Based On : Own Experience

ON-LINE (Continuous) CONDITION MONITORING SYSTEM FOR HYDROGENERATOR

1.0 GENERAL:

This specification covers the requirements for design, supply, installation & commissioning of a on-line system to continuously monitor salient parameters (i e. shaft vibrations in the vicinity of guide bearing journals and air gap in between stator & rotor etc.) of hydro generators in the powerhouse complete in all respects with sensors/ probes/ detectors, control unit, time delay relays, monitors with recorder output, alarm, level detectors, level relays etc. The complete system & the sensors offered by the supplier must be in line with equipment already installed and proven for satisfactory performance in the field for at least 5 years after commissioning. Installation & commissioning charges shall be quoted separately.

The system must be complete in itself & should provide software to measure & display the parameters being monitored, storage & post processing of the measured data, its analysis & trending to monitor the condition of the generator. It should also provide complete diagnostic analysis with polar view of rotor inside stator from the measurements for air gap.

2.0 DETAIL OF THE EQUIPMENT :

The supplier shall design, supply, permanently install & commission a complete system (hardware & software) comprising of monitor with recorder output for data acquisition, data processing, data storage, trending, alarm, level detectors and level relays etc.; colour display & printing unit; all the accessories for on-line condition monitoring system for Shaft vibrations in the vicinity of guide bearing journals generally as per BHEL Specification HG55036 (Rev.02) and Air Gap in between stator & rotor generally as per BHEL Specification HG55035 (Rev03) of hydro generator in the powerhouse, complete in all respects with detectors, pre-amplifiers, control unit, power supply, time delay relays; all interconnecting & field cables etc.

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				NAME	SIGNATURE & DATE
TSX	AK CHATURVEDI				
HGE	SANT KUMAR				
QAX	S.S. Chauhan		TRANSLATED BY		
GRI	P.J.BAGAWADE		WORKED BY	R.C.Sharma	09.04.06
AGREED DEPTT	NAME	DATE & SIGNATURE	CHECKED BY	R.C.Sharma	09.04.06
			SUPERVISED BY	Manjit Singh	09.04.06
SUPERSEDES			APPROVED : HEAD HYDROGENERATOR ENGG. Manjit Singh		
REV NO. 01	REV. NO 02		PREPARED : HGE	ISSUED : TSX	DATE 12-04-06
Dt. 7.8.08	15.03.2010				

SUPERSEDES INVENTORY NO. P-4067

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However, the specific requirements furnished below shall be additional to the requirements given in earlier referred Specifications i.e. HG55035 (Rev03) & HG55036 (Rev.02) & over riding in case of any ambiguity.

2.1 ON-LINE CONTINUOUS MONITORING SYSTEM SHALL BE PROVIDED WITH:

- No. of channels = As per Annexure – I *(of HG55064 only)* + 2nos. Spare.
- Each generating unit shall have its independent (i.e. stand alone) probes/ sensors, conditioning amplifiers, Front end Processing , *data acquisition* & display of basic parameters for each channel being monitored, its enclosure / panel (common for Vibration & Air Gap Monitoring) suitable for floor (or wall) mounting that shall to be located outside (outer periphery of) generator barrel in consultation with power house authority.
- A front-panel key pad for easy programming of all key settings such as:
  - alarm levels of each channel for overall value;
  - alarm delay time;
  - units of measurement;
  - Display brightness etc.
  - Sensitivity setting for each probe/ probe amplifier.
  - Amplifier Gain setting.

  These should be user settable in software with provision to soft lock it.
- The overall condition monitoring system (for both Vibration & Air Gap Monitoring) shall have a common multiplexed monitor-cum-controller-cum data acquisition system (data storage, post processing, analysis, its trending) for all the units in the power house to be located centrally or in the control room as decided in consultation with power house authority. It shall have provision for storing & trending of data in a seamless manner through the life of the generator. Base data updation / acquiring rate should be variable from 15 seconds to 600 seconds selectable through the programme. Party should indicate the methodology for data storage structuring & its retrieval for trend analysis. Trend analysis should be possible channel vise and simultaneously as a group of channels per generator on

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a selected time window size of the data. Window size shall be variable from one hour to 100 hrs.

- Displays provided by the system should be multi-coloured. For taking out hard copies of the output, suitable coloured printer having latest features should also be included in scope of supply.
- The overall control system shall be complete with operator console.
- System/ systems shall be suitable for voltage variation within ± 20%. This shall be applicable to Alarm output contacts.
- Systems installed within generator barrel it shall be suitable for Temp.0-100°C & R. Humidity 90%).
- A communication interface that allows data of each monitored channel to be linked with a computer/SCADA system capable of receiving analog DC signals of 4-20 mA / 0-5V, selectable through front panel program
- Front panel access through BNC connectors of raw vibration signals to be analyzed with portable equipment;
- Supplier shall provide a complete installation & operating procedure, diagnostic guide including its interpretation part in its O&M manual that should be concise & in-line with the equipment supplied & commissioned for the operating personnel.

Details of the power station & generator on which these monitoring systems are required to be to be installed is provided in Annexure – I(of HG55064 only).

2.2 **VIBRATION MONITORING** (Additions/Changes in equipment vis-à-vis HG55036-Rev 02):

- **Phase angle shall also be displayed along with the display for relative shaft vibrations.**
- **Proximity probes shall have a measuring range of 2 mm with signal non-linearity better than ±2% at the mid point of the measuring range. The probe frequency response shall cover the bandwidth of 0 to 1000 Hz.**

2.3 STATOR – ROTOR AIR GAP MONITORING:

2.3.1 Equipment as per HG55035 (Rev03).

2.3.2 O&M manual provided with the equipment should provide:

a. Installation details along with schematic diagram of the Front Panel display of each unit & common installation for all the units in powerhouse.

b. Testing, commissioning & operating procedures in detail specific to the supplied equipment.

c. Complete Diagnostic procedure guide for the operating personnel including interpretation of the results / data in respect of Air gap measurements provided by the system.

Note: In order to appreciate capability of the offered air gap monitoring system w.r.t. interpreting the data, the tenderer should submit one case study with his offer.

2.3.3 The commissioning team shall have adequate experience in interpreting the air gap readings obtained by AGMS. As a part of successful testing & commissioning the team shall submit a report giving assessment / interpretation of stator & rotor air gap, independent form of stator & rotor and overall behavior of the generator without any extra charge.

2.3.4 Besides providing assessment / Interpretation of initial system test readings as a part of commissioning activity (Ref. clause 2.3.3 above), supplier shall also provide assessment / interpretation of two subsequent test readings of each generator spread over first year of installation / commissioning without any additional charge.

2.4 TACHO PROBE / SPEED SENSOR / ROTOR REFERENCE PROBE:

A synchronization probe used for rotor pole reference purposes shall be provided in each unit and shall be suitably installed near the rotor shaft. This reference probe shall be a proximity switch that shall detect a small magnetic target rigidly fixed to the rotor shaft. The leads for the synchronization probe shall be shielded twisted pair of copper wire of suitable size. The leads from the probe to the wall / floor mounted enclosure shall also be routed in a protective conduit.

2.5 FIELD CABLES & SENSOR/ REFERENCE PROBE LEADS:

- In order to ensure completeness of the system, all field cables & connecting leads i.e. from sensors to probe amplifier to processor to monitor/ controller etc. are to be provided with the equipment as stipulated in Specifications HG55035 (Rev 03) & HG55036(Rev 02).

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- The size & configuration of leads / cables for sensor to be compatible with sensors/ conditioning amplifiers.
- Party shall provide detailed specification & test certificates for different cables used in the systems.

2.0 MOUNTING OF PROBES / SENSORS/ DETECTORS:

The supplier shall provide probe/ sensor/ detector and other accessories required to install them permanently. These mounting arrangements should be rigid enough so as not to affect the parameters being measured by the probe / sensor mounted on them.

3.0 RESPONSIBILITIES OF THE SUPPLIER: Refer HG55035 (Rev 03) & HG55036 (Rev 02).

Note: In order to get the feel of generating units and lay out of the power house, the tenderer is free to visit us with prior intimation/ permission for having a look at layout drawings to prepare / submit realistic offer.

4.0 TESTS:

4.1 Routine Tests & Acceptance Tests (at site): As per HG55035 (Rev 03) & HG55036 (Rev 02).

4.2 Type Tests (Updated):

Temperature-cycling functionality test under humidity conditions of assembled electronic items (signal conditioners, data acquisition units, monitors etc.) to be performed at following three stages:

a. Just before start of test.

b. during temperature cycling. &

c. after 16 hrs. – maximum temperature tests.

Note:

01. In case the tenderer has already conducted the Type tests as per para 4.2 above satisfactorily on a similar system and provides a valid proof for the same, BHEL may waive-off the requirement of type tests.
02. Routine tests at Sl. No.4.1 above shall be performed after having performed the Type tests (clause 4.2) satisfactorily.

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5.0 DELIVERY & ERECTION OF EQUIPMENT } Refer HG55035 (Rev 03) &
6.0 TRAINING OF BHEL & CUSTOMER PERSONNEL } HG55036(Rev 02) clubbed together.

7.0 DRAWINGS & DOCUMENTATION:

- Refer HG55035 (Rev 03) & HG55036 (Rev 02) clubbed together.
- To appreciate air gap monitoring system capability (being offered) interpreting the data, the tenderer should submit one case study with his offer.
- List for hydro installations of comparable equipment using Capacitive type air gap sensors that has been supplied & commissioned by the tenderer along with date of commissioning with offer.
- Schematic diagram giving proposed installation details of vibration & air gap monitoring equipment/ display panel of each unit & common installation for all the units in powerhouse.
- List of activities to be carried out at site to install & commission the system as a whole) along with list of testing equipment that shall be used to verify the performance of the system (ref. Clause 4.1 also).
- List of technical documentation that shall form a part of supply. This will include the schematic diagram of individual units along with detailed circuit diagrams.

8.0 PACKING & TRANSPORT } As stipulated in Specifications HG55035 (Rev 03)
9.0 GUARANTEE CERTIFICATE } &
10.0 AFTER SALE SERVICE } HG55036 (Rev 02) clubbed together.

11.0 MARKING:

- All the equipment / components shall have metal plates fixed in suitable position with full particulars engraved there on.
- The following details shall be marked on each packing case:-
  a. Manufacturer's name or trade mark.
  b. BHEL order no.
  c. BHEL standard no. HG55064.

12.0 CROSS – REFERRED STANDARDS:

- HG55035 (Rev03)
- HG55036 (Rev02)

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REV.NO.		निर्माणकर्ता WORKED BY	R.C.Sharma		09.04.2006
02		जाँचकर्ता CHECKED BY	R.C.Sharma		09.04.2006

ANNEXURE-I

DATA OF POWER STATION / GENERATOR FOR INSTALLATION OF CONDITION MONITORING SYSTEM

1.General:

- Name of P/H :Koteshwar HEP (Semi Under Ground)
- No. of Units x Rating :4 x 100MW
- Customer :Tehri Hydro Development Corporation
- Location :Koteshwar is about 150kM from Haridwar , on Down-Stream of Tehri HEP in Uttarakhand - India.
- Type of Generator :Synchronous-Vertical
- Type of Construction of Generator :Semi-Umbrella
- Rated/Run-away Speed/Frequency :142.86RPM / 265RPM / 50Hz

2.Vibration Monitoring of rotating component (Shaft) near Guide Bearings:

- Generator Guide Bearings :One No. located above the Rotor(UGB) in U-Bkt
  :One No. located below the Rotor(LGB) in L-Bkt
- Turbine Guide Bearing : One No. located on Turbine Top Cover
- No. of Proximity Probes for Vibration measurement :2 Nos. per Guide Brg. (Total 6 Nos./Generator)
- Tacho/ Speed Sensor/Rotor Pole Reference Probe :1 No. for Each Generator, mounted near Shaft
- Generator & Turbine Shaft Forging Material Chemical Composition

Carbon	Silicone	Manganese	Sulphur	Phosphorous
0.24 to 0.32	0.10 to 0.35	1.30 to 1.70	0.025 Max	0.025 Max

2.Air Gap Monitoring:

- Generator Stator Core Diameter/Height :8600mm / 1650mm
- Air Gap Between Stator & Rotor (As Built) : 18mm to 23mm
- Reduction in Air Gap from As built at
  i) Rated Speed : 1mm
  ii) Maximum (Run-away) Speed : 3mm
  (Minimum Possible Air Gap = 15mm , Maximum Possible Air Gap 23mm)
- Acceptable measuring range of Air Gap Sensor :Minimum ≤ 10mm
  :Maximum ≥ 30mm
- No. of Air Gap Sensors Per Generator :Total 8 Nos./Generator
  (4 Each at Top & Bottom of Core)

Minimum No. of Channels for each generator For				Total / Generator	Total For Four Generators
Vibration	Tacho	Air Gap	Extra		
6	1	8	2	≥17	≥68

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दिनांक एवं हस्ताक्षर SIGN & DATE
सप्लीड्स इन्वेन्टरी नं. SUPERSEDES INVENTORY NO.
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Based On : Own Experience

ON-LINE AIR GAP MONITORING SYSTEM FOR HYDROGENERATOR

1.0 GENERAL:

This specification covers the requirements for design, supply, installation & commissioning of a complete system for on-line monitoring of air gap in between stator & rotor of hydro generator in the powerhouse. The complete system & the air gap sensors offered by the supplier must be in line with equipment already installed and proven for satisfactory performance in the field for at least 5 years. Installation & commissioning charges shall be quoted separately.

The system should provide dynamic air gap measurements as required and permit static measurements to monitor the condition of generator air gap without requiring a shutdown of the machine. System offered should be such that the measurements taken by it are not affected / altered by the magnetic field, dust, oil and carbon particles found in the air gap. System installation shall be done at site during erection / commissioning of the generator at site or during a routine shutdown for inspection. The installation of the system sensors and cabling must be possible when the generator rotor is in position. The system shall not compromise with the reliability and safety of the generator.

The system must be complete in itself & should provide software for complete diagnostic analysis with polar view of rotor inside stator.

2.0 DETAIL OF THE EQUIPMENT :

Air gap monitoring unit shall consist of air gap sensors, rotor pole reference probe, sensor/ reference probe cables/leads, wall mounted enclosures & air gap monitoring system, computer, printer etc. Detail of the equipment furnished below provides a general guideline to the supplier.

Relevant data pertaining to the power station & generator in which the system is required to be installed is given in Annexure-I.

2.1 AIR GAP SENSORS:

The air gap sensors shall be of capacitive type with one plate of the capacitor being the air gap sensor and the other plate being the rotor poles. The capacitive air gap sensor is permanently installed in the air gap on the stator core packets. Number of sensors shall correspond to the bore diameter & height/length of the stator core (ref. Annexure-I). The frequency response of the sensors should be 0 to 1000 Hz for static and dynamic air gap measurements and shall have interchangeability better than or equal to ±5%.

AGREED DEPTT	NAME	DATE & SIGNATURE		NAME	SIGNATURE & DATE
TSX	D.L. OBEROI	11.8.2003			
HGE	SANT KUMAR				
QAX	S.K.ARORA		अनुवादक TRANSLATED BY		
GRI	P.J.BAGAWADE	12.08.03	निष्पादक WORKED BY	NITI KOHLI	01.08.03
			जाचकर्ता CHECKED BY	R.C.SHARMA	01.08.03
			पर्यवेक्षणकर्ता SUPERVISED BY	B.R.GAUBA	02.08.03

REAFFIRMED

स्वीकृत किये APPROVED : (B.R.GAUBA) HEAD HYDROGENERATOR ENGG

GR.NO 8,70

REV.NO.	02	03
Dt.	25.11.2008	17-03-2010

निर्माण PREPARED : HGE

जारी ISSUED : TSX

दिनांक DATE 13-12-2011

INVENTORY NO. P-3816

Maximum operating temperature of the sensor shall be 125°C. The material used for fabrication of the sensor should be preferably fiber glass with a semi-conductive material on the surface totally immune to the generator magnetic field. The supplier shall provide calibration charts for each sensor.

2.2 ROTOR POLE REFERENCE PROBE:

A synchronization probe used for rotor pole reference purposes shall be installed above the rotor near the shaft in the upper bracket.

The reference probe shall be a proximity switch that shall detect a small magnetic target rigidly fixed to the rotor shaft.

2.3 SENSOR & REFERENCE PROBE CABLES / LEADS:

The leads for sensor may be triaxial cables of suitable size. These shall be brought out and terminated in a wall-mounted enclosure. Each sensor should have one cable only. The cable lead distance between the sensors & the wall-mounted enclosure shall correspond to the generator data (ref. Anneaxure-I). The triaxial cable leads from the sensors to the wall mounted enclosure shall be routed in a liquid seal tight conduit.

The leads for the synchronization probe shall be shielded twisted pair of copper wire of suitable size. The leads from the probe to the wall mounted enclosure shall also be routed in a protective conduit.

All the cables shall be capable of withstanding the operating conditions specified for the probes/ sensors. Cables may be treated for noise level reduction, if necessary, to maintain the quality of signal transmission. Cable connectors / microdot end connectors/ microdot couplers wherever used with cable leads shall correspond to the size & type of cable.

All leads/ cables shall be suitably labeled to show the associated equipment.

The placement of all the conduits shall not interfere with normal operation & maintenance of the generator. The conduits shall be securely fastened to the stator frame / civil structure to prevent their movement due to vibrations etc. during operation of the generator.

2.4 WALL-MOUNTED ENCLOSURE:

The wall-mounted enclosure shall be oil and dust tight as per NEMA 4 or its equivalent international standard. Its dimensions shall be sized to accommodate on-line air-gap monitoring system with all cable leads. Protective conduit for sensor leads, reference probe leads and AC power line shall be rigidly fixed to the enclosure. The air gap monitoring system shall be rigidly connected to the generator earthing bus with a copper lead of suitable size with matching lugs.

- The enclosure shall be mounted on the outer wall of generator barrel. The supplier shall ensure that it doesn't interfere with normal operation & maintenance of the generator. The supplier shall also ensure the suitability of conditioning units for probes & other components installed in this enclosure for operation in the following environmental conditions:

  a. Temperature 0 - 55°C. b. Humidity up to 95% – Out Side Gen barrel
  (For rest of the system installed within generator barrel it shall be Temp.0-100°C & Humidity 90%).

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2.5 AIR GAP MONITORING SYSTEM (AGMS):

The system shall operate with a compatible computer and a printer. It shall measure the static and dynamic air gaps and shall be controlled by a user friendly software package to display the results in a suitable form say polar, rectangular & tabular.

The AGMS shall provide a polar view of the rotor shape inside the generator stator complete with rotor & stator circularity and centre off set values. For this, the system should be capable of monitoring all parameters simultaneously in order to properly correlate data to the specific moment in time. The system should have provision of sensitivity setting for each probe/ probe amplifier. It should be user settable in software with provision to soft lock it. The AGMS should provide a software / hardware alarm when the air gap reaches set alarm levels and shall store automatically at least 20 turns before and after an alarm occurred event. The system must be capable of accepting externally triggered events to be able to take measurements during machine trips.

The system shall also provide a communication inter-phase that allows the data being monitored by AGMS to be linked with SCADA system capable of receiving analog DC signals of 4-20mA.

Communication from AGMS of individual units - proposed to be installed on the outer wall of the generator barrel – shall be connected to the computer of each generator. The computer shall be mounted on a cabinet that can be placed on floor. It shall be located in consultation with powerhouse authority. Communication from AGMS to the computer should be highly reliable. All the communication links (preferably opto-isolated) required between the AGMS and the computer shall be provided by the supplier.

The feasibility of providing a common multiplexed monitor-cum-controller-cum data acquisition system for all the units in the power house to be located centrally may be examined. If found feasible, it may be offered as alternate option along with its techno-economic advantages/ disadvantages vis-à-vis independent system for each unit.

2.6 GENERAL:

- The supplier shall include all field cables i.e. from sensor to probe amplifier to processor to monitor/ controller in their scope of supply.
- Alarm output contacts shall be potential free and rated for a current of 5A, 240 volts AC 50 Hz. or 0.5A 220 V DC. All alarm output should be fuse protected.
- The system shall have the provision of a 12V buffered rotor pole reference probe signal out put, to be used for testing purposes / in vibration monitoring system.
- The supplier shall give frequency response curve along with roll-off characteristics.
- The system shall have a design feature to reject & reduce line frequency & Electro magnetic interference (EMI).
- The supplier shall provide a complete installation; test & operation guide with the AGMS for the operating personnel. It will include the circuit diagram of individual units.
- The system shall be suitable for mains operation (240V ±10%, 50Hz AC). Also there should be provision of UPS of compatible rating with 30minutes of backup
- If the system is capable of providing Creep Detection facility, it may be offered as an optional item.

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3.0 RESPONSIBILITIES OF THE SUPPLIER:

3.1 The supplier shall design, supply, permanently install & commission a complete system along with all the accessories for on-line monitoring of air gap in between stator & rotor of generator in the power house. Accordingly, the supplier shall quote for design, manufacture, testing at works, despatch to site, installation & successful commissioning of the AGMS in all the generators (ref. Annex.-I) in the power house as per the details given above in para 1.0 & 2.0.

3.2 The equipment must be complete in all respects irrespective of whatever has been mentioned in para 1.0 & 2.0 above. Any accessories or equipment that has not been mentioned in the specification but are required as a part of the system are to be specified and included in the offer.

3.3 The supplier shall ensure that the modules that require power supply other than the mains have been provided with suitable adopters.

3.4 The supplier shall indicate accuracies / error of individual items like sensors, measuring system etc. The overall accuracy of the system should be equal to or better than 7.0 %.

3.5 The supplier may additionally provide & offer measurement for rotor flux in the air gap as optional feature.

3.6 The supplier shall give procedure for functional checking and calibration of the system at site. In case any fixture is required for it, the same should be included in the scope of supply (common for all the generators in the power house) .

3.7 ***The offer shall include & indicate separately the charges for installation testing & commissioning of the equipment in the powerhouse.*** The commissioning team will carry with them all the necessary test equipment required to verify the proper operation of the AGMS. Supplier shall provide a complete diagnostic procedure guide including its interpretation part for the operating personnel. The supplier's team shall have adequate experience in interpreting the air gap readings obtained by AGMS and shall submit a report giving assessment of stator & rotor air gap, independent form of stator & rotor and overall behavior of the generator. To appreciate AGMS capability w.r.t. interpreting the data, the supplier should submit one case study

3.8 ***Offer shall be submitted in duplicate.***

4.0 TESTS:

Type / routine tests shall be carried on the equipment at works before despatch to site. However, the tenderer in his offer shall list out all the tests to be carried out on the components of the system at works to prove the equipment. The procedure for these tests and acceptance norms shall be submitted for approval to BHEL.

4.1 Routine Tests:

4.1.1 Electrical continuity tests. Certificate of compliance to be given by supplier.

4.1.2 Preliminary functionality tests of electronic components. Certificate of compliance to be given by supplier.

4.1.3 Calibration tests (i.e. Calibration curves) for all sensors.

4.1.4 Tests for compliance to the specification.

4.2 Type Tests:

Three stage temperature-cycling functionality test of assembled electronic items (signal conditioners, data acquisition units, monitors etc.) **a.** before **b.** during, & **c.** after 16 hrs. – maximum temperature tests.

Note: Routine tests at Sl. No.4.1.3&4.1.4 above shall be performed after performing the Type tests (para 4.2) satisfactorily.

4.3 Acceptance Test (at site) :

Installation of the complete system and verification of all types of measurements in conformance to the specification.

5.0 DELIVERY & ERECTION OF EQUIPMENT:

5.1 Equipment shall be delivered to powerhouse site as per the dispatch instructions of BHEL. Before dispatch, test results as per clause 4.0 shall be sent to BHEL for approval. Despatch of the equipment shall be subject to approval of these test results.

5.2 Installation / commissioning of the equipment shall match the erection of generating equipment in the powerhouse. As such, successful tenderer shall depute his team to powerhouse for undertaking site activities at 1'month notice from the purchaser as and when required at site.

5.3 In order to avoid any hold up at the time of erection / commissioning of the equipment the tenderer shall depute his representative to site for physical inspection / verification of the material as soon as it reaches site. The charges for such deputation may form part of erection / commissioning offer.

Note: There can be some time gap between delivery of the equipment at site & its installation. As such supplier shall take necessary measures to ensure that the equipment remains in healthy condition till such time it is installed / commissioned.

6.0 TRAINING OF BHEL & CUSTOMER PERSONNEL:

During erection, testing & commissioning of the equipment at site, the supplier shall provide training to BHEL & customers personnel regarding smooth operation, servicing & data interpretation to ensure proper utilisation of the equipment.

7.0 DRAWINGS & DOCUMENTATION:

7.1 Tenderer shall enclose following information with the tender:

- Complete specification including detailed description and operating principle of the basic components forming a part of AGMS as a whole.
- List of tests to be carried out on the components of the system at works before dispatch to site (Ref. Cl.4.0).
- Bill of materials that shall be supplied to complete installation.
- ***Points of departure from this specification shall be listed separately. Relative merits of each of these departures along with sufficient information in respect of operating principle, material used, relevant specifications / standards, if any, etc. shall also be provided.***
- List of installations of comparable equipment that has been supplied & commissioned by the tenderer along with date of commissioning.
- Proposed installation arrangement drawing & list of activities to be carried out at site to install & commission the AGMS as a whole along with list of testing equipment to verify the performance of the system.
- List of technical documentation that shall form a part of supply including the circuit diagram of individual units.

7.2 The supplier shall supply 10 sets of technical documentation as agreed at the time of placement of order along with a CD for the same directly to:

Head of Hydro Generator Engineering (3rd Floor,Old Engg. Bld.)
HEEP, BHEL-HARDWAR (UA) – INDIA (PIN-249403).

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8.0 PACKING & TRANSPORT:

- The equipment shall be packed suitably for transportation in view of its delicate nature & mode of transportation. Supplier shall be responsible for any damage to the equipment during transit.
- Special care shall be taken to eliminate shock etc. to parts, which may be susceptible to damages. Fragile parts shall be carefully packed and shall bear suitable marks on outside of package.
- Contents of each package shall bear markings that can be readily identified from the packing list.
- Unpacking & storage instructions / conditions considered necessary may also be provided.
- All packing cases and packing material shall remain the property of the purchaser.

9.0 GUARANTEE CERTIFICATE:

The supplier shall guarantee the equipment for trouble free operation for 18 months from date of despatch (or) 12 months from date of commissioning and its handing over to the power house authority, whichever is later. He shall be responsible for replacing free of cost at site any equipment or part thereof that prove defective either in material, workmanship or design within guarantee period.

Should the tests undertaken at site during commissioning / operation of the generator within guarantee period indicate that it does not meet the specification, the purchaser shall have the right to reject the equipment and direct the supplier to take immediate action to furnish all such parts as may be necessary to make the equipment meet the guarantees and other requirements. Supplier shall bear all the expenses on this account.

Should the tests undertaken at site during commissioning / operation of the generator within guarantee period indicate that it does not meet the specification, the purchaser shall have the right to reject the equipment and direct the supplier to take immediate action to furnish all such parts as may be necessary to make the equipment meet the guarantees and other requirements. Supplier shall bear all the expenses on this account.

10.0 AFTER SALE SERVICE:

The supplier shall confirm that the after sale service requirements of this equipment shall be met with for 3years after its commissioning at site. The address of contact person / agency shall be given in the offer.

11.0 MARKING:

- All the equipment / components shall have metal plates fixed in suitable position with full particulars engraved there on.
- The following details shall be marked on each packing case:-
  a. Manufacturer's name & trade mark.
  b. BHEL order no.
  c. BHEL standard no. HG55035.

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ANNEXURE-I

DATA OF POWER STATION / GENERATOR FOR INSTALLATION OF AIR-GAP MONITORING SYSTEM

1.General:

- Name of P/H :
- No. of Units x Rating :
- Customer :
- Location :

Refer Annexure-I of HG55064

- Type of Generator :
- Type of Construction of Generator :
- Rated/Run-away Speed/Frequency:

2.Air Gap Monitoring:

- Generator Stator Core Diameter/Height :
- Air Gap Between Stator & Rotor (As Built) :
- Reduction in Air Gap from As built at — Refer Annexure-I of HG55064
  - i) Rated Speed :
  - ii) Maximum (Run-away) Speed :
  - iii) (Minimum Possible Air Gap = mm , Maximum Possible Air Gap= mm)
- Acceptable measuring range of Air Gap Sensor :Minimum ≤ mm
  :Maximum ≥ mm
- No. of Air Gap Sensors Per Generator :Total Nos./Generator
  (Each at Top & Bottom of Core)

Minimum No. of Channels for each generator For				Total / Generator	Total For Four Generators
Vibration	Tacho	Air Gap	Extra		

अनधिकार एवं गोपनीय

INVENTORY NO. P-3816 SIGN & DATE 31/8/03

REV NO 02

तैयारकर्ता WORKED BY	NITI KOHLI		01.08.03
जांचकर्ता CHECKED BY	R.C. SHARMA		01.08.03

Based On : Own Experience

ON-LINE VIBRATION MONITORING SYSTEM FOR HYDROGENERATORS

1.0 GENERAL:

This specification covers the requirements for design, supply, installation & commissioning of on-line vibration monitoring system for hydro generators in the powerhouse, complete in all respects with detectors, control unit, time delay relays, monitors with recorder output, alarm, level detectors and level relays etc. The probes will be mounted on locations best suited to detect vibration of rotating and stationary components. The gap variation between vibration probe and shaft will give signal to a signal sensor, which will amplify it to an indicating instrument mounted on racks that shall be installed on the outer wall of generator barrel. The instrument will be solid state device and equipped with adjustable setting on display rack for alarm and trip contacts.

The complete system & the vibration probes/ detectors must be in line with equipment already installed and proven for satisfactory performance on a vertical shaft hydro generator in the field for at least 5 years.

The instrument / system shall be rack mounted programmable digital processor based unit to provide continuous display of channels indicating dynamic relative shaft & bearing bracket vibration measurements as required to frequently and randomly monitor the condition of rotating shafts & bearing brackets while the machine is operating. The system shall be such that the measurements taken by it are not affected / altered by the electro-magnetic field, residual magnetism, moist air, oil/oil vapors and other foreign particles generally found in an operating set. System installation shall be done at site during erection / commissioning of the generator or during a routine shutdown for inspection. It shall not compromise with the reliability and safety of the generator.

The system must be complete in itself along with requisite software.

2.0 DETAILS OF THE EQUIPMENT :

Details of the equipment furnished below provide a general guideline to the supplier. In case the supplier wishes to offer an alternative proven equipment that meets the functional requirements of the system and is fully compatible with the operating conditions of the generator provided in this specification. However, in that case, the points of departure shall be listed giving relative merits of each of them. This should provide sufficient information in respect of operating principle, material used, relevent specification/ standards etc.,if any, along with the offer.

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TSX	L.B.MALHOTRA			NAME	SIGNATURE & DATE
HGE	SANT KUMAR	06.09.03			
QAX	S.K.ARORA	9/9/03	TRANSLATED BY		
GRI	P.J.BAGAWADE	06.09.03	WORKED BY	NITI KOHLI	05.09.03
AGREED DEPTT	NAME	DATE & SIGNATURE	CHECKED BY	R.C.SHARMA	05.09.03
			SUPERVISED BY	B.R.GAUBA	06.09.03
			APPROVED HEAD HYDROGENERATOR ENGG	B.R.GAUBA AGM (HGE)	
REV NO	01	REV 02	PREPARED HGE	ISSUED TSX	DATE
Dt	09.09.03	14.03.2010			

SIGN & DATE 19/9/03

INVENTORY NO P-3817

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Relevant data pertaining to the power station & generator in which the system is to be installed is given as per the Annexure-I.

2.1 VIBRATION MONITORING INSTRUMENTATION & DISPLAY RACK :

The supplier shall design, supply, permanently install & commission a complete system (hardware & software) comprising of monitor with recorder output for data acquisition & data processing, alarm, level detectors and level relays etc.; display unit; all the accessories for on-line monitoring of vibrations for hydro generator in the powerhouse, complete in all respects with detectors, pre-amplifiers, control unit, power supply, time delay relays, all interconnecting cables etc.

- The system shall provide & display dynamic relative shaft & bearing bracket vibration level magnitude in displacement mode for overall, 1f & 2f components in peak-to-peak microns and trend data display at identified locations as required to monitor the condition of rotating shafts & bearing brackets while the machine is operating.
- The system shall be capable of using a buffered 12V rotor pole reference probe (i.e. speed) signal that is likely to be provided in the machine as a part of air gap monitoring system, if required for providing 1f & 2f components. Otherwise, it should be quoted as an additional item
- The software & hardware for display of vibrations in polar, orbit & transient mode may be offered as an optional item only.

The instrumentation and display rack unit shall be suitable for wall mounting. It shall be suitable for mains operation (240V, single phase, 50Hz AC). Modules / sensors that require power supply other than the mains shall be provided with suitable adopters/ connectors. In-built storage battery having suitable recharging arrangement from AC mains shall also be provided as a standby source of supply to maintain programmed variable levels when power is removed for 2 years.

It shall be provided with: -

- No. of channels in accordance with the requirement of no. of probes as per the details provided in annexure-I along with 2nos. spare channels.
- A front-panel key pad for easy programming of all key settings such as:
  - alarm levels of each channel for overall value;
  - alarm delay time;
  - units of measurement;
  - display brightness etc.
- A communication interface that allows vibration signal data of each monitored channel to be linked with a computer / SCADA system capable of receiving analog DC signals of 4-20mA;
- The system shall have provision of sensitivity setting for each probe/ probe amplifier. It should be user settable in software with provision to soft lock it.
- Front panel BNC connectors to allow raw vibration signals to be analysed with portable equipment;

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- Alarm output contacts shall be potential free and rated for a current of 5A, 240 volts AC 50 Hz. or 0.5A 220 V DC. All alarm output should be fuse protected.
- The supplier may additionally provide & offer the optional feature for display of vibration spectrum up to 500Hz, as and when required.
- It shall be possible to get DC gap voltage on the display of the monitor for non contact type probes without going to the field.
- The system shall be capable of calibrating itself to check for the drifts in the electronic circuits and to adjust the outputs accordingly based on the results of the calibration cycle.
- An intuitive user-interface shall provide help menus for each monitor display.
- The tenderer shall give frequency response curve of conditioning amplifier of each channel with the offer.
- The system shall have a design feature to reject & reduce line frequency & electro-magnetic interference (EMI).
- The system shall have provision for storing & post processing the data.
- Part of the system that shall be installed outside of generator barrel, should be able to perform satisfactorily under following environmental conditions:

  a. Temperature 0 - 55°C. b. Humidity up to 95%

  (For the system that shall be installed within generator barrel, it shall be : Temp.0-100°C & Humidity 90%).

2.2 VIBRATION PROBES / DETECTORS AND CABLE LEADS:

The operation of vibration probes / detectors to detect vibration of rotating and stationary components should be totally immune to electro-magnetic field, shaft currents, dust, oil vapors and also to any residual shaft magnetism. They shall be suitable for working in the temperature range of 0-100°C.

2.2.1 To detect the vibration of rotating components, proximity probes shall be permanently installed at or near each guide bearing in the machine. Two (2nos.) probes shall be used to measure radial vibration at each guide bearing and shall be placed 90° from each other. The system shall have a measuring range of 2 mm with signal repeatability better than ±1% at the mid point of the measuring range. The probe frequency response shall cover the bandwidth of 0 to 2000 Hz. Direct inter-changeability of the probes shall incur no more than 5% error. The probe must be insensitive to cable length changes. The vendor shall provide calibration chart for each probe. *Option of variable low pass cut-off frequency in either amplifiers or signal processing circuit shall be preferred.*

Power supply requirement, if any, for the probes shall be in-built in the system. Suitable installation details required for permanently mounting the probes at or near each guide bearing in the machine, as foreseen by the vendor, shall form a part of his supply.

2.2.2 To detect the vibration of bearing brackets, one (1no.) accelerometer probe shall be permanently installed on each bracket. These shall be of delta shear design and shall have sturdy sealed construction. It shall be possible for the accelerometer to be permanently

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installed on the steel surface of the bearing brackets as per site requirement. It shall have built in miniature co-axial connector for termination of microdot end connector of very low noise cables. The frequency range shall be 0-2000 Hz. Each accelerometer shall be individually calibrated & its calibration certificate supplied along with the supplies.

2.2.3 Cable leads/ connectors for probes and associated equipment, if any, shall be suitably designed to provide high standard of signal transmission to the instrumentation rack or signal-conditioning unit. These cables shall be capable of withstanding the operating conditions specified for the probes/ detectors. Cables may be treated for noise level reduction, if necessary, to maintain the quality of signal transmission. Cable connectors / microdot end connectors/ microdot couplers wherever used with cable leads shall correspond to the size & type of cable.

All cable leads shall be suitably labeled to show the associated probe/ channel/ equipment. All the leads connecting probes/ detectors with the monitor shall be routed in a protective conduit that shall be rigidly fixed with static parts of generator / concrete foundations to prevent their movement due to vibrations etc. during operation of the generator. Placement of conduit shall not interfere with normal operation & maintenance of the generator.

2.3 **GENERAL:-**

- The overall accuracy of the system shall be better than 7% through its operational & environmental range.
- The system shall be suitable for mains operation (240V ±10%, 50Hz AC). Also there should be provision of UPS of compatible rating with 30minutes of backup
- The supplier shall include all field cables i.e. from sensor to probe amplifier to processor to monitor/ controller in their scope of supply.
- The supplier shall provide a complete installation, test & operation guide with the Vibration Monitoring system for the operating personnel.

3.0 RESPONSIBILITIES OF THE SUPPLIER:

3.1 Supplier shall quote for design, manufacture, testing at works, dispatch to site, installation & successful commissioning of the on-line (continuous) vibration monitoring system in all the generators (ref. Annexure-I) in the power house as per the details given above in para 1.0 & 2.0.

3.2 The equipment must be complete in all respects irrespective of whatever has been mentioned in para 1.0 & 2.0 above. Any accessories or equipment (hardware / software) that has not been mentioned in the specification but are required as a part of the system are to be specified and included in the offer.

3.3 The supplier shall give procedure for periodic calibration / functional checking of the system at site. In case any fixture is required for it, the same should be included in the scope of supply (common for all the generators in the powerhouse).

3.4 ***The offer shall include & indicate separately the charges for installation, testing & commissioning of the equipment in the powerhouse.*** The installation/ commissioning team will carry with them test equipment, if any required to verify the proper operation of the on-line (continuous) vibration monitoring system. Supplier shall provide a complete installation & operating procedure, diagnostic guide including its interpretation part in its O&M manual.

3.5 ***Offer shall be submitted in duplicate.***

4.0 TESTS:

Type / routine tests shall be carried on the equipment at works before despatch to site. However, the tenderer in his offer shall list out all the tests to be carried out on the components of the system at works to prove the equipment. The procedure for these tests and acceptance norms shall be submitted for approval to BHEL.

4.1 **Routine Tests:**

4.1.1 Electrical continuity tests. Certificate of compliance to be given by supplier.

4.1.2 Preliminary functionality tests of electronic components. Certificate of compliance to be given by supplier.

4.1.3 Calibration tests (i.e. Calibration curves) for all sensors.

4.1.4 Tests for compliance to the specification.

4.2 **Type Tests:**

Three stage temperature-cycling functionality test of assembled electronic items (signal conditioners, data acquisition units, monitors etc.) **a.** before **b.** during. & **c.** after 16 hrs. – maximum temperature tests.

Note: Routine tests at Sl. No.4.1.3&4.1.4 above shall be performed after performing the Type tests (para 4.2) satisfactorily.

4.3 **Acceptance Test (at site) :**

Installation of the complete system and verification of all types of measurements in conformance to the specification.

5.0 DELIVERY & ERECTION OF EQUIPMENT:

5.1 Equipment shall be delivered to powerhouse site as per the dispatch instructions of BHEL. Before dispatch, test results as per clause 4.0 shall be sent to BHEL for approval. Despatch of the equipment shall be subject to approval of these test results.

5.2 Installation / commissioning of the equipment shall match the erection of generating equipment in the powerhouse. As such, successful tenderer shall depute his team to powerhouse for undertaking site activities at 1 month notice from the purchaser as and when required at site.

5.3 In order to avoid any hold up at the time of erection / commissioning of the equipment the tenderer shall depute his representative to site for physical inspection / verification of the material as soon as it reaches site. The charges for such deputation may form part of erection / commissioning offer.

Note: There can be some time gap between delivery of the equipment at site & its installation. As such supplier shall take necessary measures to ensure that the equipment remains in healthy condition till such time it is installed / commissioned.

6.0 TRAINING OF BHEL & CUSTOMER PERSONNEL:

During erection, testing & commissioning of the equipment at site, the supplier shall provide training to BHEL & customers personnel regarding smooth operation, servicing & data interpretation to ensure proper utilisation of the equipment.

7.0 DRAWINGS & DOCUMENTATION:

7.1 Supplier shall enclose following information with the tender:

- Complete specification including detailed description and operating principle of the basic components forming a part of the vibration monitoring system as a whole.
- List of tests to be carried out on the components of the system at works before dispatch to site (Ref. Cl.4.0).
- List of items along with quantities that shall be supplied to complete installation.
- ***Points of departure from specification shall be listed separately. Relative merits of each of these departures along with sufficient information in respect of operating principle, material used, relevant specifications / standards, if any, etc. shall also be provided.***
- List for installation of comparable equipment that has been supplied & commissioned by the supplier along with date of commissioning.
- Sketch giving proposed installation details of vibration monitoring equipment/ display panel of each unit/ common for all the units in powerhouse.
- List of activities to be carried out at site to install & commission the system as a whole) along with list of testing equipment that shall be used to verify the performance of the system (ref. Clause 4.3 also).
- List of technical documentation that shall form a part of supply. This will include the circuit diagram of individual units.

7.2 The supplier shall supply 10 sets of technical documentation as agreed at the time of placement of order along with a CD for the same directly to:

Head of Hydrogenerator Engineering (3rd Floor, Old Engg. Bld.)
HEEP, BHEL-HARDWAR (UA) - INDIA (PIN-249403)

8.0 PACKING & TRANSPORT:

- The equipment shall be packed suitably for transportation keeping in view the delicate nature of the equipment & mode of transportation. Supplier shall be responsible for any damage to the equipment during transit.
- Special care shall be taken to eliminate shock etc. to parts, which may be susceptible to damages. Fragile parts shall be carefully packed and shall bear suitable marks on outside of package.
- Contents of each package shall bear markings that can be readily identified from the packing list.
- Unpacking & storage instructions considered necessary may also be provided.
- All packing cases and packing material shall remain the property of the purchaser.

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9.0 GUARANTEE CERTIFICATE:

The supplier shall guarantee the performance of the equipment for trouble free operation for 18 months from the date of shipment (or) 12 months from the date of commissioning and its handing over to the power house authority, whichever is later. He shall be responsible for replacing free of cost at site any equipment or part thereof that prove defective either in material or in design within guarantee period.

Should the tests undertaken at site during commissioning / operation of the generator within guarantee period indicate that it does not meet the specification, the purchaser shall have the right to reject the equipment and direct the supplier to take immediate action to furnish all such parts as may be necessary to make the equipment meet the guarantees and other requirements. Supplier shall bear all the expenses on this account.

10.0 AFTER SALE SERVICE:

The supplier shall confirm that the after sale service requirements of this equipment shall be met with for 3years after its commissioning at site. The address of contact person / agency shall be given in the offer.

11.0 MARKING:

- All the equipment / components shall have metal plates fixed in suitable position with full particulars engraved there on.
- The following details shall be marked on each packing case:-
  a. Manufacturer's name or trade mark.
  b. BHEL order no.
  c. BHEL standard no. HG55036.

12.0 CROSS - REFERRED STANDARDS: -Nil-

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ANNEXURE-I

DATA OF POWER STATION / GENERATOR FOR INSTALLATION OF VIBRATION MONITORING SYSTEM

1.General:

- Name of P/H :
- No. of Units x Rating :
- Customer :
- Location :

Refer Annexure-I of HG55064

- Type of Generator :
- Type of Construction of Generator :
- Rated/Run-away Speed/Frequency:

2.Vibration Monitoring of rotating component (Shaft) near Guide Bearings:

- Generator Guide Bearings :
- Turbine Guide Bearing :
- No. of Proximity Probes for Vibration measurement : Refer Annexure-I of HG55064
- Tacho/ Speed Sensor/Rotor Pole Reference Probe :
- Generator & Turbine Shaft Forging Material Chemical Composition

Carbon	Silicone	Manganese	Sulphur	Phosphorous