

Customer:

**Ingeteam**

**INGETEAM**

MULTIPURPOSE VESSEL B618/1 and B618/2  
GENERATOR 6SBV1 450M2-4

**OPERATION AND  
MAINTENACE MANUAL**

Contract No.: 601436		Factory No.: 25398, 25399, 25400 25404, 25405, 25406		Part No.: M41296
Issued by: Technical department	Prepared by: M. Kljaić	Controlled by: I. Triplat B. Tomičić	Approved by: T. Tišljar	

Issue	Change No.	Change description	Date	Name	Signature
A	5.5379	Updated and corrected acc. to delivered generator	31.01.19.	Gruičić	
B	5.5392	Added data for PMG	20.02.19.	Gruičić	

## **PREFACE**

You are kindly directed to follow instructions given in this document which was prepared for your perusal with a view of assisting you during the useful life of the generator.

***CAREFUL HANDLING AND MAINTENANCE OF THE GENERATOR WILL RESULT IN ITS PROLONGED, CORRECT AND RELIABLE OPERATION.***

***THIS INSTRUCTION BOOK CONTAINS SHORT DESCRIPTION OF THE DESIGN, INSTRUCTIONS FOR INSTALLATION AND DISMANTLING OF THE GENERATOR, RECOMMENDATIONS FOR ITS TRANSPORT, STORAGE, SERVICE AND MAINTENANCE.***

Personnel responsible for ensuring proper operation of the generator should regularly supervise the generator behavior during operation and at standstill. It is advisable to record in the generator logbook all events that occurred during generator operation. The following data is supposed to be logged: number of service hours, number of starting and stopping, any irregularity in operation, bearing lubrications intervals, generator general overhaul, bearing replacement, three-phase bridge replacement, varistors replacement, etc.

In case of any irregularity noticed in the operation during the guarantee period of the generator the manufacturer should be notified immediately.

During the guarantee period the supplier cannot accept any responsibility for a damage caused by improper handling, insufficient maintenance, unauthorized design modifications or any other unauthorized action undertaken on the generator without getting prior approval.

For all detailed further information, additional technical data and instructions related to the generator you are free to consult the manufacturer directly. It is a pleasure for manufacturer staff to respond to your request and assist you in solving your problems.

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## 1. SAFETY INSTRUCTIONS



**WARNING:** Only authorized personnel should perform installation, operation and maintenance of this generator.

### During installation:



- *Avoid contact with energized electrical circuits and rotating parts*
- *Ensure that generator shaft is secured from rotation*
- *Avoid long exposure to high noise in operation (use safety head set)*
- *Use special care, and proper protective equipment during lifting, handling and installation*
- *Ensure generator vibrations are within limits defined in ISO 10816-3, IEC 60034-14 for grade A, and after coupling with diesel engine within limits defined in ISO 8528-9*
- *Avoid depositing any objects on generator*
- *Do not use shaft for lifting purpose*
- *Do not use automatic reset, from thermal protection*

### During service:



- *Disconnect power source*
- *Ensure that propped part of generator will not cause rotation*
- *Ensure generator is cooled*
- *Ensure that all live parts are grounded*
- *Use nonconducting tools and equipment during work with electrical parts*
- *Use nonconductive gloves, protective clothes and shoes with insulated soles*
- *Avoid water or a chemical to be spilled to electrical parts*
- *Do not store highly flammable liquids near generator*

### SAFETY SIMBOLS



*Dangerous electrical voltage*



*Installation and maintenance instruction must be followed*



*Danger of lifting*



*Danger from hot parts*



*Hearing protection is required*



*Terminal with ground*

## 2. INTRODUCTION

This manual refers to the delivery of self excited synchronous brushless generator type 6SBV1 450M2-4 according to Outline drawing M41210 D and with compliance to the contract No. 601436 closed between “Ingetaem.” and “KONČAR-GIM”, Zagreb, Croatia.

Generator 6SBV1 450M2-4 is completely developed, designed, manufactured and tested by “KONČAR-GIM”, Zagreb, Croatia.

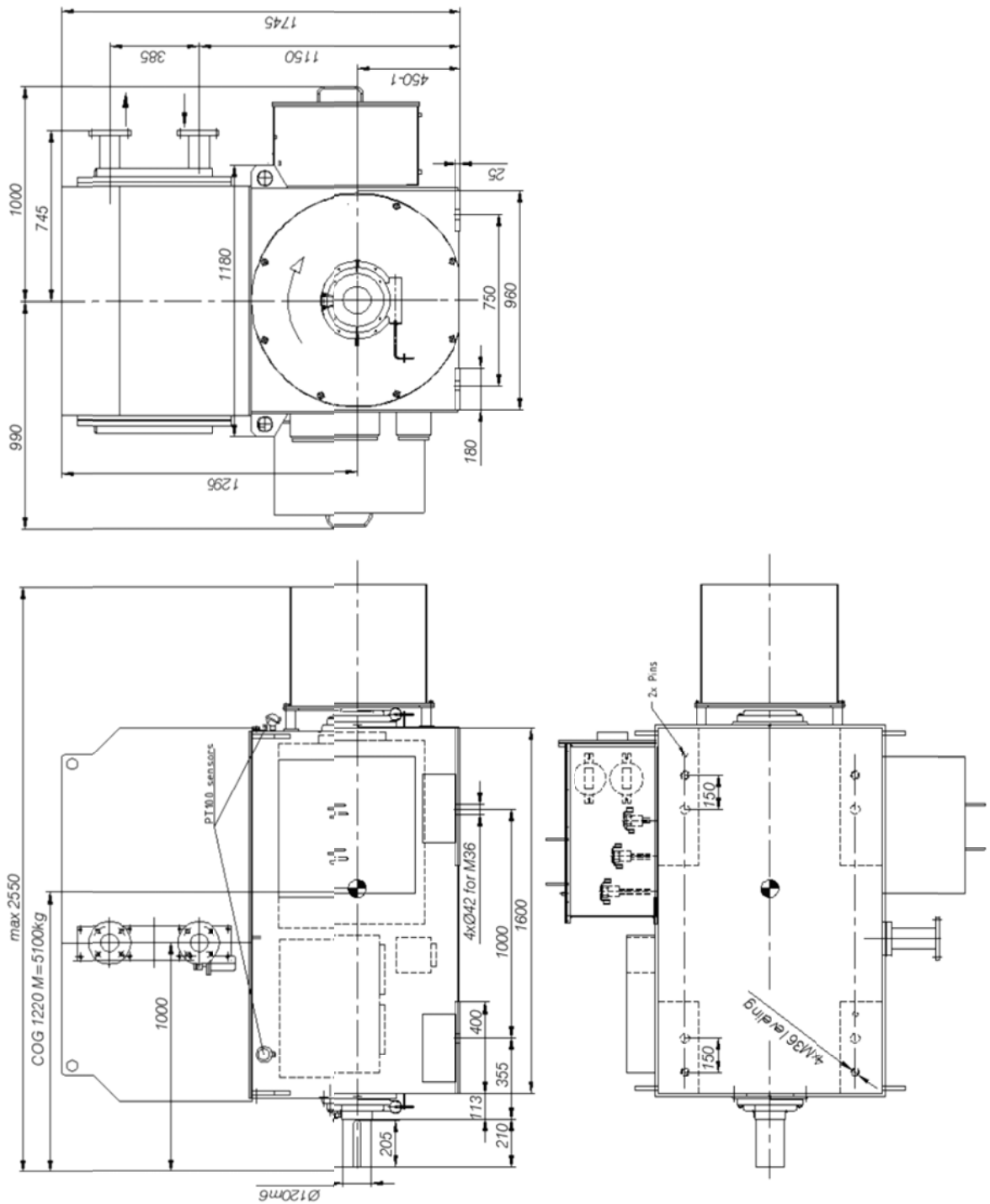
The generator consist of three-phase armature winding on the stator, D.C. excitation, a number of coils wound on individual poles - connected in series on the rotor and damping system on the poles of the rotor. The damping system is realized with the cage winding in the pole extensions.

The generator is equipped with an a.c. (synchronous) exciter with excitation on the stator and three-phase armature on the rotor. The rotating armature supplies excitation for the generator via an integrated rotating three-phase diode rectifier in bridge connection, whereby the need for sliding contacts (slip rings and brushes) is avoided.

The rotating rectifier is provided with the varistors for over voltage protection.

Generator is equipped with PMG for exciter excitation.

**All works on the generator should be done by authorized personnel only!**



*Generator outline drawing*

### 3. TECHNICAL DATA

<b>BASIC TECHNICAL DATA</b>	
Type	6SBV1 450M2-4
Rating	1500 kVA
Voltage	690 V
Current	1255 A
Frequency	60 Hz
Number of phases	3
Number of poles	4
Speed	1800 rpm
Runaway speed	2160 rpm / 2 min
Standards	IEC 60034, PRS
Weight	5100 kg
<b>DESIGN DATA</b>	
Mounting arrangement	IM 1001
Protection by enclosure	IP 54
Cooling arrangement	IC 81W
Direction of rotation	CW viewed from DE
Ambient temperature	+ 45 °C
Class of insulation	Class H
Temperature rise	Class F
DE Bearing	Rolling, grease lubricated
NDE Bearing	Rolling, grease lubricated, insulated
Excitation system	Brushless with PMG
<b>EFFICIENCY AND POWER FACTOR</b>	
Efficiency	0.961
Power factor	0.90
Duty type	S1
Prime mover	Diesel engine
<b>BUILT IN EQUIPMENT</b>	
In windings	6 x RTD Pt100
In bearings	2 x (NDE) + 2 x (DE) RTD Pt100
Space heaters	2 x 300 W, 230 V

Air/Water heat exchanger – 1 pcs	Water inlet temperature 36 °C Rated water flow 9.5 m <sup>3</sup> /h Air quantity 1.84 m <sup>3</sup> /s Flange connections DN65 Cooling media is demineralized water with particales filtration < 500 μm	
<b>BASIC TECHNICAL DATA - THREE-PHASE BRIDGE</b>		
Type	ROTATING RECTIFIER 3 pcs SKKD 260/12 VARISTORS 4 pcs VEA460E40-R3	
<b>BASIC TECHNICAL DATA - SYNCHRONOUS EXCITER</b>		
Type	21SU 450-6	
Rating	11.3 kVA	
Voltage	48 V	
Current	235 A	
Frequency	90 Hz	
Number of phases	3	
Number of poles	6	
Speed	1800 rpm	
Runaway speed	2160 rpm / 5 min	
Standards	IEC	
Class of insulation	Class H	
Temperature rise	Class F	
<b>PMG TYPE SP 423-4</b>		
Power	1.94	kW
Voltage	92	V
Current	12.2	A
<b>COOLING DATA</b>		
Cooler capacity	55	kW
Water inlet temperature	36	°C
Water quantity	9.5	m <sup>3</sup> /h
Cooled air temperature	45	°C
Filtration quality of cooling water	500	μm
Pressure drop on cooling water side	< 0.06	mPa



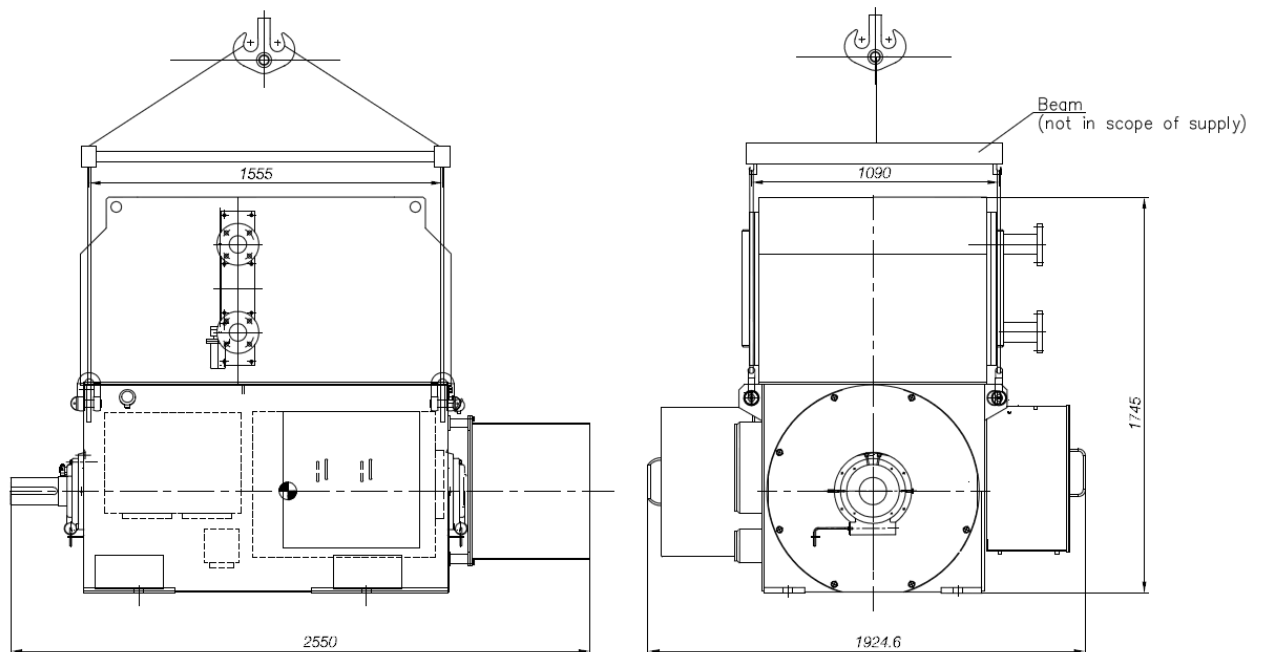
Basic pipe, tube wall & water chamber	Stainless steel
Fin of tube	ALMG3 G 24
Flanges	Acc. to DIN 2633
Coolant medium	Demineralised cooling water

#### 4. TRANSPORT, RECEPTION AND STORAGE



The generator is delivered completed with cooling device, packed on a suitable wooden basis.

During transport the generator should stay in a horizontal position – wooden beams must tightly lay down on flat surfaces of the vehicle. Marks for lifting the load are indicated on the packaging. Generator should be lifted exclusively by means of load hook. To avoid damages of the generator cover, put some distant wooden beams between the ropes.



After the generator is delivered it is recommended to check the state of package. If considerable damages to the generator are expected, the representative of the Forwarding Agent's and Insurance Company must be present at opening of the packing cases.

The generator should be checked up on the delivery in the presence of Forwarding Agent's and Insurance Company. Damages that are thought to have occurred during transport must be reported. In case of serious damage manufacturer must be notified.

The generator must be stored in a dry and clean ambient with normal temperature and humidity. Inappropriate storage conditions may cause serious damage of the generator for which the manufacturer is not responsible!

## 5. PRINCIPLE DESCRIPTION

### 5.1 VOLTAGE CHARACTERISTICS AND OVERLOADS

The generator is designed so, that depending on circumstances and needs, the generator voltage value can be chosen within limits of  $\pm 5\%$  of its declared rated value.

The generators with their excitation/regulation systems are dimensioned so that in respect of regulation dynamic characteristics they satisfy IEC Recommendations 92-5.

### 5.2 SHORT-CIRCUIT CURRENT

Generator can withstand without any damage a single-phase, two-phase or three-phase short-circuit at full voltage on generator terminals (with actuated excitation/regulation system) for 3 s which enables the use of selective protective relay. On removal of a short-circuit the generator recovers quickly its rated voltage.

### 5.3 RADIO INTERFERENCE SUPPRESSION

Synchronous generator 6SBV1 450M2-4 satisfies the N - level of radio interference suppression according to VDE0875.

### 5.4 MECHANICAL DESIGN

The generator is designed for satisfactory operation in the whole range of operation both normal and emergency, without excessive vibrations, noise or other faults. Stator frame, DE and NDE bearing's shields, fan, cooler housing are welded steel. The generator will safely withstand the runaway speed of 2160 rpm in the time of 2 min without mechanical damage.

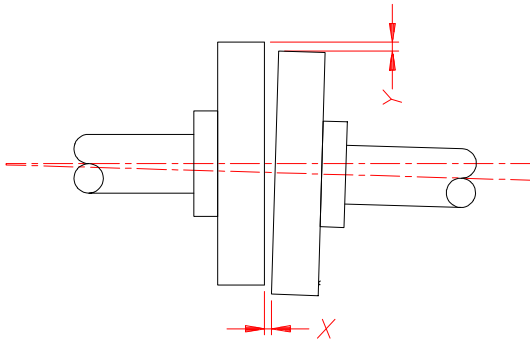
The generator is designed to satisfy the requested degree of protection by enclosure – IP 54. The basic components are described in more detail in the text that follows hereafter. All connections should be tightened acc. to table below if otherwise is not specified.

The possibility of generator resonance with the foundation must be checked. In order to avoid vibration resonance of generator, the natural frequency of the foundation combined with the generator should not exceed  $\pm 20$  [%] of the frequency at maximum operating speed (30 Hz).

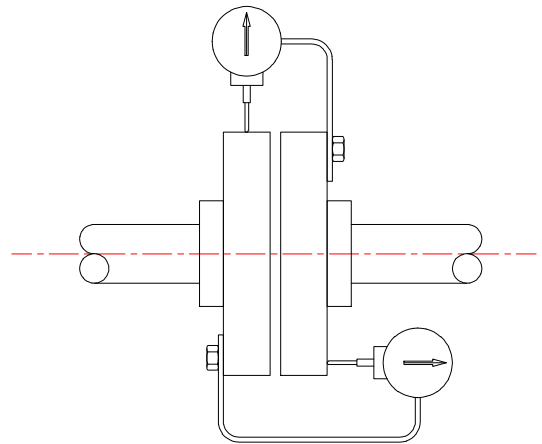
**ALL SCREW FASTENINGS ARE MADE IN METRIC SYSTEM**

Veličina navoja Thread size	Otvor klujuča (mm) Spanner opening	Momenti pritezanja (Nm) Tightening torque (Nm) <i>lubricated with Molikot 0.11/ all surfaces dry 0.2</i>						
		Ugljični čelik - Carbon steel				Austenitni čelik - Austenitic steel		
						A1, A2, A3, A4, A5		
		5.6	8.8	10.9	12.9	50	70	80
M 4	7	0.6/0.8	1.3/1.8	1.8/2.5	2.1/3	0.4/0.6	0.9/1.3	1.2/1.7
M 5	8	1.2/1.7	2.5/3.5	3.5/5	4.2/6	0.8/1.2	1.8/2.5	2.3/3.3
M 6	10	2/2.9	4.3/6.1	6.1/8.6	7.3/10.3	1.4/2	3/4.3	4/5.7
M 8	13	4.9/6.9	10.4/14.8	14.6/20.8	17.6/24.9	3.4/4.9	7.3/10.4	9.8/13.9
M 10	17	10/14	21/30	29.5/42	35.5/50.5	6.9/9.8	14.7/21	19.7/28
M 12	19	17/24	36/51	50/72	60/86	11.8/16.8	25.2/36	33.6/48
M 14	22	27/38	57/82	81/115	97/138	19/27	40.3/57.5	53.8/77
M 16	24	42/59	88/127	124/178	148/214	29/41.5	62/89	82/119
M 18	27	57/82	122/175	171/246	205/295	40/57	86/123	114/164
M 20	30	82/117	173/249	243/350	290/420	56.5/81.5	121/175	162/234
M 22	32	111/159	233/339	328/477	390/570	77/111	164/238	219/318
M 24	36	141/203	300/430	422/610	510/730	98/142	211/305	281/406
M 27	41	210/302	440/640	620/900	750/1090	145/211	311/452	414/600
M 30	46	285/410	600/880	850/1230	1020/1480	198/288	424/615	560/820
M 33	50	387/560	820/1200	1150/1680	1380/2020	269/393	575/840	770/1120
M 36	55	500/720	1060/1540	1490/2170	1790/2600	347/507	740/1090	990/1450
M 39	60	650/940	1370/2020	1930/2830	2320/3400	450/660	970/1420	1290/1890
M 42	65	800/1170	1710/2500	2400/3520	2880/4220	560/820	1200/1760	1600/2350
M 45	70	1010/1480	2140/3150	3010/4430	3610/5310	700/1030	1510/2210	2010/2950
M 48	75	1210/1780	2590/3800	3640/5340	4370/6410	850/1250	1820/2670	2430/3560
M 52	80	1560/2300	3340/4920	4690/6910	5630/8300	1090/1610	2340/3460	3130/4610
M 56	85	1930/2860	4140/6100	5830/8580	6990/10300	1360/2000	2910/4290	3880/5720
M 60	90	2410/3570	5150/7620	7250/10720	8700/12860	1690/2500	3620/5360	4830/7140
M 64	95	2910/4310	6230/9200	8760/12940	10510/15530	2040/3020	4380/6470	5840/8630

Alignment of connection between generator and driving engine should be done acc. to picture below.



Checking the angular and parallelism error



Alignment of shafts using dial gauges

## 5.5 STATOR

The stator frame is a welded structure, built up from steel plates and profiles designed to have adequate strength against vibration resulting from all operating conditions and to provide adequate flow pass through the stator windings and core. The frame is composed of vertical rings, horizontal supporting tubes and outer steel plate shell, joined together by welding. The steel used in the fabrication of stator frame are S355JR according EN 10025 – suitable for welding.

The stator core, placed inside the stator frame, is built up using segments out of cold rolled non-oriented electrical steel sheet according EN 10106, designation M330-50A according EN10027-1. Segments are insulated on both sides with a heat resisting, high quality varnish. During building of the core the partial stacking are pressed at intervals so that compact core is produced. The stator core is fixed to the stator frame and secured against turning by welding.

The stator winding is made up of insulated copper coils that are individually formed, double layer, with full class H insulation ( $\leq 155\text{ }^{\circ}\text{C}$ ). The formed stator coils are inserted in the slots. Isolation system ensured high mechanical and dielectrical strength of winding and resistance to the negative effects of environment. Stator winding insulation is moisture - resistant, and may be used in practically any climate conditions. The applied insulation system ensured high mechanical strength of the winding overhangs, giving them required rigidity. For the temperature monitoring in the stator winding are installed six temperature probes Pt100.

## 5.6 ROTOR

Rotor assembly consists of the shaft, core package with winding, fans, synchronous exciter and three-phase bridge - rotating rectifier with varistors.

Shaft is made of steel S355J2+N acc to EN 10025, with certificate according to EN 10204 3.1.

Rotor package (rotor core) is designed as cylindrical type, and is built up of cold rolled non-oriented electrical steel sheet acc. EN 10106, designation M330-50A according EN10027-1. Segments are insulated on both sides with a heat resisting, high quality varnish.

During building of the core the partial stacking are pressed at intervals so that compact core is produced. The rotor core is fixed by welding and secured against turning by key.

Rotor winding (exciter winding) is made up of cooper coils, isolated with full class H insulation ( $\leq 155\text{ }^{\circ}\text{C}$ ), inserted in the isolated slots. Rotor has a cooper damping winding placed in the slots on perimeter of rotor core.

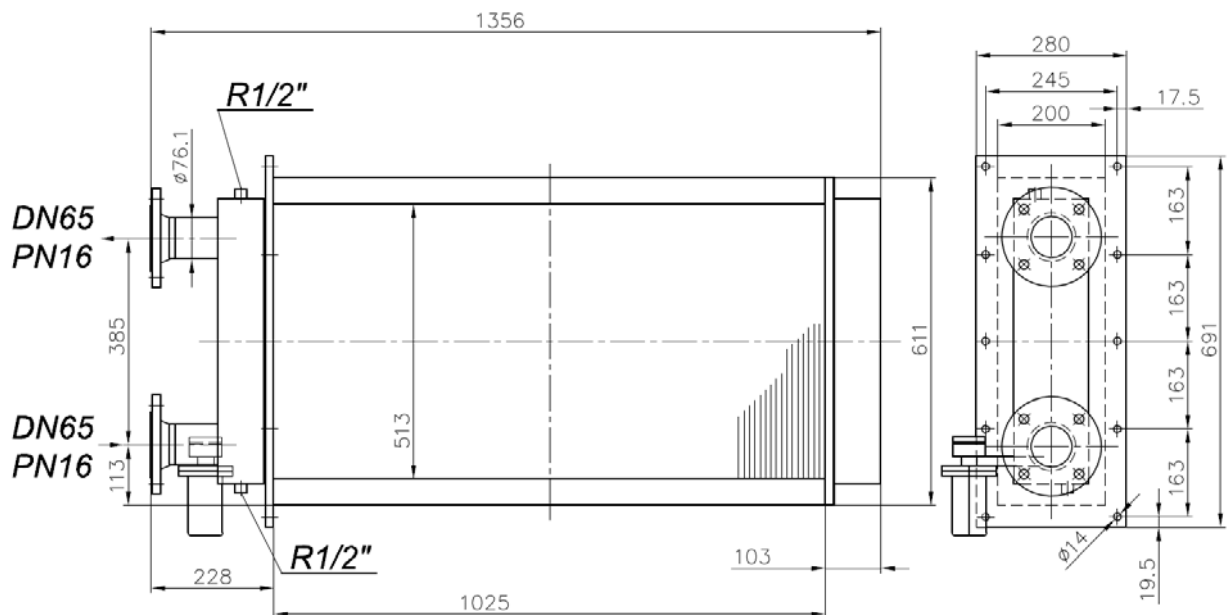
Complete rotor is balanced statically and dynamically in quality  $G = 2.5$  acc. to ISO 1940/1.

## 5.7 COOLING

IC 81W method of cooling according to IEC 60034-6 is performed. Generator is supplied with a "top" side-fitted cooler assembly - air/water heat exchanger.

Cooler assembly consists of welded steel housing and inside of housing is placed one water cooler for stator and rotor cooling.

Inside the housing, the generator is cooled by means of axial fans that lead air through the core with windings and through the heat exchanger where the heat is transferred to cooling water.



*KARAKTERISTIKA HLADNJAKA:  
COOLER CHARACTERISTICS**SNAGA ZA ODVOD PO JEDNOM HLADNJAKU . . . . . 55 kW  
COOLER CAPACITY**TEMPERATURA RASHLADNE VODE . . . . . 36 °C  
WATER INLET TEMPERATURE**KOLIČINA RASHLADNE VODE PO HLADNJAKU . . . . . 9.5 m<sup>3</sup>/h  
WATER QUANTITI PER COOLER**TEMPERATURA OHLADJENOG ZRAKA . . . . . 45 °C  
COOLED AIR TEMPERATURE**KOLIČINA ZRAKA PO HLADNJAKU . . . . . 1.56 m<sup>3</sup>/s  
AIR QUANTITY**ISPITNI PRITISAK . . . . . 0.9 MPa  
PRESSURE TEST**PAD TLAKA ZRAKA . . . . . < 200 Pa  
PRESSURE DROP ON THE AIR SIDE**PAD TLAKA RASHLADNE VODE . . . . . < 0.02 MPa  
PRESSURE DROP ON COOLING WATER SIDE**KVALITETA FILTRACIJE RASHLADNE VODE . . . . . 500 μm  
FILTRATION QUALITY OF COOLING WATER**TRAJANJE ISPITIVANJA . . . . . 30 Min.  
TEST DURATION*

## 5.8 BEARINGS

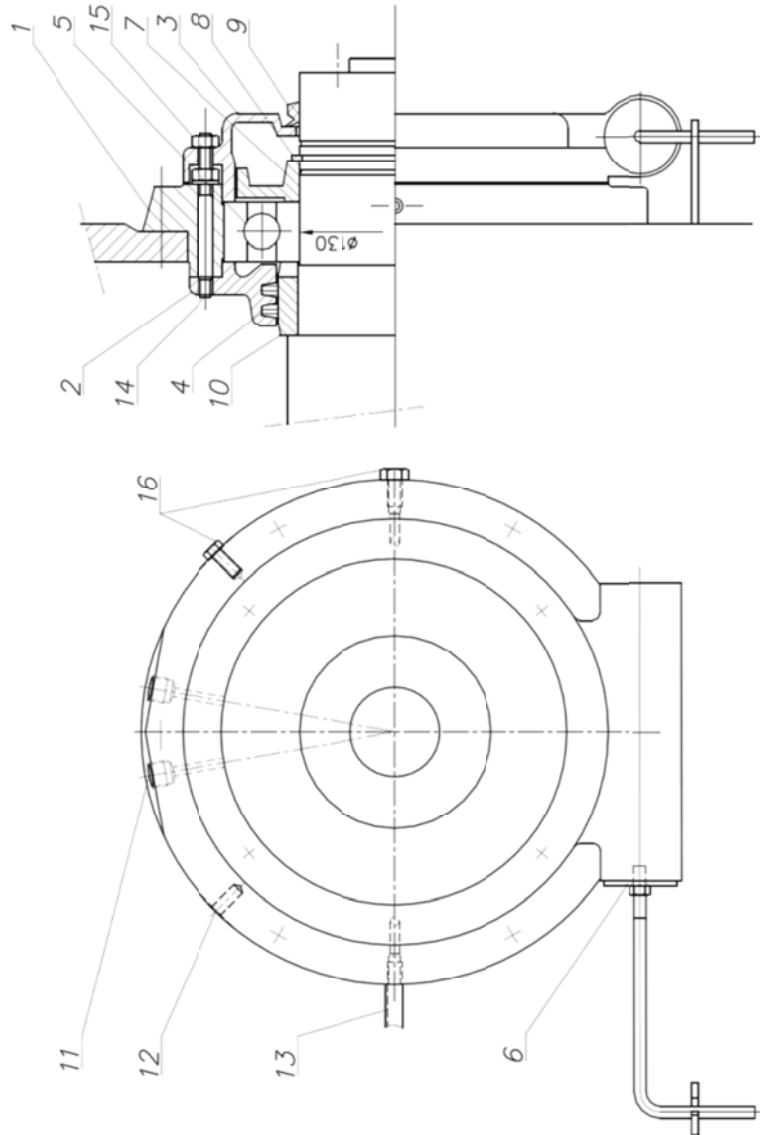
The bearing assembly delivered with the generator is already filled with high-grade grease. When relubricating the bearings, care should be taken to use grease of adequate quality. Grease suitable for lubricating roller bearings should be used. Grease should not contain neither resin nor acid, and should be proper for lubrication within a temperature range from -30 up to 130 °C, the melting point being beyond 160 °C. The use of greases based on Lithium soaps is recommended, as for inst. SHELL ALVANIA 3, MOBIL MOBILUX 1-3, ESSO BRACON 2-3, BP ENERGREASE LS 1-2, VALVOLINE LBI SPECIAL No. 2-3.

Different kinds of grease should not be mixed. Therefore, when lubricating with a new kind of grease for the first time, approximately the triple quantity of lubricant should be used so as to enable a complete extrusion of the previous kind of grease. It is recommended to lubricate while the generator is running. Further lubrications are to be carried out with the same grease. After lubrication, for a while, bearing temperature can increase. After the grease is regulated, the bearing temperatures go down to normal values.

Disregarding of lubrication instructions will, most probably, lead to excessive heating of bearings or diminishing of bearing life.

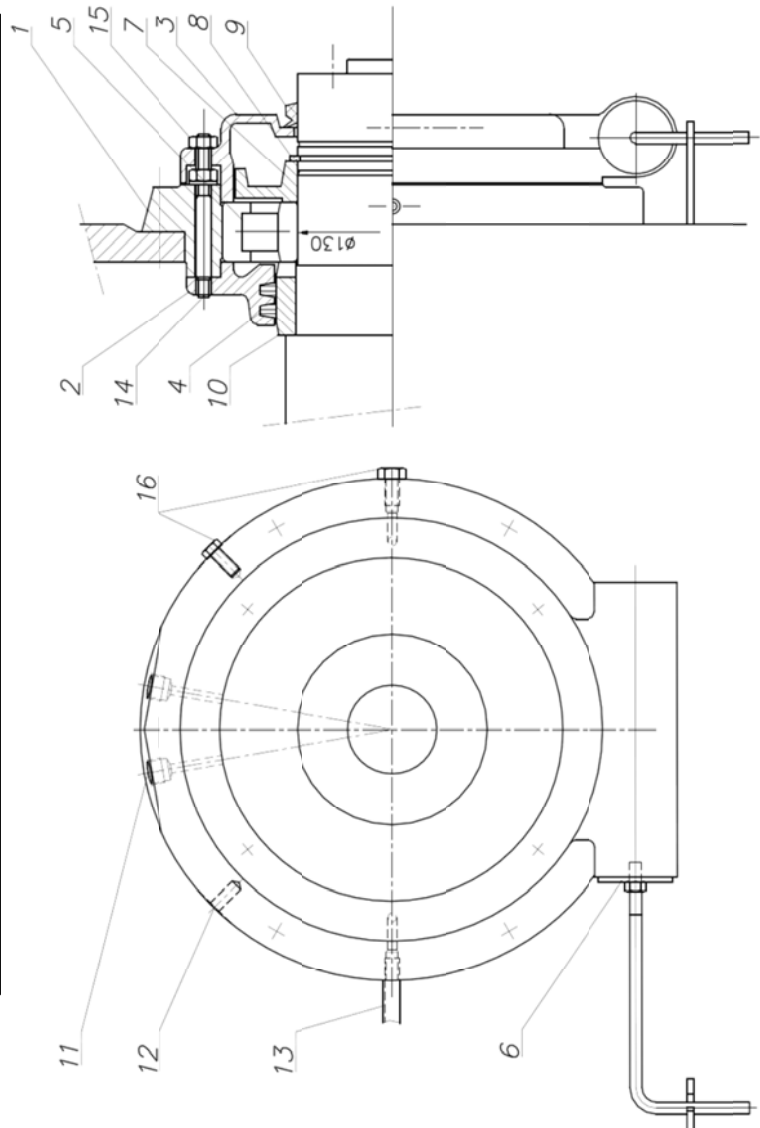
**Driving end bearing:**

Poz. Item.	Kom. Pcs.	Naziv Name
1	1	Bearing housing DE
2	1	Bearing inner cover
3	1	Bearing outer cover IP55
4	2	Felt gasket 8X13
5	1	Bearing SKF-6226 C31
6	1	Grease collector
7	1	Grease spreader
8	1	Retaining ring
9	1	Rubber V-ring seal
10	1	Distance ring
11	2	Pt-100 R3/8 connection
12	2	SPM nipple connection M8x20
13	2	Grease nipple connection M10
14	4	Threaded bolt M10
15	8	Nut M10
16	2	Plug screw



**Nondriving end insulated bearing:**

Poz. Item.	Kom. Pcs.	Naziv Name
1	1	Bearing housing NDE
2	1	Bearing inner cover
3	1	Bearing outer cover IP55
4	2	Felt gasket 8X13
5	1	Bearing SKF - NU 226 ECM/C3VL0241 Insulated outer ring
6	1	Grease collector
7	1	Grease spreader
8	1	Retaining ring
9	1	Rubber V-ring seal
10	1	Distance ring
11	2	Pt-100 R3/8 connection
12	2	SPM nipple connection M8x20
13	2	Grease nipple connection M10
14	4	Threaded bolt M10
15	8	Nut M10
16	2	Plug screw

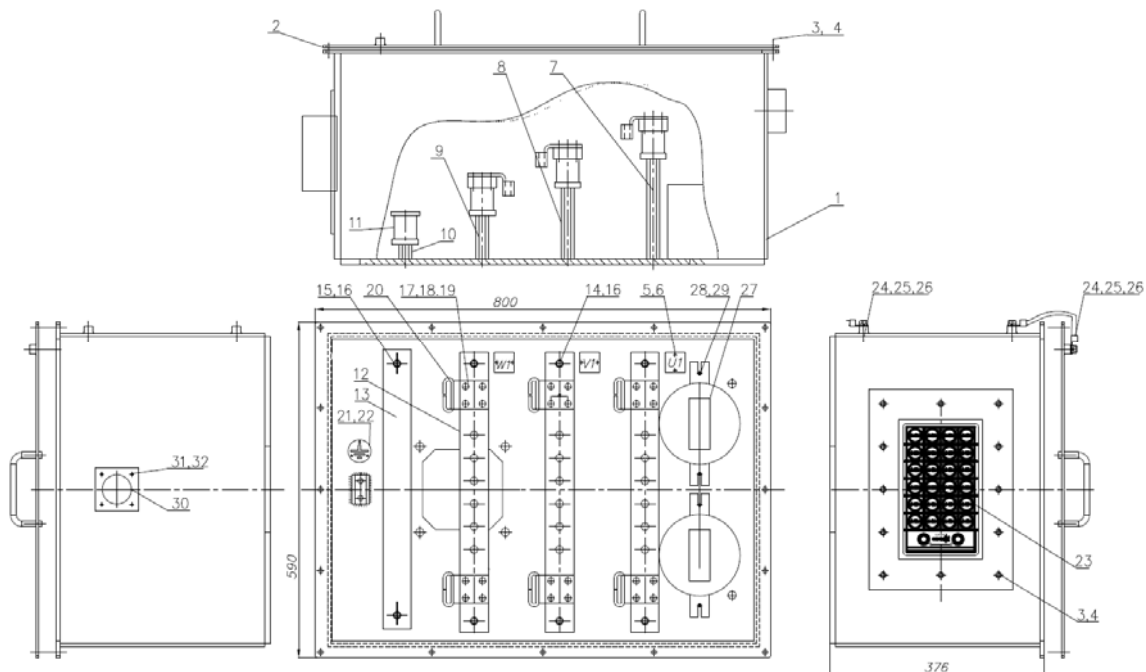




## 5.9 STATOR TERMINAL BOXES

Three-phase armature winding (i.e. the stator power winding) is connected in two separate terminal boxes.

In the main terminal box are placed winding beginnings and connected to appropriate terminals marked by designations U1, V1, W1. Cable entry is from side, using 24 Roxtec RM 30 for cables from 10 – 25 mm.



In the zero point terminal box are placed winding ends – U2, V2, W3 and connected to the terminal marked by designation N. The box is from down side covered with nonmagnetic steel plate. In the box are places to build up tree peaces of current transformers appropriate type.

In auxiliary terminal box is connected all built in equipment according to Control device diagram. Cable entries to this equipment are performed by cable glands on the auxiliary terminal box.

The main terminal box and the zero point terminal boxes are placed at opposite side of the housing in compliance with the purchaser. The auxiliary terminal box is placed at the right side near DE, in front of the main terminal box.

Earth terminals are provided inside the terminal box.

## 5.10 DIRECTION OF ROTATION

In compliance with the VDE 0530 alphabetic sequence of connections U1, V1, W1 in terminals corresponds to the phase sequence for the clockwise direction of rotation. If reverse (counter clockwise, or colloquial: anti-clockwise) direction of rotation is required, one pair of system cables shall be interchanged between two terminals to which they have to be connected in case of the clockwise direction of rotation.

At the DE-side above the generator shaft there is a plate that indicates the particular direction of rotation with phase sequence.

If counter clockwise (i.e. anti-clockwise), according to IEC 60034-8, direction of rotation is required, in a unit connected this way, the indication at the marking plate is as follows:

For parallel operation with existing mains, before the generator is switched on, the obligation of checking the respective phase sequence does remain.

## 5.11 EXCITATION SYSTEM

The excitation system consists basically of exciter with rotating diode rectifier. A.C. (synchronous) exciter and diode rectifier are placed on the alternator shaft and connected with field winding of the rotor.

The excitation/regulation system include: an electronic unit - especially voltage regulator (AVR) and self-exciter units (synchronous exciter, and rotating rectifier).

Principle of operation is that DC powers the exciter stator, setting up a magnetic field which generates AC in the exciter armatures it rotates. The alternating current is rectified by rotating diodes, providing DC power to the main field rotor. The resulting magnetic flux generates AC in the main stator windings to provide power output and power to the AVR, which regulates power to exciter stator.

The rotating rectifier is made of silicon diodes modules properly sized and protected by varistors connected in parallel on the rotor windings.

### **OPERATION OF GENERATOR WITHOUT AVR IS NOT PERMITTED**

## 5.12 GENERATOR EQUIPMENT

### ANTI-CONDENSATION HEATERS

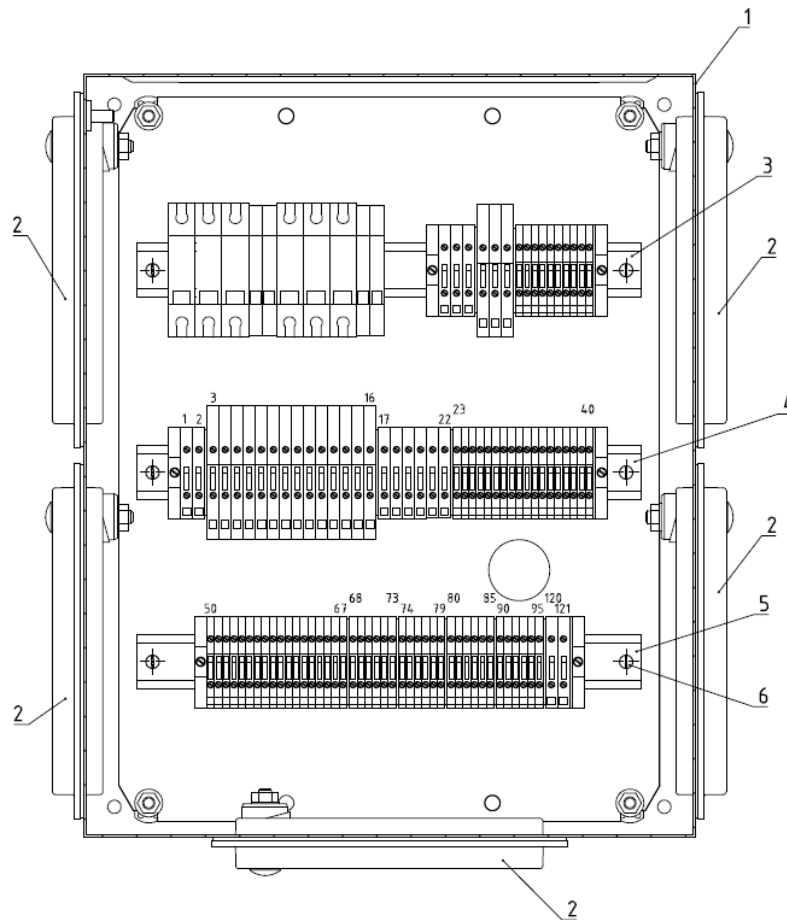
Generator has built in anti-condensation heaters 2 x 300W, 230V. They must be switched on while the machine is at standstill.

### ELECTRICAL AND THERMAL PROTECTION

Resistance thermometers RTD Pt-100 (100  $\Omega$  at 0 °C) are built in the stator winding, and in the bearing assemblies for monitoring the temperature and for their protection against excessive temperature rise.

To check temperature rise of stator winding 3 pcs resistance thermometers RTD Pt-100 are embedded in the stator winding, two per phase (+ 3 pcs spears – one per phase).

Generator is equipped with 4 pcs resistance thermometer RTD Pt-100 for monitoring thrust and guide parts of bearings.



***Thermal protection of stator winding shall be adjusted to 155 °C for alarm and 180 °C for tripping out of operation.***

***Thermal protection of bearings shall be adjusted to 80 °C for alarm and 100°C for tripping out of operation.***

A characteristic of the embedded resistance thermometers is given in TABLE I and is in compliance with DIN 43760.

To check electrical circuit of the resistance thermometer a Whetstone bridge may be used (permissible measuring current of 3 mA). Measurements are made at ambient temperature.

t (°C)	0	10	20	30	40
R (Ω)	100.00	103.90	107.80	111.68	115.34
t (°C)	50	60	70	80	90
R (Ω)	119.40	123.24	127.08	130.90	134.70
t (°C)	100	110	120	130	140
R (Ω)	138.50	142.29	146.07	149.03	153.59

TABLE I – Characteristics of Pt 100 resistance thermometers

## 6. INSTALLATION



**INSTALLATION OF THE GENERATOR MAY BE ENTRUSTED ONLY TO THE PERSONS QUALIFIED FOR THIS KIND OF WORK EQUIPPED WITH ADEQUATE TOOLS AND APPLIANCES.**

The generator is supplied with final machined surfaces at the shaft ends

For reliable and smooth operation following requirements are to be fulfilled:

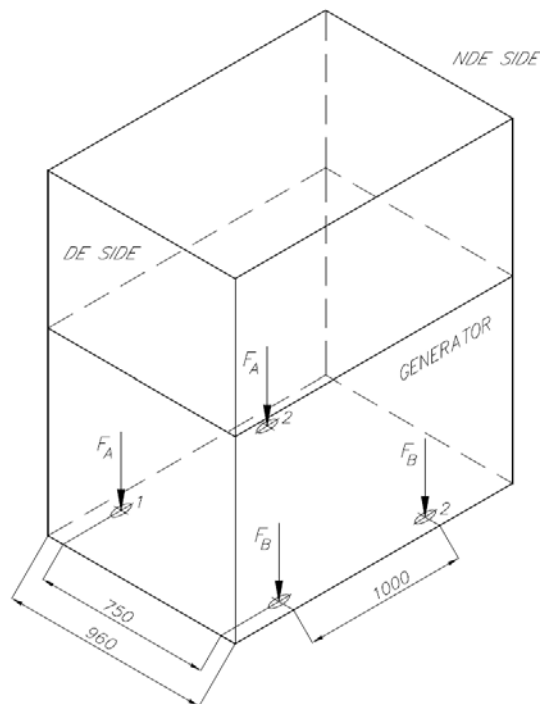
- Alignment of generator and diesel motor
- Cooling air free circulation
- Cable connection
- Earth connection
- Water connection
- (Automatic voltage regulator (AVR) unit correctly installed and connected to generator)

The sequence of the generator installation is to be as follows:

- 1.) Check the state of installation base plate seating faces, clean them if necessary and let the generator down to the seating faces.
- 2.) Adjust the position of the generator stator frame casing against the rotor and perform shafts alignment.
- 3.) Fix the generator to the seating faces
- 4.) Perform cable connection (main cables, anti-condensation heaters power supply cables and monitoring equipment cables at corresponding terminals) and earth connection to earth terminal.
- 5.) Perform bearing lubrication
- 6.) Perform water connection for cooling assembly
- 7.) Perform installation of AVR and connect excitation and regulation cables between AVR and generator

## 6.1 FOUNDATION LOADS

Generator will be direct fixed to the ships engine room floor structure by means of bolts. Foundation loads for all work case are presented below.



### FORCES DUE TO MASS

1,2	STATIC LOAD (N)
$F_A$	+11800
$F_B$	+11800

### FORCES DUE TO NOMINAL MOMENT (additional to forces due to mass)

1,2	NORMAL TORQUE (N)
$F_A$	$\pm 5300$
$F_B$	$\mp 5300$

### FORCES DUE TO SHORT CIRCUIT (additional to forces due to mass)

1,2	SHORT CIRCUIT (N)
$F_A$	$\pm 75300$
$F_B$	$\mp 75300$

## 6.2 MACHINE ROOM AIR EXCHANGE

The reliable function of generator depends on, among all other requirements, correct circulation of cooling air. It is essential that air inlet and outlet openings remain free during the operation. Besides, machine room should be adequately ventilated in aim to maintain ambient air temperature below 45 °C.

The generator is designed so, that depending on circumstances and needs, the generator voltage value can be chosen within limits of  $\pm 5\%$  of its declared rated value.

The generators with their excitation/regulation systems are dimensioned so that in respect of regulation dynamic characteristics they satisfy IEC Recommendations 92-5:

### 6.3 GENERATOR CABLE CONNECTION

Power cables should be connected to bus bars by means of cable shoes, screws with nuts and safety washers. Bus bars are marked U1, V1, W1 in the main terminal box, and N in the star point terminal box.

Cables for excitation, regulation, RTD Pt-100 measurement, and anti-condensation heaters (all built in equipment) are to be connected to corresponding terminals.

Proper wiring between the generator and AVR should be done.

### 6.4 EARTH CONNECTION

Earth connection must be done properly on visible connections on the outer side of stator frame.

## 7. PUTTING INTO OPERATION



### 7.1 DRYING - INCREASING INSUFFICIENT DIELECTRIC STRENGTH OF INSULATION

If the generator has been stored in an insufficiently dry ambient, or the climate was especially humid, dielectric strength of winding insulation must be checked. If the measured value is lower than 1 MΩ the generator windings should be dried.

When it is obvious that the dielectric strength rate of winding insulation does not satisfy requirement, drying must be carried out. It can be done by application of anti-condensation heaters.

### 7.2 GENERATOR FIRST RUNNING

After coupling and electric wiring have been done, and before the generator starts to run, the following should be checked:

- The similarity of the generator and prime mover sense of rotation
- The state of all screw fastenings (especially base screws)
- Whether AVR has been correctly installed and excitation and regulation cables accurately connected
- Whether all other wiring has been performed correctly, according to “Control device diagram” (see enclosed drawing - Fig.6)
- Whether all contact screws are tightened and secured against slackening
- Earth connection
- Whether all openings have been covered
- Whether free cooling air circulation has been assured
- Whether the bearings lubrication has been performed correctly
- Whether the bearings are filled with proper quantity and quality of greese
- Whether the water connections for cooling assembly has been performed correctly without any leakage
- Whether all measures of precaution have been taken

**BEFORE CONNECTION, COMPARE THE GENERATOR PHASE SEQUENCE AGAINST THE MAINS PHASE SEQUENCE.**

### 7.3 FIRST RUNNING CHECKING AND MONITORING

After starting of driving engine it is necessary to check level of vibrations (evaluate vibrations acc. to picture 7.1. or ISO 8528-9 ) and to monitor bearing temperature rise. Bearing temperature should be monitored until stagnation of temperatures is achieved.

If everything is in order, generator can be excited.

After checking the phase sequence and voltage against net, and if this is in order, generator can be synchronized.

The generator is supplied with statically and dynamically balanced rotor, which ensures that generator vibrations are within permissible tolerances.

If the causes of irregularities could not be removed or remedied and the circumstances indicate that the generator is at fault, supplier should be notified without any delay.

ISO 10816-3	Medium-sized machines groups 2 and 4		Large machines groups 1 and 3	
Velocity mm/s (RMS)	Rated power			
	15 kW - 300 kW		group 1: 300 kW - 50 MW, group 3: > 50 MW	
11	<b>DAMAGE OCCURS</b>			
7.1	<b>RESTRICTED OPERATION</b>			
4.5	<b>UNRESTRICTED OPERATION</b>			
3.5	<b>UNRESTRICTED OPERATION</b>			
2.8	<b>UNRESTRICTED OPERATION</b>			
2.3	<b>UNRESTRICTED OPERATION</b>			
1.4	<b>UNRESTRICTED OPERATION</b>			
0.7	<b>NEWLY COMMISSIONED MACHINERY</b>			
0	<b>NEWLY COMMISSIONED MACHINERY</b>			
Foundation	Rigid	Flexible	Rigid	Flexible

Fig. 7.1. Excerpt from the ISO 10816-3

In the case of excessive vibrations, it is necessary to stop whole aggregate immediately.

**The causes of excessive vibration may be as follows:**

- Improper alignment of shaft line,
- Improper fixing to foundation,
- Generator damaged during transport.

After coupling with diesel engine vibrations should be evaluated acc. to ISO 8528-9. Vibrations should be measured on bearing housing as shown on picture below (defined in IEC 60034-14).

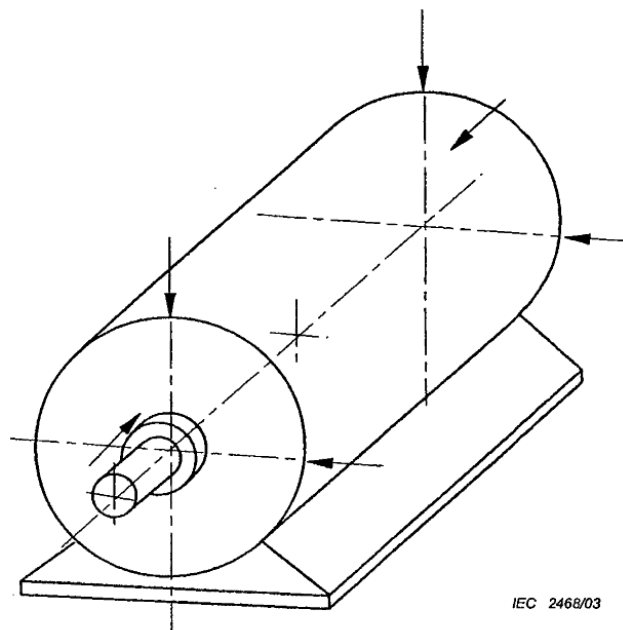


Figure 3 – Measurement positions for those ends of machines where measurements according to figure 2 are not possible without disassembly of parts

Fig. 7.2. Excerpt from the IEC 60034-14

## 8. MAINTENANCE AND CHECKING



The generator proper handling and maintenance will result in its prolonged, correct and reliable operation. Personnel responsible for ensuring machine service should regularly supervise the generator behavior during operation and carried out all necessary checking and maintenance.

Basically, the generator service, checking and maintenance consist of following activities that should be performed while the generator is in operation and / or standstill:

- Overall monitoring of generator operation
- Bearing pads replacement (if necessarily)
- Replacement of eventually faulty Three-Phase Bridge and Varistors
- Any other repairing that should be occasionally done
- Depending on generator service hours and its behavior during service responsible staff should plain and perform general overhaul. Some of mentioned monitoring, checking and maintenance activities are highlighted in further paragraphs.



## 8.1 BEARINGS MAINTENANCE

It is important to lubricate the bearings regularly. All grease-lubricated bearings have grease nipples fitted, which permits regreasing during generator run or at standstill condition. **The regreasing shall be performed according to instructions given on the plate located along the side grease nipple. It is recommended to shorten regreasing interval with smaller amounts of grease.** After regreasing it may happen that bearing temperature increases. However, temperature will fall down to its normal operation temperature once the grease has been distributed equally inside the bearing.

## 8.2 GENERATOR GENERAL OVERHAUL - DISASSEMBLING PROCEDURE

Depending on operating conditions it is necessary to perform generator general overhaul every 2 or 3 years.

First of the entire generator interior assemblies must be inspected. Therefore if the general overhaul is to be performed generator should be dismantled and the rotor removed from the stator. Enclosed drawing "Generator cross section" will help one while dismantle and / or overhaul the generator.

Generator dismantling from the operating site, disassembling and rotor removal procedure is described in further paragraphs and includes general overhaul recommendation as well.

Such action as generator disassembling and general overhaul should be appropriate planned to enable clean disassembly area, qualified person, lifting and support elements and adequate devices and tools at disposal.

### 8.2.1 GENERATOR DISASSEMBLING AND ROTOR REMOVAL

**ROTOR REMOVING IS A COMPLEX OPERATION THAT COULD BE PERFORMED ONLY BY A QUALIFIED TEAM EQUIPEPED WITH ADEQUATE TOOLS AND APPLIANCES.**

To obtain correct permissible disassembling and avoid possible failure the next disassembling procedure should be followed (the generator is in horizontal position!):

- Disconnect and remove all cables
- Disconnect water connections
- Disconnect all devices connected on generator
- Disconnect in auxiliary terminal box RTD'S Pt100 in bearing, exciter, (-connection in the small box on NDE shield)
- It is recommended to remove the cooling assembly
- For disassembling NDE bearing following SKF instructions
- For disassembling DE bearing following SKF instructions
- Remove the shield screws and disconnect NDE bearing shield
- Disassembling the seal assembly on NDE bearing shield
- Remove the shield screws and disconnect DE bearing shield
- Disassembling the seal assembly on DE bearing shield
- Now is possible to pull out the rotor assembly (including exciter's rotor, diode rectifier and fans).

- Pull out the rotor assembly in direction from DE side to NDE side of generator and put it down softly at prepared place

### 8.2.2 GENERAL OVERHAUL

General overhaul consists of through examination of all vital components of the generator.

In aim to perform any of inspection or / and repairing activity if necessary clean the generator interior. It can be carried out with vacuumcleaner and using soft rags. Eventual greasiness may be removed with a soft rag soaked in appropriate cleaning liquid.

After cleaning, visually inspection of all assemblies and repairing of eventual damages could be done.

Special attention should be paid to the following:

- Inspection of stator winding (endwinding fastenings and connections between stator winding and busbars of main terminals are to be thoroughly examined)
- Inspection of all cable connections
- Inspection of rotor windings and excitation cable connection
- Inspection of brazed joints of the Damping Cage
- Inspection of fans welded joints
- Bearing cleaning and visually checking; according RENK'S instructions
- Checking of screw tightening
- Inspection of generator interior
- Inspection of foundation
- After overhaul has been done the generator should be reassembled in reverse order from just described.

### 8.3 BEARING REPLACEMENT

DE and NDE bearing assembly or parts of bearings assembly may be replaced according to the bearing manufacturer (SKF) recommendations.

### 8.4 EXCHANGE OF THREE-PHASE BRIDGE AND VDR VARISTORS

If the faulty VDR Varistor or Three-phase Bridge has been found, replacement should be done as follows

- Remove the service cover
- Dismantle faulty Varistor or Three-phase Bridge
- Replace faulty part with the good one
- Further assembling is to be done in reverse order.

### 8.5 MAGNETIZING OF PMG

In case that permanent magnets should be remagnetized following procedure must be followed:

- Disconnect ends of two neighbour poles
- Magnetize pole with DC current of 150 – 300 A, with 3 – 5 electric shocks in duration of 1 s with pauses of 10 s.
- Connect ends of two neighbour poles
- Put the generator to nominal speed and stabilize magnets by shorting of stator winding in duration of 2-3 s.

## 9. ELECTRICAL FAULTS ON THE GENERATOR



In case that the generator losses voltage on its terminals, even if running at rated speed, causes may be:

- Interruption of the cable connection
  - o check cables in excitation circuit
- Rectifier break-down
  - o replace faulty three-phase bridge with the good one (according to procedure described in 8.4)

### **WARNING:**

**THESE OPERATION IS DANGEROUS AND THEREFORE PROHIBITED TO PERFORM ANY CHECKING OR REPAIRING ACTIVITY WHILE THE GENERATOR RUNS OR IT IS CONNECTED TO THE GRID.**

## 10. REPLACEMENT OF GENERATOR PARTS

The generator parts which should be replaced, can be ordered from the manufacturer KONČAR – GIM, Zagreb. In order should state the name of the part, item, as also type, serial number, year of production of the generator for which that particular part is required. Type, serial number and also the year of production are written on the name plate.

### ***Example for order of spare parts:***

- ***56SBV1 450M2-4*** (generator type)
- ***2019*** (year of manufacture)
- ***25398*** (serial number)
- ***Bearing DE shield***: (name and position of the part)

- 1 Housing
- 2 DE shield
- 3 NDE shield
- 4 Shield screws
- 5 Key
- 6 Shaft
- 7 Stator core
- 8 Rotor core
- 9 Stator winding
- 10 Rotor winding
- 11 Fan
- 12 DE bearing
- 13 NDE bearing
- 14 Main terminal box
- 15 Rotor earthing
- 16 Cooler housing
- 17 Cooler
- 18 Cooler housing bolts
- 19 Cooler bolts
- 20 SPM
- 21 PT 100 in bearing
- 22 Grease nut
- 23 Neutral terminal box
- 24 Auxiliary terminal box for sensors
- 25 Auxiliary terminal box for heaters
- 26 Heaters
- 27 Cover
- 28 Cover bolts
- 29 PT 100 in hot air
- 30 PT 100 in cold air
- 31 Exciter stator
- 32 Exciter rotor
- 33 PMG stator
- 34 PMG rotor
- 35 Electrifier
- 36 NDE shield adapter
- 37 PMG housing
- 38 PMG housing cover
- 39 NDE shield adapter bolts
- 40 PMG housing bolts
- 41 PMG housing cover bolts
- 42 Rotor blockade
- 43 Rotor blockade bolt

