Islamic Republic of Afghanistan
Ministry of Energy and Water
Afghanistan - Kabul

Rehabilitation of Naghlu Hydro Power Station
Electromechanical and Hydromechanical Works

**Engineer's Review Status**

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Approved with reservations
Not approved

**FICHTNER**

Checked by
Date
Signature

**Note**

AS BUILT

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<th>Drawing No.</th>
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**References**

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**Revisions**

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**Russia - Moscow**
Technopromexport

**RUSEL-PROM-engineering**

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<td>Technical Description and Erection Manual for the refurbished hydrogenerator subassemblies</td>
</tr>
<tr>
<td>Stanin</td>
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<td>Appelov</td>
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10. Coli list 1EP.261.012Д1.

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**Introduction**

This Technical Description and Erection Manual for the refurbished hydrogenerator subassemblies contains a design description, determines a sequence of erection and requirements to erection of the refurbished hydrogenerator of ВГСМ 525/110-24 type, and is intended for HPP staff and erection staff.

Before start of hydrogenerator erection, it is necessary to get familiarized not only with this document but also with all other technical documentation for hydrogenerator.

**1. Purpose**

1. After its refurbishment, hydrogenerator is intended to be installed at Naglu HPS in Afghanistan.

2. The generator type may be decoded as follows:
   - ВГСМ – synchronous, vertical-shaft, refurbished
   - 525 – stator core outer diameter, cm
   - 110 – stator core length, cm
   - 24 – number of poles

**2. Technical Characteristic**

The main technical data are shown in table 1.

<table>
<thead>
<tr>
<th>Technical characteristic</th>
<th>Unit</th>
<th>Rated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rated output</td>
<td>kVA/kW</td>
<td>29400/25000</td>
</tr>
<tr>
<td>2. Rated voltage</td>
<td>V</td>
<td>10500</td>
</tr>
<tr>
<td>3. Rated power factor, Cos ϕ</td>
<td>p.u.</td>
<td>0,85</td>
</tr>
<tr>
<td>4. Frequency</td>
<td>Hz</td>
<td>50</td>
</tr>
<tr>
<td>5. Rated speed of rotation</td>
<td>rpm</td>
<td>250</td>
</tr>
<tr>
<td>6. Rated stator current</td>
<td>A</td>
<td>1610</td>
</tr>
<tr>
<td>7. Stator winding phases connection</td>
<td></td>
<td>star</td>
</tr>
<tr>
<td>8. Number of stator winding parallel paths</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>9. Number of stator winding terminals:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-main</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>-neutral</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>10. Slip rings voltage at rated load and 120 °C rotor winding</td>
<td>V</td>
<td>135</td>
</tr>
<tr>
<td>temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Rotor current at rated load (calculated)</td>
<td>A</td>
<td>940</td>
</tr>
<tr>
<td>12. Rotor current at no-load and rated stator voltage (calcu-</td>
<td>A</td>
<td>510</td>
</tr>
<tr>
<td>lated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Rotor current at short circuit and rated stator current</td>
<td>A</td>
<td>495</td>
</tr>
<tr>
<td>(calculated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Stator winding temperature limit</td>
<td>°C</td>
<td>120</td>
</tr>
<tr>
<td>15. Rotor winding temperature limit</td>
<td>°C</td>
<td>130</td>
</tr>
<tr>
<td>16. Flywheel effect</td>
<td>ton*m²</td>
<td>1140</td>
</tr>
<tr>
<td>17. Stator weight with air-coolers</td>
<td>ton</td>
<td>67,8</td>
</tr>
</tbody>
</table>
3. Construction of the Refurbished Generator Subassemblies

3.1. GENERAL GENERATOR ARRANGEMENT

(Drawing 1EP.261.012 ED)

The hydrogenerator is of vertical type, suspended, with two guide bearings. The hydrogenerator rotor rests on the thrust bearing located in the central part of the upper bracket; the upper guide bearing is located in the same place. The lower guide bearing is located in the central part of the lower bracket.

The hydrogenerator stator is mounted on the foundation and located in the ferroconcrete enclosure.

The cooling system is of air type, ventilation takes place inside the hydrogenerator ferroconcrete enclosure.

3.2. STATOR

(Drawing 5EP.670.123 ED)

The new stator will be manufactured during the course of refurbishment. Installation of stator is performed onto former foundation. The new stator is made of two parts. Connection of the frame parts with each other is performed through the joint plates with tightening studs and nuts. In the stator frame enclosure there are windows for stator winding terminals, for installation of air-coolers, and for possibility to inspect the back side of the stator core during maintenance. Some windows are closed with removable plugs.

The stator core is laminated of sheets punched of cold-rolled silicon roll steel with thickness 0.5 mm. Заусенцы с сегментов снимаются, сегменты лакируются

The stator core is separated into stacks along height with necessary quantity of ventilation ducts which provide effective stator cooling. To reduce stray load losses from rotor leakage fields and local overheat, the extreme stacks of the stator core are manufactured of lower thickness and with steps from the bore side. To increase mechanical strength, the extreme stacks of the stator core are stacked from baked stacks of 6 mm thickness.

The core is assembled on the prismatic bars (wedges) of "double dove-tail" shape. Core laminations with slots of trapezoid shape are put onto one side of bars. Transition planks with slots of trapezoid shape are put on another side of bars. Planks are welded to the stator frame shelves. The stator core is tightened with pressing flanges and pressing studs. During assembly process, the intermediate core pressings are performed that guarantees sufficient density of the core along all its height.

Joints of the stator core are performed along the center of slots. Fillers made of elastic thermal-resistance insulating material are installed into the core joints during stator assembly into ring.

The stator winding is of double-layer Roebel bar wave type having one parallel path per phase. Six terminals of the winding are brought out of the stator frame: three main and three neutral terminals.

The stator winding insulation is of thermosetting type, made according to the “Micafil” technology from class F materials. This insulation features improved physical and mechanical properties, high dielectric strength. The insulation structure is preliminary impregnated mica containing tape called elmicaterm, which is polymerized at high temperature and hydrostatic pressure. Such approach guarantees absence of voids in insulation. This insulation does not maintain combustion.

The stator winding in stator slots is tightened with semi-conductive glass-textolite. Ripple glass laminate filler is put onto a bar from the side of slot wedge. Bars in slots are tightened with wedges that create proper initial tightness for winding fixation in slot. Ripple fillers allow keeping this initial tightness during temperature changes.
End winding is fastened to the insulated non-magnetic bandage rings with synthetic cord. Boxes made of insulating material and coated with semi-conducting enamel are installed on the slot outing.

Construction and technology of the stator winding provides for anti-corona protection on the account of semi-conductive coating applied on the stator bar insulation and slot portion of the stator core. The semi-conductive coating provides for gradual change of potential on the end-winding.

Jumpers and ring busbars between the coil groups of the stator winding are made of insulated copper busbars and fastened with the system of blocks, fillers and bandage binding.

Winding bars are connected between each other in heads of end winding by brazing. After brazing all the heads are insulated with insulating caps where epoxy compound is filled in.

3.3. ROTOR
(Drawings 5EP.674.106ED, 5EP.630.038ED, 5EP.091.258ED, 5EP.125.262ED, 5EP.555.124ED)

The new pole coils, inter-pole connections, brake disc, pole wedges and rim wedges are manufactured during the course of the rotor refurbishment.

The old slip rings will be changed for the new ones and installed on the same place.

The slip rings rocker is refurbished partly; all the insulating parts of the rocker will be changed. The new set of brushes and brush holders will be delivered.

The new thrust bearing hub with runner will be manufactured for the hydrogenerator No 3.

The new rotor consists of the shaft, welded spider, laminated rim, and 24 poles.

The generator shaft consists of the shaft itself with put onto it with tightness rotor hub, thrust bearing hub and lower guide bearing hub. The rotor spider is fastened to the rotor hub. The shaft-extension is located in the upper part of the shaft; slip rings are attached to the shaft-extension. Thrust bearing runner is fastened to the lower part of thrust bearing hub.

Connection of the rotor spider with the rotor hub is performed with fitter conical studs.

The rotor rim is fastened to the spider by the new counter wedges which are put into the slots on the spider bars and into the slots on the inside surface of the rim. On the outer rim surface there are T-shaped slots to fix poles.

Rim wedging procedure with rim wedges is performed during the erection. This creates tightness in the rim and compression in the spider to eliminate detachment of the rim from the spider during operation.

The pole coils are made of copper bars of special profile to strengthen cooling for the outer side of coils. The turn-to-turn insulation ПАКН-2 is made using epoxy bindings (class F material, “prepreg”-type). The frame insulation of a pole coil is glass laminate. The pole coils are cured under high temperature and pressure.

The poles are fastened to the rim with the T-shaped tails and counter pole wedges.

The brake disc, which is integral metal ring, is placed in the lower part of the rotor rim.

3.4. THRUST AND GUIDE BEARINGS
(Drawings 5EP.195.155 ED, 5EP.195.156 ED)

The friction surface of the refurbished pads of the thrust bearing is made of anti-friction composition on basis of Teflon (fluoroplastic). Such thrust bearings are more reliable and convenient during maintenance.

The friction surfaces of the refurbished pads of the upper and lower guide bearings have Babbitt lining.
3.5. BRAKING SYSTEM AND BRAKE DUST COLLECTING SYSTEM

(Drawings 6EP.020.176 ED, 6EP.020.183 ED)

The braking system consists of six brake-jacks fitted on the lower bracket arms under the brake disc.

During the course of the refurbishment, the new brake blocks are manufactured from material RETINAX with high friction coefficient and negligible wear. Lifetime of the brake blocks is 6 -10 years depending on the frequency of braking.

Installation of the brake dust collecting system on the brakes is provided during the course of the refurbishment. Dust appears when friction of the brake disc against brake blocks is performed. Brake dust collecting system prevents dust coming into the generator stator and rotor that averts generator from contamination. The brake dust collection system consists of the metal shields mounted in the brake-jacks zone and the system to withdraw collected dust by pipes into the dust collector outside the generator pit. The shields are made removable to provide access to the brake-jacks.

3.6. VENTILATION SYSTEM

(Drawing 6EP.020.170 ED)

Cooling of hydrogenerator active parts is realized by air circulating inside the closed circuit. Due to the ventilation effect of two axial fans and rotor poles air comes to the air ducts of the stator core and then comes to the air-coolers (six pieces) where it is cooled and goes again to the rotor. During the course of the stator refurbishment the new air-coolers will be manufactured. The new fittings are provided for installation of the air-coolers on the stator.

3.7. FIRE-EXTINGUISHING SYSTEM

(Drawing 5EP.497.327 ED, 6EP.670.116ED, 5EP.670.117ED)

The refurbished hydrogenerator is equipped with the fire-extinguishing system. Extinguishing will be fulfilled by water through the ring pipes with holes made of stainless steel. The pipes are mounted around the stator end-windings.

3.8. TEMPERATURE CONTROL

(Drawing 6EP.022.211 ED)

The temperature control is realized with RTDs and manometric signaling thermometers. Quantity and places for installation are shown in table 2.

RTDs have measuring element made from platinum alloy with 100 Ohm resistance at 0 °C.

In order to increase reliability, reserve RTDs will be installed in the stator. These RTDs can be connected to the temperature control system in case of main RTDs’ failure.

Showing instruments are located on the capillary thermometers board that is mounted on the upper bracket arm.

<table>
<thead>
<tr>
<th>Place of installation of temperature control instruments</th>
<th>RTDs</th>
<th>Bulbs of capillary thermometers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity, pcs.</td>
<td>Quantity, pcs.</td>
</tr>
<tr>
<td>Stator winding</td>
<td>9 +3 (reserve)</td>
<td>-</td>
</tr>
<tr>
<td>Stator core</td>
<td>3+3(reserve)</td>
<td>-</td>
</tr>
<tr>
<td>Cold air zone</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Hot air zone</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Thrust bearing pads</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Upper guide bearing pads</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Lower guide bearing pads</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Thrust and upper guide bearings oil-bath (hot oil)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lower guide bearing oil-bath (hot oil)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Slip rings zone (Air)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>On pipe at water outlet from parallel path of upper bracket oil-coolers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>On pipe at water outlet from lower bracket oil-coolers</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>On lower bracket arm (generator pit air)</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>On pipe at cold water inlet into collectors</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>On pipe at water outlet from air-coolers</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

### 3.9. CONTROL AND PROTECTION EQUIPMENT

(Drawings 6EP.022.211 ED, 6EP.020.182 ED, 6EP.020.206 ED)

In addition to the temperature control equipment the hydrogenerator is equipped with instruments to control oil level in the oil-baths, cooling water consumption on the total discharge and on the water outlet from upper bracket oil-coolers, air pressure values in the braking system, brake blocks position and wear (see table 3).

<table>
<thead>
<tr>
<th>Name</th>
<th>Purpose</th>
<th>Pcs.</th>
<th>Place of installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveling breaker</td>
<td>Signaling about brake block wearing off</td>
<td>1</td>
<td>On brakes</td>
</tr>
<tr>
<td>Traveling breaker</td>
<td>Signaling about and blocking unit start with lifted brakes</td>
<td>6</td>
<td>On brakes</td>
</tr>
<tr>
<td>Electric contact manometers</td>
<td>Air pressure control in brakes</td>
<td>1</td>
<td>In braking system</td>
</tr>
<tr>
<td>Electric contact manometers</td>
<td>Blocking generator start at air lack in braking system</td>
<td>1</td>
<td>In braking system</td>
</tr>
<tr>
<td>Flow meters</td>
<td>Control and protection from termination of cooling water circulating</td>
<td>2</td>
<td>On pipelines from oil-coolers of thrust and upper guide bearings; on general discharge manifold</td>
</tr>
<tr>
<td>Level relay</td>
<td>Control of oil level in oil-baths</td>
<td>2</td>
<td>In oil-baths of upper and lower brackets</td>
</tr>
<tr>
<td>Brush</td>
<td>Control of rotor insulation</td>
<td>1</td>
<td>On lower bracket</td>
</tr>
</tbody>
</table>

### 3.10. CONTROL SYSTEM OF GENERATOR’S VIBRATION CONDITION

(Drawing 6EP.022.212 ED)

The refurbished generator is equipped with the vibration control system which performs control of the following subassemblies in two mutually perpendicular directions in horizontal plane: the upper guide bearing, lower guide bearing, thrust bearing, turbine guide bearing, upper load carrying bracket – in vertical direction.
Wiring from all the vibration instruments is brought out to the terminal panel which is fitted on the upper bracket arm. The portable vibration analyzer is connected to the terminal panel.

3.11. HEATING AND LIGHTING
(Drawing 6EP.020.172 ED, 6EP.020.173 ED)

In order to eliminate the possibility of condensate appearance on the stator and rotor windings during long standstills, the refurbished hydrogenerator is equipped with heating system which consists of three electric heaters mounted under stator, start-control equipment, connecting wiring and capillary thermometer. Electric heaters of pipe-type are rated to operate on air. The total capacity of the electric heaters is 7.5 kW.

Electric heaters are switched on by the magnetic starter which is controlled automatically and manually.

The refurbished generator is equipped with cubicle for capillary thermometers and temperature control instruments.

The generator pit is equipped with the lighting system. Six lamps are mounted on the wall inside the ring corridor around the stator. Power supply for the lamps is 220 V network.

4. Erection of the Refurbished Generator Subassemblies

4.1. GENERAL INSTRUCTIONS

Hydrogenerator erection should be performed with accurate realization of all the technical requirements indicated in these instructions and in the hydrogenerator drawings.

Control of stress and uniformity for tightening of threaded connections in most critical stator subassemblies should be performed according to the directions of this Erection Manual (Appendix 1).

4.2. SAFETY PRECAUTIONS

Erection and maintenance staff should know and keep the safety rules during maintenance of electric equipment, during fulfillment of construction and erection works. Unauthorized persons are not admitted to the hydrogenerator.

Carrying out of any works on running hydrogenerator is forbidden, with the exception of special cases controlled by management of the mounting organization (before the unit commissioning) and management of the station (after the unit commissioning).

Works in stator winding circuits should be carried out keeping the rules for work in circuits under 1000 V voltage and more.

Works in circuits of automatic equipment and temperature control should be carried out keeping the rules for work in circuits under voltage of operative current.

Visual check of inside surfaces of the stopped hydrogenerator and any repair works are allowed only at braked and jammed rotor.

The hydrogenerator frame should be grounded safely.

At working with chemicals and particularly with epoxy resins, it is necessary to keep strictly sanitary rules and safety engineering indicated in Appendix 6c.

To prevent high voltage hit into the circuits of temperature control, all the dischargers in terminal boxes installed on the stator frame should be tightly pressed to grounded plate through the insulated paper of 0.05 mm thickness.
4.3. TRANSPORTATION AND STORAGE

1. Subassemblies and parts of the refurbished hydrogenerator is dispatched to the Customer partly disassembled, by individual components and details which are packed according to the drawings of the plant-manufacturer and completed according to colli list. The package is intended for transportation only and not intended for cargo storage at open air.

2. Any individual components arrived at station should be stored according to the directions in colli list under the following conditions:
   - in closed ventilated storehouse: bars and other parts of the wound stator, rotor pole coils, fasteners and other rotor parts, thrust bearing hub, thrust bearing runner, guide bearing pads, slip rings with rocker, temperature control instruments, automatic equipment, brake equipment, spare parts, auxiliary materials;
   - under shed: stator sectors and other rest parts and components of the hydrogenator in the transportation package.

3. All the packed details, components and details without package should be inspected visually immediately after arrival in order to define their safety and completeness after transportation. All the damages of package and preservation disturbances should be removed.

4. During long time storage, periodically, not seldom than once per three months, it is necessary to perform visual inspection of the most critical hydrogenerator components (stator with winding, rotor pole coils, thrust bearing runner, thrust and guide bearings pads, mounting surfaces, friction surfaces, etc.), carefully protect them from mechanical damages and from ingress of moisture. The most careful visual inspection should be performed for mounting and mating surfaces on the thrust and guide bearings hub, thrust bearing runner. Revealed corrosion should be removed, preservation should be renewed.

5. Before erection, hydrogenerator components can be unpacked only for represervation, after this, package should be recovered.

6. Spare parts should be stored in dry closed ventilated room at +5 …+35 °C temperature with relative humidity which exclude possibility of moisture condensation.

4.4. DEPRESERVATION

1. Depreservation of hydrogenerator components should be carried out in the following cases:
   - Partly or fully at represervation on the expiry of the guarantee time for the preservation life which is 6 months since the preservation moment;
   - partly or fully at periodical visual inspection to check condition of surfaces;
   - fully at preparation to erection.

2. Package opening, visual inspection and represervation of hydrogenerator components should be carried out in dry and clean room.

3. Depreservation of hydrogenerator components should be carried out as follows:
   - Remove consistent lubricant with wooden spatula, then remains of lubricant should be removed with cotton waste saturated with benzine or white-spirit.

4.5. REPRESERVATION

1. Represervation of hydrogenerator components should be performed in the following cases:
on the expiry of the guarantee time for preservation life;
on revealing corrosion.

2. In cases of corrosion revealing:
• scrape the mechanically machined surfaces of steel details with emery cloth saturated with industrial oil;
• degrease the surfaces after cleaning from corrosion with benzine or white-spirit, and wipe the surfaces with clean cotton waste.

3. Represervation should be carried out according to the instructions indicated in the coli list in the room meeting the requirements of it.2, chapter 4.4 of this Erection Manual, using preservation liquid lubricant, hydrocarbon consistent lubricant, industrial oil or other preservatives, including polyethylene film, dried silica gel.

4.6. PREPARATION TO ERECTION

1. In order to assign and prepare schedule of works it is necessary to get familiarized with all the technical documentation for the hydrogenerator and especially carefully with:
• erection documentation and this Erection Manual;
• technical requirements indicated in the drawings;
• technological instructions;
• overall dimensions of components, their weights, devices for lifting.

2. Check condition of the equipment of erection bays and conformity of this equipment to the erection conditions:
• conformity of floor durability of the erection bay to weights of heavy stator components (according to the construction documentation);
• conformity of crane lifting capacity to weight of the main stator and rotor components.

3. All the erection bays should be safely protected from atmospheric precipitation and dust.

4. Clean, depreservate and perform careful visual inspection of hydrogenerator components before erection. Remove revealed flaws.

5. Check readiness of the foundation for hydrogenerator and conformity of the foundation to the project data, foundation and installation drawings.

6. Clean the machine hall before start of erection. Keep order and cleanness during carrying out all the erection works.

4.7. ERECTION SEQUENCE

Hydrogenerator erection is carried out by arms of the Customer’s mounting organization. Technical control for erection, adjustment and start-up of hydrogenerator is performed by Supplier’s representative.

The following erection sequence is recommended.

1. Unpack hydrogenerator components, remove temporary preservation covers, and check completeness of the supplied equipment.

2. Prepare lifting equipment, devices and tools to perform erection.

3. Mount the lower bracket with brakes on the foundation (if it was dismounted before), and center it relatively the turbine shaft.

4. Mount the stator parts on the foundation in the generator pit, assemble the stator as a ring, center the stator along the unit axis and along the level sign, and then install the winding in the joint zones.

5. Hang the rotor poles on the rotor at the erection bay. Carry out preliminary “cold” wedging of the rotor rim with rim wedges.

6. Transfer and mount the rotor on the brake-jacks.

7. Mount the rotor shaft on the rotor spider. Connect the rotor hub with the rotor spider with cone studs. Carry out the final cold wedging of the rotor rim.
8. Mount the upper bracket on the stator. Mount the thrust bearing pads on the support bolts in the thrust bearing oil-bath.
9. Mount the thrust bearing hub with runner on the rotor shaft. Lower the rotor on the thrust bearing pads.
10. Center the rotor along the turbine shaft flange. Connect the rotor with the turbine shaft, assemble the upper guide bearing. Check the thrust bearing for load uniformity.
11. Check the shaft string by rotor crank, at that the generator lower guide bearing pads and turbine guide bearing pads should be taken out, and the generator upper guide bearing pads should be pressed to the shaft tightly.
12. Perform the final stator centering.
13. Install the lower guide bearing pads and the drawing gaps in both guide bearings. Install temperature control instruments in the oil-baths.
14. Install the oil-coolers and covers of the upper guide bearing oil-bath.
15. Mount the slip rings.
16. Mount the cone with the slip rings rocker.
17. Assemble the air-baffles, water pipeline, oil pipeline, drainage pipeline, upper bracket flooring.
18. Assemble the rest of subassemblies.
19. Perform the trial idling of the unit by the turbine.
20. Dry the generator.
21. Perform testing of the generator including testing under load.
22. Perform hydrogenerator inspection.
23. Prepare the hydrogenerator for commissioning and operation.

Erection should be performed according to the erection drawings and Erection Manual.

Note: The erection sequence can be changed depending on conditions and erection staff experience. These changes should be approved by manufacturer’s representative at the generator erection bay.

4.8. STATOR ASSEMBLY
(Drawings 5EP.670.123ED, 5EP.670.123SH- ED, 5EP.487.222ED)

1. Before installation of the stator sections, perform careful visual inspection for them, and then remove revealed troubles.
2. Perform cleaning and blowing of winding and core with dry and clean air with pressure not more than 0.2 MPa.
3. Clean the joint planes of the stator sections, file revealed nicks and scratches.
4. Fastening and transferring of stator sections should be performed with great care. Handling of stator sections from horizontal position into vertical should be performed on wooden bars in order to avoid winding damages.
5. The stator is assembled on the foundation in the generator pit. Put the stator sections onto the sole plates according to the available marking. Remove radial jacks.
6. After mounting the first section on supports, it should be checked for verticality along the core. The first section should be fixed carefully. Only after this step the second section can be mounted and connected.
7. Install paronite fillers into the stator core joints according to the drawing EP.670.123ED. The stator joint plates should be tightened with tightening studs with the force indicated in Appendix 1. Install all the pins in joints.
8. Check core verticality near every joint. If any clearance in joint plates is revealed during the final tightening, put fillers made from sheet steel into these joints. Connect between each other bandage rings sectors, joint places should be insulated according to the drawing requirements. Check the internal diameter along top and bottom of the stator core, in the center and along edges of every section (Fig.1).
10. After assembling the stator on the foundation, check the height position of its magnetic axis by the design sign as well as check verticality of the stator core inside surface. Center the stator along the unit axis. Stator centering should be performed using two ring belts – on the core top and bottom along the 3rd in height stack from the edge (Fig.2). Quantity of points for measurements should not be less then three for every section along every belt. If necessary perform stator shift on the basis of results.

<table>
<thead>
<tr>
<th>Section No</th>
<th>Top</th>
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<tr>
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\[ D = \frac{D_{AV\, MAX} - D_{AV\, MIN}}{2} \leq 2mm \]

\[ R_{AV} = \frac{\sum R}{12} ; \quad \Delta R = R_{\text{max}} - R_{AV} \leq 1mm \]
11. After stator assembly finishing, begin to lay the winding in the stator joints zones. Slots in joints should be checked visually and blown with dry and clean air.

12. Perform laying of bars very gently. It is strictly forbidden any hits of insulation (5EP.487.218ED).

13. Special attention should be paid to tightening of bars in slots. Clearances between bars and core should be filled with semi-conductive fillers according to the assembly drawing of wound stator (drawing 5EP.670.124R1-ED).

14. Fixation of winding in slots should be done with insulating wedges which should be driven in by mandrel. Wedges should be installed without any clearances along the stator length. Slots in wedges should be located opposite ventilation ducts of the core. Ripple fillers should be installed on the upper bar (under wedge).

15. When installing slot wedges, pay attention to reliable tightening of winding in stator slots. This can be controlled by absence of trembling of slot wedges when rapping.

16. Stator winding heads brazing should be performed with silver brazing ПСр-15. Perform heating the brazing places with two gas burners (appendix 6a). At that the insulated end-winding portions should be coated with wet asbestos in order to protect the insulation from the flame of burners. During stator winding brazing process perform welding quality control – hack 1-2 brazings up to the middle along columns of conductors. All the conductors should be brazed to walls of straps. In the conductors joint filling with brazing should not be less than 60% of cross section. After checking, the shape of suitable brazing should be recovered. Brazings with deviations from standard should be re-brazed.

17. After brazing the heads should be cleaned, straightened, and additional insulation should be applied if necessary. Then insulating caps should be put on the heads and filled with compound (appendix 6d).

18. When working with compound, all the rules for safety requirements should be kept strictly (appendix 6c).

19. Use instructions of corresponding assembly drawings when brazing and insulating winding, assembling and insulating bandage rings, stator winding jumpers and terminals (5EP.588.206 ED).

20. After finishing the stator winding insulating, it should be blown with compressed air, and then coated with red-brown, electrical insulating enamel of cold drying.

21. Perform all the subsequent procedures on stator assembly. Connect the conductors layed from the stator RTDs (6EP.020.168ED). Install on the stator the tested air-coolers (6EP.020.170ED).
22. High voltage testing of the stator winding during the assembly procedure should be performed according to appendixes 2 and 3.
23. Before testing, measure insulation resistance of the winding relatively the frame, separately for every phase at grounding two other phases.
24. In order to detect condition of insulation, it is necessary to measure resistances $R_{15}$ and $R_{60}$ that are measured in 15 and 60 sec respectively after applying voltage from mega ohmmeter with output voltage 2,500 V. On results of this measurements, the polarization index will be defined $K_a = R_{60}/R_{15}$. It should not be less than 1.7.
25. After high voltage testing, repeat measurement of insulation resistance.
26. After finishing the insulation resistance measurements, the tested circuit should be discharged by electrical connection to grounded structures. Duration of discharge is not less than 3 minutes.

4.9. ROTOR ASSEMBLY
(5EP.674.106 ED)

The rotor assembly is performed in the following order.
Dismount the cone pins of the rotor shaft fixation to the rotor spider. Lift, transfer and handle the rotor shaft on the erection bay.
Prior to rotor extraction from the stator bore, the old brake disc should be dismounted. For this purpose, unscrew all the bolts of brake disc fixation to the spider bars (Fig.3).

Mount the new brake disc on supports on the erection bay.
Lift, transfer and mount the rotor spider on the new brake disc installed on supports. Connect the brake disc with the rotor spider (Fig. 4).
Dismount the sections of the fans on the rotor rim upper part to have the possibility of poles removing.

Dismount the rotor poles (5EP.487.210ED). Remove the old coils from the pole cores. Mount the new coils on the pole cores according to the drawing (5EP.630.038 ED), use special device to press coils on poles (5EP.487.212 ED). Position of the coils on the cores and mutual position of an insulating washer and a pole core should be checked during mounting the coils. If necessary, adjust coils in such a way that glass laminate washers do not project out of the core line. Position of the insulating washer when it is above the adjoining surface between the core and the rim is not allowed. Air clearance between a coil and a pole core should be closed according to the technical requirements of the drawing (5EP.630.038 ED). Check resistance of the frame insulation of the pole coils. It should not be less than 5 MOhm, otherwise the poles should be dried. Test turn-to-turn and frame insulation of the coils, testing voltage of industry frequency is according to appendix 3. During turn-to-turn insulation testing, impedances of all the coils are defined and compared.

Prepare the poles to hanging onto the rotor rim:
- check them visually, blow with dry and clean air,
- sort the poles by weight hanging the poles with equal weight diametrically in order to provide rotor balance. Check the slots for springs in the rotor rim. Springs in these slots should be placed loosely. In order to prevent spring from falling out when installing a pole, springs should be closed with metal strips. After installation of poles, remove strips.

In order to prevent rotor turnover, perform poles hanging subsequently in four diametrically opposite points of the rotor rim, using the device 5EP.487.214ED.

Install the fans sections on the rotor rim upper part.

Install the poles wedges and perform preliminary wedging of a pole. The working surface of wedges before installation into slots should be lubricated. Ends of pole wedges should be cut according to the drawing. Markings with paint should be done on the upper ends of wedges. Mutual movements of wedges should be controlled according to these markings.

In order to prevent shift of holes for cone studs in the rotor spider as well as shift of rotor rim relatively the rotor spider during transferring, the preliminary wedging should be carried out in the following order.

Lubricate the support surfaces of teeth of the rotor spider bars in the zone of rim supporting on them. Install the rim wedges and using the hammer of not more than 3 kg weight drive these wedges “alternately” (by turns diametrically located every couple of wedges). At that, it is necessary to control constantly the concentricity of the rim with uniformity of the clearance between the rotor rim and spider bars as well as using the arm for measuring 5EP.441.002ED. Driven in home rim wedges should lock the rim position relatively the spider at rotor transferring. At the same time it is necessary to prevent shift of
holes for cone pins in the rotor spider. For this purpose, the wedging force during rim wedging on the rotor spider at removed rotor from the hub should be minimum.

Measure the rotor shape along poles by the string after the preliminary rotor wedging (Fig.5), using the special arm 5EP.441.002ED. Draw up a form of measurements. Do not cut the wedges!

The final wedging should be carried out only after connection of the rotor spider to the hub that is put onto the shaft. Connection is made with cone pins.

![Fig.5. 1-Arm for measuring, 2-Rotor, 3-String](image)

Mount the rotor current leads according to the drawing.
Mount the connectors of damper segments and connectors of the pole coils.
Prior to assembling the connectors, it is recommended to carry out repeated testing of the turn-to-turn insulation of every pole.

After assembling the interpole connectors, carry out testing of pole coils frame insulation according to Appendix 3. Braze connections between the coils according to the drawing (5EP.674.106 ED).

Check the quality of contacts of the interpole connectors by measuring voltage drop on every contact. Connect the rotor winding to the d.c. supply. During these measurements, it is better to obtain rotor current value not less than 50 % of the rated one.

Blow out the rotor with dry and clean air with the pressure not more than 0.2 MPa, and coat it with enamel according to the rotor drawing directions (5EP.674.106 ED).

Note: rotor insulation testing can be carried out both prior to coating applying and after it, but not earlier than after 24 hours.

Prior to rotor lift be sure that ropes and crane are in good condition. Transfer the rotor from the erection bay to the place of installation, then lower it to the stator bore and support it with the brake disc on the brake-jacks. Perform this procedure with great care, in order not to damage the stator winding and core. On the height about 0.5 m above the stator winding, the rotor should be very accurately centered relatively the stator bore. Before the further rotor lowering it is necessary to put strips of plywood of cardboard of 5-8 mm thickness and 100 mm width between the stator and rotor. If any strip is pressed during the rotor lowering, suspend the lowering and correct the rotor centering.

Install the shaft onto the rotor in order to have coincidence of current lead direction and mounting holes for cone pins in the rotor spider and in the hub of the generator shaft.
Connect the rotor with the shaft.
Carry out the final rotor rim wedging. For this purpose, drive in the wedges with big sledge hammer (of weight not less than 8 kg) “alternately” up to the ringing sound.

In the end of the final wedging, ends of drive wedges should be cut according to the drawing.

Carry out the additional wedging of the pole wedges (in cold condition).
4.10. UPPER BRACKET ASSEMBLY

Mount the upper bracket on the stator. Check height position of the central part and upper bracket arms. Height position should be regulated by machining the intermediate plates according to technical requirements (it.13, drawing 5EP.670.123 ED). Weld the intermediate plates to the stator and between each other only after air gap checking and final unit centering.

Prior to installation of thrust bearing parts it is necessary to clean all the parts of the support subassembly. Check abutment of elastic supports and thrust bearing pads (clearances more than 0.03 mm are not allowed). Check thread in support sleeves and on support bolts. Support bolt should be screwed into the support sleeve by hands without jamming.

Install elastic supports with the thrust bearing pads 5EP.195.155ED according to marking. Adjust all the pads to one plane (friction plane) 1-2 mm lower than drawing value. For this purpose, put the thrust bearing runner onto the preliminary adjusted in height and lubricated pads. Adjust height of pads positions with support bolts by uniformly abutting pads to the runner.

Mount the thrust bearing hub (5EP.091.258ED) on the shaft, install locking ring. Connect the thrust bearing runner with the thrust bearing hub to have coincidence of the following places: place of maximum end run-out of the thrust bearing hub with place of minimum thickness of thrust bearing runner. Shift the rotor from the brakes onto the thrust bearing. Mount the guide bearing housing.

Assemble the upper guide bearing. Check visually the guide bearing pads 5EP.195.156ED. Scrape the Babbitt surface of the pads on the journal surface of the guide bearing hub (prior to installation of hub on rotor). Area of friction surface contact should not be less than 80% from the entire friction surface of the pad at the contact density not less than two spots per 1 cm². Check and if necessary refresh chamfers on trailing and incoming edges of the pads. Install the guide bearing pads.

The final adjustment of the clearances between the journal and guide bearing pads should be carried out after the unit centering is finished. Put necessary quantity of distance fillers between a pad and a block.

Lubricate the Babbitt surface of the guide bearing pads with uniform film layer.
Insulation resistance of the guide bearing pads should not be less than 1 MOhm.
Place the shaft vertically and check the generator shaft centering by the turbine shaft.
Bracket centering in radial direction should be carried out relatively the guide bearing journal with the accuracy up to 0.5 mm.
See the information about inspection of non-perpendicularity of thrust bearing runner plane to the rotor shaft axis in the section "Unit Centering".
Check the thrust bearing runner insulation.
Perform uniform loading of the thrust bearing pads. For this purpose, abut uniformly the thrust bearing pads with support bolts, simultaneously controlling declination of the shaft near the turbine guide bearing by two indicators installed at the angle of 90°. Lining should be performed for all the support bolts by turn along circle not less than 2-3 times. Abutting of every pad should be stopped at shaft declination by 0.01 mm (indicator's reading).

Assembly of the upper bracket flooring should be carried out according to the drawing 6EP.020.180ED.

4.11. UNIT CENTERING

1. Prior to the whole work it is necessary to inspect verticality of the turbine shaft with strings and inside caliper gage.
Centering a hydrogenerator is a set of the following procedures:
• aligning the generator rotor with the turbine shaft; the turbine shaft is the base for hydrogenerator centering;
• connecting the turbine shaft and generator rotor shaft;
• inspecting perpendicularity of the thrust bearing runner mirror to the unit shaft rotation axis and inspecting radial run-out of the upper shaft end;
• inspecting stator position relatively the rotor by the air gap and height position;
• inspecting position of the upper and lower brackets relatively the generator shaft rotation axis and height position;

2. Align the hydrogenerator rotor shaft to the turbine shaft. Alignment of the generator rotor shaft to the turbine shaft should be performed with synchronous shift of the rotor shaft in the horizontal plane in the required direction and adjustment of the height of the thrust bearing pads support bolts. It is necessary to get such a position when the end plane of the rotor shaft flange is parallel to the plane of the turbine shaft flange (accuracy up to 0.02 mm).

3. Perform coupling of the rotor shaft and turbine shaft after achieving satisfactory results of alignment. Pull up the turbine shaft to the generator shaft; install bolts into the flange coupling. Tighten the bolts.

4. Set the “zero” clearance in the upper guide bearing, keeping the generator shaft position without any changes. Remove lower guide bearing pads and turbine guide bearing pads.

5. Install 6 indicators in one plane: on the turbine bearing hub, on the turbine shaft flange, on the generator shaft flange, on the generator lower guide bearing, on the generator upper guide bearing, on the seat place for the rotor slip rings. These indicators will detect run-outs of the unit shaft.

Cranking the shaft, measure value of run-out in every 45 degrees.

If non-perpendicularity of the rotor shaft axis to the thrust bearing runner plane is revealed upon results, it should be corrected by scraping the regulating filler on “wedge” on the value corresponding to run-out.

6. Perform measurement of the air gap between the rotor and stator on the stopped rotor.

Measurements should be conducted with probes between a stator core tooth and core middle of every pole on the top and bottom.

Check the rotor shape and stator bore shape. For this, measure the gap between the core of one marked pole and the stator bore on the bore top and bottom at rotor cranking by 360°.

Adjustment of the air gap between the rotor and stator is performed by stator shift in the necessary direction or rotor shift in the allowed limits. The allowed value for rotor shift to adjust the air gap between the stator and rotor should be agreed with representative of the turbine's manufacturer.

Deviation of the mean arithmetic value of gap measurements under a pole from the mean arithmetic value of gaps under all poles is allowed in the ±5% limits.

To define coincidence of the stator and rotor magnetic symmetry axes, it is necessary to measure the distance from the edge of pole end plate up to the stator core step. Non-coincidence of the magnetic planes is defined as the difference between mean arithmetic values of measurements on the top and bottom of poles (Fig.6).

Admissible disagreement of magnetic planes is not more than 3 mm.
7. Radial position of the upper bracket relatively the shaft should be checked by measuring dimensions between the working surface of the guide bearing hub and guide bearing frame in four diametrically opposite points. Radial displacement of the bracket should not exceed 0.5 mm.

Vertical position of the bracket should meet the requirements of drawing dimensions. Mutual shift of the stator and upper bracket should be performed on the base of all the measurements analysis. It will be much better that rotor position remains permanent.

In the end of stator shift and upper bracket shift it is necessary to check the air gap again; height position of the stator relatively the rotor, radial and vertical positions of the bracket, and then the stator and upper bracket should be fixed finally.

### 4.12. OIL-BATHS ASSEMBLY

1. After the final unit centering and thrust bearing adjustment the following procedures should be performed:
   - check visually the working surfaces of the thrust bearing pads. Before this procedure, lift the rotor on brakes and lock it in this position with the nuts of brakes;
   - lubricate the thrust bearing pads and runner with a lubricant, then install the pads into the place;
   - install the lower guide bearing pads (scrape the working surfaces of pads along the journal surface of the lower guide bearing hub until the shaft sets onto the rotor. Contact area of the friction surface should not be less than 80% from the entire pad friction surface at the contact density not less than two spots per 1 cm²).
   - set the required clearances in the guide bearings;
   - measure repeatedly insulation resistance of every guide bearing pad and thrust bearing runner. Use mega ohmmeter with 1000 V output voltage, class of accuracy is not lower than 1. Insulation resistance should not be less than 1 MΩhm.
   - perform connections of the temperature control scheme according to the drawing (6EP.022.211 ED). Clean the oil-baths finally, assemble the shields, which cover the oil-baths, and sealings;
   - mount the oil-coolers according to the marking;
   - pour oil into the oil-baths.
It is recommended to pour oil in the following order: fill the oil-bath with oil, then discharge it, and then again fill the oil-bath with fresh oil. This enables to remove remains of contamination from the oil-bath. After filling the oil-baths with oil, check them visually for lack of leakages.

4.13. AIR-BAFFLES ASSEMBLY

Air-baffles assembly is performed according to the directions of the drawing (6EP.020.179 ED).
Install the air-baffles sealing pads, adjust them in radial and axis directions. When idling the rotor, make sure that the air-baffles do not touch the rotor.
All the elements should be mounted according to the plant marking.

4.14. INSTALLATION OF BRAKE DUST COLLECTING SYSTEM

Installation of the brake dust collecting system is performed in the zone of brake-jacks according to the drawings 6EP.020.176 ED, 6EP.020.183 ED.

4.15. UPPER HOOD ASSEMBLY

1. The upper hood assembly should be performed in the following order:
   • mount the slip rings (5EP.555.124 ED);
   • mount the hood frame with the slip rings rocker (5EP.125.262 ED);
   • mount boxes of the brush holders at the 3-4 mm distance from the slip rings surface, grind brushes;
   • adjust brushes pressing on the slip rings in the range 1.2-2 kg-force. Adjustment can be considered finished when the given pressure balanced with spring dynamometer enables remove easily the sheet of paper put between the brush and ring contact surface.
2. All the brushes working in parallel should have the same grade.
3. Install the technical data plate according to the drawing 6EP.030.056ED.

4.16. INSTALLATION OF TEMPERATURE CONTROL INSTRUMENTS, AUTOMATIC EQUIPMENT, VIBRATION CONTROL SYSTEM, HEATING SYSTEM, AND LIGHTING SYSTEM

(Drawings 6EP.022.211 ED; 6EP.022.212 ED; 6EP.020.172 ED; 6EP.020.173 ED, 6EP.020.206ED, 6EP.020.182ED, 6EP.020.183ED)

1. Install the temperature control instruments and automatic equipment.
2. Wiring from the temperature control instruments and automatic equipment should be performed according to the generator main subassemblies assembly.
3. Pay special attention to compacting the places where conductors and capillaries (ТКП-160 instruments) go out of the oil-baths.
4. Be careful when laying capillaries. Keep the 50 mm minimum bending radius.
5. Install the instruments of the stationary vibration control system.
6. Installation of the instruments should be performed according to the directions of drawings and instruments’ manuals.
7. Installation of the heaters and lamps should be performed according to the directions of the corresponding drawings.
5. Start-up and Adjustment

5.1. PREPARATION TO START AND FIRST START

1. It is necessary to perform the thorough cleaning of whole generator from dust and rubbish. Blow the hydrogenerator with dry clean compressed air. Clean with vacuum cleaner and wipe with rags the internal cavities of stator frame, baffles, brackets, generator pit, covering of turbine pit. Foundation surfaces under generator should be painted with oilpaint before the first start-up of generator.
2. Inspect all internal surfaces of generator to be sure that it is free of foreign subjects and tools. The air gap and rotor should be inspected most carefully.
3. Check the pinning and bolts tightening of stator, rotor, brackets, brake jacks and all mechanical fastening. Check the locking of all nuts, especially on rotating components of generator. Perform this operation according to closing of some individual inaccessible places of generator. Register the check results in log.
4. Check the operation of temperature control, protection, alarm and start/stop automatic systems. Make sure in correctness of fire-extinguishing system functionality.
5. Make sure beforehand in correctness of water circulation in cooling system of generator.
6. Perform the blowing and check the operation of brake jacks
7. Test the samples of oil from bottom parts of thrust and guide bearing oil baths regarding their type conformity and absence of water and pollution a few hours before start.
8. Perform the start of unit. Keep the 30% of the rated rotation speed (1-1.5 minutes) and after making sure in absence of touching, strange noise or abnormally high run-out increase the rotation speed up to 60-70% of the rated value.
9. At the hydrogenerator first start the excitation should be disconnected.
10. Keep an eye on vibration and temperature condition of the thrust and guide bearings during the hydrounit operation. From the very moment of rotor rotation beginning, temperature should be increased without sudden changes: at first with even increase, then with diminishing increase and after 2-3 hours of operation it should be set in permanent condition.

The steady temperature of the thrust and guide bearings should be within 50-60 °C depending on temperature of cooling water. If abnormal vibration will arise during rotor rotation, then clarify it cause.

5.2. STOP AND HYDROGENERATOR INSPECTION

After unit stop, perform thorough visual inspection of the hydrogenerator, check all the main mechanical fixations of the brackets, stator, baffles, and upper hood.
Eliminate all the revealed at generator operation malfunctions. Clean the hydrogenerator.

5.3. INSULATION DRYING

Newly erected hydrogenerator or hydrogenerator after long standstill should be exposed to drying before start.

The recommended types of drying:
• by short circuit current;
• by d.c.;
• by ventilation losses.
Follow the following instruction at all the types of drying.
Perform heating slowly, by not more than 4 -5°C per hour.
The maximum allowed temperature in the most hot spot should not be more than 75 °C at measuring with thermometer and 90 °C at measuring by resistance method. The indicated temperature should be reached after 15-20 hours, not earlier.
Keep the constant observation for temperature and draw up the protocol of drying. At the beginning of drying write down temperature in every 15 minutes, and after reaching the temperature permanent condition write down temperature every 60 minutes.
As far as possible perform the generator drying at rotor rotation, as ventilation quickens drying process.
Resistance measurement should be performed at disconnected current supply. Measurement of insulation resistance of the stator winding should be carried out with mega ohmmeter with 2,500 V output voltage and of 1.0 accuracy class, of the rotor winding – with 500 V voltage.
During drying procedure insulation resistance is decreased firstly because of moisture evaporation at heating, and then it is increased gradually, and then it becomes constant and increased slightly.
Bring drying up to the constant condition of insulation resistance.
Drying is considered to be finished, if the insulation resistance value remains constant during 6 hours at constant temperature.
The minimum allowed insulation resistance of the stator winding every phase (R_{60}) at the 75 °C temperature is 12.4 MOhm.
At the temperature lower than 75 °C, the minimum allowed insulation resistance value should be defined by multiplying the resistance at 75 °C by the “K” coefficient.

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<th>Temperature °C</th>
<th>75</th>
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<td>coefficient “K”</td>
<td>1</td>
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<td>5.5</td>
<td>8.5</td>
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Value of the insulation polarization index R_{60}/R_{15} should not be less than 1.7 at the temperature range from 10 to 30 °C.
For the rotor winding allowed insulation resistance should not be less than 0.5 MOhm at the temperature range from 10 до 30 °C.
In case of drying by short-circuit current, place for circuiting of all three phases should be chosen before breaker; speed of rotation can be lightly reduced; in the initial drying period stator current should not be more than half of the rated value, further it can be increased up to the rated value.
The stator frame should be grounded fail-safely.
Drying with d.c. should be carried out by feeding the stator with current. Stator phases should be connected in series. Current value is defined by maximum heat temperature.
Supply scheme should provide for the possibility of smooth current regulation at switching on and off, as at abrupt change of the stator current value insulation breakdown can happen.
It is not recommended to dry with d.c. the hydrogenerator wet insulation. Prior to this it is recommended to dry insulation by ventilation losses a little.
Insulation drying by ventilation looses should be performed at the rated speed of rotor rotation without excitation and without water supply to air-coolers. It is allowed to increase speed of rotor rotation up to 110% of the rated value.
After drying, the hydrogenerator should be checked visually according to the Program agreed with the manufacturer’s representative. Eliminate all the imperfections and only then start testing.
6. Hydrogenerator Testing

Every hydrogenerator should be subjected to testing in accordance with the Contract. Standards of test voltages are indicated in Appendixes 2 and 3.

6.1. TESTING DURING AND AFTER ERECTION (BEFORE FIRST CONNECTION TO GRID)

Measure insulation resistance of stator winding every phase relatively the unit frame and between phases, rotor winding – relatively the frame. Measure insulation resistance of embedded RTDs.

Measure ohmic resistance of the stator and rotor windings by d.c. at practically cold condition.

Measure resistance of RTDs in practically cold condition.

Test with d.c. the stator winding insulation relatively the stator frame and between phases for electrical strength (prior to testing with a.c.). Standards of test voltages are indicated in Appendix 2.

Perform high voltage testing with increased voltage, 50 Hz for insulation of the stator and rotor windings relatively the frame and between the windings for electrical strength. Standards of test voltages are indicated in Appendix 3.

Measure the insulation resistance of the thrust and guide bearings.

Measure impedance of every pole by a.c. in order to detect inter-turn short circuit.

Measure vibration of the support subassemblies and stator core.

Perform preliminary checking of normal functioning and regulating of the control and safety equipment, including calibration of instruments and RTDs.

Measure the air gap value in practically cold condition of the unit.

6.2. TESTING AFTER FIRST CONNECTION TO GRID

1. Carry out heat tests of the hydrogenerator components (3 - 4 heat modes).
2. Perform measurement of consumption and temperature of cooling water.
3. Perform the complete control of the excitation system functioning at no-load and at load.
4. Test the hydrogenerator at increased speed of rotation, which is reached by the unit at load rejection (this test is combined with the test when the turbine governor is adjusted).
5. Perform control of vibrations, carry out balancing if necessary.

6.3. INSPECTION OF TECHNICAL CONDITION AFTER UNDER LOAD TESTING

Check visually condition of the main fixations of the rotor, stator, air-baffles, upper and lower brackets, sheets and bars of flooring, hood and brakes.

Check poles wedging, rim wedging. Correct wedges position if necessary.

Check visually the damper system and interpole rotor connectors.

Check visually the stator winding for absence of insulation damages.

Check visually sealings of oil-baths for absence of leakages.

Check visually oil- and water pipelines, oil- and air-coolers for absence of water or oil leakages.

Check visually the brakes and brake pipeline for absence of oil leakages at rotor lift on brakes.

Check visually instruments to measure oil level, water consumption, as well as temperature control.

Check proper operation of the braking system.

Measure insulation resistance of all the hydrogenerator windings.
Check visually the brush system. If necessary, clean the slip rings and brush system from brush dust.
Check visually connections of the current leads and busbars.
Compare oil levels in the oil-baths with the initial condition. Write down working changes of oil level.
Eliminate all the imperfections revealed during testing and visual checking.

6.4. INSPECTION OF HYDROGENERATOR TECHNICAL CONDITION AFTER 6,000-7,000 HOURS WORK

1. Check visually the stator end-winding, jumpers, busbars, and stator bore in reachable places. Check stator winding wedging in slots, fixation of end-winding. In reachable places check visually fixation of the stator core to the stator frame.
2. Check visually and measure the air gap between the stator and rotor, compare the value with the installation data.
3. Check pinning and stator fixation to the foundation.
4. Measure ohmic resistance to d.c. and insulation resistance for the stator winding, and compare them with the previous results.
5. Check the clearance value between the air-baffles and rotor rotating parts.
6. Check fixation and locking of the air-baffles connections.
7. Blow the stator winding, stator core, bandage rings zone with compressed air.
8. Check proper operation of temperature control of the stator winding and core.
9. Check visually the stator winding, pole insulating washers, rotor current leads. Check condition of the interpole connectors, rotor damper winding.
10. Check fixation of the rotor poles, correct positions of the pole and rim wedges, as the most intensive loosing of wedging happens during the initial hydrogenerator operation period.
11. Check all the connections and fixations of the rotor spider; check visually weld seams, check locking of all the rotor bolts and nuts.
12. Measure resistance to d.c. and insulation resistance of the rotor winding and compare them with the previous results.
13. Clean the rotor from contamination and blow it with compressed air.
14. Remove the upper hood; open the upper bracket oil bath.
Old oil discharging should be performed immediately after the unit stop when different impurities are still in suspension state.

Measure clearances for every guide bearing pad and compare them with the installation and drawing data. Measurements should be performed considering the actual position of the shaft axis after stop. Usually shaft stops and presses to one or two pads. That is why it is necessary to accept the sum of clearances in opposite points. Prior to measurement of clearances, install perpendicularly to each other indicators to the shaft journal. This enables to control shaft shift at changes of clearances.

To measure a clearance, press a pad to the hub journal, and then measure the clearance between the block crown and bearing seat with a probe. At next adjusting of the clearance it is necessary to be guided with the following: if bearing pads are overheated, the clearance should be increased slightly; if horizontal vibration of the brackets and shaft run-out are increased, then the clearance should be decreased slightly.

15. Prior to removing the guide bearing pads, clutch the shaft from four sides with four pads and remove four other. After the work with these pads is finished, install them back and clutch the shaft with them, remove four other pads. After removal perform visual checking of every pad, if necessary scrape the friction surface. Checks visually the bearing journal, if necessary polish it.
17. Check visually the working surfaces of the thrust bearing pads and check uniformity of wear by measuring lines which are on the friction surfaces of the pads.

18. Check visually the support surfaces of elastic supports (plates) of pads. They should be uniform without any damages and cracks.

Do not remove the support bolts, if all the thrust bearing pads worked equally in order not to damage pads position on height.

19. If pads worked unequal, adjust pads abutting to the runner, correct eccentricity (shift) if wear of pads friction surfaces is irregular. Detect wear if measuring lines have disappeared.

20. Check condition of the runner surface. If there are scratches, polish them.

21. Measure insulation resistance of the thrust bearing. Compare this value with previous data.

22. Clean the thrust bearing thoroughly. Assemble the thrust bearing. Lubricate the working surfaces of the pads and runner with thin layer of thick lubricant. Check proper operation of temperature control instruments of the thrust bearing.

24. Clean all the internal cavities of the oil-baths from contamination, wash them with kerosene, and then wipe them with clean rags dry.

25. Check condition of weld seams of oil-baths, absence of leakages in oil pipes.

26. Install oil-coolers and assemble oil-baths sealings. Fill the oil-baths with new oil of corresponding grade.

27. Check condition of weld seams of the brackets, fixation of the brackets: the upper bracket – to the stator, the lower bracket – to the sole plates.

28. Check fixation and locking of all the bolts and nuts of floorings of the upper and lower brackets. Clean the floorings from contamination.

29. Check proper operation of the braking system. Check fixation of brakes. If necessary, perform inspection of the brakes and braking system control cubicle. Change worn gaskets of brakes pistons. In order to install brake piston into cylinder, wrap and press the gasket with thin cord or durable filament. Then install the brake piston into cylinder, remove the cord carefully.

Check sealings of connections of brake pipeline.

30. Check condition of wire to every temperature control instrument. Check rightness of readings of the temperature control instruments.

31. Check tightness of connections of the air-coolers to the stator frame. Clean the air-coolers. Even in case of slight contamination clean them with water going in back direction under 0.3 MPa pressure during 1 hour. After assembly, test every air-cooler with hydraulic pressure.

32. Check proper operation of flow meters and level relay, sealings in supplying pipelines.

33. Clean and blow the slip rings and brush apparatus with compressed air. Check visually the slip rings brush apparatus. Worn brushes should be changed for the new ones. Check pressing of the brushes to the slip rings.
7. Appendixes

Appendix 1

**TIGHTENING TORQUE OF CRITICAL THREADED CONNECTIONS**

<table>
<thead>
<tr>
<th>No</th>
<th>Connection</th>
<th>Type of fixation</th>
<th>Torque, at tightening kg force * m</th>
<th>Type of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connection of the joint plates of the stator sections</td>
<td>Stud M48</td>
<td>200</td>
<td>Tightening force</td>
</tr>
<tr>
<td>2</td>
<td>Connection of the stator to the sole plates</td>
<td>Bolt M48</td>
<td>145</td>
<td>Tightening force</td>
</tr>
</tbody>
</table>

Appendix 2

**STATOR WINDING INSULATION TESTING WITH D.C. VOLTAGE**

Every separate phase should be subjected to test. Two other phases should be connected to the frame.

In order to plot the \( I_{\text{leakage}} = f(U_{\text{test}}) \) characteristic, it is necessary to perform measurements of leakage currents at least at five values of test voltage with equal steps in the range from \( 0.5U_{\text{rated}} \) to \( 3U_{\text{rated}} \).

Prior to testing, check the testing unit at no-load in all the steps of test voltage in order to define inaccuracy bringing by the unit itself.

Stand voltage in every step during 1 minute and measure leakage currents in every 15 and 60 sec after voltage apply.

Voltage rise from step to step should be performed smoothly during 8-10 sec. Voltage kill should be performed smoothly also.

In case of leakage current increase after the step voltage is reached at constant test voltage, it is necessary to stop test and reveal the cause of leakage current increase.

If abrupt leakage current increase in separate points will be observed during the test or leakage currents reach the limited value (indicated in table), test should be stopped, and nonlinearity factor should be calculated.

The maximum allowed leakage currents at insulation testing with d.c. voltage:

<table>
<thead>
<tr>
<th>Test voltage step relatively to ( U_{\text{rated}} )</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leakage current, microampere (in 60 sec after voltage apply)</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>350</td>
</tr>
</tbody>
</table>

Measurement of leakage currents should be performed with measuring instruments of accuracy class at least 1.5.

nonlinearity factor \( K_n = \frac{U_{\text{min}} \times I_{\text{max}}}{I_{\text{min}} \times U_{\text{max}}} \), where:

- \( U_{\text{min}} \)- minimum step of test voltage, V;
- \( U_{\text{max}} \)- maximum step of test voltage, V;
- \( I_{\text{min}} \)- leakage current measured at minimum step of test voltage, microampere;
- \( I_{\text{max}} \)- leakage current measured at maximum step of test voltage, microampere;
- Nonlinearity factor value should not be more than 3.

Characteristic of leakage currents should not have sharp bend. In those cases when characteristic of leakage currents has sharp bend, it is forbidden to start the hydrogenerator even at \( K_n < 3 \).
If cause of leakage current increase has not been revealed but nonlinearity factor is less than 3, then the hydrogenerator should be dried repeatedly. After the repeated drying it is allowed to carry out repeated testing.

If the winding withstands 60 sec in the last stage \((3 U_{\text{rated}})\), one can consider that testing with maximum d.c. voltage is successful.

Appendix 3

**TEST VOLTAGES TO CHECK ELECTRICAL STRENGTH OF STATOR WINDING INSULATION (a.c. voltage, 50 Hz)**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Stage of work</th>
<th>Test voltage (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot portion of upper and lower bars</td>
<td>Prior to laying into slots</td>
<td>34.0</td>
</tr>
<tr>
<td>End-portion of upper and lower bars</td>
<td>Prior to laying into slots</td>
<td>17.0</td>
</tr>
<tr>
<td>Low layer bars</td>
<td>After laying into slots</td>
<td>32.0</td>
</tr>
<tr>
<td>Upper layer bars with lower layer bars</td>
<td>Prior to brazing and connecting the winding installed at plant-manufacturer</td>
<td>29.0</td>
</tr>
<tr>
<td>Terminal busbars</td>
<td>Prior to installation onto the stator</td>
<td>29.0</td>
</tr>
<tr>
<td>Connecting busbars</td>
<td>Prior to installation onto the stator</td>
<td>29.0</td>
</tr>
<tr>
<td>Entire winding</td>
<td>After laying, brazing, insulating</td>
<td>24.0</td>
</tr>
<tr>
<td>Stator of the ready generator</td>
<td>Prior to commissioning</td>
<td>19.2</td>
</tr>
<tr>
<td>Turn-to-turn insulation</td>
<td>When rotated at no-load with excitation</td>
<td>15.8</td>
</tr>
</tbody>
</table>

**TEST VOLTAGES TO CHECK ELECTRICAL STRENGTH OF ROTOR WINDING INSULATION (a.c. voltage, 50 Hz)**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Stage of work</th>
<th>Test voltage (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame insulation of pole coil</td>
<td>Prior to installation of poles</td>
<td>3.0</td>
</tr>
<tr>
<td>Turn-to-turn insulation of pole coil</td>
<td>Prior to installation of poles</td>
<td>0.13 (5 V per turn)</td>
</tr>
<tr>
<td>Frame insulation of pole coil</td>
<td>After poles installation and wedging, prior to their connection</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>After brazing and insulating all the connectors</td>
<td>1.5</td>
</tr>
<tr>
<td>Slip rings insulation</td>
<td>Prior to installation on shaft</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Assembled rotor</td>
<td>1.5</td>
</tr>
<tr>
<td>Excitation current leads with brush holder rocker</td>
<td>After assembly</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Prior to commissioning</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Appendix 4

**TEMPERATURE LIMITS**

<table>
<thead>
<tr>
<th>Object</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator winding</td>
<td>120</td>
</tr>
<tr>
<td>Stator core</td>
<td>120</td>
</tr>
<tr>
<td>Cold air</td>
<td>40</td>
</tr>
<tr>
<td>Stator hot air</td>
<td>65</td>
</tr>
</tbody>
</table>

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Appendix 5

VIBRATION STANDARDS
AMPLITUDE OF OSCILLATIONS IN HORIZONTAL PLANE

<table>
<thead>
<tr>
<th>Place of measurement</th>
<th>Maximum allowed vibration value at rated speed of rotation, mm</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper and lower bracket</td>
<td>0.1</td>
<td>Amplitude of oscillations in horizontal plane</td>
</tr>
<tr>
<td>Upper bracket</td>
<td>0.1</td>
<td>Amplitude of oscillations in vertical plane</td>
</tr>
<tr>
<td>Stator core</td>
<td>0.03</td>
<td>Amplitude of oscillations with 100 Hz frequency at load in symmetrical mode</td>
</tr>
</tbody>
</table>

Appendix 6

TECHNOLOGICAL INSTRUCTIONS

a) BRAZING OF STATOR WINDING BARS

The present instruction contains main directions on brazing of the hydrogenerator stator winding with silver containing braze with gas-flame burners at site.

1. Materials and equipment

   a) Braze as strips of 0.2-0.3 mm thickness and 25-30 mm width.
   b) Borax.
   c) Balloons with acetylene and oxygen. In the extreme case it is allowed to use acetylene gas generator.
   d) Gas burners.
   e) Oxygen and acetylene hoses.
   f) Asbestos (powder, sheet).
   g) Source of dry compressed air.
   h) Light protecting goggles.
   i) Dark protecting goggles or shields to perform gas-welding works.
   j) Screw-clamps.
   k) Fitter’s work tool: pliers, cutters, hammers, blades, chisels, lever shears, forge tongs, files, etc.
   l) Electric drill.
   m) Metal brush.
   n) Tarpaulin gauntlet.
   o) Ethyl alcohol.

2. Preparation of heads and straps to brazing process

   Clean the places of brazing before brazing of heads.
   In case of darkening of bars and straps surfaces, is necessary to clean them with abrasive paper until metal glitter is appeared, prior to this notch all the burrs. After cleaning blow straps with compressed air and degrease with ethyl alcohol.

3. Preparation of borax solution

   Pour 1 – 1.5 liters of water into metal pot and bring it to boiling temperature. During boiling, add borax until sediment is appeared (oversaturated solution). After cooling, this solu-
tion is ready to be applied. It is necessary to add 520 grams of borax to prepare one liter of the solution.

4. Assembly of heads for brazing

Press the assembled head with screw-clamp to close joints of strands between each other. This can be controlled through holes in straps. It is allowed to have 1 mm or less local gaps between joints of strands.

To have convenient access to bring braze into place of brazing, it is recommended to move apart end-portions of heads in places of bending (Fig. 1).

Gaps between the moved apart end-portions of heads should be tightened with fireproof powder in order to prevent insulation burning and compound flowing out during brazing process. It is especially important at brazing of lower heads.

Insulate end-winding tightly with wet paste from fireproof powder to prevent insulation from burner’s flame.

5. Heads brazing

It is necessary to process preliminarily the brazed surfaces with supersaturated borax solution in order to prevent oxidation of the joined surfaces during brazing.

In order to provide for uniform heating of the assembled connection, flame of the burner should be moved with vibratory motion from one bar to the strap, and then to another bar and back.

In order to heat the inside surfaces of the connection, flame of the burner should be directed mainly onto strands of the bar, at the same time do not let overburn of the strands. In order to provide quick and at the same time necessary heat of the connection (that is especially important during lower heads brazing), it is recommended to use two gas-burners (see Fig. 2).

Supply the braze to the brazed place only when it begins to melt when contacting the heated head. Originally, the braze is supplied between two moved apart half-sections of the heads synchronously from two sides of the strap. After braze appearance in the control holes of the strap, stop the braze supplying and press the moved apart half-sections of the heads with forge tongs. Then perform little supply of the braze into the clearance between the strap and strands, after that press the strap with forge tongs. If necessary, perform additional supply of rod braze through the upper holes of the strap.

The brazing is considered to be finished if the braze has filled the joint between bars, all the clearances between separate strands, and clearances between the strap and strands.

During brazing, it is recommended to heat the brazed place continuously and in case of need add dry borax.

The workers should wear dark protecting goggles and gauntlets during brazing, and it is recommended to use protecting shields during any gas-welding works.
6. Checking of brazing quality

When brazing is finished, the heads are examined visually for joint quality. There should be no unbrazed places. If unsatisfactorily brazed joints are revealed at external examination, they should be brazed again.

After visual checking of the welded joints, it is necessary to perform random control cutting of the brazed heads in quantity of at least two pieces from the top and bottom of every hydrogenerator stator joint. The brazing is considered to be satisfactory if ends of bars are brazed on the area not less than 60% of cross section of the bar. Strands between each other and with straps should be brazed on all the perimeter of the end of the strap.

Cutting should be performed along the strap in the place of connection of the head half-sections on the depth at least to the center of the connection. After visual checking of the good quality brazing, half-sections of the heads should be linked, corrected. Smooth unevenesses.

In case of bad quality brazing revealing at the control cutting, it is necessary to perform secondary control cutting in doubled quality of cut brazings.

In case of unsatisfactory results with the secondary control cutting, all the brazings should be re-brazed. Then again perform checking of brazing quality.

7. Treatment of brazed heads

Remove and notch all the braze leakages, unevenness and sharp edges after brazing finishing of the stator winding heads. The ends of bar insulation should be cut on cone, remove the carbonized insulation parts. The formed soot on the conductors should be removed. Blow carefully the processed heads with compressed air, after that one can perform their insulating process.

b) STATOR WINDING BANDING

Band the windings installed in the stator to the bandage ring with a cord. Bind the end-winding as follows: band lower sides of windings between each other and to the bandage ring by chain binding according to the scheme Fig.3. Connect the upper sides of windings between each other and to the bandage ring through clearances between the end portions. Perform binding in four or less parallel filaments. The number of turns around winding sides and between winding sides should be chosen so, that total number of cord turns corresponds to the drawing. Repeated turns are not shown in the scheme. The fillers on the bandage ring and between winding sides are not shown also.
c) SAFETY ENGINEERING FOR WORK WITH EPOXY RESINS

The instructions include the rules on safety engineering at work with epoxy resins and compositions on their base.

1. Properties of applied materials and their influence to organism

1.1. There are two ways of harmful substances penetrating to organism during work with the epoxy resins. They are inhalation and skin. The inhalation way is defined with presence in resins flying components (not more than 0.9% per weight), that begin to separate during heating, the skin way is determined with direct contact with flying and non flying resin components.

1.2. Flying components produce the irritating and sensitizing action on the skin and upper respiratory ways and eyes mucosas and also toxic action.

1.3. The toluene vapours in high concentration act as narcotic, produce irritating action on the skin. The toluene induces the irritating of eyes and upper respiratory ways mucosas, head ache, vomiting, appetite loosing at long influence. The maximum concentration limit of toluene vapours in the air is 50 mg/m³.

1.4. Dibutyl phthalate is the little toxic liquid. It is not recommended to let the contact with unprotected skin. Use the gauntlets or creams with oils.

1.5. Polyethelene-polyamine is the oily liquid, can induce the skin irritation at long influence.

1.6. Acetone is the main solvent that is used for epoxy resins, flying substance, has the narcotic action. The sharp vapor poisoning is possible only at high concentrations.

1.7. Powder-like quartz is the stuff of the epoxy compounds. The constant inhalation of the quartz powder is dangerous. It does not cause the direct organism reaction during inhalation. The maximum concentration limit of it in the air is 1 mg/m³ as aerosol state. Use the respirators for the protection.

1.8. The compounds on the epoxy resins base are widely used in electrical engineering by different firms. The toxicity of details made on epoxy resins base at right component dosage is reduced sharply after the hardening.

The epoxy compounds applied during generator mounting harden at room temperature during 24 hours and become non dangerous for the people’s health.
2. Safety engineering requirements

2.1. The manufacturing processes with epoxy resins should be carried out in a separate room or on a specially detailed area. The specially detailed area should be protected with a continued barrier from other manufacturing areas in order to reduce a people quantity having contacts with components.

2.2. All the manufacturing processes should be carried out at alive exhaust ventilation.

2.3. A special storeroom or warehouse should be equipped for material store. It is prohibited to store the materials on working areas.

2.4. It is necessary to deliver minimum material quantity to working areas that is needed per a working day, shift or for one-time job execution. It is necessary to pass the empty package in closed state to the warehouse or storeroom during the day. Transportation and shipment conditions should exclude package damage.

2.5. All the start armature of electrical appliances should be removed on enough distance.

2.6. The technical process should provide working personal with the minimal contact with epoxy resin, its vapors and hardener. The device for material heating should be equipped with blowdown ventilation.

2.7. It is necessary to cover areas of the floor, tables, etc., that can be polluted with resin or hardener, with two layers of thick paper. It should be removed immediately after the pollution.

2.8. Epoxy materials that fell into floor by chance should be removed immediately with waste and strew with dry sawdust or sand. Remove epoxy materials with waste, dry paper, scraper if they fell into equipment and instruments. After that one can wipe the equipment with duster that is wet slightly with acetone.

2.9. It is necessary to collect the dirty paper, waste, sand, sawdust to metallic boxes with covers which should be emptied in the shift end, and the contents should be collected and took out.

2.10. The wash-hand-stands with cold and hot water supply should be installed in rooms for people working with epoxy compounds. It should be available a soft soap, brushes and disposable absorbent paper towel.

3. Requirements for the persons working with epoxy resins and compounds

3.1. Only those persons are admitted to work who are at least 18 years old.

3.2. Only those persons are admitted to work who passed detailed instruction about epoxy material properties, safety engineering rules and prophylactic actions in accordance with this instruction.

3.3. It is necessary to switch on the blowdown ventilation before work beginning. It is prohibited to work at defective ventilation.

3.4. The working personal should be equipped with special clothes, special shoes and preserving devices.

3.5. Do not permit a contact of unprotected skin with epoxy materials. It is necessary to use the devices excluding hand skin contact with epoxy materials. Put on the gauntlets, use the protect creams.

3.6. It is necessary to wash carefully hands, face and another open body areas with hot water and soap after hand dirtying with epoxy materials. Make removing of adhered resin to skin with soft paper napkins. It is assumed to use minimum acetone quantity if the skin is polluted too much.

3.7. Irrigate abundantly eyes during 5 minutes with water in case of accident epoxy materials getting into them, than do with physiological solution, after that visit a doctor immediately.

3.8. Taking food, smoking and using open fire near the working section is prohibited.

3.9. Visit a doctor at bad feels during or after working with epoxy compounds.
4. Instruction

4.1. People working with epoxy compounds should be instructed against a receipt about material toxic properties, safety rules and prophylaxis actions in accordance with this instruction.

4.2. Workers getting respirators should pass the special instruction about use rules.

d) PREPARATION OF FILLING COMPOUND AND STATOR WINDING HEADS FILLING

The present instructions describe preparation of filling compound EAK and filling of hydrogenerator stator winding heads with it under erection conditions.

1. Materials

1.1. Epoxy resin ED-22.
1.2. Dibutilphtalate.
1.3. Powdered quartz.
1.4. Polyethylenepolyamin.
1.5. Technical acetone.
1.6. Plasticine.
1.7. Epoxy putty.
1.8. Epoxy filler.

2. Technological process of compound preparation

2.1. Compound formulation: Calculation on 10 kg compound. (w.p. - weighted parts)

<table>
<thead>
<tr>
<th>Material</th>
<th>Weighted Parts</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin ED-22</td>
<td>100 w.p.</td>
<td>3.7 kg</td>
</tr>
<tr>
<td>Dibutilphtalate</td>
<td>20 w.p.</td>
<td>0.74 kg</td>
</tr>
<tr>
<td>Powdered quartz</td>
<td>150 w.p.</td>
<td>5.56 kg</td>
</tr>
<tr>
<td>Polyethylenepolyamin</td>
<td>12-13 w.p.</td>
<td>0.45 kg</td>
</tr>
</tbody>
</table>

2.2. Pour the not more than 2 cm layer of powdered quartz. Dry it in furnace at 200 °C during 24 hours, cool it and screen; store it in a closed metal box.

2.3. Weigh designed quantity of epoxy resin in a bucket, add weighed out amount of dibutilphtalate and mix the mass until complete homogeneity.

   Note: Epoxy resin should have temperature within +15 to +30 °C.

2.4. Add powdered quartz to mixture, weighed out according to formulation, and mix the mass until complete homogeneity.

2.5. Just before filling, add measured amount of hardener-polyethylenepolyamin into compound with continuous mixing, continue mixing during 10 minutes until complete homogeneity.

2.6. Use ready compound not longer than during 30 minutes.

   Note: Filling with compound may be performed at temperature not less than +15 °C.

2.7. After compound using, quickly clean vessels from the rest of compound, and wash them with acetone.

3. Technological process of cap filling

3.1. Bore the holes in caps for upper heads according to Fig.4 and smooth the edges.

3.2. Clean the copper of heads, degrease with waste moistened with acetone.

3.3. Wipe the cap with waste moistened in acetone.

3.4. Install the caps on heads, fasten them by means of wooden wedges.
3.5. Prepare the putty with extender:

- Putty EP-00-10 - 100 w.p.
- Talc - 100 w.p.
- Polyethylenopolyamin - 6 w.p.

Thoroughly mix it. Use the putty within 30 min.

3.6. Hermetically seal the places of bar outlets from cap with putty. Provide the smooth vanish cone from cap to insulation.

3.7. Prepare the cardboard strips with 100x150 mm dimensions. Made the funnels of them. The bottom diameter of a funnel is 16 mm.

3.8. Install the funnels onto pouring holes of upper head caps. Install the polyvinylchloride pipes on the control holes. Seal the pipes and funnels with plasticine.

3.9. Begin filling not earlier than in 24 hours after putty applying.

3.10. Lay paper under the heads.

3.11. Perform filling of upper heads through the funnels from a cup. In the process of filling watch the checking pipe. When the pipes are filled with compound, stop filling. After that the rest of compound must stay in the funnel.

3.12. Perform filling of the lower heads through a funnel from a cup, until the cap is filled. After compound hardening, seal the places of bar outlet from the cap with putty similar to the upper cap.

3.13. In case of compound flowing out of the cap, seal the places of flowing additionally by plasticine.

3.14. Time of compound hardening at the temperature from +15 to +30 °C is not more than 24 hours.

3.15. After the end of hardening take off wooden edges, take off funnels with the rest of compound, pipes, plasticine seals; remove compound collars with a knife.

3.16. Prepare putty according to item 3.5.

3.17. Fill with putty the places of bar outlet from the cap on the lower caps, make smooth cone of running down to insulation. Fill with putty unevenness in places of filling and checking holes on the upper heads.

4. Checking

4.1. Prior the work, it is necessary to make visual inspection of dibutylphthalate and technological test for compound hardening.
4.1.1. Control visual inspection of dibutylphtalate: dibutylphtalate is transparent liquid from yellow to green-brown color with viscosity like water. In case of thickening or appearance of flake-like sediment, the product should be considered as off-quality.

4.1.2. Technological test for compound hardening:
Make testing amount of compound according to formulation:

Epoxy resin ED-22  - 100 w.p.
Dibutylphtalate       - 20 w.p.
Powdered quartz       - 150 w.p.
Polyethylenepolyamin - 12-13 w.p.

Compound should be hardened completely during not more than 24 hours at the temperature from 15 to 30 °C.

4.2. The cap should be filled with compound. Completeness of filling is determined by presence of hardened compound in checking pipe and by light tapping over a cap after compound hardening. Uniform ringing sound at cap tapping indicates the absence of voids.

4.3. Compound and putty should be hardened completely.

5. Safety engineering

5.1. Only the persons, not younger than 18 who were subjected to special medical examination, are admitted to the work.
5.2. All works on compound and putty preparation and container washing should be performed in a separate room with exhaust ventilation. Presence of strangers is forbidden.
5.3. The works on compound preparation and its filling should be performed in working clothes, hands should be protected with rubber surgeons’ gloves. After the end of the work hands should be washed with hot water and soap.
5.4. At all works with powdered quartz antidust respirator should be used.
5.5. At compound preparation, its filling and container washing, presence of open flame, work of heating appliances, electric welding, smoking in 5 m radius are inadmissible.
5.6. Eating is forbidden in the sector of compound preparation and its filling.

e) INSULATING PROCESS FOR CONNECTIONS OF BUSBARS, JUMPERS AND BARS OF STATOR WINDING

The present instructions give indications on insulating process of connection places of buses, jumpers and bars of the hydrogenerator stator winding.

1. Materials

1.1. Glass tape.
1.2. Surgical tape.
1.3. Resin ED-22.
1.4. Dibutylphtalate.
1.5. Acetone.
1.6. Polyethylenepolyamin.
1.7. Impregnated glass-mica tape 0.15x25.
1.8. Teflon film.

2. Technological process

2.1. Degrease connection places with acetone.
Note: Connection places should have no burrs.
2.2. Level connection places with epoxy paste.
Paste formulation:
1. Epoxy resin ED-22 - 100 w.p.
2. Dibutylphthalate - 10 w.p.
Mix all components carefully.

2.3. Insulate connection places with glass-mica tape in 1/2 lap, with overlap 50 to 80 mm (cone length) on the insulation of connected parts. The number of tape layers is sustained according to the drawing. Coat every layer with glue, prepared according to item 2.4.

2.4. Insulate connection places with 1 layer of glass tape in 1/2 lap, coat with cold-hardening epoxy glue. Apply the tape tightly, tightening strongly.

Glue formulation:

1. Epoxy resin ED-22 - 100 w.p.
2. Dibutylphthalate - 10 w.p.

Mix all components carefully.

2.5. Wrap connection places with one layer of Teflon film in 1/2 lap, and from above with one layer of surgical tape in 1/2 lap. Apply the tape with the greatest possible tightening.

2.6. Keep connections tightened during 24 hours.
2.7. Remove surgical tape and Teflon film.

f) IMPREGNATION OF POLYESTER CORD AND COATING OF BANDAGE BINDINGS

The present instructions cover impregnation of polyester cord, which is intended for banding of stator winding end portions, and coating of banding binding. Cord impregnation and coating of banding binding by epoxy composition are performed to increase cord linear dimensions stability and mechanical strength fastening.

1. Materials

1.1. Epoxy resin ED-22.
1.2. Dibutylphthalate
1.3. Isomethyltetrahydroptale anhydride.
1.4. Triethanolamin.
1.5. Technical acetone.
1.6. Polyethylenepolyamin.

2. Preparation to work

2.1. Preparation of composition for cord impregnation:

Epoxy resin ED-22 - 100 w.p.
Dibutylphthalate - 20 w.p.
Isomethyltetrahydroptale anhydride - 60 w.p.
Triethanolamin - 2 w.p.
Acetone - 800 w.p.
Components should be brought in turn, as enumerated above. After every component bringing in, carefully mix the composition with a wooden spade until complete homogeneity.

2.2. Composition should be stored in a flask with a tightly closed cover, not longer than 15 days at the temperature not higher than 25 °C.

2.3. Preparation of composition for coating of banding bindings.

Weigh:

- Epoxy resin ED-22 - 100 w.p.
- Dibutilphtalate - 20 w.p.
- Acetone - 20 w.p.
- Polyethylenepolyamin - 10 w.p.

Components should be brought in turn, as enumerated above. After every component bringing in, carefully mix the composition with a blade until complete homogeneity.

2.4. Composition using time is not more than 30 min.

3. Cord impregnation and coating of bindings

3.1. Put the cord in coils into a flask with the composition for 10 minutes. Then dry it in hanged up condition during one or two hours, turning the coils during the first minutes of drying to prevent varnish flowing down in one direction. Rewind impregnated cord on mandrel. During storage and impregnation the flask should be closed tightly with a cover.

3.2. Store the impregnated cord not longer than five days at the temperature of +25 °C.

3.3. After banding the stator winding with impregnated cord, banding bindings should be coated from all sides with the composition prepared according to item 2.3.

3.4. Composition hardening time is 24 hours at the temperature range from 15 to 30 °C.

4. Safety engineering

4.1. All works should be performed with inflow-exhaust ventilation.

4.2. The works should be performed in working clothes, the hands should be protected with gloves, after work they should be washed with warm water and soap.

4.3. Taking food while working is forbidden.

4.4. When performing the works, smoking, open flame, electric welding, heating appliances working are forbidden.

g) PREPARATION OF COLD HARDENING GLUE-COMPOUND D-8, D-9

The present instructions determine the formulation of epoxy glue-compound with cold hardening, its preparation and gluing together.

1. Materials

1.1. Epoxy resin ED-22.
1.2. Dibutilphtalate.
1.3. Polyethylenepolyamin.
1.4. Technical acetone.
1.5. Powdered quartz.

2. Glue formulation

Glue is prepared by components mixing directly before using according to one of formulations given below:
3. Description of technological process

3.1. Weigh the needed amount of epoxy resin in metal or porcelain cup.
3.2. Add designed amount of dibutilphtalate.
3.3. Mix the mixture carefully.
3.4. Directly before using add hardener - polyethylenepolyamin.
3.5. Mix compound carefully until the homogeneity.
3.6. After adding hardener glue-compound is suitable for use during 30 to 40 min.
3.7. Degrease glued surfaces with acetone.
3.8. Keep glued surfaces in air for 15 min.
3.9. Apply thin layer of epoxy glue-compound on glued surfaces with a brush or palette knife.
3.10. Glue the surfaces together and press them.
3.11. Take away the rest of glue with a palette knife, if needed.
3.12. Perform glue hardening at an ambient temperature during 24 hours or at the temperature of 80 °C during 3 hours.

4. Safety engineering requirements

4.1. When performing all works according to the present technological instructions, keep the safety engineering requirements on working with chemical reagents, including epoxy resins.

h) MANUAL ELECTRIC-ARC WELDING OF COPPER BUSBARS WITH GRAPHITE ELECTRODE

The present instructions are given for manual electric arc welding of copper buses with graphite electrode.

1. Materials

1.1. Copper bars
1.2. Emery cloth

2. Equipment and tools

2.1. Welding rectifier.
2.2. Electric holder.
2.3. Welding table.
2.4. Welding shield.
2.5. Graphite plates.
2.6. Graphite liners 25 to 30 mm thickness
2.7. Graphite electrodes, dia. 10 to 20 mm.
2.8. Gas burner.
2.9. Metal brush, wire diameter 0.2 to 0.25 mm.
2.10. Fitter’s hammer.
2.11. File.
2.13. Tarpaulin gauntlets.

3. Preparation of buses and additive material for welding

3.1. Straighten the buses and remove burrs before welding.
3.2. Scrape buses ends for welding on a length of 25 to 30 mm with steel brush until metal glitter appears. Do chamfer 45°÷50° on welded busbars.
3.3. Scrape additive bars with emery cloth.
3.4. Install welded buses on graphite liner (clearance between buses is admitted to be not more than 1 mm), and graphite plates on both sides of seams.

4. Busbars welding

4.1. Heat busbars joint with gas flame up to crimson glitter.
4.2. Arrange an additive bar along a seam axis with the slope of 35 to 40 °C to the seam plane.
4.3. Perform arc excitation and extinction on coal plates, which are simultaneously an obstacle for seam melted metal spreading (plate thickness should be equal to the busbar thickness).
4.4. Melt the bar end under welding arc. Perform welding in one passage. Keep current value equal to 350 to 450 A.
4.5. Weld up a crater during welding, not stopping the arc, to avoid cracks appearing in the seam end.

5. Quality control

5.1. Perform visual inspection of busbars welded joints.
5.2. The following is not admitted:
- weakening of weld seam cross section (cross-section should not be less than welded busbars thickness);
- presence of cracks;
- poor penetration;
- rolls wider than 1.3 to 1.5 of seam thickness;
- chain of pores with diameter more than 1 mm on the length more than 20 mm.
5.3. In case of detection of defective places, they should be cut out and welded again.

6. Safety engineering requirements

6.1. When performing welding of copper busbars, keep the rules of safety engineering specified in the instructions for electric welders.
6.2. During heating of busbars with gas flame, protective goggles should be used.
6.3. When welding, the worker should wear tarpaulin gauntlets and welding shield.

Erection forms

1. Installation of the rotor and stator
2. Clearances in the upper guide bearing
3. Clearances in the lower guide bearing

Appendix 7
Naglu HPS        Hydrounit No
Installation of the rotor and stator

Magnetic axis position

| Pole No | Place of measurement | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---------|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| A       |                      |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Tolerance: $\Delta L = \frac{B_{\text{mean}} - C_{\text{mean}}}{2} \leq 3 \text{ mm}$

Air gap

| Pole No | dimension | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---------|-----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| A_{top} |           |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| A_{bottom}|          |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| $\delta$ |           |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

$\delta$ – Mean value under all the poles

Tolerance: Deviation of the mean arithmetic value under a pole from the mean arithmetic value under all the poles should be in the range ±5%

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<th>Last name</th>
<th>Signature</th>
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Clearances in the upper guide bearing

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Representatives of Last name Signature Date
Mounting organization
Plant-manufacturer
Customer
Clearances in the lower guide bearing

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Representatives of
Mounting organization
Plant-manufacturer
Customer

Last name | Signature | Date
---|---|---

1EP.261.012TDEM
### List of devices for erection 0EP.430.015ED

**Appendix № 8**

### List of auxiliary materials for erection 1EP.261.012LEM

**Appendix № 9**

### Coli List 1EP.261.012Д1 in Russian  
1EP.261.012Д1 – in English

**Appendix №10**

### Drawings for erection and maintenance

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<td>Stator transportation</td>
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<td>Installation of air-baffles</td>
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<td>Installation of upper bracket flooring on stator frame</td>
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<td>Guide bearing pad</td>
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<td>Device to remove rotor rim wedges</td>
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