (i) Tank car and tank truck loading/unloading procedures should meet the minimum requirements and regulation established by the Department of Transportation.

(ii) Where rack area drainage does not flow into a catchment basin or treatment facility designed to handle spills, a quick drainage system should be used for tank truck loading and unloading areas. The containment system should be designed to hold at least maximum capacity of any single compartment of a tank car or tank truck loaded or unloaded in the plant.

(iii) An interlocked warning light or physical barrier system, or warning signs, should be provided in loading/unloading areas to prevent vehicular departure before complete disconnect of flexible or fixed transfer lines.

(iv) Prior to filling and departure of any tank car or tank truck, the lowermost drain and all outlets of such vehicles should be closely examined for leakage, and if necessary, tightened, adjusted, or replaced to prevent liquid leakage while in transit.

(5) *Oil production facilities (onshore)*. (i) *Definition*. An onshore production facility may include all wells, flowlines, separation equipment, storage facilities, gathering lines, and auxiliary non-transportation-related equipment and facilities in a single geographical oil or gas field operated by a single operator.

(ii) *Oil production facility (onshore) drainage*. (A) At tank batteries and central treating stations where an accidental discharge of oil would have a reasonable possibility of reaching navigable waters, the dikes or equivalent required under § 112.7(c)(1) should have drains closed and sealed at all times except when rainwater is being drained. Prior to drainage, the diked area should be inspected as provided in paragraph (e)(2)(iii) (B), (C), and (D). Accumulated oil on the rainwater should be picked up and returned to storage or disposed of in accordance with approved methods.

(B) Field drainage ditches, road ditches, and oil traps, sumps or skimmers, if such exist, should be inspected at regularly scheduled intervals for accumulation of oil that may have escaped from small leaks. Any such accumulations should be removed.

(iii) *Oil production facility (onshore) bulk storage tanks*. (A) No tank should be used for the storage of oil unless its material and construction are compatible with the material stored and the conditions of storage.

(B) All tank battery and central treating plant installations should be provided with a secondary means of containment for the entire contents of the largest single tank if feasible, or alternate systems such as those outlined in § 112.7(c) (1). Drainage from undiked areas should be safely confined in a catchment basin or holding pond.

(C) All tanks containing oil should be visually examined by a competent person for condition and need for maintenance on a scheduled periodic basis. Such examination should include the foundation and supports of tanks that are above the surface of the ground.

(D) New and old tank battery installations should, as far as practical, be fail-safe engineered or updated into a fail-safe engineered installation to prevent spills. Consideration should be given to one or more of the following:

(1) Adequate tank capacity to assure that a tank will not overflow should a pumper/gauge be delayed in making his regular rounds.

(2) Overflow equalizing lines between tanks so that a full tank can overflow to an adjacent tank.

(3) Adequate vacuum protection to prevent tank collapse during a pipeline run.

(4) High level sensors to generate and transmit an alarm signal to the computer where facilities are a part of a computer production control system.

(iv) *Facility transfer operations, oil production facility (onshore)*. (A) All above ground valves and pipelines should be examined periodically on a scheduled basis for general condition of items such as flange joints, valve glands and bodies, drip pans, pipeline supports, pumping well polish rod stuffing boxes, bleeder and gauge valves.

(B) Salt water (oil field brine) disposal facilities should be examined often, particularly following a sudden change in atmospheric temperature to detect possible system upsets that could cause an oil discharge.

(C) Production facilities should have a program of flowline maintenance to prevent spills from this source. The program should include periodic examinations, corrosion protection, flowline replacement, and adequate records, as appropriate, for the individual facility.

(6) *Oil drilling and workover facilities (onshore)* (i) Mobile drilling or workover equipment should be positioned or located so as to prevent spilled oil from reaching navigable waters.

(ii) Depending on the location, catchment basins or diversion structures may be necessary to intercept and contain spills of fuel, crude oil, or oily drilling fluids.

(iii) Before drilling below any casing string or during workover operations, a blowout prevention (BOP) assembly and well control system should be installed that is capable of controlling any well head pressure that is expected to be encountered while that BOP assembly is on the well. Casing and BOP installations should be in accordance with State regulatory agency requirements.

(7) *Oil drilling, production, or workover facilities (offshore)*. (i) Definition: "An oil drilling, production or workover facility (offshore)" may include all drilling or workover equipment, wells, flowlines, gathering lines, platforms, and auxiliary nontransportation-related equipment and facilities in a single geographical oil or gas field operated by a single operator.

(ii) Oil drainage collection equipment should be used to prevent and control small oil spillage around pumps, glands, valves, flanges, expansion joints, hoses, drain lines, separators, treaters, tanks, and allied equipment. Drains on the facility should be controlled and directed toward a central collection sump or equivalent collection system sufficient to prevent discharges of oil into the navigable waters of the United States. Where drains and sumps are not practicable oil contained in collection equipment should be removed as often as necessary to prevent overflow.

(iii) For facilities employing a sump system, sump and drains should be adequately sized and a spare pump or equivalent method should be available to remove liquid from the sump and assure that oil does not escape. A regular scheduled preventive maintenance inspection and testing program should be employed to assure reliable operation of the liquid removal system and pump start-up device. Redundant automatic sump pumps and control devices may be required on some installations.

(iv) In areas where separators and treaters are equipped with dump valves whose predominant mode of failure is in the closed position and pollution risk is high, the facility should be specially equipped to prevent the escape of oil. This could be accomplished by extending the flare line to a diked area if the separator is near shore, equipping it with a high liquid level sensor that will automatically shut-in wells producing to the separator, parallel redundant dump valves, or other feasible alternatives to prevent oil discharges.

(v) Atmospheric storage or surge tanks should be equipped with high liquid level sensing devices or other acceptable alternatives to prevent oil discharges.

(vi) Pressure tanks should be equipped with high and low pressure sensing devices to activate an alarm and/or control the flow or other acceptable alternatives to prevent oil discharges.

(vii) Tanks should be equipped with suitable corrosion protection.

(viii) A written procedure for inspecting and testing pollution prevention equipment and systems should be prepared and maintained at the facility. Such procedures should be included as part of the SPCC Plan.

(ix) Testing and inspection of the pollution prevention equipment and systems at the facility should be conducted by the owner or operator on a scheduled periodic basis commensurate with the complexity, conditions and circumstances of the facility or other appropriate regulations.

(x) Surface and subsurface well shut-in valves and devices in use at the facility should be sufficiently described to determine method of activation or control, e.g., pressure differential, change in fluid or flow conditions, combination of pressure and flow, manual or remote control mechanisms. Detailed records for each well, while not necessarily part of the plan should be kept by the owner or operator.

(xi) Before drilling below any casing string, and during workover operations a blowout preventer (BOP) assembly and well control system should be installed that is capable of controlling any well-head pressure that is expected to be encountered while that BOP assembly is on the well. Casing and BOP installations should be in accordance with State regulatory agency requirements.

(xii) Extraordinary well control measures should be provided should emergency conditions, including fire, loss of control and other abnormal conditions, occur. The degree of control system redundancy should vary with hazard exposure and probable consequences of failure. It is recommended that surface shut-in systems have redundant or "fail close" valving. Subsurface safety valves may not be needed in producing wells that will not flow but should be installed as required by applicable State regulations.

(xiii) In order that there will be no misunderstanding of joint and separate duties and obligations to perform work in a safe and pollution free manner, written instructions should be prepared by the owner or operator for contractors and subcontractors to follow whenever contract activities include servicing a well or systems appurtenant to a well or pressure vessel. Such instructions and procedures should be maintained at the offshore production facility. Under certain circumstances and conditions such contractor activities may require the presence at the facility of an authorized representative of the owner or operator who would intervene when necessary to prevent a spill event.

(xiv) All manifolds (headers) should be equipped with check valves on individual flowlines.

(xv) If the shut-in well pressure is greater than the working pressure of the flowline and manifold valves up to and including the header valves associated with that individual flowline, the flowline should be equipped with a high pressure sensing device and shutin valve at the wellhead unless provided with a pressure relief system to prevent overpressuring.

(xvi) All pipelines appurtenant to the facility should be protected from corrosion. Methods used, such as protective coatings or cathodic protection, should be discussed.

(xvii) Sub-marine pipelines appurtenant to the facility should be adequately protected against environmental stresses and other activities such as fishing operations.

(xviii) Sub-marine pipelines appurtenant to the facility should be in good

operating condition at all times and inspected on a scheduled periodic basis for failures. Such inspections should be documented and maintained at the facility.

(8) *Inspections and records.* Inspections required by this part should be in accordance with written procedures developed for the facility by the owner or operator. These written procedures and a record of the inspections, signed by the appropriate supervisor or inspector, should be made part of the SPCC Plan and maintained for a period of three years.

(9) *Security (excluding oil production facilities).* (i) All plants handling, processing, and storing oil should be fully fenced, and entrance gates should be locked and/or guarded when the plant is not in production or is unattended.

(ii) The master flow and drain valves and any other valves that will permit direct outward flow of the tank's content to the surface should be securely locked in the closed position when in non-operating or non-standby status.

(iii) The starter control on all oil pumps should be locked in the "off" position or located at a site accessible only to authorized personnel when the pumps are, in a non-operating or non-standby status.

(iv) The loading/unloading connections of oil pipelines should be securely capped or blank-flanged when not in service or standby service for an extended time. This security practice should also apply to pipelines that are emptied of liquid content either by draining or by inert gas pressure.

(v) Facility lighting should be commensurate with the type and location of the facility. Consideration should be given to: (A) Discovery of spills occurring during hours of darkness, both by operating personnel, if present, and by non-operating personnel (the general public, local police, etc.) and (B) prevention of spills occurring through acts of vandalism.

(10) *Personnel, training and spill prevention procedures.* (i) Owners or operators are responsible for properly instructing their personnel in the operation and maintenance of equipment to prevent the discharges of oil and applicable pollution control laws, rules and regulations.

(ii) Each applicable facility should have a designated person who is accountable for oil spill prevention and who reports to line management.

(iii) Owners or operators should schedule and conduct spill prevention briefings for their operating personnel at intervals frequent enough to assure adequate understanding of the SPCC Plan for that facility. Such briefings

should highlight and describe known spill events or failures, malfunctioning components, and recently developed precautionary measures.

APPENDIX

Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency.

SECTION II—DEFINITIONS

The Environmental Protection Agency and the Department of Transportation agree that for the purposes of Executive Order 11548, the term:

(1) "Non-transportation-related onshore and offshore facilities" means:

(A) Fixed onshore and offshore oil well drilling facilities including all equipment and appurtenances related thereto used in drilling operations for exploratory or development wells, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(B) Mobile onshore and offshore oil well drilling platforms, barges, trucks, or other mobile facilities including all equipment and appurtenances related thereto when such mobile facilities are fixed in position for the purpose of drilling operations for exploratory or development wells, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(C) Fixed onshore and offshore oil production structures, platforms, derricks, and rigs including all equipment and appurtenances related thereto, as well as completed wells and the wellhead separators, oil separators, and storage facilities used in the production of oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(D) Mobile onshore and offshore oil production facilities including all equipment and appurtenances related thereto as well as completed wells and wellhead equipment, piping from wellheads to oil separators, oil separators, and storage facilities used in the production of oil when such mobile facilities are fixed in position for the purpose of oil production operations, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(E) Oil refining facilities including all equipment and appurtenances related thereto as well as in-plant processing units, storage units, piping, drainage systems and waste treatment units used in the refining of oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(F) Oil storage facilities including all equipment and appurtenances related thereto as well as fixed bulk plant storage, terminal oil storage facilities, consumer storage, pumps and drainage systems used in the storage of oil, but excluding inline or breakout storage tanks needed for the continuous operation of a pipeline system and any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(G) Industrial, commercial, agricultural or public facilities which use and store oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(H) Waste treatment facilities including in-plant pipelines, effluent discharge lines, and storage tanks, but excluding waste treatment facilities located on vessels and terminal storage tanks and appurtenances for the reception of oily ballast water or tank washings from vessels and associated systems used for off-loading vessels.

(I) Loading racks, transfer hoses, loading arms and other equipment which are appurtenant to a nontransportation-related facility or terminal facility and which are used to transfer oil in bulk to or from highway vehicles or railroad cars.

(J) Highway vehicles and railroad cars which are used for the transport of oil exclusively within the confines of a nontransportation-related facility and which are not intended to transport oil in interstate or intrastate commerce.

(K) Pipeline systems which are used for the transport of oil exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended to transport oil in interstate or intrastate commerce, but excluding pipeline systems used to transfer oil in bulk to or from a vessel.

(2) "transportation-related onshore and offshore facilities" means:

(A) Onshore and offshore terminal facilities including transfer hoses, loading arms and other equipment and appurtenances used for the purpose of handling or transferring oil in bulk to or from a vessel as well as storage tanks and appurtenances for the reception of oily ballast water or tank washings from vessels, but excluding terminal waste treatment facilities and terminal oil storage facilities.

(B) Transfer hoses, loading arms and other equipment appurtenant to a non-transportation-related facility which is used to transfer oil in bulk to or from a vessel.

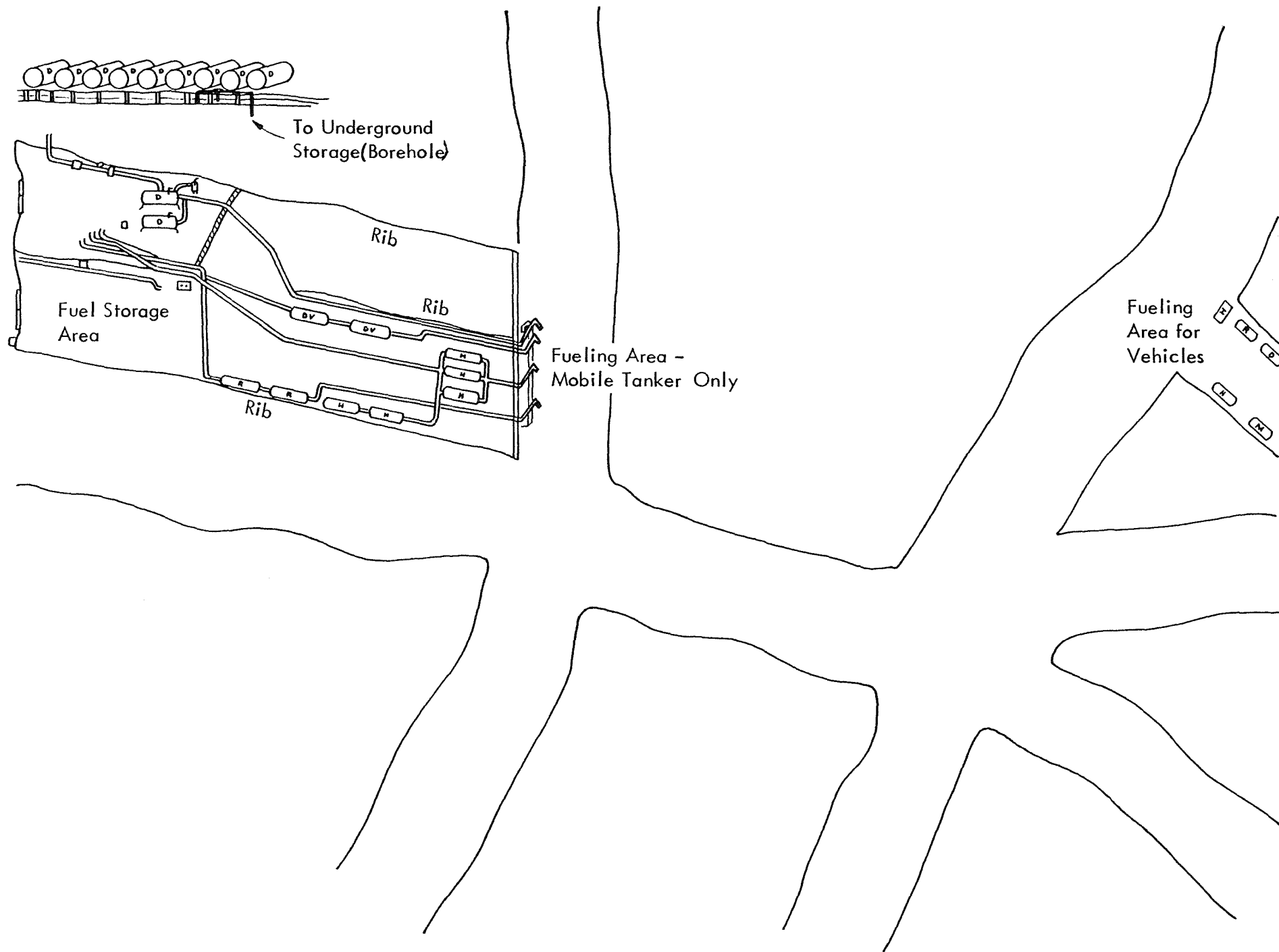
(C) Interstate and intrastate onshore and offshore pipeline systems including pumps and appurtenances related thereto as well as in-line or breakout storage tanks needed for the continuous operation of a pipeline system, and pipelines from onshore and offshore oil production facilities, but excluding onshore and offshore piping from wellheads to oil separators and pipelines which are used for the transport of oil exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended to transport oil in interstate or intrastate commerce or to transfer oil in bulk to or from a vessel.

(D) Highway vehicles and railroad cars which are used for the transport of oil in interstate or intrastate commerce and the equipment and appurtenances related thereto, and equipment used for the fueling of locomotive units, as well as the rights-of-way on which they operate. Excluded are highway vehicles and railroad cars and motive power used exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended for use in interstate or intrastate commerce.

[FR Doc.73-25448 Filed 12-10-73;8:45 am]

APPENDIX D

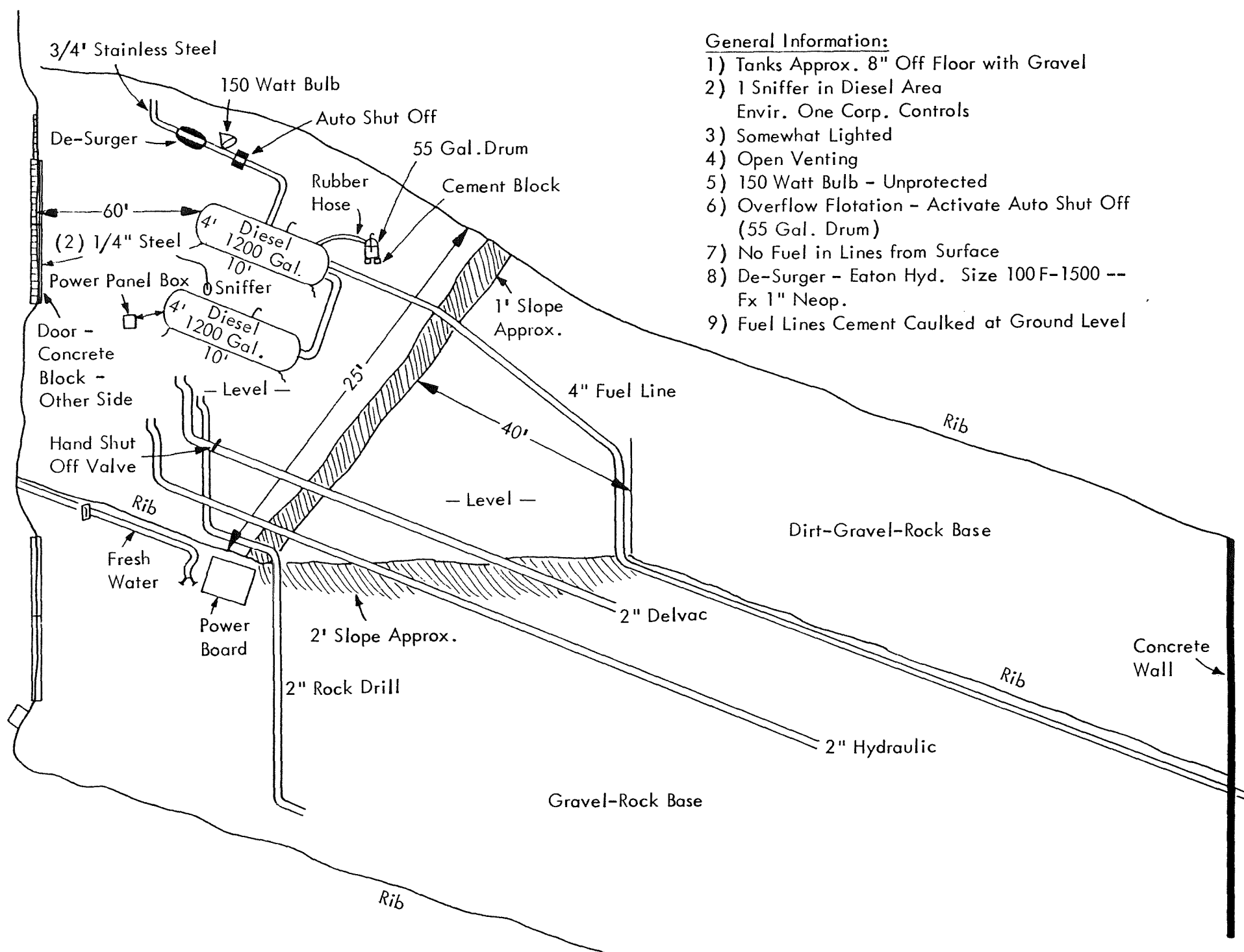
DRAWINGS OF OBSERVED FUELING AREAS



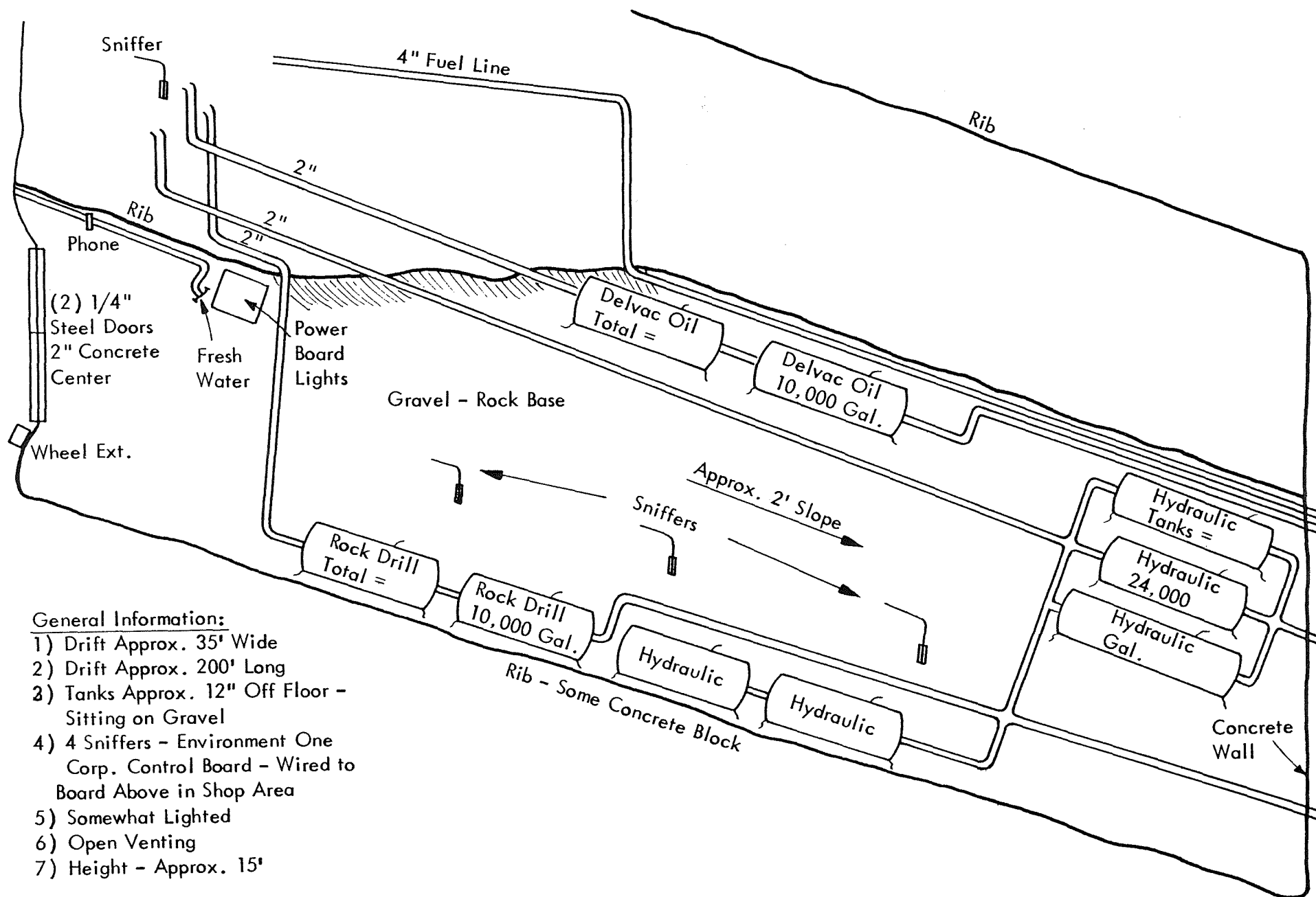
Mine 1 - Fueling System

General Information:

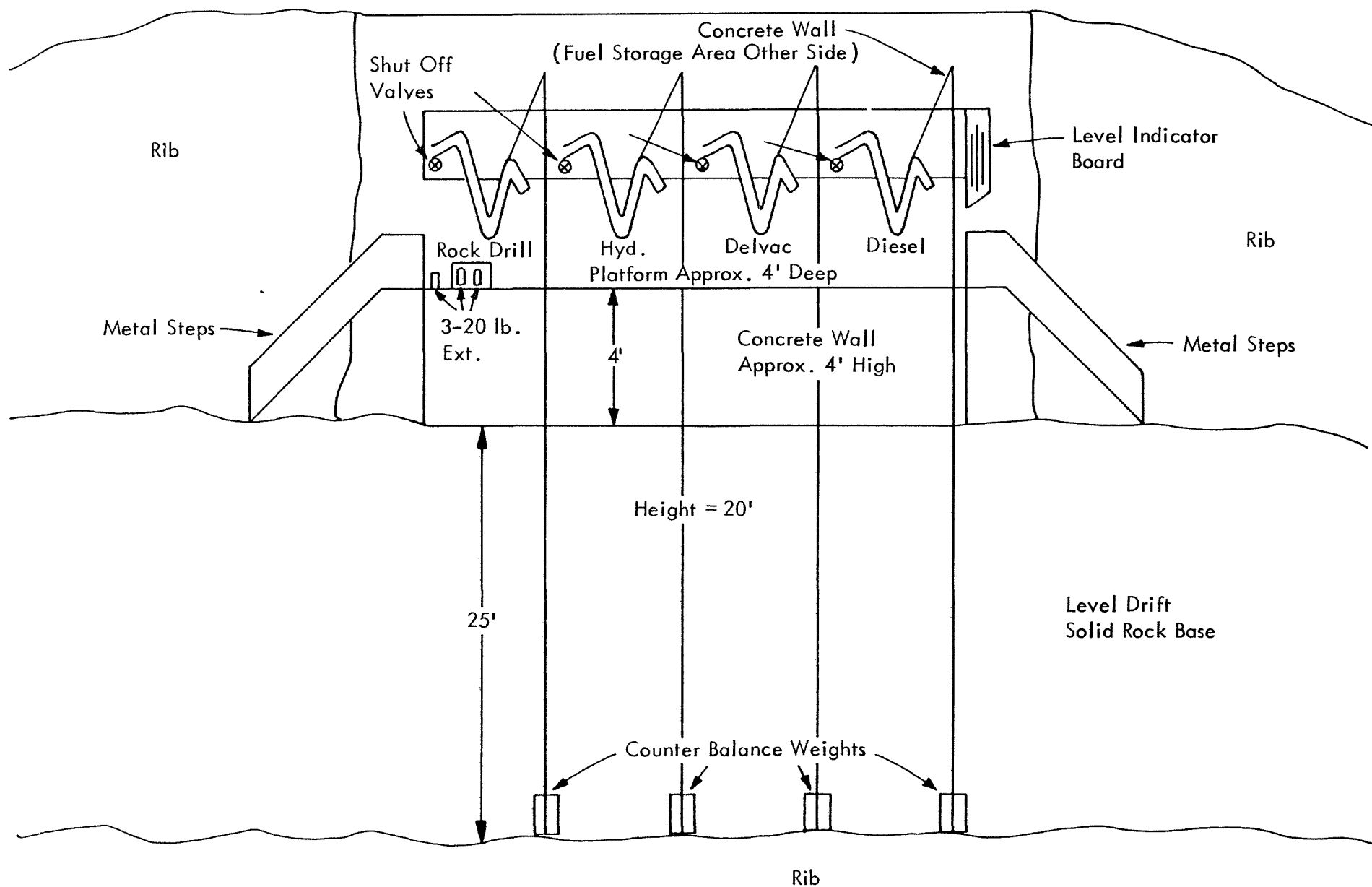
- 1) Tanks Approx. 8" Off Floor with Gravel
- 2) 1 Sniffer in Diesel Area
Envir. One Corp. Controls
- 3) Somewhat Lighted
- 4) Open Venting
- 5) 150 Watt Bulb - Unprotected
- 6) Overflow Flotation - Activate Auto Shut Off
(55 Gal. Drum)
- 7) No Fuel in Lines from Surface
- 8) De-Surger - Eaton Hyd. Size 100F-1500 --
Fx 1" Neop.
- 9) Fuel Lines Cement Caulked at Ground Level



Mine 1 - Underground Storage Area



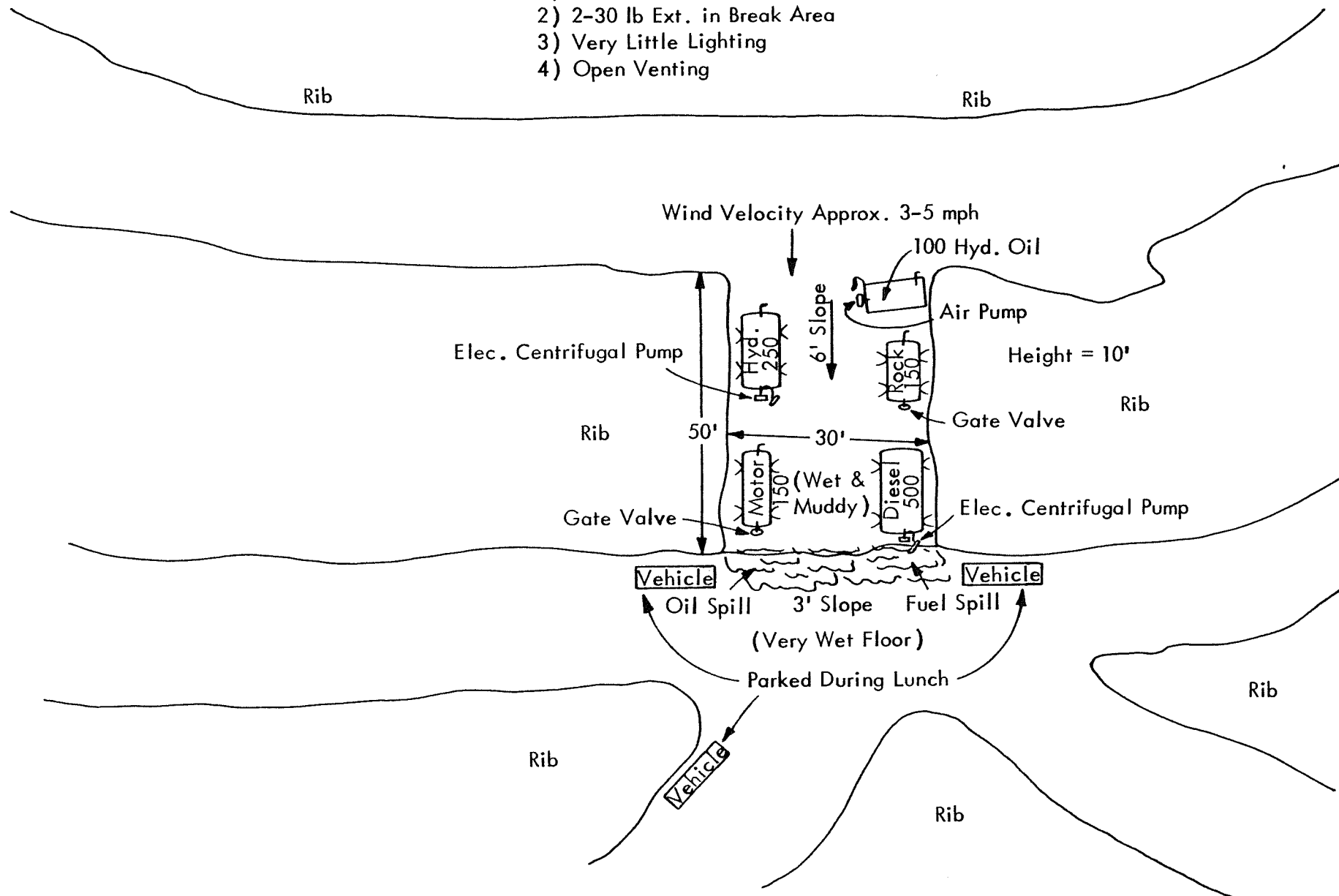
Mine 1 - Underground Storage Area



Mine 1 - Vehicle Transfer Area

General Information:

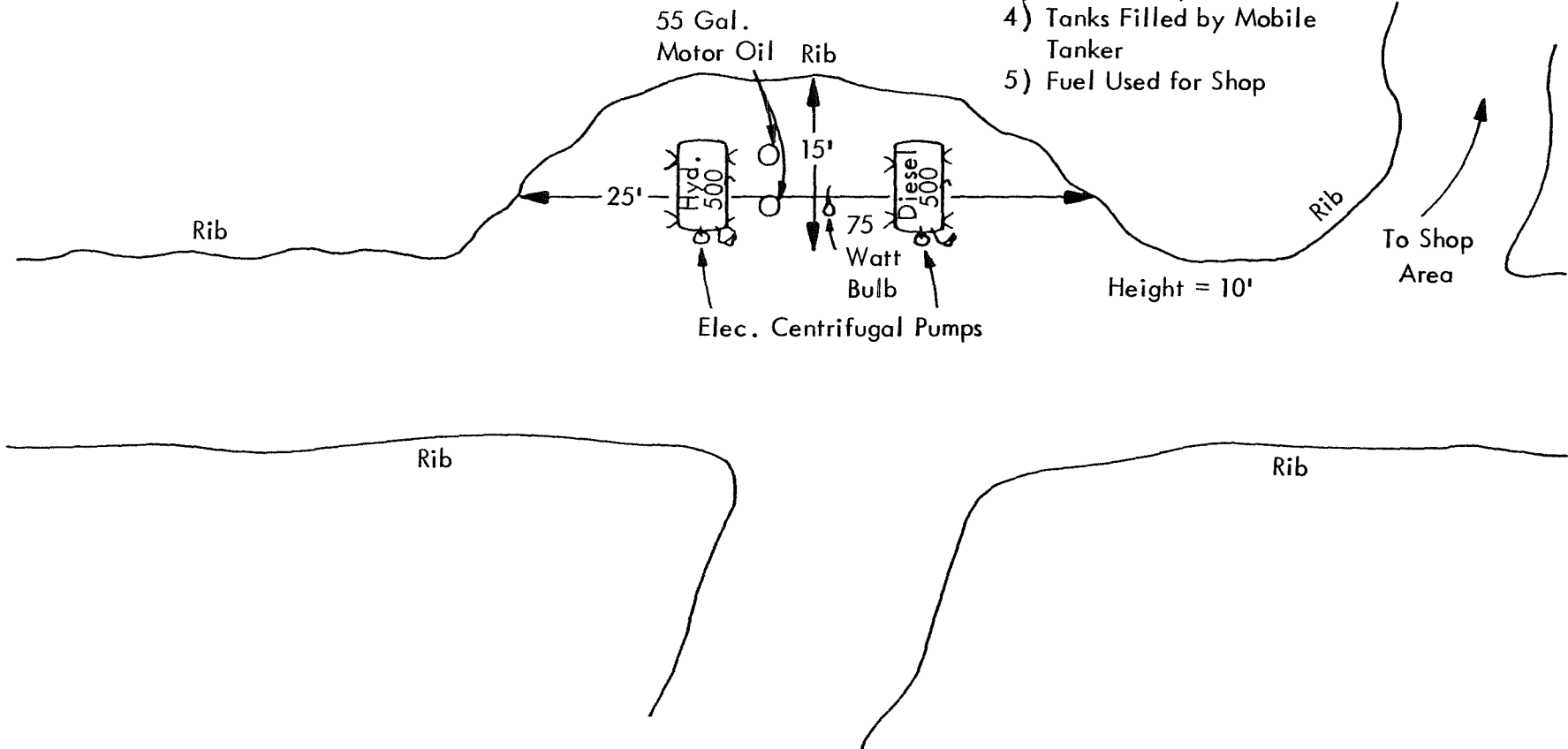
- 1) All Tanks on Metal Cradles
- 2) 2-30 lb Ext. in Break Area
- 3) Very Little Lighting
- 4) Open Venting



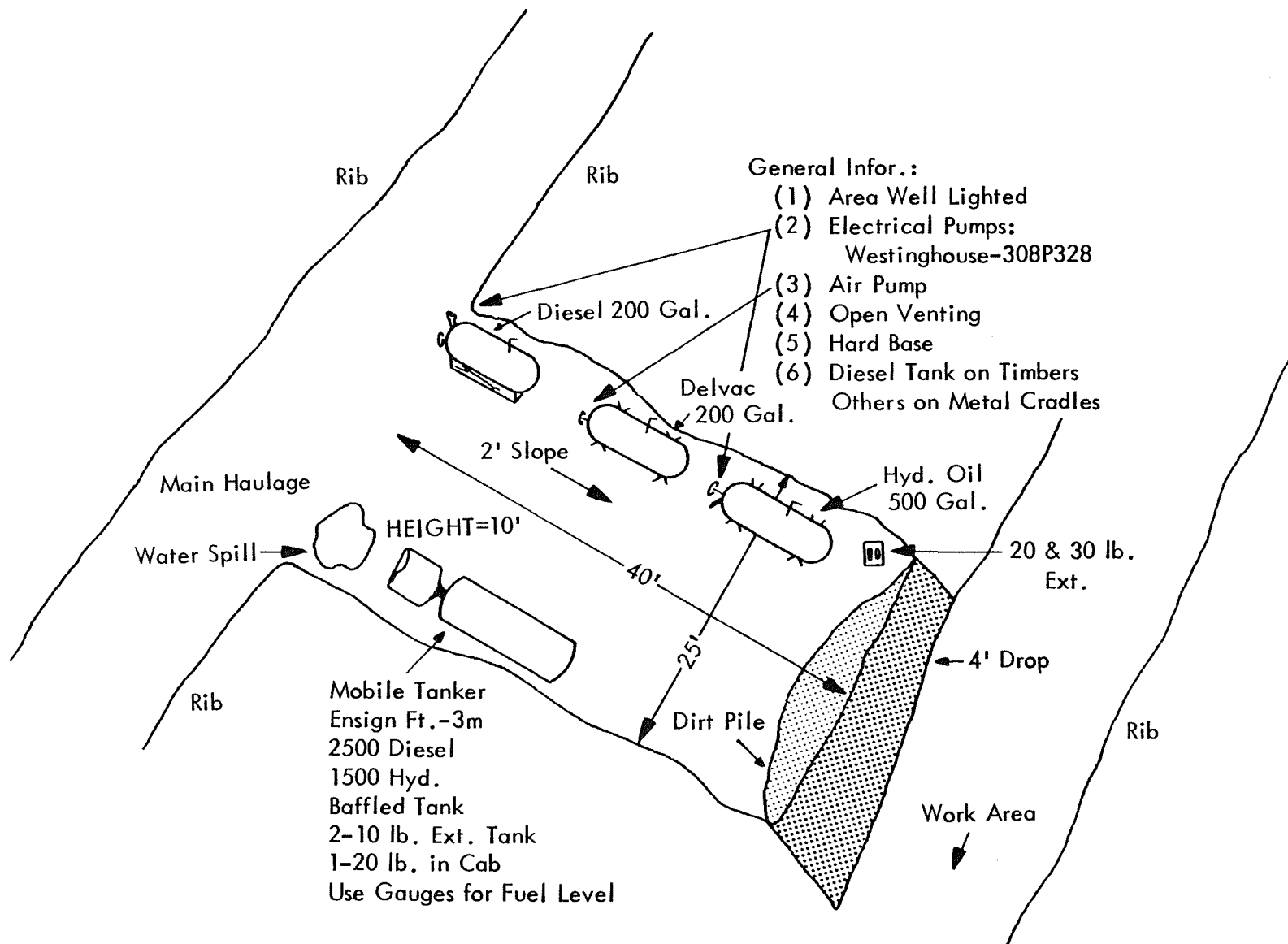
Mine 1 - Vehicle Transfer Area

General Information:

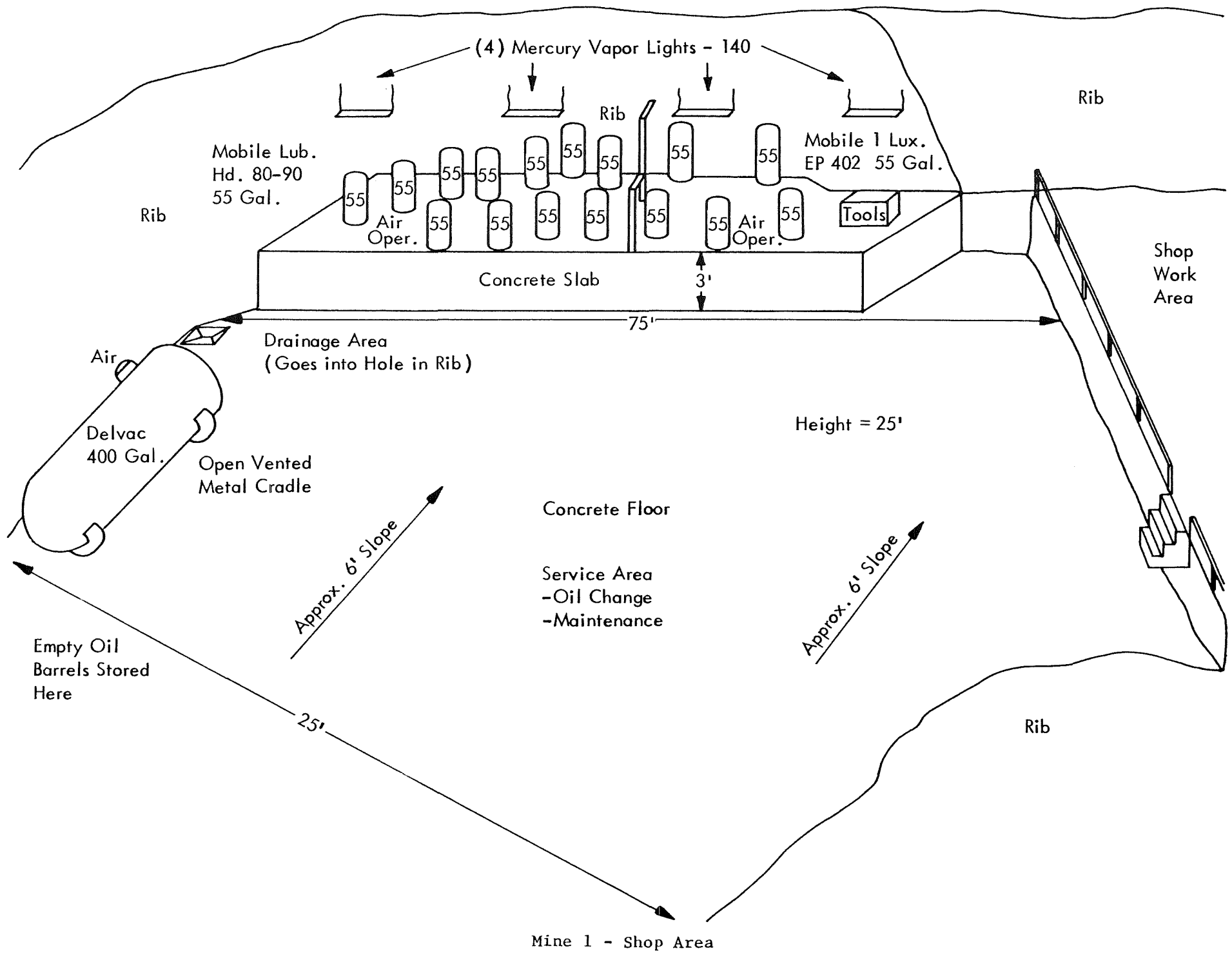
- 1) Area Slopes Toward Back
Natural Containment
- 2) Tanks on Metal Cradles
- 3) Ext. in Shop Area
- 4) Tanks Filled by Mobile
Tanker
- 5) Fuel Used for Shop



Mine 1 - Vehicle Transfer Area

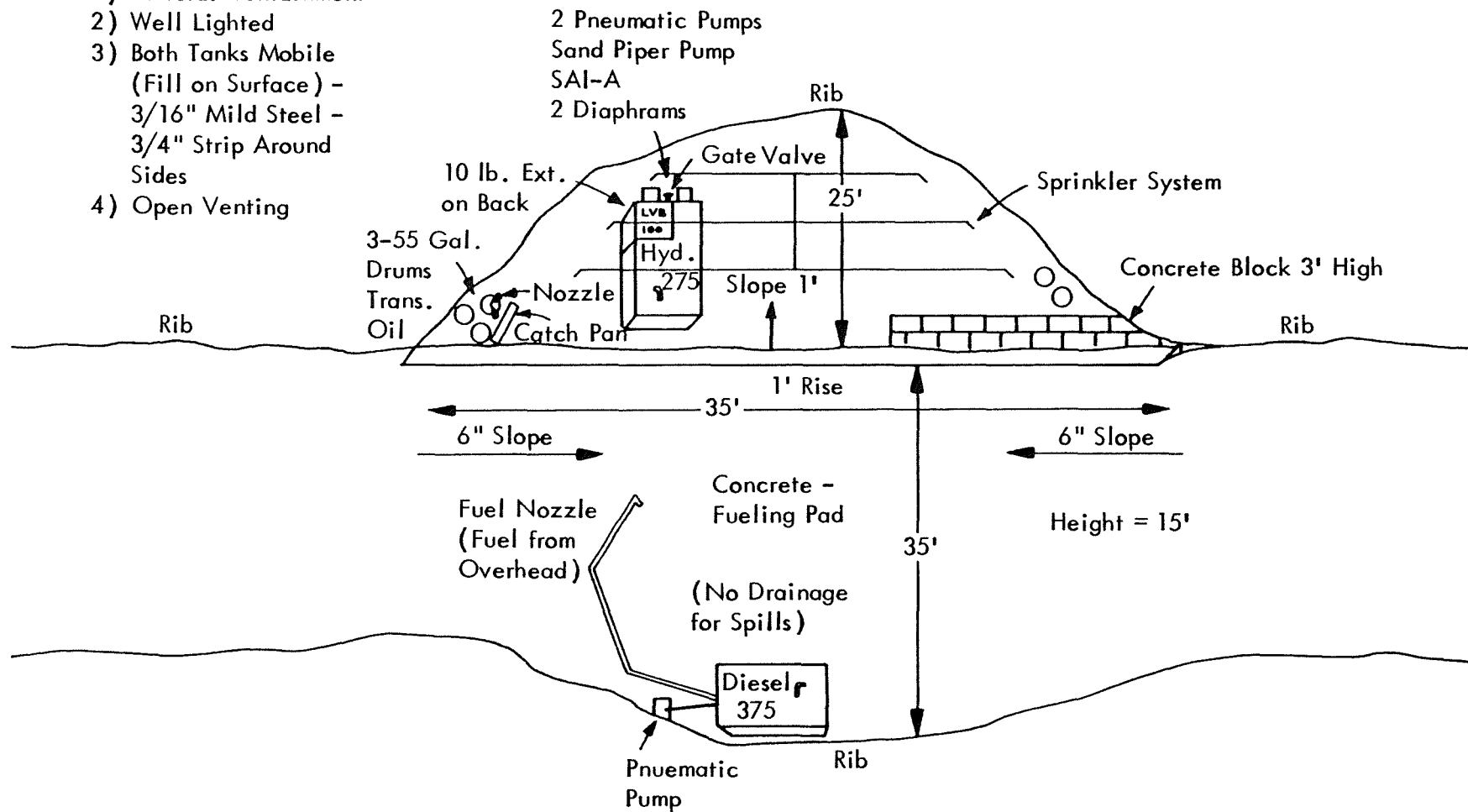


Mine 1 - Vehicle Transfer Area

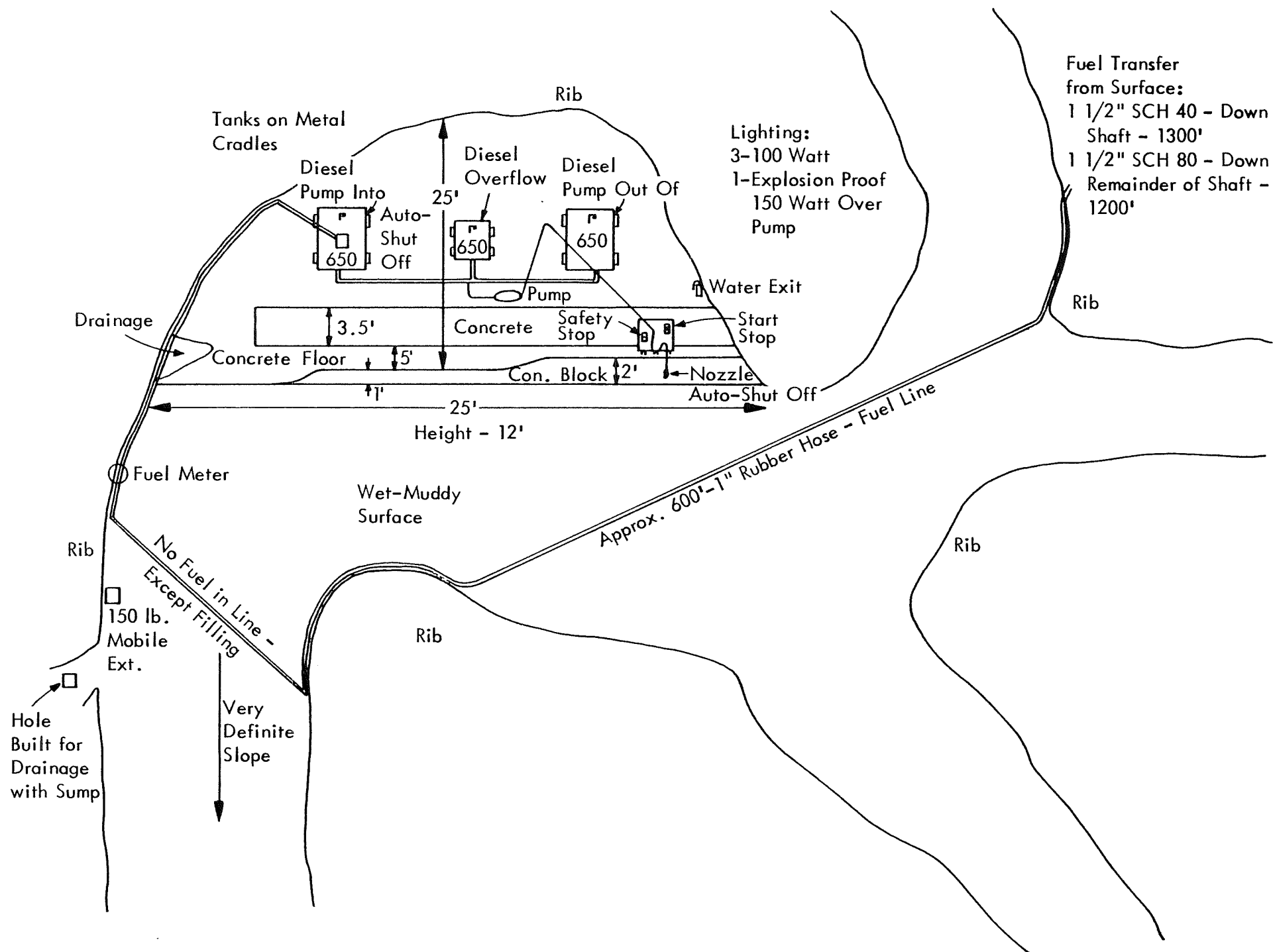


General Information:

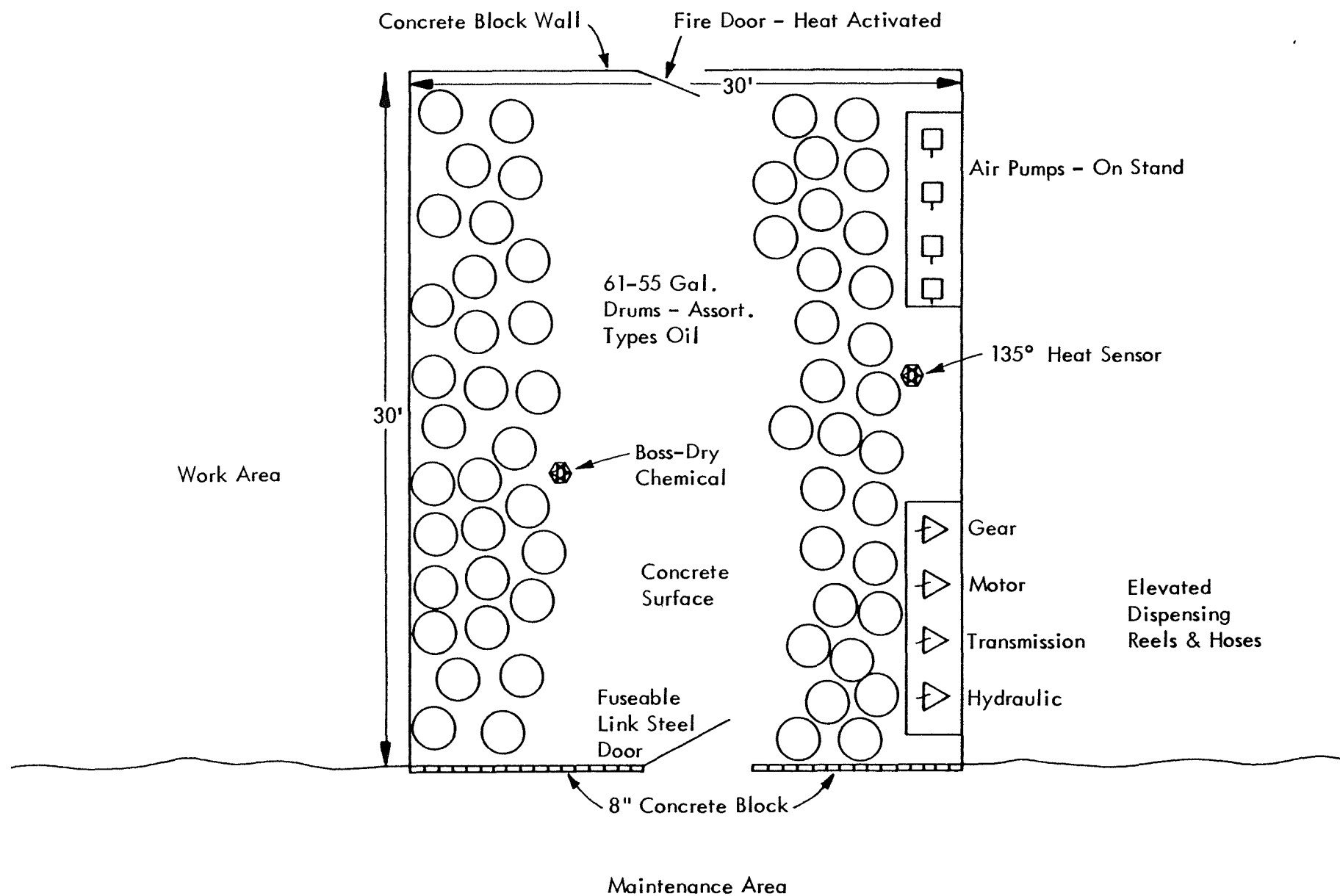
- 1) Natural Containment
- 2) Well Lighted
- 3) Both Tanks Mobile
(Fill on Surface) -
3/16" Mild Steel -
3/4" Strip Around
Sides
- 4) Open Venting



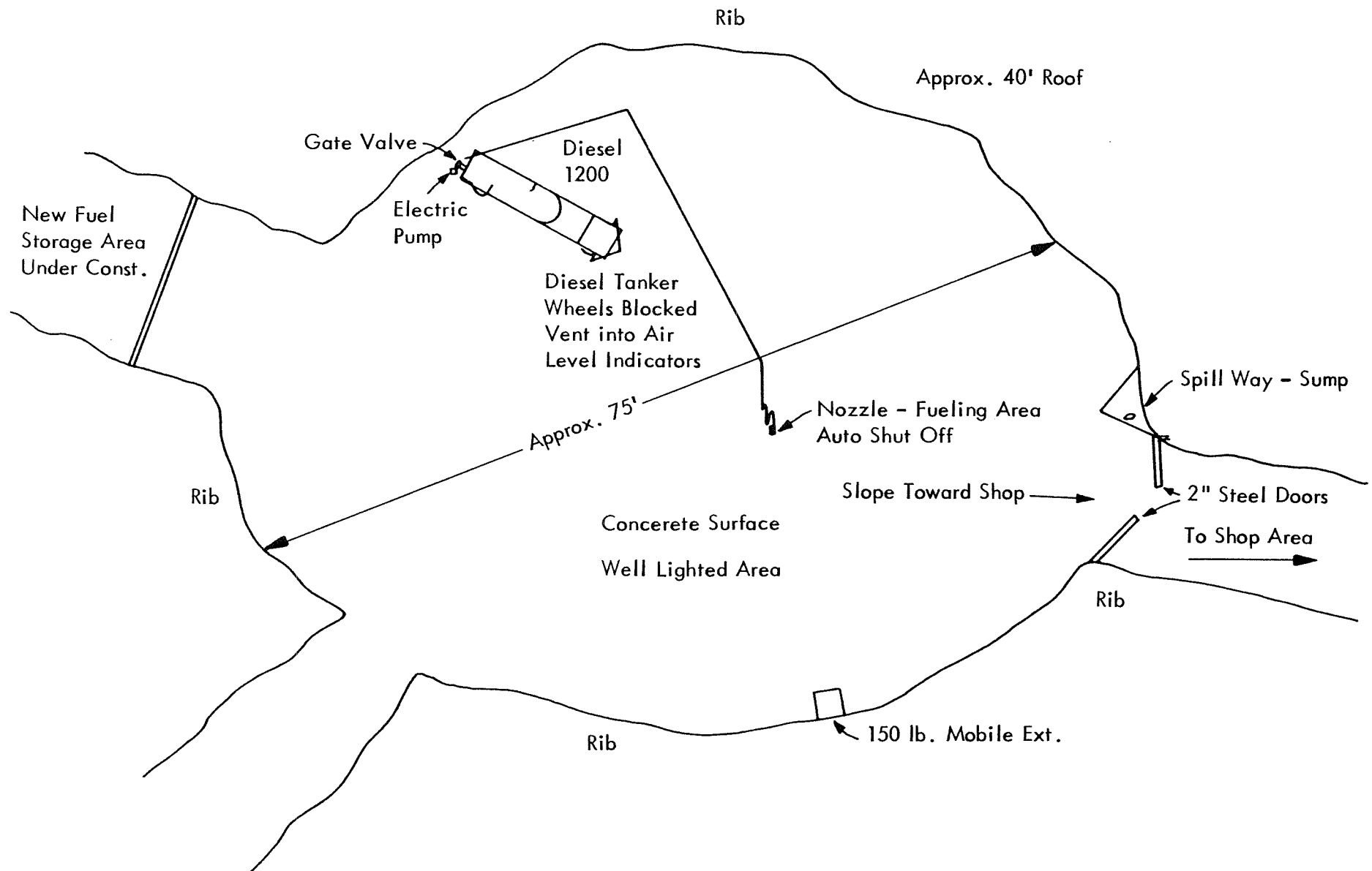
Mine 2 - Vehicle Transfer Area



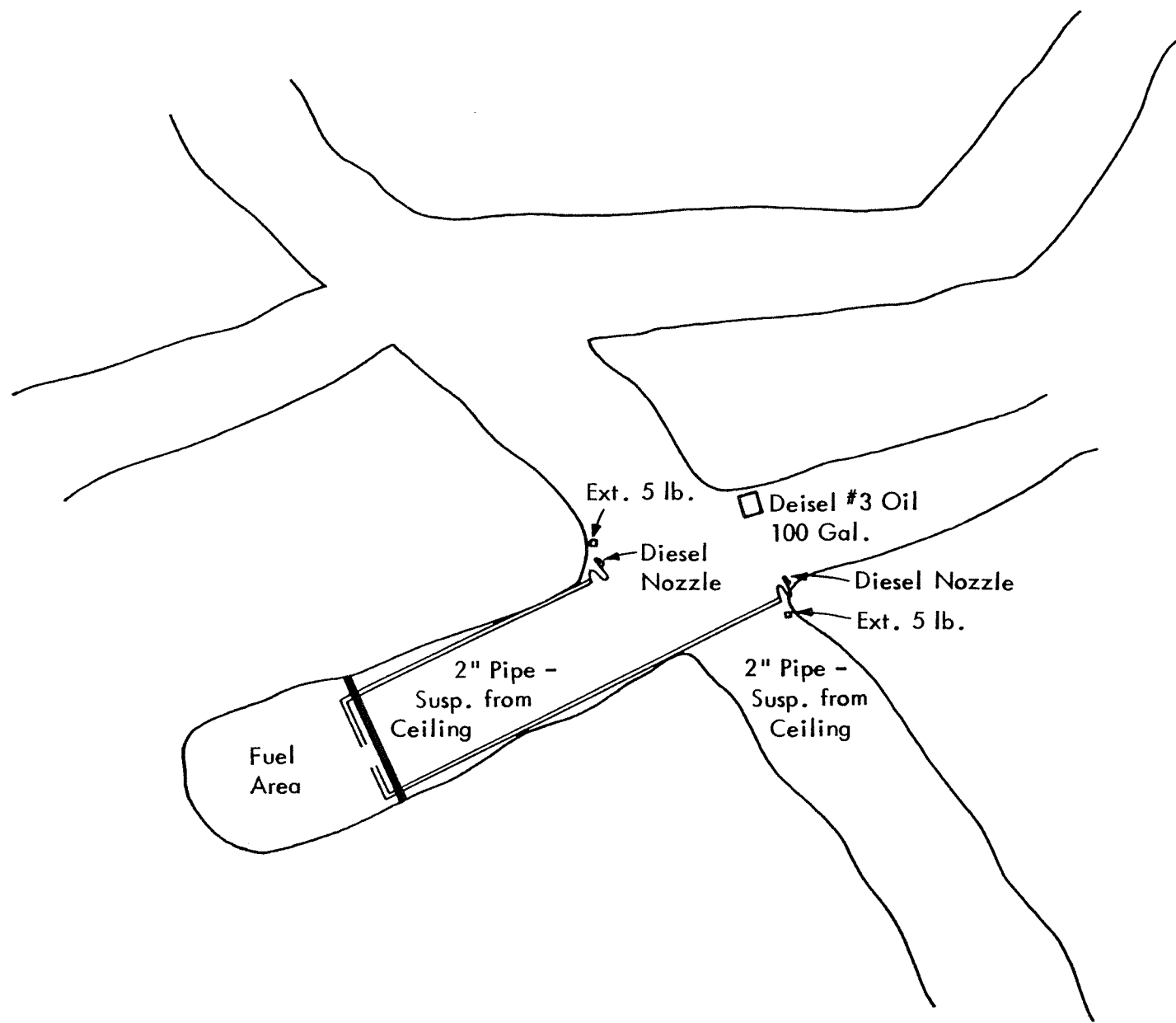
Mine 3 - Vehicle Transfer Area



Mine 3 - Shop Area Storage

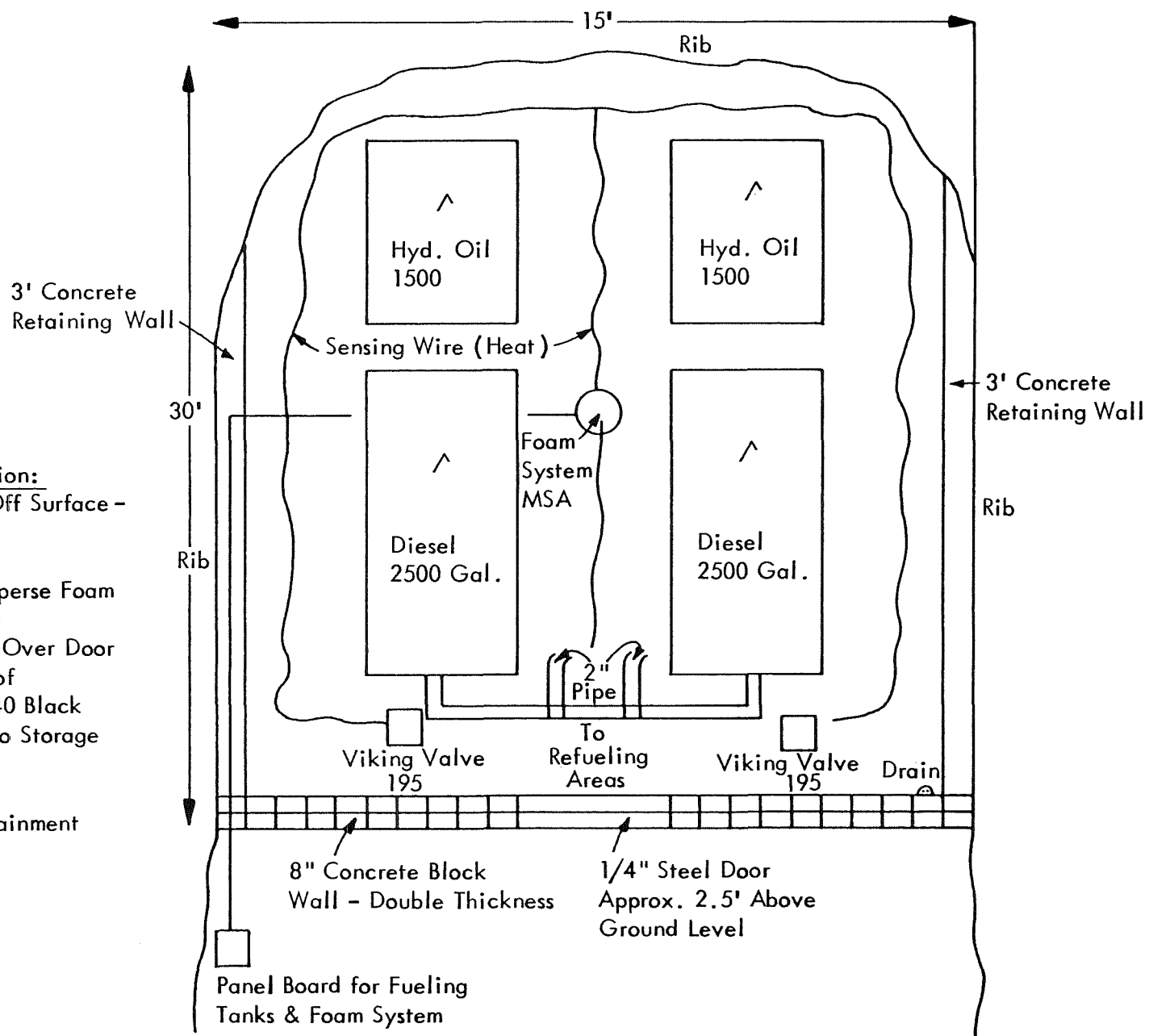


Mine 3 - Vehicle Transfer Area

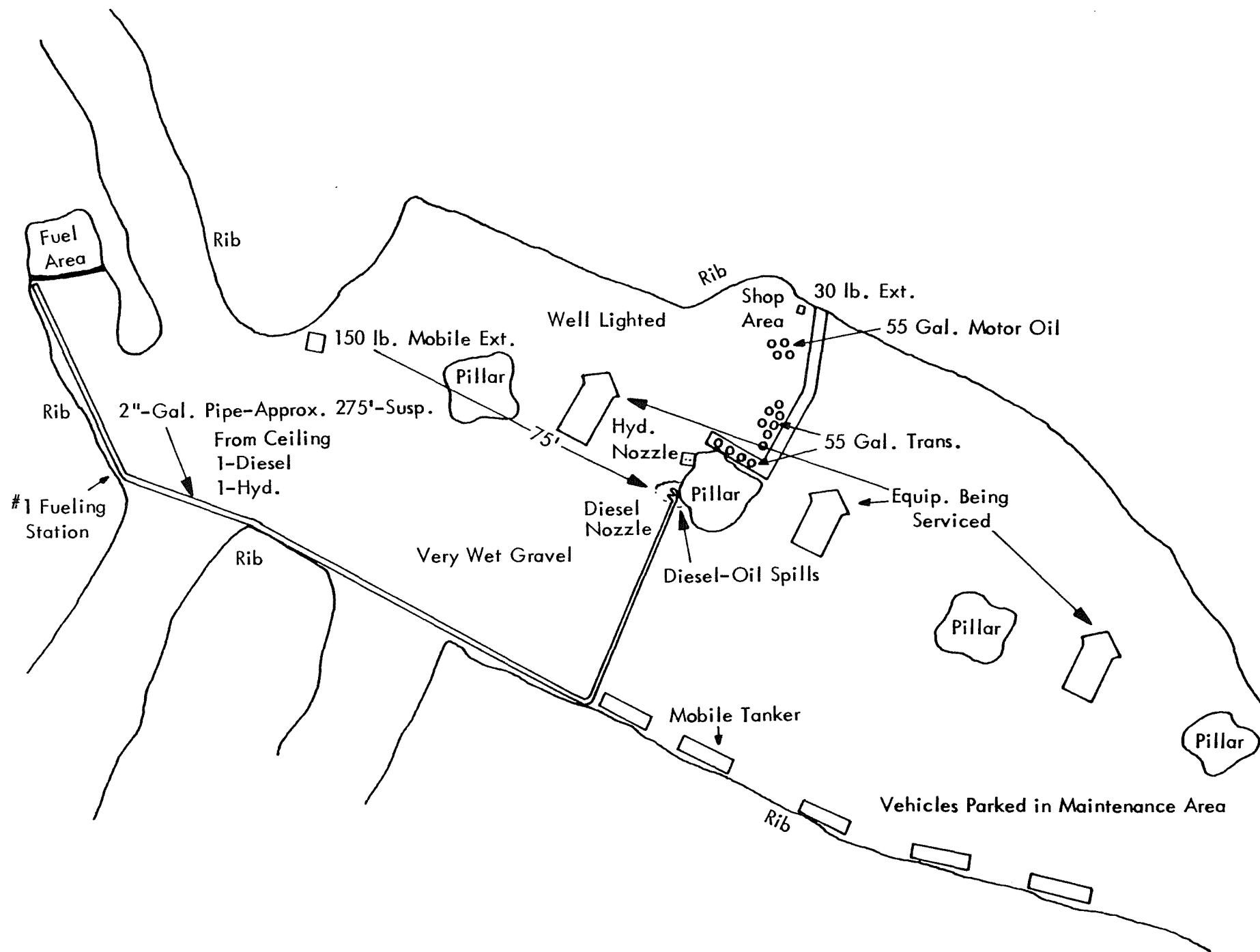


Mine 4 - Vehicle Transfer Area

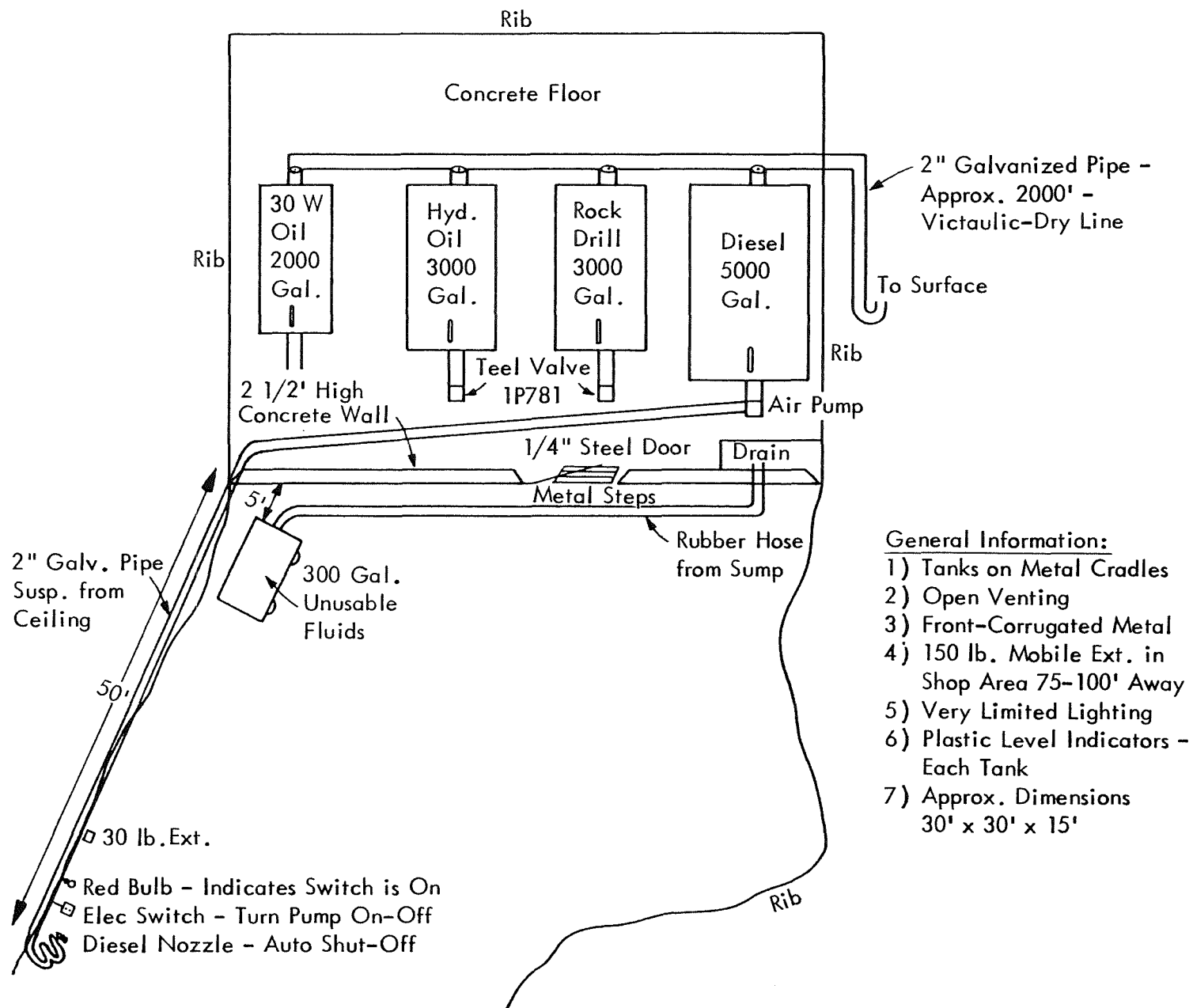
- 1) Tanks - 12" Off Surface - Metal Cradles
- 2) Rock Floor
- 3) Auto-Fan-Disperse Foam
- 4) Open Venting
- 5) 200 Wat Bulb Over Door Explosion Proof
- 6) Use 2"-No. 40 Black Iron - 2000' to Storage Area
- 7) 12' Ceiling
- 8) Natural Containment



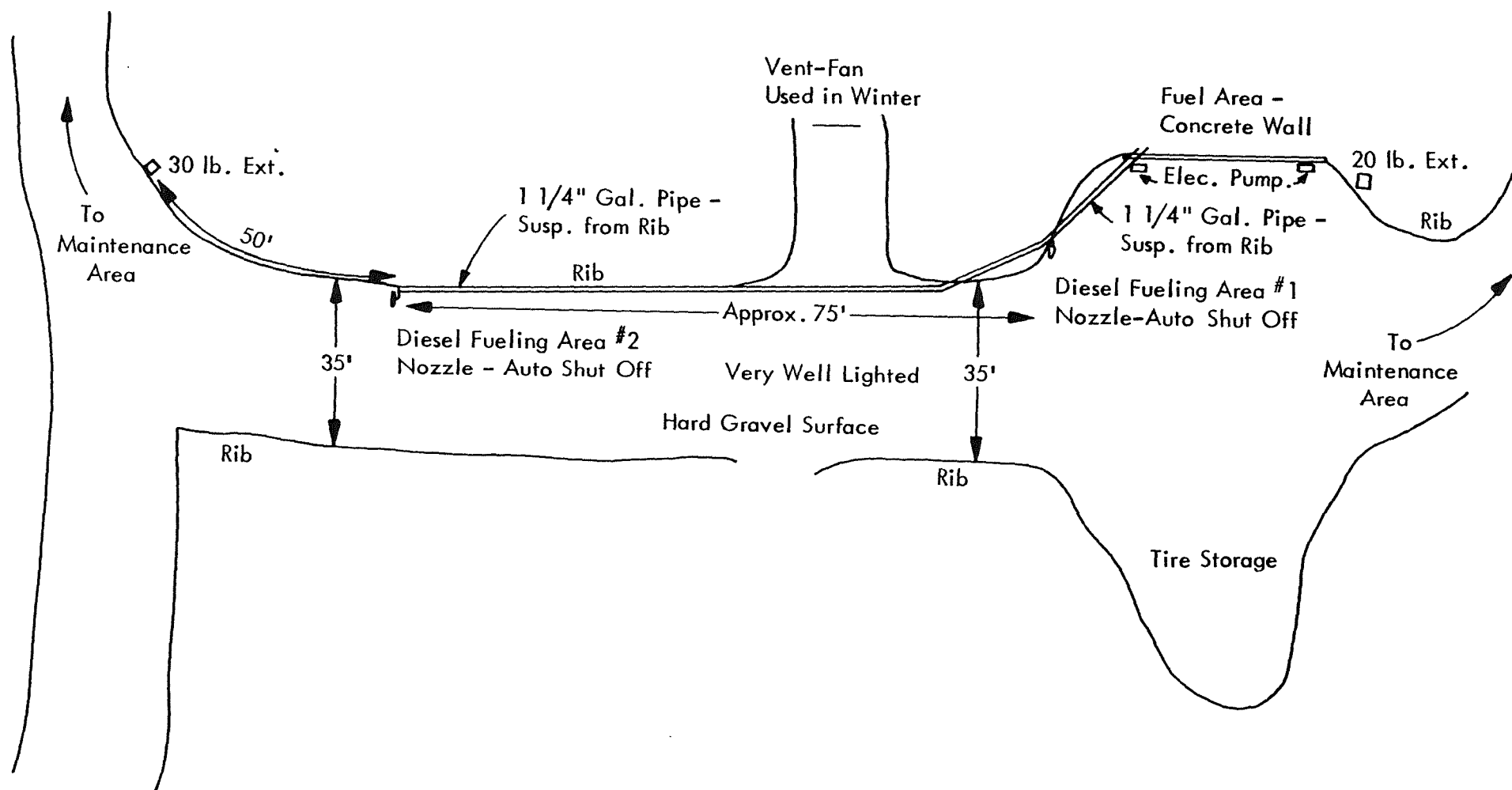
Mine 4 - Underground Storage Area



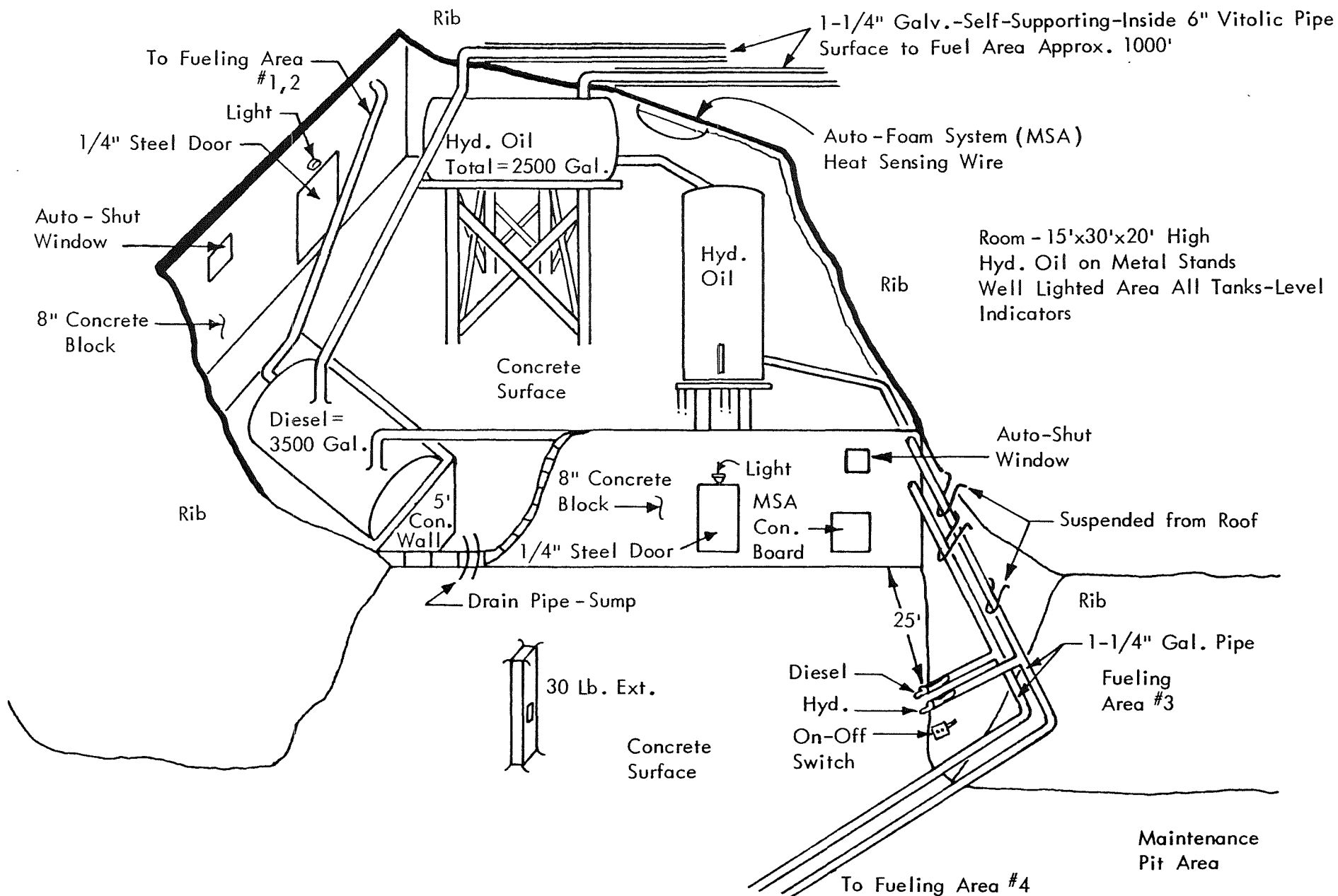
Mine 5 - Fueling System-Vehicle Transfer Area



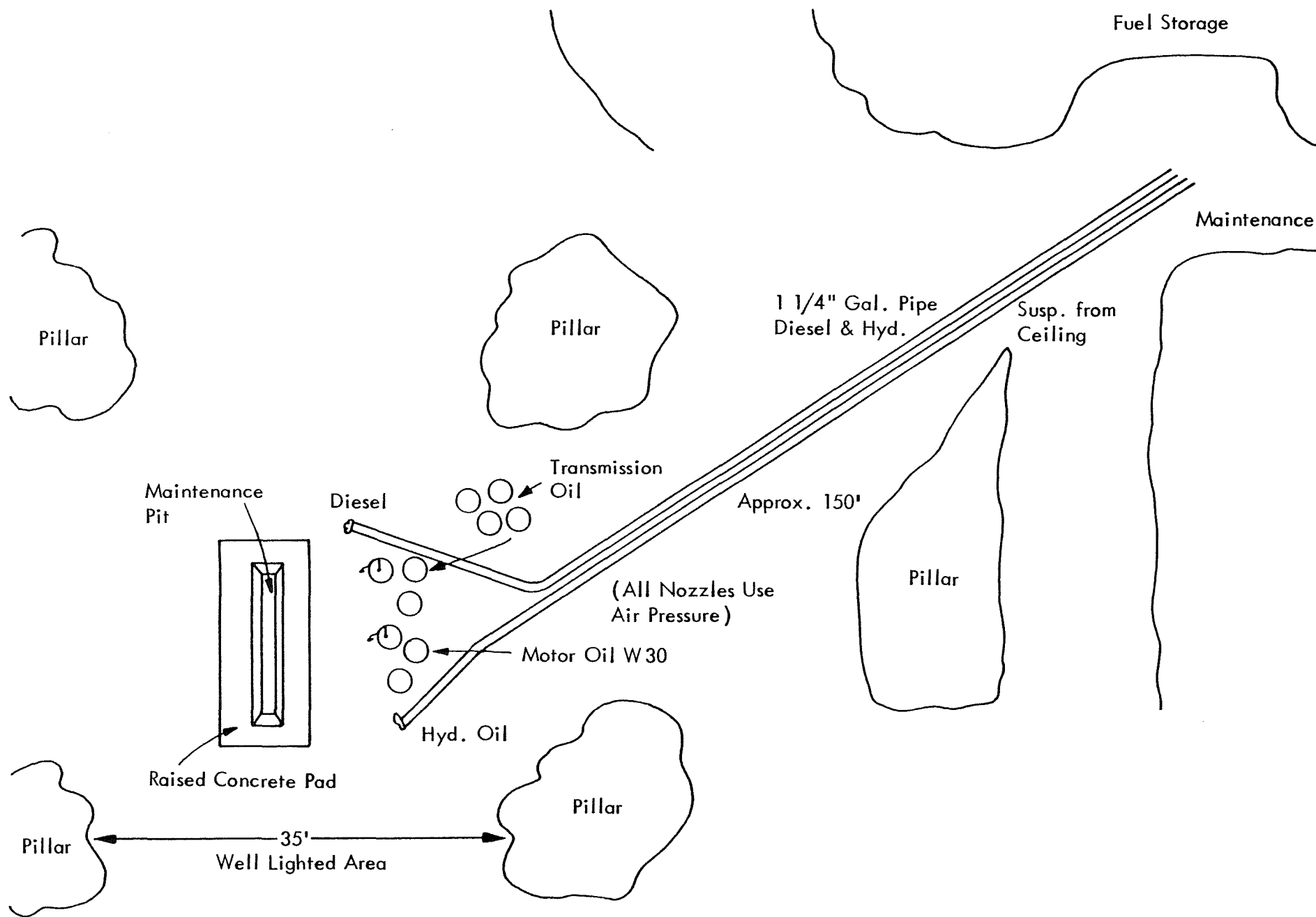
Mine 5 - Underground Storage Area-Vehicle Transfer Area



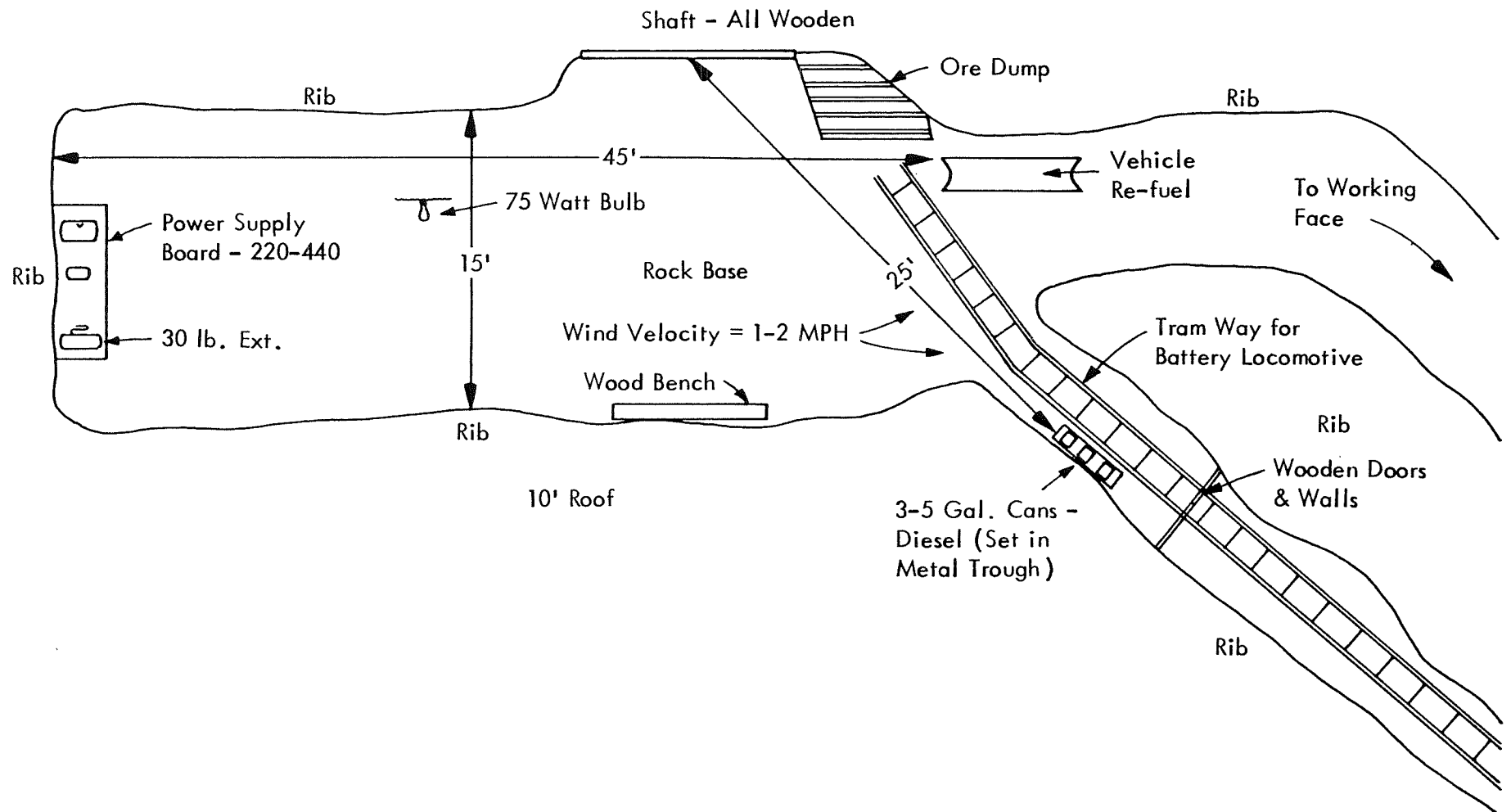
Mine 6 - Vehicle Transfer Area



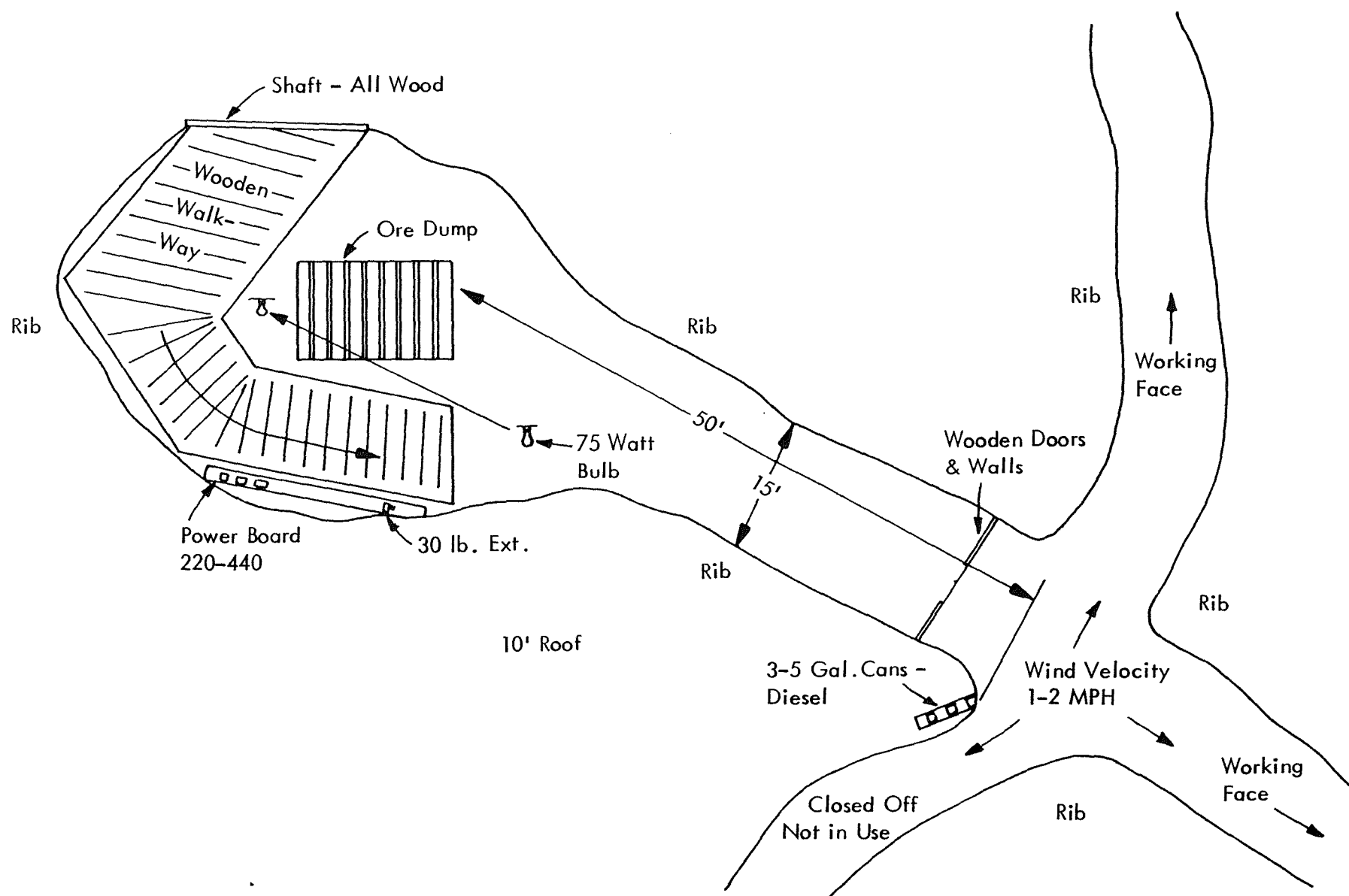
Mine 6 - Underground Storage Area-Vehicle Transfer Area



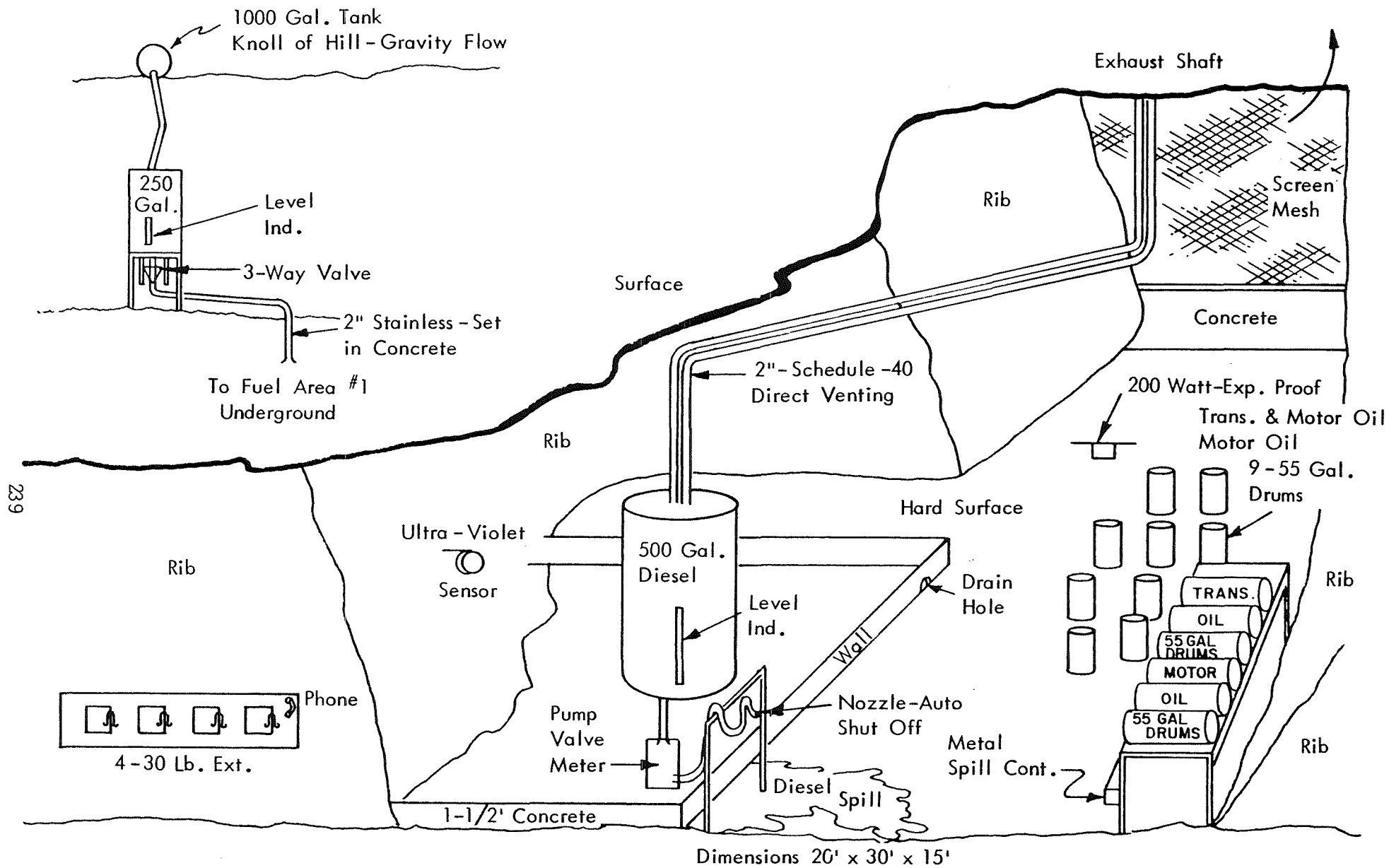
Mine 6 - Vehicle Transfer Area



Mine 7 - Vehicle Transfer Area

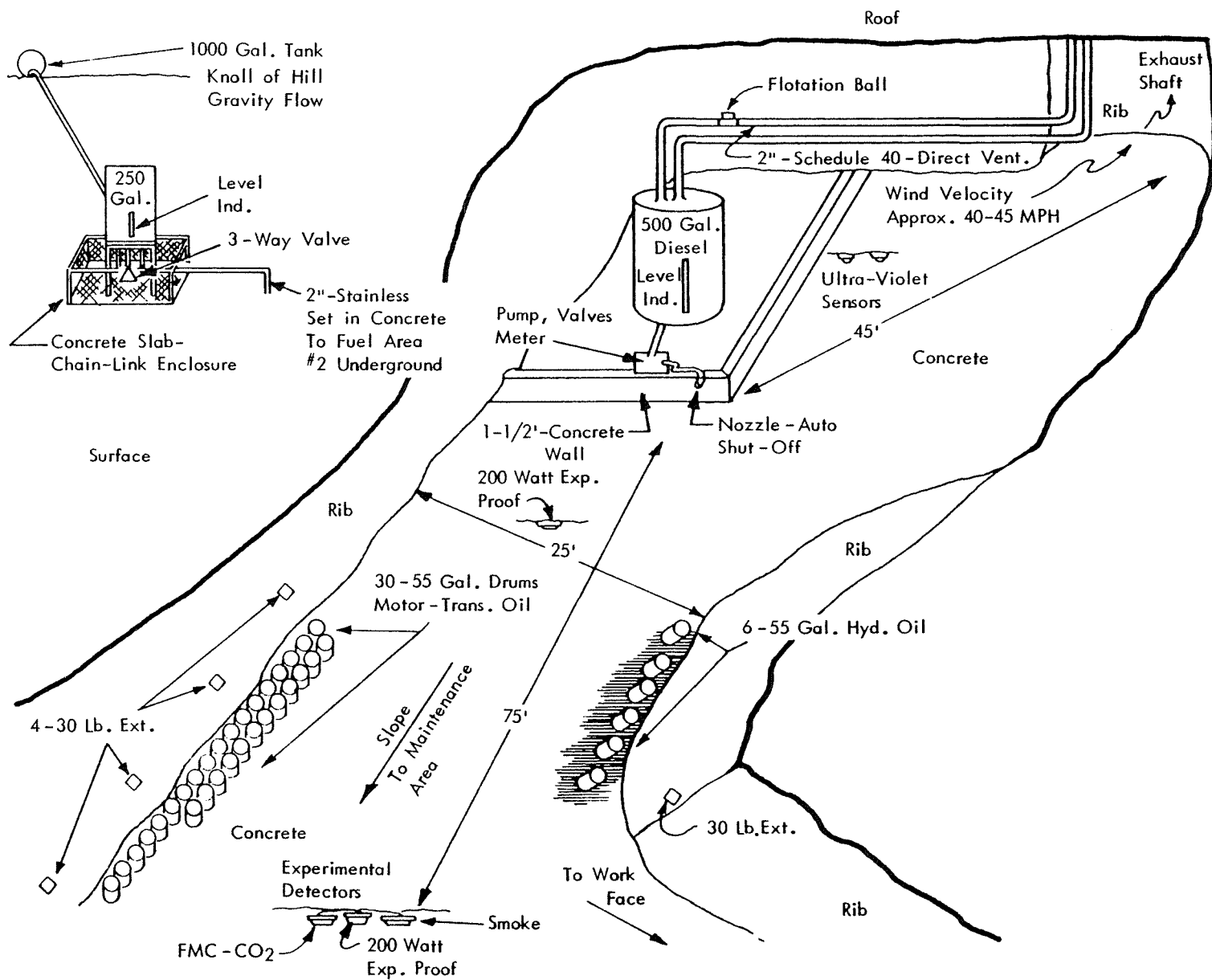


Mine 7 - Vehicle Transfer Area

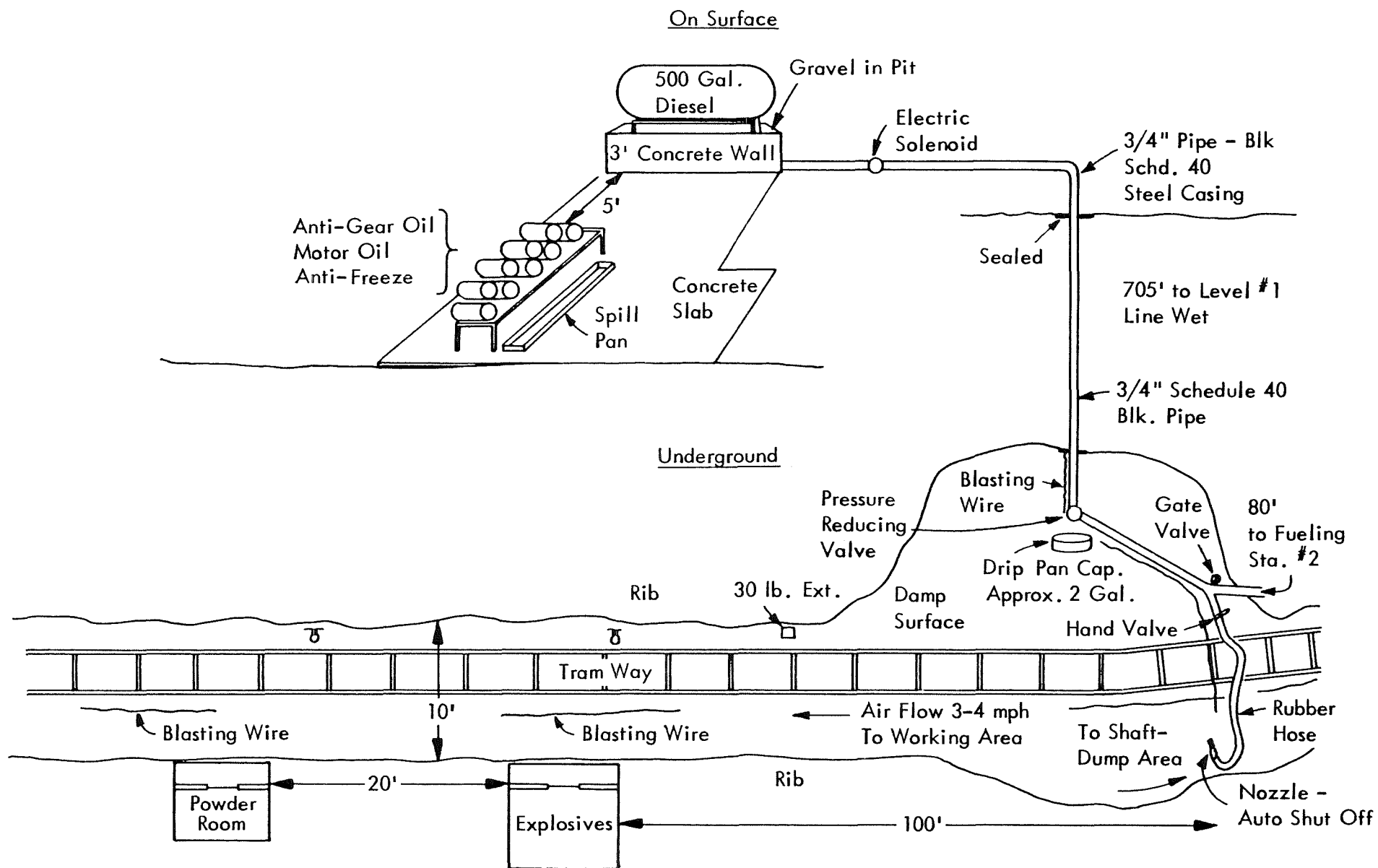


Haulageway Approx. 20' Wide
Very Wet - Muddy
25-30 MPH - Wind Velocity

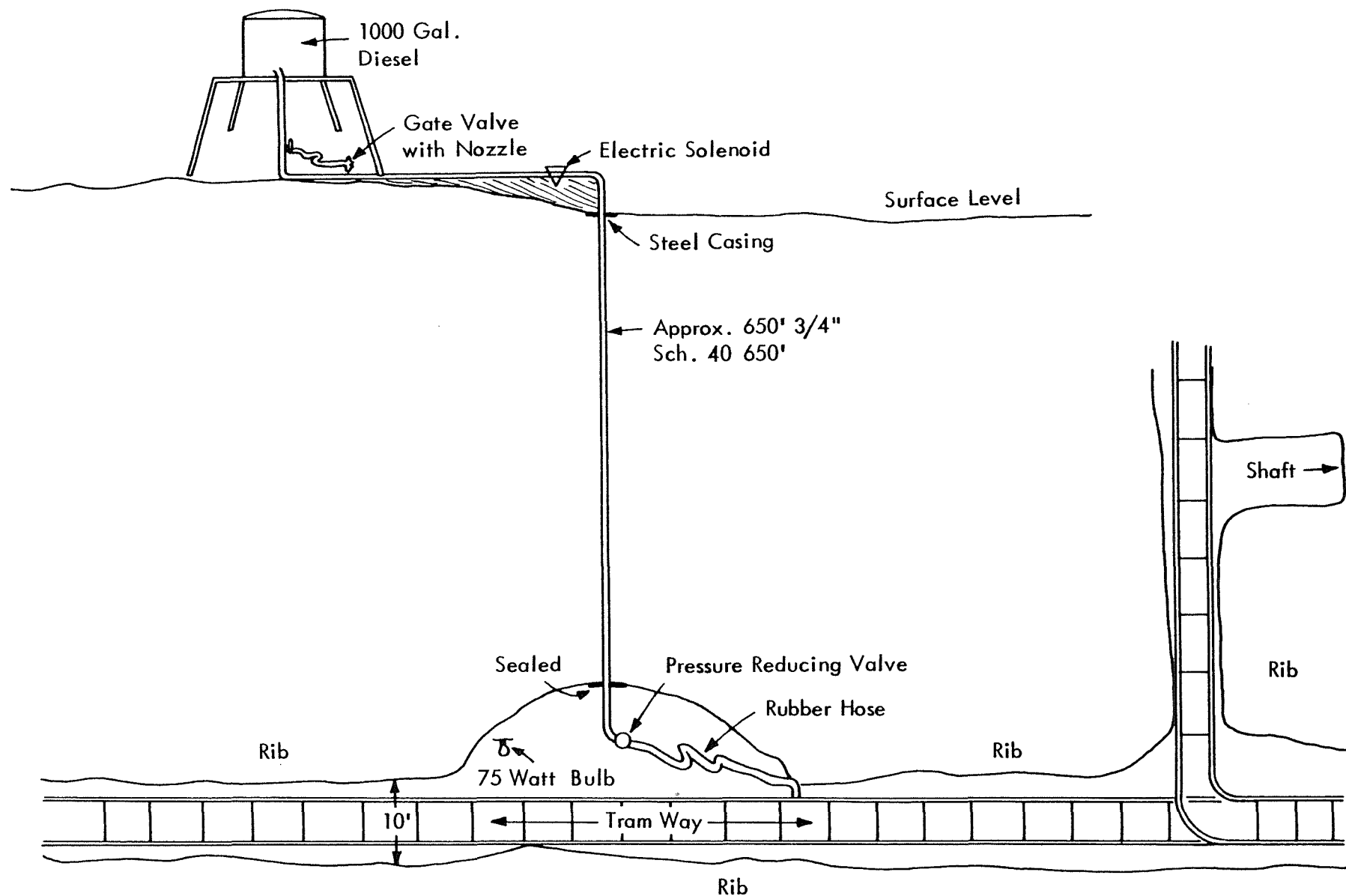
Mine 8 - Vehicle Transfer Area



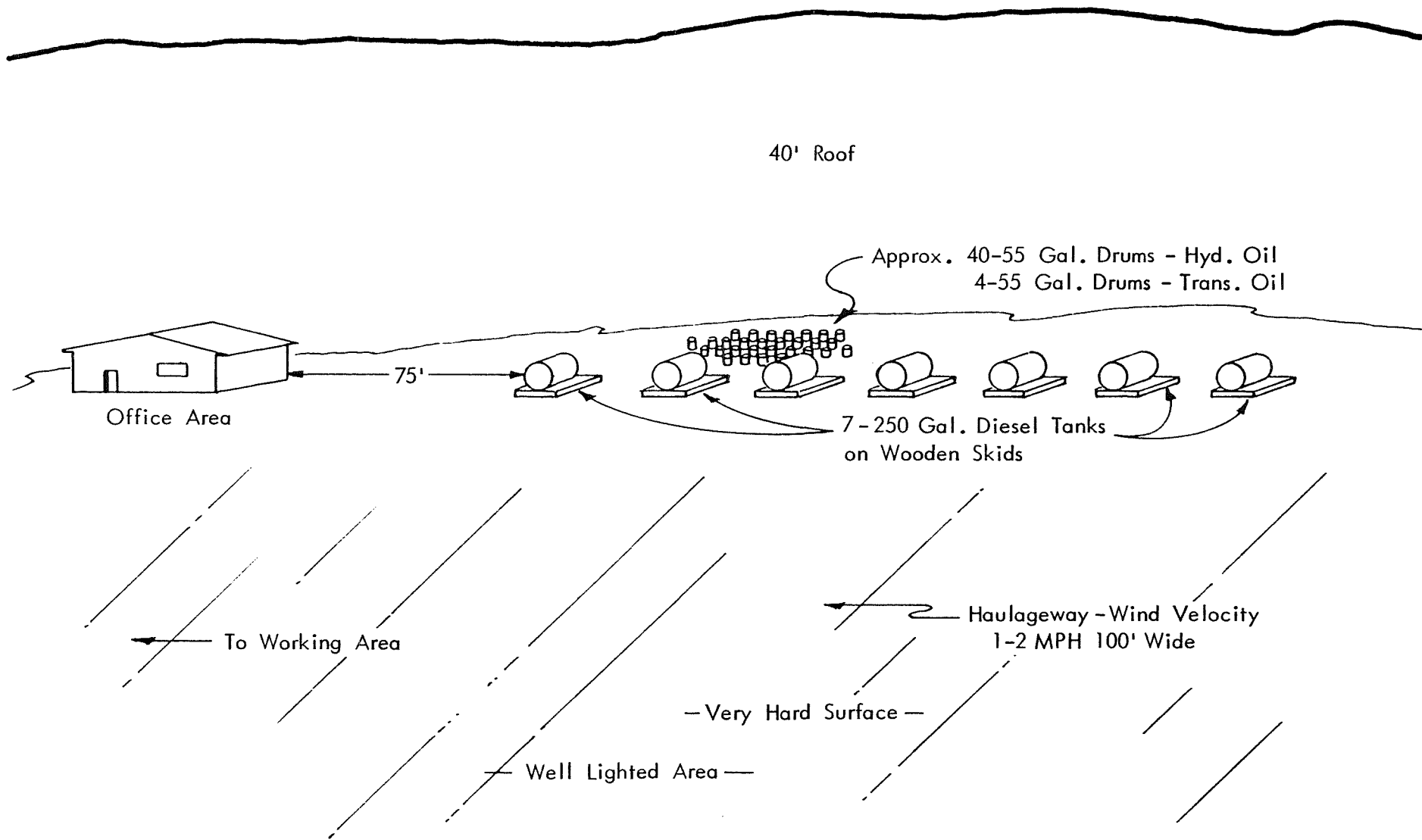
Mine 8 - Vehicle Transfer Area



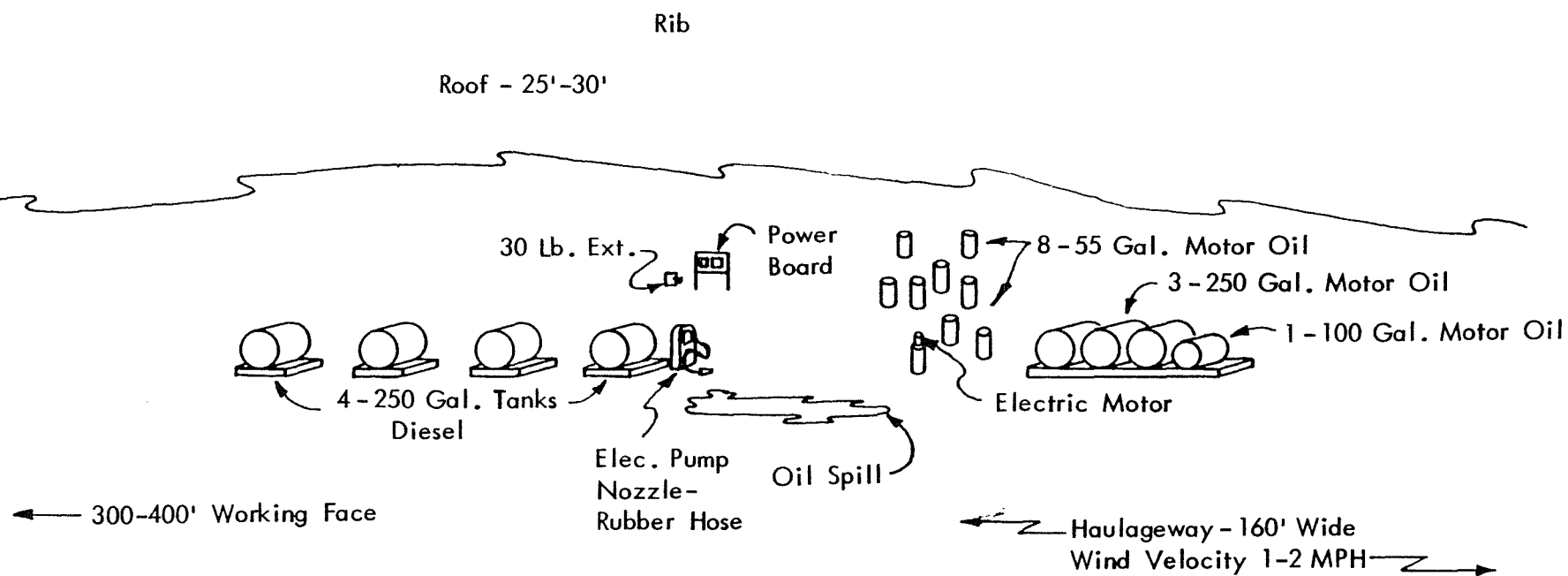
Mine 9 - Vehicle Transfer Area



Mine 9 - Vehicle Transfer Area

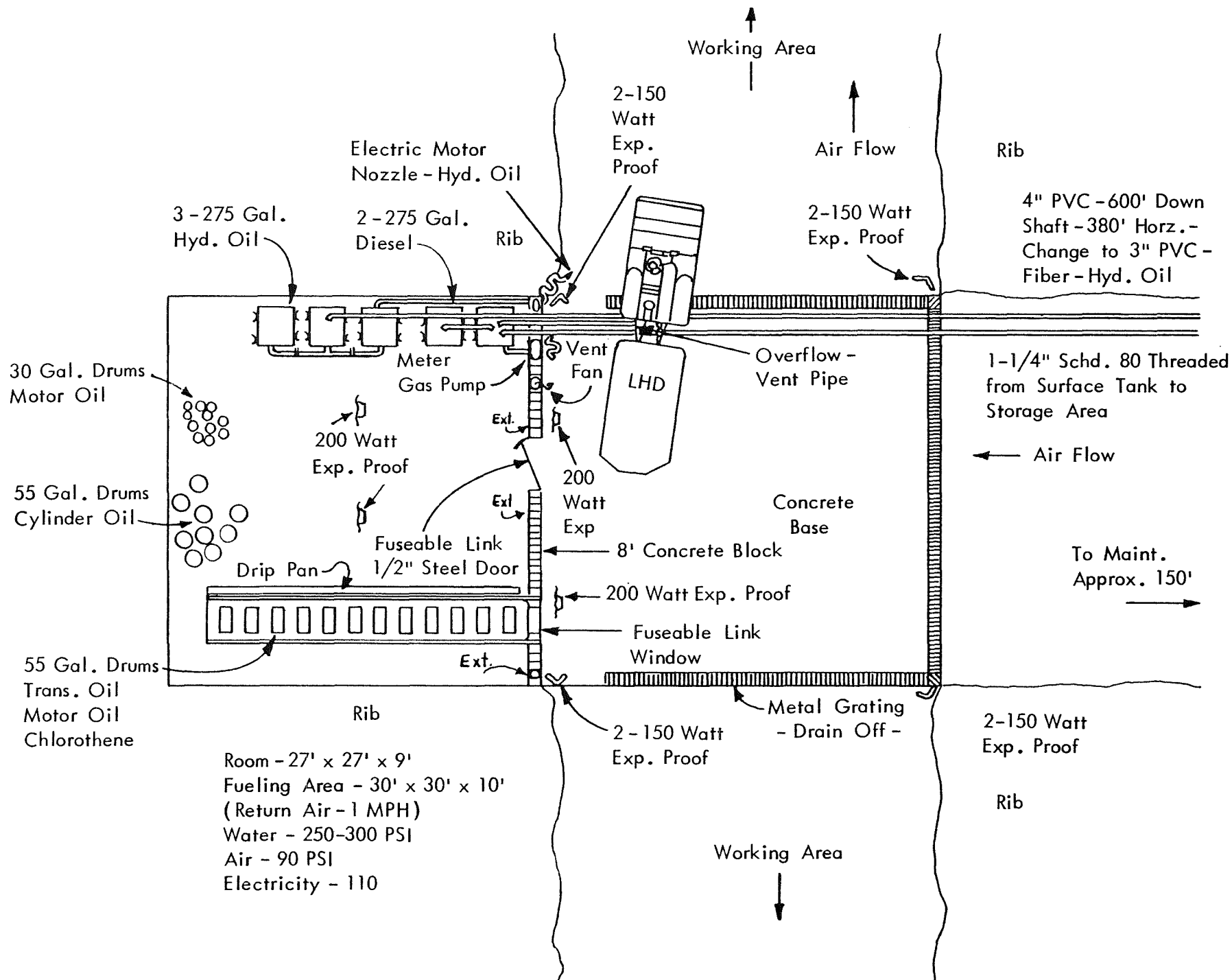


Mine 10 - Underground Storage Area

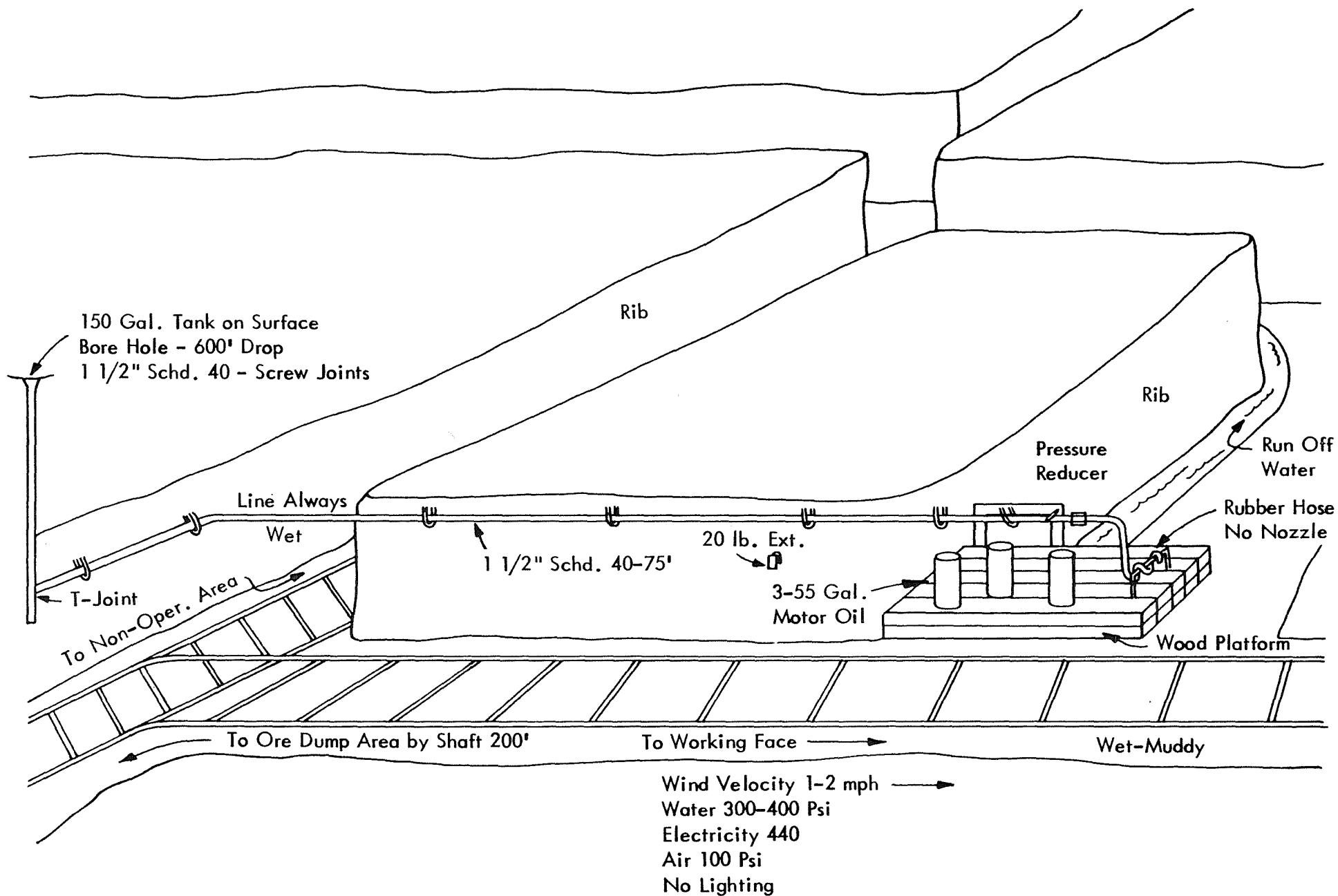


— Well Lighted Area

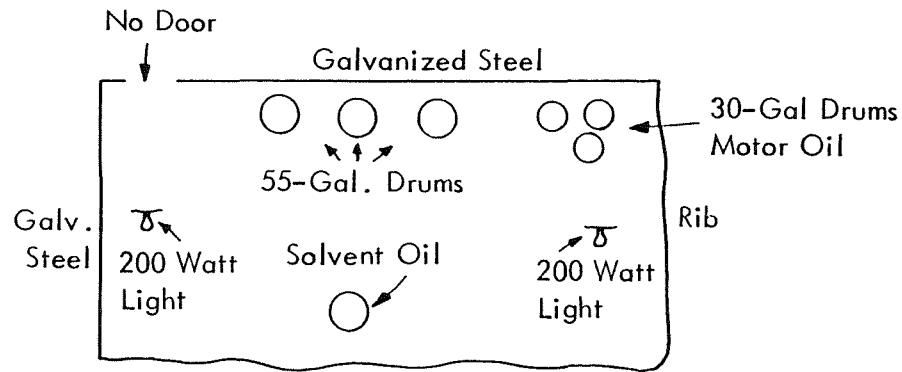
Mine 10 - Vehicle Transfer Area



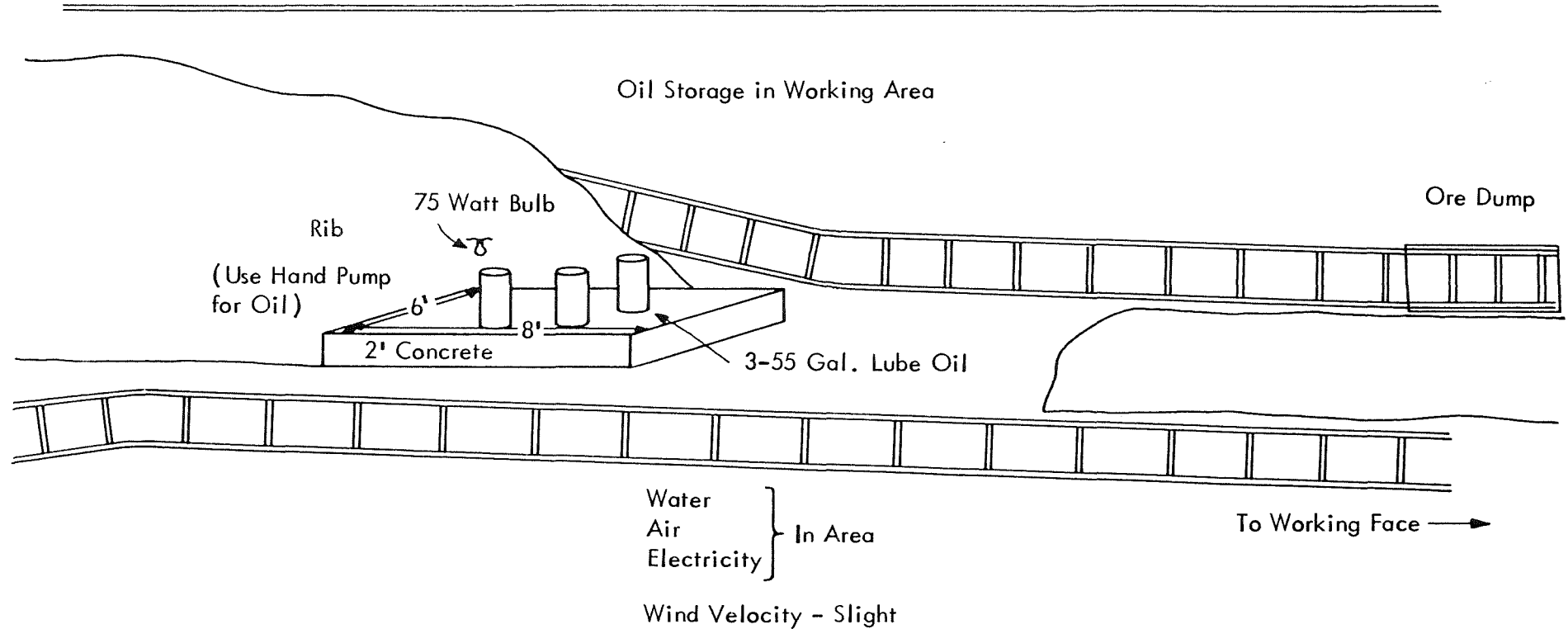
Mine 12 - Underground Storage Area-Vehicle Transfer Area



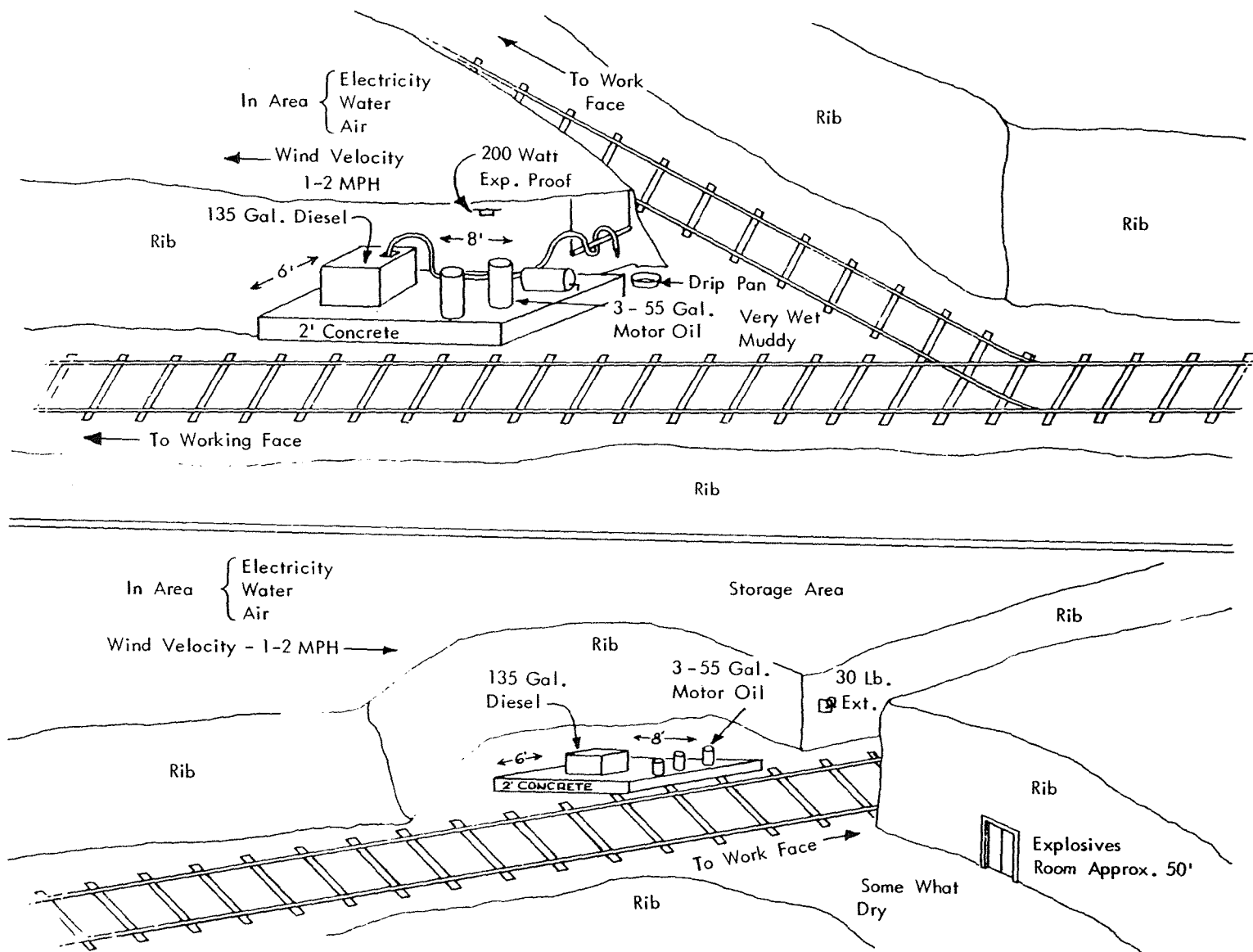
Mine 13 - Vehicle Transfer Area



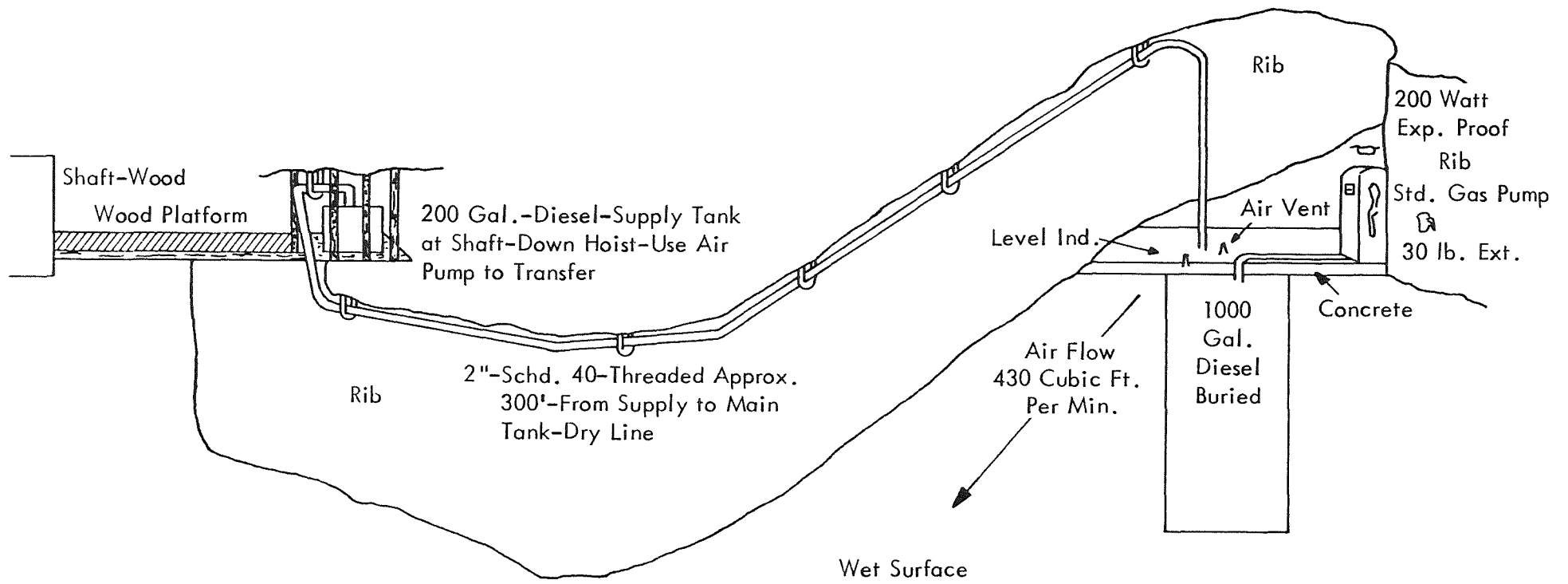
Room Dimensions -
 30' x 15' x 10'
 Ext.-30 lb. Approx. 20'
 Shaft Approx. 75'
 Oil Storage Only



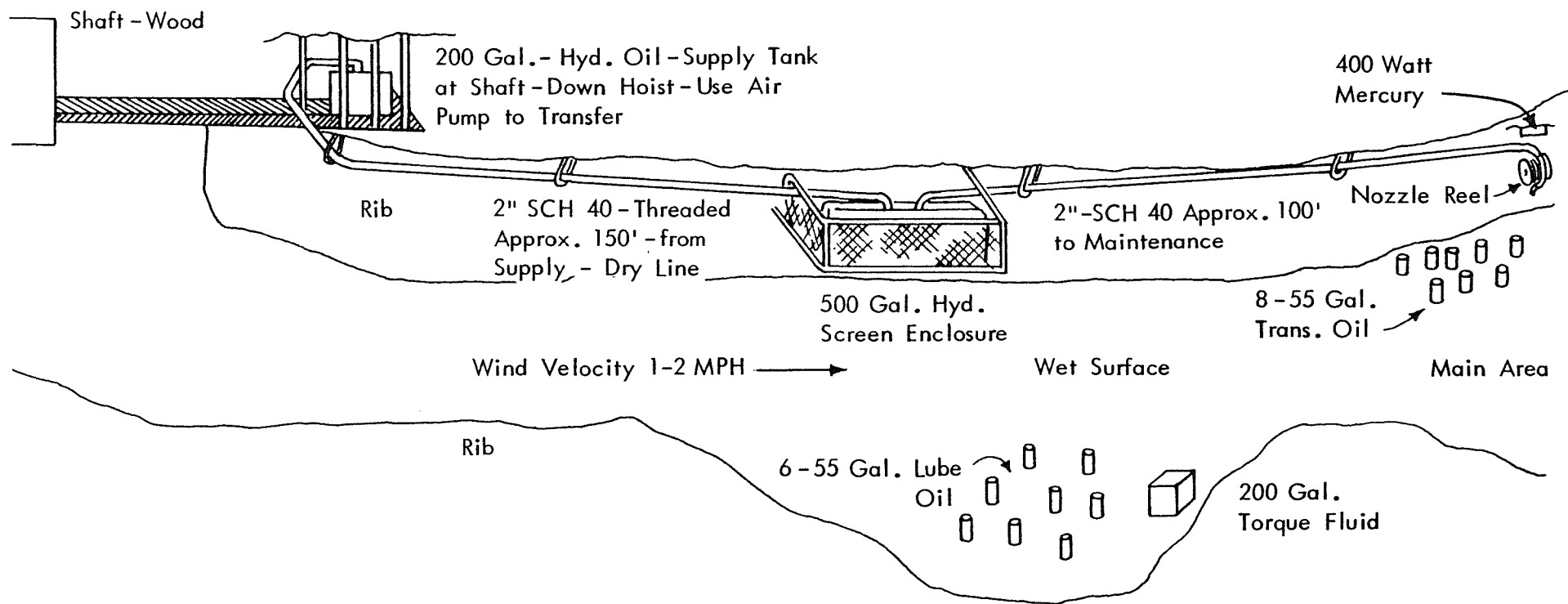
Mine 14 - Underground Storage Area



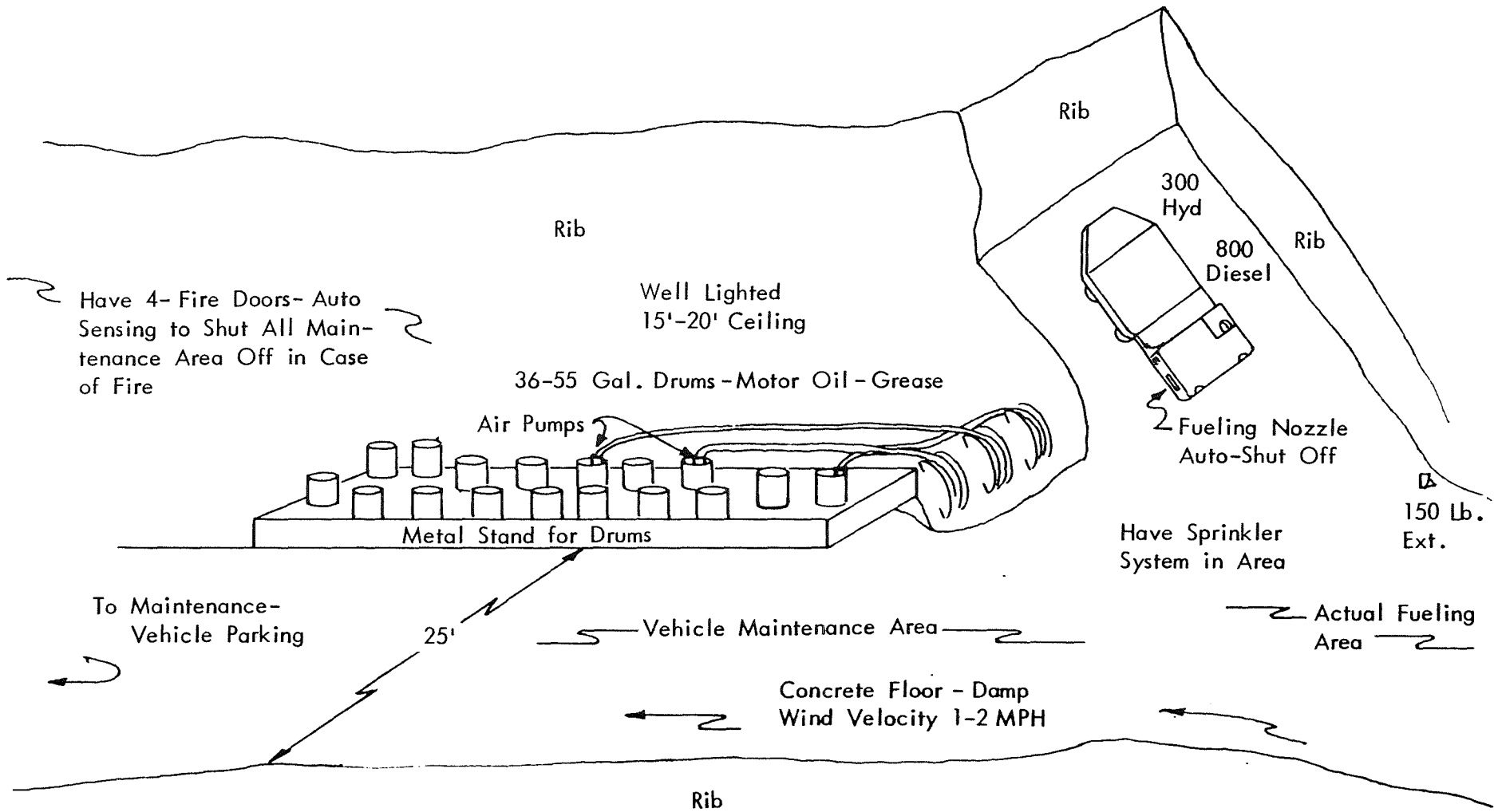
Mine 14 - Vehicle Transfer Area



Mine 14 - Underground Storage Area-Vehicle Transfer Area



Mine 14 - Underground Storage Area-Vehicle Transfer Area



Mine 15 - Vehicle Transfer Area

APPENDIX E

COMPONENT SPECIFICATIONS

DET TRONICS

SPECIFICATION DATA

Ultraviolet Fire Detection System



Unitized Detector/Controller

U7600

DESCRIPTION

The Det-Tronics U7600 Master is a completely unitized device, incorporating all electronic and switching components in the same enclosure with the UV sensor. It is particularly well suited for applications where Division 1 enclosures are required for control and switching circuits.

To increase application flexibility, the Det-Tronics U7600 has been designed for operation as either an independent unit, or as the master element in a combination using the C7050 Detector as a remote monitor. Both the U7600 and the C7050 are available with or without the **oi** feature.

oi — optical integrity — is an important step forward in ultraviolet fire protection. Developed and manufactured by Detector Electronics, it gives complete assurance that the entire fire detection system is fully operational and ready to respond to fire or explosion.

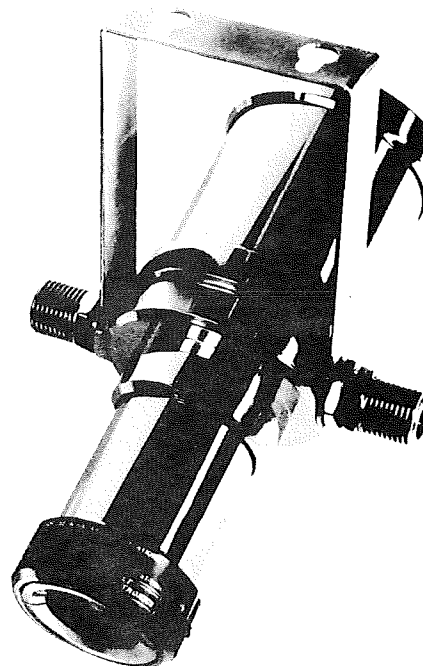
Optical integrity means that the detector's optical surfaces as well as the associated electrical circuitry can be completely checked from a test station either remote or on location. It makes certain the ultraviolet sensing system is unimpaired and unobscured, and that all sensing and alarm circuits are operational.

An important consideration with any ultraviolet fire detector is that a gradual buildup of contaminants — oil, gasoline, petro-chemicals, grime, salt, mist — on the lens surface will absorb ultraviolet radiation. When the buildup is heavy enough, the detector is blind.

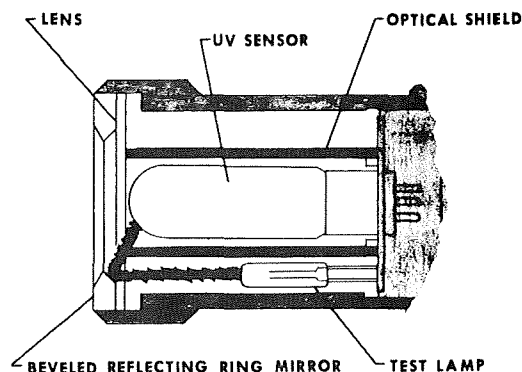
Making the problem more difficult is the fact that a buildup great enough to completely obscure the detector can be virtually undetectable to the human eye.

Detector Electronics' **oi** system has a tiny ultraviolet test lamp inside the housing, screened by a special shield so the ultraviolet sensor cannot see it directly.

Instead, ultraviolet radiation from the test lamp goes through the lens, reflects off a beveled ring mirror, and goes back through the lens to the detector's ultraviolet sensor, as illustrated in the cutaway drawing.



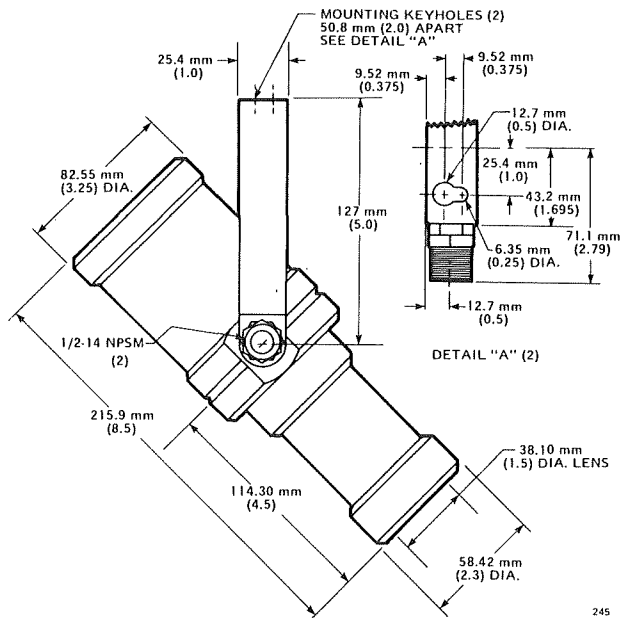
Touching a pushbutton at the test station turns on the detector's test lamp, and simultaneously locks out the alarm circuits. Response at the test source indicates a clean lens, and also proves that the detector and all electronic circuits are operational.



Cutaway drawing shows special shield that prevents sensor seeing ultraviolet radiation from test lamp. Instead radiation goes through lens, reflects off beveled reflecting ring mirror, then through lens again to sensor.

Detector Electronics Corporation

* **oi** is Detector Electronics' trademark
for its patented Optical Integrity systems.
U.S. Pat. Number 3,952,196



Dimensions of the U7600 in millimeters (inches).

FEATURES

- Master/Monitor capability allows double detection using one control package.
- **oi** – Optical Integrity feature optional.
- Fast response. Typical response to an intense ultraviolet source is less than 25 milliseconds.
- Two conduit entries, 1/2 inch NPS or 20 mm, optional.
- Not sensitive to solar radiation.
- Two independent relay actions. First relay responds instantaneously and second relay has field adjustable time delay from 0 to 30 seconds.
- Wide range of input voltage and frequency options available for applications worldwide, including 12 Volt and 24 Volt dc options.
- Not sensitive to voltage fluctuations.
- Will operate under adverse weather conditions such as wind, rain, snow and extremes of temperature.
- Light Emitting Diode (LED) to indicate detector actuation.
- Detector is swivel mounted for ease of installation.
- Detector enclosure is corrosion resistant nickel-plated brass material. Also available in stainless steel enclosures for specific applications.
- Detector module is shock and vibration mounted to meet industrial applications.
- Low power consumption. Typically 1/2 watt in quiescent state and maximum of 4 watts required for actuation.
- National service and worldwide distribution.

SPECIFICATIONS

MODEL NUMBER—

U7600. Designed for use in the protection of hazardous locations and to provide instantaneous response to flames.

VOLTAGES—

Models available for 100/120/208/220/240 Volt, 50/60 Hz; 12/24 Volt dc (reversible polarity).

RELAY CONTACT RATINGS—

For instantaneous relay and the time delay relay: Form C (N.O. and N.C.) 10 amperes resistive, 8 amperes inductive.

POWER CONSUMPTION—

Quiescent state is typically 1/2 watt. Maximum power required for actuation is 4 watts.

ENCLOSURE RATING—

Class I, Division I, Groups A, B, C, D; Class II, Groups E, F, and G, UL 698 standards for safety. Nema 4 Enclosure.

SPECTRAL SENSITIVITY RANGE—

The Det-Tronics UV detector responds in a range of 1850 to 2450 Angstroms. Detectors are not sensitive to direct or reflected sunlight or to artificial light.

SENSITIVITY—

System sensitivity is factory set at 10, 25, 100, or 200 counts per second response, such that a reference flame (consisting of a gasoline fire generated from a one square foot surface) can be detected at distances ranging from less than 10 to greater than 45 feet.

WIRING—

Three wires (DC Models 2 wires) are necessary to power the unitized UV detector. An additional two wires are needed for the optional checking function for the UV tube and optical surfaces. If one remote C7050B Detector is used with the U7600B Unitized Master, four wires are required between detectors. Six terminals are available for connection to the N.O. and N.C. outputs for each relay.

TEMPERATURE RATING—

Operating: -40 to +158°F (-40 to +70°C).

Storage: -67 to +170°F (-55 to +77°C).

SHIPPING WEIGHT—

10 pounds (4-1/2 kilograms).

CONE OF VISION—

The detector has a 90 degree cone of vision.

ORDERING INFORMATION

When ordering specify model number, voltage requirement:

U7600A— Unitized UV Detector.

U7600B— Unitized UV Detector with **oi** lens checking feature (optical integrity). When using the U7600B model, a Test Station consisting of a pushbutton and indicating lights is required.

Test Stations: W5005A - General Purpose.

W5006A - Explosion-Proof.



ANSUL HALON 1301 FIRE CONTROL SYSTEMS DATA SHEET

"ANSUL AUTOMAN" III CONTROL AND RELEASING DEVICE

Application

The ANSUL AUTOMAN III is a releasing and control device for use with Ansul's engineered halon fire protection system. It is capable of handling a single hazard with cross zoned detection or two hazards. The device has full supervision, is designed for non-coded automatic fire alarm systems, and has modules to interface with most standard approved low voltage detector heads.

Description

The ANSUL AUTOMAN III is made up of a combined electromechanical releasing device and a solid state control unit with emergency battery standby packaged separately.

The entire system is housed in NEMA Type I steel enclosures with hinged covers and key locks.

The releasing device is actuated through a manual STRIKE button or automatically via a solenoid. A spring-loaded pin is allowed to puncture the seal on a stored pressure cartridge. The released pressure provides pneumatic actuation of the agent tank valve and other pneumatically operated accessories. This means of actuation is simple, reliable and allows easy maintenance checks. It is compatible with optional remote manual or electric pull stations.

The control function utilizes solid state components, industrial grade printed circuit boards keyed to prevent improper installation, enclosed relays, and modular construction. Full supervision of the detection circuits and supervision of major-function internal components and relays is provided. A front panel trouble indicator and audible alarm warn of fault conditions that could impair proper operation. Internal light emitting diodes supplement front panel trouble indicator by providing indication of a specific trouble area. An adjustable time delay provides the capability to preset the delay between an alarm condition and system actuation. Fuses protect external detection circuits and power supply, and are easily accessible with the front panel cover open. Normal operation uses line voltage input which is converted to 24 VDC. In the event of power failure the emergency standby batteries are automatically utilized. The batteries are maintained in their

peak charge condition and are protected from total discharge damage by the battery sensing circuitry.

Performance

The unit is designed for indoor use in a clean, non-caustic atmosphere at a temperature range of 32° F. through 120° F. Wall or rack mounting is possible through the use of four mounting holes on the enclosure back, and standard knockouts are provided on all four sides. All electrical connections are through heavy duty screw type terminals with no soldering required. Five, Type C, switching relays are available with a rating of 1/10 horsepower at 120 volts AC.

Ordering Information

The ANSUL AUTOMAN III is ordered to match the type of detector and the requirements of emergency battery standby. Refer to the Ordering Information tables for part numbers. Please specify both the control and power supply part numbers.

Approvals

The ANSUL AUTOMAN III is Underwriters Laboratories Listed as a control and releasing device for a halon fire protection system. It complies with

the requirements of NFPA 12A "Standard for Halogenated Fire Extinguishing Agent Systems — Halon 1301."

Specifications*

The control and releasing device for automatic fire detection, alarm and actuation shall be ANSUL AUTOMAN III. It shall be Underwriters Laboratories Listed and approved by state or municipal regulatory agencies where required. It shall have two zone capability with supervision over detection zones, and emergency battery standby with separate internal visual indication as to the source of trouble. It shall provide for the following functions:

DC power for detectors
Control of fire alarm signals
Control of trouble signals
Control of supplementary equipment
Power for visual alarm indicators
Emergency standby batteries for up to _____ hours of operating power
Manual release capability
Full supervision

Installation and wiring shall conform, as a minimum, to the National Electrical Code and shall be performed as indicated in the specified drawings.

*Specifying engineer shall furnish applicable information.

Control Ordering Information

Part No.	Zone Card Part No.	Zone Output	Typical Detectors
29989	25945	2 wire 24 VDC	Pyrotronics
29991	17811	2 or 3 wire+ 15 VDC	Notifier (NKCRL series)
29990	17818	2 or 3 wire+ 24 VDC	Fire Alert Unitec **

+Two wire applications require an end of line resistor (100 K Ω , 10%, 1/2 WATT).
Three wire applications require an end of line module, Part No. 25946.

**All low voltage switch closure type devices.

Emergency Battery Standby Ordering Information

Part No.	No. of Batteries	Capacity (Amp. Hrs.)	Standby Power ***		
			24 hrs.	48 hrs.	72 hrs.
17897	2	4.5	100 ma	50 ma	33 ma
25976	4	9.0	200 ma	100 ma	66 ma
25977	6	13.5	300 ma	150 ma	100 ma

***Each power supply is designed to provide current for the periods of time listed in the table. After the specified period of time, 2.5 amps for 5 minutes will still be available.



ANSUL LARGE DRY CHEMICAL SYSTEMS DATA SHEET

GENERAL SPECIFICATIONS

Dry Chemical Container

The dry chemical tank shall be of welded steel construction, with two elliptical dished heads (either of one piece or segmented construction) with a welded circumferential seam. The actual capacity of the dry chemical container shall be as shown in the chart. (Specifying engineer to specify size. See chart.)

The dry chemical tank shall be designed and constructed according to the latest ASME unfired pressure vessel code for a working pressure of 250 PSI. It shall be stamped with the appropriate ASME code symbol.

The dry chemical tank shall be fitted with a gas tube arrangement to adequately fluidize the dry chemical, pressurize the dry chemical tank, and maintain a nominally constant pressure in the tank during discharge. The gas tube shall be provided with a check valve to prevent any possibility of dry chemical backup. The dry chemical tank shall be fitted with one 4" I.D. fill opening in the top head, and shall be provided with a discharge outlet suitable for the dry chemical hand hose lines and/or turret supplied.

Fill Cap

The dry chemical tank shall be provided with one fill cap. The cap shall consist of a cast aluminum body equipped with two handles extending from opposite sides of the cap to permit hand tightening so that it is free from leakage under normal operating pressure without the use of tools. The cap shall be equipped with a 5/32" thick rubber gasket inserted in a machined recess.

A safety vent hole shall be located in the fill cap so that the cap is capable of pressure venting while at least 3 1/2 threads are still engaged.

Pressure Relief Valve

An approved ASME pressure relief valve shall be furnished to prevent the pressure in the tank from exceeding 10% of the maximum working pressure of the tank.

Dry Chemical

The dry chemical for this extinguisher shall be formulated and produced by the extinguisher manufacturer and meet the requirements of the extinguisher manufacturer; Underwriters Laboratories, Incorporated; and

Factory Mutual Laboratories. The dry chemical shall be furnished in metal or plastic pails with water-tight replaceable covers.

Nitrogen Cylinders

The nitrogen cylinder(s) provided for the system shall meet D.O.T. Code 3AA2400.

Nitrogen Cylinder Valve

Each nitrogen cylinder shall be provided with an Underwriters Laboratories Listed Quick-Opening valve, having the following capabilities:

1. To be opened manually from a remote location by means of a pneumatic actuator.
2. To be opened manually at the valve by:
 - a. Quick-Opening lever action
 - b. Conventional handwheel action
3. All three opening methods shall be independent and shall not interfere with each other.
4. The valve shall be provided with an integral safety relief set at 3600 - 4000 PSI to relieve at 4000 PSI maximum at 160° F.
5. The valve shall be manually closed by conventional handwheel action.
6. The valve shall be provided with an integral pressure gauge reading from 0 to 4000 PSI, marked to show the operable range of pressure.
7. The valve shall be constructed of highly corrosion resistant materials throughout. All moving parts subject to wear shall be of hardened stainless steel and/or beryllium copper alloy.

Nitrogen Cylinder Storage

The nitrogen cylinder(s) shall be mounted in a vertical or horizontal position. The method of mounting shall be designed to permit easy access of operation and replacement of the cylinder.

Nitrogen Pressure Regulators

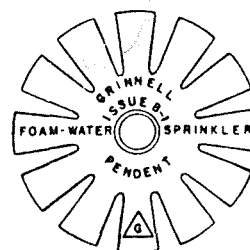
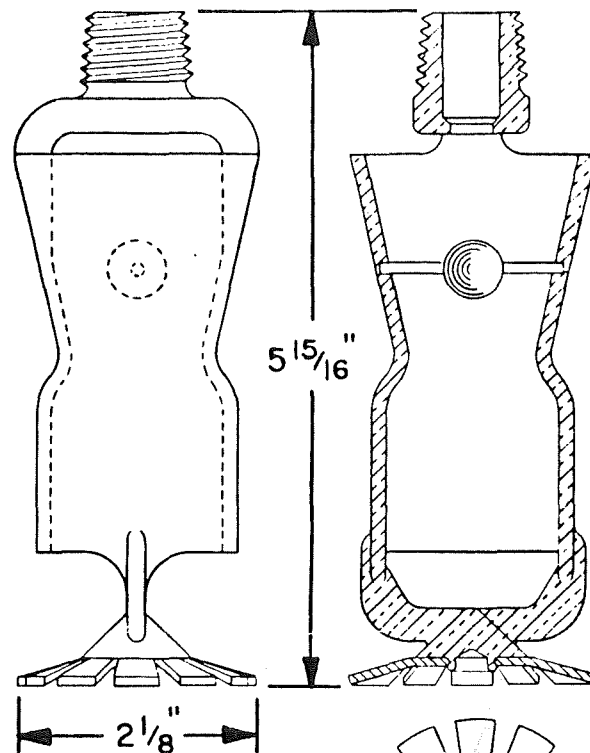
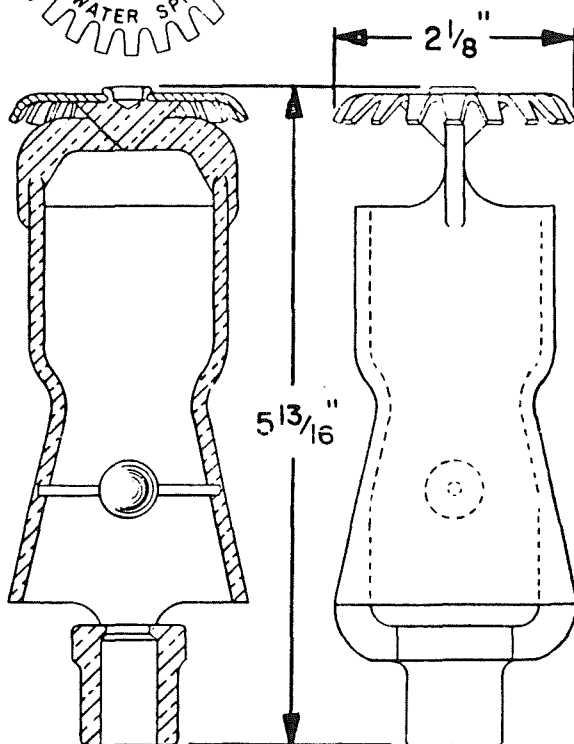
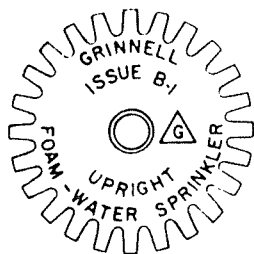
The nitrogen supply shall be directed through one regulator per nitrogen cylinder. The regulator shall be designed for an inlet pressure of 3000 PSI and shall be set to deliver nitrogen at a reduced pressure of 210 to 230 PSI. Each individual regulator shall have a spring loaded pressure relief valve. They shall be connected to the nitrogen cylinder by 3/8" I.D. wire or polyester braid hose.

Valving and Piping

The valving and piping shall be installed so that for normal operation, the nitrogen from the cylinder passes through the regulators and piping into the agent tank to adequately fluidize and pressurize the tank. The flow of agent from the tank to the distribution system shall be controlled by a normally open ball type manual valve.

Valving and piping shall be furnished so that after the extinguisher is used, the hose lines and/or turret may be cleared of agent by venting the pressure from the top of the tank through the hose lines and/or turret.

Piping and valving shall also be arranged so that pressure direct from the nitrogen cylinders may be directed through the hose lines and/or turret, if desired, for maintenance operations.



CONNECTION: $\frac{1}{2}$ " NPT OR FINISHED FOR $\frac{1}{2}$ " (.840" O.D.) BRAZED CONNECTION. FURNISHED WITH $\frac{1}{2}$ " NPT UNLESS OTHERWISE SPECIFIED.

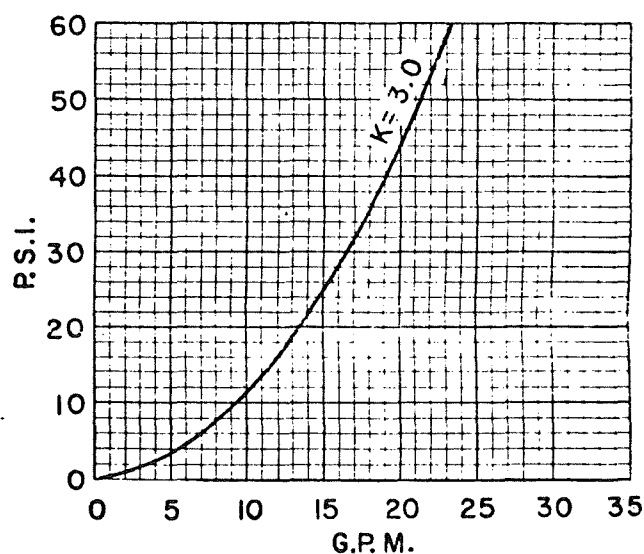
ORFICE SIZE: $\frac{3}{8}$ " AT THROAT.

DEFLECTOR: UPRIGHT OR PENDENT.

FINISH: PLAIN.

TO ORDER SPECIFY:

GRINNELL (SPECIFY TYPE OF CONNECTION) FOAM WATER SPRINKLER, ISSUE B-1 ----- (QUANTITY)



DISCHARGE CURVE

GRINNELL FOAM-WATER SPRINKLER ISSUE B-1

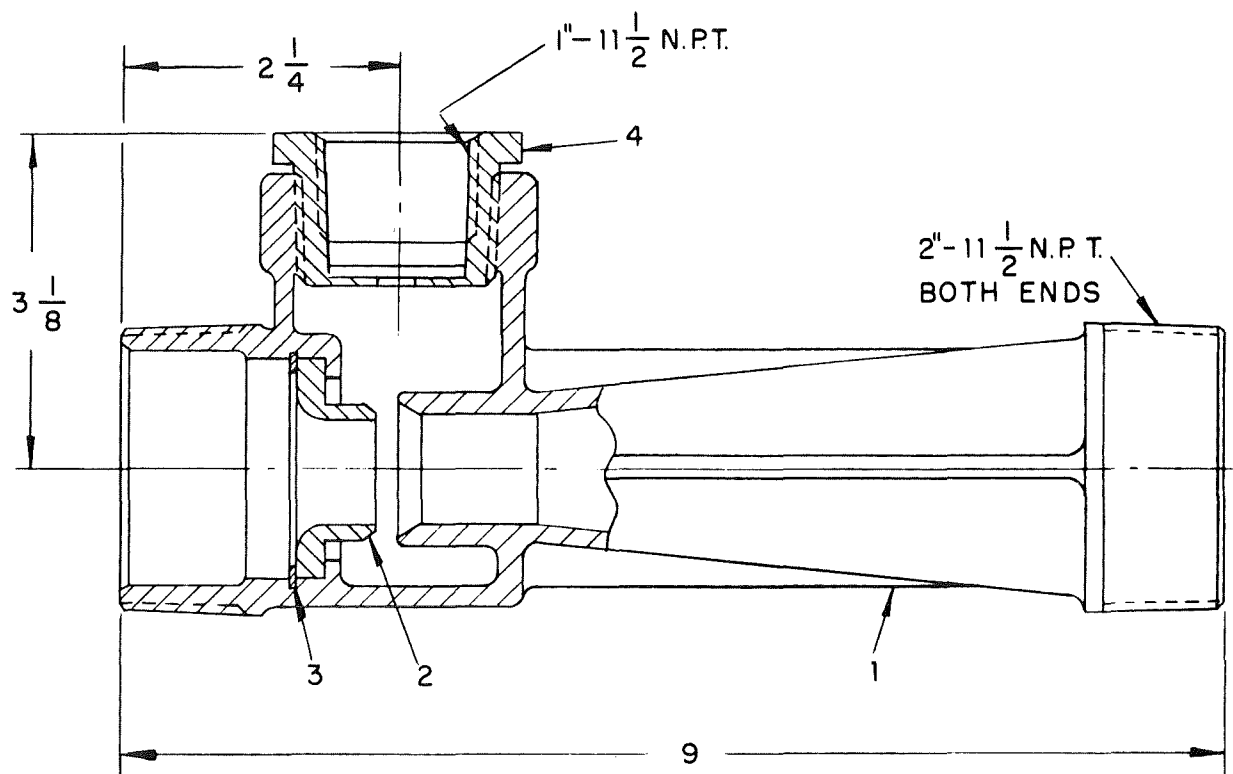


ENGINEERING DATA SHEET



PAGE NO. _____

FIG. NO. _____

2" RATIO CONTROLLER MODEL C NPT MALE**79202520**

REPLACEMENT PARTS LIST

No.	Part Number	Part Name	No. Req'd.
1	00165330	Body	1
2	00116710	Inlet	1
3	98262181	Retaining Ring	1
4	0017051X	Orifice	1

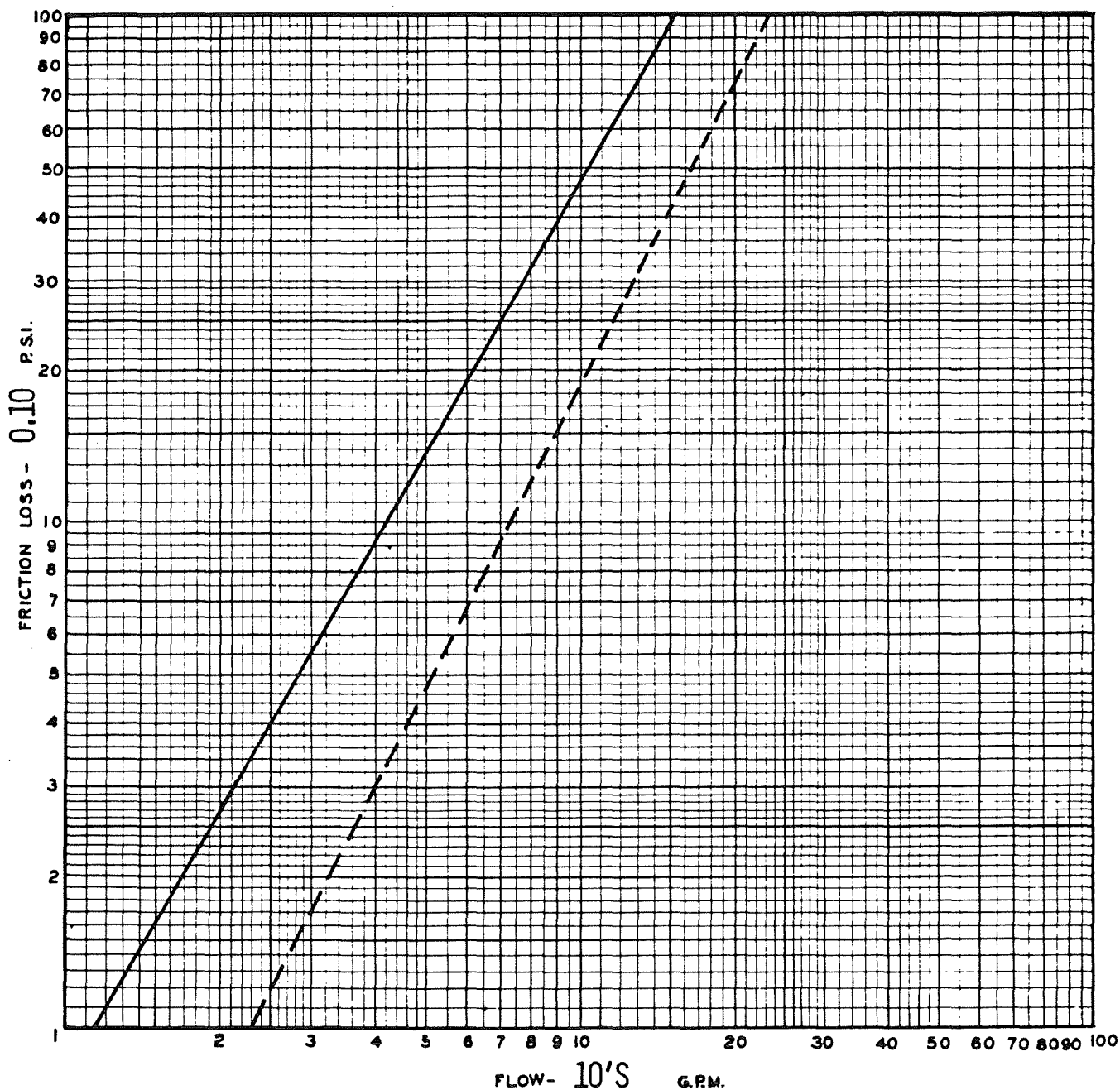


ENGINEERING DATA SHEET



PAGE NO. _____
FIG. NO. _____

FRICTION LOSS - 2" MODEL C (M) RATIO CONTROLLER



DOTTED LINE REPRESENTS FOAM METERING DROP AT ORIFICE.

FLOW @ 10'S G.P.M.

FRICTION LOSS @ 1.0 P.S.I.

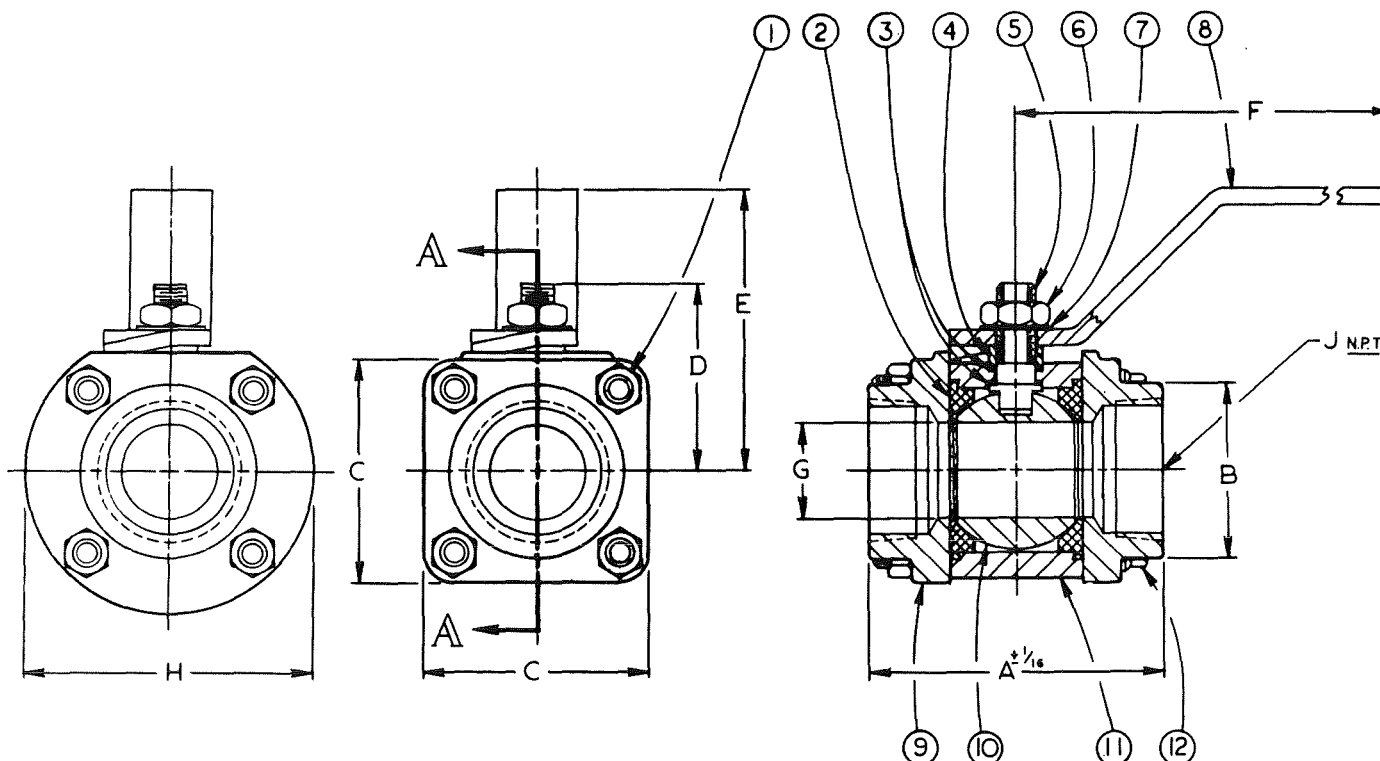
Ball Valves

This valve can carry the following figure numbers:

C-0211* C-1611*
C-1111* C-2511*

*See page B-102 for material suffixes.

SCREWED END $\frac{1}{4}$ " thru 2" Class 600



Description

DET. NO.	NO. REQ'D	DESCRIPTION
1	4	TWIN WHIZ NUT
2	2	SEAT
3	2	SEAL
4	1	GLAND RING
5	1	STEM
6	1	JAM NUT
7	1	STAR LOCKWASHER
8	1	HANDLE
9	2	END PIECE
10	1	BALL
11	1	BODY
12	4	APRON HD. CAP SCREW

Dimensions (inches)

VALVE SIZE	A	B	C	D	E	F	G	H	J NPT
$\frac{1}{4}$	$2\frac{3}{8}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$2\frac{1}{4}$	5"	$\frac{7}{16}$	2"	$\frac{1}{4}$
$\frac{3}{8}$	$2\frac{3}{8}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$2\frac{1}{4}$	5"	$\frac{7}{16}$	2"	$\frac{3}{8}$
$\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$2\frac{1}{4}$	5"	$\frac{7}{16}$	2"	$\frac{1}{2}$
$\frac{3}{4}$	$2\frac{5}{8}$	$1\frac{5}{16}$	$1\frac{7}{8}$	$1\frac{5}{8}$	$2\frac{13}{16}$	6"	$\frac{9}{16}$	$2\frac{1}{2}$	$\frac{3}{4}$
1"	$3\frac{1}{16}$	$1\frac{5}{8}$	$2\frac{1}{4}$	$2\frac{1}{16}$	$3\frac{7}{32}$	6"	$\frac{13}{16}$	3"	1"
$1\frac{1}{4}$	$3\frac{11}{16}$	$1\frac{15}{16}$	$2\frac{5}{8}$	$2\frac{3}{8}$	$3\frac{11}{16}$	7"	1"	$3\frac{1}{2}$	$1\frac{1}{4}$
$1\frac{1}{2}$	$4\frac{1}{16}$	$2\frac{1}{4}$	3"	$2\frac{9}{16}$	$3\frac{7}{8}$	7"	$1\frac{1}{4}$	4"	$1\frac{1}{2}$
2"	$4\frac{5}{8}$	$2\frac{3}{4}$	$3\frac{1}{2}$	$2\frac{15}{16}$	$4\frac{7}{16}$	9"	$1\frac{1}{2}$	$4\frac{1}{2}$	2"



CONTROMATICS

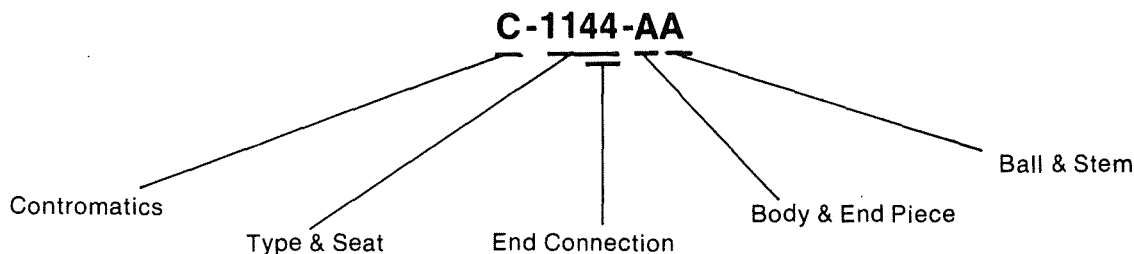
222 Roberts Street, East Hartford, Ct. 06108 Telephone (203) 528-9903 Telex 9-9298

Ball Valves

ORDERING INFORMATION

Here's how to order Contromatics standard ball valves using our figure numbering system:

Example



This is a Contromatics two-way valve, 1100 indicates T.F.E. seats, 44 means solder joint ends, and AA indicates bronze construction.

Valve Class and Seat Description

- 0200**—Buna seats with R. T. stem seals.
- 1100**—T.F.E. seats with R. T. stem seals.
- 1600**—R. T. seats with R. T. stem seals.
- 2500**—High Density Polyethylene seats with R. T. stem seals.
- 9900**—Special

Body & End Piece and Ball & Stem Material

AA —Bronze	FF —Alloy 20
BB —Carbon Steel	GG —Aluminum
CC —316 Stainless Steel	HH —Nickel
DD —304 Stainless Steel	II —Monel
EE —Ductile Iron	ZZ —Special

End Piece Description

- 11**—Screwed End.
- 22**—Socket Weld.
- 33**—Butt Weld (Sch. 40).
- 44**—Solder Joint (Brz. only).
- 55**—Class 150 flanged F. F.
- 66**—Class 150 flanged R. F.
- 77**—Class 300 flanged F. F.
- 88**—Class 300 flanged R. F.
- 99**—Special

NOTE: Specify special requirements such as Firesafe, Chip, Fullport & Flush bottom tank.

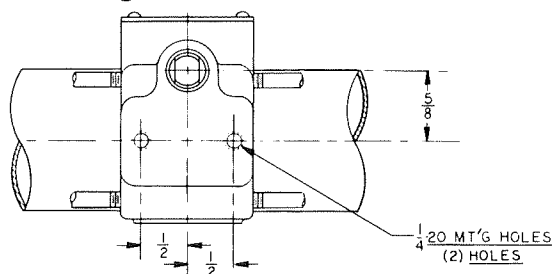
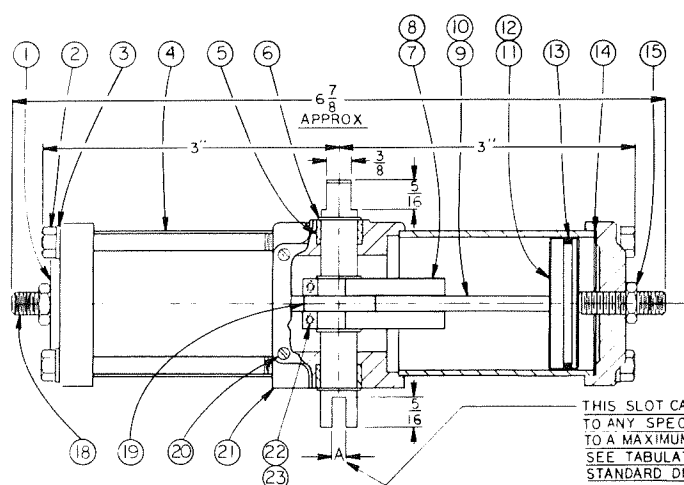


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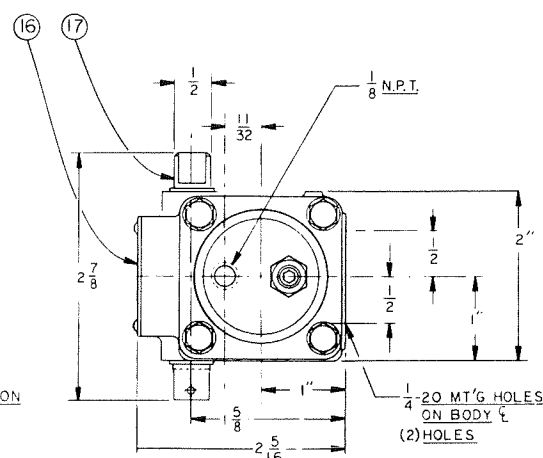
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Actuators & Control Accessories

BASIC ACTUATOR MODEL 125



A
.253
.250
.190
.187
.159
.156



Description

DET. NO.	NO. REQ'D	DESCRIPTION
1	2	END PIECE
2	8	HEX HD. CAP SCREW
3	8	LOCKWASHER
4	2	CYLINDER
5	2	BUSHING
6	4	SNAP RING
7	2	LEVER
8	2	SLIDING BLOCK
9	1	CONNECTING ROD
10	1	WRIST PIN
11	2	PISTON
12	2	SET SCREW
13	2	"O" RING
14	2	GASKET
15	2	TRU-SEAL NUT
16	1	NAME PLATE
17	1	SHAFT
18	2	TRAVEL STOP
19	1	SPACER
20	4	RD. HD. MACH. SCREW
21	1	BODY
22	2	SET SCREW
23	2	KEY

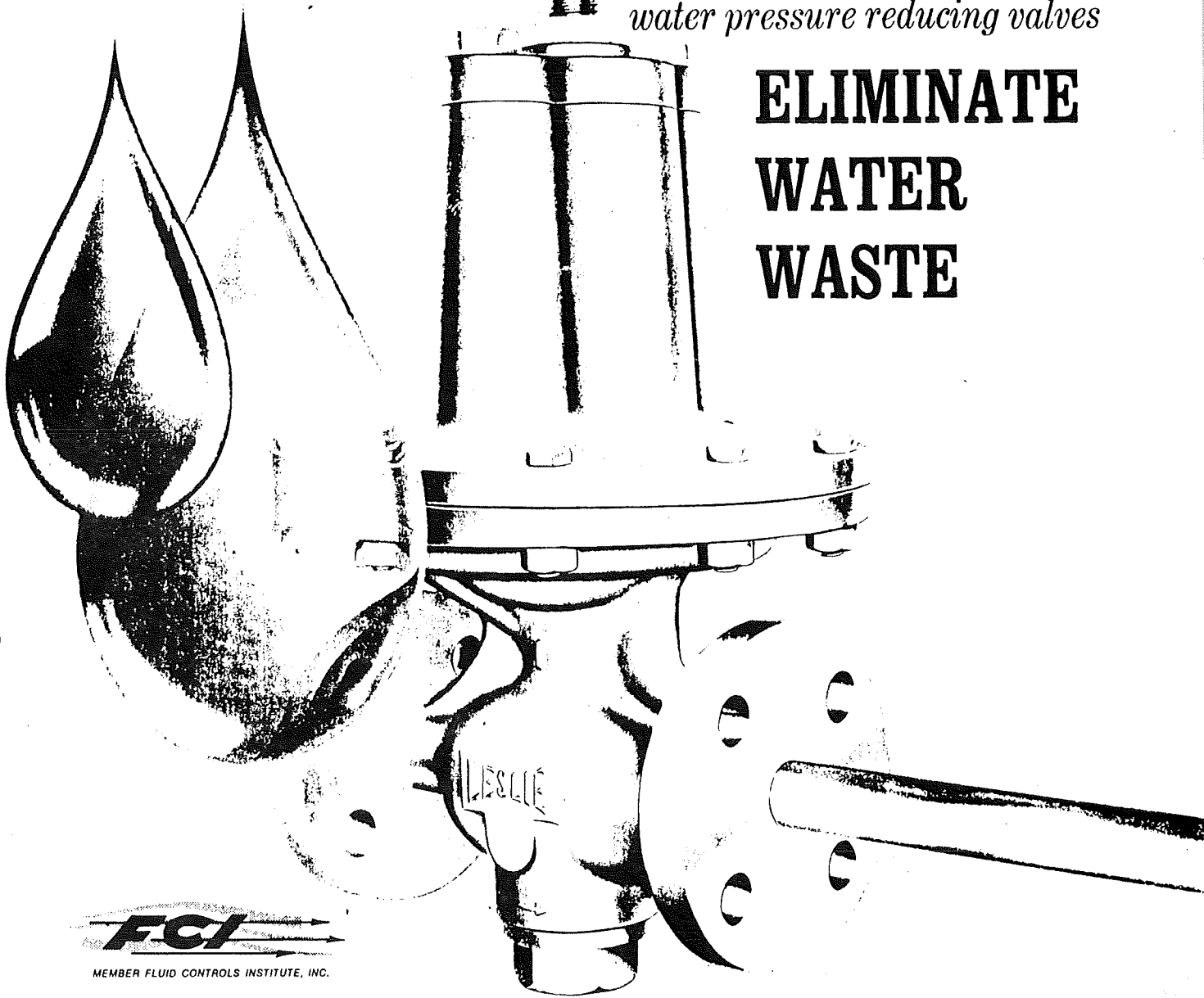


CONTROMATICS

222 Roberts Street, East Hartford, Ct. 06108 Telephone (203) 528-9903 Telex 9-9298

5 ways that **Leslie Hi-Flo**
water pressure reducing valves

ELIMINATE WATER WASTE



FCI
MEMBER FLUID CONTROLS INSTITUTE, INC.



REDUCE HIDDEN WATER LOSSES—Unnecessarily high pressures often cause obscure but steady water waste that is eliminated with accurate water pressure regulation. Even greater savings are possible if your sewage costs are based on volume.



REDUCE PROCESS WASTE—Unstable water pressure conditions that have a disrupting effect in processes are corrected easily with Leslie Hi-Flo.



REDUCE INITIAL COST—Leslie's high capacity-regulation means that you can often use a smaller and less costly reducing valve than if an ordinary valve is used.



REDUCE HIDDEN DAMAGE FROM OVER-PRESSURE—Hidden damage by uncontrolled surges in water pressure to equipment in the water line is virtually eliminated by Leslie Hi-Flow. Often, this potential cause of maintenance expense goes unspotted for years.



REDUCE MAINTENANCE COSTS ON EXISTING REDUCING STATIONS—Simply designed, the Leslie Hi-Flo is built for minimum maintenance. Internal parts can be inspected or renewed without removing the valve from the line. No stuffing boxes.



REGULATORS AND CONTROLLERS
LESLIE CO., PARSIPPANY, NEW JERSEY 07054

Awarded A.S.M.E.  and  Stamp
Approval for Classes 1, 2 and 3 Nuclear Valves.

*Here's why LESLIE HI-FLO's
provide lowest overall
operating cost per year*

Simply designed, your Leslie Hi-Flo is slated for a long, trouble-free life. Standard renewable parts never need special fitting or machining. Here's a rugged regulator built to **absorb** hydraulic system shocks that upset ordinary valves.

Military versions
of these valves
conforming to Spec.
Mil-V-2042 are available.
Contact Parsippany
for full details.

Fully Balanced floating main valve responds to every load change. Friction-free; you'll get no annoying chatter or groaning.

Balancing Diaphragm
(2½-4" sizes employ
balancing piston here)

Closes against inlet
pressure ... valve shuts
tight for dead-end
service.

Large bowl construction with long stroke valve
plug gives you full flow for the equivalent pipe
size without sacrificing accuracy.

Unique downstream demand sensing ar-
rangement insures smooth throttling action
and stable control over the full reduced
pressure range.

Fully guided — top
and bottom main
valve guides prevent
cocking, binding and
improper seating.

Valve disc can be reversed, if necessary,
in a matter of minutes for renewed life.
No special tools required.

INLET PRESSURE

REDUCED PRESSURE

How it operates

Inlet pressure acts upward on small balancing diaphragm (or piston in 2½-4" sizes) to equalize downward pressure on valve disc, providing fully balanced action. Inlet pressure variations are equalized without affecting set point. When the adjusting spring is compressed, it opens the main valve to admit fluid to downstream side.

When the downstream pressure under the large diaphragm equals the force exerted by the adjusting spring, equilibrium is restored and the main valve maintains flow of the set downstream pressure.

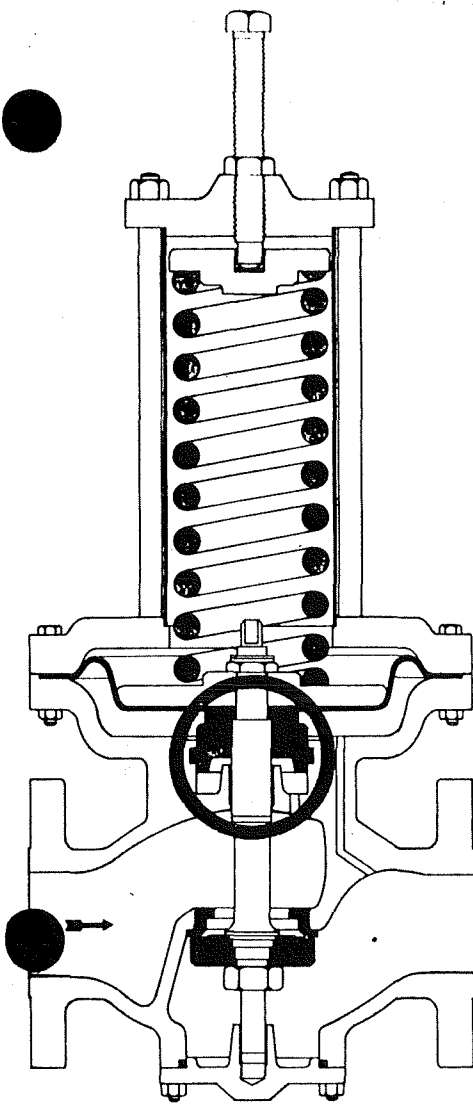
Leslie Hi-Flo's for SALT WATER SERVICE



Leslie Hi-Flo regulators with monel trim are ideally applied in salt water service. (Add W to the class designation, i.e., WW-2, WWB, WWL-2, WWLB, WWH-2, WWHB).

For complete dimension data and parts list on Leslie Hi-Flo regulators for salt water service see Drawing 30.5.4.1.3, available on request.

Leslie Hi-Flo selection table



Leslie Hi-Flo design in 2½-4" sizes (above) employs a cast bronze balancing piston and a long life low friction polyurethane piston seal.

HI-FLO CLASS	CHOICE OF SIZES AND END CONNECTIONS		CHOICE OF PRESSURE RANGES		CHOICE OF MATERIALS			
	Size Range (Inches)	End Connections	Inlet Pressure (PSI)	Reduced Pressure (PSI)	Body & Bottom .Cap	Spring Case	Spring Seats & Spring Case Cap	
WLK	½-2	Screwed	250 Max.	5-30	Cast Iron	Cast Iron	Cast Iron	
	1½-2	125 or 250 # Fig.				0-125, 100-200, 175-250	Tubular Steel	Steel
	2½-4							
WK	½-2	Screwed	250 Max.	25-80		Cast Bronze	Cast Iron	Cast Iron
	1½-2	125 or 250 # Fig.		0-125, 100-200, 175-250			20-60	Tubular Steel
	2½-4							
WHK	½-1¼	Screwed	250 Max.	50-100				Cast Iron
WL-2	½-2	Screwed 150 # Fig. 300 # Fig.	300 Max.	5-30				
W-2	½-2			25-80				
WH-2	½-1¼			50-100				
WLB	½-2			150 or 300 # Fig.	0-125, 100-200, 175-300	5-30	Cast Aluminum	Cast Bronze
	2½-4		Tubular Steel			Steel		
WB	½-2	Scr., 150 or 300 # Fig.	300 Max.	25-80	Cast Aluminum	Cast Bronze		
	2½-4	150 or 300 # Fig.	0-125, 100-200, 175-300	20-60	Tubular Steel	Steel		
WHB	½-1¼	Scr., 150 or 300 # Fig.	300 Max.	50-100	Cast Aluminum	Cast Bronze		

DIAPHRAGMS: High Strength, long travel synthetic rubber.

INTERNAL PARTS: Long lasting solid bronze (or monel-see Hi-Flo's for Salt Water Service) with resilient reversible valve disc.

MAXIMUM TEMPERATURE: ½-2 in., 150°F.; 2½-4 in., 150°F.

RE WITH BETTER CAPACITY—REGULATION

Specifying Leslie Hi-Flo water pressure reducing valves

Water Pressure Reducing Valve shall be packless construction. It shall have a diaphragm to position the main valve and a balancing diaphragm or piston to provide complete main valve balance.

Adjustment shall be made by a single adjusting screw. Valve shall close against inlet pressure. No leather cups shall be used in the valve. The main valve shall be both top and bottom guided. A single adjusting spring shall be totally enclosed in a spring case.

How to order Leslie Hi-Flo's

When ordering Leslie Hi-Flo Reducing Valves, be sure to include the following data that will insure getting the best Hi-Flo for your application.

1. Maximum and minimum inlet pressures and temperatures.
2. Reduced pressure or range desired.
3. Permissible variation in outlet pressure with load.
4. Fluid being controlled (fresh or salt water, oil, gasoline, etc., or if chemical solution, average and maximum concentrations).
5. Maximum and minimum flow requirements.
6. End connections. Specify screwed ends or flange standard and rating.

Sizing your Leslie Hi-Flo

Optimum performance of reducing valves depends on correct sizing for the operating conditions. The proper size Leslie Hi-Flo can be quickly and accurately determined by the 5 simple steps below:

1. Accurately determine:
Reduced pressure.
Inlet Pressure.
Allowable change in reduced pressure, from maximum to minimum flow, psi.
Maximum required flow.
2. Subtract the reduced pressure from the inlet pressure.
3. Note reduced pressure ranges covered in each capacity table and enter the proper, table in the extreme left column.
4. Locate pressure drop in left hand column. (Between two figures use the smaller value or interpolate.)
5. Follow table across (left to right) noting the capacity indicated and pressure deviation heading in each vertical column. When the capacity figure indicated in the table equals the required maximum flow, the proper valve size can be read from the column heading.

EXAMPLE

1. Reduced pressure: 15 psi
Inlet pressure: 75 psi
Allowable change from maximum to minimum flow: 5 psi
Maximum flow: 100 GPM
2. Difference in pressure across valve: 75-15=60
3. Reduced pressure range required: 5-30
Capacity data taken from low reduced pressure table.
4. Enter table at 60 in left hand column.
5. Follow across. The first figure greater than 100 gpm for 5 psi deviation appears in 2" valve column. (Note: If 10 psi deviation were allowable a 1 1/4" Hi-Flo could be selected.)

Sizing for smaller allowable changes in reduced pressure

Leslie Hi-Flo's can be precisely sized for smaller allowable changes in reduced pressure (from maximum to minimum flow) than shown in the sizing tables which appear in this bulletin. For applications where other allowable changes in reduced pressure are required consult your local Leslie representative.

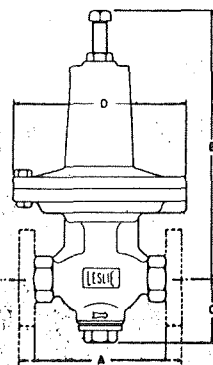
LOW REDUCED PRESSURES CAPACITY GPM																	
INLET PRESSURE MINUS SET PRESSURE PSI	5-30 PSI RANGE																
	size 1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"	3"	4"		
	pressure deviation psi				5	10	5	10	5	10	5	10	2 1/2 psi				
	5	10	5	10													
5	5.4	11.0	9.6	20.0	16.2	33.0	24.6	51.0	30.6	62.0	45.6	92.0	123	156	201		
10	6.6	13.0	12.0	23.0	19.8	38.0	30.6	59.0	37.5	73.0	55.3	106.0	174	221	284		
20	8.4	15.5	15.6	28.5	25.2	46.0	39.0	72.0	48.6	88.0	71.4	131.0	246	313	402		
30	10.2	18.0	18.6	33.0	30.0	54.0	46.2	83.0	57.0	102.0	85.3	152.0	301	384	493		
40	11.4	20.0	21.0	37.0	34.2	60.0	52.3	93.0	64.8	114.0	96.6	169.0	348	442	569		
50	12.6	22.0	23.4	40.1	37.8	66.0	58.2	102.0	72.0	125.0	106.9	185.5	389	495	638		
60	13.8	23.0	25.2	44.0	42.6	71.0	63.6	110.0	78.0	135.0	115.8	200.0	410	522	671		
70	14.4	25.0	27.0	46.5	44.4	76.0	69.6	118.0	84.0	143.5	124.9	215.0	460	586	753		
80	15.6	26.5	28.8	49.0	46.8	81.0	73.3	125.5	89.4	153.0	132.5	227.0	492	626	805		
90	16.2	28.0	30.6	52.0	49.8	85.0	77.4	132.0	94.3	162.0	140.5	239.0	522	664	854		
100	17.4	29.0	31.8	55.0	52.3	89.0	81.0	138.0	99.4	169.5	147.0	251.0	550	700	900		
120	18.6	32.0	35.0	59.0	57.0	97.0	88.3	150.0	108.8	184.5	160.4	273.0	602	766	986		
140	20.4	34.0	37.8	64.0	61.3	104.0	95.5	161.0	117.0	198.5	173.0	293.0	651	828	1065		
160	21.6	36.5	40.2	68.0	64.6	110.5	101.5	171.5	124.5	210.5	184.0	312.0	696	886	1139		
180	22.8	39.0	42.6	72.0	69.0	117.0	107.5	182.0	132.0	223.0	195.5	330.0	738	939	1208		
200	23.9	40.5	46.7	75.5	72.6	122.0	112.6	191.0	139.0	234.0	203.6	346.0	779	992	1270		
220	25.2	42.0	46.8	79.0	76.3	128.0	118.8	200.0	146.0	245.0	212.8	363.0	815	1038	1334		

MEDIUM REDUCED PRESSURES CAPACITY GPM																	
INLET PRESSURE MINUS SET PRESSURE PSI	25-80 PSI RANGE												20-60 PSI RANGE				
	size 1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"	3"	4"		
	pressure deviation psi				5	10	5	10	5	10	5	10	6 psi				
	5	10	5	10													
5	4.0	8.7	7.0	15.8	11.9	26.0	18.0	40.3	22.4	49.8	33.0	72.7	123	156	201		
10	4.8	10.3	8.8	19.0	14.5	30.0	22.4	46.6	27.7	56.8	40.5	84.6	174	221	284		
20	6.2	12.6	11.4	22.1	19.0	36.3	29.3	56.9	35.7	70.3	52.8	94.8	246	313	402		
30	7.5	14.2	13.6	26.1	22.0	42.7	33.9	65.6	41.8	80.6	62.5	120.0	301	384	493		
40	8.4	15.8	15.4	29.2	25.1	47.4	38.7	73.4	47.9	90.8	70.8	133.5	348	442	569		
50	9.2	17.4	16.7	31.6	27.7	52.2	43.1	80.6	52.8	97.6	78.4	146.1	389	495	638		
60	10.1	19.0	18.5	34.8	30.0	56.1	46.7	86.9	57.2	107.4	84.9	158.9	410	522	671		
70	10.6	20.5	19.8	37.1	32.6	60.1	50.2	93.2	61.6	114.5	91.5	169.9	460	586	753		
80	11.4	21.5	21.1	39.5	34.3	64.0	53.7	98.6	65.6	120.8	97.3	179.3	492	626	805		
90	12.3	22.1	22.4	41.1	36.5	67.2	56.7	104.3	69.1	127.9	102.9	188.8	522	664	854		
100	12.5	22.9	23.3	43.5	38.3	70.3	59.4	109.1	73.1	133.5	107.8	193.5	550	700	900		
120	13.6	25.3	25.5	47.4	41.8	76.7	64.7	118.5	79.7	146.0	117.9	215.5	602	766	986		
140	15.0	26.9	27.7	50.6	44.9	82.2	70.0	128.0	85.8	156.3	127.1	231.3	651	828	1065		
160	15.8	28.5	29.9	53.7	47.9	87.7	74.8	131.5	91.5	167.0	135.5	247.0	696	886	1139		
180	16.7	30.8	31.2	56.8	51.1	92.5	78.8	143.8	96.8	176.2	143.3	260.5	738	939	1208		
200	17.6	32.4	32.6	60.1	53.7	97.2	83.2	150.8	104.0	185.6	150.9	274.0	779	992	1270		
220	18.5	33.2	34.3	62.4	55.8	101.9	87.2	158.0	106.9	193.5	158.0	286.8	815	1038	1334		

HIGH REDUCED PRESSURES																	
Hi-Flo's with 50-100 psi reduced pressure range are available in 1/2, 3/4, 1, and 1 1/4" sizes. To size Hi-Flo's with 50-100 range use capacity data shown for medium pressures. For 1 1/4" Hi-Flo's with 50-100 psi range multiply figures in table by 0.9.																	

LESLIE HI-FLO DIMENSIONS

Valve Size (inches)	Face to Face or End to End (A)				Center of Pipe to Top of Valve (B)	Center of Pipe to Bottom of Valve (C)	Diameter of Dia- phragm Chamber (D)
	Scr.	125 # or 150 # Fig.	250 # or 300 # Fig.				
1/2	6 1/8	7 1/8	7 1/2	13 1/8	3 1/4	8 5/8	
3/4	6 1/8	7 1/4	7 5/8	13 1/8	3 1/4	8 5/8	
1	6 1/2	7 1/4	7 3/4	13 1/8	3 1/4	8 5/8	
1 1/4	7 1/4	7 3/4	8 1/4	13 1/4	3 1/2	8 5/8	
1 1/2	7 5/8	8 3/4	9 1/4	14 1/2	4	10 1/4	
2	8 1/2	10	10 1/2	14 1/2	4 3/8	10 1/4	
2 1/2	—	10 7/8	11 1/2	25 1/2	5	12 1/2	
3	—	11 3/4	12 1/2	26	5 1/8	12 1/2	
4	—	13 3/8	14 1/2	26 1/2	6 1/4	12 1/2	



REGULATORS AND CONTROLLERS

LESLIE CO., PARSIPPANY, NEW JERSEY 07054

Awarded A.S.M.E.  and  Stamp
Approval for Classes 1, 2 and 3 Nuclear Valves.

CAST CARBON STEEL

ASTM DESIGNATION A-216 GRADE WCB

Size Range (Inches)	End Connection	ASA Standard (lb.)	Catalog Order Number	Pressure-Temperature Limits		
				Primary Rating		psi at 100°F Non-Shock
				psi	°F	
¼-2	① ⑬ Screwed	600	7200	730	800	1440
½-10	③ Flanged	150	7201	150	500	275
½-10	③ Flanged	300	7203	365	800	720
4-10	③ Flanged	400	7205	490	800	960
½-10	③ Flanged	600	7207	730	800	1440
¼-2	⑤ ⑬ Socket Weld	600	7209	730	800	1440
½-10	⑥ Butt Weld	600	7210	730	800	1440
3, 4 and 6	⑦ Flanged	900	7211	1100	800	2160
½-4 and 6	⑦ Flanged	1500	7213	1830	800	3600
½-3	⑧ Socket Weld	1500	7215	1830	800	3600
½-4 and 6	⑨ Butt Weld	1500	7216	1830	800	3600
1-2	⑩ Socket Weld	2500	7219	3050	800	6000
1-2	⑪ Butt Weld	2500	7220	3050	800	6000

CAST CHROME-MOLY STEEL

ASTM DESIGNATION A-217, GRADES WC-6, WC-9 and C5

Size Range (Inches)	End Connection	ASA Standard (lb.)	Catalog Order Number	Pressure-Temperature Limits		
				Primary Rating		psi at 100°F Non-Shock
				psi	°F	
3, 4 and 6	⑦ Flanged	900	7411	900	975 (C5-950)	2160
½-4 and 6	⑦ Flanged	1500	7413	1500	975 (C5-950)	3600
½-3	⑧ Socket Weld	1500	7415	1500	975 (C5-950)	3600
½-4 and 6	⑨ Butt Weld	1500	7416	1500	975 (C5-950)	3600
1-2	⑩ Socket Weld	2500	7419	2500	975 (C5-950)	6000
1-2	⑪ Butt Weld	2500	7420	2500	975 (C5-950)	6000

Carbon, Chromium and Molybdenum content for strainers in the table above:

Grade WC-6	Carbon 0.20 Max.	Chromium 1.00-1.50	Molybdenum 0.45-0.65
Grade WC-9	Carbon 0.18 Max.	Chromium 2.00-2.75	Molybdenum 0.90-1.20
Grade C5	Carbon 0.20 Max.	Chromium 4.00-6.50	Molybdenum 0.45-0.65

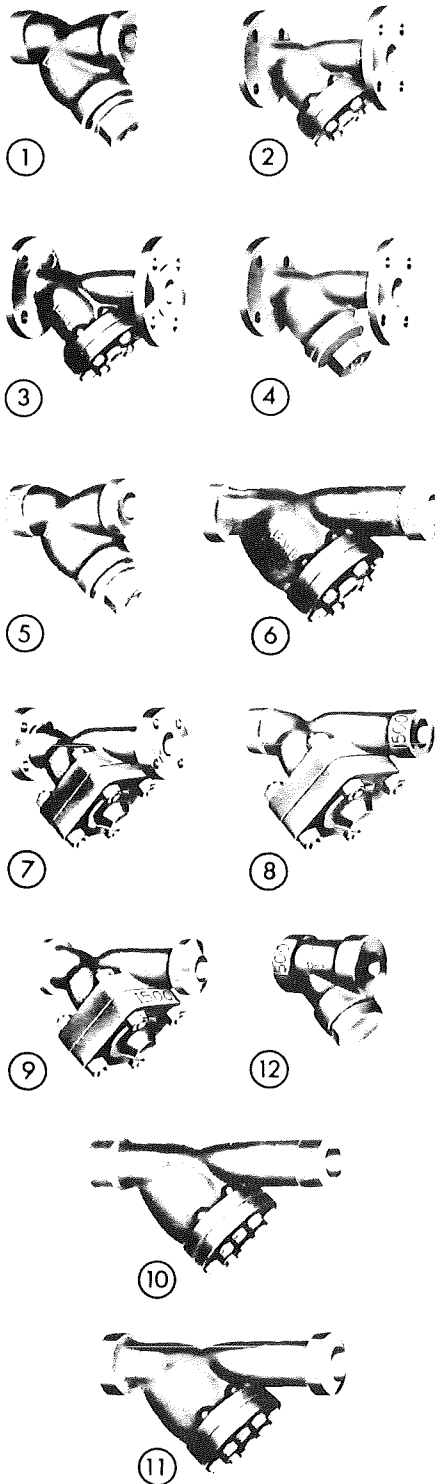
FORGED CARBON STEEL

ASTM DESIGNATION A-105 GRADE 1

Size Range (Inches)	End Connection	ASA Standard (lb.)	Catalog Order Number	Pressure-Temperature Limits		
				Primary Rating		psi at 100°F Non-Shock
				psi	°F	
½-1	Screwed ⑫ Socket Weld	1500	7600 7615	1930	800	3600

CAST STAINLESS STEEL

ASTM DESIGNATION A-296, GRADES CF8 and CF8M



Size Range (Inches)	End Connection	ASA Standard (lb.)	Catalog Order Number	Pressure-Temperature Limits					
				CF8 (Type 304)			CF8M (Type 316)		
				Primary Rating psi	°F	psi at 100°F Non-Shock	Primary Rating psi	°F	psi at 100°F Non-Shock
¼—2	① ⑬ Screwed	600	7500	600	1000	1235	600	1125	1440
½—10	③ Flanged	150	7501	150	500	275	150	500	275
½—10	③ Flanged	300	7503	300	1000	615	300	1125	720
4—10	③ Flanged	400	7505	400	1000	825	400	1125	960
½—10	③ Flanged	600	7507	600	1000	1235	600	1125	1440
¼—2	⑤ ⑬ Socket Weld	600	7509	600	1000	1235	600	1125	1440
½—10	⑥ Butt Weld	600	7510	600	1000	1235	600	1125	1440
½—3	⑧ Socket Weld	1500	7515	1500	1000	3085	1500	1125	3600
½—4 and 6	⑨ Butt Weld	1500	7516	1500	1000	3085	1500	1125	3600
1—2	⑩ Socket Weld	2500	7519	2500	1000	5145	2500	1125	6000
1—2	⑪ Butt Weld	2500	7520	2500	1000	5145	2500	1125	6000

**DIMENSION DRAWINGS
AVAILABLE ON REQUEST:**

Strainer Screens _____ 70/0.4.1

Y-TYPE STRAINERS, 600 LB. AND UNDER

Steel and Stainless Steel Strainers with Screwed, Socket Weld, Sil braz or Solder Ends _____ 70/1.4.1

Steel and Stainless Steel Strainers with Flanged and Butt Weld Ends _____ 70/1.4.3

Steel Strainers with Ring Type Joints _____ 70/1.4.4

Y-TYPE STRAINERS, OVER 600 LB.

900-3500 lb. Strainers _____ 70/2.4.1


 Cast Steel and
SSSt—¼, ⅜ and
½ inch sizes

APPENDIX F

ANSUL TEST REPORT NO. T-3608

TEST STATION REPORT
FIRE PROTECTION PRODUCTS
DEVELOPMENT CENTER

Title Performance Testing of Twin Agent Piped System
Author L. McDonald Report Approval _____ Report Date 2/23/77
Requestor B. Christensen Charge No. 33507-05103 Req. Date 2-1-77
Test Technicians Lyle McDonald & Jim Schewe
Copies to Master File, Test Station File

OBJECTIVE

Performance testing of twin agent piped system.

PROCEDURE

Testing for the twin agent piped system underground fuel area components was conducted as the components became available.

The first component received was the Contromatic Model 275B pneumatic actuator. The following tests were performed:

- (1) Break-away and running torque with no pressure.
- (2) Apply pressure beginning with 50 psi and increase to maximum pressure (300 psi) and record data in Table 1.
- (3) Place unit in salt spray (20% solution) for 240 hours.
- (4) Repeat Steps 1 and 2 after 240 hours in salt spray.

The test set-up was as shown in Figure 1.

The next component tested was the Leslie water reducing valve. The flow test was set up as shown in Figure 2. The data of Table 2 were compiled using the following procedure:

- (1) Dead set was set by adjusting compression spring with the outlet valve closed.
- (2) Flow was regulated at the outlet valve.
- (3) Record data for different dead sets and flows.

(Use Plain Sheet for Continuation)



The next component received was the bladder for the AFFF tank. The bladder was inspected and assembled into the tank using 70 ft./lb. torque to secure the flanges.

The sprinkler nozzles were received next and, using the piping arrangement of Figure 3, with the nozzles 3' from the floor, the following data were obtained:

- (Reference Tables 3A - 3K)
- (a) Flow Rate
 - (b) P_1 , P_2 , P_3 and P_4
 - (c) 25% Drain Time (when possible)
 - (d) Expansion Ratio

Next, using the same piping arrangement, but raising the sprinklers to a height of 10' from the floor and establishing a desired pressure at P_4 , the coverage of the sprinkler was obtained and data recorded in Table 3L.

Next, fire tests were conducted using the same piping arrangement with the sprinklers 28' from the floor. Sprinklers tested on the fires were the Viking C 5/16", Grinnell B-1 Upright, and Grinnell D Upright (reference Table 3M).

The following procedure was used on the fires in the 50 sq.ft. pan with 18" sides:

- (1) 15-second preburn.
- (2) AFFF application for 10 minutes.
- (3) Water application for 20 minutes after AFFF is stopped.
- (4) Burnback tests.

Next the dry chemical unit was tested using the piping arrangement of Figure 4. Using the Dynagraph, the following data were obtained and recorded in Table 4 (reference Dynagraph Chart No. H.E. 820):

Next, using the piping arrangement of Figure 5, both the dry chemical unit and the AFFF unit were tested with the 50 sq.ft. pan with the mock-up mine vehicle (Print No. X-31050). Data were recorded in Table 5.

The Dynagraph was used on the dry chemical portion of the system. The same data were compiled as in the flow testing for the dry chemical testing, with the only difference being the location of P_2 and P_3 . Data were recorded in Table 6 (reference Dynagraph Chart No. H.E. 821).

Actuation for this system was the Detronics (Part No. 6700B) UV unitized detector with one slave detector, both operated off the Ansul AUTOMAN III control panel.

DISCUSSION OF RESULTS

Using the test set-up of Figure 1, the data of Table 1 were compiled. It was observed that after 240 hours in the salt spray, the torques on the Contromatic Model No. 275B

pneumatic actuator were slightly lower. There was some corrosion on the inside of the actuator which was due to some open ports and no gasket on the nameplate. The actuator was cleaned and assembled on the AFFF unit.

The flow test of the Leslie Hi-Flow water reducing valve was conducted using dead sets between 0 - 69 psi. The reducing valve operates similar to a Rego regulator; as the compression is increased on the adjusting spring, the flow is increased. Flow can also be adjusted by a valve downstream from the water reducing valve.

The next test was the sprinkler evaluation (reference Tables 3A - 3K), with the piping arrangement of Figure 3 and the sprinklers 3' from the floor.

The first sprinkler evaluated was the Viking C sidewall sprinkler. This test was run outdoors and the high winds made it difficult to obtain samples. This sprinkler had very poor drain times and low expansion (reference Table 3A).

The next sprinkler was the Viking C 5/16" orifice sprinkler. This sprinkler also had low drain times, but the expansion was slightly higher. This test was run outdoors (reference Table 3B). This same sprinkler was also tested indoors for comparison and there was very little difference in the data (reference Table 3C). The remaining sprinklers were all tested indoors.

The next sprinkler tested was the Viking C 3/8" orifice. This sprinkler performed about the same as the previous sprinklers (reference Table 3D).

The next sprinkler was the Viking C 7/16" orifice. This sprinkler had very poor drain time and was fair for expansion (reference Table 3E).

The Grinnell Issue D upright style 1/2" orifice was the next sprinkler to be tested. This sprinkler had a fair expansion but a very poor drain time (reference Table 3F).

The next sprinkler tested was the Grinnell Issue C fusible upright style, 1/2" orifice. This sprinkler performed very poorly (reference Table 3H).

The Grinnell Issue D, pendant, 1/2" orifice sprinkler was tested next. The expansion was good, but drain times were low (reference Table 3I).

The next sprinkler tested was the Grinnell Issue B-1 pendant style. This sprinkler had good expansion and fair drain times (reference Table 3J).

The Grinnell Issue B1 sprinkler, upright style, was the next sprinkler to be tested. This sprinkler had good drain times and expansion ratio (reference Table 3K).

Next, the piping arrangement of Figure 3 was suspended at 10' in the Test House and the coverage for the Grinnell B-1 upright sprinkler and the Viking C 5/16" sprinkler

was observed with the sprinkler pressure pre-set. The Viking C 5/16" had a slightly better coverage (reference Table 3L).

Next, using the piping arrangement of Figure 3 with the sprinklers 28' from the floor of the Test House, the Viking C 5/16", Grinnell B-1 upright, and the Grinnell D upright sprinklers were tested using the 50 sq.ft. pan with 18" sides and 1" of heptane. The Grinnell B-1 upright sprinkler performed best and was the only test in which there was no open fuel in the pan after 20 minutes of water was applied (reference Table 3M).

The test of the dry chemical portion of the arrangement was next and the piping arrangement of Figure 4 was set up on the Test Field with the Dynagraph to record data (reference Dynagraph Chart No. H.E. 820). The data from the chart is also recorded in Table 4.

Wind direction and velocity is shown in Figure 4 (8-15 mph from the Northwest). The coverage was approximately 10' wide and 36' long. The Dynagraph was used to record pressures. The pressure drop across the elbow was to be recorded. Due to the difficulty in accomplishing this because of the small change expected and other error factors, it was decided that the best way to accomplish this was to use a differential to measure the actual difference before and after the elbow. So, regardless of what pressures are read at P₂ and P₃ (either of which could be in error of 4 psi to 6 psi because of the width of the pen marker alone), then P₄ measured the actual difference to within one-half of 1 psi accuracy.

The fire test for the system was using the piping arrangement of Figure 5. The Dynagraph was also used as before, with the differential between P₂ and P₃ measured. Data for the fire was recorded in Table 5. Data for the dry chemical portion can be seen on the chart (H.E. 821). The data were also recorded in Table 6.

The system, as a complete unit, worked very satisfactorily. The fire was overwhelmed immediately as the dry chemical was applied and the AFFF (3%) seemed to have begun to knock the fire down during the delay between detection and the time for the burst disc to burst.

Movies were taken by the A/V Lab (reference USBM Twin Agent Piped System, H0262023). The outside portion of the discharge was monitored by a camera to document the range of one nozzle. The first distance marker was placed 20' from the nozzle and markers thereafter at 5' increments up to 40'.

LARGE EQUIPMENT DISCHARGE TESTS

Work Req. No. T-3608

Type of Unit PS 1000

Ident. of Chem. Foray 02.12.24.7

Condition of Charge Fresh Fill

W/Cyl.	W/O Cyl.
Tare of Unit	<u>444 #</u>
Wt. of Charge	<u>850 #</u>
Gross of Unit	<u>1294 #</u>
Wt. after Disch.	<u>446 #</u>
Amt. Disch'd.	<u>848 #</u>
% Disch'd.	<u>92.8%</u>
Time Disch'd.	

Flow Rate _____ Avg. lb./sec.

Flow Rate Avg. lb./sec. during
5 sec. intervals

0-5	5-10	10-15
15-20	20-25	25-30
30-35	35-40	40-45
45-50	50-55	55-60
60-65	65-70	70-75
75-80	80-85	85-90
90-95	95-100	100-105
105-110	110-115	115-120
120-125	125-130	130-135
135-140	140-145	145-150
150-155	155-160	160-165
165-170	170-175	175-180

Charge No. 33507
05103 Date 3-23-77

Pressure Chart No. _____ Test No. 1

Room Temp. _____ Outdoor Temp. 32°F

D. C. Temp. _____ Weather _____

Wind Vel. & Dir. _____

Nit. Cyl. 2 - 400's Valve Q.O.

Max. Press. 2450 Temp. 32°F

Pressure after Pressurization _____

Press. after Disch.
at Ambient Temp. _____

Regulator 2 Rego's

Regulator Set. Factory Set

D. C. Tank Top Press. _____ Press. _____ Sec. _____
 Press. _____ Sec. _____

Avg. Press. During Disch. _____

Disch'd _____ after Pressurization

Init. Max. Range _____ Width _____ Thick _____

Working Range _____ Width _____ Thick _____

Nozzle 3/4" T Nozzle Position _____

Hose Dia. _____ Length _____

Fire Area _____ Fuel _____

Preburn _____ Depth _____

Freeboard _____ Added _____

Ext. Time _____

Disch. Time _____

COMMENTS:

Piping as per sketch

LARGE EQUIPMENT DISCHARGE TESTS

Work Req. No. 7-3608

Charge No. 33507
05103 Date 4-1-77

Type of Unit PS. 1000

Pressure Chart No. _____ Test No. 2

Ident. of Chem. FORAY 03.13.24.2

Room Temp. _____ Outdoor Temp. 35°F

D. C. Temp. _____ Weather _____

Wind Vel. & Dir. _____

Condition of Charge FRESH FILL
W/Cyl. W/O Cyl.

Nit. Cyl. 2-400's Valve Q.O.

Tare of Unit _____ 444 #

Max. Press. 2450 Temp. 32°F

Wt. of Charge _____ 850 #

Pressure after Pressurization _____

Gross of Unit _____ 1294 #

Press. after Disch.
at Ambient Temp. _____

Wt. after Disch. _____ 446 #

Regulator 2 Rego's

Amt. Disch'd. _____ 848 #

Regulator Set. Factory Set

% Disch'd. _____ 99.8%

D. C. Tank Top Press. _____ Press. _____ Sec. _____
Press. _____ Sec. _____

Time Disch'd. _____

Avg. Press. During Disch. _____

Flow Rate _____ Avg. lb./sec.

Disch'd _____ after Pressurization

Flow Rate Avg. lb./sec. during
5 sec. intervals

Init. Max. Range _____ Width _____ Thick _____

Working Range _____ Width _____ Thick _____

Nozzle 2-1" T Nozzle Position _____

Hose Dia. _____ Length _____

Fire Area _____ Fuel _____

Preburn _____ Depth _____

Freeboard _____ Added _____

Ext. Time _____

Disch. Time _____

0-5 _____	5-10 _____	10-15 _____
15-20 _____	20-25 _____	25-30 _____
30-35 _____	35-40 _____	40-45 _____
45-50 _____	50-55 _____	55-60 _____
60-65 _____	65-70 _____	70-75 _____
75-80 _____	80-85 _____	85-90 _____
90-95 _____	95-100 _____	100-105 _____
105-110 _____	110-115 _____	115-120 _____
120-125 _____	125-130 _____	130-135 _____
135-140 _____	140-145 _____	145-150 _____
150-155 _____	155-160 _____	160-165 _____
165-170 _____	170-175 _____	175-180 _____

COMMENTS: Piping as per sketch



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM Contract HO 262063

W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDonald DATE 2-23-77

Contromatics Model No. 275 B Pneumatic Actuator

MAX. PRESSURE - 300 psi

MAX TORQUE - 2686 in/LB

PRESSURE	TORQUE Before 240 Hours Salt Spray	PRESSURE	TORQUE After 240 Hours in Salt Spray
No Pressure	283 in/LB Break Away + 174 in/LB Running	No Pressure	220 in/LB Break Away + 165 Running
50 psi	429 in/LB		440 in/LB
100 psi	899 in/LB		770 in/LB
150 psi	1320 in/LB		1155 in/LB
200 psi	1955 in/LB		1540 in/LB
250 psi	2343 in/LB		1925 in/LB
260 psi	2409 in/LB		2035 in/LB
270 psi	2483 in/LB		2090 in/LB
280 psi	2623 in/LB		2145 in/LB
290 psi	2689 in/LB		2255 in/LB
300 psi	2772 in/LB		2310 in/LB

MIN OPENING PRESSURE - 20 psi

MIN. OPEN PRESSURE - 20 psi

IN SALT SPRAY 2:30 PM 2/23
Out " " 3/7/77

TABLE 1



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBIA Contract NO 262023

W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDonald DATE 3/10/77

Flow test of LESLIE H.-Flow WATER REDUCING VALVES

DEAD SET (PSI)	Flow (GPM)	P ₁ (PSI)	P ₂ (PSI)	P ₃ (PSI)	DEAD SET	Flow	P ₁	P ₂	P ₃	DEAD SET	Flow	P ₁	P ₂	P ₃
10	60	55	53	5	20	182	75	68	4.5	50	0	58	56	50
10	90	52	48	2	30	229	56	53	5	50	168	34	29	5
10	0	105	105	10.5	40	242	62	55	5					
10	60	102	98	6	40	199	70	67	20					
10	90	102	96	5	50	240	62	55	6					
10	120	95	92	2	68	243	63	55	6					
20	0	110	109	18.75	69	0	146	144	69					
20	60	108	105	14	69	240	90	83	34					
20	90	104	100	13	51	0	140	139	51					
20	120	98	95	11	51	240	82	73	23.5					
20	180	90	74	5	51	0	170	168	51					
20	0	110	109	19	51	240	108	98	29					

TABLE 2



SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM CONTRACT HO 262023
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. Mc DONALD DATE 3/15/77

[illegible]

TABLE 3A



W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/15/77

[illegible]

TABLE 3B



SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM CONTRACT H0262023
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/16/77

VIKING C 5/16" ORIFICE SPRINKLER test INDOORS (REPEAT)

[illegible]

TABLE 3C



SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM CONTRACT NO 262023
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/16/77

[illegible]

TABLE 3D



SUBJECT Twin Agent Piped System UNDERGROUND FUEL AREAS USBM CONTRACT HO262023
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/16/77

INDOOR test

[illegible]

TABLE 3E



W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDonald DATE 3/16/77

[illegible]

TABLE 3F



W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDonald DATE 3/16/77

[illegible]

TABLE 3G



SUBJECT TWIN AGENT PIPED SYSTEM UNDER GROUND FUEL AREAS USBM CONTRACT HO 262023
W.R. NO. T-3608 REQUESTOR B. CHRISENSEN DATA BY L. McDonald DATE 3/16/77

Indoor test

[illegible]

TABLE 3 H



W.R. NO. T-3608 REQUESTOR R. CHRISTENSEN DATA BY L. McDonald DATE 3/16/77

indoor test

[illegible]

TABLE 3I



W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/16/77

[illegible]

TABLE 3 J



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USDM CONTRACT HO 262023
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 3/16/77

GRINNELL ISSUE B-1 SPRINKLER, UPRIGHT style indoor test

FLOW RATE (GPM)	P ₁ (PSIG)	P ₂ (PSIG)	P ₃ (PSIG)	P ₄ (PSIG)	25% D.T.	Exp. Ratio	Comments
25	60	6	7.5	7(6)	:17	5.7	
43	55	17	18.5	15	:26	6.4	
63	50	36.5	37.5	30	1:10	4.4	
63	50	36.5	37.5	30	1:19	4.3	
72	128	49	50	40	1:43	4.1	

TABLE 3K



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPE SYSTEM UNDERGROUND FUEL AREAS USBM CONTRACT NO 060003

W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. H. DENARD DATE 3/17/77

COVERAGE TESTS

P ₄	RANGE WITH WATER RADIUS	RANGE WITH FOAM RADIUS	SPRINKLER TYPE	SPRINKLER HEIGHT	
15	8 ft	6.5 ft	GRINNELL B-1 UPRIGHT	10 FT	
32	8.5 ft	7.0 ft	GRINNELL B-1 UPRIGHT	10 FT	
15	11 ft	9 ft	Viking C 5/16"	10 FT	
40	11 ft	7 ft	Viking C 5/16"	10 FT	

TABLE 3L



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USDM Contract HO 262023

W.R. NO. I-3008 REQUESTOR B. CHRISTENSEN DATA BY L. McDonald DATE _____

DRY CHEM FLOW TEST Ref. HE 820 DYNAGRAPH CHART

TIME	WEIGHT LOSS	OUTLET PRESSURE P_1	PRESSURE BEFORE THE ELBOW P_2	PRESSURE AFTER THE ELBOW P_3	DIFFERENTIAL BETWEEN P_2 AND P_3	NOZZLE PRESSURE	COMMENTS
5 sec.	185 #	133 psi	100 psi	104 psi	P_4 + 4.0 psi	101 psi	P_4 is
10 sec.	300 #	132 psi	108 psi	112 psi	4.4 psi	110 psi	actual difference
15 sec.	420 #	129 psi	104 psi	108 psi	4.4 psi	106 psi	between P_2 & P_3
20 sec.	551 #	125 psi	96 psi	101 psi	4.6 psi	99 psi	THE difference
25 sec.	673 #	125 psi	101 psi	106 psi	4.5 psi	103 psi	in P_2 & P_3 and
30 sec.	748 #	115 psi	96 psi	96 psi	1.0 psi	92 psi	the chart is
35 sec.	806 #	102 psi	88 psi	84 psi	-2.0 psi	80 psi	inaccurate
40 sec.	835 #	75 psi	68 psi	64 psi	-1.6 psi	60 psi	when such a small
45 sec.	838 #	45 psi	39 psi	38 psi	-0.4 psi	36 psi	diff. is needed.
50 sec.	840 #	25 psi	20 psi	24 psi	+0.4 psi	20 psi	This is the
55 sec.	843 #	18 psi	12 psi	16 psi	+0.2 psi	13 psi	Reason for P_4
60 sec.	845 #	13 psi	9 psi	13 psi	+0.2 psi	10 psi	
65 sec.	848 #	12 psi	8 psi	13 psi	+0.2 psi	8 psi	

TABIE 4



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM Contract H0262023

W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONAH DATE 4-1-77

FIRE TEST

DRY CHEM (FORAY) & AFFF (3%) P.S.

		Comments
PRE BURN	10 sec	
AFFF TIME	10 sec	Time taken from the time fire was completely involved till sprinklers started
BURST DISC TIME	16.3 sec	
FIRE OUT	3 sec	AFTER DRY CHEM APPLIED
P ₁	58 psi	
P ₂	38 psi	
P ₃	40 psi	
DRY CHEM EFF TIME	15 sec	
Flow @ 90% discharge	16.3 sec. 41.7 #/sec	taken from DYNAGRAPH CHART # H.E. 82'
" @ 2/3 time	12.2 sec. 46.3 #/sec	" " " " " "

TABLE 5



THE ANSUL COMPANY / MARINETTE, WISCONSIN / FIRE TEST STATION DATA RECORD

SUBJECT TWIN AGENT PIPED SYSTEM UNDERGROUND FUEL AREAS USBM CONTRACT NO 262023

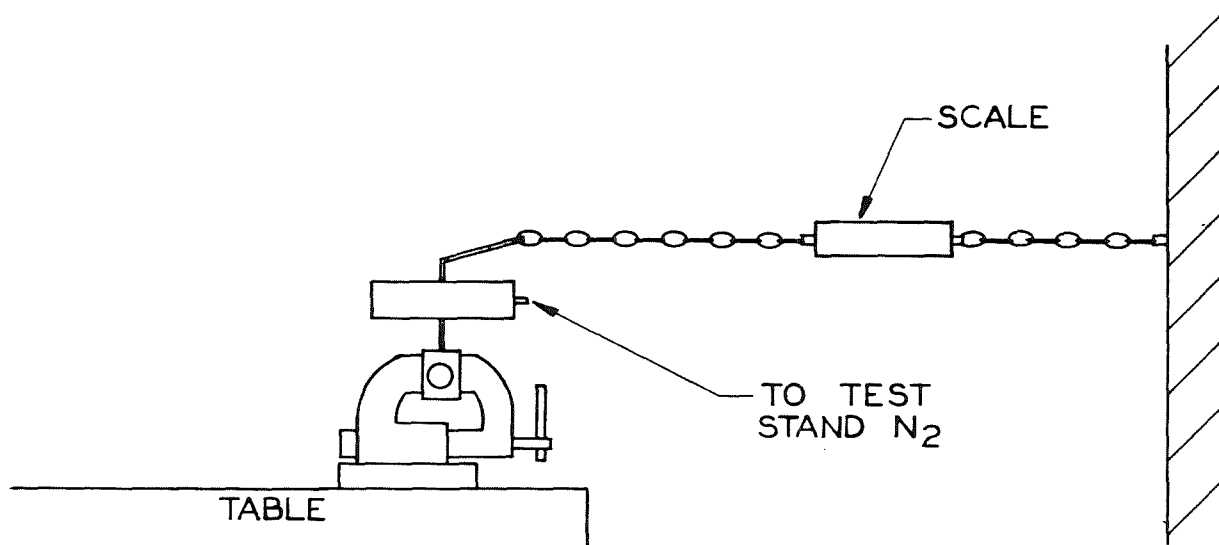
W.R. NO. T-3608 REQUESTOR B. CHRISTENSEN DATA BY L. McDONALD DATE 4-1-77

FIRE TEST

DATA FOR: DRY CHEM Unit & PIPING Ref. DYNAGRAPH CHART # H.E. 821

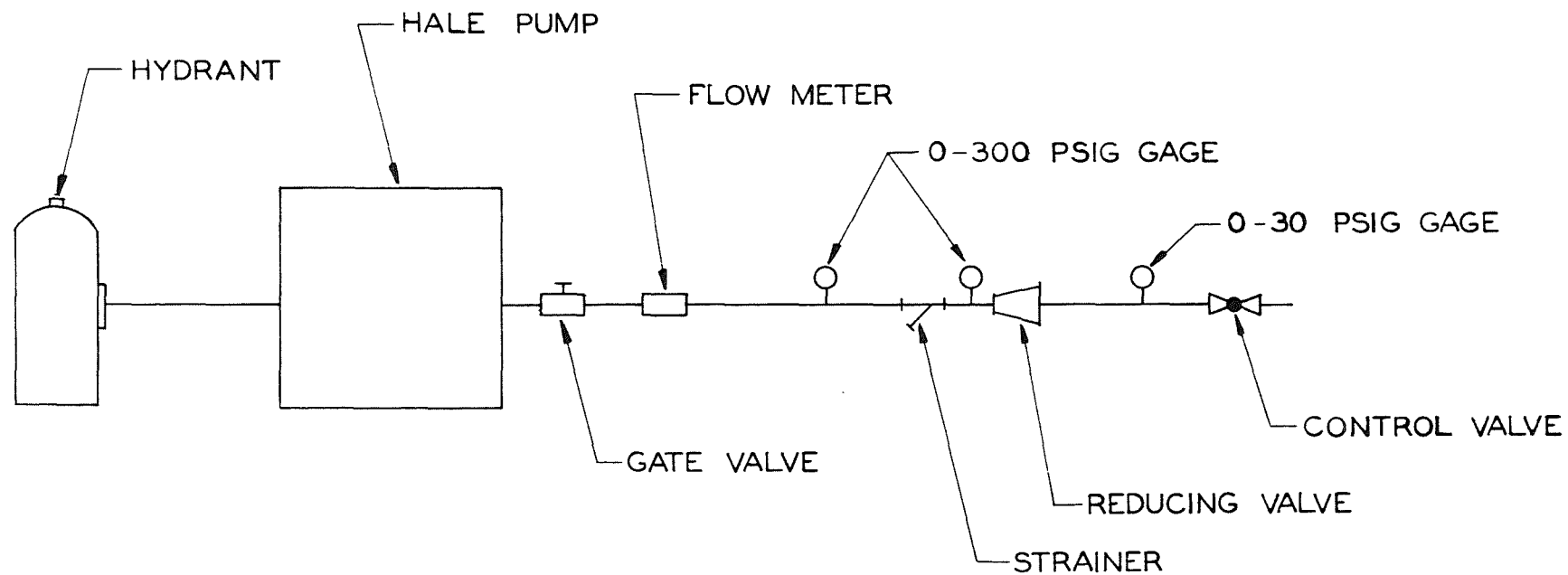
TIME	WEIGHT LOSS	OUTLET PRESSURE P_1	PRESSURE BEFORE THE ELBOW P_2	PRESSURE AFTER THE ELBOW P_3	DIFFERENTIAL BETWEEN P_2 AND P_3 P_4	NOZZLE PRESSURE P_5	
5 Sec.	257 psi	121 psi	84 psi	80 psi	+3.0 psi	70 psi	
10 Sec.	483 psi	114 psi	80 psi	76 psi	+2.4 psi	70 psi	
15 Sec.	642 psi	103 psi	74 psi	68 psi	2.0 psi	64 psi	
20 Sec.	809 psi	95 psi	76 psi	74 psi	2.1 psi	68 psi	
25 Sec.	832 psi	54 psi	36 psi	30 psi	0.4 psi	27.5 psi	
30 Sec.	848 psi	18 psi	10 psi	10 psi	0 psi	8 psi	

TABLE 6



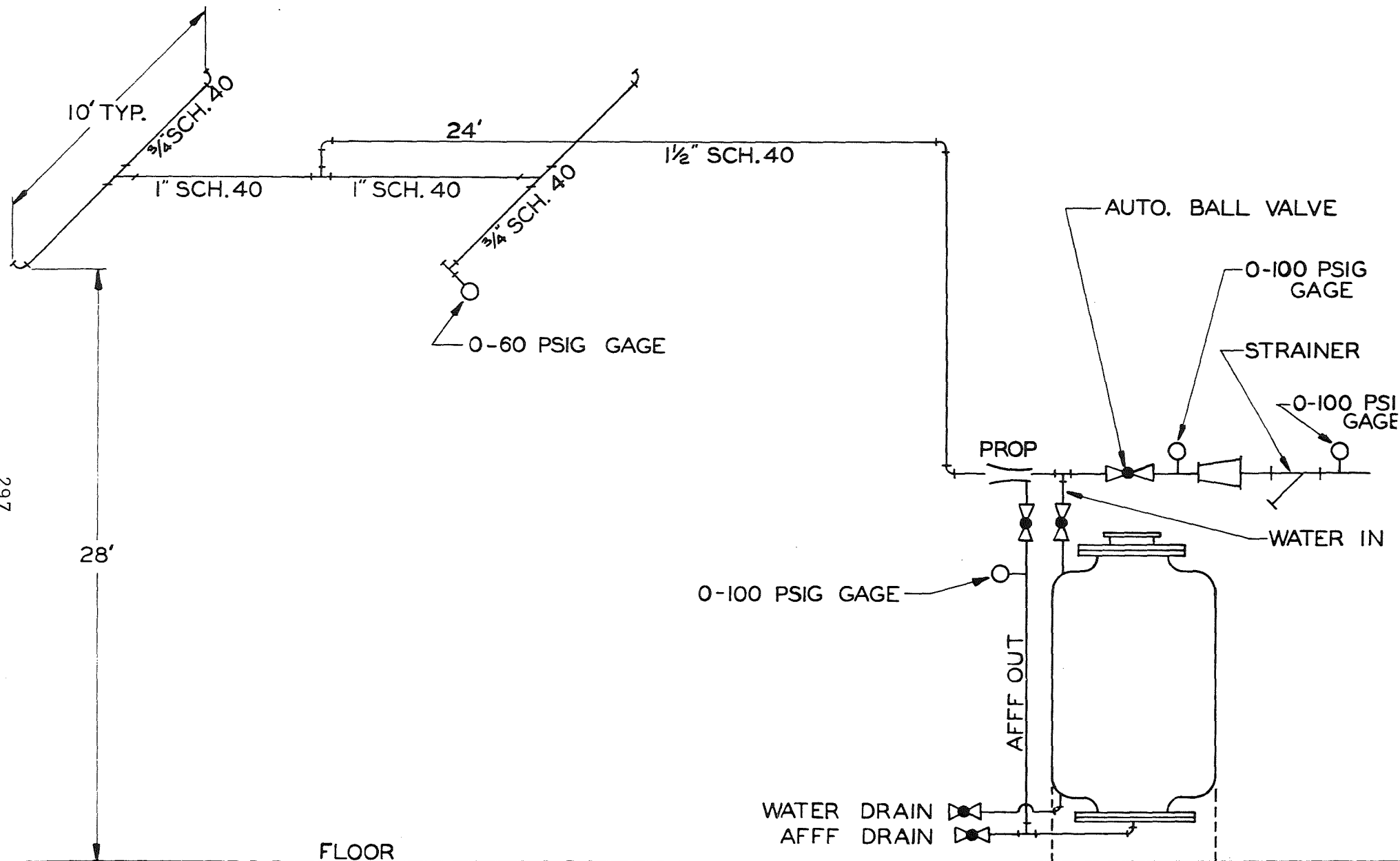
TEST SET-UP
PNEUMATICALLY OPERATED CONTROL
VALVE AFFF UNIT (TORQUE OUTPUT)

Figure 1.



TEST SET-UP
LESLIE PRESSURE REDUCING VALVE AFFF UNIT
FLOW, PRESSURE SETTING RELATIONSHIP

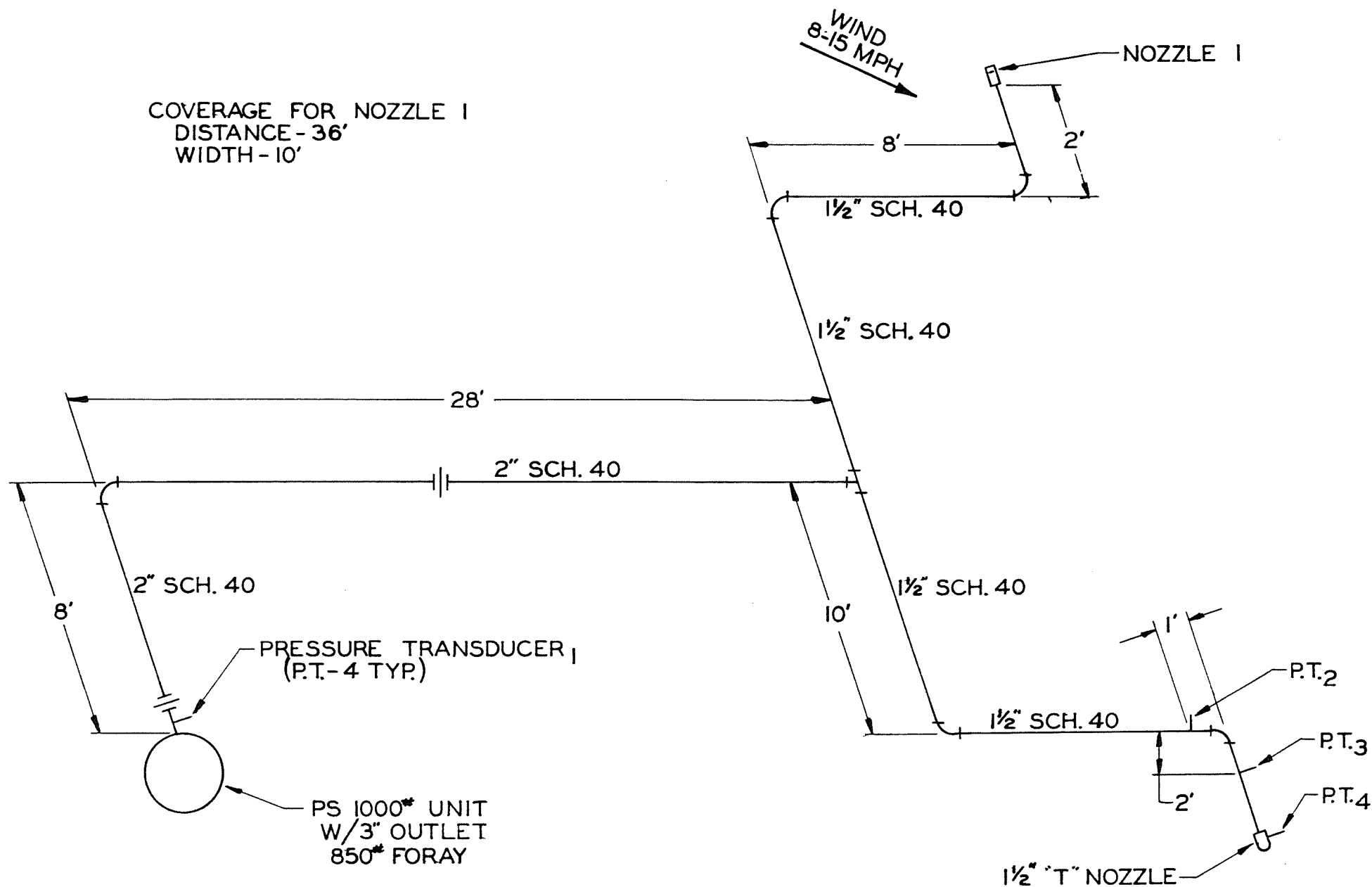
Figure 2



AFFF FIRE TESTING (NOZZLE PERFORMANCE)

Figure 3.

COVERGE FOR NOZZLE 1
DISTANCE - 36'
WIDTH - 10'



PIPING ARRANGEMENT FOR DRY CHEMICAL UNIT
TESTING OF TWIN AGENT PIPED SYSTEM

Figure 4.

TWIN AGENT SYSTEM FIRE TEST
Figure 5.

APPENDIX G

ANSUL TEST REPORT NO. T-3683

TEST STATION REPORT
FIRE PROTECTION PRODUCTS
DEVELOPMENT CENTER

Title Twin Agent System USBM Contract H0262023Author L. McDonald & D. Grant Report Approval _____ Report Date 8-17-77Requestor Bruce Christensen Charge No. 33511-05103 Req. Date 5-19-77Test Technicians Lyle McDonald, Dale Grant & Bruce ChristensenCopies to Master File, Test Station File

Objectives: To simulate fire test program to be conducted underground at Pine Creek Mine 1576 fuel dock and to install and test system in the mine.

Procedure:

- I. Assembled complete skid unit with 500 pound dry chemical tank and AFFF bladder tank
- II. Assembled piping as per X-32402 on the loading rack located on the test field.
- III. Using a 2'x3'x3" steel pan with 1 inch of fuel, the following fire tests were conducted: (Ref. movie USBM fire test contract No. H0262023).
 - A. Pan only with diesel fuel
 - 1) Ignite fuel, allow full involvement.
 - 2) Use only AFFF for extinguishment
 - B. Place mock-up over fuel pan with diesel fuel.
 - 1) Ignite fuel, allow full involvement.
 - 2) Begin with AFFF only, if the fire does not go out, activate the dry chemical (425# foray) system.

(Use Plain Sheet for Continuation)



- C. Remove the pan and create a gasoline spill under the mock up with the depth of the gas approximately $\frac{1}{4}$ ".
- 1) Ignite gasoline, allow full involvement.
 - 2) Extinguish fire with complete system
- IV. Upon completion of testing the unit was delivered to manufacturing for painting and was later shipped to the Concord, California warehouse along with the equipment needed to perform the underground testing.
- V. The unit was pick up on July 25, 1977, at Concord, California and delivered to Pine Creek Mine, Bishop, California on July 26, 1977. The unit was then transported to the 1576 fuel dock area with the assistance of Pine Creek Mine personnel.
- VI. The unit and piping were positioned in the 1576 fuel dock area as per drawing number X-32402 Rev. 2.
- VII. Underground pre-test and fire testing was performed as follows: (Ref. movie USBM Underground Fire Test Contract # HO262023)
- Turn out water pressure reducing valve adjust
 - Close all valves
 - Check Dry chemical burst disc (170 psi @ 70°F)
 - Nitrogen valve closed
 - Charge with 50 lbs. Foray dry chemical
 - Install and connect N₂ cylinder and actuator
 - Charge with 70 gallons 3% AFFF
 - Automan test switch in lamp test position
 - Push button for test lamp test
 - Test switch to head test 1 position
 - Push test button
 - Green light, normal operation at 5 sec.
 - Reset Automan
 - Insert Blinding plug in Head 1
 - Test switch in head test 1 position
 - Push test button, hold for 10 seconds.
 - There should be no response
 - Place mock-up in area

- Abort switch in abort position (ON)
- Install actuation cartridges
- Open N₂ supply valve on DC tank piping
- Light cigarette, hold for minimum of 5 seconds.
- Abort switch to off position (system ready)
- AFFF sprinklers will dribble (to be adjusted later)
- 50# dry chemical discharge
- Bleed actuation line
- Close pneumatic water valve
- Reset N₂ cylinder valve (slave actuator)
- Actuate skid manual
- Observe water nozzle pressure
- Adjust water pressure reducing valve for nozzle pressure
- Open foam concentrate valve
- Observe foam quality
- Close concentrate valve
- Bleed actuation line
- Close pneumatic water valve
- Drain water tank and piping (open & close drain valve)
- Check AFFF Supply
- Close N₂ Supply valve
- Replace N₂ cylinder (Do not connect slave actuator)
- Replace burst disc (170 psi @ 70°F)
- Charge with 425 lbs. Foray
- Open AFFF concentrate valve
- Abort switch "ON"
- Install all cartridges
- Place fuel pan on cement slab (1 gal. diesel fuel)
- Ignite fuel
- Allow total involvement of pan
- Abort switch "OFF"
- Extinguishment
- Close AFFF concentrate valve
- Bleed actuation line
- Close pneumatic water valve
- Drain water tank & piping (open & close drain valve)
- Recharge AFFF ("Top OFF")
- Open AFFF concentrate valve

- Connect Slave actuator to N₂ cylinder
- Open N₂ supply valve
- Place fuel pan under mock-up
- Check dry chemical nozzle aim
- Re-fuel pan (1 gal. diesel fuel)
- Ignite fuel
- Allow total involvement of pan
- Actuate remote manual
- Extinguishment
- Close AFFF concentrate valve
- Bleed actuation line
- Close pneumatic water valve

VIII. Recharge System for Follow-On (Field Exposures)

Discussion of Results:

For the testing done in Marinette the loading rack on the test field was used to support the system piping.

In the first fire test, only the AFFF portion of the system was used on the fire pan which was out in the open. The fire was extinguished very rapidly. The test was repeated with the same results.

Next, the LHD mock-up was placed over the fuel pan & only the AFFF used. It was observed that it would have taken more than 3 inches of foam to flow over the 3 inch sides and into the pan, so the dry chemical portion of the system was discharged. The fire was extinguished immediately.

Next, an area approximately 8' x 15' was diked to contain a spill fire with $\frac{1}{4}$ " of gasoline for the third test. This time the dry chemical did not completely extinguish the fire but knocked the flames down to where it took very little time for the AFFF to completely extinguish the fire.

After the testing was completed the unit was sent to manufacturing for painting. The skid was painted with epoxy paint. The automan III & E.P.S. and the dry chemical "T" nozzles were painted with the powder process and the automan mounting bracket was painted with enamel. This will allow for a comparison between the three types of paint.

The unit was then shipped to Concord, California to be picked up and trucked to the Pine Creek Mine, Bishop, California, Via Hertz Rent-a-truck by the Ansul Installation and testing team.

On July 26, 1977 the unit was delivered to the mine and transferred inside on the same day. While moving the unit, from the outside 1500 ' portal to the 1576 fuel dock, the unit got hung up on a beam which damaged the external piping. Repairs had to be made on site and stainless steel pipe was used to replace the broken brass pipe.

After the unit was repaired two leaks were detected and repaired. One leaking area was between the bladder and the upper flange and the other was in the water strainer.

It should also be noted that the epoxy paint had chipped off in spots due to the damages and could be potential rust areas.

The connection between our system and the existing pipe is a 2" brass ball valve.

The pressure at the inlet to the water pressure reducing valve was noted to be 220 psi, with the reducing valve closed, and 60 psi with the valve open and water flowing thru the sprinklers. This low pressure caused our pressure at the sprinkler nozzles to be decreased to 12 psi or 11 gpm which is just above the minimum recommended operating point for the nozzle.

Upon looking into the cause of this large pressure drop, it was discovered that the 4" water line at the 1576 fuel dock area was being fed upstream by 2" line.

Temperature in the fueling area is a constant $44\frac{1}{2}^{\circ}\text{F}$ and the ventilation rate was 86ft/min or .98 mph. The humidity was high.

The detection system was two separate U.V. detectors, mounted one on each side of the drift, upwind from the hazard area.

Both detectors responded normally to a match and to the U.V. test lamp.

The U.V. detectors responded to a welding arc, even though the arc was not in the direct cone of vision of the detectors. This indicates that U.V. from the welding arc was being reflected off the walls and/or ground, of sufficient intensity to trigger the detectors.

In addition, the U.V. detectors do respond to a tool commonly used in a tungsten mine, this tool is a U.V. light source (mineral light) used to locate and classify ore.

It was also noted, by observation, that the U.V. detector tube, a type of Geiger-Mueller tube was firing at a higher rate than normal. In normal surface installation the tube can be seen to fire, (glow orange), only several times a minute with random spacing between each firing, caused by the normal background radiation. In the Pine Creek installation the tube could be seen firing every few seconds indicating a higher level of background radiation.

The control system, an Automan III, and emergency power supply, fitted with six batteries was mounted as shown on X-32402, Rev. 2 and wired as in 32530.

Upon initial installation of the Automan III, the system functioned normally, however after conditioning for several days at 44°F the firing circuit card malfunctioned.

The SCR on the firing circuit cart (17809) was not being triggered, due to the unit junction Q7 not firing. The reason for Q7 not firing could not be determined on site. However, after consultation with Rick Plog in Marinette, a modification was made to 17809. This modification was the addition of two 3.9K resistors from the bases of Q2 & Q3 to ground.

The first underground fire was the 2'x3'x3" pan with one gallon of diesel fuel. It took a little longer than previously experienced in the testing completed in Marinette to extinguish the fire because of the lower expansion which is a result of the lower water pressure.

AGREEMENT

This Agreement entered into as of July 7, 1977, between The Ansul Company, a Wisconsin corporation with its principal office at Marinette, Wisconsin (hereinafter Ansul) and Pine Creek Mine, Union Carbide Corporation, Metals Division at Bishop, California, a New York corporation (hereinafter Union Carbide).

W I T N E S S E T H

WHEREAS Ansul entered into Contract HO262023 with the United States Bureau of Mines whereby Ansul will test certain fire detection and suppression devices for use in underground fueling areas; and

WHEREAS Union Carbide has agreed to make available to Ansul a section of its Pine Creek Mine in which to conduct such testing.

NOW THEREFORE, in consideration of \$1.00 and other good and valuable consideration received in hand by Union Carbide this day, the parties hereto agree as follows:

1. Union Carbide will permit Ansul to conduct the testing required by Phase IV of the United States Bureau of Mines Contract HO262023 attached to and made a part of this Agreement as Exhibit A, at its Pine Creek Mine near the 1576 Oil Dock.

2. Testing shall be completed on a date to be agreed upon by the parties hereto but in no case not later than August 31, 1977.

3. Union Carbide will permit Ansul to enter the Pine Creek Mine and to set up underground test equipment and conduct such tests as are

required by Phase IV as set forth in Exhibit A. Union Carbide will, at no cost to Ansul, assist with personnel and equipment as needed to transport and set up the underground test to enable Ansul to conduct the aforementioned test. Ansul and Union Carbide will comply with all federal and state safety requirements.

4. Notwithstanding the fact that Ansul will have principal responsibility for conducting the test, Union Carbide reserves the right to disallow the test in the event that a Pine Creek Mine management representative determines, in his sole judgment, that the location of the test or the manner in which the test is to be conducted either appears to endanger life or property or unduly disrupts mining activity.

5. Union Carbide shall furnish equipment as set forth in Exhibit B for use during the performance of this Agreement at no cost to Ansul. Said equipment is the property of Union Carbide after completion of the period of performance of this Agreement.

6. The equipment for the prototype fire protection system will be provided by Ansul, and will be installed by Ansul with the assistance of the Pine Creek Mine engineering department. After the completion of the testing program, the fire protection equipment may, if agreed upon by the parties hereto, remain installed in the mine for a period of approximately one year.

7. Union Carbide shall issue no statement to news media regarding the tests without the written approval of Ansul's designated representative. Ansul shall issue no statement to news media regarding Union Carbide's

participation in the tests without the written approval of Union Carbide's designated representative.

8. All notices concerning this Agreement shall be deemed to have been given when deposited in the United States mails, registered with the proper postage prepaid, addressed to the following parties:

If to Union Carbide to:

Pine Creek Mine
Route 2
Bishop, California 93514

Attention: Rod Philbrick

If to Ansul to:

The Ansul Company
One Stanton Street
Marinette, Wisconsin 54143

Attention: Gene R. Reid

9. Ansul shall be solely responsible for and shall hold Union Carbide free and harmless from, and hereby indemnifies Union Carbide against any and all claims, demands, causes of action, loss, cost, damage and expense, including reasonable attorney's fees asserted against or charged to Union Carbide, and arising out of or in connection with injuries (including death) to any and all persons (including but not limited to employees of Union Carbide and Ansul) and damages to property sustained as a result of the sole gross negligence of Ansul, its agents and employees, and its subcontractors in performance of this Agreement.

10. Union Carbide shall be solely responsible for and shall hold

Ansul free and harmless from, and hereby indemnifies Ansul against any and all claims, demands, causes of action, loss, cost, damage and expense, including reasonable attorney's fees asserted against or charged to Ansul, and arising out of or in connection with injuries (including death) to any and all persons (including but not limited to employees of Ansul and Union Carbide) and damages to property sustained as a result of the sole gross negligence of Union Carbide, its agents and employees, and its sub-contractors in performance of this Agreement. This paragraph shall in no way be deemed to reduce the content or obligation pursuant to subsection 1.7.5 of the contract HO262023 with the United States Bureau of Mines.

11. Neither Ansul nor Union Carbide shall conduct at the Pine Creek Mine the testing set forth in Phase IV of the United States Bureau of Mines Contract HO262023 until a representative of Union Carbide and a representative of Ansul shall have approved in writing a detailed test plan with such test plan to be attached to and become a part of this Agreement as Exhibit C.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

THE ANSUL COMPANY

Date 6/23/77

By

William A. Rickel

William A. Rickel
General Manager
Fire Protection Group

UNION CARBIDE CORPORATION

Date 7/7/77

By

L. A. Wright
Title:

APPENDIX I

TEST PLAN

The U.V. detectors responded to a welding arc, even though the arc was not in the direct cone of vision of the detectors. This indicates that U.V. from the welding arc was being reflected off the walls and/or ground, of sufficient intensity to trigger the detectors.

In addition, the U.V. detectors do respond to a tool commonly used in a tungsten mine, this tool is a U.V. light source (mineral light) used to locate and classify ore.

It was also noted, by observation, that the U.V. detector tube, a type of Geiger-Mueller tube was firing at a higher rate than normal. In normal surface installation the tube can be seen to fire, (glow orange), only several times a minute with random spacing between each firing, caused by the normal background radiation. In the Pine Creek installation the tube could be seen firing every few seconds indicating a higher level of background radiation.

The control system, an Automan III, and emergency power supply, fitted with six batteries was mounted as shown on X-32402, Rev. 2 and wired as in 32530.

Upon initial installation of the Automan III, the system functioned normally, however after conditioning for several days at 44°F the firing circuit card malfunctioned.

The SCR on the firing circuit cart (17809) was not being triggered, due to the unit junction Q7 not firing. The reason for Q7 not firing could not be determined on site. However, after consultation with Rick Plog in Marinette, a modification was made to 17809. This modification was the addition of two 3.9K resistors from the bases of Q2 & Q3 to ground.

The first underground fire was the 2'x3'x3" pan with one gallon of diesel fuel. It took a little longer than previously experienced in the testing completed in Marinette to extinguish the fire because of the lower expansion which is a result of the lower water pressure.

The second underground fire was extinguished ~~very~~ rapidly by the Foray dry chemical.

The gage before the unit & the gage at the sprinkler were left installed as a check on the next visit to the mine.

Some piping modifications that should be made to any future units should include:

- 1.) A check valve to replace the AFFF concentrate valve (located below the proportioner).
- 2.) Removal of the water feed valve into the tank.

After the testing was completed, the system was recharged for follow-on. (Field exposure).

NOTE: The drawings referenced in this report are retained in the files of The Ansul Company.

APPENDIX H
GENERAL AGREEMENT

AGREEMENT

This Agreement entered into as of July 7, 1977, between The Ansul Company, a Wisconsin corporation with its principal office at Marinette, Wisconsin (hereinafter Ansul) and Pine Creek Mine, Union Carbide Corporation, Metals Division at Bishop, California, a New York corporation (hereinafter Union Carbide).

W I T N E S S E T H

WHEREAS Ansul entered into Contract HO262023 with the United States Bureau of Mines whereby Ansul will test certain fire detection and suppression devices for use in underground fueling areas; and

WHEREAS Union Carbide has agreed to make available to Ansul a section of its Pine Creek Mine in which to conduct such testing.

NOW THEREFORE, in consideration of \$1.00 and other good and valuable consideration received in hand by Union Carbide this day, the parties hereto agree as follows:

1. Union Carbide will permit Ansul to conduct the testing required by Phase IV of the United States Bureau of Mines Contract HO262023 attached to and made a part of this Agreement as Exhibit A, at its Pine Creek Mine near the 1576 Oil Dock.

2. Testing shall be completed on a date to be agreed upon by the parties hereto but in no case not later than August 31, 1977.

3. Union Carbide will permit Ansul to enter the Pine Creek Mine and to set up underground test equipment and conduct such tests as are

required by Phase IV as set forth in Exhibit A. Union Carbide will, at no cost to Ansul, assist with personnel and equipment as needed to transport and set up the underground test to enable Ansul to conduct the aforementioned test. Ansul and Union Carbide will comply with all federal and state safety requirements.

4. Notwithstanding the fact that Ansul will have principal responsibility for conducting the test, Union Carbide reserves the right to disallow the test in the event that a Pine Creek Mine management representative determines, in his sole judgment, that the location of the test or the manner in which the test is to be conducted either appears to endanger life or property or unduly disrupts mining activity.

5. Union Carbide shall furnish equipment as set forth in Exhibit B for use during the performance of this Agreement at no cost to Ansul. Said equipment is the property of Union Carbide after completion of the period of performance of this Agreement.

6. The equipment for the prototype fire protection system will be provided by Ansul, and will be installed by Ansul with the assistance of the Pine Creek Mine engineering department. After the completion of the testing program, the fire protection equipment may, if agreed upon by the parties hereto, remain installed in the mine for a period of approximately one year.

7. Union Carbide shall issue no statement to news media regarding the tests without the written approval of Ansul's designated representative. Ansul shall issue no statement to news media regarding Union Carbide's

participation in the tests without the written approval of Union Carbide's designated representative.

8. All notices concerning this Agreement shall be deemed to have been given when deposited in the United States mails, registered with the proper postage prepaid, addressed to the following parties:

If to Union Carbide to:

Pine Creek Mine
Route 2
Bishop, California 93514

Attention: Rod Philbrick

If to Ansul to:

The Ansul Company
One Stanton Street
Marinette, Wisconsin 54143

Attention: Gene R. Reid

9. Ansul shall be solely responsible for and shall hold Union Carbide free and harmless from, and hereby indemnifies Union Carbide against any and all claims, demands, causes of action, loss, cost, damage and expense, including reasonable attorney's fees asserted against or charged to Union Carbide, and arising out of or in connection with injuries (including death) to any and all persons (including but not limited to employees of Union Carbide and Ansul) and damages to property sustained as a result of the sole gross negligence of Ansul, its agents and employees, and its subcontractors in performance of this Agreement.

10. Union Carbide shall be solely responsible for and shall hold

Ansul free and harmless from, and hereby indemnifies Ansul against any and all claims, demands, causes of action, loss, cost, damage and expense, including reasonable attorney's fees asserted against or charged to Ansul, and arising out of or in connection with injuries (including death) to any and all persons (including but not limited to employees of Ansul and Union Carbide) and damages to property sustained as a result of the sole gross negligence of Union Carbide, its agents and employees, and its sub-contractors in performance of this Agreement. This paragraph shall in no way be deemed to reduce the content or obligation pursuant to subsection 1.7.5 of the contract HO262023 with the United States Bureau of Mines.

11. Neither Ansul nor Union Carbide shall conduct at the Pine Creek Mine the testing set forth in Phase IV of the United States Bureau of Mines Contract HO262023 until a representative of Union Carbide and a representative of Ansul shall have approved in writing a detailed test plan with such test plan to be attached to and become a part of this Agreement as Exhibit C.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

THE ANSUL COMPANY

Date 6/23/77

By

William Rickel

William A. Rickel
General Manager
Fire Protection Group

UNION CARBIDE CORPORATION

Date 7/7/77

By

L. A. Wright
Title:

APPENDIX I

TEST PLAN

EXHIBIT "C" OF AGREEMENT BETWEEN ANSUL AND UNION CARBIDE

TEST PLAN FOR FUELING AREA FIRE DEMONSTRATION AT PINE CREEK MINE

Fire Protection System

The suppression system is a fixed pipe twin agent system providing 75 gallons of AFFF and 425 pounds of ABC dry chemical. The piping layout is illustrated by Drawing X-32402. Detection is provided by two ultraviolet detectors which are cross-zoned. An Ansul AUTOMAN III control console senses signals from the detectors and will automatically actuate the suppression system. The control console includes an emergency battery supply to keep the system operational in the event of the loss of mine electrical power. A more detailed description of the systems is included in the Phase III Report of H0262023.

Installation and Check-Out

All components of the fire protection system will be delivered to the mine by Ansul and will be installed at the 1576 Fuel Dock by Ansul technicians with the assistance of mine personnel.

Prior to the fire demonstration a functional check-out of the system will be performed. The system will be fully operational except:

- Only 50 pounds of dry chemical will be loaded into the dry chemical tank.
- A pressure gauge will be installed at the inlet of one of the AFFF nozzles.
- A "detection cut-out switch" will be installed in the test observers area which will de-energize the detectors when actuated.
- The AFFF concentrate valve will be closed.

The system check-out will proceed as follows:

- Perform maintenance check of detector lens integrity.
- Detection check-out switch actuated.
- Light a cigarette lighter in the fueling area.
- Turn detection cut-out switch off. (This puts the detectors back into the system. They will sense the cigarette lighter flame and actuate the system.)

- Observe the flow from each nozzle to confirm that all lines are clear.
- Adjust the regulator to provide 30 psi at the AFFF nozzle gauge and then open the AFFF concentrate valve.
- Observe AFFF foam flow at nozzles to confirm function; then shut off AFFF flow.
- Permit the dry chemical system to discharge completely. (With only 50 pounds of dry chemical in the storage tank the discharge will be mostly gas.)
- Reset the nitrogen cylinder valve.
- Actuate the manual actuator on the skid and observe the actuation of the nitrogen cylinder valve and the water valve.
- Reset the nitrogen cylinder valve and close the water valve.
- Actuate the remote manual actuator and observe the actuation of the nitrogen cylinder valve and the water valve.
- Remove electrical power from the system and arm the AUTOMAN without replacing the cartridge. Again, use the cigarette lighter flame to confirm that the system operated on battery supply.
- If no anomalies are observed the system check-out is complete.

To prepare the system for the fire test demonstration:

- Remove the pressure guage at the AFFF nozzle.
- Replace the burst disc at the outlet of the dry chemical storage tank.
- Load the storage tank with 425 pounds of dry chemical.
- Replace the nitrogen tank, but do not connect the the mechanical linkage of the valve.
- Install cartridges in the manual actuator on the skid and the remote actuator.
- Bleed the trapped water in the AFFF system and open the AFFF concentrate valve.

- Arm the AUTOMAN III system.
- Replace the LT-30 actuation cartridge. (This step will be accomplished immediately prior to the fire demonstration.)

Thus, the detection system will be armed during the period between the check-out and the fire demonstration, but cannot actuate the suppression system until the actuation cartridge is installed.

Underground Fire Demonstration

The system will be fully operational except that the detection cut-out system is installed and the dry chemical nitrogen system is deactivated. Confirm that the AUTOMAN actuation cartridge has been installed and inspect the complete system.

Fire Test No. 1

- Remove electrical power from the system. (This will cause the system to automatically switch to battery power.)
- Activate the detection cut-out switch.
- Prepare the fire pan--A steel pan (3' x 2' with 3" walls) will be placed in the fueling area 10' to 12' from the edge of the concrete pad on which fuel is stored. The pan will be partially filled with water and topped with approximately one gallon of diesel fuel (approximately 1/4").
- Ignite the fire--A propane torch will be used to ignite the diesel fuel.
- When the surface of the fire pan is fully involved in flame the detection cut-out switch will be turned "off." (This places the detectors back in the system circuit. Both detectors will instantly sense the fire and automatically actuate the system. Only the AFFF agent will flow during this test because the dry chemical system was deactivated.)
- When the pan fire has been extinguished the AFFF supply will be turned "off." (Only a small amount of the AFFF supply will have been used.)

Preparation for Fire Test No. 2

- Reset the control system (take out of the "fired" mode).
- Restore mine electrical power to the control console.
- Bleed the trapped water in the AFFF system and open the AFFF concentrate valve.

- Reactivate the dry chemical system by connecting the nitrogen valve mechanical linkage.
- Actuate the detection cut-out switch.
- Replace the actuation cartridge in the AUTOMAN.

Fire Test No. 2

- A mock-up of an LHD diesel powered vehicle will be placed in the same area as the fire pan.
- Diesel fuel will be added to the fire test pan as needed to maintain the depth of approximately 1/4".
- Slide the fire test pan under the mock-up engine area.
- Ignite the fire--the propane torch will be used again to ignite the fuel.
- When the surface of the fire pan is fully involved in flame the detection cut-out switch will be turned "off." (This action places the detectors back in the system circuit. Both detectors will instantly sense the fire and automatically actuate the system.)
- When the fire is extinguished the AFFF supply will be manually shut "off." The dry chemical system will fully discharge within 20 seconds.
- The fire test pan will be removed and the diesel fuel will be discarded.

System Preparation for Long-Term Validation Test

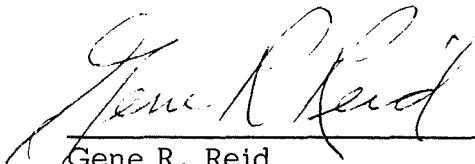
- Reset the control system (take out of "fired" mode).
- Remove the detection cut-out switch from the system.
- Replace the burst disc at the outlet of the dry chemical storage tank.
- Recharge the AFFF and dry chemical system to full capacity.
- Replace the actuation cartridge in the AUTOMAN.

Responsibilities

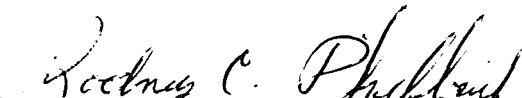
- Bruce Christensen of Ansul will be the test conductor and will be responsible for performing all tasks as described above.
- Mr. Rod Philbrick will be the safety officer in charge of the five-man underground safety crew. As the safety officer, Mr. Philbrick will have authority to direct that the test be stopped at any time he is concerned for safety. Mr. Christensen will follow the directions of Mr. Philbrick.
- Lyle McDonald and Dale Grant are Ansul technicians who will assist Mr. Christensen in performing the demonstration.
- Ralph Strutz and Girard Rudell are Ansul photographers who will document the demonstration.
- Gene Reid is the Ansul program manager who will be present to coordinate any problems.
- The Bureau of Mines will have three observers present at the demonstration.

Approvals

The described procedure is approved by the following in accordance with the terms of the agreement:

 7/13/77

Gene R. Reid (Date)
The Ansul Company



Rod Philbrick (Date)
Union Carbide Corporation

APPENDIX J
FEDERAL VARIANCE

UNITED STATES
DEPARTMENT OF THE INTERIOR
MINING ENFORCEMENT AND SAFETY ADMINISTRATION

Variance No. 277 Mine Identification
No. 04-00899

Date: June 13, 1977

Western
(District)

Phoenix
(Subdistrict)

Union Carbide Corp.
(Company Name)

Pine Creek
(Mine Name)

Route 2
(Mailing Address)

Bishop
(Town)

Inyo
(County)

California
(State)

Pursuant to Section 57.24-1 of Part 57, Title 30, Code of Federal Regulations revised as of July 1974, and the delegation of authority to grant variances from mandatory health and safety standards contained in Part 57 by the Director on January 13, 1971 (36 F.R. 836, January 19, 1971), the undersigned after due consideration of all factors involved, permits a variance from Federal Mandatory Standard 57.4-58 which will allow the Ansul Company to build a controlled fire underground for the purpose of demonstrating and documenting the results of an improved fire protection system for underground fueling areas being developed under USBM Contract H0262023, and subject to the following precautions in addition to those set forth in the variance request.

Conditions and Restrictions

1. This variance applies only to Federal Mandatory Standard 57.4-58 and does not authorize noncompliance with any other applicable Federal Standard.
2. Area of Mine: 1576 Oil Dock on the 1500 Level.
3. Period of Time: The period of time for which the variance is permitted is only during the period of July 31 to August 20, 1977.
4. Other:
 - a. Additional shield protection from heat or flame shall be provided for the electrical power cables in the immediate vicinity of the fire test site.
 - b. Install fire hose connections on the water line and provide a fire hose near the test site.

- c. Provide three additional fire extinguishers at the test site.
- d. Remove all unnecessary combustible materials near the test site.
- e. Clean and inspect the 1500 Level adit from the portal to the test site. This level shall be used by all persons going in and out of the mine during the test.
- f. Checks must be made of the mine atmosphere after each test to make certain that toxic products of combustion do not remain in the atmosphere.
- g. A qualified and currently trained mine rescue crew equipped with self-contained breathing apparatus shall be at the test site during the tests. A back-up crew shall be available at an assured fresh air location as near the test site as possible.
- h. All persons selected to remain in the mine during the tests shall carry self-contained breathing apparatus, which they have been trained to use. Apparatuses shall be worn during the actual fire test. Only persons involved in the test shall be underground.
- i. Designated qualified persons shall monitor the mine atmosphere with field-test instruments during the tests.
- j. All persons going underground shall receive Mine Emergency Training, as specified in Mandatory Standard 57.18-28, immediately before starting the testing program.
- k. Each person entering the mine shall carry a self-rescuer on their person.
- l. An organization chart, showing responsible persons and their duties during the test, shall be developed. At least one MESA supervisor shall be included as an advisor.
- m. Contingency plans to react to all foreseen emergencies shall be developed and rehearsed.

Revocations and Cancellation

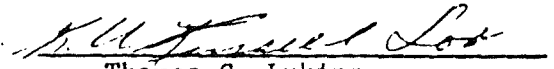
Failure to observe any or all of the conditions and restrictions set forth shall be deemed cause for immediate revocation and cancellation of this variance by the District Manager.

Findings

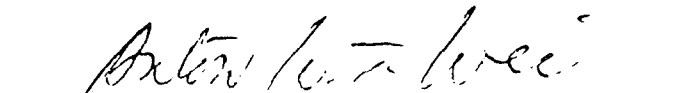
Under these circumstances the health and safety of all persons which Federal Mandatory Standard 57.4-58 is designed to protect will be no less assured.

Notice

A copy of this variance shall be posted on the company bulletin board or in some other appropriate place at the time to give adequate notice to the employees, and the variance shall be kept on file in the mine office and subject to public inspection by any interested person(s) at all reasonable times so long as the variance remains in effect.


Thomas C. Lukins
District Manager

I concur:


Assistant Administrator
Metal & Nonmetal Mine Health & Safety

APPENDIX K
STATE VARIANCE

DEPARTMENT OF INDUSTRIAL RELATIONS

DIVISION OF INDUSTRIAL SAFETY

J. GOLDEN GATE AVENUE, SAN FRANCISCO



June 10, 1977

ADDRESS REPLY TO:
P.O. Box 603
San Francisco 94101

Mr. Gene R. Reid, Manager
Contract Research
The Ansul Company
Marinette, WI 54143

Dear Mr. Reid:

We have received your letter dated May 31, 1977, requesting a temporary variance from the Mine Safety Order, Section 7061(a).

Chapter 5, Section 6452 of the Labor Code, provides for temporary variances from standards and reads as follows:

"The Division is authorized to grant a temporary variance from any standard or portion thereof whenever it determines such variance is necessary to permit an employer to participate in an experiment approved by the director designed to demonstrate or validate new and improved techniques to safeguard the health or safety of workers".

Your request for a temporary variance is granted with the following stipulations:

1. Variance period- July 15, 1977 to August 15, 1977.
2. Location for experiment:
Pine Creek Mine, Bishop, California, 1500 Level at the 1576 oil dock.
3. The test(s) will be conducted on Sunday(s) only when the test and rescue personnel are in the mine.
4. The precautions as outlined in your application will be followed.

In addition, the Division will have a representative(s) present during the test(s) to suggest further precautionary measures should the need arise.

Very truly yours

Art Carter, Chief

/vh

cc: Don Vial, Director
Ray Gray, Union Carbide Corp.
Tom Lukins, MESA
Byron Ishkanian, DIS, LA

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