Insight: Steam Turbine Mechanical Overspeed Trip Devices

Outdated Mechanical Trip Devices Should be Replaced!

Recognizing the Risk

The steam turbine overspeed event occurs when little or no energy is being consumed by the driven equipment, whether a generator, pump or compressor, and too much steam is provided to steam turbine. In these situations, speed increases rapidly above the design operating speed in such a manner that a unit is driven to the point at which internal rotating components yield strength is exceeded resulting in catastrophic failure. Overspeed loss events are the costliest equipment breakdown failure scenarios and require the longest repair time frames.

All steam turbines have overspeed systems. In the simplest form the overspeed protection system must detect when operating speed is exceeded by a designated percentage (often 10% to 13%) and must initiate successful closure of all valves to isolate any and all potential steam energy sources.

On older steam turbines the overspeed trip speed sensing and trip initiation was strictly by mechanical and hydraulic means with the key component being the "mechanical overspeed trip" device. The mechanical overspeed device typically consists of a spring-loaded piston (bolt) mounted in a shaft, typically screwed or bolted to the front of the turbine rotor. When turbine speed reaches an overspeed condition (i.e., 10% above running speed), the centrifugal force on the bolt overcomes the spring force, the bolt moves out and hits a lever which moves the oil dump valve causing depressurization of the oil supply to all steam valves. This results in all valves immediately closing.

Risk exposures associated with a mechanical overspeed trip device:

- The mechanical device has many moving parts that can malfunction. In some cases mechanical trip devices have failed to initiate a trip, resulting in an overspeed failure.
- The mechanical trip device is not precise and trip initiation speed can vary. Worn components, debris on operating cylinders can impact the speed at which the unit trips. This often results in multiple tests as the spring is adjusted to obtain the correct setting.
- The only way to accurately test mechanical trip systems is to increase turbine speed to trip speed. This operational activity is risky and exposes rotating components to much higher stress loadings. Failures have occurred during overspeed tests due to the increased stresses applied. Because the failure occurs at a higher speed the damage is greater than if the unit failed at operating speed.

Risk Mitigation

In recent years electronic overspeed trip devices have become popular. Electronic systems are more accurate and measure rotational speed to within 0.1%. They also have less mechanical moving parts that could wear and/or malfunction. The risk of failure is reduced significantly with an electronic trip system. An Electric Power Research Institute (EPRI) study on trip devices concluded the risk of failure with an electronic trip system is less than the risk of failure with a mechanical trip system.

Recommendation

If your steam turbine has a mechanical hydraulic overspeed trip device, it is recommended the overspeed trip device be replaced with an electronic overspeed system.

Compliance

Should the owner decide to replace the mechanical overspeed device with an electronic, the system should comply with the requirement of American Petroleum Institute (API) 670 R(2010) - 2000 Machinery Protection Systems, Fourth Edition and International Organization for Standardization (ISO) 10437 2003 Petroleum, petrochemical and natural gas industries - Steam turbines - Special-purpose applications Section 1.1 Turbine Shut Down Systems.

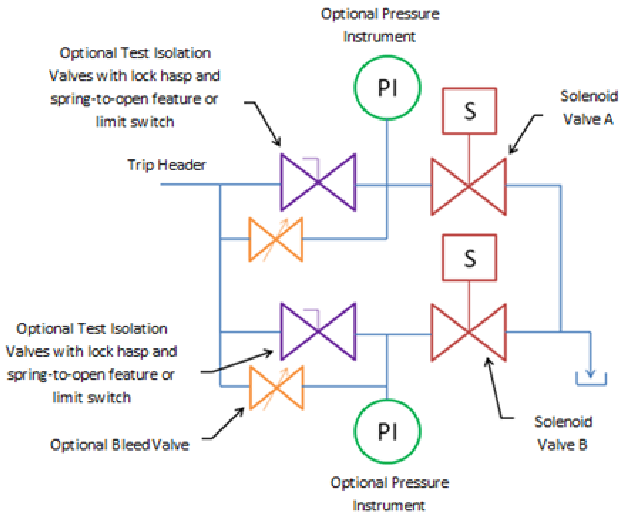

Figure 1 Recommended Trip Configuration

Electronic System Requirements

The following installation requirements should be followed when a trip system is upgraded to an electronic system.

- The trip system must be independent of other control systems.
- Trip system must not be jeopardized by a single failure of any one component or power source.
- Trip solenoids must be “deenergized” to trip.
- Trip system must be installed in a keyed & locked cabinet. (Only trained personnel are allowed access)
- Trip system processor function must not rely on a forced ventilation system that could be lost by fan failure or power outage.
- Signal cables and power supply cables must be installed separately on separate paths. Power supplies must be fed from separate sources.
- Trip system must be pretested prior to operation of the unit to prove it is fully functional before start up.
- System software and configurations must be pass word protected.
- System software and configurations must only be accessed by trained personnel.
- System must be tested quarterly at a minimum.
- The mean time to repair a system is fixed to 8 hours. (Access to trained personnel within 2 hrs.)
- An exchange module set must be available on site. (sensor, configured channel module, power supply)
- It is recommended that the existing mechanical trip device be disabled or removed. However, leaving it in place is acceptable.
- Sufficient training must be provided to all operators.

References & Resources

API 612, 2005 Petroleum, Petrochemical and Natural Gas Industries-Steam Turbines-Special-purpose Applications, Sixth Edition

API 670, R(2010) - 2000 Machinery Protection Systems, Fourth Edition

ISO 10437, 2003 Petroleum, petrochemical and natural gas industries - Steam turbines - Special-purpose applications

For more information, contact your local AIG Risk Engineer.