AEGIS

Loss Control

Precursors of Water Induction

White Paper

Importance of Steam Turbine Shell/Casing Metal Temperatures Associated With Water Induction

Recent AEGIS evaluations of steam turbine generators have highlighted concerns regarding the effectiveness and importance of monitoring the differences in upper to lower shell or casing metal temperatures. Operator training, as well as automating monitoring systems, can aid in early identification of shell/casing metal temperature discrepancies, potentially preventing costly repairs and downtime.

Abnormal Shell Metal Temperature Differences

If thermocouples are provided in matched pairs (upper and lower) at a given location, a temperature differential between the upper and lower thermocouple can be used for water detection. If only a lower thermocouple is provided, a rate of temperature change is used for water detection. Recorded temperatures from these thermocouples make it possible to determine which opening in the turbine the water entered.

During normal operation a steam turbine would have a difference in upper to lower shell metal temperature of less than 10°F. ASME TDP-1-2013 states that a difference of greater than 50°F indicates the presence of water. Excessive upper to lower shell metal temperature differences could be a result of the following conditions:

- Water induction
- Inadequate shell insulation
- Instrumentation deficiency

In the case of water induction, the quantity and temperature of water entering the turbine directly affects the extent of damage caused by quenching. In extreme cases, rotor or shell indications/cracks, a bowed rotor, or a humped shell could occur, all of which would require extensive repairs or remediation.

Other instances of excessive upper to lower metal temperatures can lead to shell or casing distortion resulting in rubbing, with corresponding high vibration levels leading to possible subsequent damage. If occurring during start-up, online time could be delayed by several hours as the rotor thermally relaxes. Over time, routinely occurring events will open seal/packing clearances, negatively impacting unit thermal performance.

In Figure 1, four sets of upper and lower steam turbine shell metal temperature thermocouples (TC) are installed: the 1st Stage Bowl, the HP Exhaust, the Reheat Bowl, and the 18th Stage WD. The HP Exhaust Metal Temperature and Reheat Bowl appear to have two separate lower shell metal TCs. It would be expected that all shell metal temperatures for a particular stage be within 10°F of each other. Shown in Figure 1, one of the lower HP Exhaust Metal TCs is more than 100°F lower than the upper shell temperature and the other paired lower TC. In this example, without detailed knowledge of the TC configuration, investigation is required to address the abnormal indications.

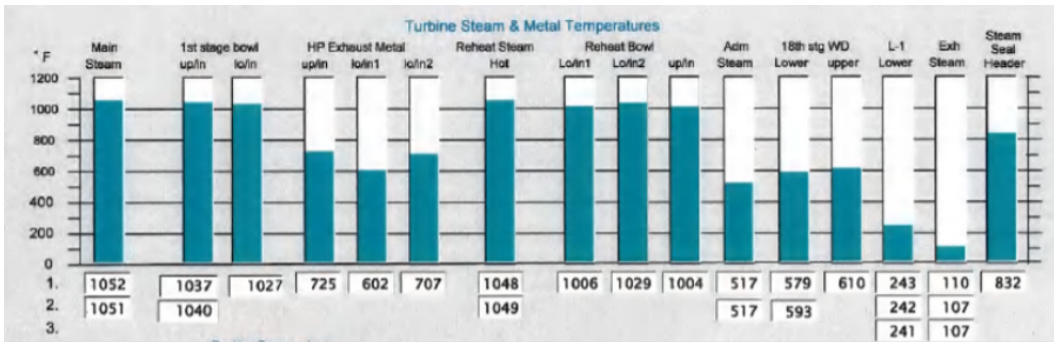

Figure 1 – *Steam Turbine Static Shell Metal Temperatures*

In Figure 2, a different scenario, start-up trends indicate a sudden drop in HP Exhaust lower metal temperature with a corresponding increase in the HP Exhaust upper to lower temperature differential. This is a clear indication of water induction. Additionally, the 9th Stage upper to lower temperature differential exceeded 50°F for an extended period, requiring investigation.

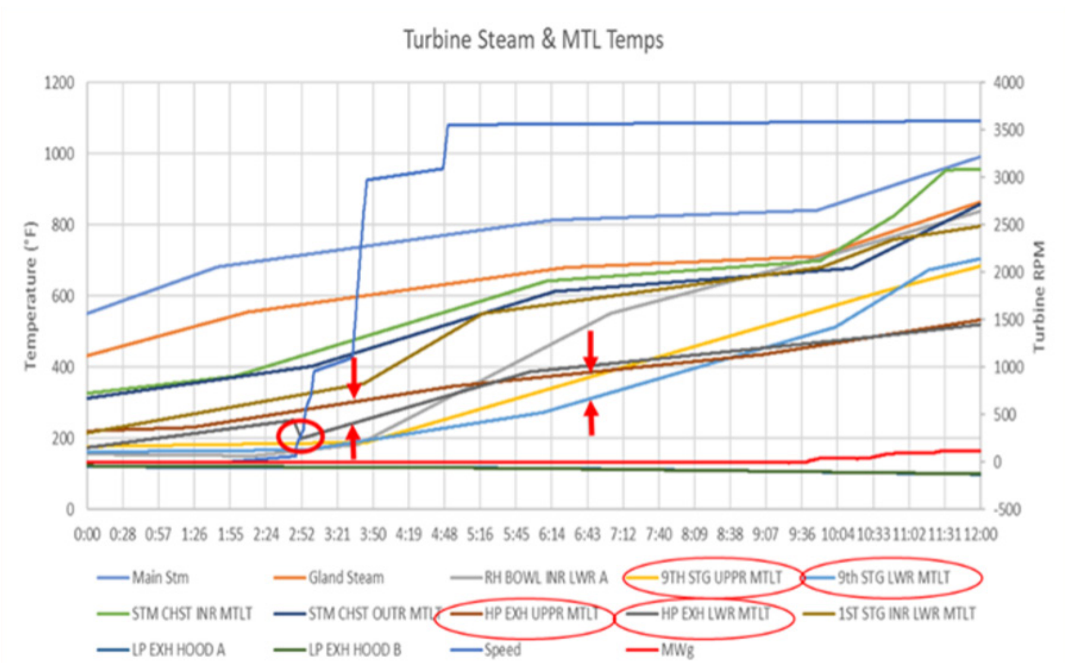

Figure 2 – *Start-up Shell Metal Temperature Trends*

ASME TDP-1-2013 History

The first steam turbine water induction standard was approved in July 1972 and was entitled TWDPS-1. Subsequent revisions included: TDP-1-1980 (major changes: steam generators, direct contact feedwater heaters, condenser steam and water dumps were added), TDP-1-1985, and TDP-1-1998. A separate standard was developed for the nuclear industry. The water induction committee was disbanded shortly after the 1998 standard but was re-established in the mid-2000s resulting in the issuance of TDP-1-2006. The 2006 standard was the first to include water induction protection issues that affect gas turbine combined cycle/co-generation operations. The 2006 standard also removed the sections identified as Main, Cold and Reheat steam and combined them into a single section identified as Motive steam. Process steam, bypass steam and dump condensers were added to address the prevention of water damage in specific co-generation, combined cycle and other operations that use those systems. It is stated in the Forward that it is "not intended to impose new requirements retroactively for existing facilities." The 2013 standard changed the recommended practice language to mandatory language. Monthly test requirements were also removed but included in the quarterly testing requirements.

Facilities built prior to the various iterations of TDP-1 are encouraged to incorporate the concepts presented in the ASME document, where reasonably applicable. AEGIS recommends testing and maintenance as described in Section 5 on all pre-TDP1 constructed facilities.

Summary

Early identification of shell/casing metal temperature discrepancies can prevent potential costly repairs and downtime. Operator training and attention as well as automating monitoring systems can avert the noted hazards.

AEGIS encourages:

- **Compliance with ASME TDP-1-2013:** Prevention of Water Damage to Steam Turbines Used for Electric Power Generation.
- **Establishing operating procedures** and conducting associated training for foreseeable water induction scenarios to enhance steam turbine operations.
- **Optimizing Turbine Water Induction Protection** (TWIP) supervisory instrumentation, including matched shell TCs at key locations.
- **Establishing suitable alarms** in the control room for excessive temperature differences and significant changes with respect to time; and, if applicable, from remote monitoring centers.

AEGIS is available to perform site-specific focused water induction surveys to identify facility risks and gaps against ASME TDP-1-2013.

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