Combined Cycle Trips Due to Lean Combustion

Primary Interest Groups

Generator Owners (GO), Generator Operators (GOP)

Overview

Multiple issues have been reported with combined cycle unit trips while operating at or near minimum load when a frequency disturbance occurs.

Details

Event #1

1. A Generator Operator identified the cause of trip for a combined cycle gas turbine unit was due to exhaust temperature spread while loaded at 35% of nameplate. The combined cycle unit was operating in a 2x1 combined cycle mode with both combustion turbines operating near minimum load on AGC. The combustion turbine-generator tripped on exhaust temperature spread caused by flameout of one or more combustion cans. The combined cycle unit trip coincided with a frequency disturbance event initiated by the trip of another large unit.

Event #2

2. A Generator Operator identified the cause of a trip for a combined cycle gas turbine unit was due to exhaust temperature spread while loaded at 43% of nameplate. The combined cycle unit was operating in a 1x1 configuration and in local setpoint (not in AGC) at minimum load. The combustion turbine (CT) unit experienced a lean flameout/blowout causing a high exhaust temperature spread condition which resulted in a unit trip. The CT unit trip in turn resulted a trip of the steam turbine. These unit trips coincided with a frequency disturbance caused by unit trips at two other facilites located within the ERCOT Region.

Corrective Actions

Event #1

The turbine was designed to operate with a lean combustion to maintain low emissions. Due to the lean combustion operation, the turbines may experience lean combustion blow out incidents. Post-event analysis by the Entity indicates that the unit trip was caused by a confluence of three factors:

1. Review of control system data indicates that the unit turbine fuel temperature control valve was operating erratically in the hours prior to the trip. This erratic operation contributed to operation operated normally upon re-start and has continued to operate without incident. The underlying cause of the erratic valve operation prior to the trip could not be determined. The controller tuning parameters were reviewed and adjusted to ensure proper operation.
2. Recent changes in ambient conditions contributed to unstable air/flow control.

3. A system frequency disturbance caused by the trip of another large generator introduced additional instability into the fuel/air flow control as the unit's speed changed a lot more than normal which changed the actual airflow to the unit.
4. The Entity is also evaluating the feasibility of adding an alarm to alert operators to potential excessive fuel-gas temperature deviations.

Event #2

The turbine was designed to operate with a lean combustion to maintain low emissions. Due to the lean combustion operation, the turbines may experience lean combustion blow out incidents. Post-event analysis by the Entity indicates that the unit trip was caused by several factors:

1. Review indicates that the unit automatically responded to the change in system conditions by raising load approximately 10 MWs. The unit was not operating on AGC at the time of the trip.
2. As noted in a technical letter from the turbine manufacturer, these types of units have experienced single chamber lean blow-outs (flameouts) due to cracking at the forward (round) end of the impingement sleeve of the transition piece. The manufacturer's root cause analysis has determined that one possible cause of this type of cracking is excessive gaps between the wear pads and the transition piece forward sleeve. Cracks in these locations can result in an increase in airflow for the affected chamber and a lean blow out event. A borescope inspection must be performed to inspect these areas.
3. Recent changes in ambient conditions may have contributed to unstable air/flow control (tuning). The controller tuning parameters were reviewed and adjusted to ensure proper operation.
4. The combustion turbine control system was re-tuned to improve combustion system stability.

Lessons Learned

Multiple issues have been reported with combined cycle unit trips while operating at or near minimum load when a frequency disturbance occurs. Lean combustion blowout is a known and documented characteristic of certain types of combustion turbines due to their lean fuel/air mixture ratio design operating parameter. While this lean fuel/air mixture ratio design contributes to very low emissions, the risk of lean flameouts increases.