Environmental Protection Department
Operations and Regulatory Affairs Division

**Engineering Assessment
and Certification of Integrity
of the 490-Q1 Tank System**

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Acronyms

ACI	American Concrete Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CCR	California Code of Regulations
CFR	Code of Federal Regulations
EPD	Environmental Protection Department
LDF	Laser Demonstration Facility
LLNL	Lawrence Livermore National Laboratory
PE	Plant Engineering
PLC	Programmable Logic Controller
ppm	parts per million
psi	pounds per square inch
psig	pounds per square inch gage
PPE	Pulse Power Electronics
PVDF	Polyvinylidene Fluoride
RCRA	Resource Conservation and Recovery Act
TCLP	Toxicity Characteristic Leaching Procedure

Engineering Assessment and Certification of Integrity of the 490-Q1 Tank System

Background

This Engineering Assessment and Certification of Integrity of used freon storage tanks 490-Q1A1 and 490-Q1A2 has been prepared in response to 40 CFR 265.192(a) and 22 CCR 66265.192(a) for new tank systems* that store hazardous waste and have secondary containment. The regulations require that this assessment be completed and certified by an independent, qualified, California-registered professional engineer before the tank system is placed in use as a hazardous waste storage tank system. The technical assessments for the 490-Q1A1 and 490-Q1A2 tank systems have been reviewed by an independent, qualified, California-registered professional engineer, who has certified that the tank systems have sufficient structural integrity, are acceptable for transferring and storing hazardous waste, are compatible with the stored waste, and the tanks and containment system are suitably designed to achieve the requirements of the applicable regulations so they will not collapse, rupture, or fail. This document will be kept on file by the Lawrence Livermore National Laboratory (LLNL) Environmental Protection Department.

* *Tank system* is defined in 40 CFR 260.10 as "one hazardous waste storage tank and its associated ancillary equipment and containment system." In the text of this report, *tank system* is used to include all the tanks and associated ancillary equipment (e.g., "the 490-Q1 tank system"). For statements regarding the certification of a hazardous waste storage tank system, the legal definition of a *tank system* is used to refer to "one hazardous waste storage tank and its associated ancillary equipment and containment system."

Description of the 490-Q1 Tank System

The Laser Demonstration Facility (LDF) within LLNL's Building 490 utilizes the 490-Q1 used freon tank system. The tank system, located north of Building 490's east end, is part of a freon purification system. The tank system collects and stores potentially hazardous used freon generated from research activities conducted by the LDF. The 490-Q1 tank system consists of two aboveground epoxy-lined carbon steel tanks, one 2,000 gallon (490-Q1A1) and one 400 gallon (490-Q1A2), within an epoxy-coated, bermed, reinforced-concrete secondary containment area; ancillary equipment, including pumps, valves, and aboveground piping; and an automatic leak monitoring system. A programmable logic controller (PLC) controls the leak monitoring system and freon transfers to and from the two aboveground tanks. Referenced drawings are contained in Appendix A.

Used freon results from the servicing of portable electronics equipment used in research activities within the east end of Building 490. Freon serves as a heat transfer fluid for the electronics equipment. Equipment is brought into the service area and, if the freon is acidic, dirty, or contaminated with water, then freon is pumped to 490-Q1A1. The used freon is pumped through a 1-1/2-inch diameter carrier pipe into the used freon storage tank, 490-Q1A1, by freon transfer pump P-FRT-1001, as shown on LLNL drawings AAA 91-101742-OA, AAA 91-102775-OA, and AAA 90-107676-OB. The carrier pipe is constructed of stainless steel within Building 490, while carbon steel carrier pipe is used in the outside bermed reinforced-concrete secondary containment area. The carbon steel portion and stainless steel portion are labeled as "1-1/2"-FRS-BS3" and "1-1/2"-FRT-SS," respectively, on LLNL drawings. The carrier pipe, supported by pipe supports as shown on LLNL drawings AAA 91-102775-OA, AAA 91-105048-OO, AAA 91-105049-OO, AAA 91-105050-OO, AAA 91-105051-OO, and AAA 91-105052-OA, extends through the north wall of Building 490 and over the south berm wall of the secondary containment area. The carrier pipe is secondarily contained by a carbon steel pipe from the indoor trench (located inside Building 490) to the bermed reinforced-concrete secondary containment area, as shown on LLNL drawings AAA 91-105047-OA and AAA 91-105049-OO. No portions of the used freon carrier pipe are in contact with soil. All portions are aboveground and visible except for the portion inside the secondary containment pipe, shown on LLNL drawings AAA 91-105046-OO and AAA 91-105047-OA.

Used freon tank 490-Q1A1, which is a horizontally-mounted cylindrical tank, is also labeled "T-9101." It is shown on LLNL drawings AAA 91-105046-OO, AAA 91-105047-OA, AAA 91-105048-OO, AAA 91-105050-OO, AAA 91-105052-OA, AAA 91-105973-OA, and PLE 90-490-110D. The required capacity of the tank was determined by a projected used freon generation rate of 400 to 500 gallons per week, or approximately 2,000 gallons per four week period. Contents from the used freon storage tank are pumped to the vertically-mounted cylindrical batch tank, 490-Q1A2, or "T-9102," as shown on LLNL drawings AAA 91-105046-OO, AAA 91-105047-OA, AAA 91-105048-OO, AAA 91-105051-OO, AAA 91-105052-OA, and AAA 91-105972-OA. Batch tank 490-Q1A2 stores the used freon before it is purified and reused.

The freon recycling system is designed to process freon at a rate of 25 gallons per hour for up to 16 hours, with present plans to operate eight hours per day. Thus, one batch consists of approximately 200 gallons, and the system is expected to operate twice a week for a total output of 400 gallons per week. As the system purifies freon, waste products in the form of freon and brine are produced. For every batch of freon that is processed, seven gallons of waste are produced. The waste is transferred to appropriately sized steel drums and disposed of in accordance with LLNL hazardous waste handling procedures.

Used freon tank 490-Q1A1 has two dry-disconnect couplings, one for vapor and one for liquid, that serve as truck connections when it is necessary to ship used freon offsite. Used freon

would be transferred by the same pump that transfers used freon to the 400-gallon batch tank, 490-Q1A2. The pump, shown in Figure 1, is labeled as "P-9101" on LLNL drawings AAA 91-105046-OO, AAA 91-105047-OA, AAA 91-105048-OO, and AAA 91-105050-OO. Additionally, pump P-9101 is capable of recirculating the contents in the used freon tank prior to a representative sample being taken from the tank for analysis. In the event that the processed freon fails purity tests, tank 490-Q1A1 has the ability to receive freon directly from the 400-gallon batch product tank, 490-V1A2, that stores freon after it has been purified by the purifier system.

Batch tank 490-Q1A2 receives used freon from tank 490-Q1A1 and meters it into the freon purification system. Freon is metered from 490-Q1A2 to the purification system by pump P-9001, after the system operator has started the purifier. Pump P-9001 is shown on LLNL drawings AAA 91-105046-OO, AAA 91-105047-OA, AAA 91-105048-OO, and AAA 91-105051-OO. Tank 490-Q1A2 also collects condensed freon from the freon system's vapor condenser.

The Gems Model ALSP-800 liquid-level switches, used for tanks 490-Q1A1 and 490-Q1A2, transmit their signals to the monitoring system control panel. The control panel is located in the same bermed reinforced-concrete secondary containment area as the tanks. Tank liquid levels are indicated for three levels as shown in Table 1.

Table 1. Tank liquid levels indicated by level switches.

Liquid Level	Indicated Level Capacities (gallons)	
	Used Freon Tank 490-Q1A1	Batch Tank 490-Q2A1
Low	69	24
High	2,215	423
High-High	2,298	446

A low liquid-level signal will cause the PLC to shut off pumps P-9001 and P-9101, while the high and high-high liquid-level signals will terminate all freon transfers into the tanks. In addition to stopping freon transfer, a high-high liquid-level signal will notify the system operator that the first high liquid-level sensor failed. The PLC screen will flash as an indication of the alarm condition. An outdoor beacon light also illuminates and an indoor audible alarm sounds in the Pulse Power Electronics (PPE) Room and Laser Workstation Room of Building 490.

Leak detection for aboveground used freon storage tanks 490-Q1A1 and 490-Q1A2 is accomplished by visual inspection, a weight monitoring system, and a freon vapor detection system. With the exception of the areas in direct contact with the two tank support saddles, the entire exterior surface of used freon tank 490-Q1A1 is visible from within the bermed reinforced-concrete secondary containment area. Because the saddles are constructed of steel plate that contain no void spaces, any leaks along the tank saddle contact area would be evident at the ends or bottom of the support saddles. Tank 490-Q1A2 is supported by four rectangular legs, and like tank 490-Q1A1, the entire surface of the tank is visible from within the bermed area, except the areas in direct contact with the four support legs. Any leaks would be evident along the sides or at the bottom of the support legs. Any leaks from the tanks would be contained by the epoxy-coated reinforced-concrete secondary containment berm, and liquid would drain into the west sump located adjacent to used freon tank 490-Q1A1 as shown on LLNL drawings AAA 91-105046-OO, AAA 91-105048-OO, AAA 91-105050-OO, PLE 90-490-110D, and PLS 90-490-048D.

The weights of the two tanks are monitored by the freon system PLC. Signals from the four load cells monitoring the weight of tank 490-Q1A1 and the platform scale monitoring the weight of tank 490-Q1A2 are sent to the PLC. The PLC will sound an alarm if the weight of one of the tanks changes by 50 pounds or more from the last freon transfer. Additionally, five freon vapor detection sensors are located within the bermed reinforced-concrete secondary containment area. A sensor is also located in the trench area inside Building 490 where the secondary containment piping for the carrier pipe ends. The secondary containment piping drains into the trench, and the freon vapor detector is located eighteen inches from the end of the piping. A typical vapor detector sensor is shown in Figure 2. The vapor detection system will activate a local alarm and alarm to the PLC. A beacon light will be activated if a leak is detected in the secondary containment area, and an indoor audible alarm will sound if the detected leak is in the trench area. The PLC will alarm to the PPE Room, LDF Control Room, and Laser Workstation Room in Building 490 if it detects freon vapors at 501 to 1000 parts per million (ppm). At a detection level of 1001 ppm or above, the same functions are performed by the PLC in addition to terminating all freon transfers within or into the area where freon vapor is detected.

Used freon storage tank 490-Q1A1 and batch tank 490-Q1A2 and their associated ancillary equipment are secondarily contained by an epoxy-coated, reinforced-concrete bermed area that is 59.5 feet by 22 feet by 18 inches to 21 inches deep, and which is covered by a canopy (the canopy was not completed when the photographs in Figure 3 and Figure 4 were taken). The bermed reinforced-concrete secondary containment area is located north of the east end of Building 490 as shown on LLNL drawings AAA 91-105046-OO, AAA 91-105047-OA, and PLE 90-490-110D. It is adjacent to another bermed reinforced-concrete secondary containment area that contains the 490-Q2 used freon tank system. Within the 490-Q1 bermed area are two sumps, both of which must be pumped out manually. During heavy rains, the sumps are inspected every 24 hours to check rainwater accumulation. Used freon storage tank 490-Q1A1 and batch tank 490-Q1A2 and some of their associated equipment are shown in Figure 3 and Figure 4, respectively. Tank 490-Q1A1 is bolted to four load cells that are bolted to the reinforced-concrete base of the bermed area as shown in Figure 5. Tank 490-Q1A2 is bolted to a platform scale that is bolted to the reinforced-concrete pad. The platform scale is shown in Figure 6. A tank foundation plan and sections are shown on LLNL drawings PLS 90-490-048D, PLS 90-490-049D, and PLS 90-490-050D.

Figure 1. Freon transfer pump P-9101.

Figure 2. Typical vapor detector sensor associated with the 490-Q1 tank system.

Figure 3. Elevation view, looking east, of aboveground used freon tank 490-Q1A1.

Figure 4. Elevation view, looking south, of aboveground batch freon tank 490-Q1A2.

Figure 5. Typical load cell associated with used freon storage tank 490-Q1A1.

Figure 6. Platform scale associated with batch tank 490-Q1A2.

Technical Certification of the 490-Q1A1 Tank System

As required by 40 CFR 265.192(a) and 22 CCR 66265.192(a), the 490-Q1A1 tank system has been found to have sufficient structural integrity and is acceptable for the transferring and storing of hazardous waste. The tank and containment system are adequately designed to achieve the requirements of the applicable regulations. This certification is valid only as long as the tank system is operated and maintained in accordance with applicable regulations for hazardous waste storage tank systems.

David A. Graser
California-Registered Professional Engineer
Science Applications International Corporation

7/7/93
Date

Technical Certification of the 490-Q1A2 Tank System

As required by 40 CFR 265.192(a) and 22 CCR 66265.192(a), the 490-Q1A2 tank system has been found to have sufficient structural integrity and is acceptable for the transferring and storing of hazardous waste. The tank and containment system are adequately designed to achieve the requirements of the applicable regulations. This certification is valid only as long as the tank system is operated and maintained in accordance with applicable regulations for hazardous waste storage tank systems.

David A. Graser
California-Registered Professional Engineer
Science Applications International Corporation

Date

Tank System Data Sheet for 490-Q1A1

EPD tank identification number:	490-Q1A1
PE tank identification number:	490-TCH02
Reference number on LLNL drawings:	T-9101
Tank volume:	2,000 gallons (nominal) 2,315 gallons (maximum capacity)
Dimensions:	Approximately 168 inches in length and 66 inches in diameter
Tank manufacturer:	Steel Structures, Inc.
Tank serial number:	143
Primary tank material:	Carbon steel
Thickness of the primary tank material:	1/4 inch
Liner material:	Plasite 7122 Hi-Solids Epoxy coating
Thickness of liner material:	12 mils
Secondary containment material:	Reinforced concrete berm
Secondary containment coating:	Cordulite Hi-Build Epoxy
Secondary containment dimensions:	59 feet 6 inches x 22 feet x 1 foot 6 inches
Secondary containment volume:	Approximately 13,000 gallons
Operating pressure:	Atmospheric
Seismic zone:	Zone 4
Stored material:	Used freon 113
Date of installation:	December 11, 1992 (Beneficial Occupancy)
Placed in service:	July 1, 1993 (scheduled)

Tank System Data Sheet for 490-Q1A2

EPD tank identification number:	490-Q1A2
PE tank identification number:	490-TCH04
Reference number on LLNL drawings:	T-9102
Tank volume:	400 gallons (nominal) 470 gallons (maximum capacity)
Dimensions:	Approximately 68 inches in height and 48 inches in diameter
Tank manufacturer:	Steel Structures, Inc.
Tank serial number:	139
Primary tank material:	Carbon steel, epoxy-lined
Thickness of the primary tank material:	1/4 inch
Liner material:	Plasite 7122 Hi-Solids Epoxy coating
Thickness of liner material:	12 mils
Secondary containment material:	Reinforced concrete berm
Secondary containment coating:	Cordulite Hi-Build Epoxy
Secondary containment dimensions:	59 feet 6 inches x 22 feet x 1 foot 6 inches
Secondary containment volume:	Approximately 13,000 gallons
Operating pressure:	Atmospheric
Seismic zone:	Zone 4
Stored material:	Used freon 113
Date of installation:	December 11, 1992 (Beneficial Occupancy)
Placed in service:	July 1, 1993 (scheduled)

Design Standards

Tanks

Aboveground used freon tank 490-Q1A1 and batch tank 490-Q1A2 were fabricated by Steel Structures, Inc. The tanks are constructed of welded carbon steel plate in accordance with the 1989 American Society of Mechanical Engineers (ASME) Code, Section VIII, Division 1, *Pressure Vessels*. The walls of each tank are 1/4-inch thick, and the interiors are coated with Plasite 7122 Hi-Solids Epoxy to 12 mils dry film thickness (approximately 1/20-inch). Used freon tank 490-Q1A1 is 66 inches in diameter, approximately 168 inches in length, has a capacity of 2,315 gallons, and weighs approximately 4,300 pounds when empty. Two steel saddles constructed of 1/4-inch-thick plate support the tank and are welded to its sides and lower half of the tank along its circumference. The saddles are mounted to four load cells that are anchored to the concrete foundation. A longitudinal view and end section view of the steel storage tank are shown on LLNL drawing AAA 91-105973-OA (which is Steel Structures, Inc. drawing 1569a-3) in Appendix A. Batch tank 490-Q1A2 is 48 inches in diameter, approximately 68 inches in height, has a capacity of 470 gallons, and weighs approximately 1,800 pounds when empty. Four rectangular steel legs constructed of 1/4-inch-thick square tubing support the tank. A 12-inch length of each tank leg is welded to the tank. The tank legs are mounted to a scale platform that is anchored to the concrete foundation. An elevation view and top view of tank 490-Q1A2 are shown on LLNL drawing AAA 91-105972-OA (which is Steel Structures, Inc. drawing 1569a-1) in Appendix A.

Concrete

The 490-Q1 used freon tank system secondary containment consists of a 59.5-foot by 22-foot by 12-inch-thick (minimum) slab of reinforced concrete surrounded by an 8-inch-thick reinforced concrete wall. The perimeter wall is 18 inches in height. The volume of the secondary containment is approximately 13,000 gallons. The concrete pad within the bermed area declines 3 inches from the perimeter to the two sump areas. The dimensions of the bermed reinforced-concrete secondary containment area and the placement of the retention tanks are shown on LLNL drawing PLE 90-490-110D. A portion of the bermed concrete secondary containment area and installed used freon storage tank (490-Q1A1) are shown in Figure 3.

All concrete structures associated with the 490-Q1 tank system were designed and installed in accordance with American Concrete Institute (ACI) Specification 318, *Building Code Requirements for Reinforced Concrete*, Uniform Building Code of 1988, and LLNL Standards. All steel reinforcing bars conform to American Society of Testing and Materials (ASTM) A615, Grade 60, *Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement*. The welded wire fabric conforms to ASTM A82, *Standard Specification for Steel Wire, Plain, for Concrete Reinforcement*. Structural steel conforms to ASTM A36, *Standard Specification for Structural Steel*, and anchor bolts conform to ASTM A307, *Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength*. The concrete was specified and constructed with a 28-day compressive strength of 4,000 pounds per square inch. Sections of the tank foundation and sumps, showing the dimensions and placement of the concrete reinforcing bar, are shown on LLNL drawing PLS-90-490-049D.

Seismic and Wind Restraints

Tanks 490-Q1A1 and 490-Q1A2 are provided with wind load and Zone 4 seismic restraints to prevent permanent displacement in any direction by wind, lateral motion, overturning, or uplift equal to or greater than those recommended for a low-hazard facility. Seismic and wind restraint guidelines for a low-hazard facility are promulgated in the 1991 Uniform Building Code.

The two saddles of used freon tank 490-Q1A1 are connected to four load cell assemblies (a load cell assembly consists of an adapter plate, load cell, and foundation plate with their associated bolts). The bottom of each saddle is bolted to an adapter plate by four 3/4-inch diameter bolts; two 13/25-inch diameter bolts connect the adapter plate to its load cell. A foundation plate is bolted to the load cell by four 5/8-inch diameter bolts and mounts the load cell with four 1-inch diameter adhesive anchor bolts to the concrete foundation. The load cell assemblies secure tank 490-Q1A1 against wind or seismic forces. The load cell assemblies are built by BLH Electronics, Co. Load cell Model KIS-1 with a 11,200-pound capacity is used in this application, and it has a seismic overload capacity in the vertical direction of three times the rated capacity or 33,600 pounds, and in the horizontal direction of two times the rated capacity or 22,400 pounds. The 1-inch diameter adhesive anchor bolts are embedded 9 inches (minimum) into the concrete pad.

The four legs of batch tank 490-Q1A2 are connected to a 10,000-pound capacity Flexweigh Model FLB4848 rectangular platform scale. Each leg is attached to the scale by two 3/4-inch diameter bolts. There are four seismic brackets, constructed of 3/4-inch-thick carbon steel plate, that allow the scale to move during operation but limit its movement during an earthquake. Each bracket encloses one corner of the platform scale and is anchored to the concrete pad by five 3/4-inch diameter adhesive anchor bolts that are embedded 6-5/8 inches (minimum) into the concrete. LLNL drawing PLS 90-490E-049D gives the seismic loading criteria for the concrete. Appendix B contains seismic analysis information and the seismic calculations provided by the tank supplier and the LLNL Mechanical Engineering Department for tanks 490-Q1A1 and 490-Q1A2.

Piping

Used freon piping within the east end of Building 490 is constructed of Schedule 40S stainless steel, while the piping outside the building is constructed of Schedule 80 carbon steel. Stainless steel is used inside Building 490 due to the necessity for cleanliness. Since stainless steel corrodes from contact with acidic freon, the stainless steel piping will be flushed with clean freon whenever acidic freon is pumped through it. A carbon steel pipe secondarily contains the pipe carrying used freon from Building 490 to the edge of the bermed reinforced-concrete secondary containment area that holds the used freon storage tank 490-Q1A1. The secondary containment piping is a 4-inch diameter pipe housing the carrier pipe. The secondary containment piping terminates at the trench within the building and where the carrier pipe goes over the wall of the bermed reinforced-concrete secondary containment area. Any leaks captured by the secondary containment piping will drain into the trench. Flex connections between the pipes and tanks 490-Q1A1 and 490-Q1A2 are Titeflex teflon hoses with stainless steel braid. Truck connections associated with the 490-Q1 tank system are OPW two-inch Kamvalok Adaptor Model 1611A and 1-1/4-inch Model 633-D coupler. The Mueller Model 758 strainer used in the system is a "Y" strainer made of cast iron with a monel screen which has 1/16-inch diameter perforations.

Backfill and Foundations

The backfill material for the soil foundation of the 490-Q1 tank system consists of 6 inches of porous, noncorrosive, Class II aggregate base. The soil below the aggregate base has been compacted to 95% relative compaction. A 10-mil vapor barrier covers the aggregate base, and a 2-inch sand layer covers the vapor barrier. LLNL drawing PLS 90-490E-049D shows the engineered backfill, aggregate base, vapor barrier, and foundation sections.

Pumps

Three pumps are associated with the 490-Q1 tank system: spent freon pump P-9101, batch tank pump P-9001, and spent freon transfer pump P-FRT-1001 that is located within Building 490. Pump P-9101, a March Manufacturing Inc. Model TE-8K-MD, is a 60-cycle, three-phase, magnetic drive pump with a Viton O-ring seal. It delivers 20 gallons per minute at 90 feet of head. Pump P-9001, a March Manufacturing, Inc. Model TE-5.5K-MD, is a 60-cycle, single-phase, magnetic drive pump with a Viton O-ring seal. It delivers 18.2 gallons per minute at 20 feet of head. Both March pumps are constructed of polyvinylidene fluoride (PVDF). Transfer pump P-FRT-1001, a Wilden Pump and Engineering Co. Model M4/KO, is a diaphragm pump that delivers 25 gallons per minute at 90 feet of head.

Valves

The valves installed in the 490-Q1 tank system have a working pressure of at least 150 pounds per square inch gage (psig) at 70°F. All air-operated valves are spring-loaded and fail closed except the vent valve, which fails open. All ball valves are constructed of Schedule 80 carbon steel with monel balls. All valves used for the control air system are constructed of bronze and have a 600 psig rating. Monel gage and needle valves and carbon steel check valves are used in the 490-Q1 tank system. Gaskets are Garlock teflon gaskets.

Control Panels and Instrumentation

The Allen-Bradley Model 5/60L PLC controls used freon transfers and the leak monitoring system for the 490-Q1 tank system. An operator inputs the volume of freon to be transferred, and the PLC executes the instructions. When freon transfers occur, the PLC will open and close valves, turn on and off pumps, and record and print scale weights. Under alarm conditions, the PLC will activate a light beacon and sound an audible alarm. The alarm beacons and audible alarms are located in the bermed reinforced-concrete secondary containment area and in the PPE and LDF rooms of Building 490. Control signals from the level switches of 490-Q1A1 and 490-Q1A2 are sent to the PLC as well. The PLC, scales, and vapor detection system are on generator emergency backup power.

Hazardous Characteristics of Contained Waste

The 490-Q1 used freon tank system collects and stores potentially hazardous spent freon from research activities in Building 490. The spent freon is purified by the recycling system located east of the two used freon tanks (490-Q1A1 and 490-Q1A2) in the same secondary containment area in which the tanks are contained. Expected average concentrations of contaminants and pH of the used freon are provided in Table 2.

Table 2. Components of the contained (used freon) waste.

Chloride	0.28 ppm	Chloride plus Chlorine	1.64 ppm
Fluoride	0.08 ppm	Fluoride plus Fluorine	0.97 ppm
pH (typical)	3.0 -6.0		

The liquid waste (used freon) in the 490-Q1 used freon tank system does not exhibit the characteristics of ignitability, as defined in 40 CFR § 261.21, or of reactivity, as defined in 40 CFR § 261.23, or of TCLP toxicity, as defined in 40 CFR § 261.24, and is not listed in "Subpart D—Lists of Hazardous Wastes" of 40 CFR § 261.33. The liquid waste (used freon) in the 490-Q1 tank system does have the potential to be corrosive, as defined in 40 CFR § 261.22, if the pH becomes less than or equal to 2.0 or greater than or equal to 12.5. However, liquid waste (used freon) is expected to have a typical pH range of 3.0 to 6.0.

Based upon the characteristics of the liquid waste (used freon) described above, and the composition and thickness of the tank system materials, used freon tanks 490-Q1A1 and 490-Q1A2 in the 490-Q1 tank system are deemed compatible with their contained waste.

Corrosion Protection Measures

All components of the 490-Q1 tank system subject to potential corrosion are fabricated of corrosion-resistant materials or are sufficiently protected from corrosion through administrative controls. The latter is illustrated by the flushing of clean freon after acidic freon has been transferred through the stainless steel pipe. The estimated annual corrosion rate for the materials described below that are exposed to air and to the expected tank contents is negligible. Because no metal components are in contact with soil, no additional corrosion protection is required.

Tanks

Used freon storage tank 490-Q1A1 and batch tank 490-Q1A2 are constructed of 1/4-inch-thick carbon steel with an epoxy interior coating. The tanks are designed with a 1/8-inch corrosion allowance. Based on the manufacturer's literature, materials used in the manufacture of the tanks are chemically resistant to the stored used freon. However, daily visual inspection will be performed to check the integrity of the tanks.

Piping, Pumps, and Concrete

All used freon piping associated with the 490-Q1 tank system is manufactured of carbon or stainless steel. Stainless steel piping is used within Building 490 since cleanliness is desired. However, stainless steel is susceptible to corrosion by chlorides in acidic freon. To prevent piping corrosion from occurring, the stainless steel piping will be flushed with clean non-acidic freon after acidic freon is pumped through the piping. All gaskets, valves, seals, and fittings associated with the 490-Q1 system that come in contact with the stored or transported used freon are fabricated of compatible corrosion-resistant materials. No metal components are in contact with used freon in the transfer pumps. Interior surfaces of the reinforced-concrete containment area that could potentially come in contact with the stored used freon are coated with a corrosion-resistant epoxy coating.

Age of Tank System

Construction of the 490-Q1 used freon tank system was completed on December 11, 1992. The construction manager for the 490-Q1 used freon tank system accepted the system from the subcontractor on behalf of the University of California, Lawrence Livermore National Laboratory, on December 11, 1992. A copy of the Final Acceptance Report is provided in Appendix C.

Certification of the 490-Q1A1 Tank System

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

7-15-93

Dennis K. Fisher
Associate Director
Plant Operations
Lawrence Livermore National Laboratory

Date

Certification of the 490-Q1A2 Tank System

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Dennis K. Fisher

7-15-93

Dennis K. Fisher
Associate Director
Plant Operations
Lawrence Livermore National Laboratory

Date

References

1. ACI 318, *Building Code Requirements for Reinforced Concrete*, American Concrete Institute.
2. ASME Section VIII, Division 1, *Pressure Vessels*, American Society of Mechanical Engineers.
3. ASTM A36, *Standard Specification for Structural Steel*, American Society for Testing and Materials.
4. ASTM A82, *Standard Specification for Steel Wire, Plain, for Concrete Reinforcement*, American Society for Testing and Materials.
5. ASTM A307, *Standard Specification for Carbon Steel, Bolts and Studs, 60,000 psi Tensile Strength*, American Society for Testing and Materials.
6. ASTM A615, *Deformed and Plain Billet-Steel Bars For Concrete Reinforcement*, American Society for Testing and Materials.
7. UBC, *Uniform Building Code (1991)*.
8. UBC, *Uniform Building Code (1988)*.
9. California Code of Regulations, Title 22, Division 4.5, Article 10, *Tank Systems*, Sections 66265.190 through 66265.196.
10. Code of Federal Regulations, Title 40, Part 265, Subpart J, 265.190 through 265.196.

Appendix A

Drawings for the 490-Q1 Tank System

Appendix A lists the LLNL drawings for the 490-Q1 used freon tank system. The drawing numbers preceded by a ✓ are referenced in the text and included herein.

AAA 90-107676-OB (Sheets 1 to 2)	P&ID, Freon System, PPE Refurb, 490E
AAA 91-101742-OA	PPE Refurb Room 1424, Arrangement
✓ AAA 91-102775-OA (Sheets 1 to 4)	PPE Refurbishment Room 1424, Trench Piping Composite Drawing
AAA 91-103233-OO (Sheets 1 to 2)	Utility Piping, Freon, Workstation
AAA 91-103878-OO (Sheets 1 to 2)	Utility Piping, Drain/Fill Station
AAA 91-104204-OO (Sheets 1 to 4)	Utility Piping, Freon, Transfer Station
✓ AAA 91-105046-OO	Equipment Arrangement
✓ AAA 91-105047-OA	Piping & Instrument Diagram
✓ AAA 91-105048-OO	Freon Purification - Plan
✓ AAA 91-105049-OO	Freon Purification - Plan
✓ AAA 91-105050-OO	Freon Purification - Sections
✓ AAA 91-105051-OO	Freon Purification Sections & Details
✓ AAA 91-105052-OA	Freon Purification-Piping Details
✓ AAA 91-105972-OA (Steel Structures, Inc. drawing 1569a-1)	Fabrication Details, Tank T-9102
✓ AAA 91-105973-OA (Steel Structures, Inc. drawing 1569a-3)	Fabrication Details, Tank T-9101
✓ PLE 90-490-110D	Building System & Equipment Grounding - Freon Purification System

✓ PLS 90-490-048D

Tank Pad & Canopy Foundation - Freon
Purification System

✓ PLS 90-490-049D

Tank Pad Sections, Details & General
Concrete Notes - Freon Purification System

✓ PLS 90-490-050D

Tank Pad Miscellaneous Sections - Freon
Purification System

ENLARGED PARTIAL PLAN
SCALE: 3"=1'-0"

REVISIONS				
NO.	LET	DESCRIPTION	DATE	BY
1	A	REMOVED MOLDS COMPLETED PIPING AROUND CLEAN STORAGE TR; ADDED MISC. DETAILS SECTIONS; AS BUILT PIPING GENERAL REVISIONS.	4/25/91	3RE

COPIES OF THIS WORK CLASSIFIED AT THE LAWRENCE LIVERMORE NATIONAL LABORATORY UNDER CONTRACT W-7400-ENG-48 BETWEEN THE UNIVERSITY OF CALIFORNIA AND THE U.S. DEPARTMENT OF ENERGY (DOE).

UPON COMPLETION OF ANY DEVELOPMENT OF THE WORK, THE UNIVERSITY OF CALIFORNIA WILL ASSIGN TO AND TRANSFER TO THE UNIVERSITY OF CALIFORNIA ALL RIGHTS, TITLE AND INTEREST IN AND TO THE WORK, AS "EMPLOYMENT INVENTIONS OF THE UNIVERSITY OF CALIFORNIA 1981". ADDITIONALLY, THE PROFESSOR IS NOT TO FURTHER TRANSFER THE WORK OR ANY INFORMATION THEREFROM WITHOUT PERMISSION FROM THE TECHNOLOGY SUPPORT OFFICE OF LAMARCA'S UNIVERSITY REGIONAL LABORATORY. USE OF THE WORK OR DERIVATIVE WORKS IS LIMITED TO RESEARCH, DEVELOPMENT AND SHARING AND THE WORK SHOULD BE CONSIDERED UNPUBLISHED WORK. IF THE WORK IS PUBLISHED, THE UNIVERSITY OF CALIFORNIA WILL BE NOTIFIED AND THE WORK SHOULD BE RETURNED IMMEDIATELY TO LAMARCA'S UNIVERSITY REGIONAL LABORATORY PRIOR TO ANY USE.

DETAIL 1
SCALE: 3" = 1'-0"

DETAIL 9
SUMP TANK LEVEL SWITCH
SCALE: 3/4" = 1'-0"

DETAIL 10
MAIN LINE DRAIN DETAIL
SCALE: 3"=1'-0"

PIPING FABRICATION NOTES

- 1 PIPING CONSTRUCTION SHALL BE IN ACCORDANCE WITH AWS: B31.1-1989 EDITION POWER PIPING CODE
- 2 SYSTEM PIPING MATERIAL SHALL BE AT LEAST WORKING PRESSURE (MAWP) 100 PSI
- 3 PIPING MATERIAL SA2 773421 73304 216 STAINLESS STEEL (ASTM A289), SCHEDULE 40S
- 4 ALL WELDED PIPE JOINTS SHALL BE V-GROOVE OR BEVEL GROOVE OPEN BUTT JOINT DESIGN AND SHALL BE WELDED IN ACCORDANCE WITH WELDING PROCEDURE SPECIFICATION WPS-55-034, WPS-55-017, WPS-55-016 ALL WELDING SHALL BE ACCOMPLISHED BY QUALIFIED AND CERTIFIED WELDERS USING APPROVED PROCEDURES
- 5 BEFORE WELDING, ALL PIPING SURFACES SHALL BE CLEANED OF ALL FOREIGN MATERIALS SUCH AS GREASE, DUST, OXIDES, AND SULFIDES
- 6 PIPE JOINTS SHALL BE LEAK TESTED USING A LIQUID MASS SPECTROMETER LEAK DETECTOR. LEAKAGE SHALL BE LESS THAN 1.110-6 STD CC/SEC HELIUM WHEN THE PIPING IS EVACUATED TO A PRESSURE OF 1 MTORR (OR DEPRESSURIZED WITH HELIUM AT 4 PSI) USING PROBE MODE
- 7 A HYDROSTATIC PRESSURE TEST SHALL BE CONDUCTED ON THE PIPING SYSTEM USING CLEAN WATER. ALL PIPING SHALL BE PRESSURE TESTED AT 150 PSI AND MAINTAINED FOR A MINIMUM OF 10 MINUTES

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	STUDENT NAME STUDENT ID NO.	DATE TIME BY	PPE REFORMULISM-ROOM 1424 TRENCH PIPING COMPOSITE DRAWING
	ADDRESS CITY STATE ZIP	10/10/77 10:00 AM 10/10/77	51 1000F AAA91-102775 1-0A
	SIGNATURE	10/10/77	10/10/77

SCALE P1

1
(F)

DETAIL 6
SCALE: 3'-0"

J-J
SCALE: 3" = 1'-0"

DETAIL 7
SCALE: 3"=1'-0"

K-K
SCALE: 3"=1'-0"

PLAN
SCALE: $\frac{3}{4}'' = 1' - 0''$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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- NOTES**
UNLESS OTHERWISE SPECIFIED:
1. ALL DIMENSIONS ARE IN INCHES.
 2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
 3. SURFACE TEXTURE PER ANSI B46.1-1978.

NOTE:
REFER TO PIPING & INSTRUMENT
DIAGRAM AAA-1-108047 AND
SPECIFICATION NO. B11004 FOR
LEGEND, SYMBOLS AND PIPE
MATERIAL SPECIFICATIONS.

MATERIAL	SPEC NO	ITEM
EQUIPMENT ARRANGEMENT		
GPP FREON SYSTEM, 490 EAST		
DRAWING NO		
AAA 91-105046-00		
SCALE 5'-4" = 1' SHEET OF

A	at 1000	DATE 10-0-00
100	1000	DATE 10-0-00

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.

NOTES

1. FOR SYMBOLS, LEGEND AND ABBREVIATIONS SEE (MWA 444 88-10519-0A, SHEET 1, 2 & 3, AND LEGEND BELOW)
FRC FLUOR FROTH
FRC SPENT FROTH
FRC FROTH (PERSISTENT OR CLEAN)
N₂ CARBON DIOXIDE
N₂ CARBON NITROGEN
2. FOR VALVE AND PIPE MATERIALS SPECIFICATIONS AND EQUIPMENT DESCRIPTIONS, SEE SPECIFICATION 911004.
3. ITEMS MARKED WITH AN ASTERISK (*) ARE FURNISHED BY SUPPLIER OF ASSOCIATED EQUIPMENT.

NO	REQD	PART / LINE	STE NO	DESCRIPTION / MATERIAL	SPEC NO
1		DWHA KAREE/DUPPLE	7-1191	CLASSIFICATION	
2		CHK	7-831	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA	
3		APVD	7-831	LAWRENCE LIVERMORE LABORATORY	
4		CHKD	7-831	REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT	
5		DATE			
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA					
DRAWING NO				SHEET 1 OF 1	
AAA 91-105047-0

NOTE:
REFER TO PIPING & INSTRUMENT
DIAGRAM AASG1-108047 AND
SPECIFICATION NO. S11004 FOR
LINED, SYMBOLS AND PIPE
MATERIAL SPECIFICATIONS.

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.

[illegible]

NAME / MATERIAL		SPEC NO	ITEM
(SECTION SHEET) FREON PURIFICATION - SECTIONS (SHEET) GPP FREON SYSTEM, 490 EAST (TOTAL)			
TYPE OF QA FORMY HOUT CAL	DRAWING NO 91-105050-00 SHEET NO 1459-66 SCALE 3" = 1' SHEET OF

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.

NOTE:
REFER TO PPMAS & INSTRUMENT
DIAGRAM AAAS1-108047 AND
SPECIFICATION NO. 811084 FOR
LEADS, SYMBOLS AND PIPE
MATERIAL SPECIFICATIONS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
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GRAND

ANICAL ENGINEERING
INSTITUTE OF ENGINEERING

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ENGINEERING DEPARTMENT

REFREON PURIFICATION SECTIONS & DETS
GPP REFREON SYSTEM - 490 EAST

DRAWING NO	
ADD NO 1459-66	AAA 91-105051-00
SCALE	SHEET OF

DOOR TO SUPPLY BLIND AIR,
IT'S A GAMBIT

NOTES:

1. REFER TO PIPING & INSTRUMENT DIAGRAM AASB-1-100047 AND SPECIFICATION NO. 011004 FOR LEGEND, SYMBOLS AND PIPE MATERIAL SPECIFICATIONS.
2. PIPE SUPPORT COMPONENTS MAY BE BLOCK, POWERSTRUT, SUPERSTRUT, UNISTRUT, OR SOCIAL MANUFACTURES & MODEL NUMBERS SHOWN ARE FOR ILLUSTRATIVE PURPOSES.

NO	RECD	P:	
		DWN	
		CHE	
		APTD	
		CLERK	
		TRNG	
		LAW	
		MATL	
		MECHAN	
		GRP

LAW
MATL
MECHAN

MATERIAL		SPEC NO	ITEM
MAJOR UNIT			
FREON PURIFICATION-PIPING DETAILS			
SUBJECT			
GPP FREON SYSTEM, 490 EAST			
OFFICE			
DRAWING NO			
REV		AAA 91-105052-C4	
SCALE		NONE	
SHEET		1

SECTION A-A

PLAN VIEW

TYP. NOZZLE SECTION

N.T.S.

SECTION @ N5

N.T.S.

ELEVATION

LL LIFTING LUG DETAIL

M1 MANWAY DETAIL

△ SPREADER BEAM DETAIL

TYP. ALL 4 ENDS

NATIONAL BOARD NUMBER		TO FILL IN	
CERTIFIED BY		STEEL STRUCTURES, INC.	
W		MADERA, CALIFORNIA	
W.A.S.P.	30	P.S.I. AT	70
W.A.S.P. TEMP	-20	P.S.I. AT	30
W.P.S. NO.	911569-1	W.P.S. NO.	1569-1
YEAR BUILT	1981	W.P.S. NO.	9153156
SHOP WELD	45	P.S.I. FOR WELD	
W.C.A.B.		P.S.I. AT	
ITEM NO.	T-9102	REMARK	1800
W.P.S. NO.	225	W.P.S. NO.	1/4"

NP = 18 GA. BLUE ENAMELED STAINLESS STEEL NAMEPLATE (SHOWN 3/4 ACTUAL SIZE)

NOZZLE SCHEDULE											
NO.	QTY.	SIZE	CLASS	F.C.E.	TYPE	PURPOSE	NOZZLE	RE-PAD	PROJECT	REMARKS	
M1	1	18"	150	RF	SO	MANWAY w/BLIND	88 .218		5" 1/4"		
N1	1	2"	150	RF	SD	LEVEL GAGE CONN.	88 .218		AR 1"	SEE ELEVATION	
N2	1	2"	150	RF	SD	LEVEL /PRESS GAGE CONN.	88 .218		AR 1"		
N3	1	2"	150	RF	SD	SPARK w/BLIND	88 .218		5" 1"		
N4	1	2"	150	RF	SD	PUMP OUTLET CONN.	88 .218		AR FLSH	SEE ELEVATION	
N5	1	2"	150	RF	SD	INLET CONN.	88 .218		AR 1"	SEE DETAIL	
N6	1	2"	150	RF	SD	VAPOR OUTLET CONN.	88 .218		AR 1"		
N8	1	2"	150	RF	SD	PSY CONN.	88 .218		AR 1"		
N9	1	4"	150	RF	SD	LAL/LAM	88 .237		AR 1"		

CONSTRUCTED ACCORDING TO ASME SECT VIII DIV 1 EDITION 1989 ADDENDUM DEC 89
 CODE SYMBOL IS ☒ IS NOT ☐ REQUIRED
 INTERNAL DESIGN PRESSURE 30 P.S.I. AT A DESIGN TEMPERATURE OF 70 DEGR F.
 EXTERNAL DESIGN PRESSURE N/A P.S.I. AT A DESIGN TEMPERATURE OF N/A DEGR F.
 H.A.W.P. (INTERNAL AT DESIGN TEMPERATURE) 30 P.S.I. LIMITED BY DESIGN
 H.A.W.P. (INTERNAL NEW AND COLD) - P.S.I. LIMITED BY -
 SHOP HYDROSTATIC TEST BASED ON H.A.W.P. N.G.C. 45 P.S.I. HORIZ ☐ VERT. ☒
 RADIOGRAPHY RT- NONE GAGE # TOP
 JOINT EFFICIENCIES HEAD 85% SHELL LONGIT 70% SHELL CIRCUM 70%
 CORROSION ALLOWANCES HEAD/SHELL 1/8 NOZZLES 1/8
 POST WELD HEAT TREAT IS ☐ IS NOT ☒ REQUIRED
 INSPECTED BY ASME AUTHORIZED INSPECTOR

MATERIAL OF CONSTRUCTION
 SHELL SA-516-70 HEADS SA-516-70
 NOZZLE NECKS SA-538 GRW MANWAY NECK SA-516-GR.70
 FLANGES SA-105 COUPLINGS SA-105
 REPAIRS NA WELD FITTINGS NA
 INTERNALS - EXTERNALS -
 SUPPORTS SA-500-GR.8 NUTS SA-194-2" (FOR M1, N3, & N5)
 PRESSURE BOLTING SA-193-8" NUTS NA
 NON PRESSURE BOLTING NA
 GASKETS 1/8" VIRGIN TEFLON (SUPPLIED FOR N3, M1, N5 ONLY)
 SANDBLAST INTERIOR SSPC-SP8 EXTERIOR SSPC-SP8
 PAINT INTERIOR (2) SHOP COATS PLASITE 7122 MI-SOLIDS EPOXY (GRAY FOLLOWED BY WHITE) TO 12 MFT.
 PAINT EXTERIOR (1) SHOP COAT S.W. KEM KROMIK PRIMER, FOLLOWED BY (1) SHOP COAT S.W. SERIES 854 "PURE WHITE" INDUSTRIAL ENAMEL.
 CUSTOMER STANDARDS NA
 REFERENCE DRAWINGS NA
 WEIGHT EMPTY 1,000# FULL OF WATER 5,720# BASIS 470 GALLONS

GENERAL NOTES

1. PROTECT ALL FITTINGS WITH PLASTIC PROTECTORS.
2. NAMEPLATE BRACKET STYLE: ☒ CHANNEL ☐ TEL. PROJECTION INCHES
3. ALL TANK SEAM WELDS TO BE WPS-14.
4. ALL TANK NOZZLE WELDS TO BE WPS-21.
5. GRIND ALL SHARP CORNERS TO 1/8" RADIUS TO PROMOTE ADHERENCE OF INTERNAL EPOXY COATING.

AAA91-105972-OA[ⓐ]

PURIFIER FEED TANK (T-9102) QTY. (1)

48"O.D. x 48"s/s ASME VESSEL	
FOR: LAWRENCE LIVERMORE LABORATORY	SCALE: 1"=1'-0"
BY: LIVERMORE, CA.	DATE: 20 FEB 91
FABRICATION DETAILS	
STEEL STRUCTURES, INC.	REV. 3- -01 REP
P.O. BOX 1170, MADERA, CALIFORNIA 93639	1569-1
PHONE: (209) 673-8821	
FAX: (209) 673-8846	
CALIF. CONTRACTOR LICENSE # 261986

8. APPS 1-185372-1/4

LL LIFTING LUG DETAIL
N.T.S.

TYPICAL NOZZLE SECTION
N.T.S.

SECTION @ A

M1 MANWAY DETAIL

1 JACKING SCREW DETAIL
(4 RE)

LEFT END VIEW

ELEVATION

2 BRACKET DETAIL
(4 REQ.)

NATIONAL BOARD NUMBER		TO FOLLOW	
CERTIFIED BY			
STEEL STRUCTURES, INC.			
MADERA, CALIFORNIA			
M.A.S.P.	30	P.S.I. AT	70 DEGR. F.
MIN. UTL. TEMP.	-20	DES. F. AT	30 P.S.I.
MFG'S. NO.	911569-3	DES. NO.	1569-3
YEAR BUILT	1991	QST. P.G.	8153136
SHOP HYDRO	45	P.S.I. AT	DEGR. F.
VACUUM		P.S.I. AT	DEGR. F.
ITEM NO.	T-9101	WEIGHT	4300 LBS.
HEAD NO. (SEE 1)	230	SHELL THK (SEE 1)	1/4"
SPENT FREGON VESSEL			

(NP) 16 GA. BLUE ENAMELED STAINLESS STEEL NAMEPLATE (SHOWN 3/4 ACTUAL SIZE)

NOZZLE SCHEDULE											
NO.	QTY	SIZE	CLASS	FACE	TYPE	PURPOSE	NOZZLE	RE-PAD	PROJECT	REMARKS	
M1	1	18"	150	RF	SO	HANWAY W/ BLIND	88 1/4		6" 13/8"		
N1	2	2"	150	RF	SO	LEVEL GAUGE CONN	88 210		6" 1"		
N2	1	4"	150	RF	SO	LAL	48 237		6" 1"		
N3	1	2"	150	RF	SO	SPARE W/B. IND	88 210		6" 1"		
N4	1	2"	150	RF	SO	VAPOR OUTLET CONN	88 210		6" 1"		
N7	1	2"	150	RF	SO	PSV CONN	88 210		6" 1"		
N8	1	2"	150	RF	SO	PRESS. INDICATOR CONN	88 210		6" 1"		
N9	1	2"	150	RF	SO	PUMP OUTLET CONN	88 210		6" 1"		
N10	1	2"	150	RF	SO	INLET CONN	88 210		6" 1"		
U1	3	1 5/8" x 9"	UNI	STRUT	BRACKET						
U2	3	1 5/8" x 12"	UNI	STRUT	BRACKET

DETAIL
(4 REQ.)

CONSTRUCTED ACCORDING TO ASME SECT VIII DIV 1 EDITION 1989 ADDENDA DEC 89
 CODE SYMBOL IS ☒ IS NOT ☐ REQUIRED
 INTERNAL DESIGN PRESSURE 30 P.S.I. AT A DESIGN TEMPERATURE OF 70 DEGR F
 EXTERNAL DESIGN PRESSURE N/A P.S.I. AT A DESIGN TEMPERATURE OF N/A DEGR F
 M.A.S.P. (INTERNAL AT DESIGN TEMPERATURE) 30 P.S.I. LIMITED BY DESIGN
 M.A.S.P. (INTERNAL, NEW AND COLD) - P.S.I. LIMITED BY -
 SHOP HYDROSTATIC TEST BASED ON M.A.S.P. N.E.C. 45 P.S.I. HORIZ. ☒ VERT. ☐
 RADIOGRAPHY RT- NONE 51 PSI HORIZ. GAGE @ TOP
 JOINT EFFICIENCIES HEAD 85% SHELL LONGIT 70% SHELL CIRCUM 70%
 CORROSION ALLOWANCES HEAD/SHELL 1/8 NOZZLES 1/8
 POST WELD HEAT TREAT IS ☐ IS NOT ☒ REQUIRED
 INSPECTED BY ASME AUTHORIZED INSPECTOR
 MATERIAL OF CONSTRUCTION
 SHELL SA-516-70 HEADS SA-516-70
 NOZZLE NECKS SA-538 ERW HANWAY NECK SA-516-GR 70
 FLANGES SA-105 COUPLINGS NA
 REPAIRS NA WELD FITTINGS NA
 INTERNALS - EXTERNALS -
 SUPPORTS A-36 NUTS SA-194-2H
 PRESSURE BOLTING SA-193-B7 NUTS NA
 NON PRESSURE BOLTING NA
 GASKETS 1/8" VIRGIN TEFLON
 SANDBLAST INTERIOR SSPC-SP5 EXTERIOR SSPC-SP6
 PAINT INTERIOR (2) SHOP COATS PLASITE 7122 HI-SOLIDS EPOXY (GRAY FOLLOWED BY WHITE) TO 12 MFT.
 PAINT EXTERIOR (1) SHOP COAT S.W. KEM KROMIK PRIMER, FOLLOWED BY (1) SHOP COAT S.W. SERIES 854 "PURE WHITE" INDUSTRIAL ENAMEL.
 CUSTOMER STANDARDS NA
 REFERENCE DRAWINGS NA
 WEIGHT EMPTY: 4,300# FILL OF WATER 23,615# BASIS 2,315 GALLONS

GENERAL NOTES

1. PROTECT ALL FITTINGS WITH PLASTIC PROTECTORS.
2. NAMEPLATE BRACKET STYLE: ☒ CHANNEL ☐ TEE, PROJECTION INCHES
3. ALL TANK SEAM WELDS TO BE WPS-14.
4. ALL TANK NOZZLE WELDS TO BE WPS-21.
5. SHOP NOTE: IF HEAD MANUFACTURER PROVIDES CENTER HOLES AND SCHEDULED FITTINGS ARE NOT REQUIRED AT THOSE LOCATIONS, PLUG WELD HOLES. DO NOT INSTALL COUPLINGS IN HEADS.

T-9101 RELEASE FOR FABRICATION 4/14/91 RLL

AAA91-105973-OA QTY. (1)

66" O.D. x 138" s/s ASME VESSEL

FOR: LAWRENCE LIVERMORE LABORATORY	SCALE: 3/4"=1'-0"
AT: LIVERMORE, CA.	DATE: 7 MAR 91
FABRICATION DETAILS	
DRAWN BY: HLP	
APPROVED BY: RLL	
REV. 1 9-2-91 HLP	

Steel structures, inc.
 P.O. BOX 1178, MADERA, CALIFORNIA 93639
 PHONE: (209) 875-8821
 FAX: (209) 875-8848
 CALIF. CONTRACTOR LICENSE # 261586

1569a-3

NOTE:
 A CAD WELD #2/0 B.C. GND. WIRE TO TANKS' SUPPORT FITTINGS ON THE HOUSEKEEPING PAD.
 RUN #2/0 BARE COPPER GND. IN 3/4" RAS C. FROM TANK TO (N) COPPER GROUNDING BUS BAR ON COLUMN *Q; MAKE CONNECTIONS PER "GROUNDING COPPER BUS BAR", DETAIL BELOW. RUN 3/4" CONDUITS ALONG (N) OVERHEAD PIPE RACK. SUPPORT CONDUITS EVERY 7'-0" ON CENTER.

PLAN

3/8" = 1'-0"

1/2" O.
 LENG.
 STEE

**BUILDING SYSTEM
EQUIPMENT
GROUNDING**

**Lawrence Livermore
National Laboratory**
Livermore, CA 94550
PLANT ENGINEERING

B-490 E

**FREON PURIFICATION
SYSTEM**

DESIGN M. PALATKA DATE 11/2-90
 DRAWN M. PALATKA DATE 11/2-90
 CHECK John A. ... DATE 1-25-91
 PE/A John A. ... DATE Feb 7-91
 SL/G A. ... DATE 1-25-91
 SECURITY ... DATE 2-2-91
 M/D R. ... DATE 2-1-91
 H.C. ... DATE 2-1-91

SHEET **E 2** OF 2
SET OF

PN 490E-90-001
 DWG NO PLE90-490-110D

$$3/e'' = 1.0''$$

REV	DESCRIPTION	DATE	DWN	APP
-----	-------------	------	-----	-----

TANK PAD & CANOPY
FOUNDATION

**Lawrence Livermore
National Laboratory**
Livermore, CA 94550
PLANT ENGINEERING

BLDG 490 E
FREON PURIFICATION
SYSTEM

DESIGN L.VALLE/A.ANTARAMIAN DATE 11-13-90
DRAWN P.HOST/L.VALLE DATE 11-27-90
CHECK A.ANTARAMIAN/A.CAMACHO DATE 12-3-90

PE/A	<u>P. E. Robinson</u>	DATE	<u>Feb 7-91</u>
SL/GL	<u>Ed. G. G. G.</u>	DATE	<u>2/10/91</u>
SECURITY	<u>1-2</u>	DATE	<u>2-5-91</u>
M/O	<u>P. E. Robinson</u>	DATE	<u>2/11/91</u>
M/C	<u>1-2</u>	DATE	<u>3-1-91</u>

SHEET OF
S-1 SET OF

PFN 490E90001
PLS 90-490-048D

• **FLIGHT**

DDJ SANITARY
TOWER
Φ CMP STORM
RAIN
PRECISE
TRACTION.

WELDED STUDS
3 MIN. EA. SIDE)

SECTION C
SCALE: 1"=1'-0"

GENERAL NOTES

- 1.0 CODES, SPECIFICATIONS, STANDARDS
 - 1.1 U.D.C. 1988
 - 1.2 A.C.I. 318
 - 1.3 LLNL STANDARDS
- 2.0 MATERIALS
 - 2.1 CONCRETE ULTIMATE COMPRESSIVE STRENGTH SHALL BE 4000 PSI MINIMUM AT 28 DAYS
 - 2.2 DEFORMED REINFORCING BARS SHALL BE ASTM A615 GRADE 60
 - 2.3 WELDED WIRE FABRIC SHALL BE ASTM A62
 - 2.4 STRUCTURAL STEEL SHALL BE ASTM A36
 - 2.5 ANCHOR BOLTS ASTM A307
- 3.0 DESIGN FORCES
 - 3.1 EQUIPMENT FORCES
 - 3.1.1 TWO FREON TANKS, EACH 30 KIPS, SUPPORTED ON 4 LOAD CELLS, AS SHOWN IN SKETCH BELOW
 - 3.1.2 ALL OTHER EQUIPMENT SHALL BE SUPPORTED SUCH THAT THE STRESSES INDUCED IN THE CONCRETE MAT SHALL NOT EXCEED THAT OF THE FREON TANKS
- 3.2 DEAD LOAD
SEISMIC FORCES
I = 1.25
Z = 0.6
- 4.0 CONSTRUCTION
 - 4.1 FIELD VERIFY ALL DIMENSIONS AND CONDITIONS PRIOR TO START OF WORK AND NOTIFY THE UNIVERSITY OF ANY DISCREPANCIES OR INCONSISTENCIES.
 - 4.2 ALL CONCRETE EMBEDDED STRUCTURAL STEEL AND GRATING SHALL BE HOT DIPPED GALVANIZED.
 - 4.3 MATERIAL, CONSTRUCTION AND CURING OF CONCRETE SHALL INSURE MINIMUM SHRINKAGE CRACKING OF CONCRETE. CONCRETE MIX PROPORTIONS SHALL BE DESIGNED TO OBTAIN AN IMPERVIOUS MAT FOUNDATION AND WALLS. CONCRETE MIX PROPORTIONS INCLUDING SHRINKAGE CHARACTERISTICS SHALL BE SUBMITTED FOR APPROVAL. SUBMITTAL SHALL INCLUDE TEST RESULTS FROM A CERTIFIED TESTING LABORATORY.
 - 4.4 ALL CONCRETE SHALL BE MOIST CURED FOR A MINIMUM OF 7 DAYS. THE MAT SHALL BE POURED IN ONE CONTINUOUS POUR WITHOUT CONSTRUCTION JOINTS EXCEPT AS SHOWN OR NOTED.
 - 4.5
 - THE CONCRETE SHALL BE PROPORTIONED AND PRODUCED TO HAVE A SLUMP OF 4 IN. OR LESS IF CONSOLIDATION IS TO BE BY VIBRATION, AND 5 IN. OR LESS IF CONSOLIDATION IS TO BE BY METHODS OTHER THAN VIBRATION. A TOLERANCE OF UP TO 1 IN. ABOVE THE MAXIMUM INDICATED SHALL BE ALLOWED FOR ONE BATCH IN ANY FIVE CONSECUTIVE BATCHES TESTED.
 - TAKE CYLINDERS AND PERFORM SLUMP TESTS IN ACCORDANCE WITH ACI 301.
 - THREE CONCRETE TEST CYLINDERS WILL BE TAKEN FOR EVERY 75 OR LESS CU. YARDS OF CONCRETE PLACED EACH DAY.
 - ONE ADDITIONAL TEST CYLINDER WILL BE TAKEN DURING COLD WEATHER AND WILL BE CURED ONSITE UNDER SAME CONDITIONS AS CONCRETE IT REPRESENTS.
 - ONE SLUMP TEST WILL BE TAKEN FOR EACH SET OF TEST CYLINDERS TAKEN.
- 5.0 ALLOWABLE SOIL BEARING PRESSURE:-

5.1 DEAD LOAD	2500 PSF
5.2 DEAD + LIVE LOAD	3000 PSF
5.3 DEAD + LIVE + SEISMIC LOAD	4000 PSF

REFER TO SOIL REPORT BY ASSOCIATED GEOTECHNICAL ENGINEERS INC. DATED 7-29-81.

DETAIL I
SCALE: 3"=1'-0"

REV	DESCRIPTION	DATE	DWN	APPD
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REDUCED DRAWING
USE SCALE BELOW

3 INCHES ON ORIGINAL DRAWING

**TANK PAD
SECTIONS, DETAILS &
GENERAL CONCRETE NOTES**

**Lawrence Livermore
National Laboratory**
Livermore, CA 94550
PLANT ENGINEERING

**BLDG. 490 E
FREON PURIFICATION
SYSTEM**

DESIGN L.A. VALLE DATE 11-13-90
DRAWN L.A. VALLE DATE 11-27-90
CHECK ANTARAMIAN/M.K.W. DATE 12-3-90
PE/A RE. Blum DATE Feb 7-91
SL/GL RE. Blum DATE 4/8/91
SECURITY RE. Blum DATE 2-2-91
M/O RE. Blum DATE 2/11/91
H.C. RE. Blum DATE 2-1-91

SHEET **S-2** OF
SET OF

PN 490E90001
DWC NO PLS90-490-049D

NOSING W/ NON-SKID
 1/3-1/2" ϕ x 6" LG.
 TUDS 2" FROM ENDS
 ENTER (TYP.)

TANK PAD
 MISC. SECTIONS

Lawrence Livermore
 National Laboratory
 Livermore, CA 94550
 PLANT ENGINEERING

BLDG. 490 E
 FREON PURIFICATION
 SYSTEM

DESIGN L.A. VALLE DATE 11-13-90
 DRAWN L.A. VALLE DATE 11-27-90
 CHECK ANTARMIAN/M. KAMATH DATE 12-3-90

PE/A R. E. J. DATE 12-7-91
 SL/GJ R. E. J. DATE 12-7-91
 SECURITY R. E. J. DATE 12-7-91
 M/D R. E. J. DATE 12-7-91
 H.C. R. E. J. DATE 12-7-91

SHEET S-3 OF SET OF

PPN 490E90001
 DWG NO. PLS 90-490-050D

Appendix B
Seismic Analysis

steel structures, inc.

Manufacturers of Steel Storage Facilities.

D. Hippie copy

P.O. BOX 1170, MADERA, CALIFORNIA 93639

PHONE: MADERA (209) 673-8021

FAX: (209) 673-8046

DESIGN CALCULATIONS
in accordance with A.S.M.E. Section VIII Div.1
1989 Edition, Dec. '89 Addenda

FOR

Lawrence Livermore National Laboratory

at

Livermore, California

(4) Freon Storage Vessels

P.O. # 8153136

Our Shop Order # 1569

*Order from = T-9101 & 9102
490-Q1A1 490-Q1A2*

Vessel T-9102, Subsection a, 8 pages *4000*
Vessel T-1000, Subsection b, 9 pages
Vessles T-9101 & T-9103, Subsection c, 10 pages *2000*

REV	PAGES	DESCRIPTION	DATE	BY	REVIEWER
0	1-27	Issued for Approval	3/01/91	RHW	<i>RHW</i>

MANUFACTURERS OF **VERTILOK** BINS

A.S.M.E. PRESSURE VESSELS • A.P.I. • A.W.W.A. • U.L. 142 • CUSTOM BUILT SILOS

CONTRACTORS LICENSE #261586

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9102 Purifier Feed Tank FOR Lawrence Livermore Laboratory

PO# 8153136 SO# 1569a

CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 1 , CYLINDRICAL SHELL at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	48.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	5.6000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	33.9336	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
SHELL IS (S)MLS OR (W)ELDED	W
LONGIT JOINT RT EXAM	None
CIRCUMFERENTIAL EFFICIENCY 'E'	0.7000
CIRCUM JOINT RT EXAM	None
LONGITUDINAL EFFICIENCY 'E'	0.7000

APPLICABLE FORMULAS:

$T = P R / S E + 0.4 P$	(T REQ'D, CIRCUMFERENTIAL STRESS)
$T = P R / 2 S E + 1.4 P$	(T REQ'D, LONGITUDINAL STRESS)
$P = S E T / R - 0.4 T$	(P ALLOWABLE, CIRCUM STRESS)

CALCULATIONS	DESIGN	NEW & COLD
REQ'D T FOR CIRCUM STRESS	0.0664	0.1914 INCHES
REQ'D T FOR LONGIT STRESS	0.0332	0.1582 INCHES
THICKNESS SUPPLIED	0.1250	0.2500 INCHES
M.A.W.P.s FOR T SUPPLIED	63.9353	128.1381 PSI

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9102 Purifier Feed Tank FOR Lawrence Livermore Laboratory

PO# 8153136 SO# 1569a

CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 2 , TORISPHERICAL HEAD at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	48.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	5.6000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	33.9336	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
HEAD IS (S)MLS OR (W)ELDED	S
HEAD JOINT RT EXAM	None
HEAD EFFICIENCY	0.8500

HEAD DATA

OUTSIDE CROWN RADIUS L	48.0000	INCHES
OUTSIDE KNUCKLE RADIUS R	3.5000	INCHES
RATIO L/R	13.7143	
FACTOR M	1.6758	

APPLICABLE FORMULAS:

$T = P L M / 2 S E + P (M - 0.2)$ (T REQ'D, HEAD)
 $P = 2 S E T / M L - T (M - 0.2)$ (P ALLOW, HEAD)

CALCULATIONS

	DESIGN	NEW & COLD	
REQUIRED HEAD THICKNESS	0.0916	0.2166	INCHES
HEAD THICKNESS SUPPLIED	0.1000	0.2250	INCHES
M.A.W.P.s FOR T SUPPLIED	37.0524	83.5598	PSI

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9102 Purifier Feed Tank FOR Lawrence Livermore Laboratory
 PO# 8153136 SO# 1569a
 CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

MAXIMUM ALLOWABLE WORKING PRESSURE COMPILATION BY COMPONENTS

COMPONENT	M.A.W.P. DESN	M.A.W.P. N&C
CYLINDRICAL SHELL at bottom	63.9353	128.1381 PSI
LESS STATIC HEAD	3.9336	3.9336 PSI
M.A.W.P. AT TOP	60.0017	124.2045 PSI
TORISPHERICAL HEAD at bottom	37.0524	83.5598 PSI
LESS STATIC HEAD	3.9336	3.9336 PSI
M.A.W.P. AT TOP	33.1187	79.6262 PSI
150# FLANGES	285.0000	285.0000 PSI
LESS STATIC HEAD	3.9336	3.9336 PSI
M.A.W.P. AT TOP	281.0664	281.0664 PSI
Design	33.9336	33.9336 PSI
LESS STATIC HEAD	3.9336	3.9336 PSI
M.A.W.P. AT TOP	30.0000	30.0000 PSI
M.A.W.P. AT DESIGN TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
M.A.W.P. AT NEW AND COLD TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
HORIZONTAL SHOP HYDRO LTD BY Design TO GAGE AT BOTTOM IN HORIZ. POSITION	51.0000	PSI
GAGE AT TOP IN OPERATING POSITION	45.0000	PSI
M.A.W.P.s FOR NOZZLE REINFORCEMENT CALCULATIONS		
LIMITING M.A.W.P.s AT TOP	30.0000	30.0000 PSI
TOTAL STATIC HEAD AT BOTTOM	3.9336	3.9336 PSI
M.A.W.P.s AT BOTTOM	33.9336	33.9336 PSI

IMPACT TESTING IS NOT MANDATORY PER UG(20)f.

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
 UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-9102 Purifier Feed Tank FOR Lawrence Livermore Laboratory

PO# 8153136 SO# 1569a

CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

VESSEL DATA	T HEAD	SHELL	
MATERIAL GRADES	SA-516-70	SA-516-70	
DESIGN TEMPERATURE	70.0000	70.0000	DEG F
ALLOW STRESS AT DESN TEMP	17500.0000	17500.0000	PSI
ALLOW STRESS AT N & C	17500.0000	17500.0000	PSI
MIN THICKNESS N & C	0.2250	0.2500	IN
CORROSION ALLOWANCE	0.1250	0.1250	IN
CORRODED (DESN) THICKNESS	0.1000	0.1250	IN

NOZZLE MARK, SIZE & SCHED: 18" - 150# RFSO Manway

JOINT EFFICIENCY 'E1' 1.0000

NOZZLE NECK EFFICIENCY 'E' 0.7000

CORRECTION FACTOR 'F' 1.0000

LOCATION (H)EAD/(S)HELL H

NOZZLE ELEV ABOVE BOTTOM (FT) 5.2000

NOZZLE PROJECTS INTO VESSEL Y

CALCULATIONS	MAWP DESN	MAWP N&C	
MAWP AT TOP OF VESSEL	30.0000	30.0000	PSI
STATIC HEAD AT NOZZLE CTR LINE	0.2810	0.2810	PSI
NOZZLE DESIGN PRESSURE	30.2810	30.2810	PSI
VESSEL INSIDE DIAMETER	47.7500	47.5000	IN
TS HEAD CROWN RADIUS	48.0000	48.0000	IN
TS HEAD KNUCKLE RADIUS	3.6250	3.5000	IN
TS HEAD FACTOR 'M'	1.6758	1.6758	
NOZZLE SA-516-70 ALLOW STRESS	17500.0000	17500.0000	PSI
CORRECTION FACTOR (Sn/Sv)	1.0000	1.0000	
NOZZLE NECK OUTSIDE DIAM	18.0000	18.0000	IN
NOZZLE NECK NOM THICKNESS	0.5000	0.5000	IN
NOZZLE NECK CORROSION ALLOW	0.1250	0.0000	IN
NOZZLE NECK MINIMUM THICKNESS	0.3750	0.5000	IN
REINFORCEMENT LIMIT (D)	17.2500	17.0000	IN
or (Rn + Tn + T)	9.1000	9.2250	IN
AREA REQUIRED BASED ON Tr			
HEAD Tr	0.0695	0.0695	IN
NOZZLE NECK Trn	0.0214	0.0210	IN
HEAD EXCESS	0.0305	0.1555	IN
NOZZLE NECK EXCESS	0.3536	0.4790	IN
NOZZLE PROJN INTO VESSEL	0.2500	0.5625	IN

AREA REQUIRED	1.1990	1.1816	SQ IN
AREA IN EXCESS IN HEAD	0.5260	2.6434	SQ IN
AREA IN EXCESS IN NOZ EXT	0.1768	0.5388	SQ IN
AREA IN EXCESS IN NOZ INT	0.1250	0.5625	SQ IN
AREA FURNISHED BY WELDS	0.3828	0.5078	SQ IN

TOTAL AREA FURNISHED	1.2107	4.2526	SQ IN
EXCESS AREA	0.0117	3.0710	SQ IN

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-9102 Purifier Feed Tank FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569a
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

WELD SIZING & STRESS PATH CALCULATIONS

NOZZLE MARK: 18" - 150# RFSO Manway
Weld Configuration: UW-16.1 (i)

WELD SIZES FURNISHED	MAWP DESN	MAWP N&C
OUTER NOZZLE TO VESSEL FILLET	0.4375	0.4375 IN
INNER NOZZLE TO VESSEL FILLET	0.4375	0.5625 IN

MINIMUM REQUIREMENTS

WELD LOAD (A-A1)S	11776.1700	-25582.0000 LBS
-------------------	------------	-----------------

MAXIMUM ALLOWABLE WELD LOADINGS

OUTER FILLET SHEAR	212145.9000	212145.9000 LBS
NOZZLE NECK SHEAR	254358.6000	336739.5000 LBS
IN FILLET WELD SHEAR	212145.9000	272759.0000 LBS

MAXIMUM COMBINED LOADINGS

OUT FIL WLD THRU NOZZLE	466504.5000	548885.4000 LBS
OUT FIL WLD THRU IN FIL WLD	424291.8000	484904.9000 LBS

STEEL STRUCTURES, INC.
P.O. Box 1170 Madera, CA 93639
Ph.(209)673-8021 FAX 673-8046
R.H. Wilson, P.E. C32343 Exp.12/92

Page: 6
Date: 02/25/91
By: R.H. Wilson
Job No.: 1569a

=====

4' OD x 4' S/S Vessel for Lawrence Livermore Labs at Livermore, CA

Vessel information: Outside Diameter (D) = 48 inches
Side Shell length (S/S) = 48 inches
Height to bottom seam = 21 inches
Head Depths = 9.6 inches
Shell thick. corr. (ts) = 0.125 inches
Vessel Weight (DL) = 0.9 kips
Stored Product: Freon ==> Spec. Gravity = 1.62
Unit Density = 13.51 Lb / gal

Working Volume = 460 gallons
Stored Product Wt. (LL) = 6.3 kips
C.G. to Live Load (CG) = 45.0 inches
40 lb / sq ft ==> Roof Live Load (RL) = 0.5 kips

Four Legs: Distance from center of leg to shell = 2 inches
Leg circle diameter (opposite legs) (X) = 52.0 inches
Distance between adjacent legs (Y) = 36.8 inches

Column loads: Dead Load: Pdl = DL / 4 = 0.23 kips +
Live Load: Pll = LL / 4 = 1.58 kips +
Roof Load: Prl = RL / 4 = 0.13 kips +
Wind Load: Add 25" for equipment, Use OHw = 73 inches
80 MPH per UBC Table 23-F ==> qs = 17 psf
Table 23-L ==> I = 1.00 Table 23-H ==> Cq = 0.8
Table 23-G: Ce V (k) Mot ("k)
0 - 20' 1.2 0.4 15

Ttl. Base Shear Total (Vw) = 0.4 kips
Ttl. Overturning Moment (Mw) = 15 in.kips
Legs on prin. axis: Opposite Legs: Pwo = Mw / X = 0.29 kips +-
Legs Strdl prin. axis: Adjcnt Legs: Pwa = Mw / Y / 2 = 0.20 kips +-

Seismic Load: UBC Table 23-Q ==> Rw = 3
Zone 4 per UBC Table 23-I ==> Z = 0.4
UBC (12-2) (max) ==> C = 2.75
Base Shear: Vs = 2 * 1.41 / sqrt(2) = 2.0 * W
= 15.4 kips
Partial OT Moments: DL * OH / 2 * Vs = 43 in.kips
LL * CG * Vs = 567 in.kips
RL * OH * Vs = 48 in.kips
Ttl. Overturning Moment (Ms) = 658 in.kips
Opposite Legs: Pso = Ms / X = 12.65 kips +-
Adjacent Legs: Psa = Ms / Y / 2 = 8.94 kips +-

STEEL STRUCTURES, INC.
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R.H. Wilson, P.E. C32343 Exp. 12/92

Page 7
Date: 02/25/91
By: R.H. Wilson
Job No.: 1569a

=====

4' OD x 4' S/S Vessel for Lawrence Livermore Labs at Livermore, CA

=====

Column Combined Load Cases:

	P1 = DL + LL + RL	=	1.94 kips
	P2 = DL + LL + RL + Wi	=	2.23 kips
(+) Compression	P3 = .85 * DL - 1.5 * Wi	=	-0.24 kips
(-) Tension	P4 = 2.41 * (DL + LL) + RL + Se	=	17.14 kips
	P5 = 0.41 * (DL + LL) - Se	=	-11.91 kips

=====

Member size: TS 4 x 4 x 1/4 Ag = 3.59 sq.in.
K = 1.5 S = 4.11 in³ r = 1.51 in. Fy = 46 ksi
Cm = 0.85 Cc = 111.6 e = 2 in. L = 19.5 in.

=====

End Legs subject to axial load & induced bending: On principle axis

	P = 17.14 kips
↓ 17.14 kips	Mx = P * e = 34.3 in.kips.
	fa = P / Ag = 4.77 ksi
19.5 inches	fb = Mx / S = 8.35 ksi
	K * L / r = 19.37
↑ 17.14 kips	AISC E2-1 ==> Fa = 26.17 ksi
▶ ◀ 2 in.	Fb = 2/3 * Fy = 30.67 ksi

=====

Combined stresses per AISC Chapter H: Euler: F'e = 398 ksi

(H1-1) ==> 0.182 + 0.234 = 0.42 < 1.33 O.K.

(H1-2) ==> 0.173 + 0.272 = 0.45 < 1.33 O.K.

TS 4 x 4 x 1/4 is ok

=====

Side Legs subject to axial load, induced & base shear bending: On axis

P = P1 =	1.94 kips
Mx = P * e =	3.88 in.kips
My = Vs/2 * L =	150.2 in.kips
fa = P / Ag =	0.54 ksi
fbx = Mx / S =	0.94 ksi
fby = My / S =	36.55 ksi

=====

(H1-1) ==> 0.021 + 0.026 + 1.014 = 1.06 < 1.33 O.K.

(H1-2) ==> 0.020 + 0.031 + 1.192 = 1.24 < 1.33 O.K.

TS 4 x 4 x 1/4 is ok

=====

Adj. Legs subject to ax. load, ind. & base shear bending: Straddle axis

P = P1 + Psa =	10.88 kips
Mx = sin45 * Vs/4 * L + P * e =	74.84 in.kips
My = sin 45 * Vs/4 * L =	53.08 in.kips
fa = P / Ag =	3.03 ksi
fbx = Mx / S =	18.21 ksi
fby = My / S =	12.91 ksi

=====

(H1-1) ==> 0.116 + 0.509 + 0.361 = 0.99 < 1.33 O.K.

(H1-2) ==> 0.110 + 0.594 + 0.421 = 1.13 < 1.33 O.K.

USE TS 4 x 4 x 1/4

steel structures, inc.

Manufacturers of Steel Storage Facilities
P.O. BOX 1170, MADERA, CALIFORNIA 93639
PHONE: MADERA (209) 673-8021

RICHARD WILSON, P.E. #C32343

SH 8 OF 8
DATE 2-25-91
BY RHW
JOB NO. 1569a

SPREADER BEAMS: TRY W6x15

WEB YIELDING: $f_u = \frac{17.14^k}{.23''(.25'' + 5 \times \frac{5}{8})2} = 11.0 \text{ ksi} \quad (K1-2)$

WEB CRIPPLING: $R = 67.5(.23)^2 \left[1 + 3 \left(\frac{.25}{6} \right) \left(\frac{.23}{.26} \right)^{1.5} \right] \times \sqrt{36 \left(\frac{.26}{.23} \right)} \quad (K1-4)$
 $= 25.1^k > \frac{17.14^k}{2} \quad (OK)$

∴ STIFFENER NOT REQ'D AT INBOARD END OF TS LEG.

JACKING POINT: $R = 2^k$

$M = 2^k(8 \frac{3}{4}'') = 17.5''k$

$I_x = (1.875'')^2 1.5''(2) + \frac{.23(3.5'')^3}{12}$
 $= 11.37 \text{ in}^4$

$S_x = \frac{11.37 \text{ in}^4}{2''} = 5.68 \text{ in}^3$

$f_{bx} = \frac{17.5''k}{5.68 \text{ in}^3} = 3.08 \text{ ksi} \quad (OK)$

$f_u = \frac{2^k}{.23(4'')} = 2.17 \text{ ksi} \quad (OK)$

ANCHOR BOLTS: $P_{UP} = 11.91^k$ $V = \frac{15.4^k}{4} = 3.85^k$

TRY $(2) \frac{3}{4}''$ A-307 BOLTS: $A_G' = .4418 \text{ in}^2$

$f_u = \frac{3.85^k}{2(.4418 \text{ in}^2)} = 4.36 \text{ ksi} < 21.0 \quad (OK)$

$f_u = \frac{11.91^k}{2(.4418 \text{ in}^2)} = 13.5 \text{ ksi}$

$F_u = 26 - 1.8(4.36) = 18.2 \text{ ksi} \quad (OK)$

USE $(2) \frac{3}{4}''$ A.B. / leg.

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-1000 Freon Storage Tank FOR Lawrence Livermore Laboratory
 PO# 8153136 SO# 1569b
 CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 1 , CYLINDRICAL SHELL at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	48.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	4.0000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	32.8097	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
SHELL IS (S)MLS OR (W)ELDED	W
LONGIT JOINT RT EXAM	None
CIRCUMFERENTIAL EFFICIENCY 'E'	0.7000
CIRCUM JOINT RT EXAM	None
LONGITUDINAL EFFICIENCY 'E'	0.7000

APPLICABLE FORMULAS:

$T = P R / S E + 0.4 P$	(T REQ'D, CIRCUMFERENTIAL STRESS)
$T = P R / 2 S E + 1.4 P$	(T REQ'D, LONGITUDINAL STRESS)
$P = S E T / R - 0.4 T$	(P ALLOWABLE, CIRCUM STRESS)

CALCULATIONS	DESIGN	NEW & COLD	
REQ'D T FOR CIRCUM STRESS	0.0642	0.1892	INCHES
REQ'D T FOR LONGIT STRESS	0.0321	0.1571	INCHES
THICKNESS SUPPLIED	0.1250	0.2500	INCHES
M.A.W.P.s FOR T SUPPLIED	63.9353	128.1381	PSI

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-1000 Freon Storage Tank FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569b
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 2 , TORISPHERICAL HEAD at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	48.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	4.0000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	32.8097	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
HEAD IS (S)MLS OR (W)ELDED	S
HEAD JOINT RT EXAM	None
HEAD EFFICIENCY	0.8500

HEAD DATA

OUTSIDE CROWN RADIUS L	48.0000	INCHES
OUTSIDE KNUCKLE RADIUS R	3.5000	INCHES
RATIO L/R	13.7143	
FACTOR M	1.6758	

APPLICABLE FORMULAS:

$T = P L M / 2 S E + P (M - 0.2)$ (T REQ'D, HEAD)
 $P = 2 S E T / M L - T (M - 0.2)$ (P ALLOW, HEAD)

CALCULATIONS	DESIGN	NEW & COLD	
REQUIRED HEAD THICKNESS	0.0886	0.2136	INCHES
HEAD THICKNESS SUPPLIED	0.1000	0.2250	INCHES
M.A.W.P.s FOR T SUPPLIED	37.0524	83.5598	PSI

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-1000 Freon Storage Tank FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569b
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

MAXIMUM ALLOWABLE WORKING PRESSURE COMPILATION BY COMPONENTS

COMPONENT	M.A.W.P. DESN	M.A.W.P. N&C
CYLINDRICAL SHELL at bottom	63.9353	128.1381 PSI
LESS STATIC HEAD	2.8097	2.8097 PSI
M.A.W.P. AT TOP	61.1256	125.3284 PSI
TORISPHERICAL HEAD at bottom	37.0524	83.5598 PSI
LESS STATIC HEAD	2.8097	2.8097 PSI
M.A.W.P. AT TOP	34.2426	80.7501 PSI
150# FLANGES	285.0000	285.0000 PSI
LESS STATIC HEAD	2.8097	2.8097 PSI
M.A.W.P. AT TOP	282.1903	282.1903 PSI
Design	32.8097	32.8097 PSI
LESS STATIC HEAD	2.8097	2.8097 PSI
M.A.W.P. AT TOP	30.0000	30.0000 PSI
M.A.W.P. AT DESIGN TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
M.A.W.P. AT NEW AND COLD TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
HORIZONTAL SHOP HYDRO LTD BY Design TO GAGE AT BOTTOM IN HORIZ. POSITION	50.0000	PSI
GAGE AT TOP IN OPERATING POSITION	45.0000	PSI
M.A.W.P.s FOR NOZZLE REINFORCEMENT CALCULATIONS		
LIMITING M.A.W.P.s AT TOP	30.0000	30.0000 PSI
TOTAL STATIC HEAD AT BOTTOM	2.8097	2.8097 PSI
M.A.W.P.s AT BOTTOM	32.8097	32.8097 PSI

IMPACT TESTING IS NOT MANDATORY PER UG(20)f.

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
 UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-1000 Freon Storage Tank FOR Lawrence Livermore Laboratory

PO# 8153136 SO# 1569b

CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

VESSEL DATA	T HEAD	SHELL	
MATERIAL GRADES	SA-516-70	SA-516-70	
DESIGN TEMPERATURE	70.0000	70.0000	DEG F
ALLOW STRESS AT DESN TEMP	17500.0000	17500.0000	PSI
ALLOW STRESS AT N & C	17500.0000	17500.0000	PSI
MIN THICKNESS N & C	0.2250	0.2500	IN
CORROSION ALLOWANCE	0.1250	0.1250	IN
CORRODED (DESN) THICKNESS	0.1000	0.1250	IN

NOZZLE MARK, SIZE & SCHED: 18" - 150#	RFSO Manway
JOINT EFFICIENCY 'E1'	1.0000
NOZZLE NECK EFFICIENCY 'E'	0.7000
CORRECTION FACTOR 'F'	1.0000
LOCATION (H)EAD/(S)HELL	H
NOZZLE ELEV ABOVE BOTTOM (FT)	2.0000
NOZZLE PROJECTS INTO VESSEL	Y

CALCULATIONS	MAWP DESN	MAWP N&C	
MAWP AT TOP OF VESSEL	30.0000	30.0000	PSI
STATIC HEAD AT NOZZLE CTR LINE	1.4049	1.4049	PSI
NOZZLE DESIGN PRESSURE	31.4049	31.4049	PSI
VESSEL INSIDE DIAMETER	47.7500	47.5000	IN
TS HEAD CROWN RADIUS	48.0000	48.0000	IN
TS HEAD KNUCKLE RADIUS	3.6250	3.5000	IN
TS HEAD FACTOR 'M'	1.0000	1.0000	
NOZZLE SA-516-70 ALLOW STRESS	17500.0000	17500.0000	PSI
CORRECTION FACTOR (Sn/Sv)	1.0000	1.0000	
NOZZLE NECK OUTSIDE DIAM	18.0000	18.0000	IN
NOZZLE NECK NOM THICKNESS	0.2500	0.2500	IN
NOZZLE NECK CORROSION ALLOW	0.1250	0.0000	IN
NOZZLE NECK MINIMUM THICKNESS	0.1250	0.2500	IN
REINFORCEMENT LIMIT (D)	17.7500	17.5000	IN
or (Rn + Tn + T)	9.1000	9.2250	IN
AREA REQUIRED BASED ON Tr			
HEAD Tr	0.0430	0.0430	IN
NOZZLE NECK Trn	0.0228	0.0225	IN
HEAD EXCESS	0.0570	0.1820	IN
NOZZLE NECK EXCESS	0.1022	0.2275	IN
NOZZLE PROJN INTO VESSEL	0.2500	0.5625	IN
AREA REQUIRED	0.7639	0.7532	SQ IN
AREA IN EXCESS IN HEAD	1.0111	3.1843	SQ IN
AREA IN EXCESS IN NOZ EXT	0.0511	0.2560	SQ IN
AREA IN EXCESS IN NOZ INT	0.0000	0.2813	SQ IN
AREA FURNISHED BY WELDS	0.0781	0.1250	SQ IN
TOTAL AREA FURNISHED	1.1403	3.8465	SO IN
EXCESS AREA	0.3764	3.0934	SQ IN

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-1000 Freon Storage Tank FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569b
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

WELD SIZING & STRESS PATH CALCULATIONS

NOZZLE MARK: 18" - 150# RFSO Manway
Weld Configuration: UW-16.1 (i)

WELD SIZES FURNISHED	MAWP DESN	MAWP N&C
OUTER NOZZLE TO VESSEL FILLET	0.2500	0.2500 IN
INNER NOZZLE TO VESSEL FILLET	0.1250	0.2500 IN

MINIMUM REQUIREMENTS

WELD LOAD (A-A1)S	-4324.7480	-42545.0800 LBS
-------------------	------------	-----------------

MAXIMUM ALLOWABLE WELD LOADINGS

OUTER FILLET SHEAR	121226.2000	121226.2000 LBS
NOZZLE NECK SHEAR	85988.8400	170775.0000 LBS
IN FILLET WELD SHEAR	60613.1100	121226.2000 LBS

MAXIMUM COMBINED LOADINGS

OUT FIL WLD THRU NOZZLE	207215.1000	292001.3000 LBS
OUT FIL WLD THRU IN FIL WLD	181839.3000	242452.5000 LBS

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.

Lawrence Livermore Laboratory - T-1000 Freon Storage Tank

PO# 8153136 S/O# 1569b CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

DESIGN PRESSURE AT TOP OF VESSEL	30.0	PSI
STATIC HEAD PRESSURE	2.8097	PSI
DESIGN PRESSURE AT BOTTOM OF VESSEL	32.8	PSI
DESIGN TEMPERATURE	70.0000	DEGR F
OUTSIDE DIAMETER	48.0000	INCHES
OUTSIDE RADIUS (R)	24.0	INCHES
TANGENT TO TANGENT LENGTH (L)	75.0	INCHES
HEAD DEPTH (H)	9.0	INCHES

-----SHELL MATERIAL IS SA-516-70

SHELL THICKNESS, Corroded (ts)	0.1250	INCHES
SHELL ALLOWABLE STRESS (Ss)	17,500.0	PSI
SHELL EFFICIENCY AT SEAMS NEAR SADDLES (JE)	0.8500	
SHELL MINIMUM YIELD (Fy)	38,000.0	PSI
MODULUS OF ELASTICITY (E)	29,000,000.0	

-----HEAD MATERIAL IS SA-516-70

HEAD THICKNESS, Corroded (th)	0.1000	INCHES
HEAD ALLOWABLE STRESS (Sh)	17,500.0	PSI
HEAD JOINT EFFICIENCY (JH)	0.8500	
HEAD MINIMUM YIELD (Fy)	38,000.0	PSI

VESSEL WEIGHT EMPTY = $2250 \# \times 2.41 =$	5,422.5	LBS
WORKING CONTENTS WEIGHT = $650 \text{ gal} \times 13.51 \#/\text{ft}^3 \times 2.41 =$	21,141.0	LBS
TOTAL WORKING WEIGHT OF VESSEL + CONTENTS	26,563.5	LBS
DESIGN LOAD PER SADDLE (Q)	13,281.8	LBS

TANGENT LINE TO SADDLE CTR LINE (A)	14.5	INCHES
SADDLE WIDTH (B)	6.0	INCHES
SADDLE CONTACT ANGLE THETA	180.0	DEGREES

-----SHELL IS UNSTIFFENED

THERE ARE NO SADDLE WEAR PLATES

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.

Lawrence Livermore Laboratory - T-1000 Freon Storage Tank
PO# 8153136 S/O# 1569b CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

LONGITUDINAL BENDING STRESS IN SHELL
-----CONDITION: AT THE SADDLES, TENSION AT THE TOP

FACTOR K1 = 0.7180
STRESS S1 = 403.8 PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) = 3,149.7 PSI
INTERNAL PRESSURE STRESS + STRESS S1 = 3,553.6 PSI
LIMIT: SHELL ALLOW STRESS x JOINT EFF. = 14,875.0 PSI
TENSION STRESS IS WITHIN LIMITS

CONDITION: AT THE SADDLES, COMPRESSION AT BOTTOM

TS/R = 0.0052
FACTOR K8 = 1.1830
STRESS S1 = -245.1 PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) = 3,149.7 PSI
INTERNAL PRESSURE STRESS + STRESS S1 = 2,904.6 PSI
LIMIT: SHELL ALLOW YIELD x .5 = 19,000.0 PSI
COMBINED COMPRESSION STRESS IS WITHIN LIMITS
STRESS S1 = -245.1 PSI
LIMIT: (ME/29)x(TS/R)x(2-(2/3))x100x(TS/R)) = 8,608.2 PSI
COMPRESSION STRESS IS WITHIN LIMITS

CONDITION: AT MIDSPAN, AT BOTTOM (-) = COMPRESSION, (+) = TENSION

STRESS S1 = 264.7 PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) = 3,149.7 PSI
INTERNAL PRESSURE STRESS + STRESS S1 = 3,414.5 PSI
LIMIT: SHELL ALLOWABLE STRESS x J.E. = 14,875.0 PSI
TENSION STRESS IS WITHIN LIMITS

CONDITION: AT MIDSPAN AT THE TOP (-) = COMPRESSION, (+) = TENSION

TS/R = 0.0052
STRESS S1 = -264.7 PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) = 3,149.7 PSI
INTERNAL PRESSURE STRESS + STRESS S1 = 2,885.0 PSI
LIMIT: SHELL ALLOW YIELD x .5 = 19,000.0 PSI
COMBINED COMPRESSION STRESS IS WITHIN LIMITS
STRESS S1 = -264.7 PSI
LIMIT: (ME/29)x(TS/R)x(2-(2/3))x100x(TS/R)) = 8,608.2 PSI
COMPRESSION STRESS IS WITHIN LIMITS

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.

Lawrence Livermore Laboratory - T-1000 Freon Storage Tank

PO# 8153136 S/O# 1569b CALCS BY: R.H. Wilson REV< 0 > 02-25-1991
-----TANGENTIAL SHEAR
-----CONDITION: SADDLES AWAY FROM HEAD

A > R/2

A =

14.5

R/2 =

12.0
-----CONDITION: NO STIFFENERS (OR) STIFFENERS NOT IN PLANE OF SADDLE

FACTOR K2 =

0.5770

SHELL TANGENTIAL SHEAR STRESS S2 =

0.0 PSI

LIMIT: SHELL ALLOWABLE STRESS x .8

14,000.0 PSI

TANGENTIAL SHEAR STRESS IS WITHIN LIMITS
-----CIRCUMFERENTIAL STRESS
-----CONDITION: UNSTIFFENED, STRESS AT HORN OF SADDLE APPLICABLE

L <= 8 x R

L =

75.0

8 x R =

192.0

FACTOR K6 =

0.0059

CIRCUMFERENTIAL STRESS S4 =

-22,365.3 PSI

LIMIT: SHELL ALLOW STRESS x 1.5

26,250.0 PSI

CIRCUMFERENTIAL STRESS IS WITHIN LIMITS

CIRCUMFERENTIAL STRESS AT BOTTOM OF SHELL

CONDITION: STIFFENED OR UNSTIFFENED

FACTOR K7 =

0.6240

COMPRESSION STRESS S5 =

-7,619.2 PSI

LIMIT: SHELL MINIMUM YIELD x .5

19,000.0 PSI

CIRCUMFERENTIAL STRESS AT BOTTOM IS WITHIN LIMITS

steel structures, inc.

Manufacturers of Steel Storage Facilities

P.O. BOX 1170, MADERA, CALIFORNIA 93638

PHONE: MADERA (209) 873-8021

RICHARD WILSON, P.E.#C32343

SH 9 OF 9
DATE 2-25-91
BY RWN
JOB NO. 1569

$$DL = 2.25^k$$

$$LL = \frac{8.75^k}{11^k} \quad (650 \text{ gal} \cdot 13.51 \text{ ft}^3)$$

$$W = 11^k (1 \pm 1.41) = 26.5^k \text{ or } -4.5^k$$

$$V_5 = 11^k (1.41) = 15.5^k$$

$$R_1 = \frac{26.5^k}{4} + \frac{3'(15.5^k)}{3.83'(2)} = 12.7^k$$

$$R_2 = \frac{-4.5^k}{4} - \frac{3'(15.5^k)}{3.83'(2)} = -7.2^k$$

$$V_5 = \frac{15.5^k}{4} = 3.9^k \rightarrow$$

$$\underline{\text{LEGS}}: \text{ TRY TS } 6 \times 6 \times 1/4: A_g = 5.59 \text{ in}^2$$

$$S_x = 10.1 \text{ in}^3 \quad r = 2.33$$

$$f_a = \frac{12.7^k}{5.59 \text{ in}^2} = 2.27 \text{ ksi}$$

$$f_x = \frac{3.9^k(2.03')12''}{10.1 \text{ in}^3} = 9.41 \text{ ksi}$$

$$\frac{KL}{r} = \frac{1.5(25'')}{2.33} = 16.1 \Rightarrow F_a = 26.46 \text{ ksi} \quad (\text{E2-1})$$

$$\Sigma \Rightarrow \frac{2.27}{26.46} + \frac{9.41}{30.67} = .392 < 1.33 \text{ (ok)}$$

USE TS 6x6x1/4 legs

$$\underline{\text{ANCHOR BOLTS}}: \text{ TRY } (4) 3/4" \text{ M.B.}: A_g' = .4418 \text{ in}^2$$

$$f_u = \frac{3.9^k}{(4) .4418 \text{ in}^2} = 2.21 \text{ ksi} \text{ (ok)}$$

$$f_a = \frac{7.2^k}{(4) .4418 \text{ in}^2} = 4.07 \text{ ksi}$$

$$F_u = 20 \text{ ksi} \text{ (ok)}$$

USE (4) 3/4" M.B. / leg

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9101 & T-9103 Freon Storage Tanks FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569c
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 1 , CYLINDRICAL SHELL at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	66.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	5.5000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	33.8634	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
SHELL IS (S)MLS OR (W)ELDED	W
LONGIT JOINT RT EXAM	None
CIRCUMFERENTIAL EFFICIENCY 'E'	0.7000
CIRCUM JOINT RT EXAM	None
LONGITUDINAL EFFICIENCY 'E'	0.7000

APPLICABLE FORMULAS:

$T = P R / S E + 0.4 P$	(T REQ'D, CIRCUMFERENTIAL STRESS)
$T = P R / 2 S E + 1.4 P$	(T REQ'D, LONGITUDINAL STRESS)
$P = S E T / R - 0.4 T$	(P ALLOWABLE, CIRCUM STRESS)

CALCULATIONS	DESIGN	NEW & COLD	
REQ'D T FOR CIRCUM STRESS	0.0911	0.2161	INCHES
REQ'D T FOR LONGIT STRESS	0.0455	0.1705	INCHES
THICKNESS SUPPLIED	0.1250	0.2500	INCHES
M.A.W.P.s FOR T SUPPLIED	46.4719	93.0851	PSI

 A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9101 & T-9103 Freon Storage Tanks FOR Lawrence Livermore Laboratory
 PO# 8153136 SO# 1569c
 CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

COMPONENT # 2 , TORISPHERICAL HEAD at bottom

DESIGN CONDITIONS

OUTSIDE DIAM	66.0000	INCHES
DESIGN PRESSURE	30.0000	PSIG
SECTION STATIC HEAD	5.5000	FEET
CONTENTS SPECIFIC GRAVITY	1.6200	
DESIGN PRESSURE + STATIC HEAD	33.8634	PSIG
CORROSION ALLOWANCE	0.1250	INCHES
MINIMUM METAL TEMP	-20.0000	DEGR F
DESIGN TEMPERATURE	70.0000	DEGR F
SA-516-70 STRESS ALLOW AT DESN TEMP	17500.0000	PSI
SA-516-70 STRESS ALLOW AT 100 DEGR TEMP	17500.0000	PSI

VESSEL RADIOGRAPHY	None
HEAD IS (S)MLS OR (W)ELDED	S
HEAD JOINT RT EXAM	None
HEAD EFFICIENCY	0.8500

HEAD DATA

OUTSIDE CROWN RADIUS L	56.1000	INCHES
OUTSIDE KNUCKLE RADIUS R	6.0000	INCHES
RATIO L/R	9.3500	
FACTOR M	1.5144	

APPLICABLE FORMULAS:

$T = P L M / 2 S E + P (M - 0.2)$ (T REQ'D, HEAD)
 $P = 2 S E T / M L - T (M - 0.2)$ (P ALLOW, HEAD)

CALCULATIONS	DESIGN	NEW & COLD	
REQUIRED HEAD THICKNESS	0.0966	0.2216	INCHES
HEAD THICKNESS SUPPLIED	0.0970	0.2220	INCHES
M.A.W.P.s FOR T SUPPLIED	34.0169	78.0042	PSI

 A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED FOR INTERNAL PRESSURE

T-9101 & T-9103 Freon Storage Tanks FOR Lawrence Livermore Laboratory
 PO# 8153136 SO# 1569c
 CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

MAXIMUM ALLOWABLE WORKING PRESSURE COMPILATION BY COMPONENTS

COMPONENT	M.A.W.P. DESN	M.A.W.P. N&C
CYLINDRICAL SHELL at bottom	46.4719	93.0851 PSI
LESS STATIC HEAD	3.8634	3.8634 PSI
M.A.W.P. AT TOP	42.6086	89.2217 PSI
TORISPHERICAL HEAD at bottom	34.0169	78.0042 PSI
LESS STATIC HEAD	3.8634	3.8634 PSI
M.A.W.P. AT TOP	30.1535	74.1408 PSI
150# FLANGES	285.0000	285.0000 PSI
LESS STATIC HEAD	3.8634	3.8634 PSI
M.A.W.P. AT TOP	281.1366	281.1366 PSI
Design	33.8634	33.8634 PSI
LESS STATIC HEAD	3.8634	3.8634 PSI
M.A.W.P. AT TOP	30.0000	30.0000 PSI
M.A.W.P. AT DESIGN TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
M.A.W.P. AT NEW AND COLD TEMPERATURE AT TOP OF VESSEL LIMITED BY Design	30.0000	PSI
HORIZONTAL SHOP HYDRO LTD BY Design TO GAGE AT BOTTOM IN HORIZ. POSITION	51.0000	PSI
GAGE AT TOP IN OPERATING POSITION	45.0000	PSI
M.A.W.P.s FOR NOZZLE REINFORCEMENT CALCULATIONS		
LIMITING M.A.W.P.s AT TOP	30.0000	30.0000 PSI
TOTAL STATIC HEAD AT BOTTOM	3.8634	3.8634 PSI
M.A.W.P.s AT BOTTOM	33.8634	33.8634 PSI

IMPACT TESTING IS NOT MANDATORY PER UG(20)f.

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '89 Addenda
 CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
 UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-9101 & T-9103 Freon Storage Tanks FOR Lawrence Livermore Laboratory
 PO# 8153136 SO# 1569c
 CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

VESSEL DATA	T HEAD	SHELL	
MATERIAL GRADES	SA-516-70	SA-516-70	
DESIGN TEMPERATURE	70.0000	70.0000	DEG F
ALLOW STRESS AT DESN TEMP	17500.0000	17500.0000	PSI
ALLOW STRESS AT N & C	17500.0000	17500.0000	PSI
MIN THICKNESS N & C	0.2250	0.2500	IN
CORROSION ALLOWANCE	0.1250	0.1250	IN
CORRODED (DESN) THICKNESS	0.1000	0.1250	IN

NOZZLE MARK, SIZE & SCHED: 18" - 150#	RFSO Manway
JOINT EFFICIENCY 'E1'	1.0000
NOZZLE NECK EFFICIENCY 'E'	0.7000
CORRECTION FACTOR 'F'	1.0000
LOCATION (H)EAD/(S)HELL	S
NOZZLE ELEV ABOVE BOTTOM (FT)	5.5000
NOZZLE PROJECTS INTO VESSEL	Y

CALCULATIONS	MAWP DESN	MAWP N&C	
MAWP AT TOP OF VESSEL	30.0000	30.0000	PSI
STATIC HEAD AT NOZZLE CTR LINE	0.0000	0.0000	PSI
NOZZLE DESIGN PRESSURE	30.0000	30.0000	PSI
VESSEL INSIDE DIAMETER	65.7500	65.5000	IN
NOZZLE SA-516-70 ALLOW STRESS	17500.0000	17500.0000	PSI
CORRECTION FACTOR (Sn/Sv)	1.0000	1.0000	
NOZZLE NECK OUTSIDE DIAM	18.0000	18.0000	IN
NOZZLE NECK NOM THICKNESS	0.2500	0.2500	IN
NOZZLE NECK CORROSION ALLOW	0.1250	0.0000	IN
NOZZLE NECK MINIMUM THICKNESS	0.1250	0.2500	IN
REINFORCEMENT LIMIT (D)	17.7500	17.5000	IN
or (Rn + Tn + T)	9.1250	9.2500	IN
AREA REQUIRED BASED ON Tr			
SHELL Tr	0.0564	0.0562	IN
NOZZLE NECK Trn	0.0218	0.0215	IN
SHELL EXCESS	0.0686	0.1938	IN
NOZZLE NECK EXCESS	0.1032	0.2285	IN
NOZZLE PROJN INTO VESSEL	0.3125	0.6250	IN
AREA REQUIRED	1.0014	0.9835	SQ IN
AREA IN EXCESS IN SHELL	1.2174	3.3915	SQ IN
AREA IN EXCESS IN NOZ EXT	0.0645	0.2857	SQ IN
AREA IN EXCESS IN NOZ INT	0.0000	0.3125	SQ IN
AREA FURNISHED BY WELDS	0.0781	0.1250	SQ IN
TOTAL AREA FURNISHED	1.3600	4.1147	SQ IN
EXCESS AREA	0.3587	3.1312	SQ IN

A.S.M.E. SECTION VIII DIV 1 1989 EDITION + Dec '8 Addenda
CALCULATIONS FOR THICKNESSES REQUIRED NOZZLE REINFORCEMENT PER SECTIONS
UG-36, UG-37, UG-40, UG-41, UG-43, UG-45, UW-15, UW-16, APP L-7

T-9101 & T-9103 Freon Storage Tanks FOR Lawrence Livermore Laboratory
PO# 8153136 SO# 1569c
CALCULATIONS ENTERED BY R.H. Wilson REV < 0 > 02-25-1991

WELD SIZING & STRESS PATH CALCULATIONS

NOZZLE MARK: 18" - 150# RFSO Manway
Weld Configuration: UW-16.1 (i)

WELD SIZES FURNISHED	MAWP DESN	MAWP N&C
OUTER NOZZLE TO VESSEL FILLET	0.2500	0.2500 IN
INNER NOZZLE TO VESSEL FILLET	0.1250	0.2500 IN

MINIMUM REQUIREMENTS

WELD LOAD (A-A1)S	-3780.2020	-42139.5900 LBS
-------------------	------------	-----------------

MAXIMUM ALLOWABLE WELD LOADINGS

OUTER FILLET SHEAR	121226.2000	121226.2000 LBS
NOZZLE NECK SHEAR	85988.8400	170775.0000 LBS
IN FILLET WELD SHEAR	60613.1100	121226.2000 LBS

MAXIMUM COMBINED LOADINGS

OUT FIL WLD THRU NOZZLE	207215.1000	292001.3000 LBS
OUT FIL WLD THRU IN FIL WLD	181839.3000	242452.5000 LBS

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.
-----Lawrence Livermore Laboratory - T-9101 & T-9103 Freon Storage Tanks
PO# 8153136 S/O# 1569c CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

DESIGN PRESSURE AT TOP OF VESSEL	30.0	PSI
STATIC HEAD PRESSURE	3.8634	PSI
DESIGN PRESSURE AT BOTTOM OF VESSEL	33.9	PSI
DESIGN TEMPERATURE	70.0000	DEGR F
OUTSIDE DIAMETER	66.0000	INCHES
OUTSIDE RADIUS (R)	33.0	INCHES
TANGENT TO TANGENT LENGTH (L)	141.0	INCHES
HEAD DEPTH (H)	13.0	INCHES

-----SHELL MATERIAL IS SA-516-70

SHELL THICKNESS, Corroded (ts)	0.1250	INCHES
SHELL ALLOWABLE STRESS (Ss)	17,500.0	PSI
SHELL EFFICIENCY AT SEAMS NEAR SADDLES (JE)	0.8500	
SHELL MINIMUM YIELD (Fy)	38,000.0	PSI
MODULUS OF ELASTICITY (E)	29,000,000.0	

-----HEAD MATERIAL IS SA-516-70

HEAD THICKNESS, Corroded (th)	0.1000	INCHES
HEAD ALLOWABLE STRESS (Sh)	17,500.0	PSI
HEAD JOINT EFFICIENCY (JH)	0.8500	
HEAD MINIMUM YIELD (Fy)	38,000.0	PSI

VESSEL WEIGHT EMPTY = $1500 \text{ #} \times 2.41 =$	3,615.0	LBS
WORKING CONTENTS WEIGHT = $2300 \text{ gal} \times 13.51 \text{ #/gal} \times 2.41 =$	74,809.0	LBS
TOTAL WORKING WEIGHT OF VESSEL + CONTENTS	78,424.0	LBS
DESIGN LOAD PER SADDLE (Q)	39,212.0	LBS

TANGENT LINE TO SADDLE CTR LINE (A)	16.5	INCHES
SADDLE WIDTH (B)	18.0	INCHES
SADDLE CONTACT ANGLE THETA	180.0	DEGREES

-----SHELL IS UNSTIFFENED
-----THERE ARE NO SADDLE WEAR PLATES

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.
-----Lawrence Livermore Laboratory - T-9101 & T-9103 Freon Storage Tanks
PO# 8153136 S/O# 1569c CALCS BY: R.H. Wilson REV< 0 > 02-25-1991
-----LONGITUDINAL BENDING STRESS IN SHELL
-----CONDITION: AT THE SADDLES, TENSION AT THE TOP

FACTOR K1 =	3.1400	
STRESS S1 =	56.9	PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) =	4,470.0	PSI
INTERNAL PRESSURE STRESS + STRESS S1 =	4,526.9	PSI
LIMIT: SHELL ALLOW STRESS x JOINT EFF. =	14,875.0	PSI

TENSION STRESS IS WITHIN LIMITS
-----CONDITION: AT THE SADDLES, COMPRESSION AT BOTTOM

TS/R =	0.0038	
FACTOR K8 =	1.1830	
STRESS S1 =	-151.1	PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) =	4,470.0	PSI
INTERNAL PRESSURE STRESS + STRESS S1 =	4,318.9	PSI
LIMIT: SHELL ALLOW YIELD x .5 =	19,000.0	PSI

COMBINED COMPRESSION STRESS IS WITHIN LIMITS

STRESS S1 =	-151.1	PSI
LIMIT: (ME/29)x(TS/R)x(2-(2/3))x100x(TS/R) =	6,619.2	PSI

COMPRESSION STRESS IS WITHIN LIMITS
-----CONDITION: AT MIDSPAN, AT BOTTOM (-) = COMPRESSION, (+) = TENSION

STRESS S1 =	1,631.8	PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) =	4,470.0	PSI
INTERNAL PRESSURE STRESS + STRESS S1 =	6,101.7	PSI
LIMIT: SHELL ALLOWABLE STRESS x J.E. =	14,875.0	PSI

TENSION STRESS IS WITHIN LIMITS
-----CONDITION: AT MIDSPAN AT THE TOP (-) = COMPRESSION, (+) = TENSION

TS/R =	0.0038	
STRESS S1 =	-1,631.8	PSI
INTERNAL PRESSURE STRESS (PxR)/(2xTS) =	4,470.0	PSI
INTERNAL PRESSURE STRESS + STRESS S1 =	2,838.2	PSI
LIMIT: SHELL ALLOW YIELD x .5 =	19,000.0	PSI

COMBINED COMPRESSION STRESS IS WITHIN LIMITS

STRESS S1 =	-1,631.8	PSI
LIMIT: (ME/29)x(TS/R)x(2-(2/3))x100x(TS/R) =	6,619.2	PSI

COMPRESSION STRESS IS WITHIN LIMITS

Lawrence Livermore Laboratory - T-9101 & T-9103 Freon Storage Tanks
PO# 8153136 S/O# 1569c CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

CONDITION: SADDLES CLOSE TO HEAD

ADDITIONAL STRESS IN HEAD

CIRCUMFERENTIAL STRESS

```

L <= 8 x R                L =                141.0
                        8 x R =                264.0
FACTOR K6 =                0.0044
CIRCUMFERENTIAL STRESS S4 =                -34,716.6   PSI
LIMIT: SHELL ALLOW STRESS x 1.5                26,250.0   PSI
CIRCUMFERENTIAL STRESS    S4/ALLOW = 1.32 < 4/3  (A) SHORT TERM COND.

```

CIRCUMFERENTIAL STRESS AT BOTTOM OF SHELL

CONDITION: STIFFENED OR UNSTIFFENED

FACTOR K7 =	0.6240	
COMPRESSION STRESS S5 =	-9,247.1	PSI
LIMIT: SHELL MINIMUM YIELD x .5	19,000.0	PSI
CIRCUMFERENTIAL STRESS AT BOTTOM IS WITHIN LIMITS		

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.

Lawrence Livermore Laboratory - T-9101 & T-9103 Freon Storage Tanks
 PO# 8153136 S/O# 1569c CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

SUPPORT MATL SA-36 YIELD STRESS	36,000.0	PSI
WEB PLATE THICKNESS	0.2500	INCHES
SADDLE CONTACT ANGLE	180.0	DEGREES
FACTOR K11	0.3180	
SUPPORT HT FROM BASEPLATE TO VESSEL BOTTOM	25.5	INCHES
BASEPLATE LENGTH	66.0	INCHES
SEISMIC ZONE, UBC Figure 2	4.0	
SEISMIC ZONE COEF., UBC Table 23-I (Z)	0.4	
SOIL / STRUCTURE FACTOR, UBC Eqn.(12-2) (C)	2.7500	
IMPORTANCE FACTOR, UBC Table 23-L (I)	1.0	
NONBUILD. STRUCT. FACTOR, UBC Table 23-Q (Rw)	3.0	
UNIT WIND LOAD, UBC Table 23-F (Uw)	17.0	PSF
HEIGHT, EXP. & GUST FACTOR, UBC Table 23-G(Ce)	1.2	
SHAPE COEFFICIENT, UBC Table 23-H (Cq)	0.8	
PRESENTED WIND AREA	76.5	SQ FT
WEIGHT OF VESSEL EMPTY (WE)	3,615.0	LBS
WEIGHT OF VESSEL + CONTENTS (WT)	78,424.0	LBS
DESIGN LOAD PER SADDLE SUPPORT (Q)	39,212.0	LBS
LATERAL SEISMIC LOAD $V_s = 1.41 * (3000 + 31060 \#) =$	48,040.0	LBS
TOTAL WIND LOAD $V_w = \text{AREA} \times U_w \times C_e \times C_q \times I$	1,249.2	LBS
HORIZONTAL FORCE, DL + LL = $K_{11} \times Q$	12,469.4	LBS/SADDLE
HORIZONTAL FORCE, SEISMIC = $V_s/2$	24,020.0	LBS/SADDLE
HORIZONTAL FORCE, WIND = $V_w/2$	624.6	LBS/SADDLE
WEB EFFECTIVE AREA = $R/3 \times \text{WEB THK}$	2.8	SQ IN
WEB STRESS DUE TO VESSEL + CONTENTS	4,534.3	PSI
WEB STRESS DUE TO SEISMIC	8,734.5	PSI
WEB STRESS DUE TO WIND	227.1	PSI
WEB STRESS VESSEL + SEISMIC	13,268.9	PSI
WEB STRESS VESSEL + WIND	4,761.5	PSI
WEB STRESS LIMIT = $F_y \times 2/3$	24,000.0	PSI
SEISMIC AND WIND CHECK: LATERAL OVERTURN		
CENTER OF GRAVITY (CG)	58.5	INCHES
LATERAL LEVER ARM (BASEPLATE LENGTH /2)	33.0	INCHES
OVERTURN MOMENT DUE TO SEISMIC (CG*VS)	2,810,340.0	INCH LBS
RESISTIVE MOMENT VESSEL + CONTENTS	2,587,992.0	INCH LBS
OVERTURN EXISTS DUE TO SEISMIC ... ANCHORAGE REQUIRED		
OVERTURN MOMENT DUE TO WIND	73,075.9	INCH LBS
RESISTIVE MOMENT VESSEL EMPTY	119,295.0	INCH LBS
NO OVERTURN DUE TO WIND		

SUPPORT SADDLE CALCULATIONS PER THE PRESSURE VESSEL HANDBOOK, 8th ED.

Lawrence Livermore Laboratory - T-9101 & T-9103 Freon Storage Tanks
 PO# 8153136 S/O# 1569c CALCS BY: R.H. Wilson REV< 0 > 02-25-1991

LOAD TRANSFER INTO CONCRETE UNDER BASEPLATES AND ANCHOR BOLTS

LATERAL SHEAR AT BASEPLATES DUE TO SEISMIC	48,040.0	LBS
LATERAL SHEAR AT BASEPLATES DUE TO WIND	1,249.2	LBS

BENDING STRESS IN BASEPLATES:

BASEPLATE EFFECTIVE WIDTH	10.0	INCHES
BASEPLATE LENGTH	66.0	INCHES
BASEPLATE THICKNESS	0.5000	INCHES
BASEPLATE AREA	660.0	INCHES
CONCRETE STRESS UNDER BASEPLATE	59.4	PSI
LIMIT: $f'_c \times 3/8 \times 2$	1,500.0	PSI
BASEPLATE CANTILEVER	4.8750	INCHES
BASEPLATE MOMENT = $W \times L^2 / 2$	706.0	INCH LBS
BASEPLATE $S_x = t^2 / 6$	0.0417	INCHES ³
BASEPLATE BENDING STRESS	16,943.6	PSI
LIMIT: $.75 \times F_y$	27,000.0	PSI

LOAD BRACKETS: $P = 2.5^k$

$$M = 2.5^k (15") = 37.5^k\text{IN}$$

$$R_y = \frac{37.5^k\text{IN}}{9"} = 4.2^k$$

TRY (4) $5/8"$ MB. $A_t' = .31 \text{ in}^2$

$$f_v = \frac{2.5^k}{4(.31)} = 2.0 \text{ KSI}$$

$$f_a = \frac{4.2^k}{2(.31)} = 6.8 \text{ KSI}$$

$$F_a = 20.0 \text{ KSI} \quad \textcircled{2}$$

USE 4 $\times$ $5/8"$ MB. / BKT.

MECHANICAL ENGINEERING SAFETY NOTE
Seismic Support of 2000 Gallon Freon Tanks
T9101 and T9103 North of Building 490
490-Q11A1

AVLIS

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MECHANICAL ENGINEERING SAFETY NOTE
Seismic Support of 2000 Gallon Freon Tanks
T9101 and T9103 North of Building 490

A. Scope

This Safety Note includes design parameters and stress analysis of the mounting and load cell installation for two Freon tanks located outdoors, just north of B490E. The tanks are mounted on load cells to permit monitoring of the tank weight. Each tank holds up to 2000 gallons of Freon 113.

The brackets shall comply with:

1. LLNL Mechanical Engineering Design Safety Standards (M-012, Revision 6), section 5.2 "Seismic and Wind Design Criteria".
2. Memorandum from H. H. Woo of Energy Systems Engineering Division, January 11, 1990 (HW-002/90) "Seismic and Wind Design Criteria".
3. Table A-3, LLNL Design Response Spectra based on results of Geometrix Consultants, Inc., 1985, (Appendix 2).

B. System Description

The load cell assemblies are built by BLH Electronics, Co. and consist of the load cell plus mounting hardware. We are using the KIS-1 load cell with a 50kN (11,200 lb) capacity. Each load cell has a seismic overload capacity in the vertical direction of three times the rated capacity or 33,600 lbs. and in the horizontal direction, two times the rated capacity or 22400 lbs.

The tank saddles are provided with a bolt pattern of four holes at each load cell location. An adapter plate will mount to the top of the load cell bearing yoke with two bolts and then to the tank with four bolts. In addition, a foundation plate will mount to the bottom of the load cell housing with four bolts. The foundation plate will be mounted to the concrete pad with four, one-inch size anchor bolts as described herein.

C. Drawing References

Below is a list of LLNL AAA- drawings referenced in this report.

AAA91-105973, Tank T9101
AAA91-105974, Tank T9103
Plant drawings PLS 90-048D, PLS 90-049D, PLS 90-050D
AAA91-105052 Freon purification piping details

D Seismic Design Criteria

1. The storage tank mounted on four load cells contains Freon R113. Failure of the system, caused by earthquake, could lead to the injury of personnel and to the release of Freon to the environment.

The tank is located outdoors on a concrete pad. The weight of Freon will be based on 13.1 lb/gallon at 70° F.

2. Hazard annual probability of exceedance is assumed to be 1×10^{-3} (important or low hazard facility).
3. The ground surface acceleration is 0.6 g per Table 1 Page 1 of HW-002/90.

Because the resonant frequencies of the system is unknown the worst condition will be assumed.

Per Table A-3 of Geometrix Consultants, Inc., 1985, shown in Appendix 2, the maximum spectral acceleration for 5% damping is 1.41 g. This analysis uses the 1.41 g acceleration acting simultaneously in all three directions.

4. Minimum seismic safety factor $SF = 1$ based on yield strength of material.
5. Tensile or compressive stress and shear stress shall be combined per Mohr's stress circle to determine the principal stress.
6. Von Mises stress shall be calculated so that the direction energy theory can be used to predict failure.
7. Anchor bolts will be epoxied in the concrete. Allowable shear and tension forces on the anchor bolts are taken from Hilti, Inc., "Fastening Technical Guide" H-437-5/89, Page 34.
8. The tension-shear interaction formula, as shown on Page 15 of HW-002/90, is used to evaluate the design of anchor bolts. The Y-exponent is shown in each case.
9. Seismic design of the tank and its support saddles has been performed by the tank supplier. The supplier was Steel Structures, Inc. on PO #8153136.

E. Summary of Stress Analysis

SF = Safety factor of seismic condition
T-S = Tension-shear interaction value for anchor bolts in concrete.
Y = Exponent applied to T-S.
Page No. = Page number of seismic bracket analysis (Appendix 1).
Minimum allowable SF = 1.00
Maximum allowable T-S = 1.00

Safety Factors and Tension-Shear Interaction					
Item No.	Description	SFs	T-S	Y	Page No.
1	Yoke mounting screw	1.3			13
2	Adater plate mounting screw	2.2			15
3	Mounting base screws	1.3			19
4	Thread shear in base	1.1			19
5	Anchor bolt in tension and shear		.98	1.66	21
6	Base plate in bending, 1 1/4 thick	1.1			25
7	Load cell assembly vertical direction	1.2			11
8	Load cell assembly horizontal direction	1.5			11

F. Conclusion

The load cell installation and the mounting of the 2000 gal. Freon tank is in compliance with the documents listed in paragraph A.

Figure 1

Base Plate

Figure 3

Material: 1.25 inch thick ASTM A36 plate.

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November 8, 1991
File #M415

**Mechanical Engineering Safety Note
Seismic Support of 2000 Gallon Freon Tanks
T9101 and T9103 North of B490**

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Appendix 1

STRESS ANALYSIS

Nomenclature

A = Area, In^2 .
 A_S = Stress area of threaded bolt, In^2 .
 a = Acceleration, in/sec^2 .
 a_x = Horizontal acceleration in x-direction, in/sec^2 .
 a_y = Horizontal acceleration in y-direction, in/sec^2 .
 a_z = Vertical acceleration, in/sec^2 .
 b = Width, horizontal distance, in.
 d = diameter, in.
 F = Force, lb.
 F_B = Force per bolt, lb.
 F_H = Horizontal seismic force ($\bar{F}_x + \bar{F}_y$), lb.
 F_s = Shear force, lb.
 F_t = Allowable tensile force (anchor bolt), lb.
 F_v = Vertical seismic force ($F_z + W$) lb.
 F_v = Allowable shear force (anchor bolt), lb.
 f_t = Actual tensile force (anchor bolt), lb.
 f_v = Actual shear force (anchor bolt), lb.
 h = height, in.
 I = Moment of inertia, in^4
 l = length, in.
 M = Moment, lb-in.
 R = Reaction force, lb.
 R_H = Horizontal reaction force, lb.
 R_v = Vertical reaction force, lb.
 r = Radius, in.
 S_S = Shear strength of material, psi.
 S_T = Tensile strength of material, psi.
 SF = Safety factor.
 $T - S$ = Tension-shear interaction for anchor bolts.
 W = Weight, lb.
 W_F = Weight of freon
 W_T = Weight of tank (empty), lb.
 Y = Exponent used in tension-shear interaction formula.
 α = Angle, degrees or radians
 σ = Compressive or tensile stress, psi.
 σ_M = Max. stress (Mohr's stress circle), psi.
 σ_m = Min. stress (Mohr's stress circle), psi.
 σ' = Von Mises stress, psi.
 δ = Shear stress, psi.

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FORMULAS USED IN THIS ANALYSIS

MOHR'S STRESS CIRCLE, VON MISES STRESS
AND NUT THREAD SHEAR.

REFERENCE:

MECHANICAL ENGINEERING DESIGN
BY JOSEPH E. SHIGLEY
SECOND EDITION

MOHR'S STRESS CIRCLE PAGE 30.
VON MISES STRESS PAGE 234.
NUT THREAD SHEAR PAGE 300.

MOHR'S STRESS CIRCLE:

$$\sigma_M, \tau_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

VON MISES STRESS:

$$\sigma' = \sqrt{\sigma_M^2 - \sigma_M \tau_m + \tau_m^2}$$

NUT THREAD SHEAR:

$$\tau_z = \frac{2F}{\pi d h}$$

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TENSION-SHEAR INTERACTION FORMULA
FOR ANCHOR BOLTS.

REFERENCE:

MEMORANDUM FROM H. H. WOO OF ESED,
JANUARY 11, 1990 (HW-002/90)
"SEISMIC AND WIND DESIGN CRITERIA"

$$T-S = \left(\frac{f_t}{F_t} \right)^Y + \left(\frac{f_v}{F_v} \right)^Y \leq 1.0$$

THE EXPONENT Y VARIES BETWEEN
1 AND 5/3 DEPENDING ON THE
CONDITION OF THE CONCRETE.

LOAD CELL ULTIMATE FORCE:

REFERENCE: BHL ELECTRONICS, INC.

CANTON, MASSACHUSETTS

TRANSDUCER SPECIFICATION SHEETS.

LOAD CELL NO. 50KN-K15-1

CAPACITY: 50KN (11,240 lb).

ULTIMATE VERTICAL LOAD AT 300% OF RATED
CAPACITY IS 33,720 lb.ULTIMATE HORIZONTAL LOAD AT 200% OF RATED
CAPACITY IS 22,480 lb.

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THIS IS A SEISMIC ANALYSIS OF THE INSTALLATION OF TWO FREON TANKS LOCATED NORTH OF BUILDING 490E. THE CAPACITY OF EACH TANK IS 2000 GALLONS. THE TANK IS MOUNTED ON A 12 INCH THICK CONCRETE PAD. THE STRENGTH OF THE CONCRETE IS 4000 PSI. (PER PLANT ENGINEERING DWGS: PLS90-490-04BD, PLS90-49D AND PLS90-45D. THE TANK IS RESTING ON FOUR BRACKETS WITH A LOAD CELL INSTALLED BETWEEN THE CONCRETE AND EACH BRACKET.

SEVERE EARTHQUAKE COULD CAUSE INJURIES TO PERSONNEL AND THE RELEASE OF FREON TO THE ENVIRONMENT. MODERATE HAZARD FACILITIES IS THEN ASSUMED IN THIS ANALYSIS.

SPECTRAL ACCELERATION FOR 5% DAMPING AND FOR HAZARD ANNUAL PROBABILITY OF EXCEEDANCE OF 1×10^{-3} IS TAKEN FROM TABLE A-3 IN APPENDIX 2.

BECAUSE THE AMPLIFICATION FACTOR OF THE DESIGN RESPONSE SPECTRA IS UNKNOWN, THE MAXIMUM SPECTRAL ACCELERATION OF $1.41g$ WILL BE SELECTED FROM THE TABLE.

THIS ACCELERATION IS ASSUMED TO ACT SIMULTANEOUSLY IN ALL THREE DIRECTIONS,

$$a_x = 1.41g$$

$$a_y = 1.41g$$

$$a_z = 1.41g$$

$$F_x = a_x W = 1.41 W$$

$$F_y = a_y W = 1.41 W$$

$$F_z = a_z W = 1.41 W$$

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THE WORST CONDITION FOR OVERTURNING MOMENT
IS WHEN F_z IS ACTING UPWARDS.

$$\therefore F_v = F_z - W = (1.41 - 1)W = 0.41W$$

THE MAXIMUM HORIZONTAL FORCE

$$F_H = \sqrt{F_x^2 + F_y^2}$$

$$F_H = \sqrt{(1.41W)^2 + (1.41W)^2} = 1.41\sqrt{2} W_D$$

THE DIRECTION OF THE HORIZONTAL FORCE
 F_H WILL BE SELECTED TO REPRESENT
THE WORST CONDITION IN THE FOLLOWING
ANALYSIS.

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TWO LOAD CONDITIONS WILL BE ANALYZED TO FIND OUT WHICH GENERATES THE HIGHER FORCE FOR ONE OF THE LOAD CELL MOUNTS.

CONDITION A: ASSUME THE HORIZONTAL SEISMIC FORCE IS ACTING 90° TO THE CENTER LINE OF THE TANK.

CONTITION B: ASSUME THE HORIZONTAL SEISMIC FORCE IS ACTING 90° TO THE DIAGONAL OF THE MOUNTING PATTERN.

MOUNTING PATTERN

$$\frac{d}{a} = \frac{b}{c}$$

$$d = \frac{ab}{c}$$

$$a = 58.00 \text{ IN}$$

$$b = 108.00 \text{ IN}$$

$$c = \sqrt{a^2 + b^2} = 122.59 \text{ IN}$$

$$d = \frac{ab}{\sqrt{a^2 + b^2}} = 51.10 \text{ IN}$$

$$h = 48.98 \text{ IN}$$

$$\left. \begin{array}{l} F_H = 60,818 \text{ lb} \\ F_V = 12,505 \text{ lb} \end{array} \right\} \begin{array}{l} \text{SEE} \\ \text{PAGE 10} \end{array}$$

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$$\sum M_2 = 0$$

$$F_H h + F_V \frac{a}{2} - R_1 a = 0$$

$$R_1 = \frac{F_H h + F_V \frac{a}{2}}{a} = \frac{F_H h}{a} + \frac{F_V}{2}$$

R₁ IS RESISTED BY 2 BOLTS.

$$\text{FORCE PER BOLT } R_B = \frac{R_1}{2}$$

CONDITION A

FORCE DIAGRAM

$$R_B = \frac{F_H h}{2a} + \frac{F_V}{4}$$

CONDITION B

FORCE DIAGRAM

$$\sum M_4 = 0$$

$$F_H h + F_V d - R_3 2d - R_5 d = 0$$

DEFLECTION DIAGRAM

$$R_3 = \Delta_3 K$$

$$R_5 = 2 \Delta_5 K \quad (\text{TWO BOLTS})$$

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$$F_H h + F_V d - 2d \Delta_3 k - 2d \Delta_5 k = 0$$

$$\frac{\Delta_5}{d} = \frac{\Delta_3}{2d} \quad \Delta_5 = \frac{\Delta_3}{2}$$

$$F_H h + F_V d - 2d \Delta_3 k - 2d \frac{\Delta_3}{2} k = 0$$

$$F_H h + F_V d = \Delta_3 k d (2 + 1)$$

$$\Delta_3 k = \frac{F_H h + F_V d}{3d} = \frac{F_H h}{3d} + \frac{F_V}{3}$$

$$R_3 = \frac{F_H h}{3d} + \frac{F_V}{3} = \frac{(60,818)(48.98)}{(3)(51.1)} + \frac{12,505}{3} = 23,600 \text{ lb}$$

$$R_B = \frac{(60,818)(48.98)}{(2)(58)} + \frac{12,505}{4} = 28,806 \text{ lb}$$

$R_B > R_3$ WHICH MEANS THE HORIZONTAL SEISMIC FORCE WILL BE ASSUMED TO ACT 90° TO THE CENTER LINE OF THE TANK, IN FOLLOWING ANALYSIS.

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FIND WEIGHT W WEIGHT OF TANK EMPTY $W_T = 4,300$ lb SEE
DWG AAA91-105974

TANK CAPACITY IS 2000 GALLON

SPECIFIC WEIGHT OF FREON 113, 13.1 lb/GAL.

WEIGHT OF FREON WHEN TANK IS FULL

$$W_F = (13.1)(2000) = 26,200 \text{ lb}$$

TOTAL WEIGHT OF FULL TANK $W = W_T + W_F$

$$W = 4,300 + 26,200 = 30,500 \text{ lb}$$

CENTER OF GRAVITY WILL BE ASSUMED TO BE
AT THE CENTER OF THE TANK.

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HORIZONTAL SEISMIC FORCE $F_H = 1.41 \sqrt{2} W$

$$F_H = 1.41 \sqrt{2} (30,500) = \underline{60,818 \text{ lb}}$$

VERTICAL SEISMIC FORCE $F_V = (1.41 - 1) W$

$$F_V = (.41)(30,500) = \underline{12,505 \text{ lb}}$$

$$\sum F = 0$$

$$F_H - R_H = 0$$

$$R_H = \underline{60,818 \text{ lb}}$$

FORCE DIAGRAM
FOR LOAD CELL SHAFT

$$\sum M_2 = 0 \quad 48.98 F_H + 29.00 F_V - 58 R_{V1} = 0$$

$$R_{V1} = \frac{48.98 F_H + 29.00 F_V}{58}$$

$$R_{V1} = \frac{(48.98)(60,818) + (29)(12,505)}{58} = \underline{57,612 \text{ lb}}$$

LOAD LIMIT PER LOAD CELL:

VERTICAL AT 300%

$$L_V = 33,720 \text{ lb}$$

HORIZONTAL AT 200%

$$L_H = 22,480 \text{ lb}$$

SEE PAGE 3

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FORCES OF LOAD CELL SHAFT

 R_H IS RESISTED BY FOUR LOAD CELLSHORIZONTAL LOAD PER CELL $F_{LH} = \frac{R_H}{4}$

$$F_{LH} = \frac{60,818}{4} = 15,205 \text{ lb}$$

$$SF_s = \frac{L_H}{F_{LH}} = \frac{22,480}{15,205} = 1.5$$

$$SF_s = 1.5$$

 R_V IS RESISTED BY TWO LOAD CELLSVERTICAL LOAD PER CELL $F_{LV} = \frac{R_V}{2}$

$$F_{LV} = \frac{57,612}{2} = 28,806 \text{ lb}$$

$$SF_s = \frac{LV}{F_{LV}} = \frac{33,740}{28,806} = 1.2$$

$$SF_s = 1.2$$

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FIND STRESSES IN YOKE MOUNTING SCREWS.

SCREW: M 16-2

$$\text{MINOR DIA} = 13.204 \text{ mm} = .520 \text{ IN}$$

$$A_s = \frac{\pi}{4} d^2 = \frac{\pi}{4} (.520)^2 = .212 \text{ IN}^2$$

$$\sum M_A = 0$$

$$2.73 F_{LH} + 2.265 F_{LV} - 4.53 R_3 = 0$$

$$R_3 = \frac{2.73 F_{LH} + 2.265 F_{LV}}{4.53}$$

$$R_3 = \frac{(2.73)(15,205) + (2.265)(28,799)}{4.53} = 23,563 \text{ lb}$$

$$\text{SHEAR FORCE PER SCREW } F_s = \frac{F_{LH}}{2} = 7603 \text{ lb}$$

$$\sigma = \frac{R_3}{A_s} = \frac{23,563}{.212} = 111,146 \text{ PSI}$$

$$\sigma_2 = \frac{7603}{.212} = 35,863 \text{ PSI}$$

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$$\sigma_M, \sigma_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$\sigma_M, \sigma_m = \frac{111,146}{2} \pm \sqrt{\left(\frac{111,146}{2}\right)^2 + (35,843)^2} = 55,573 \pm 66,140$$

$$\sigma_M = 121,713 \text{ PSI}$$

$$\sigma_m = -10,567 \text{ PSI}$$

$$\sigma' = \sqrt{\sigma_M^2 - \sigma_M \sigma_m + \sigma_m^2}$$

$$\sigma' = \sqrt{(121,731)^2 - (121,731)(-10,567) + (-10,567)^2} = 127,344 \text{ PSI}$$

MATERIAL: ALLOY STEEL ASTM A574 OR
METRIC GRADE 12.9.

$$S_y = 160,000 \text{ PSI}$$

$$SF_s = \frac{160,000}{127,344} = 1.3$$

$$SF_s = 1.3$$

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FIND STRESSES IN ADAPTER PLATE MOUNTING
SCREWS. SCREW SIZE 3/8-10UNC
SEE SKETCH ON PAGE 3.

$$A_s = .334 \text{ IN}^2$$

$$\left. \begin{array}{l} F_{LH} = 15,205 \text{ lb} \\ F_{LV} = 28,799 \text{ lb} \end{array} \right\} \text{PAGE 3}$$

$$\sum M_6 = 0$$

$$3.98 F_{LH} + 3 F_{LV} - 6 R_5 = 0$$

FORCE DIAGRAM

$$R_5 = \frac{3.98 F_{LH} + 3 F_{LV}}{6}$$

$$R_5 = \frac{(3.98)(15,205) + (3)(28,799)}{6} = \underline{24,485 \text{ lb}}$$

$$\text{TENSILE FORCE PER BOLT } F_B = \frac{R_5}{2} = \underline{12,243 \text{ lb}}$$

$$\text{SHEAR FORCE PER BOLT } F_s = \frac{F_{LH}}{4} = \frac{15,205}{4} = \underline{3,801 \text{ lb}}$$

$$\sigma = \frac{F_B}{A_s} = \frac{12,243}{.334} = \underline{36,656 \text{ PSI}}$$

$$\tau = \frac{F_s}{A_s} = \frac{3,801}{.334} = \underline{11,380 \text{ PSI}}$$

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MOHR'S STRESS CIRCLE:

$$\sigma_M, \tau_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$\sigma_M, \tau_m = \frac{36,656}{2} \pm \sqrt{\left(\frac{36,656}{2}\right)^2 + (11,380)^2} = 18,328 \pm 21,574$$

$$\sigma_M = 39,902 \text{ PSI} \quad \tau_m = -3246 \text{ PSI}$$

VON MISES STRESS:

$$\sigma' = \sqrt{\sigma_M^2 - \sigma_M \tau_m + \tau_m^2}$$

$$\sigma' = \sqrt{(39,902)^2 - (39,902)(-3246) + (-3246)^2} = 41,706 \text{ PSI}$$

MATERIAL: SAE GRADE 5 OR ASTM A449

$$S_y = 92,000 \text{ PSI}$$

$$SF_s = \frac{S_y}{\sigma'} = \frac{92,000}{41,706} = 2.2$$

$$SF_s = 2.2$$

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FIND STRESSES IN SCREWS FOR MOUNTING
BASE: 4 SCREWS, SIZE 5/8-11UNC

$$A_s = .226 \text{ IN}^2$$

MOUNTING BASE

FORCE DIAGRAM

$$\sum M_B = 0$$

$$3.248 F_{LH} + 2.264 F_{LV} - 4.528 R_7 = 0$$

$$R_7 = \frac{3.248 F_{LH} + 2.264 F_{LV}}{4.528}$$

$$R_7 = \frac{(3.248)(15,205) + (2.264)(28,806)}{4.528} = 25,309 \text{ lb}$$

$$\sum F = 0$$

$$R_B + F_{LV} - R_7 = 0; \quad R_B = R_7 - F_{LV}$$

$$R_B = 25,306 - 15,205 = 10,101 \text{ lb}$$

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YOKE LOCATION ON
MOUNTING BASE

TENSILE FORCE R_7 IS RESISTED BY
SCREWS 3 & 4

FORCE DIAGRAM

$$\sum M_3 = 0$$

$$7.85 R_7 - 9.65 R_4 = 0$$

$$R_4 = \frac{7.85 R_7}{9.65}$$

$$R_4 = \frac{(7.85)(25,309)}{9.65} = 20,586 \text{ lb}$$

SHEAR FORCE F_{LH} IS RESISTED BY
SCREWS 1, 2, 3 & 4.

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FORCE DIAGRAM

$$R_{2,4} = \frac{(7.85')(15,205)}{9.65'} = \underline{12,369 \text{ lb}}$$

SHEAR FORCE AT BOLT 4 $F_s = \frac{R_{2,4}}{2}$

$$F_s = \frac{12,369}{2} = \underline{6,185 \text{ lb}}$$

$$\bar{\sigma}_4 = \frac{R_4}{A_s} = \frac{20,586}{.226} = \underline{91,088 \text{ PSI}}$$

$$\bar{\tau}_4 = \frac{F_s}{A_s} = \frac{6,185}{.226} = \underline{27,367 \text{ PSI}}$$

MOHR STRESS CIRCLE

$$\bar{\sigma}_m, \bar{\tau}_m = \frac{\bar{\sigma}_4}{2} \pm \sqrt{\left(\frac{\bar{\sigma}_4}{2}\right)^2 + \bar{\tau}_4^2}$$

$$\bar{\sigma}_m, \bar{\tau}_m = \frac{91,088}{2} \pm \sqrt{\left(\frac{91,088}{2}\right)^2 + (27,367)^2} = 45,544 \pm 53,134$$

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$$\sqrt{M} = 98,678 \text{ PSI}$$

$$\sqrt{M} = -7590 \text{ PSI}$$

VON MISES STRESS:

$$\begin{aligned} \sigma' &= \sqrt{(98,678)^2 - (98,678)(-7590) + (-7590)^2} = \\ &= 102,684 \text{ PSI} \end{aligned}$$

MATERIAL: STEEL SAE GRADE 8 OR
ASTM A358 GRADE BD

$$S_y = 130,000 \text{ PSI}$$

$$SF_s = \frac{S_y}{\sigma'} = \frac{130,000}{102,684} = 1.3$$

$$SF_s = 1.3$$

FIND SHEAR STRESS IN THE 7/8-11UNC TAPPED
HOLE IN BASE PLATE AT POINT #4.
ASSUM MINIMUM THREAD ENGAGEMENT $h = 1.25$

MATERIAL: STEEL ASTM A36

$$S_y = 36,000 \text{ PSI.}$$

$$S_s = 18,000 \text{ PSI.}$$

$$\sigma_2 = \frac{2 R_A}{\pi d h} = \frac{(2)(20,568)}{\pi (.625)(1.25)} = 16,760 \text{ PSI}$$

$$SF_s = \frac{S_s}{\sigma_2} = \frac{18,000}{16,760} = 1.1$$

$$SF_s = 1.1$$

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FIND THE FORCES EXCERTED ON THE $\phi 1.00$
ANCHOR BOLTS, USED TO ANCHOR THE BASE
PLATE TO THE CONCRETE.

BASE PLATE

$$\left. \begin{array}{l} F_{LH} = 15,205 \text{ lb} \\ F_{LV} = 28,806 \text{ lb} \end{array} \right\} \text{PAGE 8}$$

$$\vec{M} = 0$$

$$4.498 F_{LH} + 7.5 F_{LV} - 15 R_9 = 0$$

FORCE DIAGRAM

$$R_9 = \frac{4.498 F_{LH} + 7.5 F_{LV}}{15}$$

$$R_9 = \frac{(4.498)(15,205) + (7.5)(28,806)}{15} = 18,962 \text{ lb}$$

R_9 IS RESISTED BY 2 ANCHOR BOLTS.

FORCE PER ANCHOR BOLT $F_a = \frac{R_9}{2}$

$$F_a = \frac{18,959}{2} = 9,481 \text{ lb}$$

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THE HORIZONTAL FORCE F_{LH} IS RESISTED BY
4 ANCHOR BOLTS.

SHEAR FORCE PER BOLT $F_s = \frac{F_{LH}}{4}$

$$F_s = \frac{15,205}{4} = 3801 \text{ lb}$$

TENSION-SHEAR INTERACTION FOR THE
ANCHOR BOLTS.

$$T-S = \left(\frac{F_a}{F_t} \right)^Y + \left(\frac{F_s}{F_n} \right)^Y \leq 1.00$$

THE ANCHOR BOLT SELECTED IS HILTI HVA
ADHESIVE ANCHOR. BOLT IS 1.00 DIA AND
9.00 IN MINIMUM EMBEDMENT.
MATERIAL: STEEL ASTM A307.
HILTI NO. HAS STD-1

$$F_t = 12120 \text{ lb}$$

$$F_n = 7630 \text{ lb}$$

THE CONCRETE STRENGTH IS 4000 PSI.

BECAUSE OF THE HIGH STRENGTH CONCRETE
THE EXPONENT Y WILL BE SELECTED AS

$$Y = \frac{5}{3} = 1.66$$

$$T-S = \left(\frac{9,479}{12120} \right)^{1.66} + \left(\frac{3801}{7630} \right)^{1.66} = .98$$

$$T-S = .98$$

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FIND STRESSES IN BASE PLATE ASSUMING
CONCENTRATED LOAD AT CENTER OF THE PLATE.

THIS IS A CONSERVATIVE ASSUMPTION WHICH
WILL YIELD HIGHER STRESSES THAN THE
PLATE WILL EXPERIENCE.

BENDING STRESS WILL
BE ANALYZED FOR
VERTICAL AND
HORIZONTAL DIRECTION.

SHEAR STRESS WILL
BE ANALYZED FOR
VERTICAL AND
HORIZONTAL DIRECTION
AS WELL AS FROM
TORQUE.

$$\left. \begin{array}{l} FLH = 15,205 \text{ lb} \\ FLV = 28,806 \text{ lb} \end{array} \right\} \text{PAGE 8}$$

$$A = b h = (17.5)(1.25) = 21.88 \text{ IN}^2$$

$$I_V = \frac{b h^3}{12} = \frac{(17.5)(1.25)^3}{12} = 2.848 \text{ IN}^4$$

$$I_H = \frac{b h^3}{12} = \frac{(1.25)(17.5)^3}{12} = 558 \text{ IN}^4$$

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$$J = I_v + I_h = 2.848 + 558 = 561 \text{ IN}^4$$

$$C_v = \frac{h_v}{2} = \frac{1.25}{2} = .625 \text{ IN}$$

$$C_h = \frac{h_h}{2} = \frac{17.5}{2} = 8.75 \text{ IN}$$

$$C_J = \sqrt{\left(\frac{b}{2}\right)^2 + \left(\frac{h}{2}\right)^2} = \sqrt{\left(\frac{17.5}{2}\right)^2 + \left(\frac{1.25}{2}\right)^2} = 8.77 \text{ IN}$$

VERTICAL BENDING AND SHEAR STRESS
FOR SIMPLY SUPPORTED BEAM MODEL

$$M_v = \frac{(F_L V) L}{4} = \frac{(28,799)(20)}{4} = 143,995 \text{ LB-IN}$$

$$\sigma_v = \frac{M_v C_v}{I_v} = \frac{(143,995)(.625)}{2.848} = 31,600 \text{ PSI}$$

$$\tau_{2v} = \frac{3}{2} \frac{V_v}{A}$$

$$V_v = \frac{F_L V}{2} = \frac{28,806}{2} = 14,400 \text{ LB}$$

$$\tau_{2v} = \frac{(3)(14,400)}{(2)(21.88)} = 987 \text{ PSI}$$

HORIZONTAL BENDING AND SHEAR STRESSES

$$M_h = \frac{F_L H L}{4} = \frac{(15,205)(20)}{4} = 76,025 \text{ LB-IN}$$

$$\sigma_h = \frac{M_h C_h}{I_h} = \frac{(76,025)(8.75)}{558} = 1,192 \text{ PSI}$$

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$$\sqrt{2}_h = \frac{3}{2} \frac{V_h}{A} \quad V_h = \frac{F_{LH}}{2} = \frac{15,205}{2} = 7,603 \text{ lb}$$

$$\sigma_2 = \frac{(3)(7603)}{(2)(21.88)} = 521 \text{ PSI}$$

STRESS GENERATED BY THE TORQUE ON
THE BASE PLATE.

$$T = 3.873 F_{LH} = (3.873)(15,205) = 58,889 \text{ IN-LB}$$

$$J = I_v + I_h = 2.848 + 558 = 561 \text{ IN}^4$$

$$C_T = \sqrt{\left(\frac{b}{2}\right)^2 + \left(\frac{h}{2}\right)^2} = \sqrt{\left(\frac{17.5}{2}\right)^2 + \left(\frac{1.25}{2}\right)^2} = 8.77 \text{ IN}$$

$$\sigma_2 = \frac{T C_T}{J} = \frac{(58,889)(8.77)}{561} = 921 \text{ PSI}$$

MAX. BENDING STRESS:

$$\sigma = \sigma_v + \sigma_h = 31,600 + 1,192 = 32,792 \text{ PSI}$$

MAX. SHEAR STRESS:

$$\sigma_2 = \sigma_v + \sigma_h + \sigma_T = 987 + 521 + 921 = 2429 \text{ PSI}$$

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MOHR'S STRESS CIRCLE:

$$\sigma_M, \sigma_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$\sigma_M, \sigma_m = \frac{32,792}{2} \pm \sqrt{\left(\frac{32,792}{2}\right)^2 + (2429)^2} = 16,396 \pm 16,575$$

$$\sigma_M = 32,971 \text{ PSI} \quad \sigma_m = -179 \text{ PSI}$$

VON MISES STRESS:

$$\sigma' = \sqrt{\sigma_M^2 - \sigma_M \sigma_m + \sigma_m^2}$$

$$\sigma' = \sqrt{(32,971)^2 - (32,971)(-179) + (-179)^2} = 33,061 \text{ PSI}$$

PLATE MATERIAL: STEEL ASTM A36

$$S_y = 36,000 \text{ PSI}$$

$$SF_s = \frac{S_y}{\sigma'} = \frac{36,000}{33,061} = 1.1$$

$$SF_s = 1.1$$

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Appendix 2

Table A-3

SEISMIC RESPONSE SPECTRA

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Seismic Support of 2000 Gallon Freon Tanks
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Appendix 2

Table A-3

SEISMIC RESPONSE SPECTRA

Table A-3. LLNL design response spectra based on results of Geomatrix Consultants, Inc., 1985.

Basic spectral shapes (maximum acceleration normalized to 1 g)

Period (s)	Damping (1%)	Period (s)	Damping (2%)	Period (s)	Damping (5%)	Period (s)	Damping (7%)	Period (s)	Damping (10%)
0.02	1.0	0.02	1.0	0.02	1.0	0.02	1.0	0.02	1.0
0.033	1.0	0.033	1.0	0.033	1.0	0.033	1.0	0.033	1.0
0.1479	3.558	0.1479	3.037	0.1479	2.35	0.1478	2.095	0.1479	1.818
0.419	3.558	0.427	3.037	0.475	2.35	0.47	2.095	0.495	1.818
1.0	1.802	1.0	1.538	1.0	1.19	1.0	1.061	1.0	0.921
3.0	0.621	3.0	0.53	3.0	0.41	3.0	0.366	3.0	0.317

Spectral acceleration (g) for 1% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	2.78	2.13	1.78
0.419	2.78	2.13	1.78
1.0	1.41	1.08	0.90
3.0	0.48	0.37	0.31

Spectral acceleration (g) for 2% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	2.37	1.82	1.52
0.427	2.37	1.82	1.52
1.0	1.20	0.92	0.77
3.0	0.41	0.32	0.27

Spectral acceleration (g) for 5% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.83	1.41	1.18
0.457	1.83	1.41	1.18
1.0	0.93	0.71	0.60
3.0	0.32	0.25	0.21

Table A-3. Continued.

Spectral acceleration (g) for 7% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.63	1.26	1.05
0.47	1.63	1.26	1.05
1.0	0.83	0.64	0.53
3.0	0.29	0.22	0.18

Spectral acceleration (g) for 10% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.42	1.09	0.91
0.495	1.42	1.09	0.91
1.0	0.72	0.55	0.46
3.0	0.25	0.19	0.16

**MECHANICAL ENGINEERING SAFETY NOTE
SEISMIC BRACKETS FOR FREON STORAGE TANK
SCALES NORTH OF BUILDING 490E**

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**MECHANICAL ENGINEERING SAFETY NOTE
SEISMIC BRACKETS FOR FREON STORAGE TANK
SCALES, NORTH OF BUILDING 490E**

A. Scope

This report includes design parameters, stress analysis and drawings of seismic brackets for two platform scales. Both scales hold a 400 gallon Freon tank (Nos. T-9004 and T-9102) located immediately north of Building 490E. 490-Q1A2

The brackets shall comply with:

1. LLNL Mechanical Engineering Design Safety Standards (M-012, Revision 6), section 5.2 "Seismic and Wind Design Criteria".
2. Memorandum from H. H. Woo of Energy Systems Engineering Division, January 11, 1990 (HW-002/90) "Seismic and Wind Design Criteria".
3. Table A-3, LLNL Design Response Spectra based on results of Geometrix Consultants, Inc., 1985, (Appendix 2).

B. Purpose of Brackets

The seismic brackets will prevent the scales from moving or tipping over during severe earthquake. This must be accomplished without interfering with movements of the scales during operation.

C. Configuration

The scales are restrained during earthquake by placing one bracket per corner of the scale. Each bracket is bolted to the concrete floor by anchor bolts. Three adjustment screws on each bracket limit the travel of the scale frame in case of earthquake but leave the scale free to move during operation.

Two Freon storage tanks will be installed on the same concrete pad located adjacent to and north of Building 490E. The capacity of each tank is 400 gallons.

Tank number T-9004 has rectangular shape (44 x 54 x 40) and is mounted on a 10,000 lb capacity platform scale. The platform dimensions are 48 x 66 x 9.50 inches.

Tank number T-9102 is vertically mounted cylindrical tank (48 inch diameter x 60 inches long) mounted on a 10,000 lb capacity platform scale. Platform dimensions are 48 x 48 x 9.50 inches.

The brackets will be designed for the worst seismic conditions of the two scales and the same bracket design used for both scales.

D. Drawing References

Below is a list of LLNL AAA- drawings used in this report.

AAA91-101468, SEISMIC BRACKET

E. Seismic Design Criteria

1. The storage tanks mounted on the scale contain Freon R113. Failure of the system, caused by earthquake, could lead to the injury of personnel and to the release of Freon to the environment.

The tanks are located outdoors where they are exposed to changing temperatures. The weight of Freon will be based on 13.5 lb/gallon at 28° F.

2. Hazard annual probability of exceedance is assumed to be 1×10^{-3} (important or low hazard facility).
3. The ground surface acceleration is 0.6 g per Table 1 Page 1 of HW-002/90.
4. Vibration tests were made on existing platform scales of the same design in Building 272. The tests revealed resonant frequencies which caused amplification of the acceleration in the vertical and two horizontal directions. The horizontal frequencies were measured 90° to each other.

Because the resonant frequencies of the new scales are unknown the worst condition will be assumed.

Per Table A-3 of Geometrix Consultants, Inc., 1985, shown in Appendix 2, the maximum spectral acceleration for 5% damping is 1.41 g. This analysis uses the 1.41 g acceleration acting simultaneously in all three directions.

5. Minimum seismic safety factor $SF = 1$ based on yield strength of material.
6. Tensile or compressive stress and shear stress shall be combined per Mohr's stress circle to determine the principal stress.
7. Von Mises stress shall be calculated so that the direction energy theory can be used to predict failure.
8. Anchor bolts will be epoxied in the concrete. Allowable shear and tension forces on the anchor bolts are taken from Hilti, Inc., "Fastening Technical Guide" H-437-5/89, Page 34.
9. The tension-shear interaction formula, as shown on Page 15 of HW-002/90, is used to evaluate the design of anchor bolts. The Y-exponent is shown in each case.
10. Seismic design of the tank, including it's anchor bolts, will be analyzed by the tank supplier.

F. Summary of Stress Analysis

SF = Safety factor of seismic condition
T-S = Tension-shear interaction value for anchor bolts in concrete.
Y = Exponent applied to T-S.
Page No. = Page number of seismic bracket analysis (Appendix 1).
Minimum allowable SF = 1.00
Maximum allowable T-S = 1.00

Safety Factors and Tension-Shear Interaction					
Item No.	Description	SF	T-S	Y	Page No.
1	Anchor bolt in tension only		.67	1.0	17
2	Anchor bolt in tension and shear		.96	1.0	19
3	Anchor bolt in tension and shear		.59	1.0	21
4	Corner of bracket base plate	2.7			23
5	Thread shear stress in adjustment screw	1.3			23
6	Bending stress of bracket side plate	1.8			26
7	Tensile stress in weld of top plate	26			26

G. Conclusion

The seismic bracket design is in compliance with the documents listed in paragraph A.

1. SWAGE TIE LINE PER AIRM 01-1088. 4/
2. SWAGE TIE LINE PER AIRM 111-20-1076.
3. WELD STAINLESS PER AIRM 01-1088.
4. WELD STAINLESS PER AIRM 01-1088.
5. WELD STAINLESS PER AIRM 01-1088.
6. WELD STAINLESS PER AIRM 01-1088.
7. WELD STAINLESS PER AIRM 01-1088.
8. WELD STAINLESS PER AIRM 01-1088.
9. WELD STAINLESS PER AIRM 01-1088.
10. WELD STAINLESS PER AIRM 01-1088.

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SEISMIC BRACKETS FOR FREON STORAGE TANK SCALES
NORTH OF BUILDING 490E

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Appendix 1

STRESS ANALYSIS

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SEISMIC TIE DOWN BRACKETS

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NOMENCLATURE

A = AREA, IN^2 .

A_s = STRESS AREA OF THREADED BOLT, IN^2 .

α_c = ACCELERATION, IN/SEC^2 .

α_H = HORIZONTAL ACCELERATION ($\vec{a}_x + \vec{a}_y$), IN/SEC^2 .

Q_M = AMPLIFICATION OF ACCELERATION.

Q_V = VERTICAL ACCELERATION ($\vec{a}_z + \vec{g}$), IN/SEC^2 .

Q_x = HORIZONTAL ACCELERATION IN X-DIRECTION, IN/SEC^2 .

Q_y = HORIZONTAL ACCELERATION IN Y-DIRECTION, IN/SEC^2 .

Q_z = VERTICAL ACCELERATION, IN/SEC^2 .

b = WIDTH, HORIZONTAL DISTANCE, IN .

D = DIAGONAL, IN .

d = DIAMETER, IN .

E = YOUNG'S MODULUS, PSI .

e = ECCENTRICITY OF FORCE IN A BOLTED JOINT.

F = FORCE, lb .

F_B = FORCE PER BOLT, lb .

F_H = HORIZONTAL SEISMIC FORCE ($\vec{F}_x + \vec{F}_y$), lb .

F_S = SHEAR FORCE, lb .

F_t = ALLOWABLE TENSILE FORCE (ANCHOR BOLT), lb .

F_v = VERTICAL SEISMIC FORCE ($\vec{F}_z + \vec{W}$), lb .

F_{Rt} = ALLOWABLE SHEAR FORCE (ANCHOR BOLT), lb .

f_t = ACTUAL TENSILE FORCE (ANCHOR BOLT), lb .

f_{Rt} = ACTUAL SHEAR FORCE (ANCHOR BOLT), lb .

h = HEIGHT, IN .

I = MOMENT OF INERTIA, IN^4 .

k = SPRING CONSTANT OF STRUCTURE, lb/IN .

L = LENGTH, IN .

M = MOMENT, $\text{lb}-\text{IN}$.

m = MASS, $\frac{\text{lb}-\text{SEC}^2}{\text{IN}}$.

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 N = NUMBER OF BOLTS IN A BOLTED JOINT. P = TOTAL EXTERNAL FORCE ON A BOLTED JOINT, lb. P_n = PERIOD OF RESONANT FREQUENCY, SEC. P' = SHEAR FORCE PER BOLT IN A BOLTED JOINT, lb. Q = FORCE VECTOR PER BOLT DUE TO A MOMENT
IN A BOLTED JOINT R = REACTION FORCE, lb. R_H = HORIZONTAL REACTION FORCE, lb. R_V = VERTICAL REACTION FORCE, lb. r = RADIUS, IN. S_S = SHEAR STRENGTH OF MATERIAL, PSI. S_T = TENSILE STRENGTH OF MATERIAL, PSI. SF = SAFETY FACTOR $T-S$ = TENSION-SHEAR INTERACTION FOR
ANCHOR BOLTS. W = WEIGHT, lb. W_F = WEIGHT OF FREON W_T = WEIGHT OF TANK (EMPTY), lb. W_S = WEIGHT OF SCALE, lb. Y = EXPONENT USED IN TENSION-SHEAR INTERACTION
FORMULA. $\bar{Y}$ = DISTANCE FROM FLOOR OR BASE TO C.G., IN. α = ANGLE, DEGREES OR RADIANS. β = ANGLE, DEGREES OR RADIANS. Δ = DEFLECTION OF A BOLT, IN. $\bar{\sigma}$ = COMPRESSIVE OR TENSILE STRESS, PSI. $\bar{\sigma}_M$ = MAX. STRESS (MOHR'S STRESS CIRCLE), PSI. $\bar{\sigma}_m$ = MIN. STRESS (MOHR'S STRESS CIRCLE), PSI. $\bar{\sigma}'$ = VON MISES STRESS, PSI. $\bar{\tau}$ = SHEAR STRESS, PSI.

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FORMULAS USED IN THIS ANALYSIS

MOHR'S STRESS CIRCLE, VON MISES STRESS
AND NUT THREAD SHEAR.

REFERENCE:

MECHANICAL ENGINEERING DESIGN
BY JOSEPH E. SHIGLEY
SECOND EDITION

MOHR'S STRESS CIRCLE PAGE 30.
VON MISES STRESS PAGE 234.
NUT THREAD SHEAR PAGE 300.

MOHR'S STRESS CIRCLE, STRESS ALONG ONE
AXIS ONLY.

$$\sigma_M, \tau_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

VON MISES STRESS.

$$\tau' = \sqrt{\sigma_M^2 - \sigma_M \tau_m + \tau_m^2}$$

NUT THREAD SHEAR.

$$\tau = \frac{2F}{\pi d h}$$

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TENSION-SHEAR INTERACTION FORMULA (ANCHOR BOLTS):

REFERENCE:

MEMORANDUM FROM H. H. WOO OF ESED,
JANUARY 11, 1990 (HW-002/90)
"SEISMIC AND WIND DESIGN CRITERIA."

$$T-S = \left(\frac{f_t}{F_t} \right)^{\gamma} + \left(\frac{f_v}{F_v} \right)^{\gamma} \leq 1.00$$

THE EXPONENT γ VARIES BETWEEN 1 AND $5/3$,
DEPENDING ON THE CONDITION OF THE CONCRETE.
THE CONSERVATIVE VALUE OF $\gamma=1$ WILL BE USED
IN THIS REPORT, BECAUSE THERE ARE NO DESIGN CONSTRAINTS
WHICH JUSTIFY HIGHER VALUE OF γ .

ACCELERATION AND AMPLIFICATION EVALUATION.

REFERENCE:

TABLE A-3. LLNL DESIGN RESPONSE SPECTRA
BASED ON RESULTS OF GEOMETRIX CONSULTANTS,
INC., 1985. SEE APPENDIX 2.

SPECTRAL ACCELERATION FOR 5% DAMPING
AND HAPOE OF 1×10^{-3} $a_c = .69$.

FOR MAXIMUM AMPLIFICATION $a_c = 1.41 g$.

ALLOWABLE TENSILE AND SHEAR FORCE ON ANCHOR BOLTS.

REFERENCE: FASTENING TECHNICAL GUIDE
H-437-5/89, PAGE 34
HILTI, INC.

3/4 DIA ANCHOR
BOLT, HAS STD
(A307) { TENSILE FORCE $F_t = 6680$ lb
SHEAR FORCE $F_v = 4800$ lb

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ECCENTRIC LOADING OF BOLTED JOINTS.

REFERENCE: ROARK'S FORMULAS FOR STRESS
AND STRAIN.

BY WARREN C. YOUNG

SIXTH EDITION, 1989

PAGE 659.

FOR ALL BOLTS OF THE SAME STRESS AREA
AND THE SAME LENGTH.

$$Q_x = \frac{P e r_x}{\sum r^2}$$

$$P' = \frac{P}{n}$$

BEAM FIXED AT BOTH ENDS WITH CONCENTRATED
LOAD AT ANY POINT.REFERENCE: MANUAL OF STEEL CONSTRUCTION
LOAD AND RESISTANCE DESIGN
BY AISC

FIRST EDITION, PAGE 3-135, TABLE 17

$$R_1 = V_1 = \frac{F y^2}{l^3} (3x + y)$$

$$R_2 = V_2 = \frac{F x^2}{l^3} (x + 3y)$$

$$M = \frac{2 F x^2 y^2}{l^3}$$

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THIS ANALYSIS COVERS SEISMIC BRACKETS FOR TWO FREON TANKS LOCATED ON AN OUTDOOR CONCRETE PAD JUST NORTH OF BUILDING 490E. THE PAD IS MADE OF 4000 PSI REINFORCED CONCRETE.

EACH TANK STORES 400 GALLONS OF FREON, ONE OF THEM HAS A RECTANGULAR SHAPE THE OTHER IS A VERTICALLY MOUNTED CYLINDER.

COLDEST TEMPERATURE AT THE SITE IS EXPECTED TO BE 28 °F. AT THAT TEMPERATURE, THE SPECIFIC WEIGHT OF FREON IS 13.5 ^{lb}/GAL.

THE TANKS WILL BE MOUNTED ON PLATFORM SCALES. VIBRATION TESTS MADE ON EXISTING SCALES IN BUILDING 272 REVEALED AMPLIFICATION OF ACCELERATION IN ALL THREE DIRECTIONS. THE AMPLIFICATION FACTOR VARIED BETWEEN 1.93 TO 2.35.

BECAUSE THE SEISMIC CHARACTERISTICS OF FUTURE SCALES ARE UNKNOWN, THE MAXIMUM AMPLIFICATION OF 2.35 WILL BE ASSUMED ALONG ALL THREE AXES.

$$a_x = 1.41 g$$

$$a_y = 1.41 g$$

$$a_z = 1.41 g$$

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SEISMIC TIE DOWN BRACKET

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THE WORST CONDITION FOR THE SEISMIC BRACKETS IS WHEN F_z IS ACTING UPWARDS.

$$\therefore F_v = F_z - W = a_z W - W = (1.41 - 1)W = \underline{\underline{.41W}}$$

THE HORIZONTAL FORCE F_H WILL BE APPLIED 90° TO THE SCALE SIDE WHICH RESULTS IN SHORTER SPAN, AND ALONG THE DIAGONAL OF THE SCALE FRAME TO FIND OUT WHICH EXERTS MORE FORCE ON THE SEISMIC BRACKET.

$$F_H = \vec{F}_x + \vec{F}_y$$

$$F_x = F_y$$

$$\therefore F_H = F_x \sqrt{2} = a_x W \sqrt{2} = \underline{\underline{1.41\sqrt{2}W}}$$

THE TWO TANKS AND THE SCALES THEY ARE MOUNTED ON HAVE A DIFFERENT GEOMETRY WHICH WILL RESULT IN DIFFERENT SEISMIC FORCES AND MOMENTS ACTING ON THE SEISMIC BRACKETS.

SEISMIC FORCES AND MOMENTS WILL BE ANALYZED FOR EACH TANK AND THE BRACKETS WILL BE DESIGNED FOR THE MORE SEVERE CONDITION.

THE SAME BRACKET DESIGN WILL BE USED FOR BOTH TANKS.

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SEISMIC TIE DOWN BRACKET

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TANK NO. T-9004 HAS A RECTANGULAR
SHAPE 44 IN. WIDE X 54 IN. LONG X 40 IN. HIGH.
THE PLATFORM SCALE IS 48" X 66" X 9.25"

WEIGHTS

MAX WEIGHT OF FREON $W_F = (400)(13.5) = 5400 \text{ lb}$

ESTIMATED WEIGHT OF TANK $W_T = 1000 \text{ lb}$

ESTIMATED WEIGHT OF SCALE $W_S = 700 \text{ lb}$

TOTAL $W = 7100 \text{ lb}$

FIND THE C.G. FOR THE TANK/SCALE ASSEMBLY.

$$7100 \bar{Y} = 33(5400 + 1000) + (4.625)(700)$$

$$\bar{Y} = \frac{(33)(6400) + (4.625)(700)}{7100} = \underline{\underline{30.2 \text{ IN}}}$$

TANK T-9004

THE SEISMIC FORCE ALONG EACH AXIS BASED
ON ABOVE ACCELERATION.

$$F_x = F_y = F_z = (1.41)(7100) = \underline{\underline{10,011 \text{ lb}}}$$

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SEISMIC TIE DOWN BRACKET

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$$F_V = .41 W = (.41)(7100) = \underline{2911 \text{ lb}}$$

$$F_H = 1.41 \sqrt{2} W = 1.41 \sqrt{2} (7100) = \underline{14,158 \text{ lb}}$$

SCALE DIAGONAL

$$D = \sqrt{(48)^2 + (66)^2} = 81.61 \text{ IN}$$

FIND FORCES ON THE BRACKETS WHEN F_H IS ACTING 90° TO THE LONG SIDE (66) OF THE SCALE.

$$\sum M_1 = 0$$

$$30.2 F_H + 24 F_V - 5.5 R_{HA} - 47 R_{VB} = 0$$

$$\sum F = 0$$

$$R_{HA} = F_H = 14,158 \text{ lb}$$

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SEISMIC TIE DOWN BRACKET

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$$R_{VB} = \frac{14,158(30.2 - 5.5) + (2911)(24)}{47} = \underline{8927 \text{ lb}}$$

THE HORIZONTAL FORCE R_{HA} IS DIVIDED EQUALLY BETWEEN BRACKETS 1 AND 4.

$$\therefore R_{H1} = R_{H4} = \frac{14,158}{2} = \underline{7079 \text{ lb}} \text{ PER BRACKET}$$

THE VERTICAL FORCE R_{VB} IS DIVIDED EQUALLY BETWEEN BRACKETS 2 AND 3.

$$\therefore R_{V2} = R_{V3} = \frac{8927}{2} = \underline{4463 \text{ lb}} \text{ PER BRACKET}$$

FIND FORCES ON THE BRACKETS WHEN F_H IS ACTING ALONG THE DIAGONAL $D = 81.61 \text{ IN.}$

$$\sum \vec{F} = 0$$

$$R_{HC} = F_H = \underline{14,158 \text{ lb}}$$

TANK & SCALE
DIAGONAL VIEW

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SEISMIC TIE DOWN BRACKETS

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$$\sum M_c = 0$$

$$30.2 F_H + 42.64 F_V - 5.5 R_{HC} - 83.87 R_{VD} = 0$$

$$R_{VD} = \frac{(30.2 - 5.5)(14,158) + (40.81)(2911)}{81.61} = \frac{5741 \text{ lb}}{\text{PER BRACKET}}$$

IN THIS CASE R_{HC} AND R_{VD} ARE RESISTED
BY A SINGLE BRACKET.

THE SAME ANALYSIS WILL BE REPEATED FOR
THE T-9102 STORAGE TANK.

ESTIMATED WEIGHTS

$$\text{FREON } W_F = 5400 \text{ lb}$$

$$\text{TANK } W_T = 850 \text{ lb}$$

$$\text{SUPPORT } W_{SU} = 250 \text{ lb}$$

$$\text{SCALE } W_S = 600 \text{ lb}$$

$$\text{TOTAL } W = 7100 \text{ lb}$$

FIND C.G. FOR TANK/SCALE ASSEMBLY

$$7100 \bar{Y} = (60)(5400 + 850) + (22)(250) + (4.62)(600)$$

$$\bar{Y} = \frac{(60)(6250) + (22)(250) + (4.62)(600)}{7100} = 53.98 \text{ IN}$$

$$\text{MAKE } \underline{\underline{\bar{Y} = 54.0 \text{ IN}}}$$

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FIND FORCES ON BRACKETS WITH F_H 90° TO ONE SIDE OF THE SCALE.

TANK & SCALE
SIDE VIEW

$$F_V = 2911 \text{ lb}$$

$$F_H = 14,158 \text{ lb}$$

SCALE
TOP VIEW

$$\sum M_E = 0$$

$$\sum F = 0$$

$$F_H - R_{HE} = 0$$

$$R_{HE} = F_H = 14,158 \text{ lb}$$

$$54 F_H + 24 F_V - 5.5 R_{HE} - 47 R_{VF} = 0$$

$$R_{VF} = \frac{(54.0 - 5.5)(14,158) + (24)(2911)}{47} = 16,096 \text{ lb}$$

R_{VF} IS DIVIDED EQUALLY BETWEEN BRACKETS 2 AND 3.

$$R_V = \frac{R_{VF}}{2} = \frac{16,096}{2} = 8,048 \text{ lb (PER BRACKET)}$$

R_{HE} IS DIVIDED EQUALLY BETWEEN BRACKETS 1 AND 4.

$$R_H = \frac{R_{HE}}{2} = \frac{14,158}{2} = 7079 \text{ lb (PER BRACKET)}$$

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BLDG 490E FREON SYSTEM SCALES
SEISMIC TIE DOWN BRACKETS

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FIND FORCES ON THE BRACKETS WHEN
 F_H ACTS ALONG THE DIAGONAL.

$$D = 48\sqrt{2} = \underline{67.88 \text{ IN}}$$

$$F_H = 14,158 \text{ lb}$$

$$F_V = 2911 \text{ lb}$$

$$\sum \vec{F} = 0$$

$$F_H - R_{HG} = 0$$

$$R_{HG} = F_H = \underline{14,158 \text{ lb}}$$

TANK AND SCALE
DIAGONAL VIEW

$$\sum M_G = 0 \quad 54 F_H + 33.94 F_V - 5.5 R_{HG} - 66.47 R_{VH} = 0$$

$$R_{VH} = \frac{(54 - 5.5)(14,158) + (33.94)(2911)}{66.47} = \underline{11,817 \text{ lb}}$$

THE BRACKET WILL BE STRESS ANALYZED
FOR FOLLOWING FORCES:

$$R_{VH} = 11,817 \text{ lb (VERT. FORCE ON ONE BRACKET)}$$

$$R_{HG} = 14,158 \text{ lb (HORIZ. DIAG. FORCE ON ONE BRKT.)}$$

$$R_H = 7079 \text{ lb (HORIZ. SIDE FORCE ON ONE BRKT.)}$$

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SEISMIC TIE DOWN BRACKETS.

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FIND THE MAX. TENSILE FORCE IN THE
ANCHOR BOLTS CAUSED BY $R_{VH} = 11,817$ lb.

THE FORCE R_{VH} IS ON THE DIAGONAL LINE
OF THE HOLE PATTERN IN THE BRACKET.

ALL BOLTS ARE IN
TENSION WITH MAX
TENSION ON BOLT #1

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$$\sum M_3 = 0 \quad 7.778 R_{VH} - 6.364 R_2 - 12.728 R_1 = 0$$

$$(7.778)(11,817) = 6.364 R_2 + 12.728 R_1$$

$$91,913 = 6.364 R_2 + 12.728 R_1$$

$$\sum F = 0 \quad R_{VH} - R_1 - R_2 - R_3 = 0$$

$$11,817 = R_1 + R_2 + R_3$$

ASSUME THE BRACKET RIGID ENOUGH FOR THE BOLTS TO STRETCH PER DEFLECTION DIAGRAM ON PAGE 14.

$$R_1 = K \Delta_1$$

$$R_2 = 2K \Delta_2 \quad (R_2 \text{ REPRESENTS 2 BOLTS})$$

$$R_3 = 2K \Delta_3 \quad (R_3 \text{ REPRESENTS 2 BOLTS})$$

$$\Delta_1 = \Delta_3 + \Delta'_1$$

$$\Delta_2 = \Delta_3 + \Delta'_2$$

$$\frac{\Delta'_2}{\Delta'_1} = \frac{6.364}{12.728} = .5$$

$$\Delta'_2 = .5 \Delta'_1$$

$$\Delta_2 = \Delta_3 + .5 \Delta'_1$$

$$R_1 = K(\Delta_3 + \Delta'_1)$$

$$R_2 = 2K(\Delta_3 + .5 \Delta'_1)$$

$$R_3 = 2K \Delta_3$$

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SEISMIC TIE DOWN BRACKET

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$$11,817 = K(\Delta_3 + \Delta'_1) + 2K(\Delta_3 + .5\Delta'_1) + 2K\Delta_3$$

$$11,817 = K\Delta_3 + K\Delta'_1 + 2K\Delta_3 + K\Delta'_1 + 2K\Delta_3$$

$$11,817 = 5K\Delta_3 + 2K\Delta'_1$$

$$2K\Delta'_1 = 11,817 - 5K\Delta_3$$

$$\underline{K\Delta'_1 = 5,909 - 2.5K\Delta_3}$$

$$91,913 = 6.364(2K)(\Delta_3 + .5\Delta'_1) + 12.728K(\Delta_3 + \Delta'_1)$$

$$91,913 = 12.728K\Delta_3 + 6.364K\Delta'_1 + 12.728K\Delta_3 +$$

$$+ 12.728K\Delta'_1$$

$$91,913 = 25.456K\Delta_3 + 19.092K\Delta'_1$$

$$91,913 = 25.456K\Delta_3 + 19.092(5,909 - 2.5K\Delta_3)$$

$$91,913 = 25.456K\Delta_3 + 112,815 - 47.73K\Delta_3$$

$$(47.73 - 25.456)K\Delta_3 = 112,815 - 91,913$$

$$22.274K\Delta_3 = 20,902$$

$$K\Delta_3 = \frac{20,902}{22.274} = \underline{938 \text{ lb}}$$

$$K\Delta'_1 = 5,909 - (2.5)(938) = \underline{3564 \text{ lb}}$$

$$R_1 = K(\Delta_3 + \Delta'_1) = K\Delta_3 + K\Delta'_1 = 938 + 3564 = \underline{4502 \text{ lb}}$$

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R_1 IS A TENSILE FORCE AND THERE IS NO SHEAR FORCE ASSOCIATED WITH IT. $R_1 = f_t$

$$T-S = \frac{f_t}{F_t} = \frac{4502}{6680} = .67$$

$$T-S = .67$$

$$Y = 1$$

FIND THE STRESSES ON THE ANCHOR BOLTS GENERATED BY $R_{HG} = 14,158 \text{ lb}$.

THE HORIZONTAL DIAGONAL FORCE,

THE DIAGONAL OF THE SCALE IS ALSO A LINE OF SYMMETRY FOR THE BOLT PATTERN WHICH MEANS THAT THERE ARE NO ECCENTRIC FORCES ACTING ON THE BOLTS, THE SHEAR FORCE CAN BE DIVIDED EVENLY BETWEEN THE BOLTS.

$$f_s = \frac{14,158}{5} = 2832 \text{ lb}$$

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SUBJECT BLDG 490E FREON SYSTEM SCALES
SEISMIC TIE DOWN BRACKETS

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DEFLECTION
DIAGRAM

$K\Delta$ = TENSILE FORCE EXPERIENCED
BY EACH BOLT.

K IS THE SAME FOR EACH BOLT
BECAUSE THE AREA AND THE
LENGTH IS THE SAME.

$$F_2 = 2K\Delta_2$$

$$F_3 = 2K\Delta_3$$

$$\frac{\Delta_2}{\Delta_3} = \frac{6.364}{12.728} = .5$$

$$\underline{\Delta_2 = .5\Delta_3}$$

$$\underline{F_2 = K\Delta_3}$$

$$\underline{F_3 = 2K\Delta_3}$$

$$\sum M_1 = 0$$

$$5.5 R_1 + 6 - 6.364 R_2 - 12.728 R_3 = 0$$

$$(5.5)(14,158) = 6.364 K\Delta_3 + (12.728)(2K\Delta_3)$$

$$77,869 = 31.2 K\Delta_3$$

$$K\Delta_3 = \frac{77,869}{31.2} = \underline{2496 \text{ lb}}$$

R_3 REPRESENT 2 BOLTS OR FORCE PER BOLT

$$R'_3 = \frac{F_3}{2} = \frac{2K\Delta_3}{2} = K\Delta_3$$

$$\underline{R'_3 = 2496 \text{ lb}}$$

$$f_t = R'_3$$

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$$T-S = \frac{f_t}{F_t} + \frac{f_s}{F_s} = \frac{2496}{6600} + \frac{2832}{4800} = .96$$

$$T-S = .96$$

$$Y = 1$$

FIND THE FORCES EXERTED ON THE ANCHOR BOLTS BY $R_H = 7079$ lb (PAGE 12)

$$\sum M_1 = 0$$

$$5.5 R_H - 9 R_2 - 18 R_3 = 0$$

$$5.5 R_H = (9)(.5) K \Delta_3 + (18) K \Delta_3$$

$$K \Delta_3 = \frac{(5.5)(R_H)}{(9)(.5) + 18} = \frac{5.5 R_H}{22.5}$$

$$R_3 = \frac{(5.5)(R_H)}{22.5} = \frac{(5.5)(7079)}{22.5}$$

$$\underline{R_3 = 1730 \text{ lb (TENSION)}}$$

$$R_2 = K \Delta_2$$

$$R_3 = K \Delta_3$$

$$\Delta_2 = .5 \Delta_3$$

$$R_2 = .5 K \Delta_3$$

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$$Q_3 = \frac{P e r_3}{\sum r^2}$$

$$r_3 = \sqrt{172.13} = 13.12 \text{ IN}$$

$$Q_3 = \frac{(7079)(1.75)(13.12)}{523.7} = \underline{310 \text{ lb}}$$

$$18 - \bar{x} = 11.25'$$

$$\tan \alpha_3 = \frac{6.75'}{11.25'} = .60$$

$$\alpha_3 = 30.96^\circ$$

LAW OF COSINES

$$B_3 = 90^\circ + \alpha_3 = 90 + 30.96 = \underline{120.96^\circ}$$

$$R'_3 = \sqrt{(P')^2 + (Q_3)^2 - 2 P' Q_3 \cos B_3}$$

$$R'_3 = \sqrt{(1416)^2 + (310)^2 - (2)(1416)(310) \cos 120.96} = \underline{1598 \text{ lb}}$$

$$f_t = R_3 = 1730 \text{ lb}$$

$$f_N = R'_3 = 1598 \text{ lb}$$

$$T-S = \frac{f_t}{F_t} + \frac{f_N}{f_N} = \frac{1730}{6680} + \frac{1598}{4800} = .59$$

$$T-S = .59$$

$$Y = 1$$

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FIND STRESS IN THE CORNER OF THE BRACKET
FLANGE GENERATED BY THE VERTICAL FORCE
 $R_1 = 4502 \text{ lb}$, R_1 IS SHOWN ON PAGE 16.

BRACKET
TOP VIEW

$$h = .75 \text{ IN (THICKNESS)}$$

$$b = 4.5\sqrt{2} = 6.364 \text{ IN}$$

$$l = 1.25\sqrt{2} = 1.768 \text{ IN}$$

$$c = \frac{h}{2} = .375 \text{ IN}$$

$$M = R_1 l = (4502)(1.768) = 7960 \text{ lb-IN}$$

$$A = bh = (6.364)(.75) = 4.773 \text{ IN}^2$$

$$I = \frac{bh^3}{12} = \frac{(6.364)(.75)^3}{12} = .224 \text{ IN}^4$$

$$\sigma = \frac{Mc}{I} = \frac{(7960)(.375)}{.224} = 13,326 \text{ PSI}$$

$$\sigma_2 = \frac{R_1}{A} = \frac{4502}{4.773} = 943 \text{ PSI}$$

MOHR'S STRESS CIRCLE:

$$\sigma_M, \sigma_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$\sigma_M, \sigma_m = \frac{13,326}{2} \pm \sqrt{\left(\frac{13,326}{2}\right)^2 + (943)^2} = 6663 \pm 6729$$

$$\sigma_M = 13,392 \text{ PSI}$$

$$\sigma_m = -66 \text{ PSI}$$

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VON MISES STRESS:

$$\sigma' = \sqrt{\sigma_m^2 - \sigma_m \sigma_m + \sigma_m^2}$$

$$\sigma' = \sqrt{(13,392)^2 - (13,392)(-66) + (-66)^2} = \underline{13,425 \text{ PSI}}$$

$$SF = \frac{S_T}{\sigma'} = \frac{36,000}{13,425} = 2.7$$

$$SF = 2.7$$

NUT THREAD SHEAR

THE HIGHEST FORCE ON THE ADJUSTMENT
SCREWS IS $R_{VH} = 11,817 \text{ lb}$ (SEE PAGE 13)

$R_{Hc} = 14,158 \text{ lb}$ IS RESISTED BY 2 SCREWS
AT 45° ANGLE TO THE DIAGONAL.

FORCE PER SCREW IS THEN $\frac{14,158}{\sqrt{2}} = \underline{10,011 \text{ lb.}}$

THE SCREW IS .75-10UNC $d = .75 \text{ IN.}$
THE PLATE IS .75 INCH THICK $h = .75 \text{ IN.}$

$$\sigma_2 = \frac{2 R_{VH}}{\pi d h} = \frac{(2)(11,817)}{(\pi)(.75)(.75)} = \underline{13,374 \text{ PSI}}$$

$$SF = \frac{S_s}{\sigma_2} = \frac{18,000}{13,374} = 1.3$$

$$SF = 1.3$$

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THE HORIZONTAL DIAGONAL FORCE $R_{HG} = 14,158 \text{ lb}$
(SEE PAGE 13) IS RESISTED BY 2 ADJUSTMENT
SCREWS AT 45° ANGLE TO THE DIAGONAL.

$$\text{THE FORCE PER SCREW } F_B = \frac{R_{HG}}{\sqrt{2}} = \frac{14,158}{\sqrt{2}} = 10,011 \text{ lb}$$

TO ESTIMATE THE STRESS ON CROSS-SECTION A-A,
SHOWN ON BELOW SKETCH, A SIMPLE BEAM
WITH A POINT LOAD AND BOTH ENDS FIXED
IS ASSUMED.

THIS IS A CONSERVATIVE ASSUMPTION SINCE
THE PLATE IS WELDED ON 3 SIDES.

BRACKET SIDE VIEW

$$M = \frac{2 F_B X^2 Y^2}{l^3}$$

SECTION A-A

$h = .75 \text{ IN}$ (PLATE THICKNESS).

$b = 7.00 \text{ IN}$ (ASSUMED WIDTH OF BEAM).

$d = .75 \text{ IN}$ (TAPPED HOLE IN PLATE).

$l = 9.25 \text{ IN}$ (DISTANCE BETWEEN WELDS)

$x = 4.50 \text{ IN}$

$y = 4.75 \text{ IN}$

$F_B = 10,011 \text{ lb}$

$c = .375$

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FORCE DIAGRAM

$$V_2 = \frac{y F_B}{l} = \frac{(4.75)(10,011)}{9.25} = 5141 \text{ lb}$$

$$M = \frac{(2)(10,011)(4.50)(4.75)^2}{(9.25)^3} = 11,558 \text{ lb-in}$$

SHEAR DIAGRAM

$$A = (b-d)h = (7.00-.75)(.75) = 4.688 \text{ in}^2$$

$$I = \frac{(b-d)(h)^3}{12} = \frac{(7.00-.75)(.75)^3}{12} = .220$$

$$\bar{\sigma} = \frac{Mc}{I} = \frac{(11,558)(.375)}{.220} = 19701 \text{ PSI}$$

MOMENT DIAGRAM

$$\bar{\sigma}_2 = \frac{V_2}{A} = \frac{5141}{4.688} = 1097 \text{ PSI}$$

MOHR'S STRESS CIRCLE:

$$\sigma_M, \sigma_m = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$\sigma_M, \sigma_m = \frac{19701}{2} \pm \sqrt{\left(\frac{19701}{2}\right)^2 + (1097)^2} = 9851 \pm 9911$$

$$\sigma_M = 19,762 \text{ PSI}$$

$$\sigma_m = -60 \text{ PSI}$$

VON MISES STRESS

$$\sigma' = \sqrt{\sigma_M^2 - \sigma_M \sigma_m + \sigma_m^2}$$

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$$\sigma' = \sqrt{(19,762)^2 - (19,762)(-60) + (-60)^2} = 19,792 \text{ PSI}$$

$$SF = \frac{S_T}{\sigma'} = \frac{36,000}{19,792} = 1.8$$

$$SF = 1.8$$

FIND THE TENSILE STRESS IN THE WELD
FOR THE TOP PLATE

THE MAXIMUM TENSILE FORCE
ON THE TOP PLATE IS R_{vh}
SHOWN ON PAGE 13.

$$R_{vh} = 11,817 \text{ lb}$$

$$A = (.75)(6) + .75(5.25) = 8.44 \text{ IN}^2$$

$$\sigma = \frac{R_{vh}}{A} = \frac{11,817}{8.44} = 1400 \text{ PSI}$$

$$SF = \frac{S_T}{\sigma} = \frac{36,000}{1400} = 26$$

$$SF = 26$$

FULL PENETRATION
WELD.

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**Mechanical Engineering Safety Note
SEISMIC BRACKETS FOR FREON STORAGE TANK SCALES
NORTH OF BUILDING 490E**

AVLIS

Appendix 2

Table A-3

SEISMIC RESPONSE SPECTRA

Table A-3. LLNL design
response spectra based on
results of Geomatrix Con-
sultants, Inc., 1985.

Basic spectral shapes (maximum acceleration normalized to 1 g)

Period Damping		Period Damping		Period Damping		Period Damping		Period Damping	
(s)	(1%)	(s)	(2%)	(s)	(5%)	(s)	(7%)	(s)	(10%)
0.02	1.0	0.02	1.0	0.02	1.0	0.02	1.0	0.02	1.0
0.033	1.0	0.033	1.0	0.033	1.0	0.033	1.0	0.033	1.0
0.1479	3.558	0.1479	3.037	0.1479	2.35	0.1478	2.095	0.1479	1.818
0.419	3.558	0.427	3.037	0.475	2.35	0.47	2.095	0.495	1.818
1.0	1.802	1.0	1.538	1.0	1.19	1.0	1.061	1.0	0.921
3.0	0.621	3.0	0.53	3.0	0.41	3.0	0.366	3.0	0.317

Spectral acceleration (g) for 1% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	2.78	2.13	1.78
0.419	2.78	2.13	1.78
1.0	1.41	1.08	0.90
3.0	0.48	0.37	0.31

Spectral acceleration (g) for 2% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	2.37	1.82	1.52
0.427	2.37	1.82	1.52
1.0	1.20	0.92	0.77
3.0	0.41	0.32	0.27

Spectral acceleration (g) for 5% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.83	1.41	1.18
0.457	1.83	1.41	1.18
1.0	0.93	0.71	0.60
3.0	0.32	0.25	0.21

Table A-3. Continued.

Spectral acceleration (g) for 7% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.63	1.26	1.05
0.47	1.63	1.26	1.05
1.0	0.83	0.64	0.53
3.0	0.29	0.22	0.18

Spectral acceleration (g) for 10% damping

Period (s)	Hazard annual probability of exceedance		
	2×10^{-4}	1×10^{-3}	2×10^{-3}
0.02	0.78	0.60	0.50
0.033	0.78	0.60	0.50
0.1479	1.42	1.09	0.91
0.495	1.42	1.09	0.91
1.0	0.72	0.55	0.46
3.0	0.25	0.19	0.16

Appendix C

Beneficial Occupancy/Age of Tank System

Lawrence Livermore National Laboratory

PLANT ENGINEERING — L-522

Projects Division

PFN #: 490-90-100

DATE: 12/11/92

TO: Distribution

FROM: Sheree Siemiatkoski

SUBJECT: Final Acceptance Report
Subcontract No.: B171712
Subcontractor or Supplier: Cassidy Construction
Title: B490 East Freon System

The above item of work has had final inspection. All Punch List items and deficiencies have been corrected or accounted for and the work satisfactorily completed in accordance with the plans and specifications. It was accepted on behalf of the University as of the following date: 12/11/92.

Official Start Date:	March 18, 1992
Beneficial Occupancy Date:	August 18, 1992
Subcontract Completion Date:	June 20, 1992
Number Overtime Days:	58

DISTRIBUTION

Accounts Payable: M. Thomas, L-432
Construction Manager: S. Siemiatkoski, L-522
Contracts Group: T. Del Giudice, L-522
Hazards Control: Team 4, Jim Forte, L-692
Inspector: R. Peterson, L-522
Maintenance/Operations: B. Kemp, L-601
Procurement: T. Bandy, L-652
Program/Client: M. Duffy, L-467
Project Engineer/Architect:
Project Manager: T. Dolce, L-491
Prop. Accounting: D. DuFresne, L-435
Security: R. Certo, L-503
Contract Badge Office: L. Dardeen, L-698
Subcontractor: Cassidy Construction
L. Walz, L-522

Inspector

Construction Manager

CMDsiW081ls
Rev. 2/92

Lawrence Livermore National Laboratory

PLANT ENGINEERING L-522

Projects Division

PFN: 490-90-100

DATE: 12/11/92

TO: Distribution
FROM: Sheree Siemiatkoski
SUBJECT: Facility Certification and Acceptance
Subcontract No.: B171712
Title: B490 East Freon System

The above facility is herewith certified to meet all design, safety and operating requirements as depicted on the approved plans, specifications and change orders pertaining thereto.

Effective this date, responsibility for the safety and operations of the facility is transferred to the responsible Program/Client, Hazards Control and Maintenance/Operations Organizations as applicable.

Sheree Siemiatkoski
Construction Manager

Tony DeLeon
Project Manager

Facility accepted by:

Hazards Control:

Michael J. Turo

DATE

12/1/92

Maintenance/Operations:

W. Kemp

12/17/92

Security:

Robert J. Cato

7-23-92

Program/Client:

Mike Duff

12/21/92

DISTRIBUTION:

Above Signatures
Contracts Group: T. Del Giudice, L-522
B. Kemp, L-601
Roger Lake, L-606
Bldg. Coordinator:

CMDsiW083ls
Rev. 2/92

Lawrence Livermore National Laboratory
PLANT ENGINEERING L-522
Projects Division

PFN #: 490-90-100

DATE: August 18, 1992

Cassidy Construction, Inc.
46 Rickenbacker Circle
Livermore, CA 94550

SUBJECT: Beneficial Occupancy
Subcontract No.: B171712
Title: B490 East Freon System

Effective at 3:00 PM on August 18, 1992 the University conditionally accepts from the Subcontractor the following described components of the subcontract, including responsibility for operational maintenance functions consistent with the terms of the subcontract guarantee.

Deficiencies listed on the Punch List dated July 23, '92 for the above described work shall be completed as indicated thereon. Areas involving those deficiencies will be made available to the Subcontractor until all remaining work is complete and final acceptance has been made by the University.

Sincerely,

Steve Siemiatkowski
Construction Manager

Approved:

Tony Dolce
Project Manager

DISTRIBUTION:

Construction Manager: S. Siemiatkowski, L-522
Contracts Group: T. Del Giudice, L-522
Hazards Control: Team 4, Jim Forte, L-692
Inspector: R. Peterson, L-522
Maintenance/Operations: B. Kemp, L-601
Procurement: T. Bandy, L-652
Program/Client: M. Duffy, L-467
Project Engineer/Architect:
Project Manager: T. Dolce, L-491
Property Accounting: D. DuFresne, L-435
Security: R. Certo, L-503

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Lawrence Livermore National Laboratory

PLANT ENGINEERING L-522
Projects Division

PFN#: 490-90001

DATE: Dec 9, 1992

TO: Distribution

FROM: Harry Benstead, Construction Manager

SUBJECT: Final Acceptance Report
Subcontract No.: B198886
Subcontractor or Supplier: Page Construction
Title: Building 490—Freon Canopy

The above item of work has had final inspection. All Punch List items and deficiencies have been corrected or accounted for and the work satisfactorily completed in accordance with the plans and specifications. It was accepted on behalf of the University as of the following date: Jan. 4, 1993.

Official Start Date: September 28, 1992
Beneficial Occupancy Date: December 4, 1992
Subcontract Completion Date: November 12, 1992
Number Overtime Days: _____

DISTRIBUTION

Accounts Payable: M. Thomas, L-432
Construction Manager: H. Benstead, L-522
Contracts Group: T. Del Giudice, L-522
Hazards Control: Team 4, Jim Forte, L-692
Inspector: A. Alvarado, L-522
Maintenance/Operations: B. Kemp, L-601
Procurement: J. Leimbach, L-652
Program/Client: M. Duffy, L-467
Project Engineer/Architect: A. Sisneroz, L-654
Project Manager: T. Dolce, L-491
Prop. Accounting: D. DuFresne, L-435
Security: R. Certo, L-503
Contract Badge Office: L. Dardeen, L-698
Subcontractor: Page Construction
L. Walz, L-522
Space Planning: L-544

A. Alvarado
Inspector

Harry Benstead
Construction Manager

Lawrence Livermore National Laboratory
PLANT ENGINEERING L-522
Projects Division

PFN#: 490-90001

DATE: Dec 9, 1992

TO: Distribution
FROM: Harry Benstead, Construction Manager
SUBJECT: Final Inspection Report
Subcontract No.: B198886
Title: Building 490—Freon Canopy

The undersigned jointly inspected the work performed under the subject subcontract on 12/9/92 and found the work satisfactorily completed in accordance with the plans and specifications of the subcontract, with the following exceptions: (If none, state "NONE").

"NONE"

The exceptions listed above are hereby acknowledged, and it is agreed that corrections will be completed by Dec. 13, 1992.

If no exceptions are noted, a final acceptance report of the subcontract will be issued. If exceptions are noted, they shall be completed before a final acceptance report will be issued.

DISTRIBUTION

Construction Manager: H. Benstead, L-522
Contracts Group: T. Del Giudice, L-522
Hazards Control: Team 4, Jim Forte, L-692
Inspector: A. Alvarado, L-522
Maintenance/Operations: B. Kemp, L-601
Procurement: J. Leimbach, L-652
Program/Client: M. Duffy, L-467
Project Engineer/Architect: A. Sisneroz, L-654
Project Manager: T. Dolce, L-491
Security: R. Certo, L-503
Subcontractor: Page Construction
Space Planning: L-544

A. Alvarado
Inspector

Harry Benstead
Construction Manager

Jim Forte
Hazards Control

N/A
Security

B. Kemp
Maintenance/Operations

N/A
Project Engineer/Architect

T. Dolce
Project Manager

M. Duffy
Program/Client

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END

**DATE
FILMED**

10 / 15 / 93