INVESTIGATION OF THE FIRE SAFETY CHARACTERISTICS OF PORTABLE TANKS -- POLYETHYLENE TANKS CONTAINING FLAMMABLE LIQUIDS

BY

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Avery Point, Groton, CT 06340 - 6096

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Abstract

Full scale fire tests were conducted to determine the relative fire safety characteristics of portable polyethylene and steel intermediate bulk transport (IBC) containers containing flammable fuels. The results indicated that for both small and large exposure fires, the polyethylene tanks failed after a short exposure time presenting a major fire hazard caused by the release of large quantities of flammable fuels to the deck area. The steel tanks did not fail after either fire exposure but did, in some cases, develop large fire plumes at the vent release port.

Key Words: polyethylene tanks, IBC tanks, steel tanks, large fire exposure, small fire exposure, fire safety.
### Conversions to Metric Measures

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### Conversions from Metric Measures

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ACKNOWLEDGEMENTS

Mr. Frank Thompson was program manager for this project. Important contributions to the work were made by Mr. Robert O'Hagan and Ms. Denise Baird. The work could not have been accomplished without the assistance and editing of Ms. M.E. Mahoney. Finally, appreciation is expressed for advice and technical support granted by Mr. N. Able of Poly Processing Co. with regard to polyethylene tankage.
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1.0 BACKGROUND

1.1 INTRODUCTION

In June 1984, the Department of Transportation amended DOT specification 34 to permit the use of polyethylene drums up to 55 gallons in capacity as authorized packagings for hazardous materials, including flammable liquids (1)*. The decision to authorize 55-gallon polyethylene drums was based, to a large extent, on tests performed by the U.S. Coast Guard in 1976 and 1977 (2). Even before DOT specification 34 was amended however, manufacturers of plastic portable tanks began to request DOT exemptions for their products, basing their request on the results of the drum tests (3,4). Some of these manufacturers have extrapolated the findings of these tests in order to justify a claim that a portable tank is a safer package than a drum.

The Marine Technical and Hazardous Material Division has endorsed the granting of exemptions for polyethylene portable tanks. Their use has been limited in marine transportation of corrosive and poisonous substances, and flammable liquids with a closed cup flashpoint not less than 73 deg F (23°C). The latter provision is imposed as a precaution but has no basis in either experience or testing. Therefore a research project was developed to provide information about the fire safety characteristics of commercial polyethylene tanks. The overall objectives and the technical approach used for this project are outlined in the following sections.

1.2 OBJECTIVES

The major objective of this project was to determine the fire safety characteristics of intermediate size polyethylene tanks containing flammable liquids. Specific technical objectives were to determine the fire resistance of rotationally molded polyethylene tanks containing flammable liquids with flashpoints above and below 73 deg F (23°C); and also, to compare the fire hazard potential of polyethylene and steel IBC tanks containing flammable liquids when used in the maritime industry. Questions to be addressed were:

0. Is the polyethylene portable tank a safe container for the carriage of intermediate flashpoint flammable liquids in marine transportation?

0. How does the polyethylene portable tank release its contents (fail) when subjected to external fire?

Does the tank wall weaken or melt before the pressure relief device functions?

* numbers in parenthesis indicate references contained in Section 5.
Does increasing the volume of the container from 55-gallon drums to 300-gallon tanks appreciably increase the time to release (failure?).

How does the fire resistance of a polyethylene container compare with the fire resistance of a steel DOT Specification 57 portable tank?

1.3 TECHNICAL APPROACH

In order to meet the project objectives, a series of full scale fire tests were conducted onboard the fire test ship MAYO ELYKES at Mobile, Alabama. The fire tests were divided into four tasks as follows:

- Facility development.
- Evaluation of 300 gallon steel tanks.
- Evaluation of 300 gallon polyethylene tanks.
- Inter-tank fire spread.

Three major test parameters were investigated: fire size, fuel type and materials used for tank construction.

Two types of exposure fires were used to evaluate the effect of different fire scenarios. The first used a four square foot fire placed directly under the center of the tank to simulate fires caused by a leaky valve or a small puncture in the tank wall. The second used a hundred square foot fire to simulate a tank engulfed in a large conflagration.

The effect of volatility and fuel type on onset of tank failure was determined by using two flammable liquids as tank contents: marine diesel and technical grade ethyl alcohol.

Finally, comparative tests were conducted to evaluate the relative fire safety of different construction materials. Two material types were evaluated: thermoplastic polyethylene and steel. For both materials the tanks tested were commercial IBC containers fabricated in accordance with current DOT regulations.

A variety of instrumentation was used to record major test parameters. These included: in-tank temperatures, in-tank pressures, weight loss, and heat flux. Documentary video tapes recorded the time of tank wall failure and fire fighting actions. Detailed descriptions of the facilities, instrumentation and test procedures are presented in Section 2. Results are outlined in Section 3. A brief discussion is provided in Section 4.
2.0 FACILITIES, MATERIALS, AND INSTRUMENTATION

2.1 FACILITIES

2.1.1 Deck Fire Facility

The simulated deck fire facility for this project was installed on the main deck of the MAYO LYKES. The area was located on the port side of the ship adjacent to the forward air castle. A 100 square foot area was isolated from the main deck by welding 1/4-inch steel plates to the deck. The plates were approximately 12 inches in height on the forward and starboard sides of the area. An additional six inches was added to the port side and half of the aft side of the area in order to accommodate the camber of the deck. The ship was positioned on an even keel in order to be able to measure the application rate of carbon dioxide. As a safety precaution, the fire area was surrounded by a "splash" baffle to limit the flow of spilled fuels to a confined area in the event of sudden overflow of the area caused by tank rupture. The splash baffle was also fabricated of 1/4-inch steel plate and was 24 inches high. The baffle plates were welded to the steel deck around the perimeter of the fire area at a spacing of 18 inches. The two notches in the sides of the fire area resulting from the 6-inch extension of the sides were designed to be at the same level and functioned as automatic overflow valves for the fire area. In operation, up to 600 gallons of fuel could be dumped suddenly into the fire area as a result of tank failure. The "notch" valves enabled the fuel overflow to be directed into the space between the sides of the fire area and the splash baffle. Both the fire area and the overflow reservoir had drain lines at their aft port corners. The drain lines lead directly to a set of four six-hundred gallon containment tanks. During operations, a protective water layer was put in the bottom of the fire area. Because of the camber of the deck, the depth of water varied from 2 to about 9 inches. In effect, this procedure provided a level area and fuel for the exposure fire was floated on the water layer. The fuel used for all tests was marine diesel. For the small exposure fire, a 4 square foot pan was placed directly under the center of the tank, and a similar procedure was used for protection of the steel deck. An overall view of the fire area is shown in Figure 1a,b. Detailed views of the fire area are shown in Figure 2a,b. For the steel tanks, the manhole cover at the top consisted of a 55 gallon drum lid secured with a retaining ring. In order to restrain the movement of the lid and the tank to the immediate area of the fire, chains were used to secure the lid to the tank. The chains were attached to welded support mounts on the deck. The arrangement of the chains is shown in Figure 3. A similar arrangement was used on many of the tests using polyethylene tanks.

2.1.2 Fire Suppression Equipment

Fire fighting activities were necessary in order to extinguish the exposure, plume, and spilled fuel fires. Whenever
FIGURE 1a. View Aft at the Deck Fire Area

FIGURE 1b. View Port at the Fire Area

FIGURE 1. OVERALL VIEWS OF THE DECK FIRE AREA
FIGURE 2a. Deck Fire Area Splash Baffle

FIGURE 2b. Notch Valve for Overflow Control

FIGURE 2. DETAILED VIEWS OF THE FIRE AREA
FIGURE 3a. Steel Tank Restraint System

FIGURE 3b. Placement of Restraint Chains Over the Manhole

FIGURE 3. TANK AND MANHOLE RESTRAINT SYSTEM
possible the need for extensive fire suppression actions by manned hose lines was minimized by limiting the fuel load in the exposure fire. For short duration tests this was accomplished by measuring the depth of fuel and estimating the linear regression rate of the fuel surface. For long duration fires a minimum layer of fuel was loaded into the fire area, and then a preset rate of fuel flow, from a remote location, was directed into the area in order to sustain the fire. At the end of each test hose lines were used to secure the fire area and to cool down the deck and ship superstructures. For the diesel oil exposure fire, 3% or 6% AFFF foam agents were used to secure the fire areas. Either concentration was about equally effective. Firefighting actions using AFFF or water are shown in Figure 4a from a monitor located on the 02 deck of the ships superstructure and for manned hose lines in Figure 4b.

Because of the unique safety hazards that were anticipated during these tests, special fire suppression capabilities were developed to augment the AFFF hose lines. The major concern was that of a tank explosion. This would require fire suppression systems that could be operated remotely from a secure location. Two systems were developed that could meet this requirement.

The first suppression system used a localized application of carbon dioxide. Since the fire tests were conducted on an open deck and subject to local winds, high volumetric flows of carbon dioxide were required. Initially, four discharge nozzles were installed at each corner of the fire area. Each nozzle was aimed at the center of the top surface of the exposure fire. After a series of initial test runs, two more nozzles were added. The two new streams were adjusted to impact each other directly above the top of the test tank. This change provided a more efficient extinguishment action for a three dimensional fire which is characteristic of the combined action of the exposure fire and the plume fires at the tank pressure relief vent port. A major advantage of the carbon dioxide system was that it provided a means of extinguishment of the test fires without imposing the polyethylene tank side walls to the large mechanical forces caused by impact of the hose streams. Therefore, the tank could be "frozen" in place for visual inspections after the fire to determine where the structural tank failure had occurred. The liquid CARDOX tank was suspended from a weight-load system to provide the capability of measuring carbon dioxide application rates. The total weight of the system varied from 11,500 to 24,500 lbs. depending on tank contents. The precision of measurement for 1000 lb. applications of CO₂ was +/- 15 lbs., the major uncertainty in measurement being caused by local winds. An overall view of the placement of the high and low nozzles is shown in Figure 3a. A close up view of one of the corner nozzles and the distribution piping is shown in Figure 5a. The main Cardox tank suspended on load cells is shown in Figure 5b. The effective action of this system can be observed from Figure 6a, b.
FIGURE 4a. Monitor on 02 Deck

FIGURE 4b. Manned Hose Streams

FIGURE 4. AFFF AND WATER HOSE STREAMS
Figure 5a. Corner Nozzle And Piping

Figure 5b. Carbox Tank on Load Cells

FIGURE 5. CARBON DIOXIDE FIRE SUPPRESSION SYSTEM
FIGURE 6a. Initial Attack on Fire

FIGURE 6b. Open Deck CO2 Blanket Over Fire

FIGURE 6. LOCALIZED APPLICATION OF CARBON DIOXIDE
The second method that was developed to provide remote extinguishment was a dump tank system. Drains placed in the bottom of the fire area and the surrounding splash baffle system were opened to drain the mixture of diesel oil and water together with the tank contents. The drains conducted the burning mixtures to a series of six hundred gallon dump tanks. Immediately before the dump, the tanks were purged and inerted by a discharge of carbon dioxide to prevent an explosion. Successful trial tests were conducted to ensure that this system could safely remove the flammable fuel wastes under fire conditions. An additional operational advantage was that this system enabled a faster turn-around between tests by minimizing the efforts necessary to clean up the work area before starting the next test. The four six-hundred gallon tanks used in this system were manifolded together to accommodate a total of 2400 gallons of wastes. These tanks and the drain lines are shown in Figures 7a,b.

2.1.3 Environmental Protection Equipment

The tests used hazardous materials both in the exposure fire fuels and tank contents. Air pollution was minimized by working under the operational guideline with respect to wind velocity and direction agreed to by the Environmental Protection Agency representatives in Mobile. The double containment system constructed for use as a fire area reduced the spillage of liquid hazardous materials to a minimum during and immediately after a fire test. The small quantities that did reach the deck and were washed overboard during fire fighting operations were contained by a water boom in the immediate vicinity of the ship. When necessary, they were absorbed by a commercial sorbent. Figure 8 shows the water boom placed between the ship and shore. The bulk of the waste fuels and contaminated water was drained into the holding tanks as previously described below the main deck in Hold #3. Periodically, these wastes were pumped aft to a second set of 1000 gallon holding tanks in Hold #4. At the end of the test series, these tanks were pumped out by a commercial bulk waste disposal company, and the tanks were cleaned. At the start of the tests these tanks were used to hold bulk quantities of marine diesel for use in the fire area. When needed these supplies were pumped forward. This procedure was designed to limit the quantity of flammable fuel to a minimum in the fire test area.

2.2 TEST MATERIALS

2.2.1 Exposure Fire Fuels and Tank Contents

Two hydrocarbon liquids were used on these tests to simulate either the exposure fire typical of a marine environment, or the tank contents of intermediate bulk container shipments of flammable fuels. These fuels were selected to provide information about the effect of flash point on tank failure times.
FIGURE 7a. Containment Tanks

FIGURE 7b. Drain Below Fire Area

FIGURE 7. FLAMMABLE FUEL DUMP CONTAINMENT SYSTEM
for tanks containing flammable liquids with flash points greater than and less than 73°F (22.8°C). Marine diesel with a flash point of 107°F (41.6°C) was purchased from local marine terminal suppliers for use as both a typical exposure fire and as tank contents. Technical grade ethyl alcohol (95%) was used to simulate a more volatile tank content. The flash point of the ethyl alcohol was 63°F (17.2°C).

2.2.2 Steel Tanks

Steel tanks having a nominal capacity of 320 gallons were used on this project. The tanks were manufactured to order by Custom Metalcraft Inc., Springfield, Missouri. The tanks were DOT specification 57 tanks. The tanks were 42 inches by 42 inches by 49.5 inches high and fabricated from 10 gauge steel with double welded seams. Access to the tank was through a 22-inch drum opening at the top and through a 2-inch stainless steel ball valve at the bottom. During the fire tests the nipple from the ball valve was sealed using a standard steel plug. Before each test the tanks were filled with liquid to approximately the 42-inch level. The vapor space above the liquid surface was estimated to be 10% of the total tank volume. The top of the tank contained a pressure relief plug designed to actuate when either excessive temperatures or pressures were reached. The relief vent was a 2-inch polyethylene combination burst disk and fusible plug and was set for actuation at 9 psig. Figure 9 shows a schematic drawing of the steel tanks.

2.2.3 Polyethylene Tanks

Polyethylene tanks having a nominal capacity of 300 gallons were used on this project. The tanks were manufactured by Poly Corr, Inc, Monroe, Louisiana. The tanks were DOT approved for use with corrosive materials. The tanks were cubical in shape and were fitted into stackable metal frames. The tanks dimensions were 42 inches in width, 48 inches in length by 57 1/2 inches in height with the carrier in place. The nominal wall thickness was 3/8 inches. The tanks were made from high density polyethylene and were designed to be filled within 10 inches of the top. At this level the ullage was 10% of the total volume. Weight of the tanks was 135 lbs. Weight with carrier was 550 lbs. Figure 10 is a schematic drawing of the tank.

2.3 INSTRUMENTATION

A variety of instrumentation was developed for this project. Appendix A lists the instrumentation used and provides a brief description of each major equipment item. The instrumentation can be divided into four major use categories: (1) Test Parameters, (2) Facility Operating Parameters, (3) Facility
FIGURE 9. Schematic Design Drawings for Steel Tanks
FIGURE 10. Schematic Design of Polyethylene Tanks
Safety, and (4) Facility Development. Since it was not possible to make changes in the data channel assignments during the tests, several channels were assigned as "spares" to allow for on site modification of the site procedures. Typical instrumentation required for facility development included pressure transducers (Channels 9 through 16) used in the carbon dioxide extinguishment system, and thermocouples that were used to monitor temperatures on pressure and heat flux transducers. Instrumentation used to ensure facility operating safety included; the monitoring of carbon dioxide concentrations in closed areas below deck, and the total hydrocarbon concentrations at selected locations. Since these safety channels were required both before and after the actual tests, it was necessary to modify the normal operating procedures for the computer and to continue scanning for relatively long periods of time. In one case this practice prevented the build up of explosive concentrations of fuel below decks which resulted from an unexpected volatilization of flammable fuel caused by solar heating. Facility operating parameters included: wind direction, and speed, line frequency, and voltage values. Test data parameters included: dynamic weight loss of the test tanks, in-tank pressures, in-tank temperature profiles, and radiant heat flux directed into the tank from the exposure fires.

2.3.1 Tank Weight-Loss Instrumentation

In order to be able to measure the rate of loss of the tank contents, the test tanks were installed on four load cells, one at each corner of the tank. Each cell had a capacity of 0 to 5000 lbs. The load cells were in contact with the support frame for the test tank. The weight of the tank was transmitted to the load cells using a steel pipe assembly which extended through the deck. Figure 11 shows a schematic diagram of the system. Above deck the force rod assembly consisted of three concentric pipes. The inner pipe (1.5 inches) was welded to the end wall plate on the outer pipe (2.5 inches). The inner pipe was then inserted into a center pipe (2.0 inches) which was welded through the deck plates. Sufficient clearance between the pipes (0.15 inches) minimized false readings caused by lateral side forces. Figures 12a,b show the support assembly above and below deck. Above deck, the tank, support frame, and steel pipe assembly are shown in place for a test. The height of the frame was adjusted so that flammable fuel could not overflow by going down the support shaft to the deck below. Below deck, the overhead height was approximately fourteen feet. With the close spacing between the different sections of the support assembly, the long concentric close fitting shafts tended to bind if the main deck buckled due to heat. To prevent this, water streams were used to cool the main deck for some tests. When not used under high heating conditions, deflections of up to 6 inches would occasionally occur in the main deck. A second problem resulted from the difference in the pitch of the main deck and the cargo hold deck. To accommodate this differential, expansion wood blocks were used to shim the load cells.
FIGURE 11. Schematic Diagram of Load Cell Thrust Assembly
FIGURE 12a. Above Deck

FIGURE 12b. Below Deck

FIGURE 12. TEST TANK LOAD CELL ASSEMBLY
2.3.2 In-Tank Temperature Measurements

The temperature of the tank contents was measured using Type K thermocouples. The thermocouples were installed inside the tank on a "christmas tree" thermocouple rake consisting of an array of five thermocouples spaced across the center line of the tank and a set of four thermocouples placed vertically through the tank center. The vertical rake consisted of four thermocouples; #42, #48, #41, and #43. Thermocouple 42 was located in the tank ullage space between 2.5 to 5.0 cm from the tank top. Thermocouple 43 was positioned 2.5 cm from the bottom. Thermocouple 41 was in the center and was common to both the vertical and horizontal rakes. Thermocouple 48 was installed half way between 42 and 41. The horizontal array of five thermocouples with thermocouples 44 and 45 placed 2.5 cm from the side walls and thermocouples 46 and 47 installed half way between the center and the outlying side wall thermocouples. The thermocouples were wired in place on a wood cross which was folded in order to be inserted in through the top tank opening and "expanded" once inside the tank to meet the above specifications for positioning. All thermocouples were shielded and grounded. A schematic diagram of the thermocouple placement is given in Figure 13. Figure 14 shows a typical time/temperature curve for a steel tank containing ethyl alcohol during a small fire test.

2.3.3 In-Tank Ullage Pressure Measurements

During the tests the vapor space at the top of the tank was instrumented to record the in-tank ullage pressure. The rate of rise of the pressure provided information about the thermal input to the tank contents and whether the pressure relief vent systems had actuated. Two SENTRA 103, Model 205-2 pressure transducers were installed in the tank. In order to reduce the heat load to the transducers the ullage was connected to the transducers through a length of stainless steel flexible tubing and pipe. The transducers were then installed in a protected area about 15 feet above and away from the fire area. During initial testing there was occasional condensation in the line which resulted in inaccurate readings. This was corrected by ensuring that the lines were pitched upward to allow return of condensates to the tank volume. A minimum of 1/2 inch flexible tubing was required to prevent formation of liquid plugs during testing.

2.3.4 Video/Photographic Documentation

Video was used to document the test fire and assist in the determination of time of tank failure and mode of tank failure. Three video positions were used. One camera was located on the 03 deck viewing forward. A second camera was located on the 04 deck viewing forward. And a third camera was positioned on the main deck viewing aft. The 03 and 04 cameras provided an overhead view. The main deck camera provided close up views of the tank top and vent ports. Because of variable winds, smoke obscured the view on a number of tests; however, one of the
NOTES:
#41 Center
#43,44,45 1 inch from tank wall
#42 1 inch from top of tank (in ullage)
#46,47,48 1/2 the distance between #41 and the Tank Wall

FIGURE 13. Schematic Diagram of In-Tank Thermocouple Locations
Figure 14. Time/Temperature Data for a Steel Tank Containing Ethyl Alcohol Exposed to a Small Fire

* 43.AV refers to the average value for channels 43, 41 and 48.
cameras was usually able to provide a clear view of the fire. The video coverage was supplemented by still photographs both during tests and to document the experimental arrangements.

3.0 RESULTS

3.1 SMALL EXPOSURE FIRE TESTS

3.1.1 Polyethylene Tanks

Three tests were conducted using polyethylene tanks exposed to a four square foot fire. Two tests were run using ethyl alcohol as contents. One test was made using marine diesel fuel oil. Failure times for the ethyl alcohol contents were 5'18"* for Test 22 and 4'46" for Test 23. Failure time of the tank containing marine diesel was 5'44". Figure 15 shows views of typical polyethylene single tank tests before and after the fire. Specific data for the tests is outlined in Appendix B. Within experimental error, the data indicate that differences in the volatility or flash point of the tank contents do not affect the time to tank failure. There was no indication that significant heat transfer occurred from the fire to the tank contents prior to tank failure.

3.1.2 Steel Tanks

Five tests were made to investigate the effects of a small four square foot fire on commercial steel tanks. Tests 10 and 11 used marine diesel for flammable contents. On Test 10, there was a gradual increase in temperature in the contents reaching 90°C after about 45 minutes when the test was cut off. The tank did not have a cap on the valve outlet and a leak in the valve occurred at that time. Similar results were obtained on Test 11. Test 11 was cut off after 110 minutes with a temperature rise from 30°C to 118°C. No damage was sustained by the tank as a result of either test. The internal pressure in Test 11 rose 12 psig during the test. The tank was rated for an operating pressure of 6 psig and the vent relief did not actuate at 6 psig. Tests 13, 14 and 15 used ethyl alcohol. The general characteristics of the fire safety of the tanks were similar. First there was a long period of heating which was followed by the development of a strong plume fire. The plume fire reached heights up to 75 feet above the main deck with afterburning of the fuel vapors expelled from the tank to an estimated 125 feet. None of the tanks failed before the plume fire developed. Overpressures of 16 and 26 psig were reached in the ullage of Tanks 13 and 15 respectively, even though the rated operating pressure of the tank is 6 psig and the vent relief should have functioned earlier. The time of plume development was directly related to the time of vent relief varying from 38'48" for Test 13 to 2 hours 20'56" for Test 15. Test 14 was intermediate and vented at 1 hour 23'49". Figure 16 shows four views of typical steel tank fire characteristics.

* 5'8" refers to 5 minutes 18 seconds
FIGURE 15a. Before

FIGURE 15b. Before. Detail of In-Tank Pressure Probe Locations

FIGURE 15. TYPICAL POLYETHYLENE TANK - SMALL FIRE
FIGURE 15c. After

FIGURE 15d. After

FIGURE 15. TYPICAL POLYETHYLENE TANK - SMALL FIRE (cont'd)
FIGURE 16a. Before

FIGURE 16b. During

FIGURE 16. TYPICAL STEEL TANK - SMALL FIRE
FIGURE 16c. During

FIGURE 16d. After

FIGURE 16. TYPICAL STEEL TANK - SMALL FIRE (cont'd)
3.2 LARGE EXPOSURE FIRE TESTS

3.2.1 Polyethylene Tanks

Three tests were conducted to determine the time to failure for polyethylene tanks exposed to 100 square foot fires. Tests 16 and 17 used marine diesel fuel for tank contents. Test 19 used ethyl alcohol. The time to failure for Tests 16 and 17 was 6'25" and 4'25" respectively. On Test 16, the tank failed at the top at 4'45" as recorded by visual video observations and released its load at 6'25". Tank failure for Test 19 occurred at 5 minutes as determined by load cell data. Again no particular significance is attached to the time differences that can be interpreted as dependency upon flash point or fuel volatility within the range tested. Figure 17 shows the polyethylene tanks that were exposed to 100 square foot fires. Technical data is documented in Appendix B. A detail of the tank outlet valving is shown in Figure 17b. Initial tank failure occurred at this point or at the tank top.

3.2.2 Steel Tanks

Four tests were made using steel tanks exposed to a 100 square foot fire. Tests 5 and 6 contained marine diesel as flammable contents. For these tanks there was a gradual increase in temperature and pressure. For Test 5 the valve vented after 9 minutes and a plume fire developed after 22 minutes. For Test 6 there was a gradual increase in the temperature of the tank contents to 220°C after 30 minutes and the early thermal rupture of the vent relief plug followed by a gradual development of fire on the tank top. Tests 7 and 8 used ethyl alcohol as the flammable contents. In both cases there was a rapid build up in pressure resulting in the rupture of the relief vent at about 2 minutes and the development of a plume fire within 6 minutes. The fire plume self extinguished when the exposure fire was allowed to terminate at 26 minutes. For all four tests, there was minimal damage to the steel tanks during the fire tests. The principal hazard was associated with the plume fire. Since the relief vent melted soon after the fire exposure began the in-tank pressure remained close to atmospheric and a high plume did not result until a long time period had elapsed. Figure 18 shows four views of a steel tank exposed to a large fire. No structural damage occurred to the tank which could cause release of large quantities of fuel over the deck.

3.3 INTERACTIONS BETWEEN POLYETHYLENE TANKS

Three tests were conducted to determine the failure time for two adjacent tanks. All tests were conducted using a four square foot fire exposure. The tanks were positioned with less than one foot separation between side walls. Because of test facility
FIGURE 17a. Before

FIGURE 17b. Before. Detail of Valving

FIGURE 17. TYPICAL POLYETHYLENE TANK - LARGE FIRE
FIGURE 17. TYPICAL POLYETHYLENE TANK - LARGE FIRE (cont'd)

FIGURE 17c. After. Collapsed Tank Structure

FIGURE 17d. After. Residue in Fire Area
FIGURE 18. TYPICAL STEEL TANK - LARGE FIRE
FIGURE 18. TYPICAL STEEL TANK - LARGE FIRE (cont'd)

FIGURE 18c. During

FIGURE 18d. After
limitations, the load of the outboard tank rested partly on the main deck, and the load cell data does not provide an accurate total weight. For Test 26, ethyl alcohol was used in the inboard tank. Tank failure time for the inboard tank was 5'12" from video data, and 5'05" using load cell data. Failure of the outboard tank was observed visually about 3 minutes afterwards. Tests 27 and 29 used marine diesel as tank contents. The positioning of the tanks was the same as described previously. Failure time for Test 29 was 5'10". Again the time to failure of the outboard tank was approximately 3 to 4 minutes later as determined visually. For Test 27, failure time of the inboard tank was 7'30" from internal tank pressure measurements and 8' 10" from visual video analysis. The outboard tank containing water did not fail. The reason for the lack of failure is the reduction in fire in the area caused by dilution of the alcohol fuel contents with the water blanket used to protect the main deck. For these tests there was a consistency of results with respect to the previous series with single polyethylene tanks. Figure 19 shows four views of test fires involving two polyethylene tanks.

3.4 FIRE SUPPRESSION ACTIONS

Fire fighting actions were a necessary part of the test project. Three methods were used both to extinguish the fire at the end of a test with a minimum of damage to the facility and to evaluate alternative fire suppression techniques required to maintain facility safety. The use of a localized application of carbon dioxide was successful. Since the application was made out of doors sufficient agent had to be applied to maintain extinguishment long enough to enable cooling. In practice, holding times of 5 to 10 minutes were possible, the length of time depending on wind conditions. This method was developed to provide remote fire suppression capability in the event of the need for action at a time when a tank explosion was possible. The second method involved an inerting system in which the exposure fire fuel and the liquid tank contents were conveyed to an inerted reservoir tank. This system worked very effectively during feasibility tests, but was not required during testing. Finally, the third method using AFFF foam and water or water fog nozzles was used. Because of low cost and high effectiveness, hose streams were used throughout the tests both to extinguish plume fires and to control and extinguish fires in the test area and tankage. When extinguishing fires in polyethylene tanks, there was a tendency for the tank to reflash. In some cases, this reflashng occurred over a period of 15 to 20 minutes. The primary reason for the reflashng was the trapping of flammable fuels in folds of melted plastic. Hose streams directed into the tank were not effective in extinguishing the fire. Since the hose streams were manned by highly skilled research personnel, their inability to extinguish the fires was considered significant.
FIGURE 19a. Before Fire

FIGURE 19b. During Fire

FIGURE 19. TYPICAL TANK INTERACTION TESTS
FIGURE 19c. After Fire

FIGURE 19d. After Fire

FIGURE 19. TYPICAL TANK INTERACTION TESTS (cont'd)
4.0 DISCUSSION

4.1 TIME TO FAILURE FOR POLYETHYLENE TANKS

The fire endurance for six single tanks was evaluated using diesel fuel and alcohol as flammable fuel contents. All six tanks were 320 gallons in capacity. The results are summarized in Table Ia.

<table>
<thead>
<tr>
<th>Test #</th>
<th>Fuel Contents</th>
<th>Fire Size</th>
<th>Failure Time (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Diesel</td>
<td>100 ft(^2)</td>
<td>6'25&quot;</td>
</tr>
<tr>
<td>17</td>
<td>Diesel</td>
<td>100 ft(^2)</td>
<td>4'25&quot;</td>
</tr>
<tr>
<td>19</td>
<td>Alcohol</td>
<td>100 ft(^2)</td>
<td>5'00&quot;</td>
</tr>
<tr>
<td>22</td>
<td>Alcohol</td>
<td>4 ft(^2)</td>
<td>5'18&quot;</td>
</tr>
<tr>
<td>23</td>
<td>Diesel</td>
<td>4 ft(^2)</td>
<td>4'46&quot;</td>
</tr>
<tr>
<td>25</td>
<td>Diesel</td>
<td>4 ft(^2)</td>
<td>5'44&quot;</td>
</tr>
</tbody>
</table>

The fire endurance for side-by-side polyethylene tanks was also evaluated. The results are summarized in Table Ib and indicate a delay time of approximately three minutes between the time at which the first tank failed and the time at which the second tank failed.

<table>
<thead>
<tr>
<th>Test #</th>
<th>Fuel Contents</th>
<th>Fire Size</th>
<th>Failure Time Inboard (min:sec)</th>
<th>Failure Time Outboard (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Alcohol</td>
<td>4 ft(^2)</td>
<td>5'12&quot;</td>
<td>8'10&quot;</td>
</tr>
<tr>
<td>27</td>
<td>Diesel</td>
<td>4 ft(^2)</td>
<td>5'10&quot;</td>
<td>8'20&quot;</td>
</tr>
<tr>
<td>29</td>
<td>Diesel</td>
<td>4 ft(^2)</td>
<td>7'30&quot;</td>
<td>---</td>
</tr>
</tbody>
</table>
Based on these results, the average time to failure is 316 seconds for a single tank subjected to widely differing fire exposures. The 25% spread in the data is probably within the range of experimental heating conditions resulting from such things as wind variations. No significant correlation is present between the differences in time to failure and the fuel volatility. The fact that the time to failure is independent of the size of the exposure fire suggests that there is a common underlying mechanism which is responsible for the collapse of the tank bottom. Therefore an engineering analysis was made to predict time of tank collapse. The analysis assumes that a model in which thermal heating of the tank walls softens the wall reducing its mechanical strength. The model assumes that the heat from the exposure fire is constant over time and can be described by a solution of the general one-dimensional heat-conduction equation using an unsteady-state heat-transfer analysis (5). The solution for the case involving constant heat flux into the surface is given by the following equation.

\[
T - T_i = \frac{2q_o \sqrt{\alpha \pi}}{kA} \exp \left( -\frac{x^2}{4\alpha t} \right) - \frac{q_o x}{kA} \left( \text{erf} \frac{x}{2\sqrt{\alpha t}} \right)
\]

where \(T - T_i\) is the temperature change after time \(T\) and at a depth \(x\)

\(q_o\) is the incident heat flux
\(\alpha\) is the Thermal Diffusivity
\(k\) is the Thermal Conductivity
\(A\) is the area

For these calculations a rate of heating of 1.2 watts/cm\(^2\) was used for the incident flux. This value was derived from an analysis of the rate of temperature rise for a steel tank exposed to a four square foot fire. Since the thermal conductivity of the steel is high, it can be assumed that the rate of rise of the liquid contents can be used as a measure of the effective incident heat flux at the tank surface. In effect, the tank functions as a time integrated calorimeter. The value of 1.2 watts/cm\(^2\) was obtained using data from Test 14 for ethyl alcohol and physical data (6) shown in Table II.

This solution was programmed to obtain values for the temperature of the polyethylene tank walls as a function of fire exposure time and distance from the absorbing surface. A Vicat temperature of 120°C at the inside surface of the tank wall (9.5mm) was used as a criteria for the onset of tank failure for the tanks tested on this project.

* The Vicat temperature is a physical property of a polymeric material as determined by ASTM D-1525 (7). This property corresponds to the onset of plastic flow and varies from 115 to 125°C for high density polyethylene feed stocks.
Table II
Physical Data for Ethyl Alcohol

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Weight</td>
<td>46.07</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.789 g/cc</td>
</tr>
<tr>
<td>Heat Capacity</td>
<td>26.64 cal/mole-°C</td>
</tr>
</tbody>
</table>

Results of this analysis are given in Figure 20. The predicted time to failure for the tanks tested is 380 seconds as compared to the experimental value of 316 seconds. Considering the approximations in estimating the heat input to the tank (1.2 Watts/cm²) the values are in reasonable agreement with experimental results. The shaded area indicates the predicted time to failure for high density polyethylene feed stocks characterized by Vicat temperature from 115° to 125°C. The corresponding predictions for time to failure range from about 330 to 385 seconds.

4.2 CORRELATION BETWEEN POLYETHYLENE WALL THICKNESS AND TIME TO FAILURE

Previous Coast Guard tests (2) provided experimental information on the time to failure for selected polyethylene flammable fuel containers. The containers evaluated were 5, 15, 30, and 55 gallon drums. The minimum thickness of these containers is listed in Table III together with data for the 300 gallon tanks used on this project.

<table>
<thead>
<tr>
<th>Size of Container (gallons)</th>
<th>Minimum Wall Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.27</td>
</tr>
<tr>
<td>15</td>
<td>1.90</td>
</tr>
<tr>
<td>55</td>
<td>2.54</td>
</tr>
<tr>
<td>30</td>
<td>3.2</td>
</tr>
<tr>
<td>300</td>
<td>9.5</td>
</tr>
</tbody>
</table>

TABLE III
MINIMUM THICKNESS
OF
SELECTED COMMERCIAL POLYETHYLENE CONTAINERS

38
The analytical calculations described in Section 4.1 were extended to include these containers. The results of these calculations are summarized in Figure 21 and Table IV.

### TABLE IV

**COMPARISON OF CALCULATED AND EXPERIMENTAL TIME OF FAILURE FOR SELECTED COMMERCIAL POLYETHYLENE CONTAINERS**

<table>
<thead>
<tr>
<th>Size of Container (gallons)</th>
<th>Calculated Time to Failure (seconds)</th>
<th>Experimental Time to Failure (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
<td>85</td>
</tr>
<tr>
<td>55</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>30</td>
<td>115</td>
<td>105</td>
</tr>
<tr>
<td>300</td>
<td>380</td>
<td>320</td>
</tr>
</tbody>
</table>

The general agreement between calculated and experimental values suggests that the fire endurance of polyethylene containers is primarily a function of wall thickness. Since the wall thickness of polyethylene containers usually increases with increasing liquid capacity, the fire endurance also increases with size.

### 4.3 HEAT TRANSFER MECHANISMS

The fact that there was good agreement between the experimental and calculated tank failure times suggests that most of the heat absorbed at the tank surface of the polyethylene tanks is not transferred to the liquid contents but remains in the tank wall. In effect the mass of polyethylene acts as a thermal heat sink for the fire. The experimental data from the thermocouples located in the tank and the pressure transducers monitoring ullage pressure fully support this conclusion. Therefore, the usefulness of pressure relief systems in polyethylene tanks is limited. Failure occurs in about five minutes.

For steel tanks the situation is reversed. For steel tanks the thermoconductivity of the tank walls is high and the heat from the fire is transferred rapidly and efficiently to the liquid contents. The tank contents function as a large heat sink and thereby protect the tank. For long exposures to fire there is a gradual heating of the tank contents with the resultant increase in internal pressure. For volatile liquids this process occurs more rapidly than for less volatile liquids.
Figure 21. Calculated Time to Failure as a Function of Minimum Container Thickness and Temperature.
4.4 THE FIRE HAZARD - POLYETHYLENE VS STEELS TANKS

4.4.1 Fire Spread Rate for Polyethylene Tanks

In developing information for a fire hazard assessment an important factor is the estimated rate of fire spread. In order to estimate this factor, it is necessary to assume specific characteristics for the initiating fire exposure and the spatial arrangement of the cargo. For polyethylene tanks it was assumed that the initiating fire was a small 4 ft$^2$ fire located directly underneath a polyethylene tank containing flammable fuel. The cargo was assumed to consist of 49 tanks arranged in a square close-packed array. The arrangement is shown in Figure 22. The initiating fire occurs at the center point "S" and spreads successively to the nearest neighbors indicated by X and O in a series of discrete steps.

```
X X X X X X X
X 0 0 0 0 0 X
X 0 X X 0 X
X 0 X S X 0 X
X 0 X X 0 X
X 0 0 0 0 0 X
X X X X X X X
```

FIGURE 22. SQUARE CLOSE-PACKED CARGO ARRAY

Using the data from Table 1b for fire spread between adjacent tanks it was assumed that the central tank under which the fire started failed in 8 minutes, and that all the tanks adjacent to it failed three minutes later. Further, it was assumed that this process continued to the outer ring of the array with the same delays. For 300 gallon tanks the total involvement of flammable fuel as a function of time is given in Figure 23.

4.4.2 Estimated Response Time Requirement

4.4.2.1 Polyethylene Tanks

In order to evaluate the potential fire safety hazard for polyethylene tanks, it is necessary to estimate the time needed for the combined operations of detection and damage control team response. For tanks carried in a cargo hold, it is estimated that the detection response time would be a minimum of 3 to 5 minutes, and that the time required for arrival of the fully equipped damage control team would be ten minutes after detection. For deck cargo, it is estimated that the time required for detection would be 5 to 10 minutes; and that the deck foam monitors could be manned within eight minutes after detection. For either case, it would be predicted that the damage control team would be faced with a fire involving a minimum of 2700 gallons of flammable fuel.
TANK TESTS

FIGURE 23. Rate of Involvement of Flammable Fuel
at the time of their arrival. Further, unless the team were both well trained and equipped to extinguish liquid fuel fires, it is estimated that the ship would be involved in a 10,000 gallon fire within twenty minutes.

4.4.2.2 Steel Tanks

For steel tanks, as reported in Sections 3.1.2 and 3.2.2, the tank walls did not fail. When exposed to large fires, the vent release melts and volatile fuel vapors burn as they exit the tank. Experimental times for the development of a plume fire are summarized in Table V. A worse case scenario involves exposure to a small scale fire for an extended time period coupled with a faulty pressure activated vent release. For a typical liquid such as ethyl alcohol, the delay between the start of the initiating fire and the blow-off of the high pressure fuel vapors (25 - 30 psig) was about 45 minutes. The major hazard that is involved is the extended plume fire. For this scenario to take place, it would be necessary to assume that effective fire fighting action could not take place within a 45 minute time after the start of the initiating fire. This is unlikely. The maximum quantity of fuel that would be involved is estimated to be between 250 - 300 gallons. Since damage control personnel equipped with hose streams could be directed to cool the tanks, there is a relatively low hazard compared to the large volume liquid fuel fire expected from the polyethylene tanks.

Previous Coast Guard fire tests concluded that polyethylene drums were less hazardous than steel drums when exposed to fire. These tests used steel drums which were not fitted with pressure relief closures. As a result, the steel drums developed pressures which exceeded the burst strength of the containers. The major safety hazard associated with these drums resulted from the catastrophic nature of the bursting process. The IBC tanks used on this project were required by DOT regulations to have relief vents. These vents are actuated by either high pressures or high temperatures. Although these relief devices did not function properly on all these tests, they did function effectively before major structural damage occurred. Therefore, the severe safety hazards which occurred during the fire exposure on the steel drum tests did not occur for commercial steel IBC tanks.

Consideration of these factors indicates that the use of polyethylene containers would result in an unacceptable risk to ship safety and that minimal risks would be incurred from flammable fuels in steel tanks provided the steel tanks are equipped with reliable pressure/temperature relief vents.
<table>
<thead>
<tr>
<th>Test Number</th>
<th>Fire Size</th>
<th>Tank Contents</th>
<th>Structural Damage</th>
<th>Start of Plume Fire (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Large</td>
<td>Diesel</td>
<td>None</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>Large</td>
<td>Diesel</td>
<td>None</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Large</td>
<td>Ethyl Alcohol</td>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Large</td>
<td>Ethyl Alcohol</td>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>Small</td>
<td>Diesel</td>
<td>Uncapped Valve Leak</td>
<td>No Plume</td>
</tr>
<tr>
<td>11</td>
<td>Small</td>
<td>Diesel</td>
<td>None</td>
<td>No Plume</td>
</tr>
<tr>
<td>13</td>
<td>Small</td>
<td>Ethyl Alcohol</td>
<td>None</td>
<td>39</td>
</tr>
<tr>
<td>14</td>
<td>Small</td>
<td>Ethyl Alcohol</td>
<td>None</td>
<td>84</td>
</tr>
<tr>
<td>15</td>
<td>Small</td>
<td>Ethyl Alcohol</td>
<td>None</td>
<td>141</td>
</tr>
</tbody>
</table>
5.0 CONCLUSIONS

Polyethylene tanks containing flammable fuels are more hazardous than steel tanks. These hazards result from the release of large quantities of flammable contents in a short time.

The most common failure mode for polyethylene tanks involves thermoplastic softening followed by structural collapse.

Commercial polyethylene IBC tanks may fail and release their contents within 6 minutes when exposed to fire.

Failure times for polyethylene tanks are independent of fuel volatility for the range of fuels investigated.

Failure times for polyethylene tanks are independent of fire size when the fire is in direct contact with the tank.

Failure of an adjacent polyethylene tank may occur within three minutes after the rupture of the initial tank.

Extinguishment of flammable fuel fires in thermoplastic polyethylene tanks is difficult because of the trapping of flammable fuel in pockets formed by the folding of the tank walls.

The time to failure for polyethylene tanks is primarily dependent on tank wall thickness not tank capacity.
REFERENCES


# APPENDIX A

**INSTRUMENTATION FOR TEST SERIES 43A1**

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1              | **INSTRUMENT: WIND DIRECTION**  
SERIAL NUMBER: 04401A-D  
CLASS: IW3  
MANUFACTURER: R.M. YOUNG CO.  
MODEL: 04401A  
VOLTS: 0.00 to 1.00000  
OUTPUT/RANGE: 0.0 to 360.00 DEGREES AZIMUTH  
LOCATION: North at 0 degrees.  
REMARKS: ------  
ACTUATOR: 41 Time Date Generator Close on test start, Open on test end. |
| 2              | **INSTRUMENT: WIND INTENSITY**  
SERIAL NUMBER: 04401A-I  
CLASS: IW3  
MANUFACTURER: R.M. YOUNG CO.  
MODEL: 04401A  
VOLTS: 0.00 to 1.00000  
OUTPUT/RANGE: 0.00 to 100.00 MPH  
LOCATION: Locate on main deck about 100 ft from 100 ft^2 fire pit.  
REMARKS: ------ |
| 3              | **INSTRUMENT: LINE VOLTAGE**  
SERIAL NUMBER: 45601-1  
CLASS: IO8  
MANUFACTURER: ROCHESTER INSTRUMENT SYSTEMS  
MODEL: SC-1300-U1  
VOLTS: 1.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 150.00 VAC  
LOCATION: Instrumentation trailer  
REMARKS: ------ |
| 4              | **INSTRUMENT: LINE FREQUENCY**  
SERIAL NUMBER: 45601-2  
CLASS: IO8  
MANUFACTURER: ROCHESTER INSTRUMENT SYSTEMS  
MODEL: FFX-1-60  
VOLTS: 0.00 to 0.10000  
OUTPUT/RANGE: 50.00 to 65.00 CPS  
LOCATION: Instrumentation trailer  
REMARKS: |
## INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 5              | **INSTRUMENT:** CO2 INFRARED  
**SERIAL NUMBER:** 34062  
**CLASS:** IG2  
**MANUFACTURER:** MINE SAFETY APPLIANCE CO.  
**MODEL:** LIRA 303  
**VOLTS:** 0.00 to 0.10000  
**OUTPUT/RANGE:** 0.00 to 100.00 %  
**LOCATION:** Line at top center of dump tank  
1/2 inch from inside wall  
**REMARKS:** |
| 6              | **INSTRUMENT:** CO2 INFRARED  
**SERIAL NUMBER:** 34063  
**CLASS:** IG2  
**MANUFACTURER:** MINE SAFETY APPLIANCE CO.  
**MODEL:** LIRA 303  
**VOLTS:** 0.00 to 0.10000  
**OUTPUT/RANGE:** 0.00 to 25.00 %  
**LOCATION:** 12 inches from deck on outside of dump tank  
**REMARKS:** |
| 7              | **INSTRUMENT:** CO2 INFRARED  
**SERIAL NUMBER:** 34064  
**CLASS:** IG2  
**MANUFACTURER:** MINE SAFETY APPLIANCE CO.  
**MODEL:** LIRA 303  
**VOLTS:** 0.00 to 0.10000  
**OUTPUT/RANGE:** 0.00 to 25.00 %  
**LOCATION:** 12 inches from deck on outside of dump tank  
**REMARKS:** |
| 8              | **INSTRUMENT:** CO2 INFRARED  
**SERIAL NUMBER:** 34065  
**CLASS:** IG2  
**MANUFACTURER:** MINE SAFETY APPLIANCE CO.  
**MODEL:** LIRA 303  
**VOLTS:** 0.00 to 0.10000  
**OUTPUT/RANGE:** 0.00 to 25.00 %  
**LOCATION:** Flexible line 100 ft to monitor areas as "rover"  
**REMARKS:**  
**ACTUATOR:** 44 CO2 alarm Close when ch #8 >= 3%  
**REMARKS:** |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 9              | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84387  
CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 tank pressure  
REMARKS: |
| 10             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84388  
CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure at main valve  
REMARKS: |
| 11             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84389  
CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure at entrance to reducer section  
REMARKS: |
| 12             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84390  
CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure after reducer section  
REMARKS: |
| 13             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84391  
CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure Nozzle #1  
REMARKS: |
## INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 14             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84392  
CLASS: 103  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure Nozzle #2  
REMARKS: |
| 15             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84393  
CLASS: 103  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure Nozzle #3  
REMARKS: |
| 16             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84394  
CLASS: 103  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: CO2 line pressure Nozzle #4  
REMARKS: |
| 17             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 84396  
CLASS: 103  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 500.00 PSIG  
LOCATION: Test Tank #2  
REMARKS: See channel 63 |
| 18             | INSTRUMENT: PRESSURE TRANSDUCER  
SERIAL NUMBER: 98223  
CLASS: 103  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 100.00 PSIG  
LOCATION: Test tank #2  
REMARKS: See channel 64 |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 19             | INSTRUMENT: PRESSURE TRANSUDER  
SERIAL NUMBER: 98221  CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 100.00 PSIG  
LOCATION: Spare Channel  
REMARKS: |
| 20             | INSTRUMENT: PRESSURE TRANSUDER  
SERIAL NUMBER: 98222  CLASS: IO3  
MANUFACTURER: SETRA SYSTEMS, INC.  
MODEL: 205-2  
VOLTS: 0.00 to 5.00000  
OUTPUT/RANGE: 0.00 to 100.00 PSIG  
LOCATION: Spare Channel  
REMARKS: |
| 21             | INSTRUMENT: RADIOMETER-150  
SERIAL NUMBER: 219854  CLASS: IO2  
MANUFACTURER: MEDTHERM CORPORATION  
MODEL: 64P-15-24T  
VOLTS: 0.00 to 0.01520  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Spare Channel  
REMARKS: |
| 22             | INSTRUMENT: RADIOMETER-60  
SERIAL NUMBER: 1023801  CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.00990  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Spare Channel  
REMARKS: |
| 23             | INSTRUMENT: RADIOMETER-60  
SERIAL NUMBER: 1023804  CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.00958  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Below test tank fwd  
REMARKS: Mount 1 inch below tank-pointing down |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 24             | INSTRUMENT: RADIOMETER-60  
SERIAL NUMBER: 125842  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.00710  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Below test tank aft  
REMARKS: Mount 1 inch below tank-pointing down |
| 25             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 10238014  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.01206  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Spare channel  
REMARKS: |
| 26             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 10238011  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.01060  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Spare Channel  
REMARKS: |
| 27             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 10238012  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.00935  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Below test tank fwd  
REMARKS: Mount 1 inch below tank-pointing down |
| 28             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 10238013  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.01210  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Below test tank aft  
REMARKS: Mount 1 inch below tank-pointing down |
### INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 29             | **INSTRUMENT**: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: 105  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Area #1  
                REMARKS: Air line 15 deg. radiometer |
| 30             | **INSTRUMENT**: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: 105  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Area #2  
                REMARKS: Air line 15 deg. radiometer |
| 31             | **INSTRUMENT**: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: 105  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Area #3  
                REMARKS: Air line 15 deg. radiometer |
| 32             | **INSTRUMENT**: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: 105  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Area #4  
                REMARKS: Air line 15 deg. radiometer |
| 33             | **INSTRUMENT**: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: 105  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Radiometer 125841  
                REMARKS: Monitor cooling water Channel 23 |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 34             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Radiometer 125842  
REMARKS: Monitor cooling water Channel 24 |
| 35             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Calorimeter 10238012  
REMARKS: Monitor cooling water Channel 27 |
| 36             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Calorimeter 10238013  
REMARKS: Monitor cooling water Channel 28 |
| 37             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #1  
REMARKS: |
| 38             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #2  
REMARKS: |
<table>
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<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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</table>
| **39**         | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #3  
REMARKS: |
| **40**         | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #4  
REMARKS: |
| **41**         | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: In center of tank  
REMARKS: TC #1 In-Tank |
| **42**         | THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: 1 inch from top of tank along vertical center line  
REMARKS: TC #2 In-Tank |
| **43**         | THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: 1 inch from bottom of tank along vertical center line  
REMARKS: TC #3 In-Tank |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 44             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: 1 inch from left-hand side of tank  
along horizontal center line  
REMARKS: TC #4 In-Tank |
| 45             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: 1 inch from right-hand side of tank  
along horizontal center line  
REMARKS: TC #5 In-Tank |
| 46             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Halfway between TC #5 and TC #1  
REMARKS: TC #6 In-Tank |
| 47             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Halfway between TC #4 and TC #1  
REMARKS: TC #7 In-Tank |
| 48             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/16IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Halfway between TC #2 and TC #1  
REMARKS: TC #8 In-Tank |
## INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>INSTRUMENT: #1 WEIGHT IND 4 CELLS</td>
</tr>
<tr>
<td></td>
<td>SERIAL NUMBER: 1520 CLASS: 107</td>
</tr>
<tr>
<td></td>
<td>MANUFACTURER: B.L.H. ELECTRONICS</td>
</tr>
<tr>
<td></td>
<td>MODEL: 450 ASW</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.10000</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 20000.00 LBS.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: CO2 tank</td>
</tr>
<tr>
<td></td>
<td>REMARKS: Cardox tank</td>
</tr>
</tbody>
</table>

| 50             | INSTRUMENT: #2 WEIGHT IND 1 CELL |
|                | SERIAL NUMBER: 3310 CLASS: 107 |
|                | MANUFACTURER: B.L.H. ELECTRONICS |
|                | MODEL: 450A |
|                | VOLTS: 0.00 to 0.10000 |
|                | OUTPUT/RANGE: 0.00 to 5.00 LBS. |
|                | LOCATION: Test tank |
|                | REMARKS: See Channel 107 |

| 51             | INSTRUMENT: PRESSURE TRANSDUCER |
|                | SERIAL NUMBER: 84395 CLASS: 103 |
|                | MANUFACTURER: SETRA SYSTEMS INC. |
|                | MODEL: 205-2 |
|                | VOLTS: 0.00 to 5.00000 |
|                | OUTPUT/RANGE: 0.00 to 500.00 PSIG |
|                | LOCATION: Ullage on tank |
|                | REMARKS: See Channel 61 |

| 52             | INSTRUMENT: PRESSURE TRANSDUCER |
|                | SERIAL NUMBER: 98220 CLASS: 103 |
|                | MANUFACTURER: SETRA SYSTEMS INC. |
|                | MODEL: 205-2 |
|                | VOLTS: 0.00 to 5.00000 |
|                | OUTPUT/RANGE: 0.00 to 100.00 PSIG |
|                | LOCATION: Ullage on tank |
|                | REMARKS: See Channel 62 |

<p>| 53             | INSTRUMENT: RADIOMETER-60 |
|                | SERIAL NUMBER: 92891 CLASS: 102 |
|                | MANUFACTURER: |
|                | MODEL: |
|                | VOLTS: 0.00 to 0.00950 |
|                | OUTPUT/RANGE: 0.00 to 20.00 BTU/SQFT/SEC. |
|                | LOCATION: Area #1 In-Fire See Channel 65 |
|                | REMARKS: |</p>
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 54             | INSTRUMENT: RADIOMETER-150  
SERIAL NUMBER: 219851  
CLASS: IO2  
MANUFACTURER: MEDTHERM CORP.  
MODEL: 64P-15-24T  
VOLTS: 0.00 to 0.01440  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Area #2 In-Fire See Channel 66  
REMARKS: |
| 55             | INSTRUMENT: RADIOMETER-150  
SERIAL NUMBER: 219852  
CLASS: IO2  
MANUFACTURER: MEDTHERM CORP.  
MODEL: 64P-15-24T  
VOLTS: 0.00 to 0.01510  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Area #3 In-Fire See Channel 67  
REMARKS: See Part I, Task II |
| 56             | INSTRUMENT: RADIOMETER-150  
SERIAL NUMBER: 219853  
CLASS: IO2  
MANUFACTURER: MEDTHERM CORP.  
MODEL: 64P-15-24T  
VOLTS: 0.00 to 0.01570  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Area #4 In-Fire See Channel 68  
REMARKS: |
| 57             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 10238016  
CLASS: IO2  
MANUFACTURER: MEDTHERM CORP.  
MODEL: 64-15-20-6MGO  
VOLTS: 0.00 to 0.01120  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Area #1 In-Fire See Channel 69  
REMARKS: May be operating at 18 Btu/ft2 sec |
| 58             | INSTRUMENT: CALORIMETER  
SERIAL NUMBER: 1023807  
CLASS: IO2  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.01160  
OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.  
LOCATION: Area #2 In-Fire See Channel 70  
REMARKS: May be operating at 18 Btu/ft2 sec |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>INSTRUMENT: CALORIMETER</td>
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<tr>
<td></td>
<td>SERIAL NUMBER: 92894</td>
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<td>CLASS: IO2</td>
</tr>
<tr>
<td></td>
<td>MANUFACTURER:</td>
</tr>
<tr>
<td></td>
<td>MODEL:</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.00980</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Area #3 In-Fire See Channel 71</td>
</tr>
<tr>
<td></td>
<td>REMARKS: May be operating at 18 Btu/ft2 sec</td>
</tr>
<tr>
<td>60</td>
<td>INSTRUMENT: CALORIMETER</td>
</tr>
<tr>
<td></td>
<td>SERIAL NUMBER: 1023809</td>
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<tr>
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<td>CLASS: IO2</td>
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<td>MANUFACTURER:</td>
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<td>MODEL:</td>
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<tr>
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<td>VOLTS: 0.00 to 0.01015</td>
</tr>
<tr>
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<td>OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Area #4 In-Fire See Channel 72</td>
</tr>
<tr>
<td></td>
<td>REMARKS: May be operating at 18 Btu/ft2 sec</td>
</tr>
<tr>
<td>61</td>
<td>INSTRUMENT: THERMOCOUPLE TYPE K</td>
</tr>
<tr>
<td></td>
<td>SERIAL NUMBER: K50FT1/8IN</td>
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<tr>
<td></td>
<td>CLASS: IO5</td>
</tr>
<tr>
<td></td>
<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.04150</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Pressure transducers</td>
</tr>
<tr>
<td></td>
<td>REMARKS: Channel 51</td>
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<tr>
<td>62</td>
<td>INSTRUMENT: THERMOCOUPLE TYPE K</td>
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<td>SERIAL NUMBER: K50FT1/8IN</td>
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<tr>
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<td>CLASS: IO5</td>
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<tr>
<td></td>
<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.04150</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Pressure transducers</td>
</tr>
<tr>
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<td>REMARKS: Channel 52</td>
</tr>
<tr>
<td>63</td>
<td>INSTRUMENT: THERMOCOUPLE TYPE K</td>
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<td></td>
<td>SERIAL NUMBER: K50FT1/8IN</td>
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<tr>
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<td>CLASS: IO5</td>
</tr>
<tr>
<td></td>
<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.04150</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Pressure transducers</td>
</tr>
<tr>
<td></td>
<td>REMARKS: Channel 17, Tank #2</td>
</tr>
<tr>
<td>64</td>
<td>INSTRUMENT: THERMOCOUPLE TYPE K</td>
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<td>SERIAL NUMBER: K50FT1/8IN</td>
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<tr>
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<td>CLASS: IO5</td>
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<tr>
<td></td>
<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
</tr>
<tr>
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<td>VOLTS: 0.00 to 0.04150</td>
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<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Pressure transducers</td>
</tr>
<tr>
<td></td>
<td>REMARKS: Channel 18, Tank #2</td>
</tr>
</tbody>
</table>
### INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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</table>
| 65             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #1 Water Line See channel 53  
REMARKS: Attach to output water line for Radiometer 98891 |
| 66             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #2 Water Line See Channel 54  
REMARKS: Attach to output water line for Radiometer 219851 |
| 67             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #3 Water Line See Channel 55  
REMARKS: Attach to output water line for Radiometer 219852 |
| 68             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #4 Water Line See Channel 56  
REMARKS: Attach to output water line for Radiometer 219853 |
| 69             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #1 Water Line See Channel 57  
REMARKS: Attach to output water line for Calorimeter 92892 |
<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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</table>
| 70             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #2 Water Line See Channel 58  
REMARKS: Attach to output water line for Calorimeter 92893 |
| 71             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #3 Water Line See Channel 59  
REMARKS: Attach to output water line for Calorimeter 92894 |
| 72             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: 105  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #4 Water Line See Channel 60  
REMARKS: Attach to output water line for Calorimeter 92895 |
| 73             | INSTRUMENT: RADIOMETER-15  
SERIAL NUMBER: 613862  
CLASS: 102  
MANUFACTURER: MEDTHERM CORP.  
MODEL: TGRW2-15-804  
VOLTS: 0.00 to 0.00362  
OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC.  
LOCATION: Area #1 See Channel 100  
REMARKS: +/- 5 deg. horizontal view |
| 74             | INSTRUMENT: RADIOMETER-15  
SERIAL NUMBER: 613863  
CLASS: 102  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 0.00325  
OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC.  
LOCATION: Area #2 See Channel 101  
REMARKS: +/- 5 deg. horizontal view |
<table>
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<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>75</td>
<td>INSTRUMENT: RADIOMETER-15</td>
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<tr>
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<td>SERIAL NUMBER: 613864 CLASS: IO2</td>
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<tr>
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<td>MANUFACTURER: MEDTHERM CORP.</td>
</tr>
<tr>
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<td>MODEL: TGRW-15-804</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.00323</td>
</tr>
<tr>
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<td>OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC.</td>
</tr>
<tr>
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<td>LOCATION: Area #3 See Channel 102</td>
</tr>
<tr>
<td></td>
<td>REMARKS: +/- 5 deg. horizontal view</td>
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<tr>
<td>76</td>
<td>INSTRUMENT: RADIOMETER-15</td>
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<tr>
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<td>SERIAL NUMBER: 613861 CLASS: IO2</td>
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<tr>
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<td>MANUFACTURER: MEDTHERM CORP.</td>
</tr>
<tr>
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<td>MODEL: TGRW-15-804</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.00320</td>
</tr>
<tr>
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<td>OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC.</td>
</tr>
<tr>
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<td>LOCATION: Area #4 See Channel 103</td>
</tr>
<tr>
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<td>REMARKS: +/- 5 deg. horizontal view</td>
</tr>
<tr>
<td>77</td>
<td>INSTRUMENT: POSITION INDICATOR</td>
</tr>
<tr>
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<td>SERIAL NUMBER: DUM-5 CLASS: IO8</td>
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<tr>
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<td>MANUFACTURER:</td>
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<tr>
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<td>MODEL:</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 10.00000</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 15.00 FT.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Area #1</td>
</tr>
<tr>
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<td>REMARKS:</td>
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<tr>
<td>78</td>
<td>INSTRUMENT: POSITION INDICATOR</td>
</tr>
<tr>
<td></td>
<td>SERIAL NUMBER: DUM-6 CLASS: IO8</td>
</tr>
<tr>
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<tr>
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<td>VOLTS: 0.00 to 10.00000</td>
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<td>OUTPUT/RANGE: 0.00 to 15.00 FT.</td>
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<tr>
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<td>79</td>
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<tr>
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<td>SERIAL NUMBER: DUM-7 CLASS: IO8</td>
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<tr>
<td></td>
<td>VOLTS: 0.00 to 10.00000</td>
</tr>
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<td>OUTPUT/RANGE: 0.00 to 15.00 FT.</td>
</tr>
<tr>
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</tr>
<tr>
<td>CHANNEL NUMBER</td>
<td>DESCRIPTION</td>
</tr>
<tr>
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</tbody>
</table>
| 80             | INSTRUMENT: POSITION INDICATOR  
SERIAL NUMBER: DUM-8 CLASS: IO8  
MANUFACTURER:  
MODEL:  
VOLTS: 0.00 to 10.00000  
OUTPUT/RANGE: 0.00 to 15.00 FT.  
LOCATION: Area #4  
REMARKS: |
| 81             | INSTRUMENT: HYDROCARBON FLAME  
SERIAL NUMBER: 1002592 CLASS: IG7  
MANUFACTURER: BECKMAN INSTRUMENTS  
MODEL: 400  
VOLTS: 0.00 to 1.00000  
OUTPUT/RANGE: 0.00 to 40000.00 PPM  
LOCATION: Below fire deck  
REMARKS: Use to trigger alarm at 1% actuator => 10000 PPM  
ACTUATOR: 42 Hydrocarbon Alarm Close when ch #81 >= 10000 PPM |
| 82             | INSTRUMENT: HYDROCARBON FLAME  
SERIAL NUMBER: 1002593 CLASS: IG7  
MANUFACTURER: BECKMAN INSTRUMENTS  
MODEL: 400  
VOLTS: 0.00 to 1.00000  
OUTPUT/RANGE: 0.00 to 40000.00 PPM  
LOCATION: Rover pickup line  
REMARKS: Use to trigger alarm at 1% actuator => 10000 PPM  
ACTUATOR: 43 Hydrocarbon Alarm Close when ch #82 >= 10000 PPM |
| 83             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Spare channel  
REMARKS: |
| 84             | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Spare channel  
REMARKS: |
### INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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<tr>
<td>85</td>
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<td>SERIAL NUMBER: K50FT1/8IN CLASS: 105</td>
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<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
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<tr>
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<td>VOLTS: 0.00 to 0.04150</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Cooling water</td>
</tr>
<tr>
<td></td>
<td>REMARKS: Channel 23 radiometer</td>
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<tr>
<td>86</td>
<td><strong>INSTRUMENT: THERMOCOUPLE TYPE K</strong></td>
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<td>MANUFACTURER: THERMO-ELECTRIC CO.</td>
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<tr>
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<td>VOLTS: 0.00 to 0.04150</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.</td>
</tr>
<tr>
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<td>LOCATION: Cooling water</td>
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<tr>
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<td>REMARKS: Channel 24 radiometer</td>
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<tr>
<td>87</td>
<td><strong>INSTRUMENT: #3WEIGHT IND 1 CELL</strong></td>
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<tr>
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<td>SERIAL NUMBER: 3311 CLASS: 107</td>
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<tr>
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<td>MANUFACTURER: B.L.H. ELECTRONICS</td>
</tr>
<tr>
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<td>MODEL: 450A</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.10000</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 5000.00 LBS.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Deck cell #1</td>
</tr>
<tr>
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<td>REMARKS: See channel 104</td>
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<tr>
<td>88</td>
<td><strong>INSTRUMENT: #4WEIGHT IND 1 CELL</strong></td>
</tr>
<tr>
<td></td>
<td>SERIAL NUMBER: 3590 CLASS: 107</td>
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<td>VOLTS: 0.00 to 0.10000</td>
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<td>MANUFACTURER: B.L.H. ELECTRONICS</td>
</tr>
<tr>
<td></td>
<td>MODEL: 450A</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 5000.00 LBS.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Deck cell #2</td>
</tr>
<tr>
<td></td>
<td>REMARKS: See channel 105</td>
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<tr>
<td>89</td>
<td><strong>INSTRUMENT: #5WEIGHT IND 1 CELL</strong></td>
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<tr>
<td></td>
<td>SERIAL NUMBER: 3389 CLASS: 107</td>
</tr>
<tr>
<td></td>
<td>VOLTS: 0.00 to 0.10000</td>
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<tr>
<td></td>
<td>MANUFACTURER: B.L.H. ELECTRONICS</td>
</tr>
<tr>
<td></td>
<td>MODEL: 450A</td>
</tr>
<tr>
<td></td>
<td>OUTPUT/RANGE: 0.00 to 5000.00 LBS.</td>
</tr>
<tr>
<td></td>
<td>LOCATION: Deck cell #3</td>
</tr>
<tr>
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<td>REMARKS: See channel 106</td>
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<td>CHANNEL NUMBER</td>
<td>DESCRIPTION</td>
</tr>
<tr>
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<td>-------------</td>
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</tbody>
</table>
| 90             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #1  
|                | REMARKS: Test tank #2 (Channel 41) |
| 91             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #2  
|                | REMARKS: Test tank #2 (Channel 42) |
| 92             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #3  
|                | REMARKS: Test tank #2 (Channel 43) |
| 93             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #4  
|                | REMARKS: Test tank #2 (Channel 44) |
| 94             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #5  
|                | REMARKS: Test tank #2 (Channel 45) |
| 95             | INSTRUMENT: THERMOCOUPLE TYPE K  
|                | SERIAL NUMBER: K50FT1/16IN  
|                | CLASS: I05  
|                | MANUFACTURER: THERMO-ELECTRIC CO.  
|                | VOLTS: 0.00 to 0.04150  
|                | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|                | LOCATION: Thermocouple #6  
|                | REMARKS: Test tank #2 (Channel 46) |
## INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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<tr>
<td>96</td>
<td>CHANNEL 47</td>
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<td>CHANNEL 48</td>
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<td>CHANNEL 27</td>
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<td>99</td>
<td>CHANNEL 28</td>
</tr>
<tr>
<td>100</td>
<td>CHANNEL 27</td>
</tr>
<tr>
<td>101</td>
<td>CHANNEL 28</td>
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</table>

| 96 | INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/16IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Thermocouple #7  
|    | REMARKS: Test tank #2 (Channel 47)  |
| 97 | INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/16IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Thermocouple #8  
|    | REMARKS: Test tank #2 (Channel 48)  |
| 98 | INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/8IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Cooling water  
|    | REMARKS: Channel 27 calorimeter  |
| 99 | INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/8IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Cooling water  
|    | REMARKS: Channel 28 calorimeter  |
| 100| INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/8IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Area #1  
|    | REMARKS: 15 deg. view radiometer  |
| 101| INSTRUMENT: THERMOCOUPLE TYPE K  
|    | SERIAL NUMBER: K50FT1/8IN  
|    | CLASS: 105  
|    | MANUFACTURER: THERMO-ELECTRIC CO.  
|    | VOLTS: 0.00 to 0.04150  
|    | OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
|    | LOCATION: Area #2  
<p>|    | REMARKS: 15 deg. view radiometer  |</p>
<table>
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<th>DESCRIPTION</th>
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</table>
| 102            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #3  
REMARKS: 15 deg. view radiometer |
| 103            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Area #4  
REMARKS: 15 deg. view radiometer |
| 104            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Deck #1  
REMARKS: Load Cell |
| 105            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Deck #2  
REMARKS: Load Cell |
| 106            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Deck #3  
REMARKS: Load Cell |
| 107            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Overhead  
REMARKS: Load Cell |
### INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

<table>
<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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</thead>
</table>
| 108            | **INSTRUMENT:** T/C REFERENCE JUNCTION  
**SERIAL NUMBER:** TC1  
**CLASS:** 105  
**MANUFACTURER:** OMEGA ENGINEERING  
**MODEL:** OMEGA-CJ  
**VOLTS:** 0.00 to 0.00200  
**OUTPUT/RANGE:** 0.00 to 50.00 DEG. C.  
**LOCATION:** Ch# 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 65, 66, 67, 68, 69, 70, 71, 72  
**REMARKS:** |
| 109            | **INSTRUMENT:** T/C REFERENCE JUNCTION  
**SERIAL NUMBER:** TC2  
**CLASS:** 105  
**MANUFACTURER:** OMEGA ENGINEERING  
**MODEL:** OMEGA-CJ  
**VOLTS:** 0.00 to 0.00200  
**OUTPUT/RANGE:** 0.00 to 50.00 DEG. C.  
**LOCATION:** Ch# 41, 42, 43, 44, 45, 46, 47, 48, 61, 62, 63, 64, 115, 116, 117, 118, 119  
**REMARKS:** |
| 110            | **INSTRUMENT:** T/C REFERENCE JUNCTION  
**SERIAL NUMBER:** TC3  
**CLASS:** 105  
**MANUFACTURER:** OMEGA ENGINEERING  
**MODEL:** OMEGA-CJ  
**VOLTS:** 0.00 to 0.00200  
**OUTPUT/RANGE:** 0.00 to 50.00 DEG. C.  
**LOCATION:** Ch# 86, 90-107, 111-114  
**REMARKS:** |
| 111            | **INSTRUMENT:** THERMOCOUPLE TYPE K  
**SERIAL NUMBER:** K50FT1/8IN  
**CLASS:** 105  
**MANUFACTURER:** THERMO-ELECTRIC CO.  
**VOLTS:** 0.00 to 0.04150  
**OUTPUT/RANGE:** 0.00 to 1000.00 DEG. C.  
**LOCATION:** Spare  
**REMARKS:** |
| 112            | **INSTRUMENT:** THERMOCOUPLE TYPE K  
**SERIAL NUMBER:** K50FT1/8IN  
**CLASS:** 105  
**MANUFACTURER:** THERMO-ELECTRIC CO.  
**VOLTS:** 0.00 to 0.04150  
**OUTPUT/RANGE:** 0.00 to 1000.00 DEG. C.  
**LOCATION:** Spare  
**REMARKS:** |

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### INSTRUMENTATION FOR TEST SERIES 43A1 (cont’d)

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| 113            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
| 114            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
| 115            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
| 116            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
| 117            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
| 118            | INSTRUMENT: THERMOCOUPLE TYPE K  
                SERIAL NUMBER: K50FT1/8IN  
                CLASS: IO5  
                MANUFACTURER: THERMO-ELECTRIC CO.  
                VOLTS: 0.00 to 0.04150  
                OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
                LOCATION: Spare  
                REMARKS: |
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<thead>
<tr>
<th>CHANNEL NUMBER</th>
<th>DESCRIPTION</th>
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</thead>
</table>
| 119            | INSTRUMENT: THERMOCOUPLE TYPE K  
SERIAL NUMBER: K50FT1/8IN  
CLASS: IO5  
MANUFACTURER: THERMO-ELECTRIC CO.  
VOLTS: 0.00 to 0.04150  
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.  
LOCATION: Spare  
REMARKS: |
THE FOLLOWING ARE SUPPLEMENTARY INSTRUMENTS FOR THE CHANNEL(S) INDICATED:

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Serial Number</th>
<th>Class</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Volts</th>
<th>Output/Range</th>
<th>Location</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Cell</td>
<td>56825</td>
<td>107</td>
<td>B.L.H. Electronics</td>
<td>U3G1</td>
<td>0.00 to 0.03</td>
<td>0.00 to 5000.00 LBS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Cell</td>
<td>56905</td>
<td>107</td>
<td>B.L.H. Electronics</td>
<td>U3G1</td>
<td>0.00 to 0.03</td>
<td>0.00 to 5000.00 LBS.</td>
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<tr>
<td>Load Cell</td>
<td>56906</td>
<td>107</td>
<td>B.L.H. Electronics</td>
<td>U3G1</td>
<td>0.00 to 0.03</td>
<td>0.00 to 5000.00 LBS.</td>
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<tr>
<td>Load Cell</td>
<td>56980</td>
<td>107</td>
<td>B.L.H. Electronics</td>
<td>U3G1</td>
<td>0.00 to 0.03</td>
<td>0.00 to 5000.00 LBS.</td>
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<tr>
<td>Load Cell</td>
<td>05198A</td>
<td>107</td>
<td>B.L.H. Electronics</td>
<td>U3G1</td>
<td>0.00 to 0.03</td>
<td>0.00 to 5000.00 LBS.</td>
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</table>
INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05221A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:

INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05263A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:

INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05266A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:
TEST # 5

<table>
<thead>
<tr>
<th>Event Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:04:30</td>
<td>FLAMES AROUND RELIEF VALVE</td>
</tr>
<tr>
<td>00:09:18</td>
<td>VALVE APPEARS TO BE VENTING. CONTENTS RUNNING OUT OF</td>
</tr>
<tr>
<td></td>
<td>TANK TOP</td>
</tr>
<tr>
<td>00:22:00</td>
<td>PLUME FIRE</td>
</tr>
<tr>
<td>00:28:53</td>
<td>CO2 APPLICATION #1</td>
</tr>
<tr>
<td>00:31:10</td>
<td>REKINDLE</td>
</tr>
<tr>
<td>00:32:00</td>
<td>CO2 APPLICATION #2</td>
</tr>
<tr>
<td>00:34:00</td>
<td>H2O COOL DOWN</td>
</tr>
<tr>
<td></td>
<td>TANK APPEARS INTACT</td>
</tr>
</tbody>
</table>

TYPE OF TANK: STEEL TANK
TANK CONTENTS: # 2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 20 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)
TEST # 6

TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 23 JUNE 1986

CAMERA LOCATION: MAINDECK

OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:13:23 POLE ACROSS PIT MOVED. TANK DID NOT APPEAR TO RUPTURE
00:33:06 ONLY FLAMES AROUND VALVE

CAMERA LOCATION: 03 DECK

TANK OBSCURED BY FLAMES/SMOKE. TANK DID NOT APPEAR TO FAIL
00:25:00 FLAMING AROUND VALVE - TOP OF TANK
TANK APPEAR INTACT
TANK TESTS

HEAT FLUX DATA
RADIANT HEAT
TANK TESTS

WEIGHT LOSS DATA TEST TANK

WEIGHT-LBS

0  5  10  15
Time (in Minutes)

Test -06- Channel 50
TEST # 7

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETHYL ALCOHOL
PAN FIRE SIZE: 100 SQ. FT.
NO VIDEO:
TANK TESTS

Test -07- Channel 50

WEIGHT LOSS DATA
TEST TANK
TEST # 8

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 28 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

SMOKE/FLAMES COMPLETELY OBSCURING TANK. CAMERA APPEARS TO BE TOO CLOSE - SMOKE BLOWING INTO LENS
00:12:00 TANK VISIBLE - APPEARS INTACT. APPEAR TO BE VAPORS FROM TANK - ON FIRE
00:13:50 VAPORS FROM VALVE FLAMING, PIT FIRE DYING DOWN
00:26:00 SMALL VAPOR FIRE FROM VALVE - PIT FIRE OUT
00:27:07 TANK EXTINGUISHED WITH CO2
00:27:09 FIRE OUT

CAMERA LOCATION: 03 DECK

00:02:16 RUPTURE (FROM VOICE - B. MCLAIN)
00:06:32 TANK VENTS FROM VALVE
00:06:56 PLUME FIRE (FROM VOICE - B. MCLAIN)
00:13:50 FLAME - TOP OF TANK - PIT FIRE DYING DOWN
00:26:24 PIT FIRE OUT - FLAME FROM TOP OF TANK
00:27:07 CO2 APPLICATION
00:27:09 FIRE OUT
TANK TESTS

IN-TANK PRESSURE DATA
TANK TESTS

WEIGHT LOSS DATA
TEST TANK

Test -08-  Channel 50

Time (in Minutes)
TANK TESTS

WEIGHT LOSS DATA
CARDOX TANK

WEIGHT - LBS

TIME (in Minutes)

43--08-049

B-24
TEST # 9

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 11 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK

OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:07:50 VENTED (TOP)
          FIRE PLUME
00:12:10 FIRE EXTINGUISHED

CAMERA LOCATION: 03 DECK

00:07:30 CAMERA OFF

CAMERA LOCATION: 04 DECK

00:07:30 CAMERA OFF
TANK TESTS

TIME/TEMPERATURE DATA

[Graph showing temperature over time for different tests and channels]
TEST # 10

TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 10 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:23:10 FIRE IMPINGING - VALVE LEAK AT BOTTOM
00:29:45 TANK TIPS TO ONE SIDE

CAMERA LOCATION: 03 DECK

00:23:11 TANK BOTTOM VALVE LEAK
00:29:46 TANK TIPS
00:46:03 FIRE ALMOST OUT
TANK TESTS

TIME/TEMPERATURE DATA
TEST # 11

TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
NO VIDEO:
TANK TESTS

IN-TANK PRESSURE DATA

Test 11, Channel 51
Test 11, Channel 52, Offset Voltage

Pressure (psi)

Time (in Minutes)
TANK TESTS

SUM OF CHANNELS 50 87 88 89

0 4000
3600
3200
2800
2400
2000
1600
1200
800
400

Time (in Minutes)

Test - 11 - Channel 86

WEIGHT LOSS DATA
TEST TANK
TEST # 13

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 28 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:38:48 TANK VENTS - FIRE PLUME - SAFETY
00:39:37 LIQUID STOPS - VAPOR STILL BURNING
00:44:50 AFFF APPLICATION

CAMERA LOCATION: 03 DECK

00:38:48 VENTS
00:39:36 LIQUID STOPS - VAPOR STILL BURNING
00:44:50 AFFF APPLICATION
TANK TESTS

IN-TANK PRESSURE DATA

TIME (in Minutes)

20.00
16.00
12.00
8.00
4.00
0.00

0
16
32
48

PRESSURE (psig)

B-45
TEST # 14

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 10 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

01:23:49 TANK VENTS (TOP)
01:25:30 EXTINGUISHMENT BEGAN

CAMERA LOCATION: 03 DECK
01:23:49 VENTS
01:25:33 EXTINGUISHMENT

CAMERA LOCATION: 04 DECK
01:23:49 VENTS
01:25:33 EXTINGUISHMENT BEGAN
TANK TESTS

TIME/TEMPERATURE DATA
TEST # 15

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 11 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

02:20:56 RELIEF GOES, RELEASES ETOH PLUME, NO VISIBLE FIRE
CAMERA LOCATION: 03 DECK

02:20:55 RELIEF FAILED - ETOH RELEASED, NO VISIBLE FIRE
CAMERA LOCATION: 04 DECK

02:20:55 RELIEF VALVE GOES - ETOH RELEASED, NO VISIBLE FIRE
TANK TESTS

IN-TANK PRESSURE DATA

Test -15- Channel 51
TANK TESTS

WEIGHT LOSS DATA
TEST TANK
TEST # 16

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 25 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

CAN'T TELL WHEN FAILURE OCCURRED
00:04:47 TOP BEGINNING TO GIVE
00:05:23 TOP OF TANK GONE
00:07:46 CO2 APPLICATION, FIRE NOT CONTROLLED
00:10:31 AFFF APPLICATION
00:10:50 FIRE UNDER CONTROL
00:15:00 REKINDLED

CAMERA LOCATION: 03 DECK

TANK OBSCURED BY FLAMES
CO2 APPLICATION
FLAMES OBSCURING CO2 APPLICATION
FIRE NOT CONTROLLED

00:10:31 AFFF APPLICATION
00:10:50 FIRE UNDER CONTROL
00:15:00 REKINDLED
TANK TESTS

WEIGHT LOSS DATA
CARDOX TANK

WEIGHT - LBS

TIME (in Minutes)

43--16-049
TEST # 17

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 15 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK

OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:03:54  TANK FAILED?
00:06:17  EXTINGUISHMENT
00:07:18  FIRE OUT

CAMERA LOCATION: 03 DECK

00:03:40  COLLAPSE (VOICE PER B. MCLAIN ON TAPE)
00:04:10  TANK FAILURE (VOICE)
00:06:17  EXTINGUISHMENT

CAMERA LOCATION: 04 DECK

00:03:40  FAILURE
00:06:14  EXTINGUISHMENT
TANK TESTS

TIME/TEMPERATURE DATA
TANK TESTS

TIME/Temperature Data

Time (In Minutes)

Test - 17 - Channel 45
Test - 17 - Channel 46
Test - 17 - Channel 47
Test - 17 - Channel 48
TANK TESTS

IN-TANK PRESSURE DATA
TEST # 19

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 26 JUNE 1986

CAMERA LOCATION: MAINDECK

OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

IMPOSSIBLE TO TELL WHEN FAILURE OCCURRED

00:04:50 AFFF APPLICATION
CONTROL TIME 1 MINUTE (SEE FROM TAPE)

00:22:35 REKINDLE

00:25:26 FIRST CO2 APPLICATION

00:27:30 FIRE OUT

00:27:50 SECOND CO2 APPLICATION

CAMERA LOCATION: 03 DECK

IMPOSSIBLE TO DISCERN TANK FAILURE

00:05:06 AFFF APPLICATION (CONTROL TIME 1 MINUTE 22 SECOND PER TAPE)

00:22:35 REKINDLE

00:27:41 CO2 APPLICATION (CONTROL TIME 21 MINUTES PER TAPE)
IN-TANK PRESSURE DATA
TEST # 22

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 1 JULY 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:18 TANK FAILED
00:39:30 CO2 APPLICATION, FIRE NOT EXTINGUISHED
00:50:37 PURPLE K APPLICATION, FIRE NOT EXTINGUISHED
00:56:53 H2O FOG APPLICATION
00:58:30 EXTINGUISHMENT

CAMERA LOCATION: 03 DECK

00:05:18 FAILURE
00:39:30 CO2 APPLICATION, FIRE UNDER CONTROL, NOT EXTINGUISHED
00:49:15 CO2 EXTINGUISHMENT (F&STD PERSONNEL)
00:50:35 PURPLE K APPLICATION, FIRE NOT CONTROLLED
00:56:52 H2O FOG APPLICATION
00:58:30 FIRE OUT
TANK TESTS

IN-TANK PRESSURE DATA
TEST # 23

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH 150 GALLONS
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 15 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:49 TANK APPEARS TO HAVE RUPTURED
00:12:05 EXTINGUISHMENT

CAMERA LOCATION: 03 DECK

00:04:49 TANK RUPTURES
00:09:31 TOP APPEARS CHARRED
00:21:01 FIRE IN TANK
00:12:05 EXTINGUISHMENT

CAMERA LOCATION: 04 DECK

00:04:48 TANK FAILED (00:04:50 VOICE)
00:09:33 TANK TOP APPEARS TO HAVE FAILED
00:12:05 EXTINGUISHMENT
TANK TESTS

IN-TANK PRESSURE DATA
TANK TESTS

RAD HEAT - BTU/SQFT/SEC

0.00 0.50 1.00

Time (in Minutes)

HEAT FLUX DATA
RADIANT HEAT

Test -23- Channel 53
Test -23- Channel 55
Test -23- Channel 56
TEST # 25

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 2 JULY 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:44 TANK FAILURE (BOTTOM)
00:08:00 TANK TOP ON FIRE
00:11:00 AFFF APPLICATION
00:11:45 FIRE CONTROLLED?
00:12:00 REKINDLE, EXTINGUISHMENT TIME 16 MINUTES

CAMERA LOCATION: 03 DECK

00:05:44 FAILURE
00:11:02 AFFF APPLICATION
00:11:52 REKINDLE
TANK TESTS

WEIGHT LOSS DATA
TEST TANK

Test -25- Channel 50
TEST # 26

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH 300 GALLON CENTER TANK, H2O 600 GALLON OUTBOARD
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 13 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:12 CENTER TANK FAILED
00:11:00タンク被覆される火炎
00:18:00 OUTER TANK TOP COLLAPSED

CAMERA LOCATION: 03 DECK

00:05:12 CENTER TANK FAILED (BOTTOM)
00:11:00 TOP OF CENTER TANK GONE
00:18:00 OUTER TANK TOP COLLAPSED

CAMERA LOCATION: 04 DECK

00:05:10 CENTER TANK FAILED (BOTTOM)
00:11:00 TOP OF CENTER TANK GONE
00:18:00 TOP OF OUTER TANK COLLAPSED
TANK TESTS

TIME/TEMPERATURE DATA

TIME (in Minutes)

TEMPERATURE DEG. C

43.1-26-045
43.1-26-046
43.1-26-047
43.1-26-048
IN-TANK PRESSURE DATA
TEST # 27

TYPE OF TANK: 2 POLYETHYLENE TANKS
TANK CONTENTS: #2 DIESEL 300 GALLONS, H2O 500 GALLONS OUTER TANK
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 8 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:08:42 TOP OF INBOARD (OUTER) TANK BULGES
00:08:53 TANK FAILS? (SMOKE)
00:14:30 TOP OF OUTBOARD TANK GONE
00:14:46 EXTINGUISHMENT BEGINS

CAMERA LOCATION: 03 DECK

FLAMES AND SPRAY OBSCURE TANKS THROUGH MOST OF TEST
00:08:10 TANK FAILED (INBOARD)
00:14:30 EXTINGUISHMENT BEGINS
00:15:00 FIRE UNDER CONTROL

CAMERA LOCATION: 04 DECK

00:02:12 SMOKE SHOWING
00:08:10 TANK FAILS
00:14:26 EXTINGUISHMENT BEGINS
00:15:00 FIRE UNDER CONTROL
TANK TESTS

WEIGHT LOSS DATA
TEST TANK
TEST # 29

TYPE OF TANK:   2 POLYETHYLENE TANKS
TANK CONTENTS:  #2 FUEL
PAN FIRE SIZE:  4 SQ. FT.
DATE OF TEST:   2 JULY 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS:   (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:51 INSIDE TANK FAILED
00:09:52 BOTH TANKS APPEAR TO HAVE FAILED
00:10:44 EXTINGUISHMENT BEGAN
00:17:30 REKINDLE

CAMERA LOCATION: 03 DECK

00:04:49 INSIDE TANK FAILED
00:09:18 OUTER TANK BLEW (VALVE?)
00:10:44 AFFF APPLICATION
00:18:33 REKINDLE
00:22:21 EXTINGUISHMENT
TANK TESTS

IN-TANK PRESSURE DATA

Pressure (psig)

Time (in Minutes)

Test - 29 - Channel 18
Channel 52