Insight: Steam Turbine Valve Risk Exposure

Steam Turbine Valves must be Considered Safety Critical

Recognizing the Risk

Steam turbine valves are typically so reliable they are often overlooked. However, the inspection and maintenance of these valves is critical. Failure to perform timely inspections and maintenance can lead to the total destruction of a steam turbine generator as a result of a valve not functioning and closing as required. Failures due to untimely valve maintenance include:

- Erosion, and in some cases, failure of the valve stems due to solid particle erosion
- Failures of the main steam stop valve screen or strainer
- Oxides build up on valve stems resulting in stem binding prior to full closure
- Valve stems distorting and bending resulting in binding prior to closing
- Operating hydraulic system debris and contamination build up
- Operating hydraulic oil system leaks
- Valve linkage wear and binding
- Valve seat cracking and liberation

A total destruction of the steam turbine can occur if a valve fails to close when the unit is tripped and driven equipment is no longer loaded. This is called an overspeed event and is the worst failure scenario for a steam turbine. Overspeed events not only cause very large or total destruction of the steam turbine generator, but in most cases, fire and extensive resultant damage likely follows. Overspeed events occur when little or no energy is being consumed by the driven equipment, whether a generator, pump or compressor, and even a small amount of steam is provided to the steam turbine. In these situations, rotation increases rapidly above design operating speed and in a matter of seconds the steam turbine generator's internal rotating components yield strength is exceeded, resulting in catastrophic failure.

On all steam turbines there are fast acting steam isolation valves capable of immediately terminating steam supply to the turbine. These main steam valves permit steam entry into the high pressure (HP) turbine and are referred to as main steam stop valves, throttle valves, or steam trip valves. Similarly, if the turbine also has a reheated steam supply, intermediate pressure (IP) turbine intercept valves are provided to isolate the steam turbine from steam stored in the reheater and associated piping from the boiler. Included in steam turbine key isolation valves are extraction check valves or non-return valves dedicated to steam turbine extraction applications which isolate the turbine from a reverse flow of steam or water energy sources. If any of these key isolation valves fail to close an overspeed situation is unavoidable. For this reason main steam stop valves, throttle valves, intercept and extraction non return valves must be considered "safety critical".

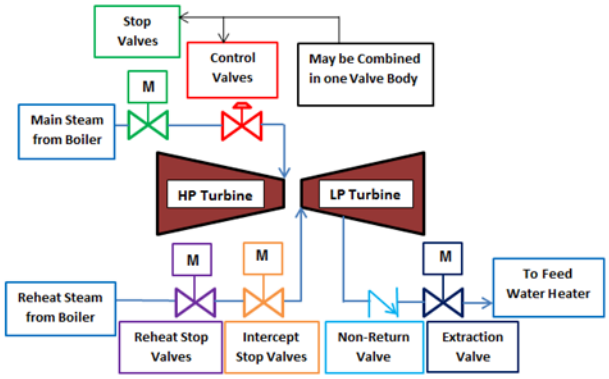

Figure 1 Typical Steam Turbine Valve Layout

In today's increasingly competitive energy market, major turbine inspection intervals have been extended. In some cases, maintenance planners or plant operators also extend turbine valve inspection and maintenance to coincide with turbine major inspections. This has often resulted in valve failures and steam turbine overspeed events, some of which have been catastrophic. Risk exposures associated with untimely or improper steam turbine valve maintenance include:

- Downstream steam path damage due to debris and solid particle erosion
- Oil leaks resulting in fire under valve areas
- Complete destruction of the unit from overspeed, including likely fire and hydrogen explosion resulting from over speed energy release

In a recent study, AIG found that one of the leading causes of major steam turbine failure is overspeed events. Of these failures 70% resulted from valves failing to close. Failures of the main steam stop or throttle valve to close accounted for 50% of these destructive events, while the failure of an extraction valve to close accounted for the remaining 20%. Studies have demonstrated that a valve open only 2% to 3% will provide enough steam to accelerate a steam turbine to destruction when driven equipment is not loaded .

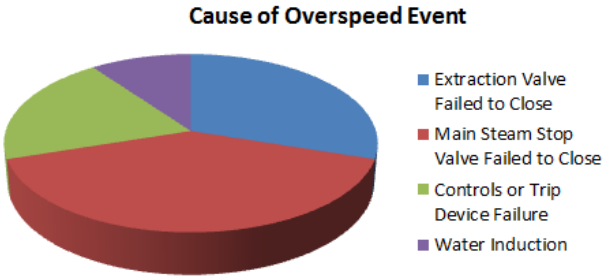

Figure 2 Cause of Turbine Overspeed

Risk Mitigation

The best way to prevent a steam turbine valve failure is for owners / operators to thoughtfully and completely evaluate the risk and consequences of a failure of these important valves, and develop a plan of training personnel, regular testing, periodic inspections and planned maintenance to prevent the failure of these safety critical valves.

Recommendation

- Owners / operators must consider the steam turbine valves as safety critical. A single failure of a valve to fully close may expose Owners to a major loss including fire and the potential for loss of life.
- Owners / operators should evaluate the risk of occurrence and consequences of a steam turbine valve failure, realizing that they are one of the most risk sensitive components in the plant.
- Owners / operators should consult with the original equipment manufacturer, regulatory agencies as applicable and insurance carriers for guidance regarding operation testing, inspection and maintenance recommendations.
- Operators must conduct proper staff training regarding the importance of steam turbine valves and highlight specific procedures to follow when a valve's function is found to be impaired.
- Owners / operators must never operate a steam turbine with critical valve(s) that are unreliable or operationally impaired.
- Owners / operators must immediately investigate steam turbine critical valve(s) operational discrepancies to determine root cause and remedy prior to continued steam turbine operation.
- Owners / operators must stock adequate critical valves and related components required to maintain critical valves functionally viable. Several failures have occurred while operators were waiting for valve parts to be delivered.
- Owners / operators must properly and timely test the valves to ensure they are capable of functioning properly at all times. All critical isolation valves, including main steam stop valves, throttle valves, intercept valves, extraction isolation valves and non-return valves must be tested regularly for freedom of movement and tightness. The valves should be stroked to demonstrate they can move freely and close completely. If your unit(s) operates continually, this can typically be done on line. Most steam turbines have the means to test critical valves for freedom, while operating. If the unit is taken out of service or operation for any reason, economic or maintenance, the valves must be checked to verify closure and tightness upon unit start up. This testing can be performed by supplying steam to increase unit speed and then locally tripping the isolation valves to verify speed decreases. Once the speed decrease is noted the steam turbine can be reset and increase in speed resumed.
- Owners / operators must inspect all steam isolation valves at intervals that reflect the safety critical nature of these valves. The only means to ensure correct operation of steam turbine valves are periodic disassembly, inspection and maintenance. The frequency of disassembly, inspection and maintenance must be determined on a unit by unit basis, and must reflect the safety critical nature of these valves. The interval period between periodic disassembly, inspection and maintenance should also factor any history of valve part erosion or binding, or other operational issues.
- Owners/ operators should take caution and avoid inspecting critical valves on the same interval period as the major unit inspection. Failure data has demonstrated that addressing critical valves in conjunction with the typical steam turbine major unit inspection interval period exposes steam turbine critical valves to a greater failure potential and presents an unacceptable level of risk for catastrophic failure. It is also important to note that plant personnel may focus on the main steam stop valves and overlook other critical valves including non-return valves, intercept valves and control valves. Major losses have occurred from the failure of these other critical valves to properly function as well.

It is clear that inspection and maintenance of all steam turbine critical valves protecting steam turbine generator sets from sudden massive destruction must be well reasoned and timely.

Resources / Standards

The references are:

ASME 54887 Steam Turbine Overspeed Protection Failures, Causes, and Strategies to Avoid Them

EPRI 1013461 Turbine Overspeed Trip Modernization: Requirements and Implementation Guidance

For more information, contact your local AIG Property Risk Control Representative.