

RPN 200 -
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TYPE	#	FUNCTION	POTENTIAL FAILURE MODE	POTENTIAL CAUSES	POTENTIAL EFFECTS	DETECTION METHOD	SEV	OCC	DET	RPN	RECOMMENDED ACTION(S)	SEV	OCC	DET	RPN
TNK	001	Vegetable Oil Settling Tank #1	Leakage	Loose Fitting	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
				Vessel Failure	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
TNK	002	Vegetable Oil Settling Tank #2	Leakage	Loose Fitting	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
				Vessel Failure	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
TNK	005	Vegetable Oil Collection Tank	Leakage	Loose Fitting	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
				Vessel Failure	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
HEX	005	Water Jacket for Vegetable Oil Collection Tank	Over temp	Hot Water Temp Control Failure	Veg Oil Too Hot, up to limit of hot water (assumed to be controlled with high limit.)	None	10	1	10	100	1. Consider temperature gauge at inlet when installing hot water system. 2. Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	9	1	1	9
					Veg Oil Too Cold	None	5	1	10	50	1. Consider temperature gauge at inlet when installing hot water system. 2. Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	5	1	1	5
			Leakage	Jacket Failure	Water in Oil	Visual Inspection	3	1	3	9		3	1	3	9
					Water on floor	Visual Inspection	4	1	1	4		4	1	1	4
HV	005	Shutoff Valve at Main Vegetable Oil Collection Tank	Leakage	Valve Failure / Stem Failure	Veg Oil Spill onto floor	Visual Inspection	9	1	3	27	Consider basin / sump below oil storage tank.	4	1	1	4
HV	010	Shutoff Valve - Veg Oil to BD Reaction Tank	Leakage	Valve Failure / Stem Failure	Veg Oil Spill onto basin / sump	Visual Inspection	4	1	3	12	Consider basin / sump below oil storage tank.	4	1	1	4
PMP	100	Process Pump - Fill, Mix, Empty - All Fluids	Leakage	Seal Failure	Spill onto basin / sump	Visual Inspection	4	3	3	36	Review pump design, seals?	4	1	1	4
			Over pressure	Blockage, valves not open down or upstream	Pump runs at max pressure, zero flow	Visual inspection (PI-120), audible change in pump operation.	9	5	3	135	1. Review motor drive controls and also pump dead-head pressure rise. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	1	35
TNK	100	Biodiesel Reaction Tank	Leakage	Loose Fitting	Veg Oil Spill onto basin / sump	Visual Inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual Inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual Inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	1	4
				Vessel Failure	Veg Oil Spill onto basin / sump	Visual Inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual Inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual Inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	1	4
			Over temp	Hot Water Temp Control Failure	Contents too hot, up to limit of hot water (assumed to be controlled with high limit.)	Visual inspection of temperature gauge on vessel (TI-100).	9	3	3	81	1. Consider temperature gauge at inlet when installing hot water system. 2. Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	9	3	1	27

FMEA

Document name
FMEA - State Line Farm Biodiesel System

System Design Process

Date
1/2/2008

Issue
Final - Pre First Batch

Issued by

Approved by

Document status
Revision 1

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			Over pressure	Blockage downstream (closed valve, etc.)	Mechanical failure of attached parts or vessel, overflow of contents in unintended locations	Visual inspection of pressure gauge on vessel (PI-100), audible spilling.	9	1	3	27	Consider pressure relief valve or BD reaction tank. Set point TBD.	9	1	3	27
			Over fill	Providing too much fluid to tank, or filling at too great a speed.	Veg Oil Spill onto basin / sump	Visual Inspection	4	3	3	36	Consider level sensor in sump to detect severe leakage.	4	3	1	12
					Reaction Mix Spill onto basin / sump	Visual Inspection	10	3	3	90	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	3	1	27
					BD Spill onto basin / sump	Visual Inspection	4	3	3	36	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	3	1	12
HEX	100	Water Jacket for BD Reaction Tank	Over temp	Hot Water Temp Control Failure	Reaction mix too hot	Visual inspection of temperature gauge on vessel (TI-100).	9	3	3	81	1. Consider temperature gauge at inlet when installing hot water system. 2. Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	9	1	1	9
			Under temp	Hot Water Temp Control Failure	Reaction mix too cold, slow reaction	Visual inspection of temperature gauge on vessel (TI-100).	2	3	3	18	1. Consider temperature gauge at inlet when installing hot water system. 2. Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	2	1	1	2
			Leakage	Jacket Failure	Water in reaction	Visual Inspection	2	1	4	8		2	1	4	8
					Water on floor	Visual Inspection	3	1	3	9		3	1	3	9
LI	100	Level Indicator / Sight Tube for BD Reaction Tank	Unreadable	Fowling	Unknown level or settling status	Visual Inspection	5	5	1	25	Confirm cleaning plan.	5	1	1	5
			Leakage	Cracks, loose fittings	Spill onto basin / sump	Visual Inspection	9	1	3	27		9	1	3	27
TNK	200	Oxide Mixing Tank	Over fill	Too much fluid pumped to vessel	Spill out vent line, or to other vessels	Visual Inspection, sight tube (LI-200)	7	3	3	63	Consider overflow pipe	5	3	3	45
LI	200	Level Indicator / Sight Tube for Oxide Mixing Tank	Unreadable	Fowling	Unknown level or settling status	Visual Inspection	5	5	1	25		5	5	1	25
			Leakage	Cracks, loose fittings	Spill onto basin / sump	Visual Inspection	9	1	3	27		9	1	3	27
TNK	300	Settling Tank	Leakage	Jacket Failure	BD on floor	Visual Inspection	3	1	3	9		3	1	3	9
			Over fill	Too much fluid pumped to vessel	Spill out vent line, or to other vessels	Visual Inspection, sight tube (LI-300)	7	1	3	21	Consider overflow pipe. TNK300 is larger than TNK100, unlikely event	5	1	3	15
LI	300	Level Indicator / Sight Tube for Settling Tank	Unreadable	Fowling	Unknown level or settling status	Visual Inspection	5	5	1	25		5	5	1	25
			Leakage	Cracks, loose fittings	Spill onto basin / sump	Visual Inspection	4	1	3	12		4	1	3	12
MI	100	Mix Indicator - Pump Outlet to Oxide and BD Tanks	Unreadable	Fowling	Unknown process flow or mixing status.	Visual Inspection	5	5	1	25		5	5	1	25
			Leakage	Cracks, loose fittings	Spill onto basin / sump	Visual Inspection	9	1	3	27		9	1	3	27
PI	100	Pressure Indicator / Gauge - BD Reactor Tank	Bad / no reading	Gauge failure	Unknown pressure condition in BD tank.	Visual Inspection, possible backup in PI-120.	9	1	5	45		9	1	5	45
			Leakage	Cracks, loose fittings	Vapor leakage overboard	None	9	1	10	90	Consider combustibility sensor above process	9	1	1	9
PI	120	Pressure Indicator / Gauge - Pump Outlet	Bad / no reading	Gauge failure	No indication of pump operation other than noise.	Visual Inspection	10	1	3	30		10	1	3	30
			Leakage	Cracks, loose fittings	Leakage of any fluid onto basin sump	Visual Inspection	9	1	3	27	Consider level sensor with alarm to alert operator that something has reached the sump.	9	1	1	9
TI	120	Temperature Indicator / Gauge - Pump Outlet	Bad / no reading	Gauge failure	No indication of pump outlet temperature, or inaccurate indication.	None	5	1	3	15	TI120 is not a process critical instrument. It serves as a backup for TI100.	9	1	1	9
			Leakage	Cracks, loose fittings	Leakage of pumped contents to basin / sump	Visual Inspection	9	1	3	27	Consider level sensor with alarm to alert operator that something has reached the sump.	9	1	1	9
TI	100	Temperature Indicator / Gauge - BD Reactor Tank Bottom	Bad / no reading	Gauge failure	No indication of reaction mixture temperature, or inaccurate indication.	Could use TI-120 as substitute	10	1	3	30	Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	9	1	1	9

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			Leakage	Cracks, loose fittings	Leakage of BD tank contents to basin / sump	Visual Inspection	9	1	3	27	Consider level sensor with alarm to alert operator that something has reached the sump.	9	1	1	9
TI	500	Temperature Indicator / Gauge - Condenser Inlet	Bad / no reading	Gauge failure	No indication of condenser inlet temperature, or inaccurate indication.	None	10	1	10	100	Consider including an aquastat or other electronic temperature control on hot water loop so visual becomes backup.	9	1	1	9
			Leakage	Cracks, loose fittings	Leakage of alcohol vapor or liquid	Visual Inspection	10	1	3	30	Consider combustibility sensor above process	9	1	1	9
SMP	001	Process Sump / Basin - Integrated with Base	Overflow	Too much fluid	Spill onto floor	Visual Inspection	10	3	3	90	Consider level sensor with alarm to alert operator that something has reached the sump.	9	3	1	27
				Blockage of areas, material displacement	Spill onto floor	Visual Inspection	10	3	3	90	1. Review secondary containment (trough in floor) 2. Consider high level sensor in basin with audible alarm.	9	3	1	27
HEX	500	Alcohol Condenser	Over temp	Water Temp Control Failure	Incomplete alcohol recovery	None	2	3	10	60	Need to review alcohol recovery process in detail. What is intended operation, what are intended controls.	2	3	10	60
			Leakage	Loose Fitting	Leakage of alcohol vapor or liquid	Visual Inspection	10	1	5	50	Consider combustibility sensor above process	9	1	1	9
				Vessel Failure	Leakage of alcohol vapor or liquid	Visual Inspection	10	1	5	50	Consider combustibility sensor above process	9	1	1	9
HV	500	Isolation Valve - Alcohol Condenser	Closed when should be Open	Operator error	Will not permit condensate alcohol to leave HEX-500 and drop back into TNK-200. Possible rise in pressure in TNK 100, with subsequent pressure relief.	Visual inspection, lack of accumulation of alcohol, no rise in LI-200.	6	5	3	90	Confirm pressure relief at TNK-100. Appropriate settings and line sizing?	2	5	3	30
			Open when should be Closed	Operator error	Will prevent intended operation and use of TNK-100 (vacuum fill will be prohibited). Potential routing of any process fluid to TNK-200 when not intended. Possible routing of alcohol vapors to other vessels.	Visual inspection of sight tube of other tanks (LI-100 / LI-300) to note unintended change in levels. Inability to draw a vacuum on other vessels.	7	5	3	105	Consider combustibility sensor above process.	7	5	1	35
			Leakage	Stem seal failure	Leakage of alcohol onto basin / sump.	Visual inspection.	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	9	1	1	9
				Seat seal failure	Routing of any process fluid to the oxide mix tank when not intended. Possible routing of alcohol vapors to other portions of the system.	Visual inspection of sight tube or oxide mix tank (LI-200).	10	1	5	50	Consider combustibility sensor above process.	9	1	1	9
HV	610	Vent Valve - Biodiesel Reaction Tank	Closed when should be Open	Operator error	Lack of venting for reaction vessel, pressure increase during fill.	Visual inspection, pressure gauge on reaction tank (PI-100) or pressure gauge at pump outlet (PI-120)	9	5	5	225	Consider pressure relief valve or BD reaction tank. Set point TBD.	7	5	5	175
					Lack of replacement air when emptying tank.	Low outlet flow, pump work increase.	7	5	5	175	Consider pump suction pressure gauge (vac / pos) for better detection.	7	5	3	105
			Open when should be Closed	Operator error	No effect	None	1	5	10	50		1	5	10	50
			Leakage	Stem seal failure	Vapor leakage overboard	None	10	1	10	100	Consider combustibility sensor above process	9	1	1	9
				Seat seal failure	Vapor leakage through valve	None	10	1	10	100	Consider combustibility sensor above process	9	1	1	9
HV	620	Vent Valve - Oxide Mix Tank	Closed when should be Open	Operator error	Lack of venting for oxide mix tank, pressure increase during fill	Visual inspection (PI-120).	7	5	5	175	1. Consider pressure relief valve on Oxide mix tank. Set point TBD. 2. Consider pressure gauge on tank for detection.	5	5	1	25
					Lack of replacement air when emptying tank.	Low outlet flow, pump work increase.	7	5	5	175	Consider pump suction pressure gauge (vac / pos) for better detection.	7	5	3	105
			Open when should be Closed	Operator error	No effect	None	1	5	10	50		1	5	10	50
			Leakage	Stem seal failure	Vapor leakage overboard	None	10	1	10	100	Consider combustibility sensor above process	9	1	1	9
				Seat seal failure	Vapor leakage through valve	None	10	1	10	100	Consider combustibility sensor above process	9	1	1	9

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HV	630	Vent Valve - Settling Tank	Closed when should be Open	Operator error	Lack of venting for settling tank, pressure increase during fill.	Visual inspection (PI-120).	7	5	5	175	1. Consider pressure relief valve on Settling tank. Set point TBD. 2. Consider pressure gauge on tank for detection.	5	5	1	25
					Lack of replacement air when emptying tank.	Low outlet flow, pump work increase.	7	5	5	175	Consider pump suction pressure gauge (vac / pos) for better detection.	7	5	3	105
			Open when should be Closed	Operator error	No effect	None	1	5	10	50		1	5	10	50
			Leakage	Stem seal failure	Vapor leakage overboard, possibly some residual alcohol vapor.	None	10	1	10	100	Consider combustibility sensor over process.	9	1	1	9
				Seat seal failure	Vapor leakage through valve	None	10	1	10	100	Consider combustibility sensor over process.	9	1	1	9
HV	390	Outlet Valve - Settling Tank	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or final product (BD/glycerin) with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	3	105	Operator checklist and operation sheets need to be developed and followed. Consider LOTO prior to operating pump (PMP-100).	7	5	3	105
			Leakage	Stem seal failure	Leakage of final product (BD or glycerin) onto basin / sump.	Visual inspection	7	1	3	21	Consider level sensor in sump to detect severe leakage.	7	1	1	7
				Seat seal failure	Mix of air (empty tank) or final product (BD/glycerin) with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	3	21		7	1	3	21
HV	380	Isolation Valve - Outlet of Settling Tank to Pump	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or final product (BD/glycerin) with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	3	105	Operator checklist and operation sheets need to be developed and followed. Consider LOTO prior to operating pump (PMP-100).	7	5	3	105
			Leakage	Stem seal failure	Leakage of final product (BD or glycerin) onto basin / sump.	Visual inspection	7	1	3	21	Consider level sensor in sump to detect severe leakage.	7	1	1	7
				Seat seal failure	Mix of air (empty tank) or final product (BD/glycerin) with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	3	21		7	1	3	21
HV	290	Outlet Valve - Oxide Mixing Tank	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or oxide mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	3	105		7	5	3	105
			Leakage	Stem seal failure	Leakage of oxide mix or alcohol onto basin / sump.	Visual inspection.	10	1	3	30	Consider combustibility sensor above process.	9	1	1	9
				Seat seal failure	Mix of air (empty tank) or oxide mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	3	21		7	1	3	21

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HV	295	Skim Valve - Oxide Mixing Tank	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or oxide mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	3	105		7	5	3	105
			Leakage	Stem seal failure	Leakage of oxide mix or alcohol onto basin / sump.	Visual inspection.	10	1	3	30	Consider combustibility sensor above process.	9	1	1	9
				Seat seal failure	Mix of air (empty tank) or oxide mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	3	21		7	1	3	21
HV	190	Outlet Valve - BD Reaction Tank	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or reactor mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	3	105		7	5	3	105
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	9	36
				Seat seal failure	Mix of air (empty tank) or reactor mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	3	21		7	1	3	21
HV	400	Vacuum Reference Valve - Top of BD Reaction Tank	Closed when should be Open	Operator error	Inability to draw vacuum on vessels for vacuum fill process	Noted lack of fill, lack of vacuum on specific vessel.	2	5	3	30		2	5	3	30
			Open when should be Closed	Operator error	Possible leakage of vented vapors from BD tank or others. Possible vacuum on any vessel when unintended (would require double failure including vacuum pump on)	Vacuum on TNK-100 when not intended.	2	5	3	30		2	5	3	30
			Leakage	Stem seal failure	Poor vacuum draw performance on system	Vacuum measurement on TNK-100	2	2	3	12		2	2	3	12
				Seat seal failure	Possible leakage of vented vapors from BD tank or others. Possible vacuum on any vessel when unintended (would require double failure including vacuum pump on)	Vacuum on TNK-100 when not intended.	2	5	3	30		2	5	3	30
HV	800	Inlet Valve - Alcohol to Oxide Tank	Closed when should be Open	Operator error	Will not permit filling of oxide tank with alcohol and catalyst, potential spill onto sump / basin	Visual inspection	10	5	3	150	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	5	1	45
			Open when should be Closed	Operator error	Venting of vapor to area other than intended vent termination.	Visual inspection	10	5	5	250	Consider combustibility sensor above process.	9	5	1	45
					Overflow of contents onto basin sump.	Visual inspection	10	5	3	150	Consider level sensor in sump to detect severe leakage.	9	5	1	45
			Leakage	Stem seal failure	Venting of vapor to area other than intended vent termination.	Visual inspection	10	1	5	50	Consider combustibility sensor above process.	9	1	1	9
					Overflow of contents onto basin sump.	Visual inspection	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9

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				Seat seal failure	Venting of vapor to area other than intended vent termination.	Visual inspection	10	1	5	50	Consider combustibility sensor above process.	9	1	1	9
					Overflow of contents onto basin sump.	Visual inspection	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
HV	300	Inlet Valve - Settling Tank	Closed when should be Open	Operator error	Will not permit filling of settling tank / transfer of product. Pump blockage, increased pump work (PMP-100) and system pressure.	Visual inspection of sight tube or settling tank (LI-300). Pump work increase, audible change. Possible pump dead-end.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of other fluids to settling tank when not intended.	Visual inspection of sight tube or settling tank (LI-300).	7	5	3	105		7	5	3	105
			Leakage	Stem seal failure	Leakage of final product (BD or glycerin) onto basin / sump.	Visual inspection	7	1	3	21	Consider level sensor in sump to detect severe leakage.	7	1	1	7
				Seat seal failure	Routing of other fluids to settling tank when not intended.	Visual inspection of sight tube or settling tank (LI-300).	7	1	5	35		7	1	5	35
HV	900	System Drain Valve	Closed when should be Open	Operator error	Will not permit drainage of system, possible future blockages or spills.	Visual inspection of outflow, lack of flow. Audible change in pump if run during drain cycle.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	5	3	150	Consider level sensor in sump to detect severe leakage.	9	5	1	45
			Leakage	Stem seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
HV	950	Outlet Valve - Take Off for BD	Closed when should be Open	Operator error	Will not permit take-off of final products. Pump blockage, increased pump work (PMP-100) and system pressure.	Visual inspection of outflow, lack of flow. Audible change in pump.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	5	3	150	Consider level sensor in sump to detect severe leakage.	9	5	1	45
			Leakage	Stem seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
HV	975	Outlet Valve - Take Off for Glycerin	Closed when should be Open	Operator error	Will not permit take-off of final products. Pump blockage, increased pump work (PMP-100) and system pressure.	Visual inspection of outflow, lack of flow. Audible change in pump.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	5	3	150	Consider level sensor in sump to detect severe leakage.	9	5	1	45

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TYPE	#	FUNCTION	POTENTIAL FAILURE MODE	POTENTIAL CAUSES	POTENTIAL EFFECTS	DETECTION METHOD	SEN	OCC	DET	RPN	RECOMMENDED ACTION(S)	SEN	OCC	DET	RPN
			Leakage	Stem seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Routing of any process fluid overboard or to take-off termination. Likely spill onto basin / sump.	Visual inspection, audible spilling.	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
HV	200	Inlet Valve - Oxide Mixing Tank	Closed when should be Open	Operator error	Will not permit pump-driven mixing and circulation of alcohol oxide mix. Increased pump work (PMP-100) and system pressure.	Visual inspection, pressure increase on pressure gauge (PI-120) lack of intended flow. Audible change in pump operation.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid to the oxide mix tank when not intended. Possible routing of alcohol vapors to other portions of the system.	Visual inspection of sight tube of oxide mix tank (LI-200).	7	5	3	105	Consider combustibility sensor above process.	7	5	1	35
			Leakage	Stem seal failure	Leakage of oxide mix or alcohol onto basin / sump.	Visual inspection.	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	9	1	1	9
				Seat seal failure	Routing of any process fluid to the oxide mix tank when not intended. Possible routing of alcohol vapors to other portions of the system.	Visual inspection of sight tube of oxide mix tank (LI-200).	10	1	5	50	Consider combustibility sensor above process.	9	1	1	9
HV	100	Fill Valve - BD Reaction Tank	Closed when should be Open	Operator error	Will prevent filling of BD reaction tank. Pump work increase (PMP-100), system pressure rise.	Visual inspection of process sight tube (MI-100), audible change in pump operation.	7	5	3	105	Consider pressure relief at pump outlet with vent line referenced to containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid to the BD tank when not intended.	Visual inspection of BD tank sight tube (LI-100).	7	5	5	175		7	5	5	175
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	4	1	1	4
				Seat seal failure	Routing of any process fluid to the BD tank when not intended.	Visual inspection of BD tank sight tube (LI-100).	7	1	5	35		7	1	5	35
HV	105	Mix Inlet Valve - BD Reaction Tank	Closed when should be Open	Operator error	Will prevent mixing and recirc of BD reaction tank contents. Pump work increase (PMP-100) system pressure rise.	Visual inspection of process sight tube (MI-100), audible change in pump operation.	8	5	3	120	Consider pressure relief at pump outlet with vent line referenced to containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid to the BD tank when not intended.	Visual inspection of BD tank sight tube (LI-100).	7	5	3	105		7	5	3	105
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility sensor above process.	4	1	1	4
				Seat seal failure	Routing of any process fluid to the BD tank when not intended.	Visual inspection of BD tank sight tube (LI-100).	7	1	5	35		7	1	5	35

FMEA

Document name
FMEA - State Line Farm Biodiesel System

System Design Process

Date
1/2/2008

Issue
Final - Pre First Batch

Issued by

Approved by

Document status
Revision 1

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TYPE	#	FUNCTION	POTENTIAL FAILURE MODE	POTENTIAL CAUSES	POTENTIAL EFFECTS	DETECTION METHOD	SM	OC	DET	RPN	RECOMMENDED ACTION(S)	SM	OC	DET	RPN
HV	120	Main Mix Line Valve - Pump Pressure Side	Closed when should be Open	Operator error	Will prevent flow of process fluids from pump (PMP-100)	Visual inspection at process sight tube (MI-100), audible change in pump operation.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Routing of any process fluid to either BD tank or Oxide mixing tank when not intended.	Visual inspection at process sight tube (MI-100), BD tank sight tube (LI-100) or oxide mix tank sight tube (LI-200)	7	5	5	175		7	5	5	175
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	1	4
				Seat seal failure	Routing of any process fluid to either BD tank or Oxide mixing tank when not intended.	Visual inspection at process sight tube (MI-100), BD tank sight tube (LI-100) or oxide mix tank sight tube (LI-200)	7	1	5	35		7	1	5	35
HV	150	Isolation Valve - Pump Inlet	Closed when should be Open	Operator error	No flow, pump work increase, pump outlet pressure increase and suction pressure decrease.	Visual inspection, pressure increase on pressure gauge (PI-120) lack of intended flow. Audible change in pump operation.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Leakage of system contents during maintenance operation. Likely spill on containment basin into sump.	Visual inspection, leakage at point of intended line break (rapid detection).	3	5	1	15		3	5	1	15
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	3	12
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	1	4
				Seat seal failure	Slow leakage of system contents during maintenance operation. Likely spill on containment basin into sump.	Visual inspection, leakage at point of intended line break (rapid detection).	3	1	1	3	Consider having a plug / cap available for these fittings. Or do not work on system unless it is completely drained. Install a dedicated drain for this purpose?	3	1	1	3
HV	160	Isolation Valve - BD Reaction Tank Bottom	Closed when should be Open	Operator error	Will not draw tank down, pump over work, suction pressure on pump inlet (PMP-100).	Low outlet flow, pump work increase.	8	5	3	120	1. Review motor drive controls and also pump dead-head pressure ride. 2. Consider recirc loop for pump. 3. Consider pressure relief valve at pump outlet with vent line referenced to secure containment.	7	5	3	105
			Open when should be Closed	Operator error	Mix of air (empty tank) or reactor mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	5	5	175		7	5	5	175
			Leakage	Stem seal failure	Veg Oil Spill onto basin / sump	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4

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TYPE	#	FUNCTION	POTENTIAL FAILURE MODE	POTENTIAL CAUSES	POTENTIAL EFFECTS	DETECTION METHOD	SEN	OCC	DET	RPN	RECOMMENDED ACTION(S)	SEN	OCC	DET	RPN
					Reaction Mix Spill onto basin / sump	Visual inspection	10	1	3	30	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	9	1	1	9
					BD Spill onto basin / sump	Visual inspection	4	1	3	12	1. Consider level sensor in sump to detect severe leakage. 2. Consider combustibility senso above process.	4	1	3	12
				Seat seal failure	Mix of air (empty tank) or reactor mix with other parts of process when not intended.	Visual inspection by sight tubes and mixing indicator (MI-100)	7	1	5	35		7	1	5	35
HV	170	Level Indicator Valve - BD Reaction Tank Bottom	Closed when should be Open	Operator error	Unknown or inaccurate level or settling status	Visual Inspection	6	5	3	90		6	5	3	90
			Open when should be Closed	Operator error	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell, audible spilling.	10	5	1	50	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	5	1	45
			Leakage	Stem seal failure	Spill of alcohol or oxide mix onto basin / sump	Visual Inspection	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell.	10	1	1	10	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	1	1	9
HV	175	Level Indicator Valve - BD Reaction Tank Top	Closed when should be Open	Operator error	Unknown or inaccurate level or settling status	Visual Inspection	6	5	3	90		6	5	3	90
			Open when should be Closed	Operator error	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell, audible spilling.	10	5	1	50	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	5	1	45
			Leakage	Stem seal failure	Spill of alcohol or oxide mix onto basin / sump	Visual Inspection	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell.	10	1	1	10	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	1	1	9
HV	270	Level Indicator Valve - Oxide Mix Tank Bottom	Closed when should be Open	Operator error	Unknown or inaccurate level or settling status	Visual Inspection	6	5	3	90		6	5	3	90
			Open when should be Closed	Operator error	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell, audible spilling.	10	5	1	50	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	5	1	45
			Leakage	Stem seal failure	Spill of alcohol or oxide mix onto basin / sump	Visual Inspection	10	1	3	30	Consider level sensor in sump to detect severe leakage.	9	1	1	9
				Seat seal failure	Leakage of oxide mix or alcohol onto basin / sump during maintenance operation (rapid detection).	Visual inspection, smell.	10	1	1	10	Consider using on-body combustibility sensors (Crickets) during maintenance operations.	9	1	1	9
HV	370	Level Indicator Valve - Settling Tank Bottom	Closed when should be Open	Operator error	Unknown or inaccurate level or settling status	Visual Inspection	6	5	3	90		6	5	3	90
			Open when should be Closed	Operator error	Leakage of settling tank contents to basin / sump during maintenance procedure (rapid detection).	Visual inspection, audible spilling.	3	5	1	15	Consider level sensor in sump to detect severe leakage.	3	5	1	15
			Leakage	Stem seal failure	Leakage of settling tank contents to basin / sump.	Visual inspection	4	1	3	12	Consider level sensor in sump to detect severe leakage.	4	1	1	4
				Seat seal failure	Leakage of settling tank contents to basin / sump during maintenance procedure (rapid detection).	Visual inspection, audible spilling.	3	1	1	3	Consider level sensor in sump to detect severe leakage.	3	1	1	3

MAX	250	MAX	175
AVG	60.2	AVG	35.5
MIN	3	MIN	2