MACHINE MONITORING SYSTEM
SPECIFICATION

FOR

HINDUSTAN PETROLEUM CORPORATION LTD.
VISAKH REFINERY

HDHT PROJECT

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1. GENERAL

1.1 Project Overview

This specification provides the minimum requirements for design, testing and inspection of the Machinery Monitoring System (MMS) and Machinery Data Management System.

A MMS provides continuous, online monitoring suitable for machinery protection applications. An independent MMS for the machine to be supplied and be located in the Satellite Rack Room with a MMS PC in control room & a display unit in the field.

1.2 Related Documents

Apart from this specification, the following documents shall be used and referenced for the design of the MMS:

a) Engineering Specification for Control and Instrumentation in Package Units (6261-KA-102)

b) Interface Block Diagram

In case of any conflict among the above documents, the following priority shall govern:

1st The above noted documents and specification/data sheets
2nd This specification
3rd Codes and Standards
2. CODES AND STANDARDS

The following documents shall form a part of this specification:

i) API American Petroleum Institute
   • 670 Vibration, Axial-Position, and Bearing Temperature Monitoring Systems
   • RP 551 Process Measurement Instrumentation
   • RP 552 Transmission System
   • RP 554 Process Instrumentation and Control

ii) IEC International Electrotechnical Commission
   • 60079 Electrical Apparatus for Explosive Gas Atmospheres
   • 60529 Degree of Protection Provided by Enclosures (IP Code)
   • 60502 Power Cables

iii) Other Standards
   • NFPA-70 National Electrical Code
3. INTRODUCTION

The scope of supply, design and installation related to the proximity probes/sensors & Machine Monitoring System is in package vendors responsibility.

3.1 Rotating Machinery Vendor’s Scope:

Transducers

The Package Vendor shall supply and install Intrinsically safe transducer systems (B/N matching probes and proximitors) according to hazardous area classification. i.e EExia IIC T4 certified transducers to be used.

Selection of the appropriate probe material and construction shall be the responsibility of the package vendor.

System

The Machine Monitoring System (Bently Nevada - BN3500) in general shall comprise of

1) Hardware required for interfacing with the above said transducers and the Package PLC & Purchaser’s Control System (DCS)

2) A workstation with all of the necessary SYSTEM-1 Software for system configuration, diagnostics and display of dynamic graphics.

3) One Colour Printer.

4) A Bently Nevada Display to be mounted in Local Panel shall be provided.

   It shall be suitable for the hazardous area classification.

5) Any other required hardware to make the system functional.

6) Engineer / program the above system(s) accordingly.

7) Testing (including the integration test with 3rd parties system, i.e. system and interface test)

8) Documentation (as required in sec. 4.2.2) and as-built documentation up to powering up of equipment on site (witnessed by vendor)

3.2 Purchaser’s Scope

The Purchaser shall supply and install field cables (from junction boxes on skid edge to SRR. Also the cables between the BN3500 System and the UCP / Plant DCS inside the SRR. (including power supply cables, communication cables etc).
This Specification is primarily for the Machine Monitoring System to be installed in the Satellite rack room (SRR).

Henceforth for this specification, unless otherwise mentioned:

- ‘Vendor’ shall mean the BN3500 system Vendor
- ‘MMS’ shall mean the BN3500 System

4. SCOPE

4.1 Scope of Supply

The Vendor shall have overall responsibilities to supply:

a) MMS hardware and software

b) MMS PC with ‘SYSTEM-1’ software. (Optional)

c) One Colour Printer. (Optional)

d) One Display unit to be mounted in local panel mounted on-kid.

e) Any other hardware / software required to meet the functionality specified in this specification document.

f) Spare parts and consumables for construction and commissioning

g) Recommend Spare parts and consumables for 2 years operation

h) Vendor's standard calibration and testing equipment and tools for BN3500 rack mounted hardware.
   (The calibration and testing equipment for field devices to be supplied by Machinery Vendor.)

i) Documentation (as required in sec. 4.2.2) and as-built documentation up to powering up of equipment on site (witnessed by vendor)

4.2 Scope of Work

The Vendor’s scope, responsibility and documentation shall be included but not limited to the following:
4.2.1 Vendor’s Scope of Work

Vendor’s Scope of Work shall be:

a) Design

b) System Configuration, Programming, System Generation, Software Installation and Debugging

c) Integrated Factory Acceptance Test (FAT) at package vendor’s works

d) Technical Support during the Integrated FAT with Rotating Machinery Control System

e) Provide all BN3500 testing hardware and software to facilitate integration (MODBUS) tests in (d) above.

f) Packing and shipping to Machine vendor’s works for integrated FAT.

g) System Power-up support on Site - as per Vendor standard

h) Documentation including “As Built” Documentation Including Vendor Site Support modifications / drawing markups.

4.2.2 Documentation

All Vendor documents shall be written in English language.

1) The following documents shall be provided by Vendor during detail engineering.

a) MMS overview diagram

b) Hardware Design Specification

c) Equipment GA and wiring drawings (including Cabinet Layout Drawing)

d) Functional Design Specification

e) Graphic Design specification for the MMS

f) Calculation sheet (CPU load, power consumption, etc.)

g) I/O Data Base (Hard & Serial )

h) Software Documentation

   (including vibration, temperature etc. trip logic detail)
i) Cable schedule (For the Vendor’s supplied cable)

j) FAT procedure, Integration Test procedure

k) Site Installation Support procedure

l) Inspection and test reports

m) Installation/Operation manual

5.  GENERAL CONDITIONS

5.1  Area Classification

The MMS Display will be located in a local control panel. The same shall be EExia IIC T4 certified or equivalent.

5.2  Environmental Conditions

All equipment shall be suitable for operation in an air conditioned environment with ambient conditions normally within the following range:

Low ambient temperature: 15ºC  High ambient temperature: 45ºC

In addition the equipment shall not suffer permanent damage if the enclosure temperature rises to 45ºC due to prolonged failure of the air conditioning system.

The following circumstances shall be considered on the design in order to ensure the Capability of functions for the field supplied instrumentation:

All equipment shall be tropicalized to eliminate mildew, fungi, and other detrimental effects of a tropical environment. And shall be suitable for operation in a corrosive, salt laden, marine atmosphere.

Packing should take account of the ambient conditions of 45ºC and solar radiation in the event of temporary storage and during transportation.

5.3  Electrical Power Supplies

The MMS shall be powered via two independent 110VAC, 1-phase, 50 Hz feeders from UCP. Field sensors and transducers / proximitors shall generally be powered from the MMS. The system shall be sized to provide 24VDC power supplies for all field transducers / proximitors from the MMS analog I/O cards.

Adequate discrimination between circuits shall be provided to ensure that faults are minimised.
The power supply distribution within the MMS cabinets shall be provided with redundant Power Supply Units (PSUs) and shall be configured such that the loss of any one power feeder will not result in a power failure of the MMS (e.g. the loss of one power feeder to the MMS shall not have any impact on the MMS monitoring and control functions, PCs, Servers and peripherals shall remain functional throughout).

A common trouble alarm shall be sent from MMS to UCP. It shall comprise of each group of PSUs associated with each controller and I/O, cabinet temperature, system failure, i.e through a single dry contact unit alarm (UA) back to the UCP for indication purpose.

Power throughout the control system, its associated peripherals and input/output equipment, shall also be distributed and protected in accordance with its importance within the relevant control system such that separate power supplies are utilised where control systems equipment is duplicated.

Failure of any component in the power distribution circuit shall not affect the functionality of the system.

5.4 Grounding

Vendor shall provide technical recommendations on the safety grounding, system grounding, intrinsically safe grounding and cable shielding arrangements, which should be followed for proper operation of the system.

6. DESIGN

6.1 General

The Machinery monitoring and management system shall continuously measure and provide online monitoring of key machinery parameters for the following critical rotating equipment and their associated drivers. This system shall provide crucial information to the operators regarding progressive damage, over heating, and early detection of machinery problem to aid in making timely intervention to take corrective measures, shutdown and maintenance. The MMS will be installed on the following plant machinery:

The field probes, sensors and transducers / proximitors etc. shall be supplied with the machinery units by the Machinery Vendor, and shall be completely installed and wired in junction boxes (mounted on the skid) and equipped with the required terminals for the multi-triad terminations.

The machinery monitoring system shall consist of a Bently Nevada Series 3500 monitoring system with a display unit on the Local panel. The system shall be of a modular design with plug-in components. Removing or inserting of any main module shall not disrupt the operation of other unrelated modules in the system.
Measurement made on different machinery elements, such as radial vibration, axial displacement, rod position, bearing temperature, speed indication, case vibration and any other shall be provided as required by the Machinery vendor to ensure adequate monitoring.

In case when a machine is provided with spare/stand-by machine, the I/O for primary and spare/standby shall not assigned into the same I/O cards, and the rack power supplies shall be redundant.

6.1.1 Functionality of the MMS

The machinery monitoring system shall:

a) Continuously monitor radial shaft vibration of each bearing, all axial measurements, bearing temperatures and case vibration.

b) Provide channel set points that are individually adjustable over the entire monitoring range.

c) Meet the various rotating machinery vendor requirements (which shall be specified during detail Engineering).

The machinery monitoring system shall consist of a rack(s) with redundant power supplies, rack system interface module and associated monitor modules (e.g. radial vibration, axial thrust position, case vibration, key-phasor, temperature, acceleration based vibration etc.) suitable to interface with the various sensors identified in the enclosed I/O List.

Communication gateway and display interfaces shall be provided in accordance with API 670.

All repeated transducer outputs shall be buffered so that a short circuit of the output shall not affect the operation of the monitoring system.

Dual redundant power supplies in the monitor rack shall convert 110VAC, 50Hz, 1 phase power into appropriate voltage levels required by the system.

The removal or failure of one-power supply in the rack shall not cause any machinery to trip. Each power supply shall have the capacity to power a fully loaded rack.

System Spare requirements: 10% Spare Channels / Points at Mechanical Completion. (Basis of design shall be 20% installed spare with delivery in order to achieve 10% spare after commissioning.)

Hot swapping of electronic cards shall be required to eliminate the requirement of machine shutdowns to facilitate maintenance of the system.
Machinery probes and transducer/proximitors shall interface to the machinery monitoring system modules in the Satellite Rack room via field junction boxes mounted on the machine skid (supplied by Machine Vendor)

6.1.2 MMS Alarms

A hardwired common trouble alarm to the UCP shall be provided to indicate that a fault has occurred in the Bently Nevada System.

Serial links between the BN3500 and Rotating vendors Control System(s) shall be as per the Interface Block Diagram, operating on an industry standard protocol such as Modbus RTU. The details are as follows:

Serial link between MMS and Rotating vendors control system: MODBUS over TCP/IP, with the Rotating vendors control system as ‘Master’ and MMS as ‘Slave’

The system fault alarms shall be provided for:

a) Field circuit failures
b) Module and card failure
c) Power supply failures
d) Cabinet Temp. High

On occurrence of a faulty transducer (probe/proximitor) the trip initiator directly related to the BAD input will go to BYPASS mode (averting a spurious trip).

A common alarm and a common trip contact (NO or NC), shall be made available from the Bently Nevada system for each of the following:

a) Axial Thrust/Position
b) Radial Vibration
c) Temperature

de) Temperature

These (applicable) contacts shall be ‘latched’ and shall be hardwired to the machinery vendor’s control panel (if applicable) for annunciation on local panel and trip initiation.

All required Resets shall be implemented at the Bently Nevada system end.
7. MACHINERY MANAGEMENT SYSTEM (MMS)

7.1 General

MMS consists of Data Acquisition system (DAS) connected to the Machinery Monitoring and Protection System (MMPS) and the data collection systems built into the MMPS. The DAS shall acquire, process, store and display the vibration, position, temperature parameters and all process variable parameters from the MMPS. The DAS shall also be capable of acquiring, processing, storing and displaying the data from portable, compatible, data collection devices which may be connected to the MMPS.

The Machinery Management System (MMS) shall consist of a dedicated real time data manager for storing all machinery monitoring data and making it available as required. The DAS shall be capable of OPC communications with the UCP for the importation and correlation of process data with the machinery data.

The system shall continuously collect real time, transient and steady state data from Bently Nevada 3500 racks.

Software must include machine diagnostic tools and historical data trending (with archiving and retrieval capability)

7.1.1 Data Management (SYSTEM-1)(To be quoted optional)

The data management system shall be Bently Nevada’s ‘SYSTEM-1’ as a minimum & shall consist of the following hardware and software:

a) Communication processor, Bently Nevada TDXnet (up to two for each 3500 system rack. as needed) or RIM card with built in TDI. The TDXnet’s, where applicable, shall be installed and wired inside the 3500 system cabinet.

b) Latest PC with windows (latest version) as the data acquisition server.

c) 17” monitor

d) Keyboard

e) Data acquisition / display software

f) Client display software

g) Operator / Engineer decision support software

h) Collection of realtime data from the BN3500 racks
i) Diagnostic tools and historical data trending (with archiving and retrieval capability)

j) Colour Printer

The Bently Nevada rack configuration software shall be installed on the MMS PC and connected by Serial link to all the racks in the cabinets such that all of the racks can be configured directly from the MMS PC.

The data manager shall communicate with all 3500 system racks through Ethernet/TCP IP. All configuration functions associated with the 3500 system, MMS shall be performed at the Vendor’s shop.

Display graphic on the MMS shall be built, based on the plant graphic standards together with the rotating machinery vendor supplied P&IDs of the machine trains.

8. ENCLOSURES

8.1 Cabinets

Cabinets will be installed in a Satellite Rack room. With a display mounted in Local Control panel. The Vendor shall advise overall sizes and weights of his proposed cabinet suite with his proposal.

A dedicated marshalling area shall be provided with the system for termination of field cabling.

8.1.1 Degree of Protection

The degree of Ingress Protection of the Cabinets shall be minimum IP-44

8.1.2 Construction

All equipment shall be housed within free-standing steel cabinets.

The SRR cabinets shall preferably be of a standard Rittal cabinet complete with a 100mm plinth, removable gland plate and front & rear lift-off opening doors.

The Inner & outer colour of the cabinet shall be Rittal standard colour RAL 7035.
Cabinet shall have two 100% redundant ventilation fans (each rated for 100% duty & powered from separate feeders) & two temperature switches in each cabinet. All switches shall be connected in series and a common signal (normal closed contacts) shall be connected to the Rotating vendors control system for monitoring.

Lighting is required in the cabinet.

Removable side panels shall be provided as appropriate.

A utility socket shall be provided for the configuration/maintenance purpose, therefore a third 110VAC, non-UPS power supply to be supplied to the panel from UCP.

Cable entry shall be at the bottom of the cabinet. Vendor is to allow sufficient space below removable undrilled gland plate to install cable glands. Cable gland supply and drilling of gland plates shall be by others.

Doors shall be secured by a three point locking system actuated by cam-operated key locks.

8.1.3 Layout

The internal layout shall be designed to provide unimpeded access to all electronic modules, power distribution, switches, protective devices, terminals and termination areas including all grounding bars.

The internal framework shall be designed to provide rigid and secure mountings for module card frames, power distribution and field termination areas.

Controller, I/O etc., shall preferably be mounted on internal swing-frames allowing access to the rear of card trays.

Cabinet ventilation shall be arranged so as to avoid ‘Hot-Spots’ and Heat dissipation data shall be provided to demonstrate this.

Forced ventilation, if required, shall consist of twin parallel units each rated for 100% duty. All air entry and exits shall have removable, cleanable filter elements.

8.1.4 Terminations and Wiring

1) Cable core markers shall be Raychem (or equal) heat-shrinkable cable marking system. All system wiring shall be labelled such that it will be possible to trace the source and destination of the wiring without the system drawings. The wire marker shall be provided with both end of wire (adjacent to the terminal), and both source and destination terminals of wire shall be labelled on the marker. All system wiring labels must be naturally readable by anyone standing on the floor,
for example, horizontal labels must be readable, in the normal fashion, left to right.

2) Connection to field cabling shall be via PHOENIX screw-less, clamp type terminals and shall be arranged grouped into banks field cabled wise. Each bank shall use a continuous numbering system.

3) The wired spares for each signal type bank shall be installed in a terminal bank directly below the main terminal bank. System wiring shall be sufficiently long so that the wired spares can be re-routed to any spare field marshalled point on the main terminal bank.

4) Terminals shall accommodate only one conductor on each side. Any looping requirements shall be achieved by using the proper designed links. The field termination side of terminal blocks shall be reserved for field cabling only.

5) All terminal blocks shall provide positive isolation from the field via a fused arm and/or disconnect switch as applicable.

6) Protective covers shall be provided for all power distribution terminals (greater than 48VDC and AC) to reduce the likelihood of accidental short circuits and contact by maintenance personnel. Appropriate and clearly defined warning labels shall be provided.

7) A minimum of 20% spare terminals shall be provided and 2% spare links to be supplied loose.

8) Internal cross-cabinet wiring to I/O cards/relays etc. shall be pre-installed (and tested by the vendor) within the cabinet suite and utilise stranded copper conductors. Internal wiring shall be 1mm2 minimum.

9) All stranded cores shall be provided with insulated pin or blade type cable crimp connectors. The head of the crimp is to be large enough to retain any conductor identification markers or tags

10) Vendor shall ensure that there is minimum stress applied to wiring harnesses to any swing frame arrangements.

11) Segregation of Power cables from Instrument cables shall be provided. All cables operating with circuit voltages of less than 48VDC are deemed to be Instrumentation cables for segregation purposes.

12) Each circuit, sub circuit and peripheral equipment shall be individually protected. Common fault alarms shall be provided. Connections to field devices shall be appropriately fuse protected.
13) Miniature circuit breakers shall preferably be used throughout the system power distribution.

14) All cables and conductors shall be sized to carry the continuous rated current of the protective device. Minimum 300 volt, PE insulation grade shall be used.

8.1.5 Susceptibility to Interference

The system as supplied shall be unaffected by the operation and dimming of fluorescent lighting, and by the use of hand-held radio transceivers up to 5 watt output power using the frequency range 27 MHz to 470 MHz. System RF immunity shall be based on the case where the equipment cabinet doors are open.

8.1.6 Regarding the wire sizes, the minimum conductor size shall be 1 mm² (2.5 mm² for power). Larger conductor sizes shall be used as dictated by power requirements, voltage drop or other technical necessity.

9. INSPECTION AND TESTING

9.1 Factory Testing and Site Installation Support

The entire system shall be tested at the Vendor’s workshop by Vendor’s technicians in the presence of the Package vendors representative. The vendor shall prepare the procedure and provide all of the necessary test equipment required to accomplish the Factory Acceptance Testing (FAT). This will include, but not be limited to, switch and lamp panels to simulate all inputs and outputs for complete testing of the plant shutdown logic, associated initiators, alarms and trip action outputs. All simulated inputs and outputs (including the interface with 3rd parties system) should be arranged and labelled for ease of identification during the FAT.

The Integration Test by purchaser, to verify the interface (both hardwire and serial link signals) with package PLC shall be executed at the respective machine vendors facilities during PLC FAT in presence of Vendor’s supervisor.

At site, the vendor’s representative shall check the installation of the system prior the power-up of the system. The representative will also carry out the Vendor’s standard tests as required to verify the proper operation of the system after it is powered up so as to ensure that the Vendor’s Warranty remains valid. The vendor’s representative shall prepare the relevant documentation to report on the Site power up activities.

9.2 System Functional Test
Before the Purchaser starts to witness the FAT, the System/machine vendor shall have performed a complete system functional test in accordance with the Vendors standard procedure as well as a test of all the I/O points, digital and analogue functions, logic resets etc. inclusive of the serial links.

9.3 Test Equipment & Simulation Facilities

The Vendor shall provide all necessary test equipment and simulation facilities required for Purchaser's witness tests and supply manpower in order to:

- Review acceptance test criteria
- Schedule and arrange test facilities
- Demonstrate the system according to acceptance test criteria
- Analyse and interpret test results for purchaser personnel
- Provide assistance in case of system malfunctions during the acceptance test period.

Note that the MMS Vendor shall provide the necessary equipment (relevant modules or test kits), personnel and transportation necessary to fulfil the Integrated Test. At Package Vendor facilities.

9.4 Factory Witnessed Test

Package vendor if required may attend the MMS FAT at MMS vendors works prior to despatch of MMS panel to Machine vendors works for Integrated FAT.