Lesson Learned

Plant Instrument and Sensing Equipment Freezing Due to Heat Trace and Insulation Failures

Primary Interest Groups
Generator Owners (GO) Generator Operators (GOP)

Problem Statement
During an extreme winter weather event, a Combined Cycle Gas Turbine (CCGT) plant (5 units available/1200 Mw) had units which failed to start or tripped numerous times due to frozen instrument transmitters and instrument sensing lines within the plant. The subsequent loss of generation and reliable operation contributed to the balancing authority and reliability coordinator having to shed load.

Details
The CCGT plant was designed to operate at a minimum ambient operating temperature of four degrees (F). Before the event, due to the weather forecasts, the plant officials held meetings to discuss the impending cold weather and additional personnel were called in to assist with any impending issues as they arose. The plant personnel verified all *heat trace equipment was functioning and ensured all insulation was in place. The area experienced extreme cold weather with temperatures in the single digits and wind chill factors below zero. This combination of frigid temperatures and continuously blowing wind removed heat from critical instrumentation and instrument sensing lines. Insufficient insulation and failed heat trace were major factors in the freezing of critical sensing and transmitting equipment. The equipment freezing caused numerous automatic and operator initiated shutdowns of Combustion Turbines (CTs) and Gas Turbines (GTs) as well as preventing numerous units from starting. The following is a partial list of the frozen equipment which froze and the resulting effect.

- Low pressure drum level transmitter sensing lines froze, which led to a failed start.
- GT combustor pressure transmitter sensing lines froze, which led to a failed start.
- GT economizer inlet valve and associated piping froze, which led to a failed start. This start was attempted after the unit tripped due to high cooling air temperatures as the flow of cooling water was restricted by frozen components.
- High pressure (HP) Steam Attemperator Flow Transmitter sensing line froze, which led to equipment protective events when the attemperator was driven to 100% open and flooded the condensate drain system.
- HP feed water pump Net Positive Suction Head (NPSH) sensing line froze, which caused a trip of the HP feed water pump.
- Condensate tank levels and drain pot levels froze as a result of the heat trace processor for the condensate system malfunctioning. The heat trace processor was providing control of the amount

of heat which was being applied through the heat trace and the processor failure resulted in various heat trace components functioning improperly. A unit tripped as a result.

- GT combustor pressure transmitters sensing lines froze, which led to automatic protective actions tripping a unit.
- Pressure line to the GT auxiliary enclosure fire protection system froze and ruptured, causing the fire protection system to activate.
- Water from the fire protection system, which had been incorrectly activated, entered the valve positioner causing the Sequential EnViromental (SEV) fuel gas control valve to register an incorrect valve position, which resulted in a unit trip.

The plant personnel performed short term actions to repair the problems, including placing tarps, space heaters, and additional insulation in locations to protect instrumentation and equipment as required. Additionally, extra staff was brought in to help, resulting in four units being brought back online later during the same day after the morning peak and one unit back online the next day

Corrective Actions

The Generator Owner/Operator performed a review of the components that experienced problems during the winter event. Identification of the failure mode was performed and it included the following categories – insulation, heat trace, heaters, heated box enclosures, etc. A corrective action plan was implemented to mitigate these problems for future cold weather events.

Lessons Learned

- Appropriate considerations should be given to the potential effects of wind in removing heat from equipment.
- The cooling water system, if possible, should be bypassed during severe cold weather events to mitigate freezing.
- It is necessary to purge transmitter sensing lines inside of the GT enclosure prior to winter weather events to make sure there is no condensation build up which could freeze.
- Before winter season, identify unit-specific critical freeze protection areas and the corresponding work needed to decrease the likelihood of long duration freeze impacts.
- Plants should have in place emergency operation plans which adequately address procedures to operate the units in freezing weather conditions with the potential loss of critical instrumentation.

Heat Trace Equipment

- Perform a complete evaluation of all heat trace lines, heat trace power supplies including all breakers and fuses and associated control systems to ensure they maintain their accuracy. This inspection should include checking for loose connections, broken wires, corrosion, and other damage to the integrity of electrical insulation which could lead to the heat trace malfunctioning.

- Where feasible, install additional heat trace circuitry metering to provide more efficient verification and monitoring of circuit integrity. Frequent monitoring of heat trace circuit integrity and protective equipment temperatures are keys to early identification of potential freezing issues during severe cold weather conditions. This active monitoring of heat trace temperatures also prevents "boiling out" of sensors and pipes, e.g. critical fluid filled sensor lines.
- Heat tracing that is modified, such as adding parallel circuits to provide additional coverage, can present problems. Testing has found that although the circuits passed continuity tests, one or more legs of the parallel circuitry (which is often covered with insulation) may fail. The partial failure can result in sub-optimal protection.
- The effect of wind should always be considered in applying heat trace and in the application of insulation.
- The amperage and voltage for heat trace circuits should be calculated. The circuits should be tested to determine whether the circuits are still producing the design output. Repairs should be made to the circuits as needed.
- The useful life of the heat trace equipment, in accordance with the manufacturer's recommendations, should be used in the routine preventative maintenance and replacement plan or schedule.

Insulation

- Before winter begins, all accessible thermal insulation should be inspected to ensure it has not reached the end of its useful life and verified that there are no cuts, tears, or holes .After maintenance on equipment, all insulation designed or intended for the equipment should be evaluated to insure it meets the original specifications and was correctly re-installed.
- Valves and valve connections should be insulated to the same temperature specifications as the piping connected to the valves.

* Heat trace or electric trace heating, also known as heat tape or surface heating, is a system used to maintain or raise the temperature of pipes and vessels. Trace heating takes the form of an electrical heating element placed in physical contact along the length of a pipe. The pipe must then be covered with thermal insulation to prevent heat losses from the pipe. Heat generated by the element then maintains the temperature of the pipe. Heat trace may be used to protect pipes from freezing, or to maintain process temperatures for piping that must transport substances that solidify at low ambient temperatures. Electric trace heating cables are an alternative to steam trace heating where steam is not available or unwanted.

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