vibro-meter

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CASE STUDY

Upgrading Condition Monitoring without Disturbing Existing Protection Systems

A vibro-meter case history featuring India's largest power utility.

When faced with an aging and unsupported condition monitoring system, **vibro-meter** was selected by India's leading state-owned power utility for a **state-of-the-art solution** that allowed them to leave their incumbent turbine supervisory protection systems and transducers undisturbed while reusing existing cabinet space and **without requiring a special outage**.

About the Project

The project covered replacement of condition monitoring instrumentation on three identical 500MW steam turbine generator (STG) trains at a Super Thermal Power Plant (STPP) in India[1].

Each STG has seven bearings and consists of HP, IP, and LP cases, a generator, and an exciter (Figure 1). The units are of German design and were supplied originally by a major Indian OEM complete with Japanese Turbine Supervisory Instrumentation (TSI) systems and companion condition monitoring. Each of the three units uses two TSI racks to address its 39 measurement points.

The existing TSI system is an aging platform, introduced in the early 1990s and was thus 15-year old technology by the time it was installed on the 3 STGs in the 2008-2010 timeframe. It was accompanied by a companion condition monitoring system from the same manufacturer, consisting of separate data acquisition hardware and corresponding software.

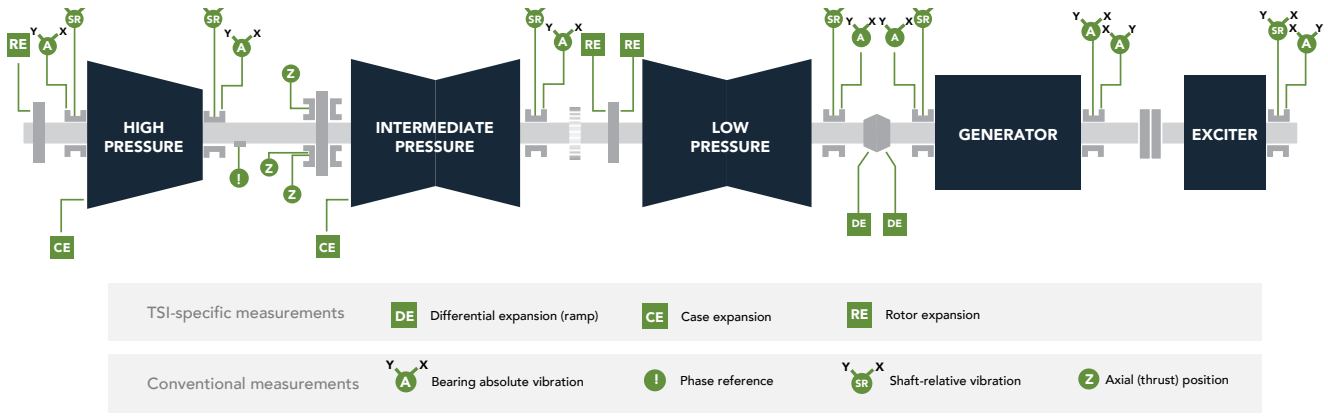

Figure 1: Machine train diagram for the STPP's three identical 500MW units.

Figure 2: Two TSI racks are used to provide machinery protection for each unit and are visible in the left-most cabinet. These racks have been in service since the units were commissioned in the 2008-2010 timeframe. The adjacent cabinet to the right holds the condition monitoring hardware.

Figure 2 shows the cabinet containing the two TSI racks on the left and the cabinet with the condition monitoring racks on the right. Figure 3 shows the right-most cabinet with the door open. While manufacturers generally introduce new protection systems every 15-20 years, and typically design them with a service life of 20+ years, the same is not often true of condition monitoring systems where software technology and operating systems typically last only half that long before they become obsolete.

[1] A STPP is defined as a thermal power plant exceeding 1000 MW in output. There are more than 65 such plants in India. India also defines an even larger category called Ultra Mega Power Plant (UMPP) that is 4000 MW or larger. There are several UMPPs in India and plans exist to build more. For comparison, the ten largest thermal plants in the world are in China, Taiwan, and South Korea, all with 5000 MW or more.

Figure 3: Cabinet from figure 2 but with door open showing vacated panel cutouts from old condition monitoring hardware. The incumbent CMS required six (6) large data acquisition units for each turbine generator and its accompanying boiler feedwater pumps (BFPs) , as noted by the six panel cutouts. Note that the new vibro-meter data acquisition hardware for the turbine generator occupies only two-thirds of a single panel cutout (fourth opening from top) and thus consumes three times less space. Fitting the new CMS into existing panel space was an important project requirement as there was no room for any additional cabinets. The BFPs are slated to be added in a later project and will use a portion of the other cutouts.

Of particular concern are evolving operating systems that also demand change of computer hardware and accompanying cybersecurity issues that require frequent patches and attention.
After experiencing difficulties obtaining support for their existing condition monitoring system (CMS), and after developing a strong appetite for advanced features such as intelligent machinery condition advisories suitable for operators, the end-user began exploring options. However, simply running without any condition monitoring system on the STGs was quickly dismissed as a viable solution because the customer is particularly noted within India for highly efficient operations and timely machinery condition information is necessary to enable this.

Upgrading the system was thus pursued but a simple upgrade path did not exist without so-called "ripping and replacing" the existing CMS solution. Since this was the case, there was no particular advantage to remain with the incumbent provider and after considering their options, vibro-meter was selected to work with the project imperatives shown in Table 1:

Table 1 – Project Imperatives

The project needed to be accomplished without requiring an outage of the affected three units.
The project would need to leave the existing protection systems and transducers undisturbed until the plant eventually decides to replace them during a scheduled plant outage.
The project would need to re-use the existing cabinet space where the condition monitoring hardware was mounted.
The project would need to deliver advanced capabilities where knowledge could be embedded in the software and thus allow intelligent advisories for operators rather than merely conventional over/under alarms.
The project would require the vendor to not only remove the old system and provide turnkey installation and commissioning of the new CM system, but also training.

Instilling Confidence

Because the customer was moving away from a system that could no longer deliver the necessary functionality, it was important for them to satisfy themselves that the new system would meet their needs prior to permanently deploying it.

This was particularly easy for vibro-meter to demonstrate because the same hardware and software we use for permanent installation can also be deployed portably. To this end, a portable system was brought to site and connected to the buffered outputs of one of the TSI racks. Figure 4 shows one of the plots obtained during that time: an orbit/timebase from the shaft-relative probes on the unit's #2 bearing.

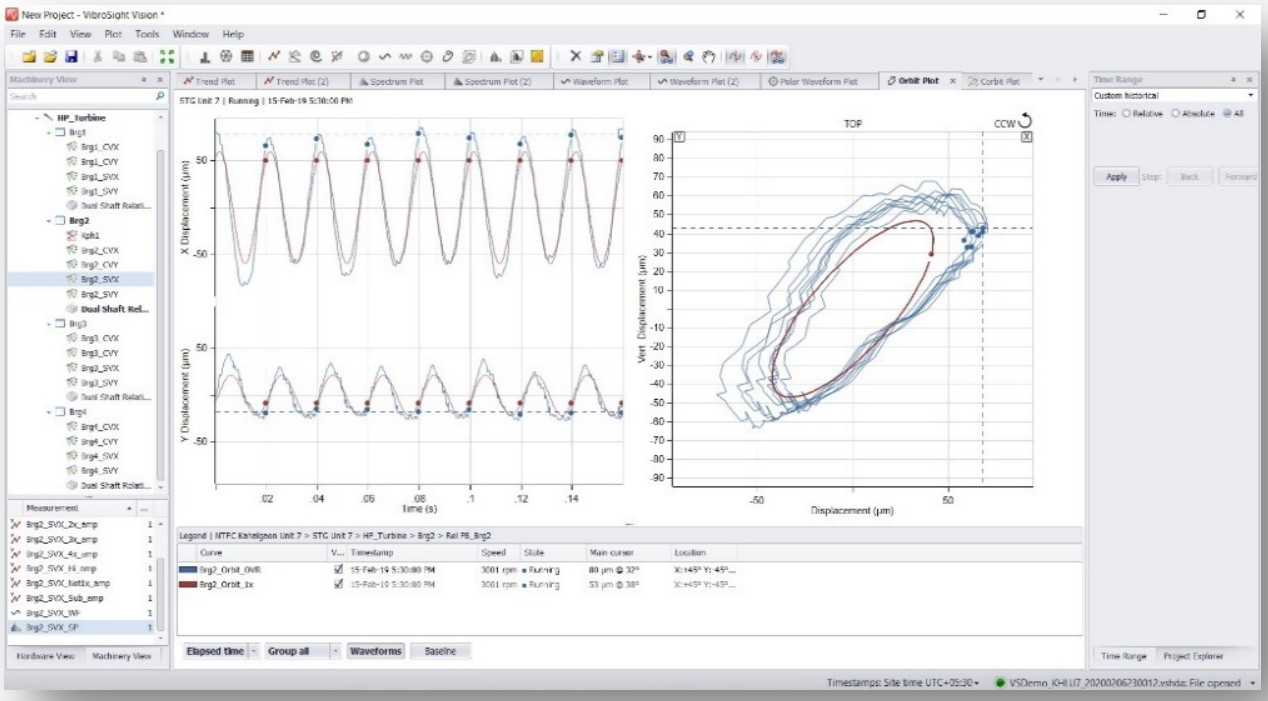

Figure 4: VibroSight Vision software showing actual plots from the pre-installation portable deployment. The ease with which this portable deployment was accomplished and the quality of condition monitoring data it collected helped the customer reassure themselves that the new CMS hardware and software would deliver the necessary functionality.

Delivering Value

Cost is of concern to all our customers but so is quality.

In scoping the project, we carefully examined the measurements that needed to come into the CMS for each of the three units and divided them into two categories: so-called quasi-static measurements like pressures, positions, loads, and speeds (Table 2) and so-called dynamic measurements such as bearing vibration and phase reference (Table 3). We then selected optimal data acquisition hardware that represented an ideal balance of capabilities and cost for addressing each of these two categories.

Table 2 - Position/Expansion and Process Measurements

Case	Measurement
HP	Rotor Expansion
	Casing Expansion
	Differential Expansion
	Main Steam (MS) Pressure
	Cold Reheat (CRH) Pressure
IP	Rotor Expansion
	Casing Expansion
	Differential Expansion
	Hot Reheat (HRH) Pressure
LP	Differential Expansion
N/A	Thrust Position (x 3 probes)
	Load
	Speed

Table 3 – Dynamic Measurements

Phase Reference	BRG 4, Shaft Rel Y
BRG 1, Shaft Rel X	BRG 4, Casing Vib Y
BRG 1, Casig Vib X	BRG 5, Shaft Rel X
BRG 1, Shaft Rel Y	BRG 5, Casing Vib X
BRG 1, Casing Vib Y	BRG 5, Shaft Rel Y
BRG 2, Shaft Rel X	BRG 5, Casing Vib Y
BRG 2, Casing Vib X	BRG 6, Shaft Rel X
BRG 2, Shaft Rel Y	BRG 6, Casing Vib X
BRG 2, Casing Vib Y	BRG 6, Shaft Rel Y
BRG 3, Shaft Rel X	BRG 6, Casing Vib Y
BRG 3, Casing Vib X	BRG 7, Shaft Rel X
BRG 3, Shaft Rel Y	BRG 7, Casing Vib X
BRG 3, Casing Vib Y	BRG 7, Shaft Rel Y
BRG 4, Shaft Rel X	BRG 7, Casing Vib Y
BRG 4, Casing Vib X	

For the dynamic measurements, vibro-meter's XMV16 modules (Figure 5) were the perfect solution, each providing 16 dynamic input channels and 4 tachometer / phase reference channels for a total of 20 possible inputs per module. Two such modules were thus required for each STG to encompass the 28 vibration inputs and associated phase reference signal. These signals were brought into the XMV16 modules from the buffered outputs of the existing TSI racks[2].

Figure 5: The VM600 XMV16 condition monitoring module consists of the signal processing and computation module (left) and the companion I/O module (right). It accepts a total of 16 dynamic signals from vibration and other sensors, and 4 tachometer signals used for speed or phase reference measurements. Gigabit Ethernet ports are provided on both the processing module and the I/O module; either one can be used to connect the processed data from the XMV16 to VibroSight condition monitoring software. The XMV16 can accept dynamic vibration signals from elsewhere in the VM600 rack via the system backplane, or (as in this project) via externally wired connections to the I/O module.

Slimline Rack

Part of vibro-meter's VM600^{Mk2} (as well as legacy VM600) architecture is a special chassis designed to hold only a single card while providing necessary power. This is known as a "slimline" rack (Figure 6) and is just 1U tall by 19" wide, designed for 19" EIA rail mounting or mounting in a 19" panel cutout. Because the outgoing CMS hardware used 19" cutouts, the two required slimline racks for each STG could be easily mounted in the existing cutouts without modification as shown in Figure 3.

Figure 6: The VM600 "slimline" rack is just 1U tall and designed for mounting in a 19" cutout or on 19" EIA rails. It provides all necessary power and holds a single VM600 module such as the XMV16 shown here to provide a 20-channel condition monitoring solution (16 dynamic channels + 4 tachometer channels). The slimline chassis can also be used with other VM600 modules such as the MPC4^{Mk2} to provide a compact, 4-channel machinery protection solution.

[2] As is the case with many systems, buffered outputs were available on the TSI racks from BNC connectors at the front and permanent wiring terminals at the rear. Because the BNC connectors on the front of racks are intended only for temporary connections to portable instruments, the wiring terminals at the rear are preferred for permanent installations whenever available as they afford more robust, trouble-free connections.

Project Execution

The project scope included not just installation of the new system, but complete documentation, procurement of necessary accessory items for networking such as switches and hubs, commissioning, and then site training for personnel on use of the new system. Figure 7 shows the system arrangement along with the distances between various components.

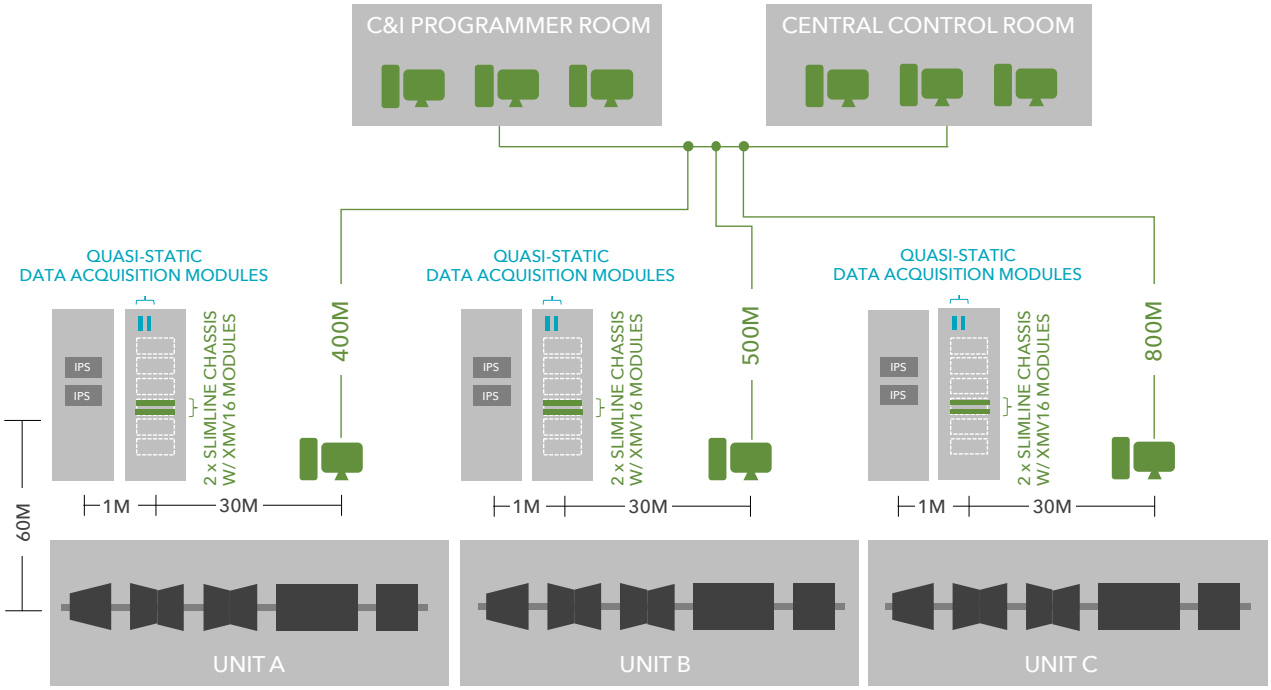

Figure 7: System arrangement showing relevant distances between machines, incumbent protection systems (IPS), new condition monitoring hardware, servers, and remote workstations.

Because vibro-meter has a strong presence not only globally but also in India, factory-direct field service personnel from our Bangalore facility were able to execute this project. The project was completed on-time and on-budget in January 2021 when the customer signed off on the project completion letter. Indeed, the customer was so pleased with vibro-meter's products and project execution that a nearly identical project was done on two units at a sister plant. In 2023, the plant showcased in this case history is planning to install condition monitoring on the two boiler feedwater pumps (BFPs) on each of the three STGs using an approach identical to that described here: retaining the existing protection systems and adding condition monitoring.

In fact, the CMS hardware will be mounted in the same cabinet as shown in Figure 3 given the generous amount of space still left for additional equipment. When complete, each cabinet will house the condition monitoring hardware for the STG and its two associated BFPs.

Universally Extensible Approach

The approach used for this project is instructive in showing how vibro-meter's condition monitoring solution is designed to be non-disruptive, simple, and cost-effective, allowing customers to retain their existing third-party protection systems and sensors while easily adding condition monitoring or replacing an aging, inadequate, or obsolete condition monitoring system (Figure 8).

Because most incumbent monitoring systems installed around the world have the raw transducer signals available through buffered output connections, the signals needed for input to vibro-meter's XMV16 modules are readily available. Although it is possible to bring quasi-static signals into XMV16 modules, there are also additional possibilities for introducing such data into the VibroSight condition monitoring software. This allows data to originate as 4-20mA signals, proportional quasi-static voltages, or digitally if the signals are already in the DCS and can be exporting via Modbus, OPC, or other suitable format. For this reason, VibroSight has been designed with the ability to ingest data via these digital protocols in addition to ingesting the dynamic data from XMV16 modules[3].

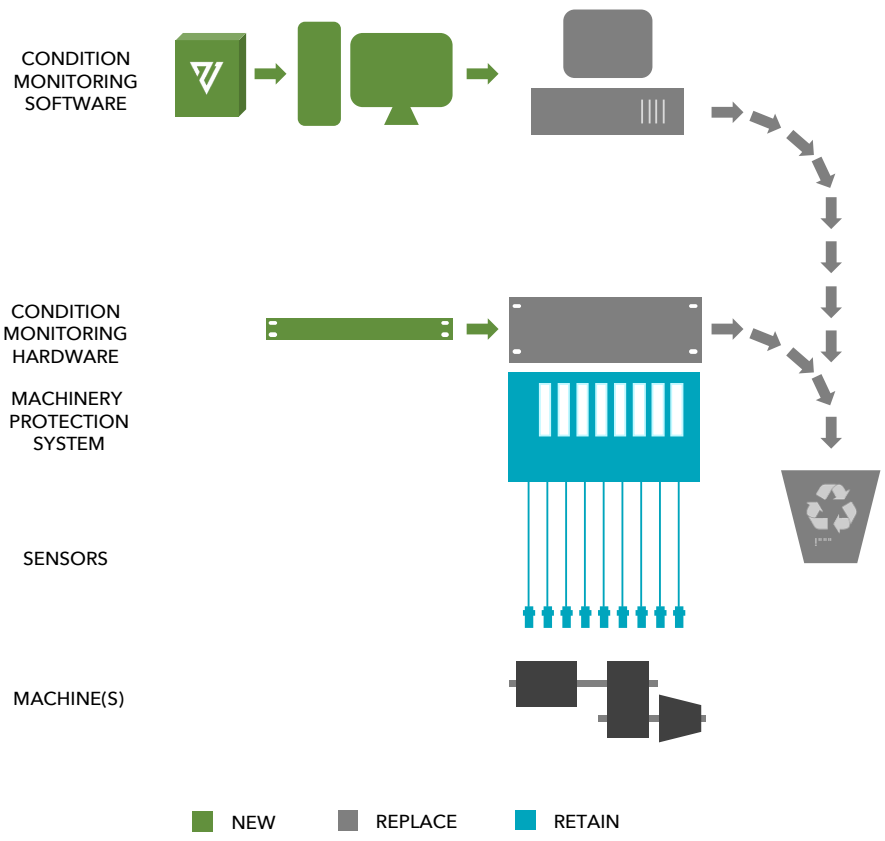

Figure 8: Retaining an existing machinery protection system and sensors while replacing an outdated condition monitoring system is non-disruptive, simple, and cost-effective using vibro-meter's XMV16 modules and VibroSight software. In most cases – such as in this project – a single XMV16 module can replace two or more chassis of outdated condition monitoring hardware.

[3] When the installation involves monitoring of gas turbines and combustion dynamics sensors are used, a variant of the XMV16 is also available for these specialized dynamic pressure signals: the XMC16.

Intelligent Advisories

While most condition monitoring software has powerful capabilities for visualizing data, the plot types are quite specialized (such as in Figure 4) and not easily interpreted by operators and others without extensive training and experience in vibration data analysis. A key aspect of the customer's desire for a new CMS was the ability to automatically analyze this data and present it in the form of intelligent advisories that could readily be understood and acted upon by plant operators.

Our VibroSight software suite can deliver such capabilities via the Diagnostic Rule Box application and was indeed part of the scope of this project. It can be configured to detect dozens of different malfunctions (Figure 9) and is limited only by the types of data available. In addition to the automatic diagnostic capabilities of Rule Box software, it also has operator "dashboard" capabilities as shown in Figure 10.

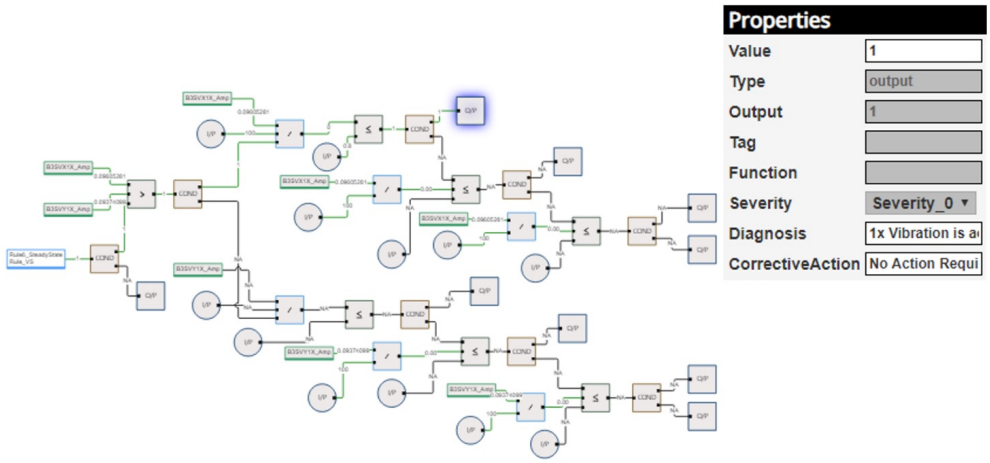

Figure 9: Rule Box allows automated malfunction diagnosis using rules that can be configured by vibro-meter or by the end-user using mathematical, logical, and other operators. The rule building environment is graphical and highly intuitive, as shown here, accomplished by simply joining operators. The result is rules that are powerful yet easy to build and easy to understand. Notice here that the selected output node at the top of the diagram (as noted by the blue "glow") has severity level 0 as indicated in the properties box. Complex rules can have multiple outputs that result in various severity levels.

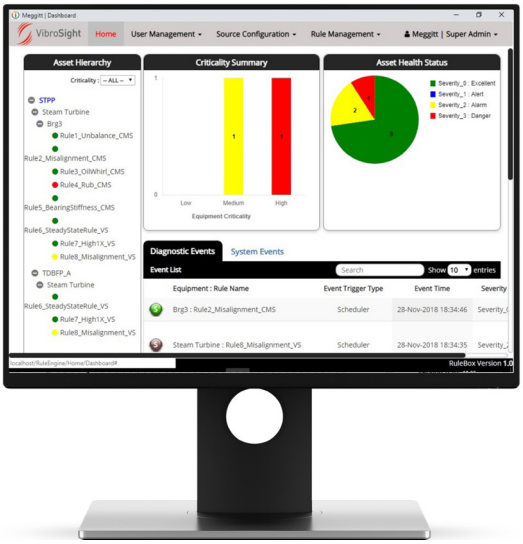

Figure 10: Many customers prefer the user interface of VibroSight's Rule Box software as the primary window into their condition monitoring system because it provides a high-level dashboard summarizing anything an operator needs to act on. Instead of complicated and specialized plots, it uses simple status indicators and narrative descriptions of problems detected, their severity, and what actions to take. This dashboard is taken from an actual vibro-meter installation at a STPP in India.

Conclusion

The ability to add or replace condition monitoring hardware and associated software without disturbing the underlying protection system is a frequently encountered scenario.

It can arise for a variety of reasons, including:

• The protection system still has remaining useful service life while the condition monitoring software is often designed with a shorter lifespan and thus becomes obsolete more quickly.

• The protection system has also reached the end of its useful life but the plant's next scheduled outage may not occur for several years and replacement of machinery protection is generally scheduled during an outage since it is unwise to run critical machines without protection. In the meantime, however, the plant may need better condition monitoring to ensure the unit can indeed continue to run until its scheduled outage. This is particularly true if the unit is exhibiting anomalies but the severity and cause is unknown.

• A plant may have a variety of machinery protection systems and wants to unify them all under a common, integrated condition monitoring environment.

The cost to replace all of the protection systems before installing condition monitoring might represent unacceptable delays and entail numerous outages.

• A plant may have no condition monitoring and because its units are now undergoing more aggressive operation such as frequent starts and stops rather than baseload, stead-state conditions for many months or even years at a time, insight into real-time machinery health is more important and required continuously.

Even when large amounts of cabinet space are available, as was the case in this project, the spare cabinet space could be used for networking appliances and peripherals, and no issues with air circulation, cooling, or other aspects needed to be addressed as is often the case with bulkier solutions.

Finally, this case study has shown that vibro-meter has not just the technology to make a retrofit or replacement very straightforward, it has the experienced field service engineers to manage the entire project in turnkey fashion and to provide training for personnel.

While this project involved replacement of only the condition monitoring environment, vibro-meter is also able to replace the

"As this case study has shown, vibro-meter has an engineered solution that is non-disruptive, simple, and cost-effective. It also consumes very little cabinet real estate which can be especially important when no condition monitoring system was initially present and large amounts of spare panel space are unavailable."

underlying sensors and machinery protection systems when necessary – in which case the condition monitoring hardware discussed in this article can be replaced with hardware that provides integrated protection and condition monitoring without requiring any additional cabinet real estate at all.

You can contact your nearest vibro-meter sales professional through our extensive network of factory-direct personnel and representative partners.

Turnkey Solution Portfolio

○	Replaced protection system
○	Replaced sensors
✓	Replaced condition monitoring system
○	Upgraded condition monitoring system
○	Upgraded protection system
✓	Project Management
○	Fully instrument "bare" machines
○	Sensor Installation and Verification
✓	Turnkey Service
✓	Custom Products (Modbus process data import solution)
✓	Documentation
✓	Training
○	Remote Machinery Diagnostic Support
✓	Expert knowledge embedded in Rule Box software

✓ services provided for this project

Contact Information

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