Hazard and Operability Study

IC Engine Remediation System

Prepared by

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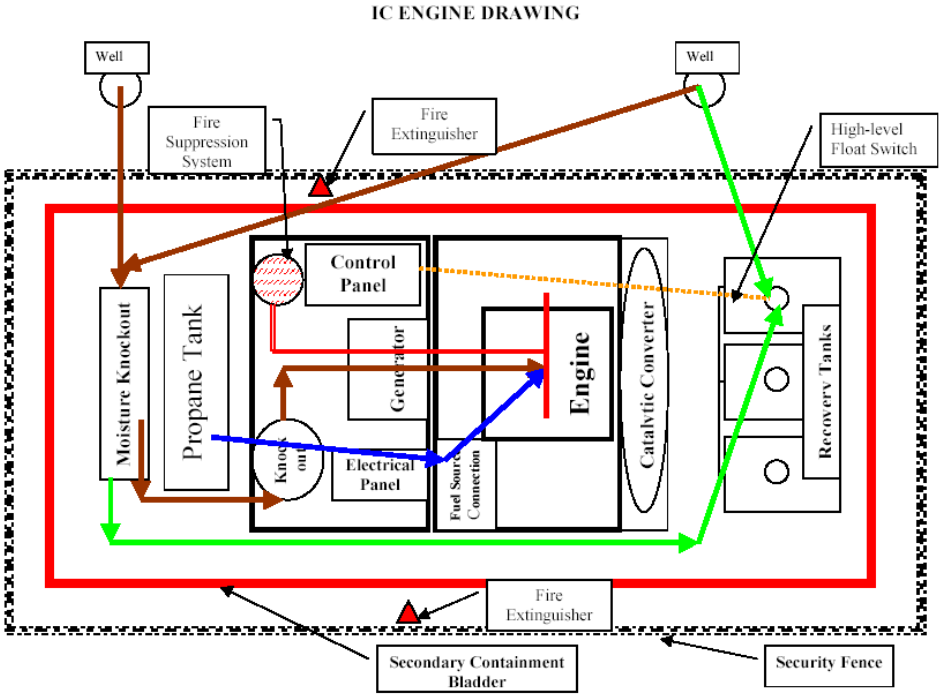
A Hazard and Operability Study (HAZOPS) is a process used to critically evaluate facilities and operations in order to identify hazard risks. HAZOPS examine system operation by evaluating hypothetical deviations from design or acceptable operating practice that could lead to hazard situations. It is the goal of a HAZOPS to identify potential hazards and protective measures that reduce their probability and/or the severity of their potential consequences.

The IC Engine Remediation System is designed for safe operation from the manufacturer (Remediation Services Int'l.). The system has several key safety systems to prevent personnel from being exposed to hazards and to prevent a release of potential constituents of concern to the environment. EA has incorporated additional safety systems and operational protocols to further ensure the safety of personnel operating the system and to protect the environment.

The following drawing illustrates the typical system configurations at a site for operation.



The unit and the recovery tanks will be located in a containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use. The large red box in the drawing represents the containment. The site will be secured from access by the placement of a six-foot chain link fence around the containment area. The dotted line surrounding the majority of the drawing illustrates the fencing used for securing the system.

The brown lines represent piping or hoses under vacuum. The green lines represent hoses that are under pressure from pumps. The blue line illustrates the propane fuel line. The orange dotted line represents the high-level float switch and wiring to control panel.

FIRE PROTECTION SYSTEM

The fire protection system on the unit consists of a Kiddie IND 21 dry chemical suppression system. The system is actuated by either one of the 2 rate of rise detectors located in the engine compartment or the manual actuator located adjacent to the control panel. The rate of rise detectors are preset to actuate if the temperature rises at a rate equal or greater than 15°F in one minute at temperatures greater than 450°F. In addition to the fire protection system, Two 10 lb. ABC dry chemical fire extinguishers are available for use if needed.

The recommended maintenance is described in the operations manual. Personnel operating the unit will conduct per use and monthly visual inspections. Semi-annual, six year, and twelve-year inspections and maintenance will be conducted by a qualified fire protection service agency.

SPARK ARRESTERS

A spark arrester is installed on the engine exhaust to protect the well gas source from any flash back from the engine. There is an additional flame arrester pad located in the carburetor adapter plate located between the carburetor and intake manifold. The spark arrester requires no maintenance but should be replaced after every 4000 hours of operation. The flame arrester should be checked for cleanliness every 2160 hours of operation.

HOSE CONNECTIONS

Connections of removable hoses are cam lock connections. The connections are secured in place and locking pins are installed or plastic ties are installed to prevent inadvertent disconnection of the connections. The connections on the unit and recovery tanks are in secondary containment constructed of 2.04 mm thick HDPE that is inspected prior to each use. Hose connections are inspected to insure they have been secured with locking pins or plastic ties and that the hose connections are properly seated.

HOSES

The hoses associated with the IC engine process are under negative pressure with the exception of the hoses from the submersible pump utilized for the de-watering process and the water knock-out tank discharge pump. The failure of hoses under negative pressure will have no consequences to risk. The submersible pump utilized is a 1/2 HP that has the capability of producing a maximum of 140 PSI. The hoses utilized for this portion of the process are rated at 200 PSI. Devices designed for vehicle traffic protection of cable and hoses protect hoses that are routed in traffic areas. Visual inspection of hoses is made prior to use. Where feasible, hoses are routed in secondary containment. Protective devices are utilized to surround and protect hoses in traffic area.

RECOVERY TANKS

The recovery tanks are constructed of high-density plastic. Each tank has a capacity of 525 gallons and are plumbed together to equalize the capacities. A high-level float switch was wired into the control panel that will shut the system down when activated. The switch is positioned in one of the recovery tanks that are connected together. The recovery tanks are positioned inside the containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use. High-level tank shutoff switch.

ELECTRICAL

The Gen-Set Module consists of a direct drive generator powered by the onboard Natural Gas/Propane engine that is in turn controlled by the Phoenix Control System. The Gen-Set Module provides a source of AC power for local and/or distributed power generation. The electricity generated from this unit is routed through a control panel that has 80 amp main breakers and 20 amp breakers for individual connections. A GFCI outlet protects the 120-volt outlet. Prior to operations the unit is connected to a grounding rod that is positioned in close proximity to the unit.

GUARDING OF MOVING PARTS

The protection of personnel from moving parts is accomplished by design and additional safeguards associated with the process. The engine compartment where the fan and belts are located is interlocked with the control panel with switches that will not allow the engine to start if the doors are open raised. Once the engine is started the interlock switches are not operable. The doors on the engine compartment shall be closed and locked during operation of the engine. The key for the doors is located on the key ring with the ignition key to assure the engine switch is off prior to opening compartment doors. The engine fan is protected with a shroud for additional guarding.

Additionally, a six-foot chain link fence with single point entry surrounds the area where the IC Engine is located. EA personnel monitor the unit continuously during operations.

Safety Features of the Model V3

1. High Coolant Temperature Automatic Shutoff set at 220° F
2. Low Oil Pressure Automatic Shutoff set at 20 psi
3. Engine Over-Speed Protection set at 2800 rpm (programmable)
4. Spark and Flame Arrestor
5. Automatic Fire Suppression System with Manual Discharge Feature
6. Automatic Oil Level Regulator
7. Oversize Radiator Coolant System
8. Well Filter Housing High Water Level Shutoff
9. Locking Access and Service Doors
10. Strategically Located Information and Warning Decals
11. Safety Door Interlocks (Prevents engine start only)
12. Low/High Battery Voltage Safety Shutdown
13. High Exhaust Temperature Safety Shutdown
14. Vacuum Lockoff on Propane Fuel System
15. Thermal Resistant Ceramic Coated Exhaust System

Operator Safety

1. Make sure that all guards, shields and shrouds originally installed on the machine are properly in place and in good working order.
2. Make sure that the fire suppression system is properly charged.
3. The unit is to be operated by one person only. Keep everyone except authorized personnel away, while the machine is operating.
4. Never touch the exhaust system, its support assembly, or the exhaust duct.
5. Keep hands away from moving parts while the unit is running.
6. Operate machine in adequately ventilated areas only. Carbon monoxide is a dangerous gas that can cause serious injuries or death.
7. Use extreme caution when handling Liquid Propane Gas (LPG) fuel and store the LPG in approved containers only.
8. Wear ear protection when operating equipment or in immediate area of the unit.
9. Be sure that the machine housing is bolted to the transporter before moving.

Area Control And General Safety

1. Smoking is prohibited, at all times, in venting area.

2. Start up and maintenance personnel will keep a fire extinguisher readily available at all times.

3. When the machine is being started or being serviced, access to the machine and the work area will be limited to operating personnel ONLY in order to reduce the possibility of physical injury to visitors or the public.

4. The operator technician is responsible for keeping unauthorized person(s) out of the area. Authorized visitor(s) will be instructed to remain clear of Remediation Unit until they have been briefed on safety.

5. When the unit is operating unattended, it must be secured on all sides by a chain link fence, cement block wall or other security barrier. The access to the area will be securely locked.

Fire Suppression System (Automatic)

Caution: *THE SQUIB CARTRIDGE, WHICH AUTOMATICALLY ACTIVATES THE SYSTEM, IS AN EXPLOSIVE DEVICE. SEE THE MATERIAL SAFETY DATA SHEET MATERIAL DATA SHEET - CARTRIDGE), AND THE WALTER KIDDE INSTRUCTION MANUAL FOR IMPORTANT SAFE HANDLING INFORMATION.*

INSPECTION AND MAINTENANCE

Caution: *THE BATTERY SHOULD BE DISCONNECTED WHEN WORKING ON THE FIRE CONTROL SYSTEM.*

MONTHLY

1. Check all parts of system for physical damage, corrosion, or for loose parts and fittings.
2. Inspect the fire sensors. If they are coated with mud, grease or dirt, wipe with a clean, dry cloth. If foreign matter cannot be removed, the sensor must be replaced with a new sensor with the same rating.
3. Inspect the cylinder and gauge. The cylinder should not show any signs of mechanical damage, rust or corrosion. The nameplate must be legible. The pointer on the gauge should point to the green "Service Pressure" area on the gauge face. If the system fails to pass any of these checks or inspections, call a qualified, licensed, fire equipment service agency immediately for maintenance service.

SEMI-ANNUALLY

The following procedures must be accomplished every six months by a qualified fire protection service agency or a factory-trained representative, in accordance with the detailed procedures specified in the Factory Instruction Manual. It is the owner's responsibility to arrange and schedule these required procedures on a semi-annual basis.

1. The cylinder and valve must be disconnected from the system. The flexible piping or hoses are then blown out only with clean, dry air or nitrogen to verify that these lines are clean and free of obstruction.
2. The Nitrogen Actuation Cylinder must be removed and inspected for physical damage, rust and corrosion. It must be weighed and its weight must be within 1/2 ounce of the weight stamped on the cartridge. If the cartridge does not meet these inspection requirements, it must be replaced.

EVERY SIX YEARS

The dry chemical agent in the cylinder should be discarded and replaced with a fresh recharge of the same agent in accordance with the instructions on the nameplate of the cylinder. A qualified fire equipment distributor should only do recharging.

EVERY TWELVE YEARS

The cylinder containing the dry chemical agent must be hydro-tested by a qualified fire equipment distributor for compliance with National Fire Protection Association (NFPA) pamphlet 17. The hydro test procedure used must comply with the Compressed Gas Association (CGA) pamphlet C-6, "Standards for Visual Inspection of Compressed Gas Cylinders", and C-1, "Methods for Hydro Testing of Compressed Gas Cylinders".

If the cylinder is mechanically damaged, or has any signs of rust or corrosion, then the cylinder must be inspected and tested, as outlined above before the twelve-year interval.

Alternator & Battery

It is also helpful to compare current operating values against previously taken measurements ("baseline" or "snapshot" samples taken under static conditions). If these readings are taken (and recorded) at regular intervals, it will be easier to see what, if any, changes have taken place over time. Use the chart below to establish baseline values for the Alternator during operation.

ALTERNATOR BASELINE CHART

Baseline	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Voltage												

Catalytic Converter

The catalytic converter has no maintenance that needs to be performed, but monitoring of the efficiency is critical to the performance of the IC engine and the emissions of the entire system. A baseline chart for monitoring the operation and performance is included below.

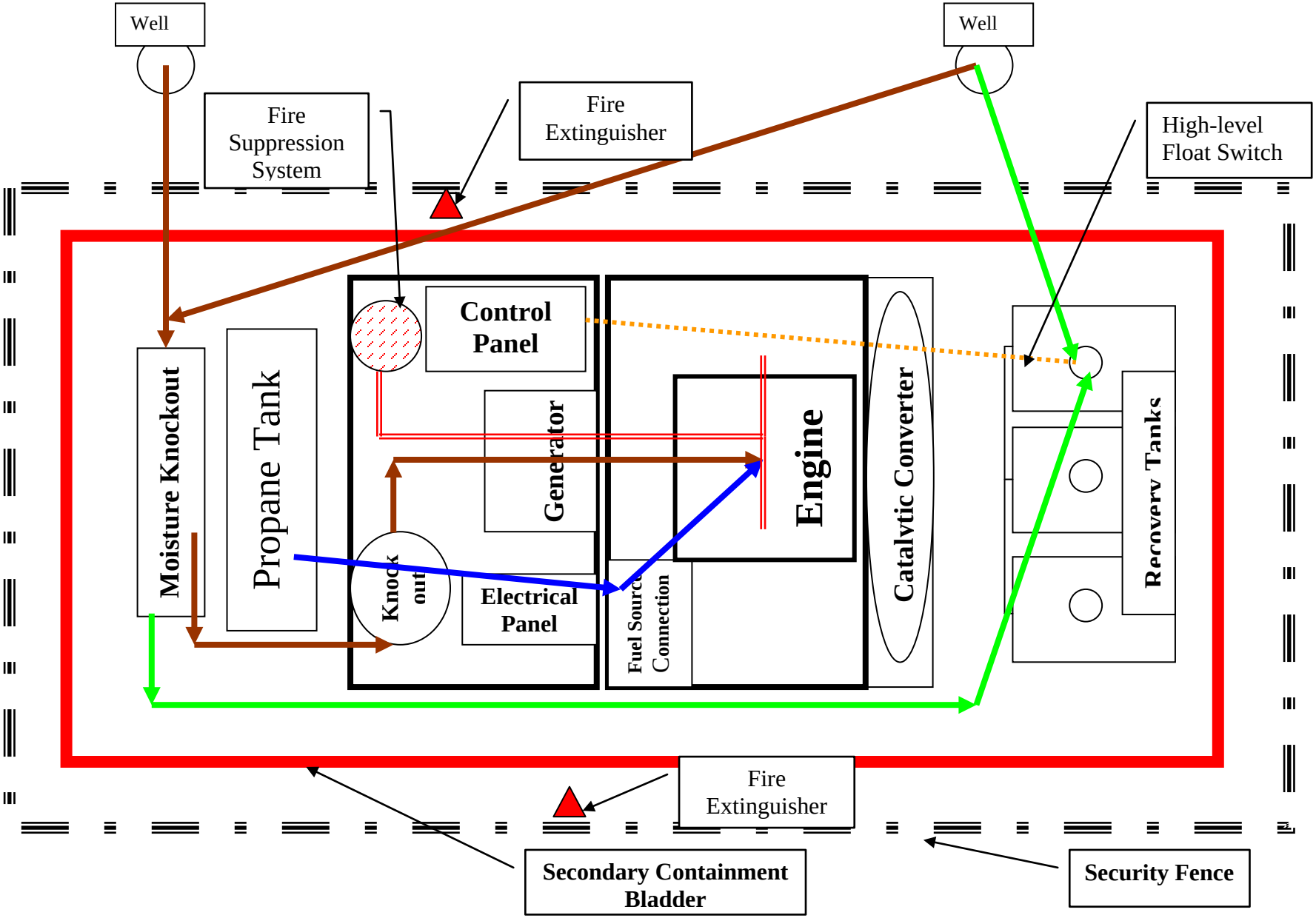
Baseline		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature	Pre-Cat												
Post-Cat													
Pressure	Pre-Cat												
Post-Cat													
Gases	CO												
NOx													
VOC													

MAINTENANCE SCHEDULE

Maintenance Schedule				Maintenance Schedule - (Continued)		
Check all Fluid Levels: (add as necessary)	each visit			Oil Change/ Replace Oil Filter	Every 360 hours*	
Coolant, (record coolant temp); (F)	each visit			Exhaust and Intake Manifold Bolts Torqued (Note 1)	Every 360 hours*	
Oil, (record oil pressure): psi	each visit			Fresh Air and Well Gas Filter Replaced	Every 360 hours*	
Record Cat Temps: Pre (F) Post (F)	each visit			Spark Plugs Replaced - Autolite #AUT 25	Every 360 hours*	
Check Battery Connections and volts: (DC)	each visit			Rotor & Cap Replaced	Every 2160 hours*	
Check & Drain Moisture Knockout Tank	each visit			PVC Valve Replaced	Every 2160 hours*	
Check Emergency Contact Switches	each visit			Radiator Pressure Washed and Degreased	Every 2160 hours*	
Check Belts, Hoses	each visit			Check Propane Filter- Replace If Necessary	Every 2160 hours*	
Check charge on Fire Suppression System	each visit			Flame Arrestor Serviced or Replaced	Every 2160 hours*	
Inspect Fire Suppression System	monthly			Spark Plug Wires Replaced - 8 mm premium conductive silicon core & silicon jacket	Every 2160 hours*	
Service Fire Suppression System	semi-annually			Catalytic Converters and O2 Sensor Replaced	Every 2880 hours*	
Replace Ignition Module and Coil (as a set)	as needed			Coolant Changed & Radiator Flushed	Every 4320 hours*	
Clean Flow Measurement Devices	as needed					
SPECIFY BRAND, MODEL& QTY OF ALL PARTS AND MATERIALS USED:				COMMENTS:		

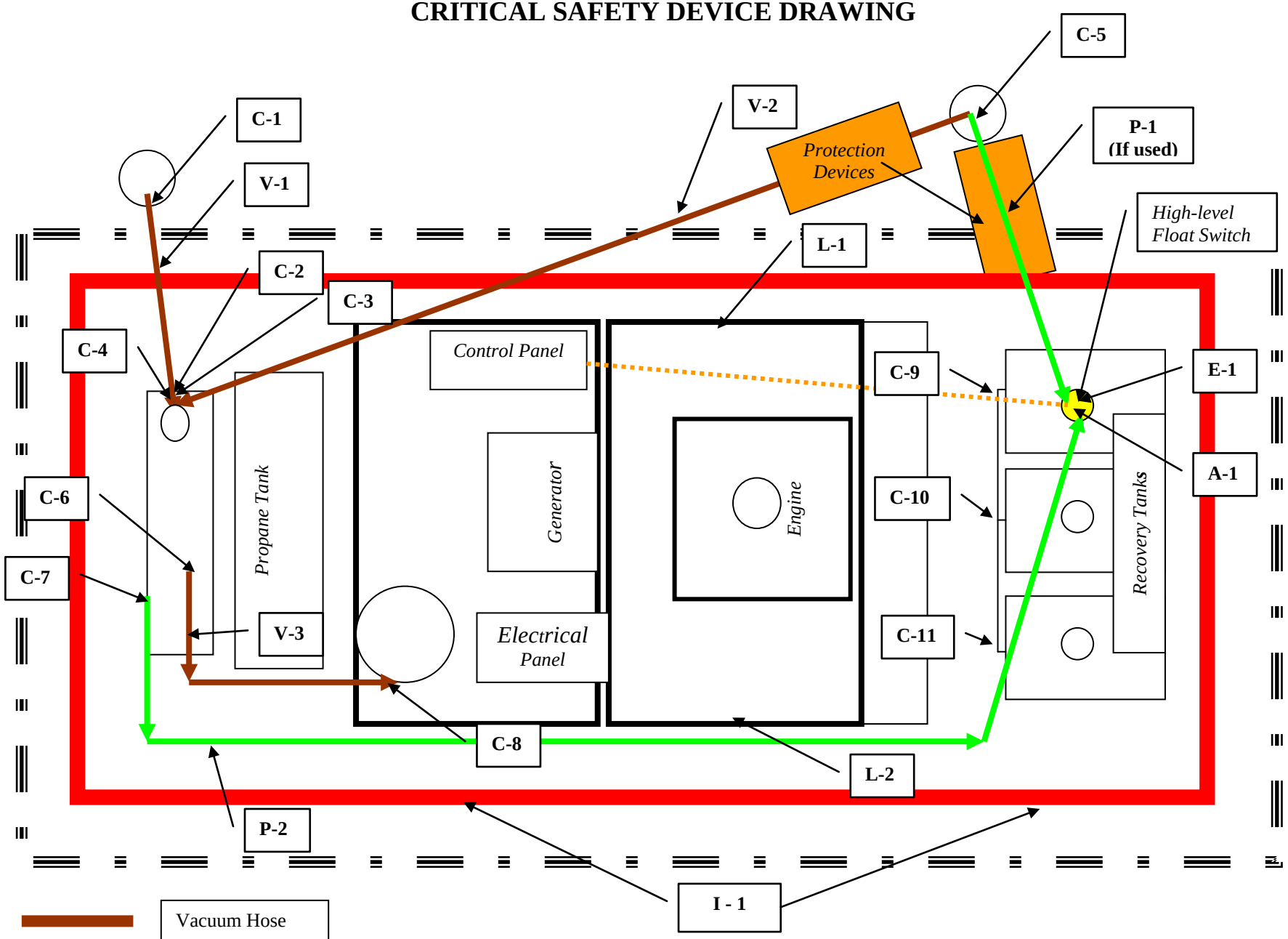
Note 1. See torque specifications in Operators Manual. Perform only when engine is cold.
*UPON INITIAL START-UP (AND AFTER A LENGTHY STORAGE) RSI ADVISES THAT THE USER VISUALLY CHECK THE UNIT MORE OFTEN THAN SCHEDULED MAINTENANCE EVENTS DICTATE. AIR QUALITY MONITORING AND/OR WATER DISCHARGE SAMPLING MAY BE REQUIRED IN MORE FREQUENT INTERVALS AS PERMIT CONDITIONS SPECIFY.
IMPORTANT: CERTAIN SITE CONDITIONS, SUCH AS LEADED FUELS, EXCESSIVE DUST AND TEMPERATURE EXTREMES MAY REQUIRE MORE FREQUENT SERVICING OF COMPONENTS THAN OUTLINED ABOVE. THIS MAINTENANCE SCHEDULE IS INTENDED TO PROVIDE GENERAL MAINTENANCE ADVICE AND MAY REQUIRE MODIFICATION TO FIT ACTUAL SITE CONDITIONS.

IC ENGINE DRAWING



Critical Safety Device	Function	Inspection Procedures	Trouble Shooting Procedures
Secondary Containment	Contain liquid from any leak within containment area.	- check during installation for signs of wear and tear or leaks - ensure containment liner is adequately secured to the metal support structure once the IC Engine and tanks are in place	- repair or replace - reposition and secure
Hose Connections (cam-lock)	Secure hoses in place to prevent leakage.	- visually inspect for proper seating - visually inspect locking pins are secured with pins or plastic ties	- clean and replace seal as necessary - replace as necessary
Hoses	Carry liquid and vapors to designated locations.	- visually inspect for cracks or punctures - ensure discharge hoses are secured to tanks	- replace as necessary
High-Level Float Switch	Prevent overfilling of recovery tanks.	- check both sensor's movement - position sensor tree at pre-determined level - engage engine, trip sensor to test	- clean sensor if necessary - replace sensor as necessary

CRITICAL SAFETY DEVICE DRAWING



Critical Safety Device Inspection Checklist

Site Location:_____

Date of Inspections:_____ **Time of Inspections:**_____

Location	Item	Criteria	Inspector Initials
C-1	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-2	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-3	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-4	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-5	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-6	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-7	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-8	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-9	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-10	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
C-11	**Cam-lock**	- visually inspect for proper seating and locking pins are secured with pins or plastic ties	
I - 1	**Secondary Containment Bladder**	- check during installation for signs of wear and tear or leaks - verify no signs of damage after setup completed prior to start of operations	
L-1	**Locking Engine Compartment**	- ensure compartment door is locked and key is in ignition switch	
L-2	**Locking Engine Compartment**	- ensure compartment door is locked and key is in ignition switch	
E-1	**High Level Float Switch**	- check both sensor's movement - position sensor tree at pre-determined level - engage engine, trip sensor to test	
A-1	**Hoses Routed into Recovery Tanks**	- ensure hoses are attached to top of tank securely with plastic ties	
V-1	**Vacuum Hose**	- visually inspect for cracks or punctures	
V-2 **(if used)**	**Vacuum Hose**	- visually inspect for cracks or punctures	
V-3	**Vacuum Hose**	- visually inspect for cracks or punctures	
P-1 **(if used)**	**Pressure Hose**	- visually inspect for cracks or punctures	
P-2	**Pressure Hose**	- visually inspect for cracks or punctures	

Risk Matrix Worksheet

	PROBABILITY				
CONSEQUENCES	A	B	C	D	E
I					
II					
III					
IV					

X represents initial risk based on description.
Y represents risk after prevention and mitigation.

DEVICE: Cam-lock connections on hoses

DESCRIPTION:

Connections of removable hoses are cam lock connections. The connections are secured in place and locking pins are installed or plastic ties are installed to prevent inadvertent disconnection of the connections.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:			Material Release

ALTERNATE TO AVOID THIS OPERATION: The connections on the unit and recovery tanks are in secondary containment constructed of 2.04 mm thick HDPE that is inspected prior to each use.

POTENTIAL PREVENTION MEASURES: Inspect for good seal, secure with locking pins or plastic ties.

POTENTIAL MITIGATION MEASURES: Secondary containment constructed of 2.04 mm thick HDPE.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

Note: This matrix is a simple analytical tool to help identify and manage risk. It represents a qualitative analysis of only one hypothetical scenario and is not intended to depict the probability, consequences, or risk of any other hypothetical scenario or the range of possible scenarios.

Risk Matrix Worksheet

	PROBABILITY				
CONSEQUENCES	A	B	C	D	E
I					
II					
III					
IV					

X represents initial risk based on description.
Y represents risk after prevention and mitigation.

DEVICES: Hoses (Vacuum and Pressure)

DESCRIPTION:

The hoses associated with the IC engine process are under negative pressure with the exception of the hose from the submersible pump utilized for the de-watering process and the hose from the 30 gallon tank to the recovery tanks. The failure of hoses under negative pressure will have no consequences to risk. The pump utilized is a 1/2 HP that has the capability of producing a maximum of 140 PSI. The hoses utilized for this portion of the process are rated at 200 PSI. Devices designed for vehicle traffic protection of cable and hoses protect hoses that are routed in traffic areas. The hose from the 30 gallon tank is routed inside the secondary containment bladder.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:			Leak of material

ALTERNATE TO AVOID THIS OPERATION: None

POTENTIAL PREVENTION MEASURES: Visual inspection of hoses prior to use. Where feasible, hoses are routed in secondary containment. Protective devices are utilized to surround and protect hoses in traffic area. Hoses are securely fastened

POTENTIAL MITIGATION MEASURES: Where feasible, hoses are routed in secondary containment. Protective devices are utilized to surround and protect hoses in traffic area.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

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Risk Matrix Worksheet

PROBABILITY

CONSEQUENCES	A	B	C	D	E
I					
II					
III					
IV					

X represents initial risk based on description.
Y represents risk after prevention and mitigation.

DEVICE: High-Level Float Switch

DESCRIPTION:

The recovery tanks are constructed of high-density plastic. Each tank has a capacity of 525 gallons and are plumbed together to equalize the capacities. A high-level float switch was wired into the control panel that will shut the system down when activated. The switch is positioned in one of the recovery tanks that are connected together. The recovery tanks are positioned inside the containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:			Over flow of tanks

ALTERNATE TO AVOID THIS OPERATION: None

POTENTIAL PREVENTION MEASURES: High-level tank shutoff switch.

POTENTIAL MITIGATION MEASURES: The recovery tanks are positioned inside the containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

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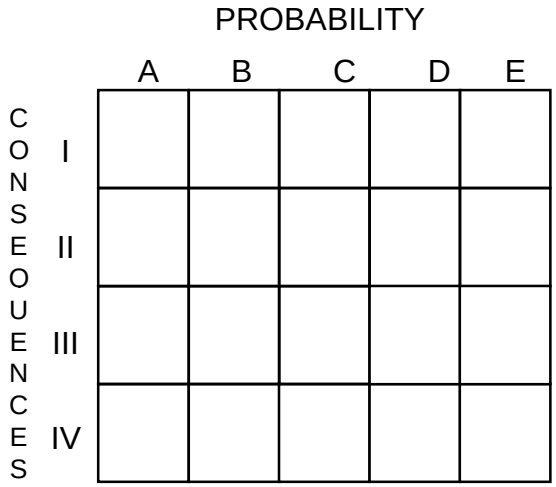

X represents initial risk based on description.
Y represents risk after prevention and mitigation.

DEVICE: Locking Engine Compartment Doors

DESCRIPTION:

The protection of personnel from moving parts is accomplished by design and additional safeguards associated with the process. The engine compartment where the fan and fan belts are located is interlocked with the control panel with switches that will not allow the engine to start when raised. The doors on the engine compartment shall be closed and locked during operation of the engine. The key for the doors is located on the key ring with the ignition key to assure the engine switch is off prior to opening compartment doors. The engine fan is protected with a shroud for additional guarding.

Additionally the area where the IC Engine is located is surrounded by a six foot chain link fence with single point entry. EA personnel monitor the unit continuously during operations.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:	Guarding		

ALTERNATE TO AVOID THIS OPERATION: None

POTENTIAL PREVENTION MEASURES: Machine guarding

POTENTIAL MITIGATION MEASURES: Compartment doors locked while engine is running, compartments are interlocked with control panel to not allow the engine to start when doors are opened. Key control is accomplished by keeping keys for ignition and doors on same key ring.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

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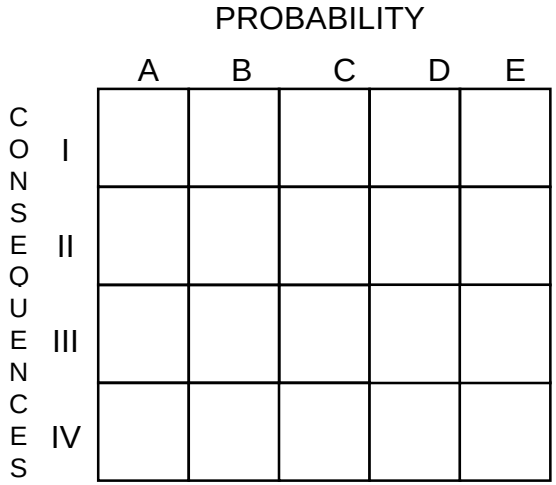

X represents initial risk based on description.
Y represents risk after prevention and mitigation.

DEVICE: Secondary Containment Bladder

DESCRIPTION:

The recovery tanks are positioned inside the containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:			Over flow of tanks

ALTERNATE TO AVOID THIS OPERATION: None

POTENTIAL PREVENTION MEASURES: High-level tank shutoff switch.

POTENTIAL MITIGATION MEASURES: The recovery tanks are positioned inside the containment area that is constructed of 2.04 mm thick HDPE which is inspected prior to each use.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

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II					
III					
IV					

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DEVICE: Spark Arresters

DESCRIPTION:

A **spark arrester** is installed on the engine exhaust to protect the well gas source from any flash back from the engine. There is an additional flame arrester pad located in the carburetor adapter plate located between the carburetor and intake manifold.

	HEALTH/ SAFETY	PUBLIC DISRUPTION	ENVR. IMPACT
CONSEQUENCES:	Flash Back		

ALTERNATE TO AVOID THIS OPERATION: None

POTENTIAL PREVENTION MEASURES: The spark arrester requires no maintenance but should be replaced after every 4000 hours of operation.

POTENTIAL MITIGATION MEASURES: The flame arrester should be checked for cleanliness every 2160 hours of operation.

PROBABILITY WITH PREVENTION MEASURES:

SEVERITY WITH MITIGATION MEASURES:

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