MeeFog TECHNICAL APPLICATION NOTE AN-GT-206

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Failure Modes Effects and Criticality Analysis (FMECA) for MeeFog™ Gas Turbine Inlet Fogging Systems.

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1. INTRODUCTION

FMECA (Failure Modes Effects and Criticality Analysis) is a bottom-up analysis of component-level failures and their effects on higher-level systems; it can be used to assist safety personnel to perform hazard analyses and supplement, not replace, hazard analyses. The FMEA in hardware/software systems such as the MeeFog Inlet Fogging System is an important technique for evaluating the design and documenting of the review process. All credible failure modes and their resultant effects at the component and system levels are identified and documented.

The analysis follows a well-defined sequence of steps that encompass:

(1) Failure Mode;

(2) Failure Effects;

(3) Causes;

(4) Severity Index,

(5) Probability Of Occurrence

(6) Criticality Index.

The comments section in the table provides information on delectability, and appropriate maintenance and operational aspects pertaining to mitigation of problems. A Failure Mode, Effects and Criticality Analysis is a procedure for identifying potential failure modes in a system and classifying them according to their severities. A FMECA is usually carried out progressively in two parts. The first part identifies failure modes and their effects (Failure Mode and Effects Analysis). The second part ranks failure modes according to the combination of severity and the probability of that failure mode occurring (Criticality Analysis). In this document, the tabulation contains both the failure mode and the criticality.

Two alternative approaches may be used when performing a FMECA - a functional approach or a hardware approach. The functional approach has been used in evaluating the MeeFog System considering major sub-systems in terms of their **function** within the system

1. SYSTEM UNDER CONSIDERATION

The system under consideration is a typical MeeFog Gas Turbine Inlet cooling System defined by the P&ID diagram shown in Figure 1. While the details of the components may vary slightly from project to project, the basic design philosophy and block functionality remains the same, thus allowing this FMECA to apply to all MeeFog Systems. This would apply to any high pressure fogging system regardless if the operating mode was evaporative cooling or over spray.

2. BASIC ASSUMPTIONS

The following basic assumptions are made in developing this FMECA.

[1] Gas Turbine inlet Air Filtration system is adequate to protect the gas turbine from the environment. Very often, poorly designed or degraded inlet systems can allow atmospheric contaminants even in the ppb range to <u>create severe acidic conditions at the inlet to the axial compressor</u>. This situation exists regardless if a fogging system is present or not, because when ambient conditions are at RH > 50%, the intake static temperature depression will result in water condensing at the bellmouth which can create an acidic condition. The situation is particularly important for 403 SS compressor blading and proper blade and stator coatings should always be considered.

[2] The analysis assumes that the recommended inlet duct drainage systems are installed and that all operating instructions are followed- i.e., never using the fogging system when intake icing conditions may occur (stop use at 60°F, never apply fog cooling at part load conditions, and never fog in conjunction with on-line water washing)

[3] The analysis also assumes that the client or third party HAS NOT MADE ANY CHANGES TO THE FUNDAMENTAL FOG SYSTEM DESIGN as supplied by Mee Industries. Modifications to pump speeds, piping manifolds etc, will VOID any warrantee and may nullify any results of this FMECA. This is because the system as designed in Monrovia has extensive safety factors built in, so as to obtain safe and reliable operation. Speeding up of pumps and other such actions should only be done after obtaining written permission from Mee Industries.

[4] It is important to note that the MeeFog System is designed to boost power and such its shutdown will not impair the mechanical operation of the base gas turbine unit. In this sense, it is not itself a critical component in the plant overall Availability. Further, most failure modes as indicated in the following Table, will result in partial operation of the fog system, i.e., all stages may not work but useable cooling potential will still be available.

[5] Items that could potentially damage the turbine include:

- Foreign Object Damage
- Excessively large water droplets
- Severe temperature distortion
- Slugging of water with improper operating duct drains and;
- Casing temperature distortion in the case of an over spray fog intercooling system.

Note: Electrostatic bearing damage has not been noted on MeeFog Systems with the moderate over spray levels used, but we are aware that this could be a potential problem (build up of static charges similar to the LP section of a Steam turbine which runs wet).

[6] Fog system must **NOT** be operated at part load conditions or under conditions where icing may occur. Further, the system should never be operated in conjunction with on line water washing.

[7] The FMECA is based on the assumption that ducts are in good condition and not already rusted and corroded. These conditions will have an adverse impact on gas turbine operation, regardless if fogging is used or not. Ducts must be appropriately painted, or be of SS 316L construction and not contain any galvanized metal parts. Silencers must be cleaned thoroughly prior to the use of fogging systems especially in retrofit applications as fog droplets can pick up fine dust and redeposit it in the compressor.

[8] Important safety considerations:

1. The MeeFog System must be operated by personnel who have a general understanding of gas turbine operation and good engineering practices.
2. Any changes to the control system, set points, or modifications to control parameters may void Mee guarantees and may cause damage to the turbine.
3. As part of the general O&M requirement is a visual walk around safety inspection of piping, connections and ensuring that the air inlet ducts are free of all foreign objects.
4. Know where the shutdown switches are and acquaint all operators with these.
5. When working on inlet nozzles of non-operating gas turbine always lock out start circuit to avoid any inadvertent start of the gas turbine.
6. Always check for zero system pressure <u>before</u> disconnecting any system lines.
7. Stand clear of all pressure lines and fittings during first start.
8. Always use good engineering practices during operation. If in doubt please contact Mee Industries Inc.
9. The demineralized water supply for gas turbine inlet fogging must meet the Gas turbine's OEM specification for <u>on-line</u> water washing and/or combustion injection water quality.
10. The condition of the duct must not be deteriorated- problems such as rusting, corrosion etc can be washed into the turbine by the fogging system.
11. Ensure that there are no galvanized materials present in the airflow path after the fogging manifold system.
12. The fogging system must ONLY be operated at Base load conditions. Do not operate the fog system at part load conditions.
13. Never operate the fogging system in conjunction with on-line water washing.
14. Never operate the fog system without continuous drains in the duct and bellmouth floor. (See MeeFog Drain Drawing for details).

3. EVALUATION CRITERIA

The following qualitative framework has been used

Tabulation for Severity Evaluation Criteria

IMPACT OF EFFECT	DESCRIPTION	SEVERITY
Hazardous- without warning	Potential Failure mode affects safety of system/ potential damage to Gas Turbine	5
Hazardous – with warning	As above but system can detect problem	4
High	MeeFog System is Inoperable (total shutdown)	3
Moderate	MeeFog System is partially operable	2
Low	Defect is of nuisance value- noise, rattle etc	1

Tabulation for Probability of Failure

Failure Occurrence	P (Failure)	RANK
Very High Failure- almost inevitable	0.5-0.7	5
High Repeated Failures	0.125-0.05	4
Moderate Occasional Failures	0.0125- 5E-4	3
Low Relatively few failures	6.66E-5 – 6.66E-6	2
Remote – Failure is unlikely	2E-6	1

Please note that these are subjective qualitative numbers to indicate a feel for the situation.

CRITICALITY INDEX [CI] = (S) x (P)
CI range is 1-25

For overall Criticality, the following classification is used:

CRITICALITY	RANGE OF CRITICALITY INDEX
High	**CI >/= 9**
Moderate	**6< CI < 8**
Low	**CI < 6**

EVENTS THAT CAN CAUSE TURBINE DAMAGE WILL BE FLAGGED AS "TD" IN THE CRITICALITY COLUMN

FMECA TABULATION

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
1.0 NOZZLE MANIFOLDS AND PIPING						
1.1 Fog Nozzles	Nozzles plug due to high colloidal silica content or dirt in water or due to skid inlet filter deterioration	Flow through nozzle will decrease. If several nozzles are plugged, that section will put out low flow.	2	2	4, LOW. If only one section is plugged small possibility of compressor inlet air temperature distortion.	This is a rare occurrence because of the high pressures involved, the required high water quality and the filtration that is done to 0.3 microns. Maintenance procedures for the skid inlet 0.3 micron line filter avoids this happening.
1.2 Fog Nozzles Orifice	Orifice diameter erosion	Improper fog plume, Slightly increased droplet diameters	2	2	4, LOW	This will not occur with proper demin water supply and increased flow rate will reduce pressure and shut down the pump.
1.3 Fog Nozzle tie wire	breaks	Tie wire can get ingested into gas	2	1	1, LOW	Size of the tie wire is so small that no damage would occur-

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
		turbine-				also due to the low velocity region of the nozzle manifolds, the wire would drop to the floor.
1.4 Fog Nozzle assembly	breaks loose	Possible FOD incident if the nozzle can be transported to the axial compressor inlet by airflow. Due to the low L/D ratio and weight, the airflow velocity should not cause this to happen unless over spray nozzles are present in high velocity region of duct close to bellmouth.	4	1	4, LOW	No FOD incidents have occurred on MeeFog turbines (Aprox 400 gas turbines with MeeFog Systems) For nozzle assembly to come loose, the tie wire would have to break and the nozzle to rotate and threads to disengage. This is unlikely as any flow induced vibration would be damped by the interior nozzle o-ring seal.
1.5 Fog Nozzle 40 micron Filters (special filter within Nozzle body)	Plug	Nozzle flow drops	2	1	2, LOW	If this is isolated situation, then there will not be a problem. If a series of nozzles block that are connected to one pump

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
						temperature stratification may result Nozzle filter lockage can occur when pump plunger seals wear and should be corrected.
1.6 Impaction Pin	Breaks	Impaction pin may get transported to GT and ingested.	2	1	2, LOW	Studies have shown that the only way a pin can be physically broken from the nozzle is to hold it in pliers and physically fatigue it by repeated plastic bending . There is no naturally occurring situation where the welded impaction pin can break, The Margin of Safety on the forces developed by the orifice jet on the pin are several times below the stress limit for combined static bending and tension for the impaction pin.
1.7 Impaction Pin	Permanent Deflection	Nozzle spray plume changes and droplet	1	2	2, LOW	Deflection during system operation is not possible.

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		sizes increase. This failure mode only affects at most, a few nozzles (see comments)				Deflection during installation is possible IF procedures are not followed and the protective caps on the nozzles are removed prior to completion of the installation and final inspection.
1.8 Gyrolock Fittings	Leak	Loss of water	1	1	1, LOW	This should not occur with proper installation. Leaks can be detected visually and are caught during the commissioning phases.
1.9 FeedlineTubing from Skid to Duct or Manifolds within duct.	Breakage or rupture	Partial Flooding of the Duct until pump shutoff.(this would occur within seconds) Loss of water	4	2	8, MODERATE	Breakage or rupture will result in immediate shut down of the pump due to immediate loss in pressure.
1.10 Manifold array in intake duct	Catastrophic Failure due to	Gas turbine FOD	5	1	5, LOW Possible TD.	Computational models are used to review the design to avoid

COMPONENT	**FAILURE MODE**	**EFFECT**	**SEVERITY EVALUATION**	**PROBABILITY INDEX**	**CRITICALITY FACTOR**	**COMMENTS**
	flow induced vibration (vortex shedding)					excitation and natural frequencies caused by flow induced vibration. Basic manifold system rigidity and damping of Vibrasorb fixtures and the low energy level of the driving frequencies make this mode very unlikely.
1.11 Drains in Duct (Flapper Valve Type)	malfunction	Excessive water in ducts- can get transported to axial compressor in large droplets	5	2	10, HIGH TD possible if extreme water transport occurs.	It is imperative that proper continually operating drains be employed at the intake duct at locations suggested by Mee Industries. (See Mee Drain Dwg) Some water fallout is expected with any fogging system, of the order of 2-10%. Viewing windows at nozzle manifold array location are highly recommended.

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
1.12 Drains in Intake Plenum (at bellmouth). Flapper Valve Type.	malfunction	Water collection in intake plenum to bellmouth	5	2	10, HIGH TD	Excessive collection of water in intake system can be dangerous as it may get ingested due to vortex flow into the compressor in a slug. This must be avoided at all costs. Continuous bellmouth floor drains with flapper valves must be employed to avoid this and viewing windows are recommended.
1.13 Drains (P-Trap Type)	P Trap type run dry	Loss of water seal will cause unfiltered air to enter due to static pressure depression in the intake duct.	2	3	6, MODERATE	Maintenance procedures must be instituted to ensure drains operate properly and if seal legs exist that they are full of water. Preference is given to Flapper type valves which are not affected by loss of water. (See Mee Drain Dwg)
1.14 Skid Inlet Water Pressure Regulator	malfunction	On supply systems exceeding 60 psi a	5	1	2, MODERATE	Seal damage can occur from excessive inlet pressure (60 psi

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		pressure regulator is required. Failure of the regulator can allow main supply pressure into the pump inlet.				or more). Seal particles can then go downstream and block the nozzle filters. The resulting increase in pump bypass flow can cause overheating of the pump, causing further seal damage and a runaway failure of the pump.
1.15 Overall piping and nozzle system	Water Freezes in Piping or fittings	Breakage of piping and Manifolds	4	3	12, LOW	This can and does happen when plants do not follow cold weather procedures for draining and purging the MeeFog System. The pump system will shut down in 30 seconds thus max water release is 3 gallons.
1.16 Overall duct system and connecting piping	Growth of anaerobic bacteria during idle periods.		4	1	2, LOW	Stagnant water will cause the growth of anaerobic bacteria particularly if iron ions present. It is important that the MEE

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
						recommendations relating to preservation during idle periods be followed.
2.0 MeeFog SKID						
2.1 Water Supply System (Customer scope)	Loss of water supply (partial)	Skid will operate degraded to the number of stages that is possible	2	1	2, LOW	This is a very rare problem. It does not represent a critical situation in that if water flow is too low, inlet pressure drops and the skid will shut down.
2.2 Water Supply System	Loss of water supply(full loss)	Skid Shutdown	2	1	2, LOW	Low pressure sensors will detect loss of supply pressure to skid and shut it down.
2.3 Water Supply System	Loss of water quality integrity	Fouling of Axial flow compressor, hot section corrosion, sulphidation. Etc. THIS IS A SERIOUS ISSUE.	5	2	10, HIGH TD	It is imperative that the customer supply water to the Gas Turbine OEMs on line water wash and/or combustion injection water specification? (Injection water?). Customer should conduct ongoing program of

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
						tests to ensure water quality us maintained. NO CARBON STEEL OR GALVANIZED FITTINGS SHOULD BE USED IN THE SUPPLY LINE.
2.4 Ball valve [BV] after skid water inlet connection point	Closes due to control problem?	Shut down of the specific CAT Pump	2	1	3, LOW	This valve is designed to close when the permissives request it i.e., in the event of under pressure etc when the pump would be shut down
2.5 Drain Valve [DBV]- located upstream of filter	Open	Trip of skid system	3	1	3, LOW	This valve is for use for maintenance only and should be kept closed.. Opening this valve during operation will immediately cause a shutdown as the PLC will sense loss in inlet pressure.
2.6 Low Pressure Water Filter System	Filter plugs partially	Filter pressure drop increases	1	2	2, LOW	Moderate increase in filer pressure can be accommodated till the degradation reaches critical at which point the low

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
						pressure alarm at the PLC OIT will trigger. At this point corrective action can be taken
2.7 Low Pressure Water Filter System	Loss of Filter integrity(media damage)	If severe will cause pump damage and nozzle filter plugging	4	1	4, LOW	Use Filter replacements provided by MEE.. Total breakdown of the inlet supply line filter is exceedingly rare unless damaged upon installation.
2.8 Pressure Indicator (PI) upstream/ downstream of the Filter	Bourdon Tube rupture	Filter pressure drop not known	1	1	1, LOW	These are extremely rugged units and rarely fail. If they do, low inlet pressure sensor will shut down skid.
2.9 Pressure Indicator (PI) upstream/downstream of the Filter	Inaccurate reading	Filter pressure drop not known	1	1	1; LOW	As above 2.8
2.10 Flow Transmitter (FT)	Failure	If signal is totally out, the PLC will indicate, If reading is wrong, system keeps operating.	2	2	4, LOW	PLC will report failure as flow over range, No effect on fogging water flow computation.
2.11 Common Drain Valve (DBV) on inlet header	Fails open or is left open-	Trip of system due to low inlet pressure	3	1	3, LOW	Almost impossible event as this has to be manually opened and

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
	and blind flange removed					blind flange removed during system operation by deliberate action. Other than shutdown of the MeeFog System , no other impact will be derived.
2.12 Solenoid Valve (SV)	Coil burns out	Valve will close causing LP switch to shut down pump.	3	2	6, MODERATE	This is normally closed, and is energized to open. Failure mode would enable partial operation with other pump stages in operating.
2.13 Low Pressure Pump Outlet Switch (LPS)	Indicates normal pressure when pressure is too low	If problem persists for a time, the outlet high pressure sensor will shut down the pump.	2	2	4, :LOW	This switch is normally closed., Failure mode would enable partial operation of fog system with other pumps
2.14 Low Pressure Switch (LPS)	Incorrect electrical connection	Would not permit initial startup	1	1	1, :LOW	Wiring is checked prior to ship out and prior to system startup at site – see inspection checklists.
2.15 Flexible Hose (FH)-upstream and downstream of	Rupture	Shut down of pump	4	1	4, LOW,	Hose rupture is practically impossible as inlet water

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
the CAT pump						pressure is controlled in (20-60)psi range and inlet temperature below 130F.
2.16 CAT Triplex Pump	Slipping Belt	Pump flow and eventually outlet pressure will drop		4	1 LOW	If flow drops below 70% or pressure drops below 1500 psi the pump is shut down
2.17 CAT Triplex Pump	Worn Valves and Seals	Reduced outlet pressure	1	2	2 LOW TD	Replace with valve and seal kit. This is exceedingly rare with peaking operating turbines and with good fog system maintenance practices. See Manual for seal life limits at prescribed inlet pressure requirements.
2.18 CAT Triplex Pump	Total mechanical failure	MeeFog system will continue to operate without one or possibly 2 stages.	2	2	4, LOW	Pump would have to be replaced. Depending on configuration, we may recommend the stocking of spare pumps. Cat pumps as sized by MEE industries meet very

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
						conservative design requirements in terms of the flow and speed ranges. On no account should users attempt to " adjust' Speeds.
2.19 pump High Pressure Regulator (BPR)	Does not relieve pressure	Over pressure of manifolds until pressure switch trips pump	3	2	6, MODERATE	Rare occurrence
2.20 Pump high Pressure Regulator (BPR)	Fails normally open	Bypasses excessive flow to pump inlet side.	3	2	6, MODERATE	Rare occurrence. Low pressure switch may shut down pump.
2.21 Pump High Pressure Regulator (BPR)	Regulator unstable and cycles	Will cause unstable flow conditions	2	2	4, LOW	When this happens, the underlying cause is probably air in the system or worn pump seals that causes erratic pressure manifesting itself as an unstable regulator.
2.22 Pressure Regulator (BPR)	Does not come up to pressure	Control problem noted during commissioning	2	2	4, LOW	Can be caused by use of excessive torque during adjustment and or foreign material under seat.
2.23 Pressure Regulator (BPR)	Leakage from	No major effect	1	1	1, LOW	Caused by worn o-ring around

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
	regulator vent hole					regulator piston
2.24 Pulsation Dampener	Total failure	Increased pulsations and flow induced vibration	2	2	4, LOW	Damper should be replaced.. Depending on the configuration, increased pulsation may or may not be evident in the piping from skid to gas turbine inlet duct.
2.25 Pulsation Dampener	Partial failure due to loss of charge	Increased pulsations and flow induced vibration	2	2	4, LOW	Maintenance procedures call for recharging at 75% if system operating pressure. Must be checked regularly if continuous fogging is being done.
2.26 Pressure Indicator (PI) downstream of pressure dampener	Fails totally	System keeps operating	1	2	2, LOW	Change at next maintenance.
2.27 High Pressure Switch (HPS)	Out of Cal and indicates no pressure or low pressure when pressure is too high	Minimal effect as the pressure relief system will relieve the pressure	2	2	4, LOW	Change at next maintenance.

COMPONENT	FAILURE MODE	EFFECT	SEVERITY EVALUATION	PROBABILITY INDEX	CRITICALITY FACTOR	COMMENTS
2.28 TEFC Motor	Total motor failure	Particular Pump stage will not operate.	2	2	4, LOW	There are several predictors of motor failure including current analysis, vibration etc.
2.29 TEFC Motor	Fan plugs up and motor overheats	Can cause pump overheating and shorten life	2	2	4, LOW	
2.29a TEFC Motor/drive	Does not start or stalls/hums	Pump stage will not be operational	2	2	4, LOW	Problem is usually related to wrong wiring for the incoming voltage or loose or dirty connections in the junction box.. This is fully tested at the FAT.
2.30 TEFC Motor/drive	Belt slippage	Pump performance may be affected, if pressure drops droplet sizes may increase	2	3	6, Moderate TD.	Mitigated by proper inspection procedures. Note that the pressure regulator will compensate to a point.
2.31 TEFC Motor/drive	Pulley key shears	Pump stops and cooling stage is lost	2	1	2, LOW	This is a very rare outcome.

3.0 CONROLS AND INSTRUMENTATION & ALGORITHMS						
3.1 Weather Station	Total failure	Skid Shutdown	3	2	6, LOW	
3.2 Weather Station	Temperature/ Relative Humidity inaccuracy-	If RH/T is underreported to actual- system can inject more water than design. IF RH/T is over reported, under spray can occur	5	2	10, HIGH TD	Turbine damage can occur if there are gross errors so causing significant over spray. Problem will be compounded if compressor is excessively fouled or intake filter system of gas turbine has excessively high Delta P. REGULAR CALIBRATION IS OF SUPREME IMPORTANCE..
3.3 Weather Station	Total Failure	MeeFog System will be shut down	3	2	6, Moderate	Weather station will have to be replaced or repaired prior to skid operation
3.4 Weather Station	Reports wrong temperature not representative of gas turbine inlet conditions due to mis location	Depending on the location of the weather station with respect to the gas turbine or other site specific factors, this can cause over spray	5	2	10, High	Care should be taken to locate the weather station out of the direct sun and also away form sources of temperature variation (example near exhaust of fan or near heat exchanger etc.)
3.5 PLC malfunction	Total failure of PLC	Shutdown of the MeeFog System	3	2	6 LOW	Total skid shutdown.
3.6 PLC Malfunction	Software	Glitches in operation	3	1	4, LOW	Software self checks can

	problem					minimize problem. Sometimes loss of power can create problems during extended shutdowns is power is fully cut to the skid.
3.7 PLC User Editable Parameters	Unauthorized or wrong modification of USER parameters **Max overcool**	Wrong setting of this parameter can cause excessive over spray. Factory default is 0°F	4	2	8, MODERATE TD	The system is shipped with certain default values. If users elect to modify these values, there is a possibility of over spray application.
3.8 PLC user editable parameters	Wrong setting of: • Staging delay • Minimum WBT • Delay parameters for in/Out low pressures • Low flow set point	Gross user modifications of these parameters can degrade the safety of the system. The only problem from a Turbine standpoint is the minimum WBT (Icing considerations)	3	2	6, MODERATE.	User must be adequately trained in the meaning of the parameters and be told of the consequences of modifications.
3.9 Control Wiring	Damage or failure	Degradation /Shutdown of the skid	2	1	3, LOW	Visual checks can be done and this is exceedingly rare.
3.10MCC, fuses, open circuit, grounded wires, loose connections	Failure	Skid will not operate/ partially operate depending on specifics	2	2	4, LOW	PLC can report motor status.

FIGURE 1- SCHEMATIC OF TYPICAL MeeFog System.