

SPECIFICATION FOR DEVELOPMENT OF TECHNIQUE FOR REMOVAL OF BLOCKAGE IN STATOR BARS AT SITE

Indent No.- 20145894 dated: 27/02/15, Spec. No.: GRI/27/03/2013-14

Process Flow for Carrying out the Test:

Generator stator bars of high rating m/c's of 500MW and above consists of rectangular solid & hollow copper conductors for direct cooling of the winding by passing water through hollow copper conductors. Due to certain operational deficiencies, scaling/ corrosion takes in the hollow copper conductors developing blockages. This test device/installation is required to assess and remove the blockages caused by deposition of oxidation and corrosion products in water cooled turbogenerator stator bars.

This installation should consist of circulating pump for circulation of acid(H₂SO₄, Hydrogen peroxide & sodium hydroxide solution) and DM water, a Storage tank for acid, a stainless steel storage tank for storage and circulation of DM water in closed circuit, temperature measurement, control and heating provision for water in the tank. There should also be provision of measurement of flow, pressure, temperature and conductivity(in uS/cm) in the circuit. Flow of acid(during pickling) and water in the stator bars (02 no. bar) shall be monitored at the inlet by electronic flow-meters (2 Nos. required at the inlet for 2nos. of bar) having manual valve(total = 02 nos. required at inlet & outlet.). Pressure transmitter and Pressure gauges(02 no. each required. Total 4nos each for 2 no.s of bars) at the inlet and outlet to monitor the pressure. Conductivity measurement device (01 nos) is required at the outlet of the header to monitor the conductivity of the acid mixture and DM water. Air puffing shall also be carried out after pickling with acid and flushing with DM water. 04 nos. of acid resistant suitable steel-wire jacket reinforced hoses along with interconnection accessories including any special tools are required which shall be connected to the stator bars at the entry and exit by suitable nipples. 04 nos. of nipples shall be supplied to you during fabrication of this system. Fixed stands(04 no.s required) for supporting central portion of stator bars (02 no.s) & flexible stands(4 nos. required) for supporting the overhang part of stator bars.

The muck(oxidation products) and flushed water in the system shall be collected in separate containers. These containers are available at our works and at site and are not included in the scope of supply.

A schematic sketch is indicated in Annexure-1. Detailed specification is given below.

The experimental exercise/trial work for removal of blockage of stator work shall be carried out using two stator bars at BHEL works. At site this exercise of removal of blockages shall be carried on a fully assembled generator. The Schematic Diagram for carrying out the test at site is as per Annexure-II.

The detailed specification as mentioned here covers the complete scope of work during trial work at BHEL, Haridwar and at site.

Suparna
सुपर्णा मजुमदार
उप महाप्रबन्धक
आई.एस.ई एवं सी.पी.एल
बी.एच.ई.एल. (सीप), हरिद्वार

The scope of supply includes Design, Manufacturing, Supply, Erection, Commissioning and Job Proving of the complete portable device for reduction of blockage of water cooled TG stator bars and Installation at BHEL Haridwar works.

The general practice shall be to clean the stator bars with non acidic solution like by EDTH solution, water flushing(forward & reverse) and air purging(forward & reverse). The acid cleaning shall be performed at the most once in the life time of a generator under extreme and unavoidable rare condition. However, it is required preferably that the provision of acid cleaning is included in the scope of supply to get a feel of acid cleaning.

Overall Scheme for device for removal of blockage of the stator bars of water cooled TG's at works at BHEL, Haridwar is given in Annexure-I and shall be referred.

The Test equipment and items required(Scope of Supply) as a part of overall system are as follows:

1. Acid Storage Tank - 1no
2. DM water Storage Tank - 1no
3. Pump/ Motor Assembly for pickling & DM water flow – 1 no
4. Tank Supports – 2nos
5. Tank Level Sensors – 2nos
6. Temperature measurement and control of water in the tank
7. Interconnections
8. Steel tubes/pipes/flanges/ flexible reinforced hoses
9. Stainless Steel Header (Inlet) & Outlet – 1no each = 2nos.
10. Acid & Water Pressure indicator and Controller
11. Data Acquisition Arrangement: Desktop Computer & Data acquisition software(optional)
12. Control Panel & Power Controller(1 no each)
13. Vacuum Pump – 1no
14. Flow-meter(1 no), conductivity measurement device(1 no),Pressure Transmitters (2 nos),Pressure gauge(2 nos), Thermocouples/PRTs(2 nos)
15. Fixed & Flexible Stands (Optional) - 2 nos each
16. Teflon- O rings- 16 nos
17. Teflon Hoses – 16nos

Detailed Specifications:

1.0 Storage Acid Tank :

It should be atleast 100 Ltr capacity of suitable material to withstand acidic nature of H₂SO₄. Tank should be made up of suitable material. Its inner tank should be lined with corrosion resistant coating and capable to store acid(for a period of a week at a time during testing of one sample).

Fresh acid input facility : There should be provision of removable **top lid** with pipe fittings for piped or manual acid filling in the tank and also provision at bottom of the tank for draining out of acid at the end of the test (manually). Small inclination at the base of the tank for complete drain out of the acid from the tank / cleaning of the tank, if situation demands.

The tank should have suitable separate flange connection for following:

- Flange connection from side/top for filling fresh acid
- Flange connection from side for outgoing acid to inlet header through acid Circulation pump
- Flange connection at the side of the tank for the return of acid to the acid collector Chamber/tank
- Flange connection at the bottom face of the acid collector tank for complete drainage of acid from the acid collector Chamber/tank.
- Flange connection on bottom face of the tank to facilitate the complete drainage of the acid from the tank / to clean the tank from inside as and when required especially when not in use

2.0 Storage DM Water Tank:

It should be 100 Ltr capacity SS tank made up of at least 4mm thick stainless steel plate. Its inner tank should be lined with corrosion resistant coating and capable to store DM water(for a period of a week at a time during testing of one sample). The gap between inner tank and outer tank should be filled with glass wool. It should have provision of separate pipe fittings for closed loop water circulation as well as input fresh water filling and draining out of water. It should be provided with glass type of water level indicator.

The tank should be provided with in-built indirect heating arrangement with heater assemblies of suitable rating and PT 100 based thermostat (Exact heating capacity shall be indicated later). There should be uniform distribution of heaters in the tank at suitable locations preferably at the bottom of the tank. There should be suitable cut out in the tank for fixing heaters. Temperature measurement and control to be achieved by PT100 based thermostat and PID controller.

Range of temperature = 30°C to 70°C

3. Pump/ Motor Assembly for Pickling and DM water:

The pump should be high pressure suitable for continuous rating, silent running, suitable for circulation of acid during pickling and during flushing of water after pickling. A provision of rinsing of closed loop path with plain water is desirable to extend the life of pump. This will avoid damage to pump and associated elements in the loop due to ageing caused by toxicity of the acid medium.

It should have sufficient flow rate handling capacity and sufficient discharge pressure. The pump should have Teflon coated bearings to withstand the acid in case of leakage of acid to bearings.

Although we have given following specification for the pump alternate kind of pump / rating fulfilling the said requirement head pressure of 4 - 6 bar (1Kg/cm²=0.98 bar) will also be considered.

Suparna
सुपर्णा मजुमदार
उप महाप्रबन्धक
आई.एस.ई एवं सी.पी.एल
बी.एच.ई.एल. (हीप), हरिद्वार

Type of pump : Gear pump/or any other type for corrosive liquids
 Motor : Matching motor along with suitable coupling for the pump
 Capacity : Minimum 1500 – 2000 litres per hour ~ 20 litres per minute per stator bar
 Head/Pressure : 10 kg/cm²(max)
 Flow : Flow and pressure control should be smooth and pulsation free
 Control : Starter, Auto-control panel and sensor
 Protection : Standard protections against failure

Supply : Should be able to operate on 1-Ø/3-Ø, 50Hz, 230/ 415V± 10 %

Installation : Portable, stable & suitable for floor installation without need to grout it

Ambient : Suitable for operation under ambient temperature of 0° to 45°C
 Temperature

The same pump/motor assembly shall also be used for circulating DM water after pickling of the bars.

Fresh water input facility : There should be provision of removable top lid with pipe fittings for piped or manual fresh water filling in the tank and also provision at bottom of the tank for draining out of water at the end of the test (manual). Small inclination at the base of the tank for complete draining out of water from the tank / cleaning of the tank, if situation demands. It should have provision for overflow of water in case top level sensor fails.

The tank should have suitable separate flange connections for following:

- Flange connection from side for filling fresh water and make up water through online water softening unit
- Flange connection from side for outgoing hot water to inlet header through hot water circulation pump
- Flange connection on bottom face of the tank to facilitate the complete drainage of the water from the tank / to clean the tank from inside as and when required especially when not in use.

4.0 Tank Supports:

For ease of handling the tanks should be supported on a simple & stable stand of about 50cm height. Top level of hot water tank after fixing of the fabricated structure, shall be maximum 1700.00 mm.

5.0 Tank Water Level Sensors:

There should be a provision of top and bottom water level sensors for indication / control. Top Level Sensor should cut off the DM water / make up water supply and bottom level sensor to commence water supply in the tank.

6.0 Temperature measurement and control of water in the tank:

There should be a provision of temperature indicator with accuracy of 0.5 % or better.

Water temperature in the tank during testing should be maintained between $T_s \pm 2^\circ\text{C}$ using PID controller and in-built heater. Also there should be provision of under / over temperature, audio and visual alarm and trip mechanism in case of excessive temperature.

T_s = Set temperature

Range of temperature Setting $T_s = 30^\circ\text{C}$ to 70°C

7.0 STAINLESS STEEL HEADER (INLET) & OUTLET: 1 no each. Total=2nos.

One no. header made up of SS material that can handle acid and water mixture for (inlet) and One no. for (outlet), of length approx. 390 mm, diameter approx. 114mm and wall thickness 3.00 mm approx. as shown in attached Annexure I, shall be supplied. Inlet and outlet headers shall be fixed on suitable fabricated stand. Height of stand will be 1000 mm approx. from the floor of the shop.

In case of inlet header, on one side flange connection shall be provided for connecting the hot water output from the tank and ambient temperature water circulation & on other side, manually operated Valves (MVI) and 02 no. nipple shall be provided, for fixing flexible hoses to connect to 2no.s of stator bars with the inlet header.

All the welded and flange joints must be leak proof.

One no. of thermocouple/PRT shall be provided at the inlet header for the measurement of inlet water temperature of hot water and One no. thermocouple/PRT shall be provided for the measurement of outlet water temperature on return path, as shown in attached Annexure – I.

ID of teflon hose pipe is 12 mm and length is max. 1000 mm. Both ends of teflon hose has Union Nut provision to be fitted to nipple of matching threads($\text{Ø}30\text{mm}$). Nipple for both ends will be provided by BHEL to be fitted by you to above mentioned interconnection hoses.

8.0 Acid & Water Pressure indicator and Controller :

There should be provision of water and acid pressure indication by Pressure Transmitter (Analog /or Digital) and Pressure Gauges and PID control with measuring accuracy of 0.5 % or better at inlet and outlet. Pressure transmitters shall be at the inlet and also at the outlet for Water pressure indication. Pressure transmitter/pressure gauges should have able to withstand acidic water flow in the system.

9.0 Data Acquisition Arrangement(Optional):

It should consists of

1. Desktop Computer
2. Data acquisition software
3. Interface and Communication link between control panel and Computer

Software should provide accuracy of time and date to second from any time span of the recorded information, data handling and manipulation, and data storage and retrieval.

10.0 Control Panel & Power Controller:

This power panel/controller should distribute mains power to various units i.e. pump motors of acid and water tank, heaters, pressure transmitter, PID controllers, conductivity measuring devices, flow-meters, pressure transducers etc. and should also incorporate switching, indication and protection devices. The control panel should incorporate following functions and features.

- Manual and Automatic operation of the solenoid valves as indicted in operation in sl. No.17.0.
- Feedback of water temperature at inlet and outlet header for automatic "ON" and "OFF" of the hot water / acid circulating pump, vacuum pump and compressed air puffing device.
- Automatic control to maintain the hot water temperature in hot water tank(=60° C)
- Automatic control to maintain the water /acid pressure at the water/acid inlet end of the stator bar, preferably at inlet header.
- Automatic control of top level of water in hot water tank & acid tanks

This panel should also provides 4-20 ma control/measurement signal to PC for logging of temperature and pressure data.

11.0 Vacuum Pump

Before pickling of the bars with acid solution, the bars are evacuated to generate vacuum in the stator bar. The vacuum pump shall be able to generate vacuum of at least 25- 30 mbar.

Volume of air to be handled= 80 litres

12.0 Flow-meters, conductivity measurement devices, Pressure gauges & Pressure Transmitters, Thermocouples/ PRTs

Flow-meter is required at the inlet to monitor the flow of DM water.

Conductivity of flow of water/solution in the stator bars shall be continuously monitored by conductivity measuring device at the outlet header. It should be able to measure the conductivity of solution and DM water flowing in the bars in the range of 50 – 100uS/cm preferably with accuracy of 0.5%.

Pressure Gauges are required (having features like illuminated dials and digital readouts for better visibility, Vibration, Pulsation and shock free with preferably precision of C grade i.e 4% accuracy) and Pressure transmitters are required at inlet and outlet header to monitor the pressure of DM water/acid at the inlet and outlet headers. Preferably the accuracy of pressure transmitters should be of 0.30% or better and able to measure pressure in the range of (0 – 10) bar. The flow-meter shall be two wire or four wire with preferable standard accuracy of 0.35% of reading or better.

Thermocouple/ PRT's are also required at the inlet & outlet of the headers to monitor the temperature of DM water during flushing.

13. Fixed & Flexible Stands(Optional)

Fixed stands are required to support 2 No. of stator bars for operation at our works.

Flexible stands are also required to support the overhang portion of the bars.

Photos of the stands shall be sent later.

14.0 General Requirements of Interconnections :

14.1 Interconnection between tank outlet & pump inlet, between pump output & teflon hose of stator bar under test, between teflon hose & pressure gauge/control valve and back to storage tank inlet can be steel tube/pipe or flexible reinforced hoses. Material of Sealing arrangement, packing and glands in the water circuit should be such that there should be no water leakage at joints at pressure and temperatures indicated above.

14.2 Stainless Steel Flexible Hose 2.0 mtr length each, complete with union joint M30X1.5 at both ends, shall be supplied along with the system, to connect the stator winding bar with Inlet Header and Outlet Header (as shown in attached Annexure-I).

Material of all hoses should be corrosion resistant and capable to handling acid mixture.

These shall be used in place of Teflon hoses interchangeably as and when required. Teflon "O" rings (made up of Viton material. Chemical name Fluro-carbon) shall also be supplied along with the hoses.

Quantity required: 16 Nos. for 08 stator bars

Suparna
 सुपर्णा मजुमदार
 उप महाप्रबन्धक
 आई.एस.ई. एवं सी.पी.एल.
 बी.एच.ई.एल. (हीप), हरिद्वार

14.3 All the pipe lines as shown in water circuit, shall be stainless steel(which is corrosion resistant and capable of handling required quantity of DM water) of outer diameter approx. 50 mm, wall thickness 3 mm approx. and compatible with required pressure and temperature.

14.4 Material of all flanges and valves in water circuit, shall be stainless steel which is corrosion resistant and capable to handling DM water.

15. Operational/ Technical Requirement of job and test process:

15.1 Actual stator winding bar, 02 nos shall be kept on the fixed stands (S1, S2, S3, S4, and S5 - refer Annexure I) with overhead crane. Teflon hose joints and Stator bars are connected with water inlet header and water outlet header, by (steel) flexible hoses.

15.2. Air shall be evacuated in the bars and vacuum shall be generated in the stator bar by the vacuum pump.

15.3 Pickling of the stator bar shall be carried out by acid mixture(Sulphuric acid, hydrogen peroxide & sodium hydroxide solution) and shall be forced into the bars to remove the oxidation/corrosion products deposited inside the bars due to continuous flow of water over a period of time.

15.4. The muck shall be collected in separate collector.

15.5 Solenoid valve SV is open to fill the water in the hot water tank.

15.6 On attaining the required water level in hot water tank, valve SV will be closed.


15.7 Water will be heated up to temperature $T_s=60\text{ }^\circ\text{C}$ in Hot Water Tank by immersion heater. On attaining the required temperature, hot water at temperature T_s Degree Centigrade will be circulated through the stator winding bars by circulating pump at minimum pressure(4 kg/cm^2) as marked in Annexure - I.

15.8 On attaining the same hot water temperature at the inlet header and outlet header (C&H W HEADER as marked in Annexure I), water pressure is increased to P_s (Set Pressure level between 4 kg/cm^2 to 6 kg/cm^2).

15.9 This water flushing is carried out for 60-70 minutes. Water at $60\text{ }^\circ\text{C}$ shall be forced into the bars and then this water shall be drained out and collected in suitable container. The pressure at the inlet and outlet shall be monitored continuously. Then again water shall be forced into the bars and this flushing shall be extended to total of 7 No.s of flushes depending on the DP values obtained at the inlet and the outlet.

15.10 Circulating water pressure shall be brought to minimum. Heaters shall be switched off. Water shall be removed automatically by pumping out the water.

15.11 Air puffing shall be carried out using the compressed air or nitrogen and pressure monitoring is to be incorporated in logic & control manner at the inlet and outlet of the headers.


 सुपर्णा मजुमदार
 उप महाप्रबन्धक
 आई.एस.ई. एवं सी.पी.एल.
 वी.एच.ई.एल. (सीप), हरिद्वार