

Turbine Supervisory Instrumentation (TSI) - An Overview

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Turbine Supervisory Instrumentation

Turbine Supervisory Instrumentation (TSI) or Turbine Supervision Equipment (TSE) is a generic term used in the power generation industry. TSI refers to instrumentation systems that specifically perform measurements of critical control parameters on large steam turbine generator trains. The size of the machines can range between 50 - 1200 MW, and their age can often be in excess of 30 years. TSI systems are normally a mandatory requirement.

The same technology is employed on other turbine types and in other industries - such as the hydrocarbon processing sector - however different terminology tends to be used.

This application note briefly introduces TSI. A detailed examination of each specific TSI measurement can be found in related SKF Reliability Systems application notes.

TSI Benefits

The use of - and experience with - TSI assists in reducing operating costs of the generation units by:

- **Reducing turbine roll time.** During the run-up and coast-down of large turbines, there are extensive soak periods, to ensure stationary and rotating parts thermally expand equally. These periods have to be conservatively long, but can be reduced with continuous and accurate measurement of key expansion clearances (and related parameters) available with TSI systems.

- **Time Between Overhauls.** Using precise TSI measurement information, the exact and proper amount of work can be scheduled in an outage with reduced risk of unknown problems occurring after the overhaul is completed.

- **Diagnostic and Troubleshooting.** The trending of TSI data provides the user with the basic operating characteristics of the machine. Early detection of changes in the trended data and comparison to normal conditions permits decisions to be made more quickly and inexpensively. More advanced analysis methods of this same raw data can diagnose problems like mass unbalance, misalignment, loose or broken parts, shaft cracks, seal rubs and bearing instabilities caused by improper lubrication or bearing design. The early identification of these problems allows for correction at a time convenient to the work force and system load.

- **Automatic Shutdown.** Some problems arise so quickly that this capability may limit damage to the machine and protect against total destruction or catastrophic failure. With the long lead times associated with turbine/generator parts, confining the damage flagged by vibration can make the difference between a two week outage and three to six months of down time.

TSI Retrofits

The turbine generator and boiler units are comprised of a complex group of control elements that require constant, reliable and accurate measurement and control. Hence TSI measurements of varying scope and technology are as old as steam turbines themselves. However, the state-of-the-art of available instrumentation - with its associated technological benefits - develops far more quickly than the turbine itself. Over the lifetime of a typical steam turbine (maybe 50 years!) the instrumentation may be upgraded by retrofit a number of times, in order to further maximize the above mentioned TSI benefits. Some of the points of consideration are:

- What information will the new system provide?
- How is this information displayed to the operator?
- How is analytical information displayed?
- How will this system interface with other systems
- What type of transducers should be used?
- Should the system use absolute or relative measurements?



Figure (1) : Typical TSI Monitoring System

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- How will the installation be completed?
- How reliable is the existing instrumentation? Are spare parts and service readily available?
- Will the installation meet the outage schedule?
- What makes a given TSI system different from any other?
- How can the TSI system be cost justified?

In order to answer these questions, the machine in question should be scrutinized in detail - design, service, normal operating conditions, bearing type and design, and history should all be factored in to the equation.

Although no TSI system available will prevent 100% of all machinery malfunctions, **reliability** of the system is a must. Operations and maintenance personnel must be able to depend on the information the system provides. The reliability and accuracy of this information eliminates second guessing and allows sound decisions to be made with confidence.

TSI Measurements

TSI system measurements can be broken down into four major categories:

(1) Motion measurement. Vibration monitoring, using eddy current (proximity) probes, case mounted velocity (seismic) transducers, shaft riders, and/or accelerometers. Monitoring points may include vibration on main turbine generator and exciter, boiler feed pump and turbine, and FD and ID fans. Eddy current probes may also be used to measure rotor eccentricity.

(2) Position measurements. Eddy current probes, LVDT's and linear/rotary potentiometers can be used to monitor thrust bearing wear, rotor position, casing (shell) expansion, differential expansion and control valve position.

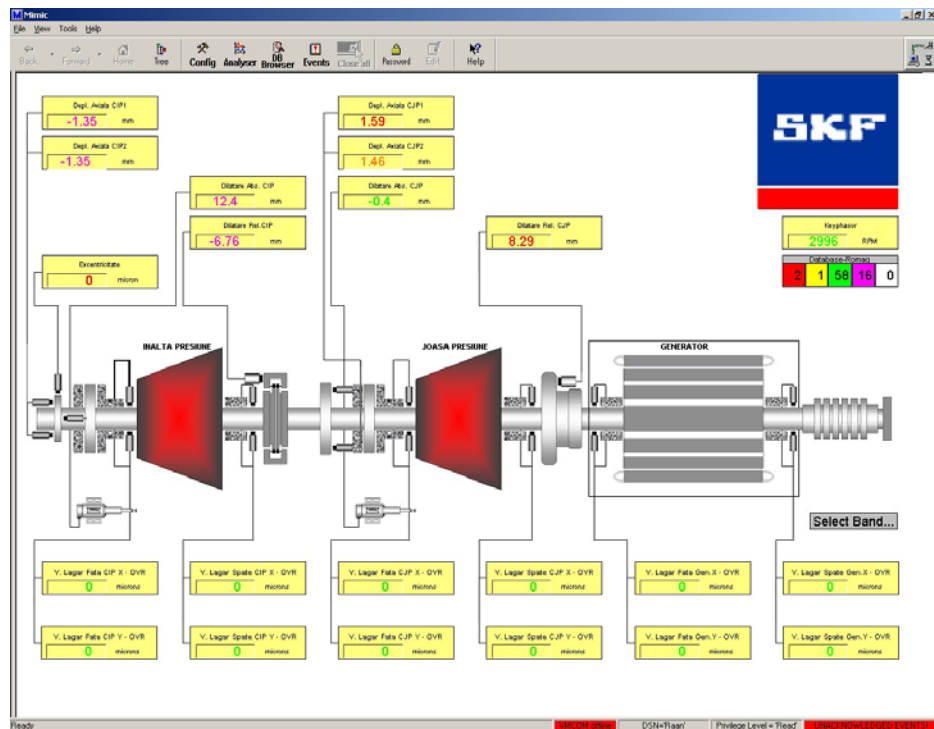


Figure (2) : Example TSI System HMI

(3) Speed measurements. Active or passive electromagnetic or eddy current probes can be used to monitor main turbine speed and acceleration, over-speed detection, zero speed detection, boiler feed pump speed, FD and ID fans speed.

(4) Process measurements. Use of thermocouples or RTDs to monitor bearing white metal temperature, shell differential temperature, and lube oil temperature. Piezoelectric or strain gauge pressure transducers measure oil and hydraulic pressures.

Each component plays a key role in the success of the overall system. The correlation of these different measurements may show the effects of one parameter to the other.

The ability of the user to apply all available information is extremely important in determining the condition of the machine, and to maintaining safe and efficient operating conditions. Here a good HMI (Human Machine Interface) is essential - see Figure (2).

TSI measurements have their own own conventions and technical nuances, and are generally considered complex to both understand and implement. This complexity is the reason why the measurement technology is often - but not exclusively - provided by the vibration monitoring industry, which is accustomed to complex sensor signal conditioning. The following parameters are considered in detail in separate SKF documents:

- Eccentricity
- Differential Expansion (straight, complementary, ramp)
- Casing (Shell) Expansion
- Valve Position
- Rotor Axial Position
- Absolute Bearing Cap Vibration
- Relative Shaft Vibration
- Absolute Shaft Vibration
- Speed (Zero Speed, Rotor Acceleration, Over-Speed, Phase Angle)

This family of SKF Reliability Systems application and technical notes are designed to help in detailing a solution to the above TSI challenge.