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TANK 241-AN-107 MIXER PUMP/CAUSTIC ADDITION PROJECT PLAN OF ACTION TO MITIGATE FLAMMABLE GAS CONCERNS

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Abstract: The tank 241-AN-107 mixer pump/caustic addition system has been lock-and-tagged to preclude operation of the mixer pump and video camera installed in the primary tank. These equipment components represent potential ignition sources for flammable gas that may exist in either the waste and/or the tank dome space. This path-forward plan presents the result of an evaluation to determine the compliance status of the caustic addition system equipment with the East and West Tank Farms Standing Order 97-1 controls and recommends modifications and activities needed to meet the Standing Order requirements.

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APPENDIX A A-1

APPENDIX B B-1

LIST OF TERMS

ALARA	As Low As Reasonable Achievable
ATG	Advanced Technology Gauge
DNSFB	Defense Nuclear facility Safety Board
DOE-HQ	U.S. Department of Energy-Headquarters
FGEAB	Flammable Gas Equipment Advisory Board
ft	feet
HP	horsepower
ISC	Ignition Source Control
LFL	Lower Flammability Limit
MCCS	Mobile Color Camera System
OH^-	hydroxide ion
PET	Portable Enraf Terminal
POA	Plan of Action
RL	U.S. Department of Energy-Richland Operations Office
rpm	revolutions per minute
RTD	Resistance Temperature Detectors
SCC	stress corrosion cracking
USQ	Unreviewed Safety Question
%	percent

TANK 241-AN-107 MIXER PUMP/CAUSTIC ADDITION PROJECT PLAN OF ACTION TO MITIGATE FLAMMABLE GAS CONCERNS

1.0 EXECUTIVE SUMMARY

The tank 241-AN-107 (hereafter referred to as AN-107) mixer pump/caustic addition project has installed a mixer pump, an in-tank imaging system (video camera), and density/level monitoring instrumentation into the primary tank region of AN-107. This equipment was evaluated for compliance with the East and West Tank Farms Standing Order 97-1 and recommendations were made by the Flammable Gas Equipment Advisory Board (FGEAB). The results were that the equipment complies with the applicable Ignition Source Control (ISC) Sets in Standing Order 97-1 except for the pit leak detector, pump motor moisture sensor, pump turntable limit switches, and the dc motor driven pan/tilt positioning unit of the video camera. It was concluded that if the inductive relays for the leak detector, moisture sensor, and limit switches were replaced with intrinsically safe relays, and if, with the approval of RL, lockable breakers or switches were installed on the video camera pan/tilt unit power supply so it can be locked out during pump operations, or during any waste disturbing activity, then the original caustic addition project work scope could be resumed. The cost for implementing these equipment modifications is estimated to be $51,800. If RL approval is not granted to the preferred pan/tilt unit solution, then one of three other alternatives examined in this plan will be pursued. Each of these require removal of the camera from the tank, and modification and reinstallation of the camera, or replacement with a new camera system. These alternatives entail significantly higher risk from handling potentially contaminated equipment and higher use of resources than the preferred option. Costs of these alternatives were estimated to range from $100,000 to $250,000.

When the above tasks are complete, the mixer pump/caustic addition project can be restarted to finish the activities necessary to implement the caustic addition process and make the adjustments in waste chemistry needed to comply with tank farm procedures.

2.0 INTRODUCTION

In March 1996, the AN-107 mixer pump system was shut down and the project placed on hold because of emerging flammable gas safety concerns. An evaluation for trapped flammable gas in underground nuclear waste storage tanks at the Hanford Site concluded that an episodic gas release event in AN-107 could potentially result in a flammable atmosphere at 112.81 percent of the lower flammability limit (Hodgson, et. al. 1996). Subsequently, Standing Order #96-23, Rev. 1, "Operating Specifications for Watch List Tanks," was issued to apply the flammable gas controls of OSD-T-151-0030 to AN-107. With the issuance of the Standing Order, all electrical power to the mixer pump and video camera was locked out until the safety concern could be resolved.

East Tank Farms Standing Order 96-36[1] established compensatory actions in October 1996 for the Flammable Gas USQ (TF-96-0433, Rev. 1), which applies to AN-107. The compensatory actions implement ISCs on a graded basis to the equipment installed or used during work activities in tanks. AN-107 has been placed into Facility Group 2 classification, for which equipment located in the central pump pit, in the dome region of the tank, and in the waste must meet specific controls of the Standing Order[2]. The listed compensatory actions for the AN-107 mixer pump and imaging system requires lock out of all electrical power until the effected mechanical and electrical components can be evaluated for compliance with the applicable Ignition Source Controls and accepted for use by the FGEAB.

This path forward plan documents both the results of evaluating the mixer pump and video camera systems for compliance with Standing Order 97-1 requirements and the recommendations of the FGEAB. The tasks that must be completed to resolve or mitigate the safety concerns from operating the installed equipment are identified and their implementation costs estimated. With completion of these tasks, the project can be restarted to finish the activities necessary to implement the caustic addition process and make the adjustments in waste chemistry needed to comply with tank farm procedures.

3.0 SCOPE

The AN-107 mixer pump/caustic addition project action plan identifies the tasks that need to be completed to bring the mixer pump, video camera, and density/level monitoring equipment into compliance with the controls of East and West Tank Farm Standing Order 97-1. The resources required to perform the indicated tasks and estimated costs are also included. This plan is not intended to resolve the Flammable Gas USQ (TF-96-0433, Rev. 1) of AN-107. Likewise, the plan does not address the activities that will be required to complete the original project work scope; process installation, readiness review, start-up, and operation. The latter scope of work will be included in the Multi-Year Program Plan or a Change Control Package as appropriate.

4.0 BACKGROUND

Analysis of waste samples taken from AN-107 indicate that its waste has not met operating specifications relative to free hydroxide ion (OH^-) concentration (not synonymous with pH) for over 12 years. The OH^- concentration is below the range specified to prevent stress-corrosion cracking (SCC), a suspected fault mode of Savannah River Site tanks and

---

[1] East and West Tank Farm Standing Order 97-1 has superseded East Tank Farm Standing Order 96-36.

[2] The reader is directed to Standing Order 97-1 for a complete definition of Facility Group 2 classification, and Ignition Source Control Set #1 and #2 criteria.

Hanford single-shell tanks that have leaked. Since the progress of SCC is difficult to detect, bringing the tank contents back into conformity with the operating specifications is vitally important to prevent degradation of the tank. This action has been a topic of concern of the Defense Nuclear Facility Safety Board (DNFSB), ITR Red Team, Structural Integrity Panel, and DOE-HQ.

To mitigate the low OH^- concentration, a caustic addition and entrainment system utilizing a mixer pump was installed at AN-107 in the fall of 1995. Approximately 60,000 gallons of 19 molar (50:50 wt.%) aqueous caustic solution was to be injected into the tank and mixed with its contents. The caustic was to be delivered to the farm in 4,000 gallon tanker trucks and pumped directly into AN-107 over a duration of approximately one month. The mixer pump would uniformly distribute caustic into the waste while, at the same time, ensuring that the upper bound for free hydroxide would not be exceeded locally during the caustic addition.

Acceptance testing of the mixer pump installation was concluded in February 1996. The testing included several mixer pump runs at reduced speed for durations under one minute, to ensure the pump did in fact work (Leshikar, 1997). Shortly after the testing, the waste tank flammable gas issue emerged. A temporary lock-out of the mixer pump and video camera power was followed by the current long-term lockout that has lasted over a year while criteria were developed and implemented for operating equipment and conducting activities in tanks included in the Flammable Gas USQ.

Because of the lengthy delay in completing the AN-107 mixer pump/caustic addition project, the operability of the mixer pump is being jeopardized as it remains inoperative and submerged in the radioactive waste. Also, long term exposure of the camera unit and its lighting system to the radiation field in the tank dome space can cause equipment degradation and malfunction.

If the installed equipment can be shown to comply with tank farm Standing Order 97-1 controls either by its current design or with modification, then the AN-107 mixer pump/caustic addition project could proceed with the goal of eliminating the risk of failure of the primary tank from stress corrosion cracking. Alternatively, obtaining an exemption from the Standing Order controls may be possible where modifications are considered impractical and compensatory measures can be implemented to mitigate the potential flammability hazards. A controlled sequence of mixer pump operation starting at very low shaft speeds to mix a small radius around the mixer pump and release controlled amounts of entrained gas if present, followed by small increases in the pump speed to mix a larger and larger radius is planned. This procedure will be an effective means of ensuring any trapped gas is released in a controlled manner such that flammable constituents in the tank dome space do not exceed 25 percent (%) of the lower flammability limit (LFL). This expected waste behavior was demonstrated during acceptance testing of the mixer pump when flammable gas concentrations at less than 3% of LFL were measured at the AN-107 primary ventilation duct during several brief pump operating periods. Following this mixer pump start up sequence, the caustic addition operations could begin and would result in mitigating a serious tank farm problem for a relatively small expenditure of resources.

5.0 EQUIPMENT DESCRIPTION

A schematic of the caustic addition apparatus is shown in Figure 1. Figure 2 depicts the installed AN-107 mixer pump.

5.1 Mixer Pump System Description

5.1.1 Pump Background

The 75 horsepower (HP) Hazleton submersible pump (spare parts # 6411-2225-5661) was purchased in 1987 as a mixer pump for the AY/AZ tank farm and was stored at 2101-M laydown yard before shop modifications to the pump were undertaken beginning in July 1993. The pump is physically similar in design to the 150 HP Hazleton mixer pump that is currently installed in tank 241-AP-102 and the 150 HP Hazelton mixer pump that has been modified for use as the Hydrogen Mitigation Pump for tank 241-SY-101.

5.1.2 Pump Data

Pump Manufacturer :	Barrett, Haentjens & Co. Hazleton, Pa.
Pump Serial Number :	N-20801
Pump Type/Size :	SSB / 5N
Flow :	950 gallons per minute
Total Dynamic Head :	115.5 feet

The mixer pump is installed on a pump stand above the 42 inch riser of the AN-107 central pump pit. A thick rubber gasket seals the gap between the riser and the mixer pump mounting flange.

Pump suction is taken approximately 68 inches above the tank bottom. The impeller draws in fluid through a screen and expels it through a twin volute that circulates the waste over the motor casing, for cooling purposes. The waste then flows down through two pipe extensions and then exits through two opposed 1.5 inch diameter nozzles located approximately 11 inches above the tank bottom. The pump nozzles are side-by-side with the caustic nozzles so that mixing into a uniform solution can be immediately achieved.

5.1.3 Submersible Pump Motor

The pump motor is a submersible type which operates in an air chamber isolated from the waste by a double mechanical seal and barrier fluid. The motor is a 75 HP Reliance Electric, 1800 rpm, 460 volt, 3 phase. The motor is located in the AN-107 supernate layer just above the approximately 80 inches of settled solids at the tank bottom. It is operated via an Eaton variable frequency drive located in the 241-AN-274 control building.

FIGURE 1

AN-107 Mixer Pump and Caustic Addition System

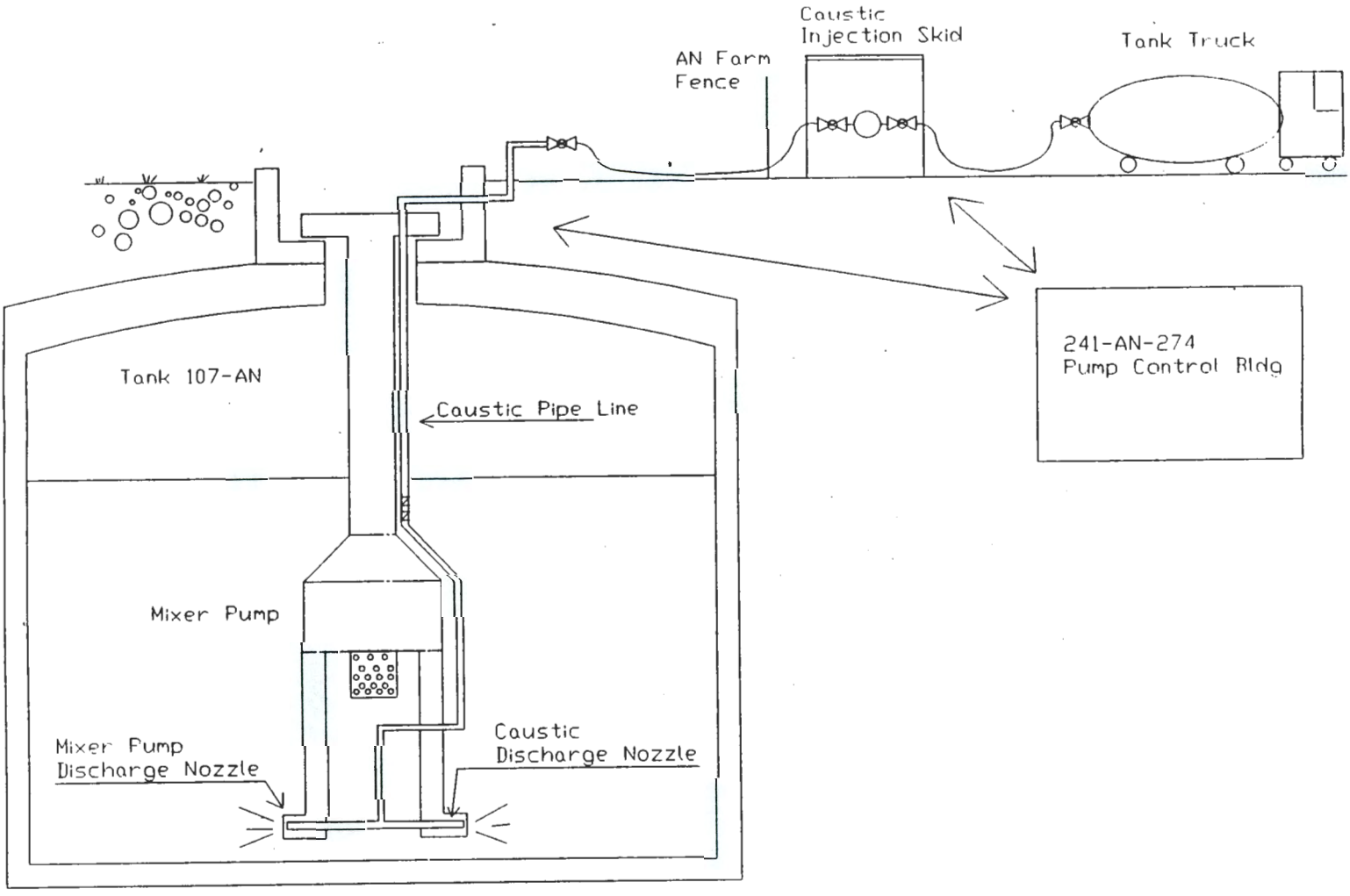
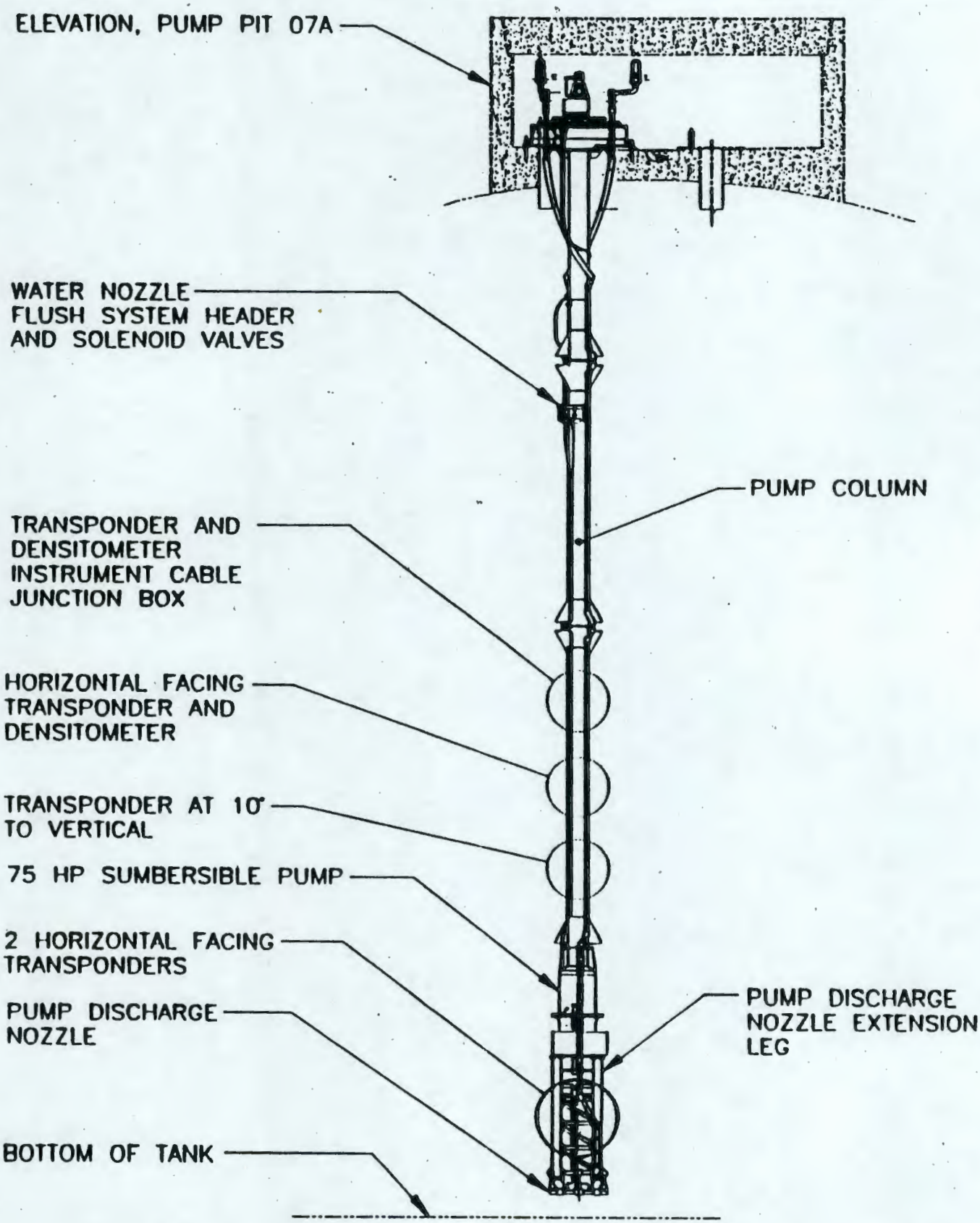


FIGURE 2



241-AN-107 MIXER PUMP

The motor cavity contains a moisture sensor and temperature sensor. A moisture detection circuit provides an ON/OFF indication of the presence of liquid in the motor cavity. The AN-107 pump system has an interlock set to shut the mixer pump off if fluid in the motor is detected.

The temperature sensor is a RTD located in the pump motor windings. The AN-107 pump system has an interlock set to shut the mixer pump off if the temperature exceeds 240°F.

5.1.4 Pump Column

The pump column is constructed of three 10 inch diameter schedule 40 pipes and a transition piece to the motor. The column is air-filled and the pipes are flange connected with an o-ring for sealing from the external environment. The pump column also acts as a housing for the motor power cable and instrumentation cables. A load cell, which is interlocked to shut off the pump if the programmed force limits (due to plugged nozzle) are exceeded, is located on the outside of the pump column middle section above the level of the waste.

5.1.5 Rotational Drive Mechanism

A Rotek bearing and 1 HP AC induction motor located in the pump pit provide capability to rotate the pump column to achieve 360 degrees of coverage through the opposed discharge nozzles. The motor is coupled to a double reduction worm gear which drives a pinion gear which provides the final coupling to the large ring gear/bearing (i.e., Rotek bearing or turntable) which supports the pump column. A position resolver coupled to the 1 HP motor provides an electrical signal of the turntable angle to a position controller located in 241-AN-274.

Two limit switches mounted on the pump top plate provide overtravel shutdown. The limit switches trip when the mixer pump main gear (turntable) reaches either the extreme clockwise or counter-clockwise travel limit.

5.1.6 Water Flush System

A temporary water source can be attached outside the central pump pit to the mixer pump's water flush system piping. Three solenoid valves mounted on the outside of the pump column middle section, above the level of the waste, provide flow control whereby a high pressure jet of water can be directed at the throat of either discharge nozzle (to blast out potential clogs) or by which dilute water can be provided to the pump intake. Two check valves in series prevent waste backflow to each of the valve ports.

5.1.7 Ultrasonic Scanning System

The AN-107 mixer pump has four echo-ranging transducers and one densitometer attached to the outside of the pump column and pump discharge legs. Their purpose is to detect the amount of mixing that has occurred through differences in the speed of return of an acoustic pulse. They are located as follows:

- two transducers located 3 feet (ft) above the tank bottom,
- one transducer located 15 ft above the tank bottom,
- one transducer and the densitometer located 20 ft above the tank bottom.

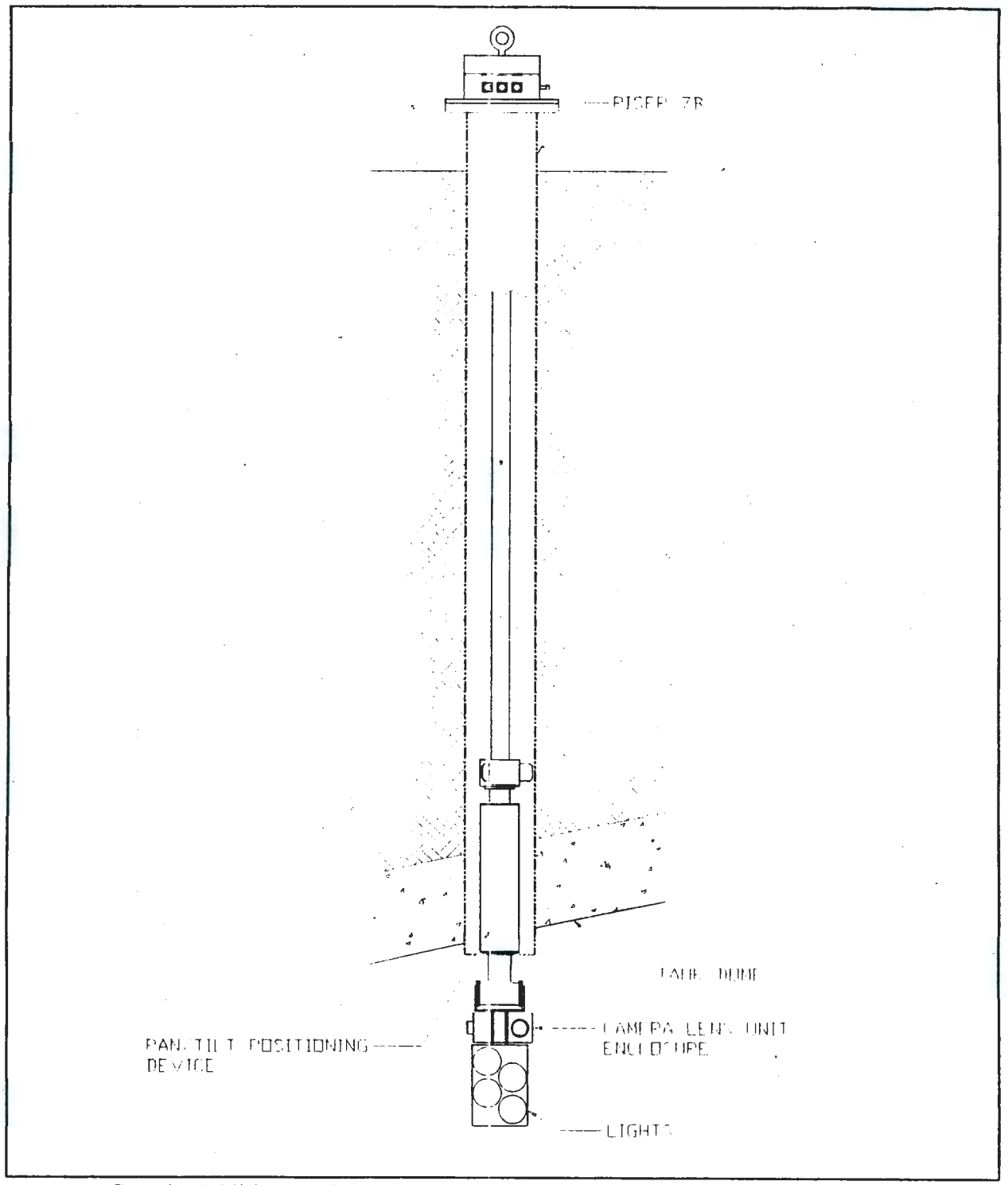
The transducers and densitometer are housed in boxes made of 0.075 inch thick 1010 steel that are welded all around and filled with a potting material. A Rockbestos instrument cable leaves each box and runs through 3/4 inch stainless steel tubing to a welded all around "pull" box located midway up the pump column. From there, the six cables continue up a 1-1/2 inch schedule 40 pipe attached to the pump column, enter a flexhose which accommodates rotation of the pump assembly, and leave the mixer pump through a sealed stubout in the mounting flange.

5.2 Video Camera System Description

The video camera system was procured for the caustic addition project in early 1994. The camera is designed with the capability to view the entire content of the tank dome space, but the primary purpose of the camera system is to monitor the tank thermocouple tree for deflection caused by operation of the nearby project mixer pump. The camera system consists of elements located inside of the tank dome space and riser, as well as two sets of external controls. The in-tank components were installed in riser RIS-WST-111G (7B) on August 1, 1995.

The primary camera control location is an equipment rack located in building 241-AN-274. A second set of camera controls is mounted in an electronics enclosure located on the north side of the tank, near riser 7B. The primary camera control location also contains recording equipment, a color monitor, and a video micrometer. The video micrometer can be used to measure deflection of the thermocouple tree at the waste surface during pumping operation. This is accomplished by pointing the camera at the thermocouple tree and imposing cursers on-screen with the video micrometer. The distance between the cursers is calibrated on a known dimension (i.e., the width of the thermocouple pipe) after which the distance between the cursers is constantly displayed as they are repositioned. As the thermocouple tree is deflected by the waste stream from the pump, the cursers can be adjusted to track this movement and deflection distance read out directly on the video micrometer display.

FIGURE 3



Caustic Addition Project In-Tank Imaging System

The in-tank portion of the video camera system, shown in Figure 3, consists of a Crestone Products model PTE-300 variable speed pan-and-tilt unit, an R. J. Electronics model RCS-521 radiation tolerant S-VHS video camera, and four General Electric model Q250PAR38SP quartz halogen spotlamps. These components are attached to a 10 ft long stainless steel mast which positions the camera in the tank dome space approximately 1 ft beneath riser 7B. At this location the camera is approximately 10 ft from the thermocouple tree, and approximately 23 ft from the pump.

5.3 Enraf Densitometer Description

Two Series 854 Advanced Technology Gauges (ATGs) from Enraf-Nonius, Inc. are installed on AN-107 to make both slurry density and sediment level measurements. (These density gauges are also referred to as Densitometers.) The gauges are mounted on decontamination/isolation assemblies installed on tank riser flanges. One densitometer is located in riser RIS-WST-101G (1C) which is 20 ft from the tank's center, while the other is placed in riser RIS-WST-131G (15A) which is 28 ft from the center. Both risers are 4 inch schedule 40 pipes.

The Enraf Series 854 ATG is a microprocessor controlled gauge normally used for inventory tracking in the petroleum and chemical industries. The gauge can be operated either as an autonomous gauge making periodic level measurements or in conjunction with a host computer making a variety of level and density measurements. Measurements can also be made with a Portable Enraf Terminal (PET) via an infrared optical port on the gauge.

The ATG consists of three distinct and isolated compartments: the drum housing, the terminal compartment and the instrument compartment. Only the interior of the drum housing is exposed to the tank's vapors. The drum compartment contains the measuring drum which is magnetically coupled to the motor in the instrument compartment. A displacer (plumb bob) attaches to a thin wire wound on the gauge drum and is suspended into the tank through the mounting assemblies and risers. The drum compartment is gas-tight, preventing tank vapors from entering the terminal and instrument compartments.

The decontamination/isolation assembly is used to wash the displacer and displacer wire, and to isolate the instrument from the tank. The assembly consists of a sight glass, spray rinse spool assembly, and an isolation valve mounted on the riser flange. A ball valve attached to the top of the riser flange provides both a passageway for the ATG displacer and wire when open and a seal to maintain containment of the tank's vapors when closed. The rinse spool assembly attaches to the top of the ball valve and is used to flush tank waste from the displacer and wire as they are retrieved from the tank. The rinse spool assembly consists of a flanged pipe spool, three wash ports, a water manifold, and three hydraulic hoses. The sight glass is mounted on the rinse spool assembly and attaches to the Enraf 854 gauge. The sight glass is used for visual inspection of the displacer and the wire as they are retrieved from the tank and also allows access for displacer maintenance.

Densities at different elevations are measured by moving the vertical position of the displacer. The gauge also automatically makes a density profile by taking density measurements at ten intervals between two specified elevations.

6.0 EQUIPMENT EVALUATION

FGEAB-97-021, Rev. 1, presents the FGEAB's evaluation of the mixer pump system and video camera equipment and is included as Appendix A of this report. Table 1 (taken from FGEAB-97-021), summarizes the items evaluated, findings, and recommendations. The following sub-sections contain further detail and discussion of the evaluation.

6.1 Mixer Pump System

The AN-107 mixer pump system was broken down into components which were evaluated against each requirement in the applicable ISC Set. This item-by-item evaluation is included as Appendix B.

The results were that the mixer pump system complied with the ISC Sets, except for the electrical relays associated with the pit leak detector, pump moisture sensor, and turntable limit switches. Replacement of the deficient items can be achieved as described in Section 7.1.

The FGEAB concluded that for the waste intrusive components, i.e., mixer pump and ultrasonic scanner system, double fault protection was demonstrated by design. The ultrasonic cabling in the dome space provides no normally sparking mechanisms, and the rotary position sensor located in the pit is also a non-sparking piece of equipment. Carbon steel or cast iron components were designed to not be capable of sparking under application.

6.2 Video Camera System Equipment Evaluation

The video camera system contains three electrical components which are located in the tank dome space (dome intrusive): the camera/lens unit, the camera lights, and the pan/tilt positioning device. As shown in Table 1, these components are located in an ISC Set #2 location and were evaluated for compliance with ISC Set #2 requirements.

6.2.1 Camera/Lens Unit

The camera/lens unit contains an electronic imaging sensor which operates at 12 volts dc and 5.8 watts. The camera zoom lens is remotely controlled by three small electric motors which operate at 5 volts dc and 25 to 40 milliamps. The image sensor is normally non-sparking by design. The lens motors operate at energies which fall below the ignition energy curves for hydrogen as defined in UL913, "Intrinsically Safe Apparatus." The camera/lens unit has been evaluated by the FGEAB and found to be acceptable for use (FGEAB-97-021, Rev. 1).

6.2.2 Camera Lights

The lights consist of four quartz halogen spotlamps which operate at 120 volts ac and 250 watts. The lamps are non-sparking under normal operation but generate considerable heat energy. On-site testing of identical lamps found that the maximum surface temperature reached during operation is less than 80 percent of the autoignition temperature of hydrogen (HNF-SD-WM-RPT-298, Rev. 0). The FGEAB has reviewed this data and found the camera lamps to be acceptable for use (FGEAB-97-021, Rev. 1).

6.2.3 Pan/Tilt Positioning Device

The pan/tilt positioning device contains two electric motors which operate at 30 volts dc and 1.25 amps. The motors in this device are not in compliance with nor equivalent to ISC Set #2 requirements. Compensatory measures were proposed to the FGEAB, which concurred, however, RL approval is required in order to proceed (FGEAB-97-021 Rev. 1). Section 7.2 of this document outlines the alternatives which were considered, as well as the approach selected as the path forward for this plan.

6.3 Enraf Densitometers

Only the interior of the Enraf Series 854 ATG drum housing is exposed to the tank vapor space. Additionally, the drum compartment is gas-tight, preventing vapors from entering the terminal or instrument compartments of the gauge. The AN-107 gauges (the portion exposed to the tank vapor space) are explosion proof and Factory Mutual approved for use in a Class I, Division 1, Group B, C or D classified hazardous location. The balance of the gauges (housing for the motor and electronic circuitry) is exposed to the unclassified (non-hazardous) environment outside of the riser.

Table 1: Summary of Findings

Item (1)	Location (2)	Ignition Control Set (3)	IC Set Met (4)	FGEAB Safety Equivalence Ruling (5)	Approved Temporary Exception (6)
Reliance Electric Submersible Pump Motor	Waste Intrusive, Facility Group 2	1	Yes	N/A	N/A
Mixer Pump (Column, Intake, Impeller) - Hazleton # 6411-2225-5661	Waste Intrusive, Facility Group 2	1 2	Yes Yes	N/A	N/A
Ames/Airmar Ultrasonic Assembly	Waste Intrusive, Dome Intrusive (cabling) Facility Group 2	1 2	Yes Yes	N/A	N/A
Autotech Rotary Position Sensor RL-100	Ex-Tank Facility Group 2	2	Yes	N/A	N/A
Allen-Bradley Model 802T Limit Switches	Ex-Tank Facility Group 2	2	Yes - if I.S. Barriered	N/A	N/A
Leak Detector H-2-34965f, Shts 1-3	Ex-Tank Facility Group 2	2	Yes - if I.S. Barriered	N/A	N/A
Pump Moisture Sensor SL Auburn Inc., Model F-050	Waste Intrusive, Facility Group 2	1	Yes - if I.S. Barriered	N/A	N/A
Hottinger Baldwin Measurements, Inc. Pump Column Load Cell	Dome Intrusive, Facility Group 2	2	Yes	N/A	N/A
Rosemount Series 78S RTD Pump Motor Temperature Detector	Waste Intrusive, Facility Group 2	1	Yes	N/A	N/A
Circle Seal Controls, Model SV-432T32P8P03 Solenoid Valves	Dome Intrusive, Facility Group 2	2	Yes	N/A	N/A
Mixer Pump Rotation Assembly - Reliance Duty Master, Gearbox - Boston Gear Co.	Ex-Tank, Facility Group 2	2	Yes	N/A	N/A
In-Tank Vision System (Crestone PTE-300; RJ Electronics RCS-521)	Ex-Tank, Dome Intrusive Facility Group 2	2	No	No*, see recommendations	Requires DOE exception

7.0 PLAN OF ACTION TO MITIGATE FLAMMABLE GAS ISSUE

7.1 Mixer Pump Equipment

The interpretation/recommendation of the FGEAB is that the mixer pump and its related equipment meet the Standing Order 97-1 ISC Set requirements, except for:

- Limit switches on the pump mounting flange (2)
- Pit leak detector
- Pump motor moisture sensor

This situation is recoverable because each of the non-conforming items can be modified to meet the ISC requirements. By changing the inductive relays for each of these components to ones that are intrinsically safe, those circuits become non-incendive. The four relays are located in the 241-AN-274 pump control building located outside of 241-AN Tank Farm.

Table 2 itemizes the required actions and their cost. The estimated cost to replace the existing relays with intrinsically safe relays is $26,800 based on fully burdened Hanford labor rates of $63/hour exempt, $35/hour non-exempt, and $47/hour bargaining unit.

Table 2 - POA to Replace Non-Conforming Electrical Relays

ITEM	LABOR HOURS	MATERIAL COST
Generate engineering documents for relay replacement (ECN(s) to H-2-85573)[1]	80	
Procure replacement relays, CVI (≈ $1000/per relay; 4 relays total)		$4000
USQ preparation and signoff	40	
Engineering support for planning and installation	80	
Work package planning[2]	40	
Installation cost[2] (electrician only, assume it takes 1 electrician 1 day to replace 1 relay; 4 man-days total)	32	
Admin./clerical and material adders	54	$1000
TOTAL HOURS	326	
COST	$21,800	$5,000
TOTAL	$26,800	

1. Fully burdened rate of SESC engineering support assumed at $90/hour.
2. Person-in-charge (PIC), QA/QC, Safety, etc. support personnel costs neglected for this estimate.

7.2 Video Camera System

The camera/lens unit and lights were evaluated and found acceptable for use in ISC Set #2 location. The pan/tilt positioning unit was found to be unacceptable. Several alternatives are available for modification/replacement of the existing pan/tilt positioning unit, or replacement of the entire camera system. The options are described in the following sections.

7.2.1 Alternative 1: Purge and Pressurize Pan/Tilt Positioning Device

A spare pan/tilt positioning device was acquired with the video camera system. This spare unit could be modified to allow purging and pressurization of the unit housing. The pan/tilt unit presently installed could then be replaced with the modified unit. Purging and pressurization of electrical equipment enclosures with instrument air or inert gas is in general use in hazardous locations.

In order to bring the spare pan/tilt positioning unit into compliance with ISC Set #2 requirements, a purge gas flow path must be established through the pan/tilt positioning unit housing, a pressure sensor must be installed in the housing, and a purge gas flow switch interlock must be placed on the system power supply.

The existing camera system design includes a purge gas path through the camera/lens enclosure which vents to tank atmosphere. This feature was included to allow flowing a dry gas over the camera components in the event that condensate formed inside the enclosure. However this purge gas flow path was not included to purge and pressurize electronic equipment for use in hazardous locations, consequently it does not include pressure/flow sensors nor electric power interlocks.

A local off-site vendor has been used previously for similar work on the W-320 Project camera system. This vendor has personnel familiar with the requirements for purging and pressurizing electrical equipment enclosures for hazardous locations. This vendor is also a supplier of electric power interlocks.

Field modifications required to implement this alternative include removing the camera system from the tank, disassembly of the components, rework of the existing purge gas system to provide a flow path to the pan/tilt positioning unit, reassembly with the modified spare pan/tilt positioning unit, and reinstallation.

Table 3 summarizes the costs and actions necessary to implement Alternative 1. The estimated cost is $77,200 based on Hanford labor rates as noted in Section 7.1, and use of an off-site vendor for modifications to the spare pan/tilt positioning device.

Table 3 - POA for Pan/Tilt Alternative 1

ITEM	LABOR HOURS	MATERIAL COST
Generate engineering documents for activity (drawings and ECNs, procurement, testing, CVI)	180	
Off-site vendor cost (modify spare p/t unit, supply sensors and power interlocks)		$32,000
USQ preparation and signoff	40	
Engineering support for planning	40	
Work package planning[1]	80	
Field work:[1] Crane and rigger - 48 Pipefitter - 8 Electrician - 48 Engineer - 24 HPT - 24	152	
Miscellaneous parts (purge platform, fittings)		$2,500
Admin./clerical and material adders	98	$8,600
TOTAL HOURS	590	
COST	$34,100	$43,100
TOTAL	$77,200	

1. Person-in-charge (PIC), QA/QC, Safety, etc. support personnel costs neglected for this estimate.

Disadvantages associated with this alternative involve removing the existing camera system from the tank and making field modifications on potentially contaminated items. Modifications required include disassembly of complex video electronic components, drilling and taping of the stainless steel camera mast, running new instrumentation wiring through the mast and junction boxes, and testing. Personnel performing this work may need to be wearing personal protective equipment, including full face respirators. The estimate given above assumes three days of field work to accomplish this task. While there is some conservatism in this estimate, potentially it could require several more days to accomplish.

7.2.2 Alternative 2: Replace Existing Camera System With Previously Approved Hydrogen Watch List Tank Camera System

Camera systems have been procured and installed in tanks at the Hanford site which meet the requirements for ISC Sets #1 and #2. Such systems are presently installed in tanks 241-SY-101, 241-SY-103, 241-AN-103, 241-AN-104, 241-AN-105, and 241-AW-101 (these six tanks are Hydrogen/Flammable Gas Watch List Tanks per OSD-T-151-00030). These systems were obtained prior to the implementation of the current tank farms Standing Order, however, since they were designed for use in tanks containing (potentially) explosive quantities of hydrogen they meet the current Standing Order requirements. These camera systems employ purging and pressurization of electronic equipment enclosures and use explosion-proof lighting.

This alternative involves obtaining another camera system utilizing existing design requirements and replacing the existing camera system. Some design modifications would be required because the previously approved system design employs lighting which is too large for deployment in riser 7B.

Table 4 summarizes the costs and actions necessary to implement Alternative 2. The estimated cost is $223,400 based on Hanford labor rates as noted in Section 7.1, procuring the replacement camera system from the same manufacturer who supplied the previously approved equipment, and procuring the purge control panel containing the sensors and power interlocks from the same vendor who has previously supplied this item.

Table 4 - POA for Pan/Tilt Alternative 2

ITEM	LABOR HOURS	MATERIAL COST
Generate engineering documents for activity (ECNs, procurement, testing, CVI)	240	
Off-site vendor cost (approved camera system)		$120,000
Off-site vendor cost (purge control panel)		$15,000
USQ preparation and signoff	40	
Engineering support for planning	40	
Work package planning[1]	80	
Field work:[1] Crane and rigger - 48 Pipefitter - 16 Electrician - 160 Engineer - 16 HPT - 16	256	
Miscellaneous parts (hose, wiring, conduits, fittings)		$8,000
Admin./clerical and material adders	131	$35,800
TOTAL HOURS	787	
COST	$44,600	$178,800
TOTAL	$223,400	

1. Person-in-charge (PIC), QA/QC, Safety, etc. support personnel costs neglected for this estimate.

The main disadvantage to this alternative is cost. In addition to the expenses shown above for the replacement system, the existing system must be decontaminated for storage, or disposed of as radwaste. Ultimately this will be true for all caustic addition project components, but by replacing the existing camera system this cost would be incurred twice.

7.2.3 Alternative 3: Replace Existing Camera System With Previously Approved Mobile Color Camera System

Recently, a new camera system has been designed and fabricated for temporary deployment in Hanford waste tanks. This system is known as the Mobile Color Camera System (MCCS). The MCCS utilizes purging and pressurization of electrical components to meet the requirements for ISC Sets #1 and #2.

Alternative 3 involves acquisition of a MCCS to replace the existing camera system. Table 5 summarizes the costs and actions necessary to implement this alternative once. The estimated cost is $90,000 based on Hanford labor rates as noted in section 7.1, and procuring, assembling, and testing a new MCCS. Currently, East Tank Farms Operations, West Tank Farms Operations, and Characterization Project Operations each own a MCCS. It may be possible to utilize one of these existing systems for the caustic addition project, replacing any damaged or contaminated components, if necessary, upon completion.

Table 5 - POA for Pan/Tilt Alternative 3

ITEM	LABOR HOURS	MATERIAL COST
Generate engineering documents for activity (ECNs, procurement, testing, CVI)	96	
Off-site vendors costs (MCCS components)		$53,700
Critical spare parts (camera)		$5,300
USQ preparation and signoff	24	
Engineering support for planning	8	
Work package planning[1]	40	
Field work (removal of existing system only):[1] Crane and rigger - 24 Pipefitter - 8 Electrician - 16 Engineer - 8 HPT - 8	64	
Admin./Clerical and Material Adders	46	$14,800
TOTAL HOURS	278	
COST	$16,200	$73,800
TOTAL	$90,000	

1. Person-in-charge (PIC), QA/QC, Safety, etc. support personnel costs neglected for this estimate.

The disadvantage of this alternative is that the MCCS was designed for deployment through tank risers four inches (or larger) in diameter. This design constraint limited the quantity and size of lights which could be used, and precluded the use of radiation shielding around the imaging components. Consequently, the MCCS is limited to about 30 feet maximum viewing distance, and the expected useful lifetime of the camera (shown as critical spare part in the above estimate) inside AN-107 is about 200 hours. The primary need for an in-tank imaging system during the caustic addition project is to monitor deflection of the thermocouple tree. A MCCS would provide adequate illumination for that purpose. However, the camera would require replacement about once a week due to radiation induced degradation and lens browning. It is expected that caustic addition operations will last for three to five months, necessitating many changeouts of the camera. The expense of removing and working on contaminated equipment, purchase of new components, decontamination and disposal of failed components, and reassembly and installation of the MCCS many times would be prohibitive. Additionally, the operating efficiency of the caustic addition operations would be reduced substantially thereby increasing overall operating costs.

7.2.4 Alternative 4: Use Existing Camera With Additional Engineered and Administrative Controls

The camera/lens unit and lights have been reviewed and found to be acceptable for use in AN-107 dome space. Only the pan/tilt positioning device does not meet ISC Set #2 requirements. This alternative involves adding lockable breakers or switches to the pan/tilt unit power supply so that it can be locked out during pump operations, or during any other waste disturbing activity. With this alternative, the pan/tilt unit would only be operable while the pump is off, and after the tank dome space has been sampled for flammable gas concentrations above 25% of the LFL.

Implementation of this alternative does not meet the requirements of ISC Set #2. Therefore RL approval is required. The mechanism for this approval is to request a non-de minimus exemption and listing on Table 3 of Standing Order 97-1. Table 6 summarizes the costs and actions necessary to implement this alternative. This estimate is the cost to modify the existing pan/tilt unit so that power can be locked out when the pump is operating. The estimated cost is $25,000 based on Hanford labor rates as noted in Section 7.1.

Table 6 - POA for Pan/Tilt Alternative 4

ITEM	LABOR HOURS	MATERIAL COST
Generate engineering documents for activity (ECNs, testing)	60	
Materials (enclosure, breakers, indicators)		$10,000
USQ preparation and signoff	24	
Engineering support for planning	4	
Work package planning[1]	40	
Field work:[1] Electrician - 48 Engineer - 4	52	
Admin./clerical and material adders	36	$2,500
TOTAL HOURS	216	
COST	$12,500	$12,500
TOTAL	$25,000	

1. Person-in-charge (PIC), QA/QC, Safety, etc. support personnel costs neglected for this estimate.

The disadvantage of this alternative is that the camera could not be repositioned while the pump is running. However, since the primary purpose for the camera is to monitor deflection of the thermocouple tree while the pump is running, the camera will be permanently positioned at the intersection of the thermocouple tree and the waste surface before starting the pump for the operational phase of the caustic addition project. Power to the pan/tilt unit could then be locked out to prevent inadvertent operation, and the camera utilized in a fixed position to monitor thermocouple movement after the pump is started.

Alternative 4 is by far the least costly option for restarting the camera system and is the preferred path forward. Additional costs will be incurred pursuing RL approval of the non-de minimus exemption. These costs are not estimated, but should not be great. This alternative has been discussed with the FGEAB and the Board has indicated that this exemption would likely be approved.

This alternative also has the advantage of not requiring removal of the existing camera system. All other options require removal of the camera, and modification and reinstallation of the camera, or replacement with a new camera system. There are ALARA concerns, as well as personnel and

equipment safety concerns to consider whenever equipment is removed from a tank. Alternative 4 is very low risk in this regard.

Besides being lowest cost and achieving the best ALARA, this alternative also offers comparable risk to the best alternative (#2) from a flammable gas safety concern. Locking out the power to the pan/tilt unit during mixer pump operation eliminates the potential for a sparking event capable of igniting a gas plume that could temporarily exist with fuel concentrations above flammability limits. Starting up the pump in a controlled manner (i.e., at low speed followed by progressively higher speeds) will relieve any trapped gas gradually without exceeding the flammable gas limit of 25% of the LFL. Once the tank is fully mixed, any flammable gas release concerns will be eliminated as long as the mixer pump is running. The project plans to run the pump virtually continuously during the caustic addition operational phase. Because the caustic addition project will be of limited duration (three to five months), use of administrative controls on the video camera operation will be short-lived. These factors when considered jointly result in an acceptable risk for this alternative relative to the other options evaluated.

This alternative has some risk that the picture quality may be found to be poor when the camera is reactivated. The imaging components of the camera system may have become degraded by continuous exposure to the high radiation levels in the dome space of AN-107. The camera was installed in August 1995, but was removed to replace a non-conforming viewing window in February 1996. At that time the imaging sensor and lights were changed out as well as the viewing window. However, the camera lens was not replaced. If the picture is found to be unacceptable it will be necessary to remove the camera and replace imaging components again.

7.3 Enraf Densitometers

The two Series 854 ATGs in AN-107 comply with the requirements of East and West Tank Farm Standing Order 97-1 as installed. No further action is required to operate the densitometer gauges in the tank.

8.0 CONCLUSIONS

To bring the AN-107 mixer pump and video camera equipment into compliance with the controls of East and West Tank Farms Standing Order 97-1 and the recommendations of the FGEAB, the following tasks shall be performed:

1. Inductive relays for the limit switches on the mixer pump mounting flange, central pump pit leak detector, and pump motor moisture sensor are to be replaced with intrinsically safe relays.

2. With the approval of the RL, the video camera pan/tilt unit power supply shall have lockable breakers or switches installed so it can be locked out during pump operations, or during any other waste disturbing activity. The pan/tilt unit would only be operable while the pump is off, and after the tank dome space has been sampled for flammable gas concentrations above 25% of the LFL. This is the preferred path forward.

   The mechanism for DOE approval is to request a non-de minimus exemption and listing on Table 3 of Standing Order 97-1.

3. If RL approval of the preferred path is not granted, another of the three alternatives presented will be selected. Each of these require removal of the camera from the tank, and modification and reinstallation of the camera, or replacement with a new camera system. These options entail significantly higher risk from work on contaminated equipment and higher cost and use of resources than the preferred option.

All other components of the mixer pump/caustic addition system were found to comply with Standing Order 97-1. Completion of the above tasks will allow the original caustic addition project work scope to be resumed.

9.0 REFERENCES

East Tank Farms Standing Order #96-23, Rev. 1, *Operating Specifications for Watch List Tanks*.

East Tank Farms Standing Order #96-36, *Compensatory Actions for Open Discovery USQs*.

East and West Tank Farms Standing Order #97-01, Rev. 2, *Compensatory Actions for Open Discovery Unreviewed Safety Questions (USQs)*.

FGEAB-97-021, Rev. 1, *Flammable Gas Equipment Advisory Board Interpretation/Recommendation Report*, dated June 26, 1997.

Hodgson, K. M., Anantatmula, R. P., Barker, S. A., Fowler, K. D., Hopkins, J. D., Lechelt, J. A., Reynolds, D. A., *Evaluation of Hanford Tanks for Trapped Gas*, WHC-SD-WM-ER-526, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Leshikar, G. A., 1997, HNF-SD-WM-ATR-155, Rev. 0, *Acceptance Test Report - Field Test of 75 HP Mixer Pump for 241-AN-107 Caustic Addition Project*, SGN Eurisys Services Company, Richland, Washington.

Pedersen, L. T., 1997, HNF-SD-WM-RPT-298, Rev. 0, *Temperature Measurement Test Results for 241-AN-107 In-Tank Imaging System Spotlamps*, Lockheed Martin Hanford Co., Richland, Washington.

APPENDIX A

FGEAB-97-021, Rev. 0

Flammable Gas Equipment Advisory Board Interpretation/Recommendation Report

June 26, 1997

Flammable Gas Equipment Advisory Board Interpretation/Recommendation Report

Date: June 26, 1997

Board Members at Hearing:	**Report No:**
N. F. Barilo Jr. (for R. A. Huckfeldt) *J. R. Kriskovich* *G. P. McDonald* *C. C. Scaief III* *R. A. Wahlquist*	FGEAB-97-021 Revision 1 **Date:** 6/26/97

Requestor/Presenters:

K. G. Carothers, J. L. Dowell, G. A. Leshikar and L. T. Pedersen Jr.

Problems/Issue Statement: Evaluate per Standing Order 96-36, Revision 3, the compliance status of equipment and activities associated with the AN-107 Caustic Addition Project.

Equipment/Activity Description: A 75hp mixer pump, installed in Tank AN-107, will be used to distribute and mix a caustic additive to the waste contents for corrosion mitigation. The mixer pump (Hazelton submersible #6411-2225-5661) and associated components (Ames/Airmar ultrasonic sensor assembly; Autotech Rotary Position sensor #RL100, limit switches, moisture sensors, load cell, solenoid valves, temperature detector, pump column and impeller), pit leak detector, in-tank vision system (RCS 521), and pressure testing of the UT transducer housing and mixer pump motor chamber and transition sections were evaluated against the Authorization Basis ignition source control sets.

References: Ultrasonic Assembly Dwgs. - Airmar 01-150-1 Rev. B; Mixer Pump Dwgs. - H-2-85264, Revs. 0 and 1; Iowa State University Memo - Dr. Amanda Clark to Kelly Carothers, "Information about Ames Laboratory Transducers"; Iowa State University Memo - Constantine Marmaras to Bob Eggars, "System Description"; Autotech Controls Rotary Position Transducers Manual. AN-107 Project "Evaluation of AN-107 Mixer Pump Assembly against WHC-SD-WM-JCO-007, Rev. 0A" - Kelly Carothers, dated 12-14-96.

Applicable Authorization Basis: Standing Order 97-01, Rev. 2 **Dated:** May 5, 1997

Does Equipment/Activity Comply with the AB Ignition Control Requirements?
[X]Yes [X]No [X]Other (See Recommendations)

If No, Does Equipment/Activity Provide Equivalent Design/Measures/Controls?
[ ]Yes [X]No [ ]Other (See Recommendations)

Explanation/Justification: N/A

If Not Equivalent, What Changes are Necessary to Comply or Provide Equivalency?

(See Recommendations)

FGEAB INTERPRETATION/RECOMMENDATION:

The mixer pump, ultrasonic assembly and rotary position sensor all complied with the Ignition Source Control Sets. If waste intrusive, i.e., mixer pump and ultrasonic system), double fault protection was demonstrated by design. The ultrasonic cabling in the dome space provides no normally sparking mechanisms, and the rotary position sensor located in the pit is also a normally non-sparking piece of equipment. Carbon steel or cast iron components were designed to not be capable of sparking under application. All of the other listed equipment complies with the appropriate Ignition Source Control Set (see General Application of Findings), except for the In-Tank Vision system.

The in-tank vision system was evaluated to contain normally sparking components. The iris, focus and zoom lens motors contained within the camera housing were of a sparking dc type, however they operated at nominal energies of 5 volts and 25 to 40 milliamps. At these levels they fall below the ignition energy curves for hydrogen as defined in UL913, "Intrinsically Safe Apparatus". The lighting system consists of 4 independently controlled sealed incandescent bulbs. The Board required temperature test data be provided and has reviewed the data which demonstrates that the lighting temperatures normally operate well below the upper limits established in the controls. (See Report HNF-SD-WM-RPT-298, Rev. 0)

The dc motor driven pan-and-tilt unit was evaluated to not be in compliance nor equivalent to ISC Set 2 requirements. It is a 24 volt unit that is sparking during normal operation. Compensatory measures have been suggested by the Design Authority with FGEAB concurrence, however, DOE will have to approve them.

Equipment, Materials & Work Practices (1)	Location (2)	Ignition Control Set (3)	IC Set Met (4)	FGEAB Safety Equivalence Ruling (5)	Approved Exception (6)
Reliance Electric Submersible Pump Motor	Waste Intrusive, Facility Group 2	1	Yes	N/A	N/A

Equipment, Materials & Work Practices (1)	Location (2)	Ignition Control Set (3)	IC Set Met (4)	FGEAB Safety Equivalence Ruling (5)	Approved Exception (6)
Mixer Pump (Column, Intake, Impeller) - Hazelton # 6411-2225-5661	Waste Intrusive, Dome Intrusive, Facility Group 2	1 2	Yes Yes	N/A N/A	N/A N/A
Ames/Airmar Ultrasonic Assembly	Waste Intrusive, Dome Intrusive (cabling), Facility Group 2	1 2	Yes Yes	N/A N/A	N/A N/A
Autotech Rotary Position Sensor RL-100	Ex-Tank Facility Group 2	2	Yes	N/A	N/A
Allen-Bradley Model 802T Limit Switches (2)	Ex-Tank Facility Group 2	2	Yes - if I.S. Barried	N/A	N/A
Leak Detector H-2-34965, Shts 1-3	Ex-Tank Facility Group 2	2	Yes - if I.S. Barried	N/A	N/A
Pump Moisture Sensor SL Auburn Inc., Model F-050	Waste Intrusive, Facility Group 2	1	Yes - if I.S. Barried	N/A	N/A
Hottinger Baldwin Measurements, Inc. Pump Column Load Cell	Dome Intrusive, Facility Group 2	2	Yes	N/A	N/A
Rosemount, Series 78S RTD Pump Motor Temperature Detector	Waste Intrusive, Facility Group 2	1	Yes	N/A	N/A

Equipment, Materials & Work Practices (1)	Location (2)	Ignition Control Set (3)	IC Set Met (4)	FGEAB Safety Equivalence Ruling (5)	Approved Exception (6)
Circle Seal Controls Inc., Model SV-432T32P8P03 Solenoid Valves	Dome Intrusive, Facility Group 2	2	Yes	N/A	N/A
Mixer Pump Rotation Assembly - Reliance Duty Master, Gearbox - Boston Gear Co.	Ex-Tank, Facility Group 2	2	Yes	N/A	N/A
In-Tank Vision System (Crestone PTE-300; RJ Electronics RCS-521)	Ex-Tank, Dome Intrusive, Facility Group 2	2	No	No* see recommendations	requires DOE exception

General Application of Finding, If Any:

1) Use of AC induction motors in waste intrusive applications is acceptable, provided the motor is adequately isolated from the waste environment. This provides double fault protection from ignition.

2) The use of carbon steel components in controlled areas is acceptable if, by design, they are evaluated to be incapable of sparking under the applied conditions.

3) The replacement of normally sparking relays with intrinsically safe relays is acceptable for existing installed equipment. Code requirements for marking and or color coding is not a strict requirement because of negligible safety value added versus cost. The Board does recommend, however that, when practical, code compliance be strived for. This would be especially appropriate for future equipment projects.

FGEAB Representative: _____ **Date:** 6/26/97
D. B. Smet (Signature on file)

Reviewer Signature: _____ **Date:** 6/26/97
R. L. Schlosser (Signature on file)

APPENDIX B

Item-by-item Evaluation of AN-107 Mixer Pump Assembly Against East and West Tank Farms Standing Order 97-1

Component: Position Resolver

Classification: Ex-Tank Intrusive

Description: This device measures the rotational position of the pump turntable using 2 fixed windings and a moving winding. The resolver is an Autotech Corp, Model RL100. It is coupled to the 1 Hp rotation motor which drives the large ring gear (turntable) and provides electrical signal to the position controller located in 241-AN-274 control building.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The position resolver is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	There are no exposed polymer materials on the position resolver.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The position resolver generates a negligible amount of heat.

Component: Position Resolver Classification: Ex-Tank Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	The position resolver is a normally nonsparking piece of equipment.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

Component: Limit Switches

Classification: Ex-Tank Intrusive

Description: Two Allen-Bradley, Model 802T, limit switches mounted on the pump top plate provide overtravel shutdown. The limit switches trip when the mixer pump main gear (turntable) reaches either the extreme clockwise or counter-clockwise travel limit. The switch arm must be rotated 18° in order to activate the switch. Once activated, the switch arm must travel 7° in the opposite direction in order to deactivate the switch.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The limit switches are not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	There are no exposed polymer materials on the limit switches.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The limit switches generate a negligible amount of heat.

Component: Limit Switches Classification: Ex-Tank Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	The limit switches fall under NFPA 70, Article 501-3 (b) (1) Contacts. Currently they are not non-sparking in normal operation. By using intrinsic safety barriers the circuit would become non-incendive. In doing this, the circuit becomes acceptable per (c) of the exception to Article 501-3 (b) (1) and thus meets the requirements of the Standing Order.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

Component: Pit Leak Detector

Classification: Ex-Tank Intrusive

Description: This detector provides an ON/OFF indication of the presence of moisture using moisture to provide a conductive path for an inductive relay. The leak detector is fabricated per H-2-34965, Shts. 1-3, Leak Detector Assembly [using p/n 75, H-2-85573 for the inductive relay].

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The leak detector is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	There are no exposed polymer materials on the leak detector.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The leak detector generates a negligible amount of heat.

Component: Pit Leak Detector Classification: Ex-Tank Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	The leak detectors appear to fall under NFPA 70, Article 501-3 (b) (1) Contacts. Currently this circuit does not meet the requirements of the Standing Order. By changing to an inductive relay that is intrinsically safe the circuit would become non-incendive. In doing this, the circuit becomes acceptable per (c) of the exception to Article 501-3 (b) (1).
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

Component: Pump Motor Moisture Sensor

Classification: Waste Intrusive

Description: The moisture detection circuit provides an ON/OFF indication of the presence of liquid in the motor cavity in a manner very similar to existing leak detectors in the tank farms. The probe is located in a "well" at the lowest point inside the motor. The probe is located near the bottom of the well which holds less than 1 pint of fluid. Liquid provides a conductive path for an inductive relay. The moisture element is an SL Auburn Inc., Model F-050 while the inductive relay is a B/W Controls, Model 1500D-L1S7.

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The moisture circuit is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The moisture circuit has no exposed polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	No heat is generated by this circuit.

Component: Pump Motor Moisture Sensor Classification: Waste Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	This circuit does not meet the requirements of the Standing Order. By changing to an inductive relay that is intrinsically safe the circuit would become non-incendive. In doing this, the circuit becomes acceptable per(c) of the exception to Article 501-3 (b) (1).
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A The moisture element is not in a purged or pressurized atmosphere.
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components, a minimum of four enclosure volumes shall be purged through the enclosure for energized components, and/or 10 volumes shall be purged for enclosed motors prior to controlled start-up of the system components (NFPA 70)	N/A The moisture element is not purged or pressurized atmosphere.

Component: Pump Column Load Cell

Classification: Dome Intrusive

Description: The load cell is located on the outside of the pump column middle section, above the level of the waste. The load cell is manufactured by Hottinger Baldwin Measurements, Inc. for tension-compression weight and force measurements. Load cells measure strain via changing electrical resistance; the change in resistance is caused by the deformation of a specialized resistor mounted on the monitored item.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	The load cell is stationary and not capable of mechanical induced sparking.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The load cell is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The load cell does not contain any polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The load cell does not generate heat.

Component: Pump Column Load Cell Classification: Dome Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	The load cell is non-sparking under normal or abnormal operation.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

Component: Pump Motor Temperature Detector

Classification: Waste Intrusive

Description: This device measures temperature via changing electrical resistance (i.e. RTD). It is located in the pump motor windings. The RTD is a Rosemeount, Series 78S platinum resistance temperature sensor.

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The motor temperature sensor is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The temperature circuit has no exposed polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	No heat is generated by this circuit.

Component: Pump Motor Temperature Detector Classification: Waste Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	This device is non-sparking and isolated under normal operation and thus meets the requirements of the Standing Order without modification.
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A The temperature sensor is not in a purged or pressurized atmosphere.
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components, a minimum of four enclosure volumes shall be purged through the enclosure for energized components, and/or 10 volumes shall be purged for enclosed motors prior to controlled start-up of the system components (NFPA 70)	N/A The temperature sensor is not in a purged or pressurized atmosphere.

Component: Ultrasonic Transducers

Classification: Waste Intrusive

Description: The Ultrasonic Transducers are mounted on the pump column in welded stainless steel enclosures. It operates by transmitting ultrasonic pulses, receiving the return signal then analyzing the signal to determine the parameters of interest. These transducers differ little from the units installed on tank 241-SY-101 and the following is based on the safety analysis for the units on tank 241-SY-101. Reference: LA-UR-92-3196 (revised), Appendix X.

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	N/A
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The ultrasonic transducers are not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	There are no exposed polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	Assuming the electrical energy to the transducers is completely converted to heat, the calculated temperature rise of the enclosure is 3°F. (Per LA-UR-92-3196 (revised), Appendix X).

Component: Ultrasonic Transducers Classification: Waste Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	The transducer enclosures are nonsparking under normal operation <u>and</u> have been designed to be isolated from the waste environment [Ref: LA-UR-92-3196 (revised), Appendix X, Section 4.6, para 2, sections 4.9 through 4.11, inclusive.]
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A The enclosure is not purged or pressurized.
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components ...	N/A The enclosure is not purged or pressurized.

Component: Submersible Pump Motor

Classification: Waste Intrusive

Description: The submersible motor is a 75 Hp, 3-phase, 460V AC induction motor manufactured by Reliance Electric. It operates in an air chamber isolated from the waste. The motor is located in the AN-107 supernate layer just above the ≈ 80 inches of settled solids at the tank bottom. The motor cavity contains the motor windings, stader, rotor, bearings, moisture sensor, and temperature sensor. The moisture sensor and temperature sensor are evaluated in another section. The mechanical seal, while not inside the motor cavity, is evaluated with respect to overall motor operation.

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	The motor moving mechanical parts: rotor, roller bearings, and mechanical seal, are normally non-sparking and are evaluated not capable of sparking under the applied conditions.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The motor is grounded per H-2-85573, Sht 23.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The motor has no exposed polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	Hazleton's Operation & Maintenance Manual for the mixer pump limits it's operation to temperatures below 240°F. An RTD located in the motor windings gives feedback as to the internal temperature of the pump. If the RTD reaches 240°F, an interlock located in the pump control building, 241-AN-274, will shut down the pump and an alarm will indicate over-temperature.

Component: Submersible Pump Motor Classification: Waste Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	See attached page.
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A The motor is not purged or pressurized.
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components ...	N/A The motor is not purged or pressurized.

Justification/Basis for Pump Motor meeting intent of Criteria #5.

In this case the last sentence of Criteria #5 applies. The submersible electric motor is an AC induction motor which by type are normally nonsparking which satisfies the first requirement. Based on the design of the mixer pump motor it also conforms to the second requirement (i.e. is designed to be isolated from the waste environment).

The motor is located in the supernatant portion of the waste, which poses no restriction to the continuous release of flammable gas to the tank vapor space. Pockets of trapped gas are only postulated to occur in the settled solids layer. Since the motor isn't physically located in the solids layer, it cannot be exposed to trapped pockets of gas where diffusion into the motor cavity could occur. The impeller (≈ 71" above the tank bottom) is below the measured settled solids level (≈ 80") but pump insertion into the tank and pump operation during acceptance testing have almost certainly created a "well" so that the impeller is also in the supernate layer.

A postulated scenario is that flammable gas could accumulate in the pump casing (impeller area) and leak past the seals into the motor. This was examined and found to be impossible since the pump and motor housings are separated and the shaft passes through an intervening space that is open to the waste environment. This feature also means that pump discharge pressure does not act against the mechanical seal.

The paths of entry to the motor space are relatively tortuous. The possible leak paths from the waste to the motor are:

1. Through the mechanical seal
2. Through the o-ring gasket that fixes the mechanical seal to the motor cavity
3. Through the two drain plugs on the motor cavity
4. Through the two o-ring gaskets between the top of the motor cavity and the stader cover (Item 43)

All of the above features are designed to isolate the motor air chamber from the waste.

The most probable leak path is through the John Crane manufactured double mechanical seal. Upper and lower silicon carbide seal faces act in conjunction with Buna-N O-rings and a barrier fluid, which provides a buffer against external liquid entering the motor cavity, to seal the motor cavity from the waste. Shaft rotation circulates the barrier fluid from a reservoir through the mechanical seal housing. The barrier fluid is at a lower pressure than the waste so leakage will occur into the barrier fluid. The reservoir is a closed system; since fluids are incompressible very little waste can mix with the barrier fluid without subsequent leakage into the motor cavity. If the upper seal were to leak and fluid entered the motor cavity, a moisture sensor (conductivity probe) located in the motor will trip an alarm and a

mixer pump shutdown interlock in 241-AN-274. Any fluid leakage from the mechanical seal housing into the motor would likely be mostly barrier fluid. The barrier fluid/waste mixture that leaks into the motor cavity will shut down the mixer pump before the anticipated low flammable gas generation rate could increase concentrations to the lower flammability limit.

Component: Pump Intake / Pump Impeller

Classification: Waste Intrusive

Description: Pump suction is approximately 68" above the tank bottom. The impeller draws in fluid through a screen and expels it into a "twin volute" that circulates it up over the motor casing, for cooling purposes, before it is discharged through the two nozzles. Both the impeller and the casing are Cast Iron (ASTM A48 Class 40).

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	Pump operation is a normally non-sparking activity. The pump intake, being in the supernatant layer is constantly flooded. Specified clearance between the impeller and suction head was verified and locked in prior to installation. This component is evaluated not to be capable of sparking under the applied conditions.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	N/A
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The pump intake has no exposed polymer materials.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The pump intake meets this criteria.

Component: Pump Intake / Pump Impeller Classification: Waste Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	N/A
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components, a minimum of four enclosure volumes shall be purged through the enclosure for energized components, and/or 10 volumes shall be purged for enclosed motors prior to controlled start-up of the system components (NFPA 70)	N/A

Component: Pump Column

Classification: Waste Intrusive (Lower part of the column only. The upper portion of the column is dome-intrusive only and has different criteria)

Description: The pump column acts as a housing for the motor power cable and instrumentation cables. A transition piece is located between the motor and the three 10" diameter, schedule 40 pipes that form the column. Each section is air-filled. The transition piece and the pipes are flange connected with an o-ring for sealing from the external environment. One of the flanges on each section is a blind flange with holes drilled and tapped for the cord grip assemblies that pass the electrical and instrumentation cables through each section. Each section is therefore isolated from the other, but the barrier is not necessarily vapor tight. The transition piece contains an enclosure located just above the motor where the motor leads are attached.

Ignition Source Control Set 1	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	All parts inside and outside the lower portion of the pump column are stationary, except that the pump column itself is capable of rotating slowly (≈ 0.5 rpm). By engineering judgement, no mechanical induced spark is possible.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The pump column is not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The only exposed polymer material on the waste-intrusive portion of the pump column is the defunct vibration cable (Bostrad 7E 600V double shielded instrument cable with chlorosulfonated jacket). The cable is tightly strapped to the carbon steel pump column to prevent electrostatic buildup.

Component: Pump Column Classification: Waste Intrusive (Lower part of the column only. The upper portion of the column is dome-intrusive only and has different criteria)	
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	No heat is generated by the pump column.

Component: Pump Column Classification: Waste Intrusive (Lower part of the column only. The upper portion of the column is dome-intrusive only and has different criteria)	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 1, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment can result in an arc or spark, or gas burn propagation to the environment external to the source enclosure. In the case of waste-submerged equipment containing potential ignition sources, demonstration by design that the equipment is nonsparking under normal operation <u>and</u> is designed to be isolated from the waste environment is an acceptable alternative.	The motor cable and instrumentation cables are the only electrical equipment inside or outside the waste-intrusive portion of the pump column (with the exception of the ultrasonic transducer assemblies which are evaluated separately). They are nonsparking under normal operation. The column was designed to be isolated from the waste environment. An o-ring provides a seal at the flange faces. In addition, 101-SY Safety Assessment (LA-UR-92-3196) for a 150 Hp Hazleton mixer pump of similar design to this one, includes the results of an analysis that shows the structural integrity of that pump column is maintained during a hydrogen burn. The calculated pressure for the 101-SY pump 16" column was 280 psi, which results in a hoop stress of 5973 psi (ASTM A53 yield stress = 35,000 psi). The analysis concluded ignition will not propagate outside of the pump structure. The AN-107 mixer pump 10" column contains 60% less volume and possible fuel mixture resulting in less pressure buildup, and everything equal, the resulting hoop stress is lower due to the smaller radius and same wall thickness. The safety margin found by LA-UR-92-3196 for the 101-SY pump is larger for the AN-107 pump.
6. Shutdown of purged and pressurized electrical equipment and purged and pressurized heat-generating equipment, upon loss of protective gas pressure or flow, shall be automatic by design as defined by NFPA 496 Type X pressurization.	N/A The pump column is not purged or pressurized.

Component: Pump Column Classification: Waste Intrusive (Lower part of the column only. The upper portion of the column is dome-intrusive only and has different criteria)	
7. Interlocked start-up of purged and pressurized electrical or purged and pressurized heat-generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g. adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are used to isolate energized components, a minimum of four enclosure volumes shall be purged through the enclosure for energized components, and/or 10 volumes shall be purged for enclosed motors prior to controlled start-up of the system components (NFPA 70)	N/A The pump column is not purged or pressurized.

Component: Pump Column

Classification: Dome Intrusive (Upper part of column only; that part located above the waste)

Description: The pump column acts as a housing for the motor power cable and instrumentation cables. It is air filled and is constructed out of three 10' sections (approximately) of 10" diameter, schedule 40 pipe. The pipes are flange connected with an o-ring for sealing from the external environment. One of the flanges on each section is a blind flange with holes drilled and tapped for the cord grip assemblies that pass the electrical and instrumentation cables through each section. Each section is therefore isolated from the other, but the barrier is not necessarily vapor tight. The upper section ends in a large diameter flange that forms part of the rotational turntable, inside the central pump pit. Piping and instrument cable run down the outside of the column.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	All parts inside and outside the upper portion of the pump column are stationary except for 3 stainless steel flexhoses and an electrical wire bundle (solenoid valve cables) that accommodate rotation of the pump column. These items are located within the riser and could possibly contact it. By engineering judgement, the pump column rotates so slow (≈ 0.5 rpm) that a mechanically induced spark is not possible. Near the mounting flange there are carbon "bumper blocks" that help stabilize the pump in a seismic event. During shop testing the column / block contact area was lubricated to eliminate a high pitched squeal. Slow contact of the carbon blocks against the carbon steel pump column is judged to be incapable of sparking.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The pump column is not an electrostatic ignition source.

Component: Pump Column Classification: Dome Intrusive (Upper part of column only; that part located above the waste)	
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The exposed polymer materials on the dome-intrusive portion of the pump column are the solenoid valve cables, part of the load cell cable, and the defunct vibration cable. These are not an electrostatic ignition source.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The pump column contains no heat generating equipment.
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	All electrical equipment on or within the pump column is non-sparking under normal operation. See waste intrusive portion of the pump column for more justification of equipment within the column. The load cell and solenoid valves located outside the column are evaluated separately.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A The pump column is not purged or pressurized.

Component: Pump Column Classification: Dome Intrusive (Upper part of column only; that part located above the waste)	
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components, a minimum of 4 enclosure volumes shall be purged through the enclosure for energized components, or 10 volumes shall be purged for enclosed motors prior to controlled start-up of the system components (NFPA 70, NFPA 496). When combustible gas detection shut down systems are employed, start-up of equipment shall only be allowed once measured acceptable flammable gas levels are indicated.	N/A The pump column is not purged or pressurized.

Component: Solenoid Valve

Classification: Dome Intrusive

Description: Three solenoid valves are mounted on the outside of the pump column middle section, above the level of the waste. They provide flow control for the mixer pump's water flush system whereby a high pressure jet of water can be directed at the throat of the discharge nozzles or by which dilute water can be provided to the pump intake. Two check valves prevent waste backflow to each of the valve ports. The solenoid valves are manufactured by Circle Seal Controls Inc., Model SV-432T32P8P03.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	The valve is evaluated to be incapable of sparking under the applied conditions. See answer to Criteria #5 for more information.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The solenoid valves are not an electrostatic ignition source.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	The polymer materials in the wetted internals of the solenoid valve body, seal material - ethylene propylene and the seat material - nylatron polyamide, are qualified by meeting MIL-STD-810 as described below.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The solenoid valves generate a negligible amount of heat.

Component: Solenoid Valve Classification: Dome Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure.	This device is non-sparking under normal operation. The manufacturer has tested and qualified the solenoid valves to MIL-STD-810, "Military Standard Environmental Test Methods and Engineering Guidelines". MIL-STD-810 contains provisions for an Operation in explosive atmosphere test and an Explosion containment test. The manufacturer's representative indicated that the valves passed, at minimum, one of the tests meaning either that the solenoid did not ignite the test fuel vapor in the explosive atmosphere test and/or there was no propagation of flame to the environment external to the enclosure in the explosion containment test. The solenoid was then termed by the manufacturer "explosion-proof". We have not modified the solenoid valves in any way so they should be qualified for dome-intrusive service.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

Component: Mixer Pump Rotation Assembly
(1 Hp Rotation Motor and Gear Drive)

Classification: Ex-Tank Intrusive

Description: Mixer pump rotation is achieved via a 1 HP Reliance Duty Master Vertical Solid Shaft AC Motor, 1200 rpm, 230/460 volt, 3 phase, 60 Hz. The motor is reversing and is Totally Enclosed Fan Cooled (TEFC) type. The motor is coupled to a double reduction worm gear with 600:1 reduction ratio in a gear box manufactured by Boston Gear Co. A 14 tooth pinion gear provides the final coupling to the 110 tooth ring gear/bearing (i.e. Rotek bearing or turntable) which supports the pump and rotates.

Ignition Source Control Set 2	Justification/Basis for Equipment Qualification
1. Mechanical tooling, equipment, and materials (including lubricants, adhesives, gaskets, etc.) shall be constructed of spark-resistant materials or rendered incapable of sparking or analyzed and evaluated not to be capable of sparking under the applied conditions. Evaluate for thermite reaction potential.	Mating of the high rpm components occurs in the gear box which is filled with lubricating oil. Outside the gear box, the pinion (≈ 2 rpm) drives the Rotek bearing at a very low speed. By engineering judgement, these components are incapable of sparking.
2. Electrostatic ignition sources shall be controlled by providing bonding or grounding.	The rotation motor is grounded per H-2-85573, Sht 23.
3. Exposed polymer materials shall be rendered incapable of electrostatic discharge potential either by design or through acceptable workaround practices.	There are no exposed polymer materials on the gear box or the rotation motor.
4. The surface temperatures of heat-generating devices shall not exceed 80% of the autoignition temperature of the flammable gas or a maximum of 320°F ... Internal temperatures of heat generating devices may exceed 80% of the autoignition temperature if the heat source is either isolated from the gas environment, or if the design of the device enclosure meets the requirements for explosion-proof housings.	The surface temperature of the rotation motor and the gear box is significantly less than 320°F while operating. During testing the motor casing was never more than warm to the touch.

Component: Mixer Pump Rotation Assembly (1 Hp Rotation Motor and Gear Drive) Classification: Ex-Tank Intrusive	
5. Electrical equipment shall be designed to meet NFPA 70 Class 1, Division 2, Group B criteria to the maximum extent practical. As a minimum, this shall be interpreted to mean the equipment is nonsparking under normal operation or, if normally sparking, the sparking component(s) shall be continuously isolated (purged and pressurized) from the potentially flammable gas environment, or the design of the device enclosure shall be of sufficient strength (explosion-proof) to prevent propagation of a gas burn to the environment external to the enclosure	The rotation motor is induction type which is non-sparking under normal operation.
6. Either automatic shutdown or alarming with manual shutdown will be required upon loss of protective gas pressure or flow as defined by NFPA 496 (1993) Type Z pressurization. In ex-tank area applications, electrical equipment that does not meet Class I, Division 2, Group B may be used, if it is automatically shutdown by combustible gas detection systems.	N/A
7. Automatic or manual start-up of purged and pressurized electrical or purged and pressurized heat generating equipment shall only be allowed upon system sensing of pre-set safety limits (e.g., adequate protective gas pressure established as defined by NFPA 496). If pressurized enclosures are utilized to isolate energized components ...	N/A

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