ATTACHMENT E

Oxidizer Shutdown Root Cause Analysis Memorandum (September 18, 1994))

Memorandum

To: Bruce Thompson, Jessie McCusker, ***demaximis, inc.***

CC: Jim Galligan, TerraTherm, Inc.

From: Tim Mahoney, Steve McInerney, Robin Swift, TerraTherm, Inc.

Date: 17 September 2014

Re: ***Thermal Oxidizer – Summary of Root Cause Analysis***

The thermal oxidizer shut down on 13 August due to a high temperature alarm in the unit. An initial inspection of the unit after the shutdown revealed what appeared to be a metal object lodged in the oxidizer chamber obstructing the flame. After thorough evaluation of the oxidizer, it was determined that the daisy wheel, which is internal to the oxidizer chamber that directs flow to the burner, had been damaged and/or melted. TerraTherm, Inc. (TT) performed a root cause analysis of this failure with its engineers and vendors to 1) identify the cause, 2) identify appropriate modifications, if any, to the oxidizer/overall treatment system to prevent recurrence, 3) develop a plan to bring the system back online, and 4) evaluate our current operating plan. Below is a summary of these efforts.

GENERAL TIMELINE OF EVENTS

On 11 August, intermittent spikes of elevated temperature were observed at the process effluent side of the oxidizer heat exchanger (E-103). As the source of these temperature excursions was being investigated, the heat exchanger bypass valve was opened to reduce the heat exchanger effluent temperature and a dilution air intake valve upstream of the main process blowers was partially opened to allow approximately 420 standard cubic feet per minute (scfm) of dilution air into the process stream to reduce vapor concentrations and aid in cooling. The inlet to the oxidizer was reduced from a peak temperature of approximately 1550°F to a steady temperature of approximately 220°F.

As a result of these changes, the combustion blower increased flows from approximately 250 scfm to approximately 500 scfm, and the natural gas flow increased from approximately 20 scfm to approximately 40 scfm. With the stream not being pre-heated, and the increase in added dilution air flow, these increases in fuel usage and combustion air flow were expected. These operations are depicted in Sheet 4 of the selected Piping and Instrumentation Diagram (P&ID) in Attachment A.

Coincident with the spikes in heat exchanger process effluent temperature, the operators observed the flammability analyzer located downstream of the heat exchanger would periodically increase sharply above a baseline lower flammability limit (LFL) reading of approximately 30% up to approximately 38%, then drop precipitously to less than 5%. This drop was followed by a steady rise in LFL values back to the baseline of approximately 30%. At a fairly predictable interval, this cycle would repeat itself where the LFL value would hold for a period at a baseline level, rise sharply above the baseline, drop quickly, and then steadily recover to the baseline level over a brief period.

Operators also observed that the spikes in heat exchanger outlet temperatures and the spikes/decline cycles of LFL coincided with the oil water separator (OWS) pumps cycling to transfer fluids. Note that the OWS is controlled by level switches, and the fluid transfers are an intermittent operation. The Operators received several system warning alarms during the night of 12 August for LFL >40% at which point the oxidizer controls call for the introduction of dilution air flow. The shutdown alarm limit of 50% LFL was never reached, but dilution air was added to the system as designed.

Figure 1 below shows the history of project LFL data. It should be noted that the logging interval for these data was set to take a snapshot of data every two hours, whereas the cycles described above were occurring approximately every 20 minutes and the spike/drop conditions were of very limited duration. Therefore, the cyclical behavior of these readings was not captured on the logged data. On 12 August at midnight, the data logging schedule was changed to record LFL data every minute. A plot of the LFL data from this point in time until the oxidizer failure is provided below in Figure 2. The average and peak LFL values measured during this time interval were 23% and 43%, respectively.

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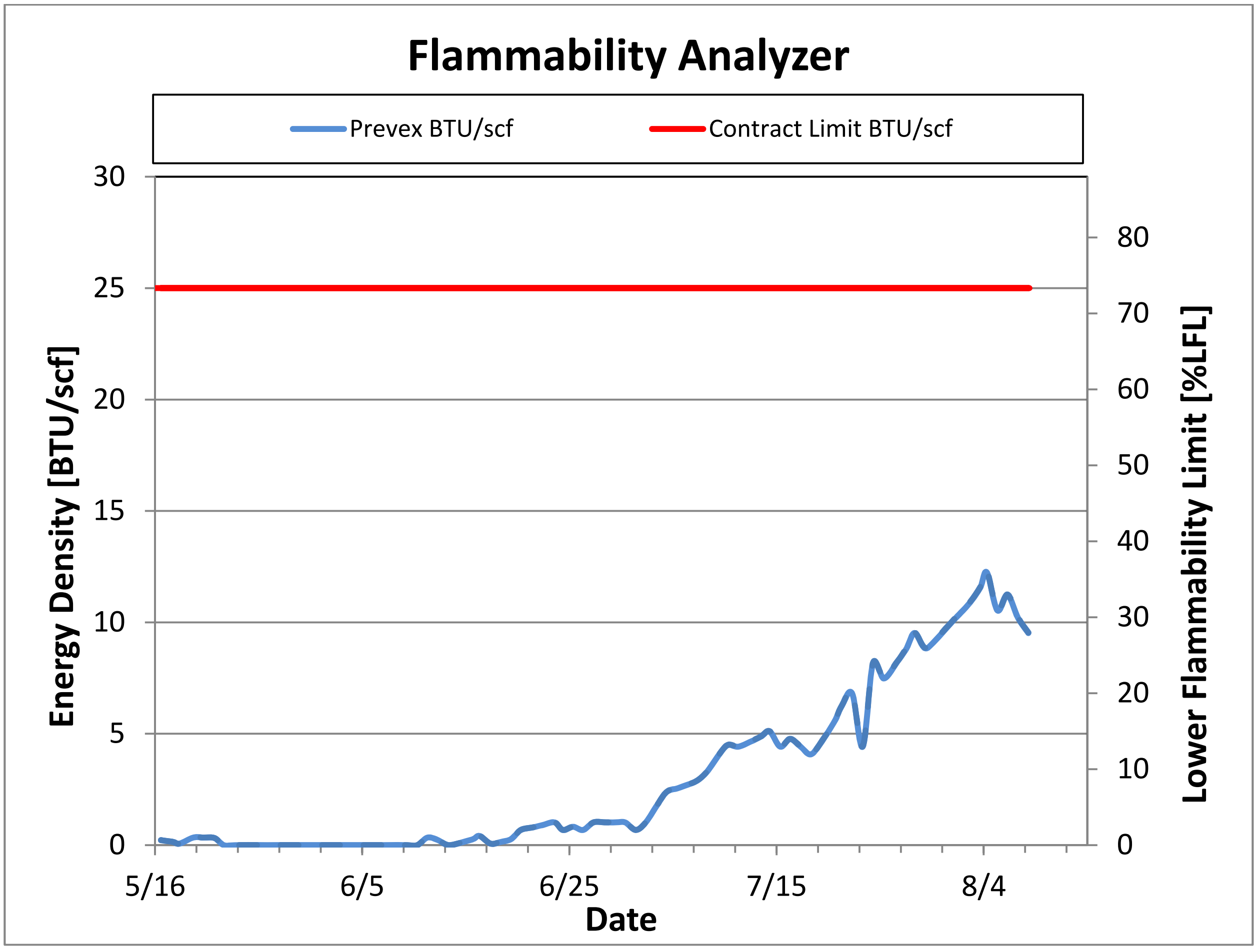

Figure 1 - Daily Average of Flammability Analyzer

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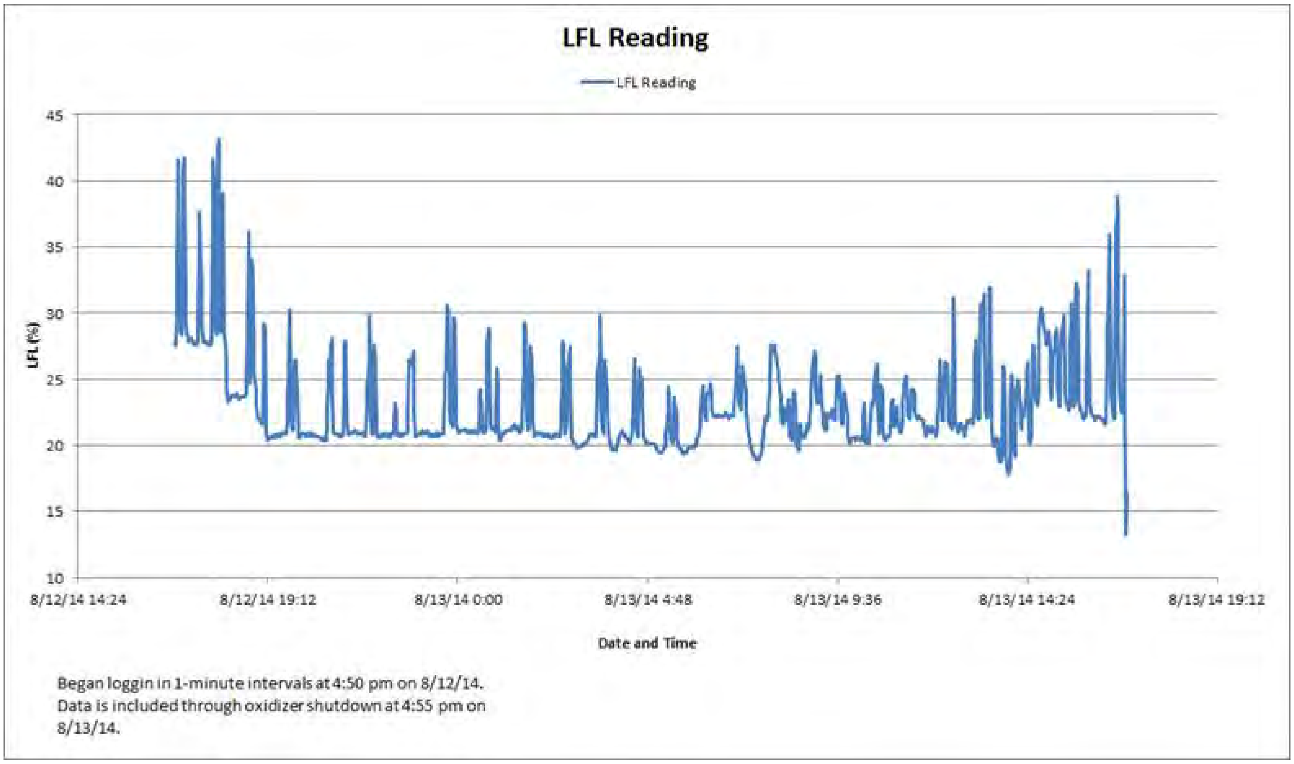

Began loggin in 1-minute intervals at 4:50 pm on 8/12/14.
Data is included through oxidizer shutdown at 4:55 pm on 8/13/14.

Figure 2 – Logged LFL Data - One Minute Logging Interval

TerraTherm's Project Engineer remotely observed LFL levels and temperatures in the effluent of the heat exchanger increase when the OWS pump cycled before the heat exchanger was bypassed. Our interpretation of these conditions is that vapor concentrations increased sharply, or perhaps an oily mist was present, when the OWS transferred fluids to the air stripper, and the stripper blower conveyed these materials towards the oxidizer. The heat exchanger operating temperature was above the auto-ignition temperature for some constituents, and brief pre-combustion episodes were occurring inside the heat exchanger. This may have resulted in the increased heat exchanger outlet temperature, and the spike and subsequent drop in LFL as the fuel value of the process stream was depleted by the combustion event. Therefore, the LFL sensor did not register values in excess of programmed alarm limits, and the meter readings never approached or exceeded flammable limit due to the location of the meter relative to where the combustion was occurring.

As indicated above, the heat exchanger was bypassed and the dilution air was introduced to the process vapor as discussed and agreed upon by Catalytic Combustion Corporation (CCC) to keep the system operational during further troubleshooting and information gathering activities. As a result, the heat exchanger inlet temperature was decreased from 1100˚F to approximately 220˚F, and LFL values stabilized.

TerraTherm believed that an emulsion or droplets of free phase materials may have been passing through the OWS to the air stripper and contributing to the transient spikes observed in LFL. The OWS and air stripper were opened and inspected. From the inspection, the OWS was found to contain both emulsified materials and a significant accumulation of Light Non-Aqueous Phase Liquid (LNAPL) (see below photos), even though the material was skimmed daily by the Operators.

Photo of OWS Emulsion

The air stripper trays were found clean other than a glob of “black tar” (as shown below). A sample of the material was collected for analysis. However, once dried, it was no longer a liquid and the laboratory was not able to perform analysis on it due to insufficient volume. We have not seen this black tar material in the process stream since. It is possible that NAPL carryover or emulsified organic material occurred in the OWS and was conveyed to the air stripper, creating brief spikes in oily mist or elevated vapor phase concentrations. Based on the sampling methodology for the LFL devices, the presence of an oily mist may not be detected by the LFL sensor.

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Photo of Glob of "Black Tar" in Air Stripper

As a precaution, TerraTherm installed an organoclay media vessel downstream of the OWS to capture any free phase or emulsified organic material that may pass through the OWS. We also installed an additional liquid granular activated carbon vessel at the end of the process stream (just prior to discharge to the sewer) to facilitate change-out of two primary vessels at a time to better manage higher loading rates.

We further contacted our OWS vendor to confirm the size/flow/temperature/retention time of the design. They confirmed that the tank was appropriate for the operating conditions at the site. Refer to the vendor modeling summary below. Note that inputs are maximum system design rates, not current operating scenarios.

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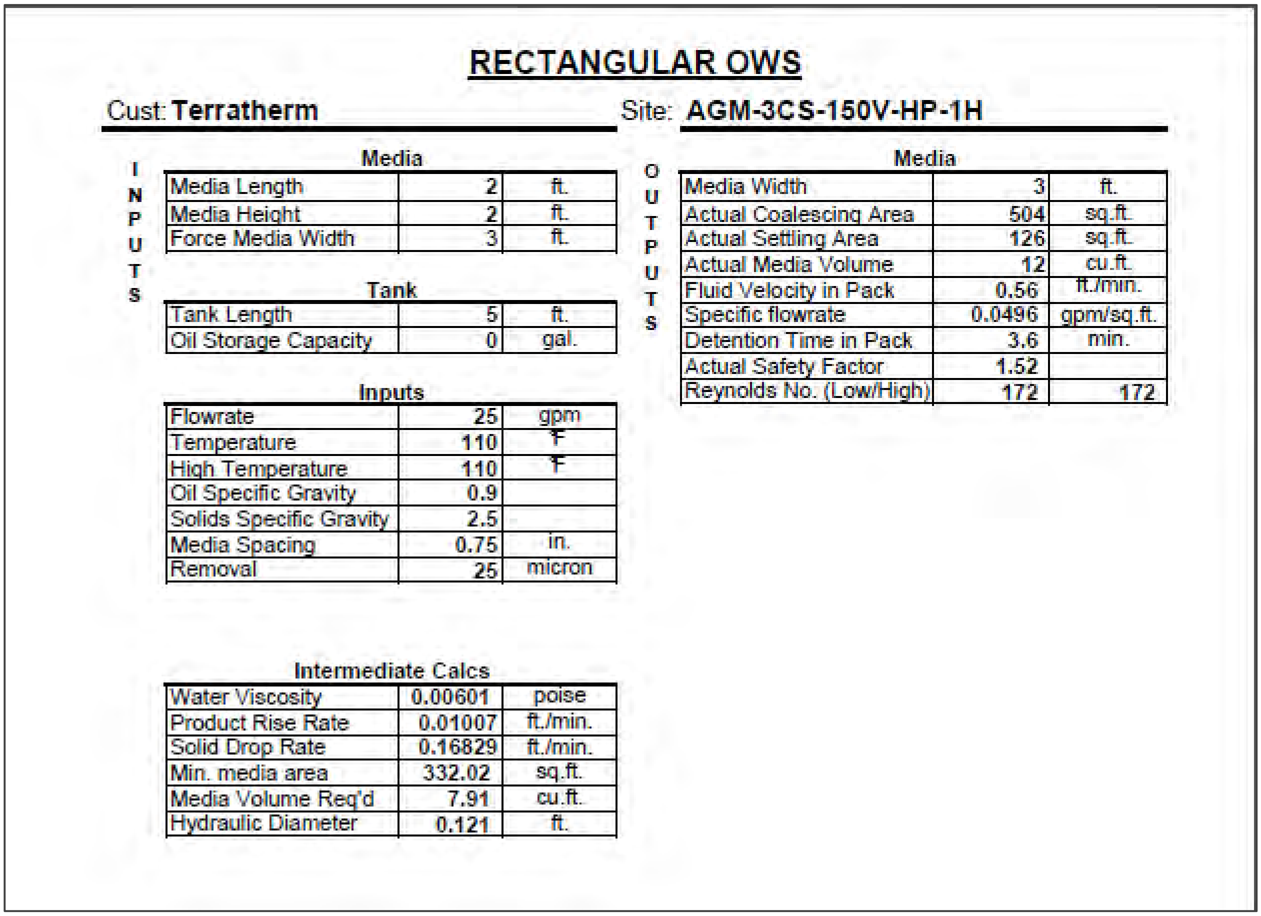

RECTANGULAR OWS

Cust: **Terratherm** Site: **AGM-3CS-150V-HP-1H**

INPUTS

Media

Media Length	2	ft.
Media Height	2	ft.
Force Media Width	3	ft.

Tank

Tank Length	5	ft.
Oil Storage Capacity	0	gal.

Inputs

Flowrate	25	gpm
Temperature	110	°F
High Temperature	110	°F
Oil Specific Gravity	0.9	
Solids Specific Gravity	2.5	
Media Spacing	0.75	in.
Removal	25	micron

Intermediate Calcs

Water Viscosity	0.00601	poise
Product Rise Rate	0.01007	ft./min.
Solid Drop Rate	0.16829	ft./min.
Min. media area	332.02	sq.ft.
Media Volume Req'd	7.91	cu.ft.
Hydraulic Diameter	0.121	ft.

OUTPUTS

Media

Media Width	3	ft.
Actual Coalescing Area	504	sq.ft.
Actual Settling Area	126	sq.ft.
Actual Media Volume	12	cu.ft.
Fluid Velocity in Pack	0.56	ft./min.
Specific flowrate	0.0496	gpm/sq.ft.
Detention Time in Pack	3.6	min.
Actual Safety Factor	1.52	
Reynolds No. (Low/High)	172	172

On 13 August at approximately 5:00PM, the system shut down due to a high temperature alarm in the oxidizer. The oxidizer attempted to reignite three times; failing each time. Upon visual inspection of the flame through the peek hole, it was observed that a large metallic object was obstructing the flame. Later, we would learn this was the daisy wheel. The oxidizer was officially taken offline, the power to the heater wells throughout the entire wellfield was reduced to 10%, and the extracted vapors were redirected through the backup vapor phase carbon units, consistent with the contingency plan design.

Starting on 15 August, TerraTherm began disassembling the inlet and outlet piping to the oxidizer for further internal inspections. With phone support from CCC, we were able to confirm that the daisy wheel had failed. CCC mobilized to the site on 21 August for additional disassembly of the oxidizer chamber itself.

VENDOR INSPECTIONS

CCC disassembled the oxidizer piping before and after the combustion chamber, and the chamber itself. A summary of their findings is provided below:

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- In the photo below, the process vapor inlet is from the left, and the burner flange is in the center. Note the shell discoloration is most likely from overheating. Combustion is designed to start ~3 ft away from this end plate, and there is evidence that pre-combustion was occurring upstream of the daisy wheel.

- The photo below shows the daisy wheel process flow distributor mounted on the end plate. The bent “petals” were oriented between 11:00 and 3:00 positions when viewed from the burner end plate. The impacted petals were discolored, further suggesting localized over-heating from influent vapors. A new daisy wheel assembly was designed, fabricated, and installed after this unit was removed for inspection. The replacement unit included a reinforcing ring welded to the petals of the wheel to minimize the chance of the assembly becoming distorted again due to high influent operating temperatures.

- In the photos below, the combustion chamber & roof show discoloration, likely due to impingement from a re-directed burner flame from the distorted shape of the daisy wheel.

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- In the photo below, refractory has separated from the combustion chamber wall at the process inlet location, presumably due to localized over-heating.

Inspection of the heat exchanger showed some discoloration of the “turbulators” installed inside the heat exchanger tubes. These are helical bands of metal installed to boost heat transfer rates. Though discolored, there was no apparent distortion or damage observed on these devices. More importantly, the heat exchanger tubes and shell were in good condition.

CONCLUSIONS AND CORRECTIVE ACTIONS

- *CONCLUSION #1:* We suspect, but cannot confirm, that this failure may be due to a higher fuel value in the process vapor stream than detected by the single flammability analyzer. One plausible explanation is the analyzer location is not optimal, and we were getting some dilution flow through the dilution blower.
- *CORRECTIVE ACTION:* We have installed a second flammability analyzer at a sampling location influent to the heat exchanger, upstream of the dilution blower.

  If both units consistently read acceptable LFL levels (<40%), and we still see evidence of pre-combustion, then that would suggest that additional testing is necessary to determine the nature of the contaminants and their combustion characteristics.

- *CONCLUSION #2*: Transient bursts of oily mist carrying fuel value in the process stream may have condensed or dropped out in the sample line and were not fully detected by the LFL sensor. It is possible that the mist eliminator in the air stripper was fouled and not properly removing mist from the stripper vent stream.
- *CORRECTIVE ACTION:* We have installed an organoclay media vessel downstream of the OWS to remove any free or emulsified oil from the OWS effluent. Once a day, the water color in the air stripper is inspected to confirm that the clay is not saturated. Spare clay is onsite. The mist eliminator in the air stripper was inspected, cleaned, and put back into service.

- *CONCLUSION #3:* We suspect that pre-combustion was occurring not only inside the heat exchanger when it was online, but may also have occurred in the inlet chamber of the oxidizer. This suspicion is based on visual observations of the inlet plenum where localized overheating appeared to have cause discoloration and deterioration of insulated surfaces inside this chamber. However, we cannot confirm this based on available operating data.
- *CORRECTIVE ACTION*: We have installed a new thermocouple sensor at the inlet to the oxidizer chamber and have programmed a high temperature shutdown alarm based on this device.

  Additional *CORRECTIVE ACTION*: We have also increased our recording frequency to 1 minute intervals in order to better troubleshoot transient operating conditions that may occur in the future.

INTERLOCKS

The system modifications described in this memorandum are depicted in the updated P&ID (only sheets modified are included). Additionally, the Alarm/Interlock schedule for the project has been updated to include the newly installed instruments and alarm settings. The Alarm/Interlock schedule is also provided as Attachment B. A summary of system improvements to address the operational issues described here is summarized below:

- An organoclay filter was added between the OWS and the air stripper to remove free or emulsified oil, and to reduce or eliminate any transient spikes in vapor concentrations related to fluid transfers between these two operations.
- A redundant LFL sensor was installed upstream of the heat exchanger and upstream of the dilution air blower. Like the primary unit, this device is programmed to alert operators with a warning alarm when 40% LFL is reached, and a shutdown alarm at 50%.

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Additionally, a differential shutdown alarm will terminate operations if the readings from the two LFL sensors differ by more than 15%.

- The primary LFL sensor will continue to control the dilution air blower operation. The blower will idle whenever LFL levels are below 40%, and will speed up as LFL rise above this level.
- A temperature sensor was installed upstream of the daisy wheel to ensure that the inlet chamber temperatures remain close to the inlet process temperature. A shutdown Alarm is currently programmed to shut down operations if temperatures increase above 500°F in the inlet chamber to the oxidizer. Currently, the temperature of the process vapor as it enters the inlet plenum is approximately 220°F.

OPERATIONS GOING FORWARD

To control the restart, the focus of subsurface heating operations will be on Phase 1 solely. Once the oxidizer is back online, data will be collected for some period (a couple days) to confirm the new instrumentation is functioning as designed. During this time, the pump to the OWS will be manually turned on in an attempt to replicate conditions seen prior to the daisy wheel failure.

If data appear to be consistent with design, Phase 1 will be increased over approximately one week in roughly 10% daily increments. Once we are at conditions similar to those observed prior to the shutdown event, and we are confident with the data collected/observed, we will begin to increase energy to the heaters in Phase 2. This will occur much slower than the original plan to ensure we do not exceed the operational limitations of the oxidizer, and that unexpected operating conditions do not adversely impact ongoing operations.

WHERE WE ARE TODAY

We have had multiple discussions with CCC, Control Instruments (CI) (Prevex), and Bill Troxler sharing our analytical influent data results, the calculated BTU content data provided by the laboratory, and any system data requested to assist us in evaluation of the oxidizer shutdown.

Although still under review, at this time, none of our external support can identify a root cause for the oxidizer failure but has indicated that the flammability analyzer in use at the site may have up to a 50% error in its readings. This is largely because flammability analyzers are typically used in industrial settings where the process stream is consistent and can be easily monitored. CI has confirmed that the flammability analyzer in use is the best type for our application.

While the evaluation continues, we have made a conscious decision to operate extremely conservative, focusing on Phase 1 until the mass removal rate has decreased. We are assuming that the flammability analyzer readings are at least 1/3 of the actual LFL value and will adjust as necessary based on recent laboratory data results. We have introduced dilution air into the system to maintain LFL levels below 12% and have reprogrammed the automated blower to begin ramp-up at 14% LFL.

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ATTACHMENT A

Select P&ID Sheets Illustrating System Modifications

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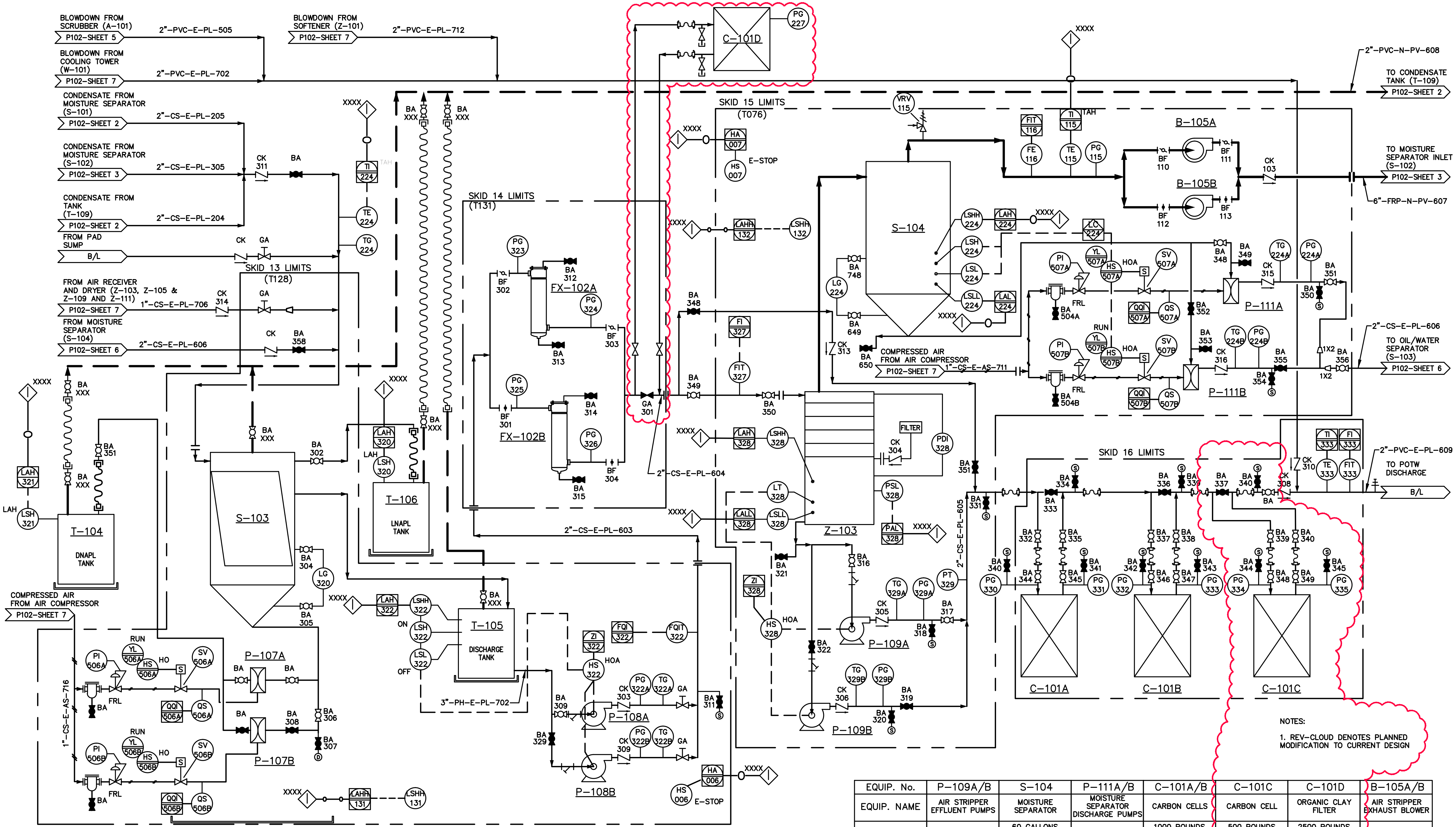

NOTES:

1. REV-CLOUD DENOTES PLANNED MODIFICATION TO CURRENT DESIGN

EQUIP. No.	T-104	P-107A/B	S-103	T-105	T-106	P-108A/B	FX-102A/B	Z-103
EQUIP. NAME	DNAPL TANK	DNAPL PUMPS	OIL/ WATER SEPARATOR	DISCHARGE TANK	LNAPL TANK	DISCHARGE PUMPS	BAG FILTER	AIR STRIPPER
VOLUME	55 GALLONS			150 GALLONS	55 GALLONS			
FLOW RATE		3 GPM	20 GPM	*INTEGRAL TO		20 GPM	20 GPM	50 GPM
PRESSURE		20 FT TDH		S-103*		80 FT TDH		
POWER								

EQUIP. No.	P-109A/B	S-104	P-111A/B	C-101A/B	C-101C	C-101D	B-105A/B
EQUIP. NAME	AIR STRIPPER EFFLUENT PUMPS	MOISTURE SEPARATOR	MOISTURE SEPARATOR DISCHARGE PUMPS	CARBON CELLS	CARBON CELL	ORGANIC CLAY FILTER	AIR STRIPPER EXHAUST BLOWER
		60 GALLONS		1000 POUNDS	500 POUNDS	2500 POUNDS	
FLOW RATE	30 GPM		20 GPM	20 GPM	20 GPM	20 GPM	600 SCFM
PRESSURE	60 PSI		40 PSI	50 PSI	50 PSI	50 PSI	
	3 HP						15 HP

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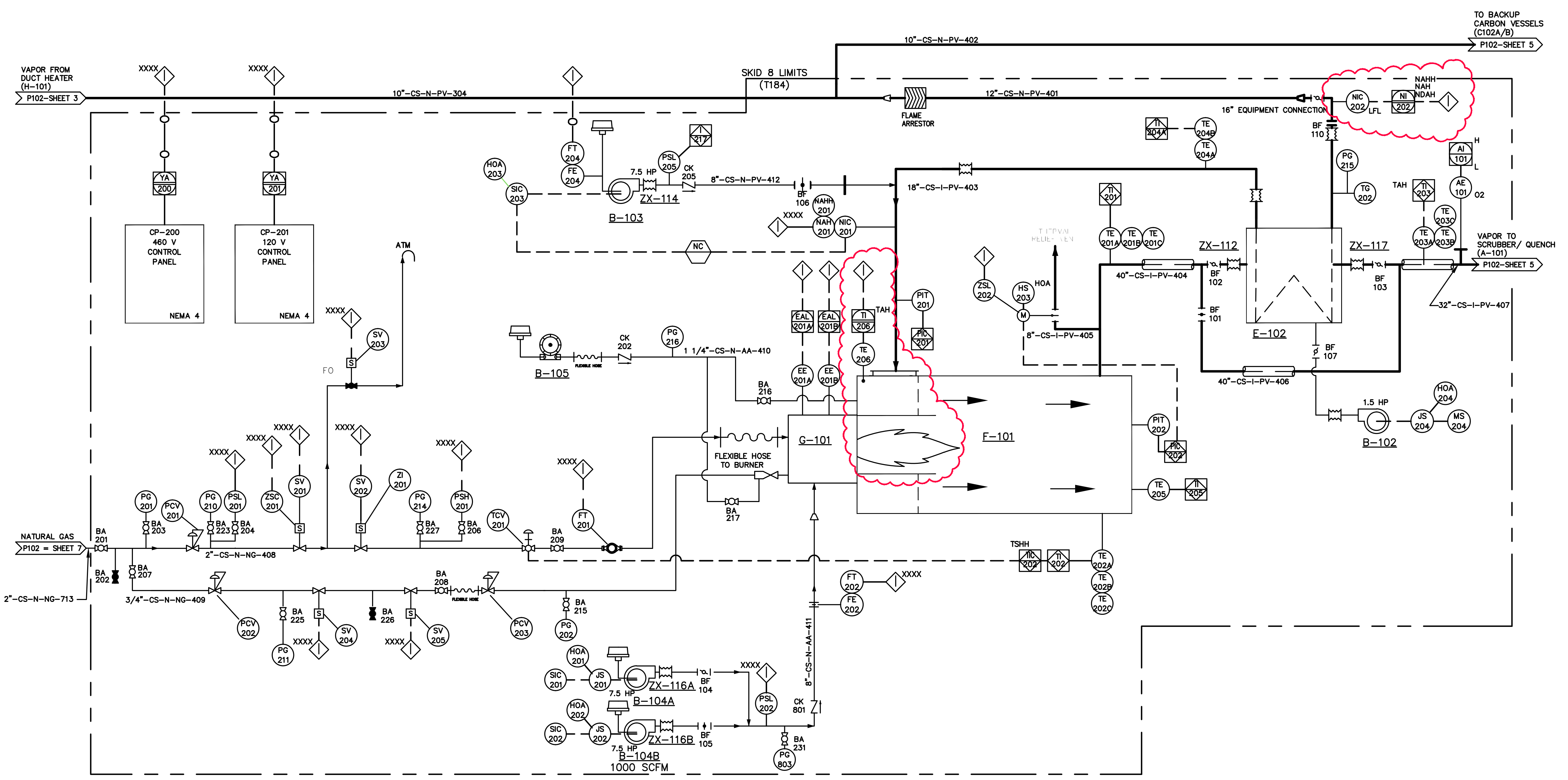
SRSNE SUPERFUND SITE
PIPING & INSTRUMENTATION DIAGRAM
LIQUID TREATMENT SYSTEM

SIZE D
DWG NO. P102
REV 2
SCALE: NONE
SHEET 6 OF 8



EQUIP. No.	B-103	B-104A/B	G-101	V-101	E-102	B-102
EQUIP. NAME	DILUTION AIR BLOWER	COMBUSTION AIR BLOWERS	OXIDIZER BURNER	THERMAL OXIDIZER	HEAT EXCHANGER	AIR SEAL BLOWER
VOLUME			4 MMBTU			
FLOW RATE	750 SCFM	1000 SCFM		3000 SCFM	3000 SCFM	
PRESSURE						
POWER	7.5 HP	7.5 HP				1.5 HP

NOTES:

1. REV-CLOUD DENOTES PLANNED MODIFICATION TO CURRENT DESIGN

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SRSNE SUPERFUND SITE
PIPING & INSTRUMENTATION DIAGRAM
THERMAL OXIDIZER

SIZE D
DWG NO. P102
REV 1
SCALE: NONE
SHEET 4 OF 8

ATTACHMENT B

Interlock Table

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SRSNE
PLC Interlock Table
Date **11/22/2013**
Rev **0**

Checked
Approved

DATE:	BY	P&ID Sheet	Unit	Operation	Alarm ID #	Alarm Description	Setting	Delay (secs)	Heaters	Skid 1 P-112 A/B	Skid 3 BF-301 (C)	Skid 3 BF-302 (O)	Skid 3 P-102 A/B	Skid 3 P-113	Skid 5 B-101 A/B	Skid 6 P-103 A/B	Skid 7 H-101	Skid 8 F-101	Skid 9 A-101	Skid 9 SV-601	Skid 9 P-110 A/B	Skid 13 P-107 A/B	Skid 13 P-108 A/B	Skid 14 P-109 A/B	Skid 14 B-105 A/B	Skid 14 P-111 A/B	Skid 18 W-101	Skid 18 P-101 A/B	Skid 19 Z-103	Skid 20 Z-109	Alarm Lite	Callout	Comments	Notes
		1	**Wellfield**	**Wellfield**	ESTOP	Field ESTOP	NA	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Field ESTOP terminates all system operations	
8-May	RS				PAL-101	Low Pressure Alarm on Wellfield Header	-30" wc	30																							x	x	Notification only	
8-May	RS				PAH-101	High Pressure Alarm on Wellfield Header	0" wc	30																							x	x	Notification only	
1-May	DL				TAH-101	High Temperature Alarm on Wellfield Header	250 F	30			x	x																			x	x	Isolate wellfield and purge header	
1-May	DL		**Skid 1**	**Condensate Separator**	TAH-102	High Temperature Alarm from T-109	250 F	30			x	x																			x	x	Isolate wellfield and purge header	
1-May	DL				LAL-220	Low Level Alarm in T-109	Fixed	5		x																					x	x	Redundant low level switch	
1-May	DL				LAH-220	High Level Alarm in T-109	Fixed	5			x	x																			x	x	Redundant high level switch, block wellfield, purge header	
1-May	DL				LAHH-1301	High High Level Alarm at Skid 1	Fixed	5																							x	x	Notification only	
1-May	DL	2			ESTOP	Panel ESTOP	NA	0		x																					x	x	Shuts down skid components	
1-May	DL				LAHH-221	High Level Alarm in S-101	Fixed	5			x	x																			x	x	Redundant high level switch, block wellfield, purge header	Updated Alarm ID from LAH-401 to LAHH-401
1-May	DL				LALL-221	Low Level Alarm in S-101	Fixed	5					x	x																	x	x	Redundant low level switch	Updated Alarm ID from LAL-201 to LALL-201
1-May	DL				TAH-106	High Temperature Alarm at S-101 Inlet	250 F	30			x	x																			x	x	Isolate wellfield and purge header	
1-May	DL				TAH-107	High Temperature Alarm at S-101 Outlet	250 F	30			x	x																			x	x	Isolate wellfield and purge header	
1-May	DL		**Skid 3**	**Moisture Separator**	LAHH-1302	High High Level Alarm at Skid 3	Fixed	5																							x	x	Notification only	
1-May	DL				ZSO-106	Process Block Valve Not Closed Alarm	Fixed	30																							x	x	Notification only	
1-May	DL				ZSC-106	Process Block Valve Not Open Alarm	Fixed	30																							x	x	Notification only	
1-May	DL				ZSO-801	Vent Valve Not Closed Alarm	Fixed	30																							x	x	Notification only	
1-May	DL				ZSC-801	Vent Valve Not Open Alarm	Fixed	30																							x	x	Notification only	
1-May	DL				ESTOP	Panel ESTOP	NA	0					x	x																	x	x	Shuts down skid components	
			Skid 4	**Caustic Supply**	LAL-901	Low Level Alarm Caustic Tank	Fixed	5						x																	x	x	Shuts down pump	
2-May	DL				ESTOP	Panel ESTOP	NA	0							x		x														x	x	Shuts down blowers	
2-May	DL				YA-101A	Vacuum Blower B-101A VFD Fault	NA	5									x	x													x	x	Represents multiple source alarms. Shut down heater and TOX	
2-May	DL		**Skid 5**	**Vacuum Blowers**	YA-101B	Vacuum Blower B-101B VFD Fault	NA	5									x	x													x	x	Represents multiple source alarms. Shut down heater and TOX	
7-May	RS				PAL-109	Low Pressure Alarm Blower Discharge	5" wc	30																							x	x	Notification only	
7-May	RS	3			PAH-109	High Pressure Alarm Blower Discharge	50" wc	30																							x	x	Notification only	
2-May	DL				LAH-223	High Level Alarm S-102	Fixed	5			~~x~~	~~x~~			x																x	x	Redundant high level switch, block wellfield, purge header	
2-May	DL		**Skid 6**	**Moisture Separator**	LAL-223	Low Level Alarm S-102	Fixed	5								x															x	x	Redundant low level switch	
2-May	DL				TAH-110	High Temperature Alarm S-102 Outlet	250F	30							x																x	x	Isolate wellfield and purge header	
2-May	DL				ESTOP	Panel ESTOP	NA	0								x															x	x	Shuts down skid components	
2-May	DL				LAHH-1203	High Level Alarm at Skid 6	Fixed	5																							x	x	Notification only	
			Skid 7	**Duct Heater**	TAH-111	Heater Element High Temperature Alarm	500F	5									x														x	x	Shuts down heater	
2-May	DL	4	**Skid 8**	**Thermal Oxidizer**	YA-200	General VFD Alarm Oxidizer CP-200	NA	2			x	x			x		x														x	x	Source alarm code available at TOX	
					YA-201	General Instrument Alarm Oxidizer CP-201	NA	2																							x	x	Source alarm code available at TOX	
					TE-206	Oxidizer Combustion Hi Temp Alarm	500F	2										x													x	x		
					NDAH-202	LFL Differential Alarm	± 15%	2			x	x						x													x	x	Source alarm code available at Flame Analyzer #1	
					NAHH-201	LFL Meter #1 Hi Shut Downalarm	50%	2			x	x						x													x	x	Source alarm code available at Flame Analyzer #2	
					NAHH-202	LFL Meter #2 Hi Shut Down alarm	50%	2			x	x						x													x	x	Source alarm code available at Flame Analyzer #2	
					NAH-201	LFL Meter #1 Warning alarm	40%	2																							x	x	Source alarm code available at Flame Analyzer #1	
					NAH-202	LFL Meter #2 Warning alarm	40%	2																							x	x	Source alarm code available at Flame Analyzer #2	
					YA-612	General Instrument Alarm Scrubber CP-612	NA	2			x	x						x													x	x	Source alarm code available at Scrubber/Quench	
		5	**Skid 9**	**Scrubber**	YA-613	General VFD Alarm Scrubber CP-613	NA	2			x	x						x													x	x	Source alarm code available at Scrubber/Quench	
1-May	DL				PSAL-301	Low Pressure Alarm Quench Supply Water	NA	2			x	x								x											x	x	Initiates backup water flow N/A?	Should isolate wellfield/open dilution, shut down Oxidizer & open Thermal Vent ZSL-202
5-May	RS				TAH-224	High Temperature Alarm S-103 Inlet	150F	30																							x	x	Notification only	
5-May	RS				LAHH-131	High High Level Alarm Skid 13	Fixed	5																							x	x	Notification only	
5-May	RS		**Skid 13**	**Oil Water Separator**	LAH-322	High High Level Alarm T-105	Fixed	5		x			x	x		x										x					x	x	Redundant high level switch, shuts down feed pumps	
5-May	RS				LAH-320	High Level Alarm T-106 (LNAPL)	Fixed	5		x			x	x		x										x					x	x	Shuts down feed pumps	
5-May	RS				LAH-321	High Level Alarm T-107 (DNAPL)	Fixed	5		x			x	x		x										x					x	x	Shuts down feed pumps	Same function as LNAPL alarms. Both level sensors are tied into same input
5-May	RS				ESTOP	Panel ESTOP	NA	0															x										Shuts down skid components	
5-May	RS	6			LAHH-132	High High Level Alarm at Skid 15	Fixed	5																							x	x	Notification only	
5-May	RS				LALL-328	Low Low Level Alarm Z-103	Fixed	5																x							x	x	Redundant low level switch	
6-May	RS				LAH-328	High High Level Alarm Z-103	Fixed	5															x								x	x	Redundant high level switch, shuts down feed pumps	
8-May	RS		**Skid 15**	**Air Stripper**	PAL-328	Low Pressure Alarm Z-103	2 " wc	5															x		x						x	x	Shuts down blowers and feed pumps	Pressure Switch broken. Replaced 5/8/2014
5-May	RS				LAH-224	High High Level Alarm S-104	Fixed	5															x		x						x	x	Redundant high level switch, shuts down blowers and feed pumps	
5-May	RS				LAL-224	Low Low Level Alarm S-104	Fixed	5																		x					x	x	Redundant low level switch	
5-May	RS				TAH-115	Temperature Alarm High Z-103 Vent	150F	30																							x	x	Notification only	
5-May	RS				ESTOP	Panel ESTOP	NA	0																x	x	x					x	x	Shuts down skid components	
			Skid 17	**Emergency Water**	LAL-603	Low Level Alarm T-108	Fixed	5													x										x	x	Shuts off pumps N/A?	Should shut down Oxidizer & open Thermal Vent ZSL-202, SV-601 is N/A
		8			LAH-603	High Level Alarm T-108	Fixed	5																							x	x	Notification only	
8-May	RS				TALL-401	Low Low Temperature Alarm CW Supply	35F	5																							x	x	Notification only	
8-May	RS		**Skid 18**	**Cooling Tower**	TAL-401	Low Temperature Alarm CW Supply	40F	5																							x	x	Notification only	
8-May	RS				TAH-401	High Temperature Alarm CW Supply	85F	5																							x	x	Notification only	
7-May	RS	7			FAL-401	Low Flow Alarm CW Supply	Yes/No	5																							x	x	Notification only	
8-May	RS		**Skid 19**	**Air Compressor**	PAL-501	Low Pressure Alarm Air Supply																									x	x	Notification only	
8-May	RS		**Skid 20**	**Air Compressor**	PAL-501	Low Pressure Alarm Air Supply																									x	x	Notification only	Skid 19 and Skid 20 share the same Low Pressure Switch
		-	-	**Power Supply**	-	Power Failure	NA	10																							x	x	Notification only, shutdowns incidental to power loss	

Note: A comprehensive alarm/interlock summary for the Thermal Oxidizer and Quench/Scrubber is excluded from this table.
Interlocks within these vendor packages will permit/terminate all operations within the package boundaries.

Additions