Engine Systems integration
2900 Main Street, Building 137, Suite 105
Alameda, California 94501
510.500.1249 | 510.775.1594 FAX

Safety Evaluation
East Bay Municipal District
Wastewater Treatment Plant

Client: Advanced Engine Technologies Corp.

Submitted by:
Jim Dyer, Principal Engineer
Neil Holmgren, President
09/22/2020

Revision: 1

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Introduction

This report is based upon a site survey performed by Engine Systems integration (ESi) at the East Bay Municipal Utility District (EBMUD) Wastewater Treatment Plant. The survey was conducted to fulfill Task 3: Safety Evaluation of the Power Generation Station – Engine Generators and Auxiliary Equipment Assessment project. The survey area included the Power Generation Station-1 (PGS-1) and relevant system piping.

The purpose of the survey was to evaluate the engine fuel systems and safety equipment at PGS-1 as they relate to protection of personnel and machinery, reliability, and code compliance. Items of concern and recommendations for improvements are detailed within the body of this report.

ESi surveyed the site on August 4-5, 2020. A return visit was made on August 31st at the invitation of EBMUD to participate in troubleshooting of the Fire Detection System and engine shutdowns in collaboration with Advanced Engine Technologies Corp. and Global Fire and Safety.

Most of the issues identified in this report are typical to this type of facility. The value of a third-party independent evaluation is in providing a fresh set of eyes unconstrained by the daily necessities of the plant. The fact that ESi spends time in many different types of facilities enables cross pollination of approaches to engine room safety.

The body of this report presents ESi's findings and recommendations for remedy. The first section of Code Recommendations identifies issues where rules and codes are in violation. The second section discusses findings based not on code or rule violations, per se, but recommendations for improved or best practices identified by ESi. The third section provides recommendations which are not specifically targeted to remedy immediate problems, but rather to evaluate new technologies for future safety upgrades. The fourth section identifies concerns ESi raised while onsite in areas that were not within our scope.

The report concludes with a spreadsheet estimating costs for the suggested remedies.

Survey Findings

1.0 Code Recommendations

The findings in this section identify problems with current safety and/or building codes. The items either identify a specific violation or provide recommendations for code interpretations that yield safer results.

1.1 Low-Pressure Digester Gas Piping Repair

References:

- California Mechanical Code, Chapter 16, Stationary Power Plants
  - Installation of gas engines shall conform to NFPA 37.
- NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, Chapter 5 Fuel Supply – Gaseous, 5.1 Gas Piping, 5.1.2.
- NFPA 54 National Fuel Gas Code, Chapter 5 Gas Piping System Design, Materials, and Components, 5.6 Acceptable Piping Materials and Joining Methods, 5.6.4 Plastic Pipe, Tubing, and Fittings, 5.6.4.1.1 Standard and Marking.

Survey Findings:

The overall condition of the low-pressure fuel gas piping within the engine room shows indication of many repairs. Discussions with plant personnel revealed a collection of patchwork to prevent leaks. ESi understands that this piping is already being considered for replacement. Some of the temporary repairs however are not compliance with current code.

Figure 1 shows a section of Polyethylene (PE) piping used to replace the leaking carbon steel piping in the LPDG supply to the gas compressors located in the overhead of the basement on the East wall.

Figure 1: LPDG Gas Piping

NFPA 37 identifies that “Plastic pipe shall not be used to carry fuel within a room housing an engine(s).”

The Polyethylene (PE) piping is installed in the PGS-1 basement below the engine level. As there are no fire partitions between the engines and basement, plastic piping should not be used.

Additionally, closer inspection of the PE piping showed that it was not compliant with NFPA 54. *Figure 2* shows the piping marked ASTM F-714. NFPA 54 states that PE piping used for fuel gas is required to be marked “gas” and “ASTM D2513”.

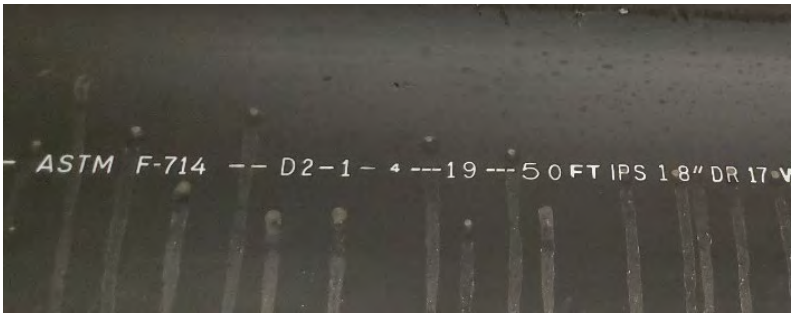


Figure 2 – Installed LPDG Labeling

Remedy:

The polyethene section of piping in the engine room should be replaced with code compliant steel piping.

1.2 Fire Detection System Shop Drawings

References:

- California Code of Regulations, Title 24, Chapter 9 Fire Protection Systems, 907-Fire Alarm and Detection Systems, 907.1.2 Fire Alarm Shop Drawings.

Survey Findings:

Investigation of the Fire Detection System revealed that much of the documentation was out of date. Shop drawings for fire alarm systems have many requirements including the “interface of fire safety control functions.” Comparison of the drawings (Fire Alarm System Upgrade, Sheet FA-04) to the system as wired revealed many discrepancies largely related to the integrated functions (Fire Detection System Outputs). The following outputs were listed in the drawings but did not have wiring terminated in the panel:

1) MIP FB1
2) DCR (terminals 10 and 11)
3) DCR (Terminals 18 and 19)
4) Generator #2
5) Generator #3
6) To Designated Points
7) Halon Release System “A”
8) DCR (Terminals 2 and 3)
9) Halon Release System “B”
10) MIP General Alarm

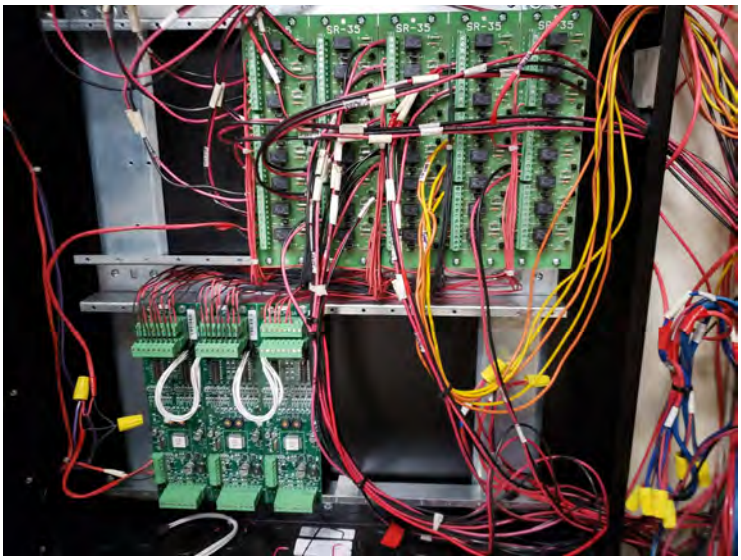


Figure 3: PGS-1 Fire Detection Panel Internal Wiring

Additionally, the following items were installed differently than depicted in the drawings:

1. Generator #1 - labeled as "Fire Alarm" on input to upper terminal block to MIP. Labeled as "MIP Fire +(-)" at output of terminal block.
2. Magnetic Fire Door Holder - drawing shows wires to NC contact (17, 18). Actually, wired to NO contact (18, 19)

3. To Heat Pump Control - drawing shows wires to NC contact (21, 22). Actually, wired to NO contact (22, 23)

It is unclear if the system has been modified over time or was never wired as per the drawings.

While the incorrect (potentially out of date) drawings are a violation of the California Code of Regulations, perhaps more importantly, lack of reliable documentation in general leads to difficulty in system comprehension and troubleshooting for facility personnel.

During ESi's investigation, it appeared that plant personnel were not as familiar with some of the details of the system as they desired to be. This was likely due to the lack of documentation in general and incorrect drawings specifically. The current documentation received by ESi is a mix of the previous system and the Siemens system installed in 2014 with incorrect drawings.

Remedy:

A complete and accurate set of *as built* drawings are required to conform to code. Inspection of the panels, circuit tracing, and testing will be required to determine the "as-built" condition of the Fire Detection System. This is essential for plant personnel to understand the proper operation, have accurate expectations during testing or an emergency event, and troubleshoot the system should expectations not be met.

In addition, ESi recommends developing a manual that includes a description of operation for the installation at EBMUD that includes the operation of the interface devices. This manual should be available to operations personnel for routine training and bringing on new personnel.

1.3 PGS-1 Fire Alarm Manual Pull Station Location

References:

- California Fire Code, Chapter 9 Fire Protection Systems, 907 Fire Alarm and Detection Systems, 907.4 Initiating Devices, 907.4.2 Manual Fire Alarm Boxes.
- NFPA 72 National Fire Alarm and Signaling Code, Chapter 17 Initiating Devices, 17.15 Manually Actuated Alarm-Initiating Devices, 17.15.9.4.

Survey Findings:

California Code and NFPA requires the fire alarm manual pull stations be located within 5 feet of each exit from the protected space. The PGS-1 control room was modified with a new motor-control center installed against the south wall. When this was done, one of the exit doors for the control room was blocked by the new equipment. The fire alarm pull station was located adjacent to this abandoned door (*Figure 4*) that was covered by the motor-control center. The current exit from the control room is on the opposite side of motor control center outside of the 5 feet requirement. It there is not a pull station located adjacent to the door exiting to outside this pull station needs to be moved closer to the existing exit door.

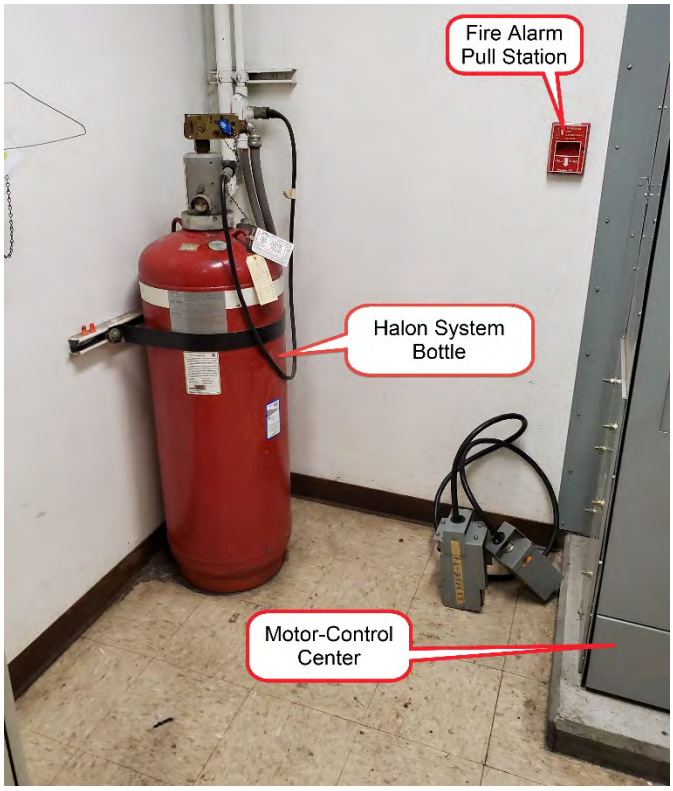


Figure 4: PGS-1 Control Room Fire Alarm Pull Station

Remedy:

Relocate the fire alarm manual pull station to a location adjacent to an exterior exit door.

1.4 Leak Test Valve

References:

- NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, Chapter 5 Fuel Supply – Gaseous, 5.2 Gas Trains.

Survey Findings:

A manual leak test valve is required for each automatic safety shutoff valve (ASSV). The purpose of leak test valves is to prove positive closure of ASSVs. The ASSVs for the Enterprise engines are the Block and Vent (B&V) valves and the Gas Metering Valves (GMV). The leak test valves are typically small, instrument valves plugged at the outlet. *Figure 5* shows the required component arrangement to comply with NFPA 37 code for engines with outputs greater than 732 kW.

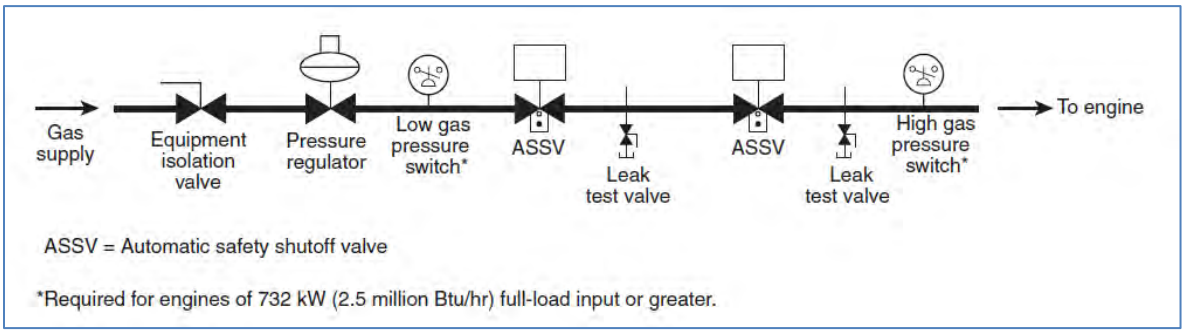


Figure 5 - NFPA 37 Fuel Gas Supply Arrangement

No leak test valves were installed downstream of the GMVs, but each engine has an available port for installation (*Figure 6*). A leak detection valve is not required between the ASSVs because the upstream ASSV vents to the PGS-1 roof when closed.

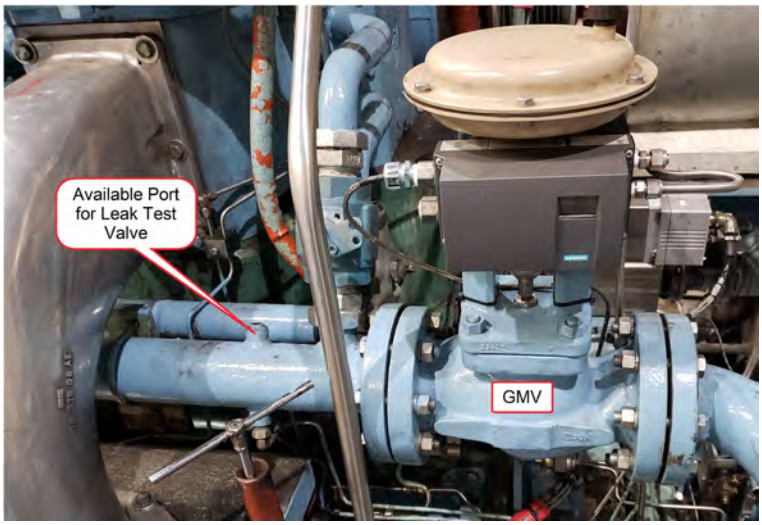


Figure 6: Engine Fuel Gas Metering Valve and Gas Header

Remedy:

Install valves and plugs in available port for Leak Test valves. This can be performed by plant personnel, likely with instrument valves and fittings available on site.

1.5 Engine Fuel Gas Vents

References:

- NFPA 54 National Fuel Gas Code, Chapter 12 Venting of Appliances, 12.7 Gas Vents, 12.7.3.1 (b) Gas Vent Termination.

Survey Findings:

NFPA 54 requires gas vents on the roof to terminate two feet above the highest part of the building that is within 10 feet. The engine fuel gas piping vents did not meet this requirement (*Figure 7*).

Figure 7 – Engine Vent Piping

Remedy:

The engine fuel gas vents need to be raised to terminate two feet above the parapet. A spool piece can be installed between the flame arrestor and the gooseneck. This repair can likely be performed by plant personnel or a local mechanical contractor in regular employ of EBMUD.

1.6 Boiler Fuel Gas Vents

References:

- NFPA 54 National Fuel Gas Code, Chapter 12 Venting of Appliances, 12.7 Gas Vents, 12.7.3.1 (b) Gas Vent Termination.

Survey Findings:

NFPA 54 requires gas vents on the roof to termination not be blocked or covered. The engine fuel gas piping vents did not meet this requirement due to the tarp installed in the boiler structure (*Figure 8*).

Figure 8 – Boiler Gas Vent Terminates Under Tarp

Remedy:

Remove the tarp covering the boiler structure and confirm the gas vent is unobstructed.

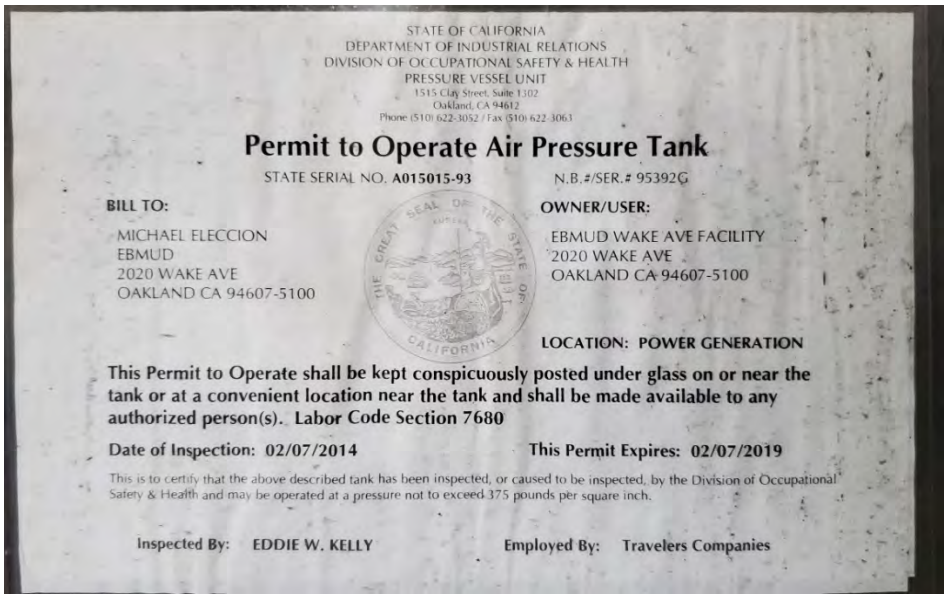
1.7 Compressed Air System

References:

- California Labor Code, Chapter 3 Operation of Tanks and Boilers 7684.

Survey Findings:

Air receivers were visually inspected. Two of the four had valid pressure tank permits, one permit had expired (*Figure 9*), and the last had no permit posted. California Labor Code 7684 states that "Each permit or a clear reproduced copy thereof shall be posted in a protective container in a conspicuous place on or near the tank..."



STATE OF CALIFORNIA
DEPARTMENT OF INDUSTRIAL RELATIONS
DIVISION OF OCCUPATIONAL SAFETY & HEALTH
PRESSURE VESSEL UNIT
1515 Clay Street, Suite 1302
Oakland, CA 94612
Phone (510) 622-3052 / Fax (510) 622-3063

Permit to Operate Air Pressure Tank

STATE SERIAL NO. **A015015-93** N.B.#/SER.# 95392G

BILL TO:
MICHAEL ELECCION
EBMUD
2020 WAKE AVE
OAKLAND CA 94607-5100

OWNER/USER:
EBMUD WAKE AVE FACILITY
2020 WAKE AVE
OAKLAND CA 94607-5100

LOCATION: POWER GENERATION

This Permit to Operate shall be kept conspicuously posted under glass on or near the tank or at a convenient location near the tank and shall be made available to any authorized person(s). Labor Code Section 7680

Date of Inspection: 02/07/2014 **This Permit Expires: 02/07/2019**

This is to certify that the above described tank has been inspected, or caused to be inspected, by the Division of Occupational Safety & Health and may be operated at a pressure not to exceed 375 pounds per square inch.

Inspected By: EDDIE W. KELLY **Employed By: Travelers Companies**

Figure 9: Air Pressure Tank Certificate

Remedy:

Determine if inspections were performed and permits not displayed. If inspections were not performed, request an inspection by contacting the following:

DEPARTMENT OF INDUSTRIAL RELATIONS
Division of Occupational Safety & Health
Pressure Vessel Unit
1515 Clay Street, Suite 1622-A
Oakland CA 94612
Tel: (510) 622-3066 Fax: (510) 622-3063
Email: capvinsp@dir.ca.gov

1.8 Fuel Gas Flexible Hose

References:

- NFPA 54 National Fuel Gas Code, Chapter 9 Appliance, Equipment, and Accessory Installation, 9.6 Appliance and Equipment Connections to Building Piping, 9.6.1 Connecting Appliances and Equipment.

Survey Findings:

NFPA 54 requires that fuel gas connection hoses be UL Listed and rated for gas service meeting ANSI/CSA standards. The flexible hoses connecting the Fuel Gas Supply to the engines (*Figure 10*) have no labels to indicate that they are rated for gas service.

For ESi, these are familiar Enterprise hoses and appear to be (or equivalent to) the OEM units. The NFPA code does not require the hoses be labeled, they simply need to be compliant with ANSI/CSA standards. Without a label, the only way to prove compliance is with documentation from the OEM and tracking of the part through inventory and installation. New hoses will come labeled as compliant.

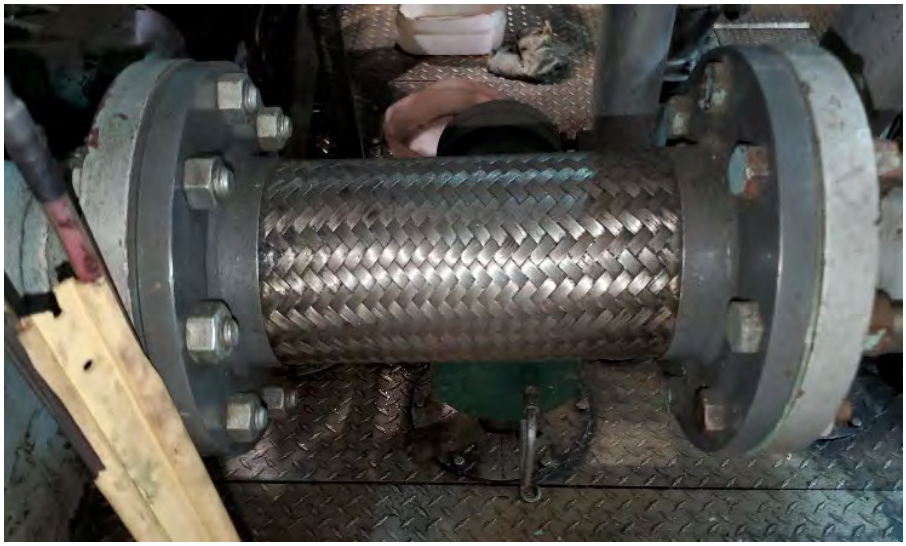


Figure 10: Engine Fuel Gas Supply Hose

Remedy:

If these are indeed OEM hoses, no immediate remedy is required. Documentation may be requested with a Fire Marshall inspection. EBMUD may want to consider stocking labeled hose for the future.

1.9 Gas Detection System Alarms

The Gas Detection System alarms require additional signage, as discussed below. Additional alarm signaling devices will improve safety (especially for non-watch personnel) in the machinery spaces and more closely follow the intent of the California Code referenced below. Additional signaling devices are not required, but recommended by NFPA and ESi.

1.9.1 Gas Detection System Signage

References:

- California Code of Regulations, Title 24, Chapter 9 Fire Protection Systems, 916-Gas Detection Systems, 916.9 Signage.

Survey Findings:

The California Code of Regulations states that "Signs shall be provided adjacent to gas detection system alarm signaling devices that advise occupants of the nature of the signals and actions to take in response to the signal."

The existing gas detection signaling devices are in the PGS-1 (annunciator) and PGS-2 (DCS) control rooms. Gas detection alarm instructions were not visible in either location.

EBMUD will need to develop the proper text to direct the actions for alarm response. Signs could include statements like the following:

- *Evacuate non-essential personnel.*
- *Notify watch personnel.*
- *Shift engines to diesel.*

Remedy:

Signs should be placed in the PGS-1 and PGS-2 control rooms identifying actions to take in the case of a Gas Detection System alarm.

1.9.2 Gas Detection System Alarm Indication

References:

- NFPA 820 2020 Standard for Fire Protection in Wastewater Treatment and Collection Facilities Table 7.6.1 Requires Gas Detection Alarm indication at the entrance and interior of remote spaces that are not constantly occupied.

NFPA 820 recommends distinct alarm signaling for Combustible Gas Detection. While this is not required, EBMUD should consider the advantages. The current system sounds an alarm during a gas detection event but watch personnel will not know the cause of the alarm until viewing the signaling devices in the PGS-1 and

PGS-2 control rooms. This means that they cannot interpret a gas detection alarm locally. Non-watch personnel will likely not respond to a gas detection alarm at all until directed by watch personnel.

A unique strobe light and horn in the machinery spaces could identify a gas detection event. This would enable watch and non-watch personnel in the spaces to immediately identify a gas leak condition. If these devices are installed, signage would be required adjacent to the strobe light, providing instruction. This would likely include the evacuation of non-watch personnel when the strobe light is initiated.

Remedy:

It is recommended (but not required) to install distinct Gas Detection System alarm signaling devices in the PGS-1 Engine Room. A dedicated strobe light that differs from the fire alarm strobe light would be installed and could be activated preferably by the Gas Detection System directly or alternatively by the DCS. If additional alarm signaling devices are installed, appropriate signage will be required adjacent to the signaling device.

1.10 Insulation of Turbocharger & Jacket Water Piping

References:

- OSHA Standards Interpretation - 1910.261(k)(11) - Workers must be protected from hazards of heated (hot) surfaces.

It is common for pipe insulation to be degraded through routine wear and tear during engine maintenance and especially during an overhaul. The engines were missing insulation on the exhaust and jacket water systems. Discussions with plant personnel indicated that the piping will be insulated at the completion of the current overhauls.

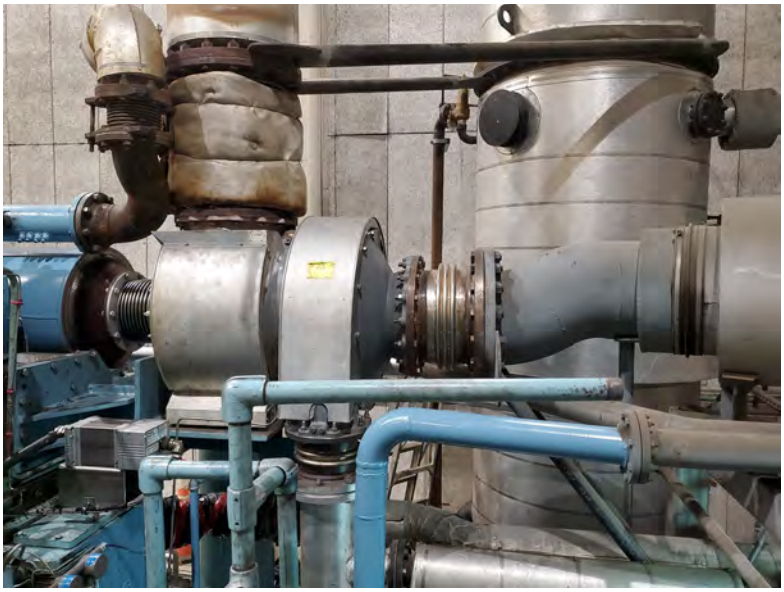


Figure 11 - Uninsulated Elements of Exhaust and Jacket Water System

Remedy:

Insulate piping after completion of overhaul as currently planned.

1.11 Platform Handrails

References:

- OSHA Standards Interpretation - 1910.23(c)(3) Regardless of height, open-sided floors, walkways, platforms, or runaways above or adjacent to dangerous equipment, pickling or galvanizing tanks, de-greasing units, and similar hazards shall be guarded with a standard railing and toe board.

Survey Findings:
The handrails on Engine 3 were not correctly installed on the gearcase end of the engine.

Figure 12 - Platform Handrail not Correctly Installed

Remedy:

Missing components or improperly mounted handrails should be properly installed to reduce the risk of fall from the engine platform. This can be performed by plant personnel or by the party responsible for their disassembly.

1.12 Fuel Tank Vent Piping

References:

- NFPA 30 Flammable and Combustible Liquid Code, Chapter 27 Piping Systems, 27.8.2 Vent Piping for Underground Tanks.

Survey Findings:

It appears that a flame arrestor (or other device) originally installed in the diesel fuel tank vent line has been removed and the piping now vents below the roof of the gas compressor pad (*Figure 13*). Code prohibits the venting on underground tanks to a location allowing the vapors to become trapped under the eaves of a building.

Figure 13: Overhead of Gas Compressor Pad Showing Fuel Oil Tank Vent Pipe to Roof

Remedy:

Reinstall the removed flame arrestor (or other device) in the piping system. If the device cannot be located a spool piece can be installed in its place and still meet NFPA code requirements.

1.13 Fuel Tank Fill Connection

References:

- NFPA 30 Flammable and Combustible Liquid Code, Chapter 27 Piping Systems, 27.10 Identification and Marking of Piping Systems.

Survey Findings:

The diesel fuel tank loading connection is not marked to identify the product service (*Figure 14*). NFPA states, "Each loading and unloading riser shall be marked to identify the product for which it is to be used."

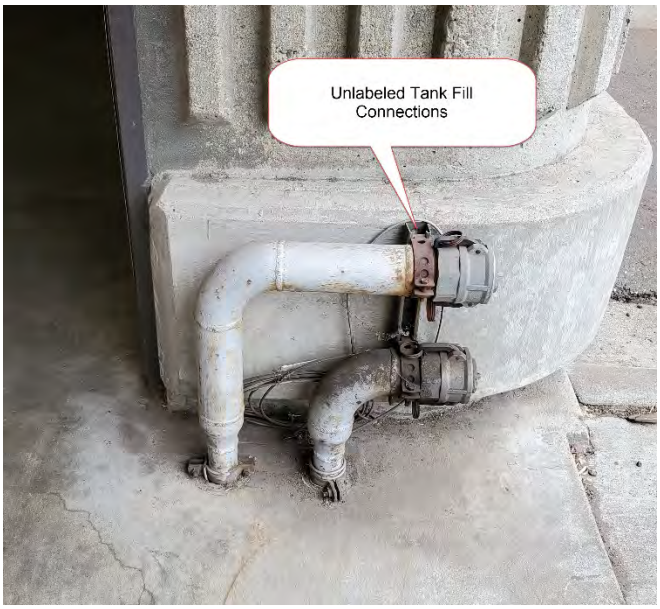


Figure 14: Fuel Oil Tank Connections

Remedy:

Provide proper markings for the Fuel Oil Storage tank fill connection.

1.14 Gas Detection System Power Supply and Alarm

References:

- California Code of Regulations, California Fire Code Title 24, Part 9, Section 916 Gas Detection Systems, 916.4, 916.5.
- NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities, Chapter 7 Fire and Explosion Prevention and Protection, 7.4 Combustible Gas Detection.

Survey Findings:

Based on preliminary reports from Plant Personnel following the August 14 unplanned outage, the Gas Detection System indicated a "System Failure" when the control panel was deenergized after the loss of utility power. When power was restored, one of the detectors failed which prevented an engine start. The faulty gas detector was bypassed and the engines were started.

California Fire Code allows for a single power supply if a "trouble alarm" is provided. NFPA recommends a redundant power supply in the event the primary power supply fails.

The Gas Detection Panel located in PGS-1 is powered from the L1 lighting distribution panel. The gas sampling pumps are powered through electrical receptacles (*Figure 15*). ESi recommends the trouble signal not initiate an engine shutdown or prevent a restart.

Figure 15: PGS-1 Fire Detection and Gas Detection Panels

Remedy:

A redundant power supply should be installed to comply with NFPA recommendations and the trouble alarm (loss of power alarm) should not initiate a shutdown or prevent engine start.

The gas detection alarming circuits should be tested to determine the outcomes of alarms. The results should be written up and included in a Gas Detection Manual available to the operators. If it proves accurate that the "Gas Detection Trouble" alarm leads to an engine shutdown, this should be changed in the PLC program

to an alarm that notifies the operator and allows them to make decisions regarding continued operation and plant safety.

Like the Fire Detection System literature, the Gas Detection System literature needs to be verified for accuracy with an operational manual available to plant operators.

1.15 Plant Safety and Fire Drills

References:

- California Code of Regulations, California Fire Code Title 24, Part 9, Section 406 Employee Training and Response Procedures.

Survey Findings:

The unplanned outage of August 14th revealed some unfamiliarity with the facilities Fire and Gas Detection Systems.

The State of California requires that employees "receive training in the contents of fire safety and evacuation plans and their duties as part of new employee orientation and not less than annually thereafter. Records of training shall be maintained. "

Remedy:

ESi recommends that regular drills be performed in which personnel interact with the Fire and Gas Detection Systems and the Interface devices/systems. This will verify functionality and improve familiarity with the system.

Fire and Evacuation drills are required annually and when training new personnel.

2.0 Recommended Practices

The items listed in this section are not code violations. They are recommendations based upon common or best practices within the industrial engine industry.

2.1 Fire and Gas Detection System Investigation/Testing

On August 31st, ESi returned to PGS-1 at the invitation of EBMUD to assist with testing of the fire detection system. The purpose of this visit was to troubleshoot unplanned engine shutdowns that occurred earlier that month. The suspected cause of the engine shutdowns was the fire detection system. Troubleshooting was performed in concert with EBMUD personnel, Advanced Engine Technologies Corp. (AETC), and Global Fire & Safety (GFS).

While ESi was not present for the unplanned shutdowns of engines 2 and 3, the following sequence of events were put together through discussion with plant personnel:

1. "General Fire Alarm" was indicated on the Fire Control Panel for most of the day prior to engine shutdown. Operators felt it was due to the high ambient temperature on that day.
2. Engines 2 and 3 tripped off at the same time. The data log came from the breaker open command on the SEL gear. No shutdown for the engines was recorded, only the breaker open command.
3. The utility was lost shortly after the engine trip. The cause was still unknown at the time of the ESi site visit.
4. Operators were unable to restart the engines during the power outage due to a Gas Detection "System Failure" alarm. Following the outage operators were still not able to start the engines until a faulty gas detector was identified and bypassed.

The troubleshooting of the shutdowns revealed several weaknesses in the system.

2.1.1 Heat Detector Temperature Setpoint

<u>Survey Findings:</u>

The Fire Detection System uses a *Smart Fire Detector* (which includes smoke and heat detection in one housing) at most of the locations in PGS-1. GFS identified that the heat detectors installed in the Engine Room overhead had 135°F trip points. The day of the unplanned shutdown, the Bay Area was experiencing a heat wave and ambient temperatures at the facility were far higher than normal.

It appears likely that the shutdown was caused by temperatures in the overhead of the engine room exceeding the trip points of the heat detectors. Plant personnel reported a Fire Detection System "General Alarm" prior to the shutdown. Triggering one fire detector initiates the general alarm. Triggering a second fire detector from a different zone will initiate an engine shutdown via the Fire Detection System's Interface Panel. This means that the Fire Detection System was likely functioning as intended rather than issuing a false alarm. The Fire Detector heat setpoint is likely too low for days with high ambient temperatures, and we will likely have more of these in the future.

Remedy:

GFS indicated that the fire detectors can be replaced with units that have a 190°F trigger point. This will likely prevent high ambient temperature trigger events and still initiate quickly in case of fire.

2.1.2 Unexpected Outcomes from Manually Initiated Engine Shutdowns from Fire Detection Panel

Survey Findings:

The Fire Detection System Output labeled “Generator #1” on the Fire Detection System drawing set sheet FA-04 was labeled “Fire Alarm” and “MIP Fire” on the wire labels located inside the panel. During the troubleshooting, these terminals were shorted to simulate a closed contact. This yielded the following results:

- With engines secured, shorted contact for "Fire Alarm"/"MIP Fire” at terminal strip in fire control panel.

    1. No “General Fire Alarm” indication on the annunciator.
    2. “Engine #2 Emergency Shutdown” indication on the annunciator.
    3. No audible alarm.
    4. No indication of Engine #3 shutdown.
    5. The operator on watch said that alarms in PGS-2 control room were "Engine #2 Trouble" and "Fire", but no alarms for engine #3.

- With engines 2 and 3 running (no load), shorted contact for "Fire Alarm"/"MIP Fire” at terminal strip in fire control panel.

    1. No “General Fire Alarm” indication on the annunciator.
    2. Audible alarm in PGS-1 (old) control room.
    3. Engine #2 and #3 Shutdown indication on annunciator.
    4. The operator on watch said that alarms in PGS-2 control room were "Engine #3 Shutdown", "Engine #2 Shutdown", "Engine #2 Fire" alarms.
    5. When shutdown occurred, gas compressors stayed running. It appears that an engine shutdown initiated by the Fire Detection System does not stop the gas compressors.

This troubleshooting revealed differing results for engines #2 and #3 (#1 was not tested) with a Fire Detection System initiated shutdown (labeled Generator #1 in drawing set). As alluded to earlier in this report, the lack of a proper drawing set and manual have made it difficult for operators to anticipate the results of a fire detection system initiated shutdown. Additionally, control program code seems to be different between the engines.

As noted above, the gas compressors did not stop running when the Fire Detection System engine shutdown was initiated.

Testing should be performed to verify the conditions that initiate the outputs on the Fire Detection Interface Panel and what outcomes are achieved.

Remedy:

As stated in section *1.2 Fire Detection System Shop Drawings* of this report, the Fire Detection System should be investigated and tested to develop an accurate set of "as-built" drawings and an operator's manual. During this testing, inconsistencies in the MIP and engine PLC programs should be remedied so the operators may have consistent expectations of alarm functions and machinery operations in emergencies.

Additionally, ESi recommends that gas compressors should be added to the machinery shutdown list for an engine room shutdown initiated by the Fire Detection System. This may require additional relay installation and the updating of drawings and manuals.

2.1.3 Condition of Fire Detection Panel Wiring Layout

Survey Findings:

The Fire Detection System was upgraded in 2014. It appears that the new equipment was placed inside a previous system panel cabinet (*Figure 16*). The general condition of the wiring inside the panel was disarrayed. Specifics are detailed below.

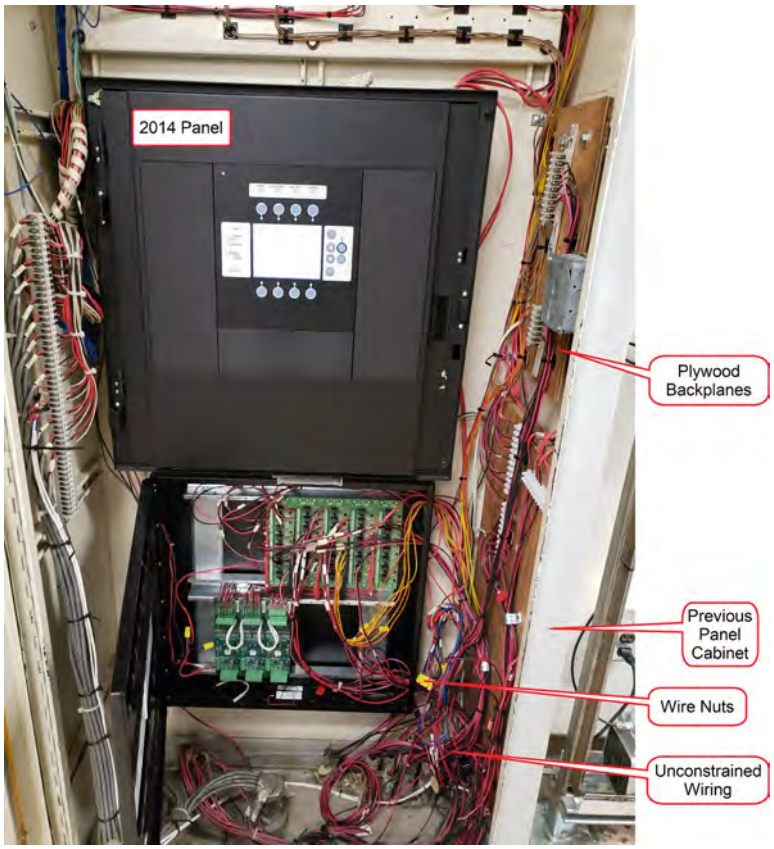


Figure 16: Internals of PGS-1 Fire Detection Panel

2.1.3.A – Improve Labeling

Many of the wire labels were deteriorated and unreadable. This made troubleshooting difficult. Some wire labels changed as the conductor traversed the terminal blocks and did not match the drawings. Several terminal strips have been added to the panel in what appears to be an unplanned manner, some without labels for the terminal block or individual terminals.

2.1.3.B – Remove or Terminate Abandoned Wires

Some conductors inside the Fire Detection Panel are no longer in use. There are unconstrained wires, cut with the conductors exposed (*Figure 17*). Wires removed from service should be either completely removed or terminated in a terminal strip to eliminate any chance of accidental grounding or energizing. If terminated in a terminal strip as a spare, drawings need to indicate where both ends of the wires are terminated and labels need to be installed on the conductors.

Figure 17: Severed Wires in PGS-1 Fire Detection Panel

Some wires in the panel are dead ended at terminal strips (*Figure 18*). As stated above, this is acceptable for future expansion if the wires are labeled in the drawings. However, it is not known if these wires are spares or have been removed.

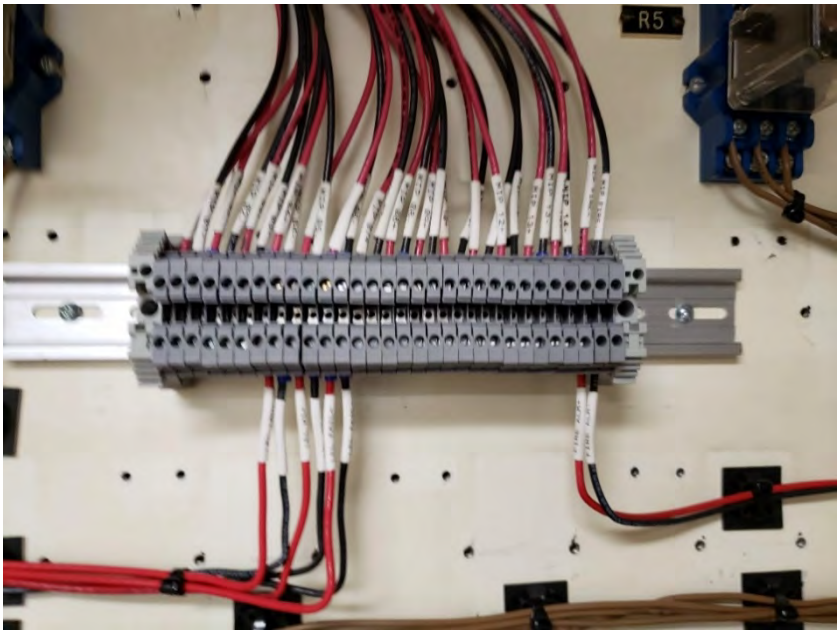


Figure 18: Terminal Strip in PGS-1 Fire Detection Panel

2.1.3.C – Remove Plywood Panels

There are two plywood backplane panels installed in the Fire Detection cabinet. It appears that these are used to mount terminal strips. Plywood is not a standard industrial panel material due to the risk of fire and the insulating properties prevent the backplane from acting as part of the panel ground system.

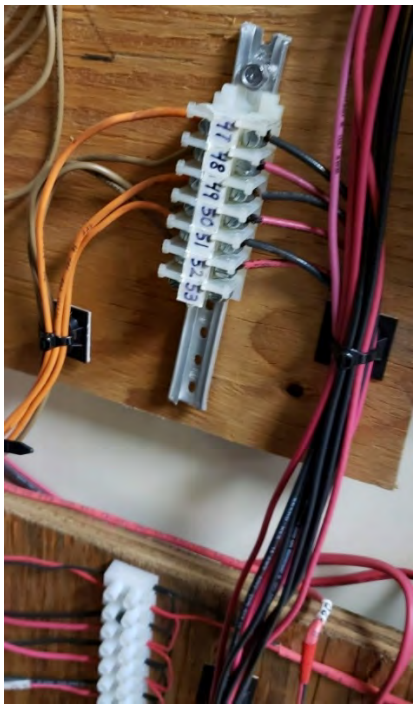


Figure 19: Plywood Backplane in PGS-1 Fire Detection Panel

2.1.3.D – Remove Wire Nuts

Wire nuts are not prohibited by the NFPA or any California requirements as they relate to Fire Detection Systems. However, they are less reliable in industrial environments due to vibration and a lack of positive indication of wire contact. The Fire Detection Panel had several wire nut connections (*Figure 16*). The fire alarm interface panel provides a lot of Normally Open contacts for the alarming circuits. This means that a closed contact initiates the response to fire detection. A failed wire nut connection will prevent the fire detection response. No "trouble" warning will be detected or initiated.

Anecdotally, researching this issue, ESi discovered several individuals who reported Fire Marshalls who refused to accept wire nuts even though they were not prohibited in their local regulating rules.

Remedy:

The panel wiring layout should be cleaned up, wires relabeled as required, plywood backplanes replaced with DIN rail (or equivalent), terminal strips laid out logically to accommodate all wires (including spares), and Panduit (or equivalent) installed to neatly contain wiring. A new drawing should be produced that reflects the improvements.

2.2 Exterior Door to Fuel Oil Day Tank

Survey Findings:

The exterior door to the Fuel Oil Day Tank room was tied open (*Figure 19*) during the site survey. The Fuel Oil Day Tank room is protected by the Halon system. The door needs to remain closed or be fitted with a magnetic hold that will release the door in the event of fire. The door closer will need to be routinely tested to ensure it effectively closes the door if this option is used.

The fire alarm pull station at the exit to the Fuel Oil Day Tank room is in a difficult spot to access (*Figure 20*), especially with the door held open. ESi recommends changing the orientation of this pull station to the door for better access. Even if the door is kept shut, it could become stuck open during an emergency egress making it difficult to reach the pull station. The door can be hinged on the opposite side or the pull station moved to the other side of the door.

Figure 20: Exterior Door to Fuel Oil Day Tank Room

Remedy:

ESi recommends keeping all openings to protected spaces closed and relocating the manual pull station to the opposite side of the door.

2.3 Failed Gas Vent Piping

Survey Findings:
Discussions with plant personnel revealed that the piping for the manual gas vent on engine #2 failed at the pipe nipple between the fuel gas piping and the manual vent valve. The pipe nipple broke and separated the manual vent valve from the fuel gas line completely. As a result, pressurized fuel gas sprayed from the fuel gas line until the operator discovered the leak, switched the engine to diesel mode, and manually secured gas to the engine. The repair was performed prior to ESi's discussion with the operator.

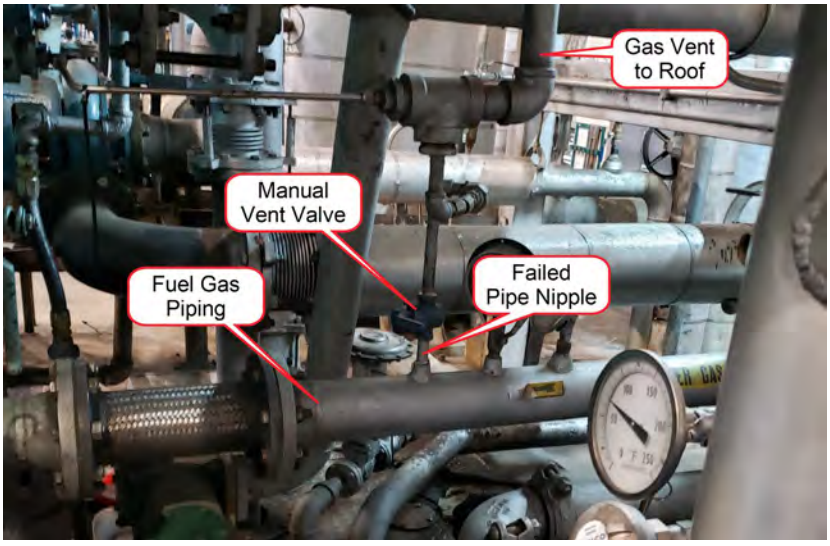


Figure 21: Engine 2 Fuel Gas Supply Piping

While the failure mode was not identified conclusively (ESi did not examine the failed components), it was likely caused by vibration. This means that manual vent piping was not properly supported and/or isolated from vibration.

The vent line downstream of the manual vent valve connects to the gas vent to the roof via a short hose (*Figure 22*). This hose is too short to provide any meaningful vibration isolation.

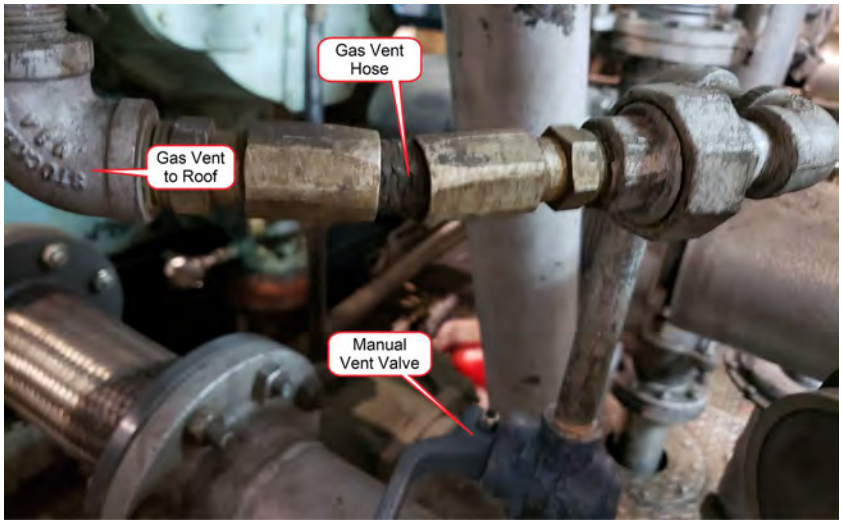


Figure 22: Engine 2 Fuel Gas Vent Line

For a hose to provide vibration protection, there needs to be room for the hose to move. Most hose manufactures will require a curve, belly, or “S” to be present in the hose after installation. *Figure 23* depicts an installation recommendation from a typical manufacturer.

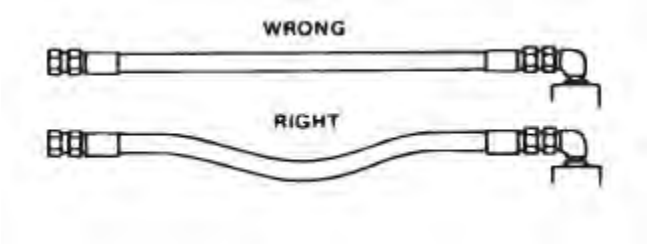


Figure 23: Proper Hose Connection

Proper installation will allow for more flexibility in the hose connection allowing for better vibration isolation.

Remedy:
Ensure all pipe supports are tight.

Install a close nipple between the manual vent valve and the fuel gas supply. Install an appropriate hose with compression fittings between the outlet of the manual vent valve and the tee in the gas vent to roof.

2.4 Unplugged Natural Gas Piping

Survey Findings:

The pipe connection between the natural gas supply and LPDG systems (located in the basement along the east wall) is disconnected and not plugged (*Figure 24*). The Natural Gas supply valve to the engine room is currently locked out and there is very little chance of leakage into the engine room. If the natural gas system is placed back in service, gas could flow into the machinery spaces if this pipe is not plugged. It is good practice to plug the natural gas piping to prevent inadvertent leaks and keep the piping clean.

Figure 24 - Natural Gas Piping Open to Engine Room

Remedy:

Plant personnel can install a pipe plug.

2.5 Modified Pipe and Tubing Fittings

Survey Findings:

The engine Fuel Oil system contained many modified fittings, mostly around the micro-pilot fuel system. These fittings are not installed as designed and little is known about the quality of the modification. Proper fitting selection from the Swagelok catalog could have been substituted for these modifications. *Figure 25* is a typical modification identified by ESi. It appears that the original fitting was drilled/tapped for insertion of a new fitting. In this case, there is an additional port that could have received the proper Swagelok fitting in lieu of modification to the elbow.

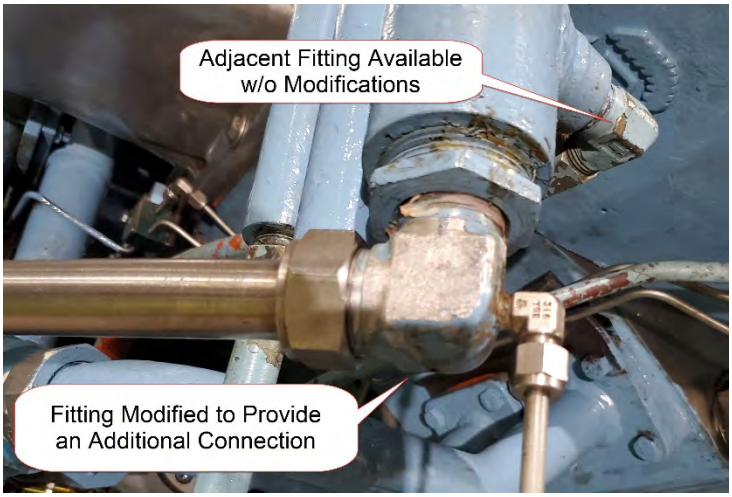


Figure 25: Modified Fuel Oil Elbow

The cooling water systems contained modified fittings as well (*Figure 26*). These modification points can become sites for erosion or corrosion which can lead to leakage.

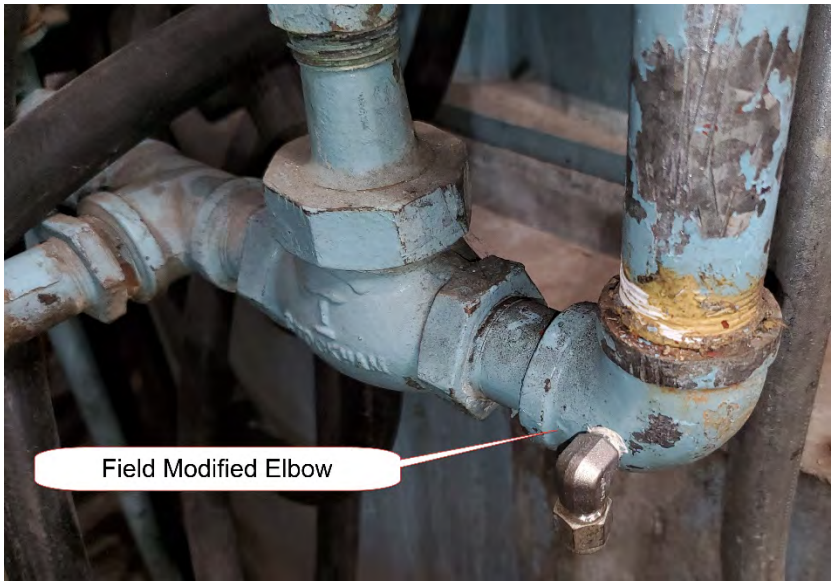


Figure 26: Modified Cooling Water Elbow

ESi recommends replacing these modified fittings with the proper selection of manufactured fittings as best practice.

Remedy:

Plant personnel can procure and replace modified fittings with manufactured fittings.

2.6 Abandoned Piping

Survey Findings:

All three engines have decommissioned fuel piping abandoned in place (*Figure 27*). Best practice is to remove unused piping especially if it was used to carry environmentally sensitive fluids. This is done to reduce clutter, risk of leakage, possibility for inadvertent use, and potential for operator confusion.

Figure 27 - Decommissioned and Abandoned in Place Piping

Remedy:

Cap or plug the termination points as close as possible to the piping remaining in service and removing the unused piping. This can be performed by plant personnel or a mechanical contractor.

2.7 Pipe Caps for Cooling Water Systems

Survey Findings:

The engine cooling water systems had valved connections that were not capped/plugged. Accidental opening of these valves can lead to burns to personnel or damage to equipment. It is common practice to provide double protection (Valve/Plug) to prevent accidental release of scalding water. *Figure 28* shows the connection to the engine cooling water system which was operating at a temperature exceeding 150°F.

Figure 28 - Cooling Water System Uncapped Connection

Remedy:

Install caps/plugs on all valved connections open to atmosphere to prevent injury or damage to equipment.

2.8 General Electrical

Survey Findings:

Conduit and junction box covers were missing. This is a common occurrence but should not become standard practice. This exposes conductors to the environment and can lead to accumulation of water, dirt, oil, and grease. Regular effort should be maintained to identify these locations for work orders to ensure the conduit integrity is maintained. The missing conduit elbow cap shown in *Figure 29* is located adjacent to the Engine #3 cooling water standpipe.

Figure 29 – Conduit Elbow Missing Cover

Remedy:

Request that personnel identify these for maintenance; when missing covers are identified they should be documented for replacement.

2.9 Insulating floor mats

Survey Findings:

Insulating electrical mats should be used any time maintenance is conducted on a live electrical circuit. Code allows for the mats to be transported to the site of maintenance or permanently installed at the panels and switchboards. Best practice is to have mats permanently installed to reduce the burden of transporting the mats and reduce staging time for routine maintenance.

Figure 30 – Panel without Electrical Safety Mat

Remedy:

Mats should be installed at the panels that receive frequent maintenance and inspections.

2.10 Technical Library

Survey Findings:

ESi discovered that the fire detection system manuals in the technical library that were not up to date with equipment upgrades.

Personnel need contemporary documentation to maintain and troubleshoot the machinery systems. This information should include the generic OEM manuals as well as details of the site-specific installation for systems such as the Fire and Gas Detection Systems. Outdated information should be archived.

ESi recommends that the powerhouse technical library is checked, manual-by-manual, to confirm that the literature reflects the current machinery systems in operation. Any out of date or missing materials should be obtained and added to the library.

Amongst the final tasks toward completion, all equipment modification/installation projects should have a documentation review, including additions to the technical library.

2.11 General Housekeeping

Survey Findings:

There are some minor housekeeping issues to address to improve overall safety and cleanliness. These items are likely the result of actions taken by contractors but EBMUD plant and safety personnel should monitor the spaces to ensure contractors are following best practices and not creating hazards. Inspections should be made at the end of every day, at least until contractors demonstrate they are following best practices, to ensure that tools, supplies, and refuse are properly stowed before departure.

A half-full gasoline can was found in the engine room on the fuel injector test bench adjacent to bags of rags and empty paint cans (*Figure 31*). Flammable liquids should be stored in a designated and secure location like a flammable liquid locker. Contractors can be asked to provide their own flammable liquids containment for extended projects onsite.

Figure 31 - Gasoline Stored Adjacent to Combustibles

Oil absorbent pads appeared to be in semi-permanent use in the basement adjacent to the engine foundation. Best practice is to locate and repair any oil leaks on the engine. ESi appreciates that is an arduous effort that requires constant attention. In the meantime, the use of oil absorbing materials is important to prevent slips and falls. The pads should be changed prior to oil saturation.

Figure 32 - Oil Absorbent Pads in Basement

Some potentially combustible trash was found in the PGS-1 control room (*Figure 33*). Trash bins should be placed in spaces with heavy use by plant personnel and contractors. These bins need to be routinely emptied to prevent accumulation of refuse in places that it can tend to remain for long periods of time.

Figure 33 - Trash and Debris Left by Contractors

Remedy:

Daily inspections of contractor workspaces should be performed initially. When best practices are established a customized frequency of inspection can be fine-tuned based upon contractor performance.

3.0 Recommended Equipment

This section identifies equipment and technologies that can benefit the PGS-1 facility. These are not requirements but would enhance safety. They are all technologies ESi has seen installed in other facilities and are sometimes required with more stringently regulated sectors of the industrial engine world. It is intended that ESi introduce EBMUD personnel to these technologies for their own review and discussion.

3.1 Thermal Shut-off Valves

"Fire safe thermal shut-off assemblies are designed for automatic shut-off in case of a fire. They are ideal for flow shut-off protection in systems conveying flammable gasses or liquids."[1] The valves are placed in an armed position with a fusible link, which holds a Normally Closed valve actuator against spring force. With the valve actuator armed, they can be operated normally with a handle. The fusible link melts if the ambient temperature around the valve exceeds a desired setpoint and the spring drives the valve to the Normally Closed position. This is a passive actuation so no action from an operator or signals/inputs from other devices are required.

The basic valve provides the passive heat actuation. Enhancements can provide position indication and active shut-off from an alarm/control system in addition to the passive function.

These valves can be installed in the fuel systems (Fuel Oil and Fuel Gas) to stop the fuel flow in case of an engine room fire. It is common to install these valves at the point where the fuel enters the engine room, but it may also be beneficial to include them at each engine in case of an engine or generator fire. *Figure 34* shows thermal valves being installed at another facility adjacent to the engines to quickly secure fuel in the case of engine fire.

Figure 34: BiTorq Fusible Link Valve

[1] From Bi-Torq Valve Automation website bitorq.com.

These valves are not required for your facility. They do offer a passive form of fire protection to ensure that fuel is quickly shut off should there be an engine/generator fire or a fire elsewhere in the engine room. EBMUD can evaluate this as an option for future upgrades.

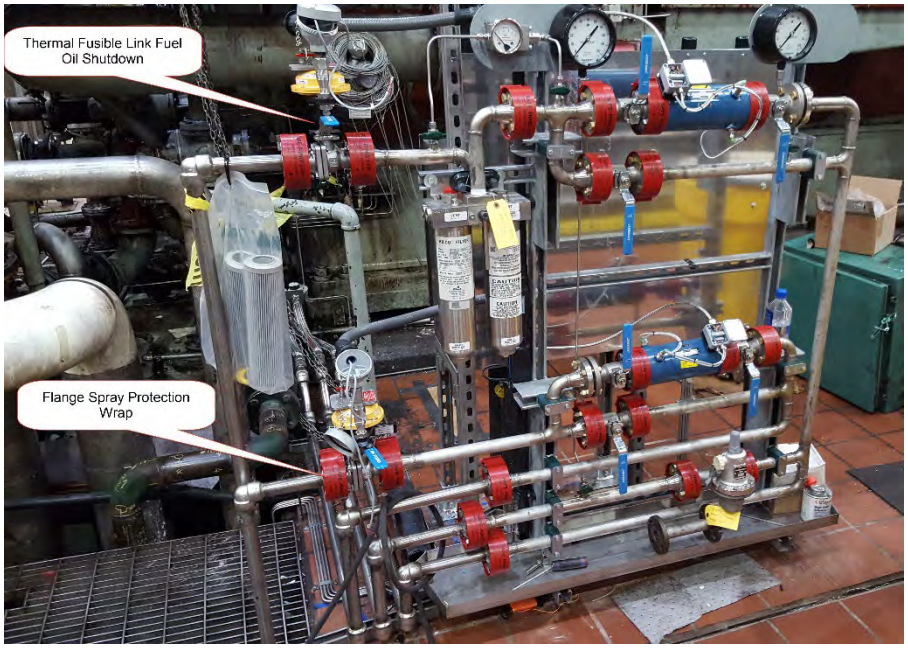


Figure 35: Fuel Oil Service Rack Designed by ESi with Fusible Link valve Connections

The use of thermal trip fusible link valves should also be considered in the fuel oil system. The engines are located two floors below and at a significant distance from the fuel oil pumps. Thermal shutoff valves installed adjacent to the engine would reduce automatic shutoff time for an engine or generator fire. A shutoff valve should be provided for all fuel sources (oil and fuel gas).

The valve can be fitted with a proximity switch to monitor valve position. This switch can be incorporated in the feedback system to display valve position. This provides feedback to acknowledge closure in time of emergency and notify plant personnel should an unplanned closure occur.

Flange leak spray protection should also be considered for fuel oil and Lube Oil system flanges to reduce the chance of atomized flammable liquids reaching an ignition source.

3.2 Fuel Oil High Pressure Leak Detection

ESi observed that each engine's high-pressure fuel injection lines have been modified. These high-pressure fuel lines connect each cylinder's fuel injection jerk pump to the corresponding fuel injector. These are double-walled fuel lines that typically operate with fuel pressure near 3,200 psi. *Figure 36* shows how the outer tubing has been cut away to expose the void space between outer and inner tubes, just above the jerk pump. It is likely that this was done to detect a leak in the inner tube. Should a leak occur, fuel would be contained by the outer tubing (as long as the leak was not in the uncovered area) and fuel would be directed to drip down on the jerk pump and avoid spraying uncontrollably into the area around the engine. Operators would be able to see the fuel leakage and determine which fuel line has failed.

Figure 36: Modified High Pressure Fuel Injection Line

ESi has not seen this modification before. If EBMUD has operated this successfully for long periods of time it appears the risk of the modification is low. ESi does want to inform EBMUD that there is an alternative.

Maritime regulations require diesel engines to collect any fuel leakage from the void space between double-wall high-pressure lines and provide a detection alarm. Because of this maritime requirement, the technology is common and offered by the OEM. For Enterprise, the system consists of a similar double-walled high-pressure line between the jerk pump and the injector with a drain port for the void space (*Figure 37*).

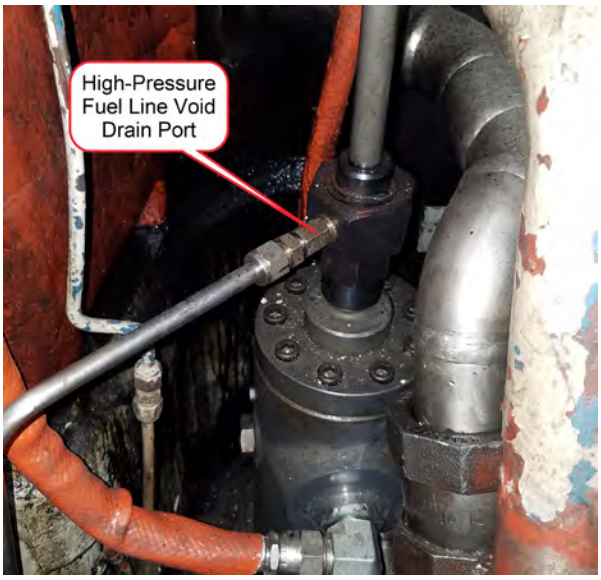


Figure 37: High Pressure Fuel Line with Drain Port (From Another Site)

All the high-pressure line drain ports are plumbed to a single collection tank with a level switch to provide an alarm should the level rise.

This system is not required for California Mechanical Code or NFPA compliance. This system should be considered an enhancement to the current system as it will contain any leaked fuel, provide protection for the entire length of the high-pressure fuel line, and provide an alarm input to notify the operator.

The OEM solutions that ESi has inspected come with the correct OEM high-pressure fuel line, but the rest of the system is fabricated onsite. This includes modifications to the start air jumpers and fabrication of high-pressure fuel line supports, the collection tank, and the plumbing lines. With some guidance, EBMUD or a local contractor could perform most of the modification and fabrication after purchasing the OEM high-pressure lines.

4.0 Additional Findings

Items in this section were outside of ESi's scope of investigation, but worthy of mention.

4.1 Condensate Drip Trap

Survey Findings:

The condensate trap (*Figure 38*) and drain installed adjacent to the new Low-Pressure Digester Gas (LPDG) flares presents some risks. Inspection revealed a steady trickle of water from the trap overflow. The automated level control is bypassed to provide constant make-up water to maintain level in the trap. This was likely a temporary solution, but it appears to have been in effect for quite some time. The automatic level control should be restored to operation.

Figure 38 - Condensate Drip Trap Observations

If the trap were to lose the water seal, LPDG would vent through the trap. A Flame Arrestor should be installed in the vent line if this configuration is maintained as LPDG would be exposed to the atmosphere. EBMUD should consider a level alarm to alert operators of a low water event in the trap.

Another condensate trap was inspected at EBMUD (*Figure 39*). This unit contained a float trap on the overflow leg above the drain.

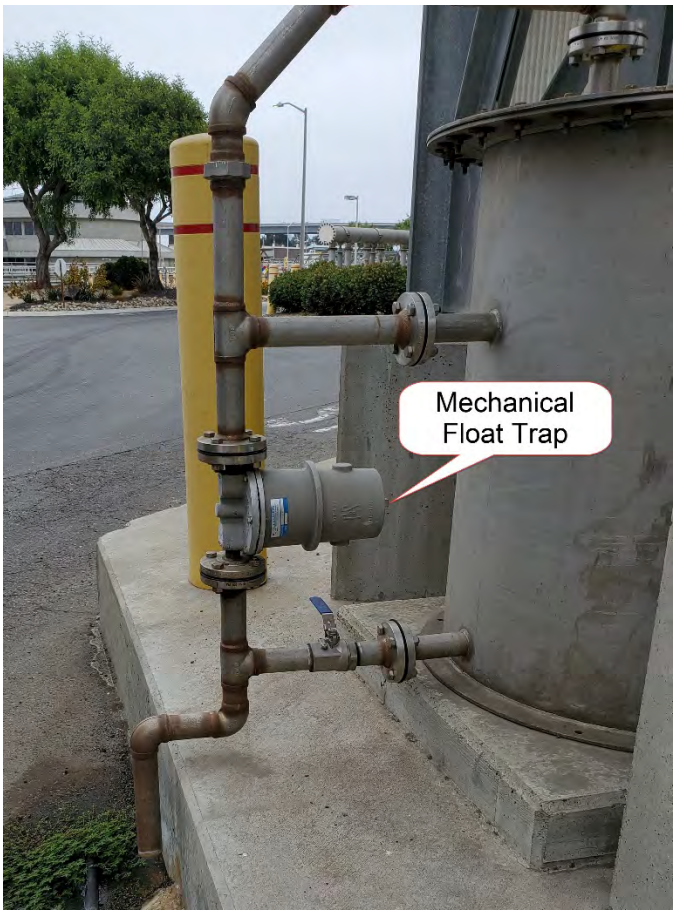


Figure 39 - Similar Condensate Drip Trap with Mechanical Float Installed in Overflow Leg

ESi's scope of work focused upon our core expertise in PGS-1. ESi could review the system in greater detail and provide recommendations for the condensate trap repairs, but as it was outside of ESi's scope of work, we have simply provided the cost for replacement with an approved trap at this time. This pricing can be compared with the necessary repairs.

Cost Estimates

ESi	**Cost Estimate**

Date:	30-Sep-20
Subject:	Safety Evaluation EBMUD Wastewater Treatment Plant
Prepared by:	J. Dyer
Prepared for:	Advance Engine Technologies Corp
Client Contact:	Liz Richardson
Site Contact:	Brian Dunston (EBMUD)
Revision:	1

Labor Rates : Estimated labor rate of $110/hr. unless otherwise noted with asterisk.
Labor rate is for construction only. Does not include Admin, Bidding, CM, Profit and Overhead, etc.
* Pricing based upon previous work performed at EBMUD.
** Pricing based upon quotes obtained by ESi.

Task	Title	Description	Labor	Materials	Subtotal	
1.0	Code Requirements					
1.1	Low-Pressure Digester Gas Piping Repair	**Replace HDPE Low-Pressure Digester Gas Piping**: HDPE piping in the basement does not meet NFPA requirements. It is recommended that the HDPE piping be replaced with stainless steel piping.	$ 210,000	$ 16,000	$ 226,000	*
1.2	Fire Detection System Shop Drawings	**Compile As-Built Fire Detection System Manual:** Test Fire Detection System to verify wiring and operation. Update system drawings as-built. Compile manual for system as configured for PGS-1.	$ 17,600	$ -	$ 17,600	
1.3	PGS-1 Fire Alarm Manual Pull Station Location	**Fire Alarm Pull Station in PGS-1 Switchgear Room**: Relocate the existing pull station for the Halon system so that the pull station is within 5 feet of the exit door.	$ 2,640	$ 2,860	$ 5,500	
1.4	Leak Test Valve	**Install a Leak Test Valve for each Gas Metering Valve (GMV)**: There is one GMV for each of the engines. Use the existing welded coupling on the piping downstream of each GMV to install a valve to test for leakage when the GMV is closed. New piping is 1/2 inch or smaller.	$ 440	$ 800	$ 1,240	
1.5	Engine Fuel Gas Vents	**Extend Piping for Fuel Gas Vents on Roof**: Extend each of the three vent pipes so that they discharge at a point that is a minimum of 24 inches above the adjacent roof parapet. This is a NFPA 54 code requirement. The piping is approximately 2 inches in diameter. The existing piping currently discharges at approximately the same level as the top of the parapet.	$ 660	$ 1,000	$ 1,660	
1.6	Boiler Fuel Gas Vents	**Boiler Fuel Gas Vent**: Reposition the temporary canopy tarp cover so that it does not cover the gas vent pipe.	$ 440	$ -	$ 440	
1.7	Compressed Air System	**Update Certificates for Compressed Air Receivers**: Update certificates for two of the four compressed air receivers in the PGS-1 basement. At the time of the site inspection (8/4-5), one certificate was missing and another was out of date.	$ 300	$ -	$ 300	**
1.8	Fuel Gas Flexible Hose	**Documentation for Fuel Gas Braided Hose Spools**: The existing spools (2 inch diameter) in the gas piping for each engine are not labeled with UL Listing and ANSI/CSA standard compliance. Verify status of existing spools and stock only labeled spools for future use.	$ 880	$ 3,300	$ 4,180	

Task	Title	Description	Labor	Materials	Subtotal	
1.9.1	Gas Detection System Signage	**Provide Signage for Gas Detection System**: There is no signage in the PGS-2 Control Room to direct operators what to do in the event of a gas detection alarm.	$ 220	$ 250	$ 470	
1.9.2	Gas Detection System Alarm Indication	**Install Additional Alarm Signaling Devices:** Install dedicated strobe lights, horns, and signs for indication of gas leak.	$ 17,600	$ 3,000	$ 20,600	
1.10	Insulation of Turbocharger & Jacket Water Piping	**Insulation of Turbocharger & Jacket Water Piping**: The insulation is missing in some locations on the piping in the Engine Room and should be replaced.	$ -	$ -	$ -	
1.11	Platform Handrails	**Repair Platform Handrails**: The handrail around each of the three engines is not continuous in all locations.	$ 880	$ -	$ 880	
1.12	Fuel Tank Vent Piping	**Restore the Piping Connection for the Diesel Tank Vent**: It appears that a flame arrestor was removed from the vent piping so that, now, instead of discharging above the roof over the gas compressors, the pipe vents under the roof.	$ 440	$ 300	$ 740	
1.13	Fuel Tank Fill Connection	**Provide Signage at the Fill Connections for the Buried Diesel Tank**: There is no labeling at the fuel fill connection point for the buried diesel storage tank on the south side of the east rollup door.	$ 220	$ 100	$ 320	
1.14	Gas Detection System Power Supply and Alarm	**Upgrade Existing Gas Detection System:** Test Gas Detection System to verify functionality, Compile O&M manual for the use of operators and instrument techs., and install UPS for panel and pump power.	$ 9,680	$ 10,000	$ 19,680	
1.15	Plant Safety and Fire Drills	**Perform Drills to Familiarize Personnel with Safety Systems.**	$ -	$ -	$ -	
2.0	Recommended Practices					
2.1	Fire and Gas Detection System Investigation/Testing					
2.1.1	Heat Detector Temperature Setpoint	**Change Fire Detector High Temp. Setpoint**: Replace existing 135F detectors with 190F detectors**.**	$ 3,500	$ 1,100	$ 4,600	*
2.1.2	Unexpected Outcomes from Manually Initiated Engine Shutdowns from Fire Detection Panel	**Fire Detection System – Correct Deficiencies**: Correct deficiencies in controls/shut downs; add gas compressor shutdown with Engine shutdown when there is alarm in Engine Rm.	$ 880	$ -	$ 880	
2.1.3	Condition of Fire Detection Panel Wiring Layout	**Fire Alarm Panel – Cleanup Wiring**: Upgrade wire labeling, remove or terminate abandoned wires; remove plywood back-panels; remove wire nuts**.**	$ 1,760	$ 750	$ 2,510	
2.2	Exterior Door to Fuel Oil Day Tank	**Relocate Pull Station at the Fuel Oil Day Tank Room**: The existing pull station is obstructed behind the door, when the door is in the open position.	$ 2,640	$ 2,860	$ 5,500	
2.3	Failed Gas Vent Piping	**Install Flex Hose in Gas Vent Piping**: Piping recently failed, probably due to vibration; piping is <1 inch diameter**.**	$ 880	$ 360	$ 1,240	
2.4	Unplugged Natural Gas Piping	**Install plug in Natural Gas Piping**: In the basement there does not seem to be a plug (approx... 2 inch) in the open end of the NG piping where it was recently disconnected from the low pressure gas piping.	$ 880	$ 20	$ 900	
2.5	Modified Pipe and Tubing Fittings	**Replace modified small piping**: There are a number of elbows and fittings (lube oil and cooling water systems cited) that have been drilled for connections of smaller piping and tubing. These modified fittings should be removed and replaced with new whole fittings and the tubing connections should be made with separate fittings.	$ 4,400	$ 2,000	$ 6,400	
2.6	Abandoned Piping	**Remove Abandoned Diesel Piping**: Remove old abandoned diesel piping in Engine Rm.	$ 4,400	$ 100	$ 4,500	
2.7	Pipe Caps for Cooling Water Systems	**Install Caps/Plugs on Cooling Water Piping**: Small piping, safety feature downstream of valve**.**	$ 1,760	$ 100	$ 1,860	
2.8	General Electrical	**Minor Electrical – Install covers on Conduit LBs**: Basement**.**	$ 440	$ 600	$ 1,040	
2.9	Insulating Floor Mats	**Insulating floor mats**: Buy floor mats for electricians when working on MCC and electrical gear**.**	$ 880	$ 9,600	$ 10,480	

Task	Title	Description	Labor	Materials	Subtotal	
2.10	Technical Library	**Technical Library**: Review and update manuals in PGS-1 – Switchgear Rm (Old Control Room).	$ 6,400	$ 3,000	$ 9,400	
2.11	General Housekeeping	**General Housekeeping**: Shop area, separate out paint, diesel can from rags; general housekeeping.	$ 440	$ 2,200	$ 2,640	
3.0	Recommended Equipment					
3.1	Thermal Shut-off Valves	**Thermal Shut-off Valves**: Can install one on each eng.-gen. and/or at entrance to Engine Rm; also consider adding spray protection covers at flanges in gas piping.	$ 57,000	$ 16,800	$ 73,800	**
3.2	Fuel Oil High Pressure Leak Detection	**High Pressure Fuel Injection Piping Leak Detection**: New piping and drain from double wall piping.	$ 51,880	$ 94,500	$ 146,380	**
4.0	Additional Findings					
4.1	Condensate Trap	**Condensate Drip Trap**: restore automatic fill feature (seems to be plugged by growth in process water; add flame arrestor to vent; add low level float switch for alarm; install automatic.	$ 18,000	$ 32,000	$ 50,000	**
		SUBTOTAL:	**$ 418,140**	**$ 203,600**	**$ 621,740**	

Grand Total: **$ 621,740**