**NAVAL HEADQUARTERS**

**DIRECTORATE OF ELECTRICAL ENGINEERING**

# *REQUIREMENT FOR DC AND AC HELO STARTING AND SERVICING SYSTEM FOR NAVAL SHIPS*

***EED-Q-267 (R4)***

**Feb 15**

**ISSUING AUTHORITY**

**DIRECTORATE OF ELECTRICAL ENGINEERING**

**(NAVAL HEADQUARTERS)**

## RECORD OF AMENDMENTS

| SL NO | AMENDMENT | AUTHORITY | DATE | SIGNATURE |
|---|---|---|---|---|
| 1. | Amendment-I | EE/03/5181 | 06 Dec 04 | |
| 2. | Amendment-II | EE/03/5181 | Aug 06 | |
| 3. | Amendment-III | EE/03/5181 | 23 Dec 09 | |
| 4. | Amendment-IV | EE/03/5181 | Feb 15 | |
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## INTRODUCTION

1. This EED-Q-267(R4) Electrical Specification applicable to all DC and AC Helo starting/servicing systems for Naval ships is sponsored by the Indian Navy, Naval Headquarters, Directorate of Electrical Engineering, Sena Bhavan, New Delhi- 110011.

1. It is to be applied as required for contracts concerning supply of DC and AC Helo starting/servicing system on for Naval ships.

3. If it is found to be technically unsuitable for any particular requirement, the Sponsor is to be informed in writing of the circumstances with a copy to Directorate of Electrical Engineering, Naval Headquarters, Sena Bhavan, New Delhi-110011.

4. Any user of this Specification may propose an amendment to it. Proposals for amendments which are:-

(a) Not directly applicable to a particular contract are to be made to the Sponsor of the EED-Q-267(R4).

(b) Directly applicable to a particular contract are to be dealt with using existing procedures or as specified in the contract.

5. No alteration is to be made to this EED-Q specification except by the issue of a formal amendment by Director of Electrical Engineering, Naval Headquarters.

6. Unless otherwise stated, reference in this EED-Q specification to “approval”, “approved”, “authorised” or similar terms means “by the Naval Headquarters”.

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## SECTION-I

## SCOPE

0101. This EED-Q-267(R4) covers the design, manufacturing, testing and onboard commissioning of the (a) 28 V DC system 12 KW (b) 200 V, 400 HZ, 3 PH AC system 30/ 75 KVA and (c) Their associated sub assemblies. The rectifier designed as per the specifications mentioned in EED-Q-267(R4) should be suitable to start ALH, Seaking, Chetak and KM-28.

0102. This standard defines the requirements and describes the characteristics of aircraft electric power provided at the input terminals of electric utilisation equipment. This statement of requirement covers the design, construction test and Test procedure, documents, spare gears etc to ensure compatibility between the aircraft electric system, airborne utilisation equipment and external DC and AC power equipment for starting and servicing to be fitted onboard naval ships and establishments.

0103. Consideration to departure from the specification will be given when difficulties are encountered during the construction of equipment/machine but no departure may be made without prior approval NHQ/DEE or DQA (WP)/ DGQA.

0104. Statement of requirement is to be deemed to take precedence over this specification and any other documents quoted therein.

## SECTION II
## RELATED DOCUMENTS AND APPLICABLE STANDARDS

0201. The following documentation or the latest issue in effect is to form a part of this specification to the extent specified herein, except where a specific issue is indicated. In case of a conflict between the contents of this document and the applicable portions of the referenced documents, the contents of this document shall take precedence.

(i) MIL STD 704E & DEF STAN 61-5 Part 5 - Characteristics electric power for aircraft

(ii) NES-536 - Requirement of static conversion equipment

(iii) NES-537 - Requirement for testing transformer and static conversion equipment.

(iv) NES-501 - General requirements for the design of electro-technical equipment.

(v) NES-629 - Requirement for testing rotating electric machine.

(vi) NES-723 - Tally plates.

(vii) JSS-55555 - Environmental test methods for electrical and electronic equipment.

(viii) JSS-0251-01 - Preparation of Electrical & Electronic

(ix) NES-581 - Guide to electronic components and practice.

(x) EED – S-806 (R1) - Requirement of Ship- born Frequency Converter.

(xi) EED-Q- 071 (R4) - Requirement of AC Motors and Starters.

(xii) EED-Q-242(R2) - Requirement of AC generators.

(xiii) EED –S-048 - Equipment documentation.

(xiv) IS- 2147 - Starter enclosure.

(xv) IS- 12063/87 - Classification of Degree of Protection provided by enclosures.

(xvi) BS-5424- Control Gear voltages upto and including 1000 VAC Part 1 - contactors.

(xvii) NES 511 - Requirements for Electrical testing of equipment

(xviii) NES 514 & DGS/EED/VI/1535/R6 - Cable Glands

(xix) NES 526 - Requirement for cables, electric rubber insulated LFH sheathed for general services

(xx) NES 642 - Requirement for Aircraft Starting and Servicing Cable Assemblies.

## SECTION III

## DEFINITIONS

0301. For the purpose of this EED-Q, the definitions that apply in addition to the general terminology are contained in succeeding paragraphs.

0302. **Abnormal Operation.** Abnormal operation occurs when a malfunction or failure in the electric system has taken place and the protective devices of the system are operating to remove the malfunction or failure from the remainder of the system before the limits for abnormal operation are exceeded. The power source may operate in a degraded mode on a continuous basis where the power characteristics supplied to the utilization equipment exceed normal operation limits but remain within the limits for abnormal operation.

0303. **AC Voltage.** AC voltage is the root mean square(RMS) phase to neutral value for each half cycle. Steady state AC voltage is the time average of the RMS voltage over a period not to exceed one second. Peak AC voltage is the maximum absolute value of the instantaneous voltage. The direct current (dc) component of the AC voltage is the average value of the voltage.

0304. **Aircraft Electric Power Systems.** An aircraft electric power system consists of a main power source, emergency power source, power conversion equipment, control and protection devices, and an interconnection network (wires, cables, connector, etc.). The main power is derived from aircraft generators driven by the aircraft propulsion engines. Emergency power is derived from batteries, independent auxiliary power units, ram air or hydraulically driven generators.

0305. **Crest Factor.** The crest factor is the absolute value of the ratio of the peak to the RMS value for each half cycle of the voltage waveform measured over a one second period under steady state conditions.

0306. **DC Voltage.** Steady state DC voltage is the time average of the instantaneous DC voltage over a period not to exceed one second.

0307. **Distortion.** AC distortion is the RMS value of the AC waveform exclusive of the fundamental. In a DC system, DC distortion is the RMS value of the alternating voltage component on the DC voltage.

0308. **Distortion Factor.** The AC distortion factor is the ratio of the AC distortion to the RMS value of the fundamental component. The DC distortion factor is the ration of the DC distortion to the DC steady state voltage.

0309. **Distortion Spectrum.** The distortion spectrum quantifies AC or DC distortion in terms of the amplitude of each frequency component. The distortion spectrum includes the components resulting from amplitude and frequency modulation as well as harmonic and non-harmonic components of the waveform.

0310. **Electric Starting Operation.** Electric starting operation is a specialized case of normal electric system operating conditions where the normal voltage limits may be exceeded due to the high electric demand. The voltage limits for normal operation may be exceeded during the following starting conditions :-

(a) An electric start of the propulsion engine.
(b) A battery start of an auxiliary power unit.

0311. **Emergency Operation.** Emergency operation occurs following the loss of the main generating equipment when a limited electric source, independent of the main system, is used to power a reduced complement of distribution and utilization equipment selected to maintain flight and personnel safety.

0312. **External Power Source.** The external power source refers to the ground or shipboard power source used to provide power to the aircraft's electrical distribution system.

0313. **Frequency.** Frequency is the reciprocal of the period of the AC voltage. The unit of frequency is designated hertz(Hz). Steady state frequency is the time average of the frequency over a period not to exceed one second.

0314. **Frequency Modulation.** Frequency modulation is the difference between the maximum and minimum frequency values that occur in a one minute period during steady state operating conditions. Frequency modulation is a measure of the stability of the power source's frequency regulation (in Hz).

0315. **Load Unbalance.** Load unbalance for a three-phase load is the difference between the highest and lowest phase loads.

0316. **Normal Operation.** Normal operation occurs when the system is operating as intended in the absence of any fault or malfunction which degrades performance beyond established requirements. It includes all system functions required for aircraft operation except during the electric starting of propulsion engines and the battery start of an auxiliary power unit. Normal operation includes switching of utilization equipment, prime mover speed changes, synchronizing and paralleling of power sources. And operation from external power sources. Although transfer operation as defined herein is a normal function, it is treated separately in this standard because of the power interruption which it may produce. Conducts switching spikes, which are excursions of the instantaneous voltage not exceeding 50 microseconds, shall be considered normal operation characteristics.

0317. **Over Frequency and Under Frequency.** Over frequency and under frequency are those frequencies which exceed the transient limits for normal operation and are limited by the action of protective devices.

0318. **Over Voltage and Under Voltage.** Over Voltage and under Voltage are those voltages which exceed the transient limits for normal operation and are limited by the action of protective devices.

0319. **Point of Regulation.** The point of regulation (POR) is that point at which a power source senses and regulates the system voltage. The POR shall be at the input terminals of the line contactor connecting the power system to the load bus.

0320. **Ripple .** Ripple is the variation of voltage about the steady state C voltage during steady state electric system operation. Sources of ripple may include, but are not limited to, voltage regulation stability of the DC power source, commutation/rectification within the DC power source, and load variations within utilization equipment. Ripple amplitude is the maximum absolute value of the difference between the steady state and the instantaneous DC voltage.

0321. **Steady State.** Steady state is that condition in which the characteristics remain within the limits for normal operation steady state characteristics throughout an arbitrarily long period of time. Steady state conditions may include lesser transients.

0322. **Transfer Operation.** Transfer operation occurs when the electric system transfers between power sources, including transfers from or to external power sources.

0323. **Transient.** A transient is a changing value of a characteristic that usually occurs as a result of normal disturbance's such as electric load change and engine speed change. A transient may also occur as a result of a momentary power interruption or an abnormal disturbance such as fault clearing. Transients that do not exceed the steady state limits are defined as lesser transients. Transients that exceed the steady state limits but remain within the specified normal transient limits are defined as normal transients. Transient that exceed normal transients limits as a result of an abnormal disturbance and eventually return to steady state limits are defined as abnormal transients.

0324. **Utilization Equipment.** Utilization equipment is that equipment which receives power from the electric power system.

0325. **Utilization Equipment Terminals.** Utilization equipment terminals provide the interface with the electric power system. Power interconnections within the utilization equipment or equipment system are excluded.

0326. **Voltage Modulation.** Voltage modulation is the variation of AC voltage during steady state AC electric system operation. Sources of voltage modulation may include, but are not limited to, voltage regulation

stability of the AC power source, generator speed variations. And load variations within utilization equipment. Voltage modulation amplitude is the difference between the maximum and minimum AC voltage values that occur in a one second period during steady state operating conditions.

0327. **Voltage Phase Difference.** The voltage phase difference is the difference in electrical degrees between the fundamental components of any two phase voltages taken at consecutive zero crossings traced in the negative to positive direction.

0328. **Voltage Unbalance.** Voltage unbalance is defined as the maximum difference between RMS phase voltage amplitudes at the utilization equipment terminals.

0329. **Helicopter Starting System. The helicopter starting system comprises of main equipment i.e. rectifier in case of DC starting system and converter in case of AC starting system and all other associated cables (both portable & ship laid cables), power panel with MCB, switch sockets, JB, contactors boxes, S/V mounts, cables, cable glands and OBS etc. During acceptance trials of helo starting system at firm's premises, all the associated units will be connected up with the main equipment for load trials. The Ordering Authority should order for supply of all the associated units along with main equipment for installation and exploitation on board ship.**

## SECTION- IV

## INFORMATION TO BE SUPPLIED WHEN TENDERING

### Tender Drawings

0401. Tender drawings comprising of three clear prints of the outline of the equipment, showing approximate overall dimensions of the equipment and proposed mounting/ fixing arrangement are to be provided. The layout and size of any auxiliaries are also to be shown together. The manufacturer shall also furnish the following information of the equipment at the time of tendering: -

(a) Estimated total weight
(b) Input and output supplies
(c) Control and protection system
(d) Ripple factor
(e) Class of insulation
(f) Efficiency
(g) Method of output voltage adjustment
(h) Shock grading and Vibration standard
(j) Noise level.
(k) Heat dissipation and Type of cooling system.
(l) Control and indication facility
(m) Output at rated load and maximum transient (current and voltage) levels.
(n) Circuit diagram of the equipment.
(p) Confirmation for carrying all specified tests in this specification.
(q) List of recommended on-Board and B & D spares
(r) No. and Type of S/V mounts
(s) Enclosure protection
(t) Details of starting cables
(u) Details of equipment sub-units
(v) Details of type testing, if carried out previously
(w) Details of previously supplied Orders of similar equipment to Navy/other defence organisations.

## SECTION- V

## ENVIRONMENTAL CONDITIONS

0501. The design of the rectifier/ Rotary frequency converter and their associated control gears is to be catered for the most adverse of the environmental and ambient conditions. The conversion equipment and it's control equipment shall conform to the following specification: -

0502. **Environmental Conditions.** The equipment offered for marine applications shall achieve specified output and function smoothly under tropical conditions. It shall withstand air contamination through oil, salt and other contaminants associated with the marine environment. The equipment shall be water drip proof as a minimum requirement. The equipment shall operate under the following environmental conditions: -

| SL | CONDITION | NORMAL | CLOSED DOWN |
|---|---|---|---|
| 1. | Temperature<br>Ambient air<br>Engine room<br>Sea water | <br>5 to 45 °C<br>up to 55 °C<br>2 to 35 °C | Up to 55 °C |
| 2. | Relative Humidity at 38 ° C | Up to 100% | Up to 100% |
| 3. | Time | Continuous | Up to 48 hrs. |

0503. **Seaway Conditions.** The equipment shall be capable of efficient and unrestricted operation without any deviation from its normal operating parameters under the following seaway conditions:-

(a) Roll : max. ± 30 deg. With 10 s period } Operational

(b) Pitch : max. ± 10 deg. with 20 s period

(c) List : max. 20 deg. from vertical (permanent) } Survival

(d) Trim : max. 5 deg.

**Shock and Vibration Requirement**

0504. The helo starting rectifier, converter & its control gear/panel are to be designed to withstand their full shock levels without allowing for the protection afforded by shock mountings.

0505. The equipment shall comply with either of the following shock standards to be specified in SOTRs:-

(a) Indian Naval shock grade curve "A" ( Appendix 'A') in conjunction with BR-3021. All equipment which affect the ship's combat efficiency come under this category.

(b) Indian Naval shock grade curve “B” (Appendix ‘B’) in conjunction with BR-3021. All equipment which do not affect the fighting capability of the ship, come under this category.

0506. In general, the shaft deflection under designed shock and acceleration shall not exceed the air-gap dimension.

0507. The equipment shall be capable of withstanding forced vibrations within the range of 5 to 33 Hz for major warships and 7 to 300 Hz for minor warships and other naval ships/crafts built in accordance with society’s rules and regulations. Precautions must be taken against vibration excited by any attached driving or driven machinery having reciprocating parts.

0508. The fixing position for shock vibration mountings are to be such that the height of the machine center of gravity above the plane of fixing does not exceed one half of the minimum span of the mountings.

## SECTION- VI

## 12 KW HELICOPTER STARTING/SERVICING RECTIFIER

0601. This statement of requirement covers the manufacturing, testing and onboard commissioning of the transformer rectifier unit required to provide 28.5 Volts DC for helicopter starting/servicing and shall generally conform to specification MIL STD 704 E/ NES–536 and other specifications mentioned therein. The equipment is to be designed to meet the input and output characteristics for the most adverse environmental and electric conditions.

0602. **Duty Cycle**

(a) Helicopter starting 1200 Amps for maximum 5 seconds falling to 225 Amps in 15 to 30 seconds.

(b) Helicopter servicing compressor washing servicing output current of 750 A at 18 V for 20 seconds.

Note:- Up to 8 starts in half an hour period providing 3 minutes cooling interval between 2 engine starts and up to 6 compressor washing with 1 minute interval in half an hour are permitted.

**Technical Specification**

0603. The rectifier shall be manufactured to the following **specifications**:-

**Input**

(a) **Voltage (Steady State)** - 380V/415 V/440V $\pm$ 5% 3 Ph 50/60 Hz (to be specified clearly by the Ordering Authority).

**(Transients State)** **-** $\pm$ 15% of rated voltage

(b) **Frequency**

(i) **Nominal frequency** - 50/60 Hz (as specified).

(ii) **Constant load tolerance** - $\pm$ 0.5 Hz or $\pm$ 1.0%

(iii) **Load range tolerance** - $\pm$1 Hz or $\pm$ 2.0%

(iv) **Transient** - $\pm$ 2.5 %

(v) **Time of recovery** - 2 Sec to within 1% of transient

(vi) **Modulation** - $\pm$ 0.25%

(c) **No. of phases** - 3(Three)

(d) **Supply system** - 3 wire, floating Neutral (not earthed )

**Output**

(e) **Power output** - 12 KW (400 Amps)

(f) **Nominal voltage** - 28.5 Volts

(i) **Voltage Steady State** - 28.5 $\pm$ 0.5 V and 18 V DC for compressor washing

(ii) **Transients** - Voltage should not drop below 18 V (for not more than 15 ms) on application of 1000A load and not below 21 V on application of 800 A load and be restored to a voltage between 22-29 V in 100 ms.

(iii) **Ripple Peak To Peak Overall** - **Peak to peak ripple voltage 1.0 V under all load conditions.**

(iv) **Voltage Modulation** - 2% under all operating conditions.

(v) **Fundamental Frequency of ripple** - 360 Hz + 2.5 %

(vi) **Distortion factor** - 0.035 Maximum.

(vii) **Distortion Amplitude** - Appendix 'C'

(viii) Acceptable voltage at helicopter external power supply receptacle:-

(aa) At the time of starting - 18 V to 28 Volts.

(ix) **Daily inspection and ground service voltage.** 28 V DC at 100 amps continuously.

(x) **Starting Cycle current envelope.** Though the starting current envelope are different for different helicopters, the starting rectifier will be tested for the helicopter starting current envelope as given below:-

(aa) Peak starting current: 1200 Amps for 5 Sec.

(ab) 1$^{st}$ stage starting current: 850 amps for 10 Sec.

(ac) 2nd stage starting current: 300 amps for 15 Sec.

(ad) 3rd stage starting current: 200 amps for 30 Sec.

(ae) Total starting period/cut off period: 25 to 60 seconds depending on OAT & power sources.

(g) **Wiring System** - 2 Wire, the negative terminal of each source of supply to be connected to the aircraft structure (ground) at the aircraft receptacles.

(h) **Rating** - Continuous 400 Amps (100% output)

(J) **Class of Insulation** - Insulation should be of `F' class.

(k) **Permissible Temperature rise** -

(a) Transformer Core - $80^0$ C
(b) Heat Sink - $55^0$ C
(c) Inside panel - $10^0$ C

(l) **Cooling** - Natural Air/Forced Air cooling

**Design Requirements.**

0604. The design of the rectifier be thyrister/IGBT/any other Technology (Subject to acceptability by the IN) to provide input and output characteristics as specified in clause 0603 above under most adverse environmental and the electric conditions. Standstill anti condensation heater suitable for operation on 230 V, 60 HZ, 1 Ph supply is to be fitted inside the rectifier to prevent condensation when the equipment is switched off.

0605. Supply interruptions lasting up to five seconds must not cause malfunction of the equipment and normal performance must be restored automatically on restoration of the supply.

0606. The harmonic distortion of the input supply due to the design of the equipment, is to be no greater than the levels quoted in NES 532. The distortion levels should be minimized where possible and distortion factor should not exceed 0.035.

0607. The rectifier is likely to cause waveform harmonics and electromagnetic noise to be fed back into the input supply. Harmonic contribution of the rectifier will be greatest at the highest expected value of source impedance. All efforts are to be made to incorporate techniques to minimize harmonic distortion and electromagnetic noise within the equipment design. The input supply should normally be isolated by means of a screened transformer.

0608. The equipment is to be capable of withstanding, for the operating time of the output fuses or the output circuit breaker, a short circuit applied to the output terminals when running at any load between the normal full load and no-load.

0609. Unless otherwise specified, means are to be provided in the output of the equipment to prevent excessive voltage rise on o-load.

**Permissible Temperature Rise**

0610. The equipment must be designed so that the maximum permissible operating temperature of components is not exceeded during normal operating conditions in a maximum ambient temperature as specified in this specification.

**Cooling**

0611. Experience in Fleet use indicates a significant proportion of static conversion equipment failures occur as a result of overheating. Suitable exhaust fan be provided in the rectifier to meet the permissible helo rectifier operating temperature limit.

**Electromagnetic Compatibility (EMC)**

0612. The DC & AC helo starting system should conform to Spec. MIL STD 461 C/E in respect of EMI/EMC test requirements - CE 101,102 CS 101,114,115 RE 101,102 RS 101,103. Static Conversion techniques can excite electromagnetic noise and guidance for EMC is to be sought from NES 515.

**Reliability and Maintainability(R&M)**

0613. **Mean Time Between Failure (MTBF**). The design of the equipment shall be such that the estimated mean time interval between failure shall not be less than 10000 hours.

0614. **Self Noise & Vibration.** Care is to be taken in the design and manufacture to ensure that the airborne noise and structure borne vibrations produced by the transformer rectifier, the self induced airborne noise and vibration level must not exceed **60 dB**. Vibration levels and methods of taking measurements are given in clause 630 of specification NES-537. The other general requirements for the design of electro-technical equipment are given in specification NES-501.

**Control and Protection**

0615. The following protection principles are to apply to all rectifiers: -

(a) Internal Fault protection is to:-

(i) Prevent further damage within the equipment, subsequent to a fault
(ii) Prevent damage to the converted power loads.
(iii) Prevent the primary supply going out of specification.

(b) External Fault protection is to:-

(i) Prevent damage to the equipment, subsequent to a fault external to the equipment
(ii) Where practicable, include current limiting techniques to allow the equipment to work with a short circuit onto the output.
(iii) Be defined in terms of the condition under which the equipment shall trip.

(c) Estimated and calculation of the effects of fault conditions are to include:

(i) Stored energy in the load (e.g. resulting from shunt capacitors or motor loads).
(ii) Stored energy in the equipment itself (e.g., in back-up batteries)

(d) Following protections to be provided:-

**AC**
Under Voltage
Over Voltage
Single phasing

**DC**
Under Voltage: Tripping at 18$\pm$0.5 V with delay of 5 Sec.
Over Voltage : Tripping at 32$\pm$0.5 V with delay of 1 Sec (settable).
Overload: Tripping when the load exceeds the specified output current Short Circuit to be checked during FATs only.

**Short Circuit and Over current Protection**

0616. The equipment is to be designed to withstand, without damage, a short circuit at the output terminals when being supplied at the upper limit of input voltage for the maximum time required to rupture the output fuse or operate the circuit breaker. The over current protection of the rectifier is to be set at 125% of maximum output load (1200 amps) of the unit with the minimum time lag possible. Hand reset of the over current protection unit is to be provided.

0617. A multi setting overload trip with suitable selection switch in the output circuit of rectifier be incorporated. Each setting of overload trip will correspond to the starting current envelope of a particular type of aircraft and will trip the rectifier in case of overload to preset current value. The

selection switch should be panel fitted and user friendly for ease of operation. Also the overload trip should have provisions of calibration.

**Control Principles**

0618. The following general control design principles apply:-

(a) No control fault shall lead to damage to the power circuit, or other circuits.
(b) Power supplies to control circuits are to be protected by fuse. Fuses for control and protection circuits are to be kept separate.

**Voltage control**

0619. Closed loop voltage control is to be provided in the rectifier for controlling the rectifier output voltage characteristic within the specified limit.

0620. **Control Circuit Wiring.** LFH (Limited Fire Hazards) cables are to be used for internal wiring.

0621. **Indication Circuit.** The equipment shall be provided with the following indications:

(a) Equipment supply available - Lamp (Green)
(b) Equipment `On' - Lamp (Green)
(c) Overheating
(d) Local / Remote Control available
(e) DC Voltmeter / Ammeter.

0622. **Remote Starting & Instrumentation Panel.** The helo starting rectifier shall be provided with a remote starting panel along with following metering facility:-

(a) Main AC input voltage monitoring meter with 3 way selector switch.
(b) DC output voltage meter
(c) Output ampere meter
(d) Hand Voltage Regulator

## SECTION - VII

## FREQUENCY CONVERTER 200V, 400 HZ, 3 PH, 30/ 75 KVA

### Technical Requirement

0701. The frequency converter shall be designed to meet the input and output supply characteristics for the appropriate load and duty cycle. The design is to be catered for the most adverse of the environmental and electrical conditions. Standstill anti condensation heater suitable for operation on 230 V, 50 HZ, 1 Ph supply is to be fitted inside the converter to prevent condensation when the converter is not working. Remote control of converter is to be fitted in control switchboard panel located in Hangar. The frequency converter shall conform to specification EED-Q-267(R4) and other specifications mentioned therein.

### Technical Specifications.

0702. The converter shall be manufactured to deliver AC power of single-phase or three- phase wye- connected grounded neutral having a nominal Voltage of 200 Volts having following characteristics:-

**Input**

(a) **Voltage** - 380V/415 V/440V $\pm$ 1% 3 Ph 50/60 Hz (to be specified clearly by the Ordering Authority).

**(Transients State)** **-** $\pm$ 15% of rated voltage

(b) **Frequency**

(i) **Nominal frequency**
- 50/60 Hz ( as specified)

(ii) **Constant load tolerance**
- $\pm$ 0.5 Hz or $\pm$ 1.0%

(iii) **Load range tolerance** - $\pm$1 Hz or $\pm$ 2.0%

(iv) **Transient** - $\pm$ 2.5 %

(v) **Time of recovery** - 2 Sec to within 1% of transient

(vi) **Modulation** - $\pm$ 0.25%

(c) **No. of phases** - 3(Three)

(d) **Wiring system** - 3 wire, floating Neutral (not earthed)

**Output**

(e) **Power output** - 30 KVA

***** Power output is 75 KVA for INS Jalashwa***

(f) **Nominal voltage** - 200 Volts

(i) **Voltage Steady State** - 190 to 208 Volts

(ii) **Transients** - +/- 10%

(iii) **Recovery Time** - 0.5 sec

(iv) **Voltage unbalance** - 3 V RMS Maximum

(v) **Voltage phase difference** - 116 ° to 124°

(vi) **Voltage Modulation** - 2.5 V RMS maximum.

(vii) **Crest factor** - 1.31 to 1.51

(g) **Nominal frequency.** - 400Hz

(h) **Steady State Frequency** - 393 to 407 HZ

(j) **Constant Load Tolerance** - ± 0.5 %

(k) **Frequency modulation** - 4 Hz

(l) **Wiring System** - 4 wire system (3 Phases and neutral) Single phase AC power shall be used on a line to neutral basis.

(l) **Rating** - Continuous (100% output)

(n) **Insulation** - **M**ain equipment and sub assembly of AC starting system should have 'F' class insulation.

## DESIGN AND PERFORMANCE

### General Requirements

0703. The frequency converter should comprise directly coupled three phase squirrel cage induction /Synchronous motor and a synchronous generator.

0704. The frequency converter set is to be of closed air circuit monoblock type. The frequency converter set design is to permit ready removability of the item without undue disturbances to the system.

0705. The frame size of M/G set shall be selected from the standard range. In case of motor alternator, the coupling set must be direct coupled type only(belt or gear driven not permitted). The specification for design/testing of motor and its starter/control panel should conform to EED-Q-071 (R4). The converter for helo starting system shall conform to EED-Q-242(R1) and EED-S-806.

0706. All other equipment's necessary for starting and control of the motor generator shall be provided in a suitable bulkhead mounting panel.

0707. **Excitation.** The frequency converter is to be brushless excitation type.

0708. **Internal Wiring.** Only LFH (Low Fire Hazards) cables are to be used for internal wiring.

**Output Capability**

0709. Sustained overload capacity is not required. However the frequency converter set should be capable of withstanding the following overload capacity:-

(a) Supplying 110 % rated load at 0.8 power factor for one hour in any 12 hour period.

(b) When running at any load up to 94 % of rated load at 0.8 power factor, the frequency converter is to be capable of withstanding for 30 seconds the application of an additional load of 50 % KVA at any power factor between zero and 0.4 lagging.

0710. The frequency converter is to be capable, in the normal working condition, of accepting the sudden application and removal of the rated load without damage.

0711. **Voltage Regulation.** Voltage trimmer for both auto voltage regulator and hand voltage regulator is to be provided for varying the generator voltage from 5 % below and 5 % above the rated voltage at all conditions of load and all frequencies within 5 % of the normal.

0712. **Voltage Modulation.** The modulation of the voltage is not to exceed 2% under all operating conditions of load and power factor.

0713. **Wave Form Harmonic Content.** The maximum total harmonic content waveform is not to exceed 5 % of the amplitude of fundamental.

0714. **Transient Voltage Performance.** The transient voltage performance of the generator with AVR is to be as mentioned at para 0715 to 0717.

0715. When the frequency converter set is supplying any load up to 94 % of the rated load at 0.8 lagging power factor and a load equal to 50 % KVA

at any power factor between zero and 0.4 lagging is suddenly applied the momentary voltage change must not exceed 15 % of the rated voltage.

0716. When the frequency converter set is supplying at any load between 25 % and 100 % of rated load at 0.8 lagging power factor and a load equal to 25 % rated load at 0.8 lagging power factor is suddenly removed the momentary voltage change must not exceed 7.5 % of the rated voltage.

0717. In both the cases, the voltage must be restored to and remain within 0.5 % of the final steady state voltage within 1 second of the instant of load change.

**Short Circuit Requirements**

0718. The short circuit current when in AVR control and with the generator hot is to be at least three times the rated current and is to be sustained for at least 3 seconds.

0719. The frequency converter terminal voltage is not to exceed 130 % of rated voltage after a short circuit which has been applied for 3 seconds is suddenly removed.

0720. **Overall Efficiency.** Frequency Converter M/G set over all efficiency should not be less than 80 % and the same to be indicated in binding drawings and rating plate.

**Control and Protection**

0721. All the control and protection required for the converter shall be fitted in a control panel and facility for remote control (Start, Stop, Indication and hand voltage adjustment (HVR) is to be provided in C & C switchboard or as specified in the TSPs.

0722. The motor starter shall be of Soft starter type/Star Delta conforming to EED-Q- 071(R2)

0723. **Control And Indication Facilities.** Following local and remote control indication facilities are to be provided:-

(i) Start Push-button - Green
(ii) Stop Push-button - Red
(iii) Supply available - Lamp - White
(iv) Equipment `ON' – Lamp - Green
(v) Equipment overheat/Trip-Lamp - Red
(vi) Anti-condensation Heater Lamp - Amber
(vii) Hand Voltage Regulator
(viii) Any other control/indication as recommended by the manufacturer.

0724. **Voltage Control.** The AVR is to provide all the circuitry and tuning control necessary to ensure that the converter under control of AVR,

meets all the steady state, transient, short circuit, trim range and output voltage adjustment.

0725. **Hand Voltage Control.** A hand voltage regulator (for voltage adjustment) is to be provided separately for installation in the Control Panel in the hangar. Hand voltage regulator must give a voltage range ± 5 % of the nominal voltage at all operating conditions of load and speed. The hand regulator system is to be as independent of the AVR circuitry as possible.

0726. **Frequency Control.** Automatic control of frequency be provided for frequency converter. Compensation for drift under varying ambient conditions, voltage and loads shall be automatic.

0727. **Protections.** The frequency converter is to be provided with the following protections: -

(i) Over voltage and under voltage
(ii) Over frequency and under frequency
(iii) Short circuit and over load
(iv) Single phase protection
(v) Thermisters protection for motor and generator

0728. **Over Voltage Protection Unit.** The generator AVR and OVPU are to be designed so that the voltage protection unit does not operate under any of the following conditions:-

(i) On removal or application of the generator rated load.
(ii) In between 1 or 2 seconds when the generator terminal voltage exceeds 110 % of the rated voltage.
(iii) As rapidly as possible, when the generator voltage exceeds 130 % of the rated voltage.

0729. **Over Load Protection.** Over load protection setting should be 125 % of the full load current and it should be adjustable with calibrating arrangement.

0730. **Single Phase Protection**. The control panel shall be provided with the suitable arrangement for protection of the motor against single phase protection.

0731. **Thermister Protection.** Each winding of prime-mover motor shall be provided with a thermister and these thermisters are to be connected in such a way that only two leads shall come out of the motor for connection inside the control panel.

0732. **Radio Interference Suppression.** Radio interference suppression unit shall be incorporated as per specification BS-1597 to limit the interference to 5.0 mV.

0733. **Mean Time Between Failure (MTBF**). The design of the equipment shall be such that the estimated mean time interval between failure shall not be less than 10000 hours.

## SECTION -VIII

## CONSTRUCTION

0801. **Enclosure.** The enclosure of transformer rectifier and converter control panel shall be fabricated from with 14 SWG mild steel sheet conforming to IS-226. Drip proof totally enclosed construction (up to 45 deg from vertical) shall conform to specification BS-2817. The enclosure protection of various equipment shall be as follows:-

| | | |
|---|---|---|
| (a) | Rectifier | = IP-55 |
| (b) | Frequency converter | = IP-23 |
| (c) | Control Panel | = IP-55 |

0802. **Accessibility of Rectifiers/Components.** The equipment shall be designed so that all components may be removed from the front of the cubicle with the front cover only removed. There shall be no hidden connections. Rectifier cells are to be mounted so that they may be removed from the front of the equipment without prior removal of other components. All the components of the equipment should have easy access for removal/refit.

0803. **Components.** All components used in equipment shall be of Naval/LCSO approved type only. Contactors used shall be in accordance to specifications BS-5424 and motor should not trip below 110% of full load current. Standard specification, grade of material, make and type of components are to be listed in the binding drawings.

0804. Indication lamps used shall be of neon type.

### Mounting of Equipment

0805. The rectifier/converter shall be designed for installing on to the deck with suitable shock mounts. Deck mounted equipment shall be designed to ensure that no live part is less than 12 inches from the deck.

0806. The control panel shall be designed suitable for bulkhead mounting.

0807. Number and type of Shock mounts required for rectifier, converter and control panel are to be supplied along with the main equipment.

0808. **Shock Standard.** The Rectifier, Converter, motor and control panel should meet the shock levels stipulated in IN Shock grade NSS-II (Inherent) in conjunction with BR 3021. Further all the equipment be supplied with shock mounts. For the type testing, the equipment shall be subjected to actual shock tests at NSTL (Viz.) and the charges for those tests shall be borne by the equipment supplier.

0809. **Vibration standard.** 5-33 Hz conforming to specification JSS-55555.

**Terminals**

0810. Bolted type terminals and crimping sockets of electrolytic copper are to be provided for all incoming and outgoing cables. Adequate spare terminal strips are to be provided to facilitate remote control/additional control (if any) and indication purpose.

0811. Adequate space is to be provided inside the transformer rectifier unit and control panels for bunching, bending and termination of incoming and outgoing cables._

0812. **Earthing.** The equipment is to be fitted with a double ended threaded M-10 earth stud both sides of the equipment.

**CABLE DETAILS AND CABLE ENTRY GLANDS**

0813. **Cable Entry Glands.** Cable entry glands of mild steel for body and Naval brass for nut and their sizes shall conform to specification DGS/EED/VI/1535/R6 for incoming and outgoing cables. The gland nut and washers are to be left undrilled. Cable glands are to be supplied along with the main equipment for all incoming and outgoing cables.

0814. **Anti-Condensation Heaters.** Approved type of non-luminous low temperature heaters operating at voltage 230 V, 50/60 HZ, 1 Ph supply shall be fitted inside the rectifier, motor, generator and control panel to prevent condensation. The control of the heaters shall be provided in the control panel. The anti-condensation heater is to be switched on simultaneously when the equipment is in `OFF' positioned, Arrangement for cutting off supply to anti-condensation heaters when equipment is put to `ON' position to be provided.

0815. **Earthing Terminals.** An external earthing terminal of brass or stainless steel is to be provided for converter and control panel.

0816. **Lifting Arrangement.** Eye bolts is to be provided for lifting the equipment if it weighs more than 40 Kg.

0817. **Dimensional Limitations,** The overall dimensions of the rectifier, frequency converter and control panel are to be kept as minimum as possible and confirmation in regard shall be given with in one month of issuing of this specification.

0818 **Estimated Weight**. Estimated weight of rectifier, frequency converter and control panel etc, within 5% tolerance are to be indicated within one month of approval of basic configuration of the equipment.

0819. **Shaft Material** :- Shaft of the frequency converter shall be of EN-57 material. The shaft is to be so designed to withstand vibration that

occurs at any speed within the operating range or at speed specified for over speed test.

0820. **Material and Workmanship.** The equipment shall be made from approved material as specified in the specification NES 507. Workmanship shall be of highest quality and to the entire satisfaction of the inspecting authority. Standard specification and grade of material of each component used to be indicated in the binding drawings.

0821 **Painting.** Powder coating shade 632 of IS: 5

## MARKING

### Tally and Diagram Plates.

0822. A diagram plate indicating the details of connection is to be provided on the equipment. In case of motor it is to be affixed on rear of the terminal cover of the motor. All tallies and diagram plates shall be of anodized aluminium alloy.

0823. Tallies indicating Warning/ Danger 380V/415V/440 V (as applicable) etc are to be fitted on control panel.

0824. Size of the tally plate, diagram plate, danger plate, equipment start/stop, adjustable output etc. and their letters shall conform to NES-723. Rating plate shall indicate the following

(a) **INPUT**

(i) Voltage
(ii) Current
(iii) Frequency
(iv) Phase
(v) Power factor
(vi) Converter motor RPM

(b) **OUTPUT**

(i) Rated Voltage
(ii) Rated Current

(c) Power in KW and KVA.
(d) Power Factor (where applicable)
(e) Frequency (where applicable)
(f) Phases (where applicable)
(g) Rated output with cooler in operative

0825. Marker Plates are also to be fitted in each equipment/subassemblies giving:-

(a) Name of manufacturer
(b) Manufacturers' Part No.

(c) Weight in Kg.
(d) Year of manufacturing
(e) Equipment Sr.No.

## SECTION - IX

## SCOPE OF SUPPLY

0901. **DC System** The details of equipment, accessories, cables/ gland size etc to be supplied along with the equipment are as follows:-

(a) Transformer- rectifier 28± 0.5 V DC, 12 kW, 400 A with suitable shock mounts (04 nos.) conforming to IN shock grade NSS-II.

(b) One number contactor box arranged to take the following cables.

| S.No | Cable Part No. | Cable size | No. of cables | OD(mm) | Gland Size |
|---|---|---|---|---|---|
| (i) | 521-6824 | 1x300 sq.mm | 6 | 31.0 | 6 |
| (ii) | 521-6877 | 4x1 sq.mm | 1 | 10.1 | 3 |
| (iii) | 521-6880 | 10x1 sq.mm | 1 | 14.5 | 3 |

(c) One no. 300 Amps Flight deck socket box fitted with one 300 Amps socket ( the socket to receive helo starting cable [Patt No: 0564-525-0974(23 Mtrs length)] end connector be fitted on the front panel of the box for ease of plugging in/ un-plugging of connector) and arranged to take following cables:

| S.No | Cable Part No. | Cable size | No. of cables | OD(mm) | Gland Size |
|---|---|---|---|---|---|
| (i) | 521-6824 | 10x300 sq.mm | 2 | 31.0 | 6 |
| (ii) | 521-6828 | 2x1 sq.mm | 1 | 9.1 | 2 |
| (iii) | 521-6880 | 10x1 sq.mm | 1 | 14.5 | 3 |
| (iv) | 521-6913 | 4 pair x 1sq.mm | 1 | 16.1 | 4 |

(d) One no. hangar socket box having two 300 Amps sockets and arranged to take following cables.

| S.No | Cable Part No. | Cable size | No. of cables | OD(mm) | Gland Size |
|---|---|---|---|---|---|
| (i) | 521-6824 | 1x300 sq.mm | 2 | 31.0 | 6 |
| (ii) | 521-6871 | 4x1 sq.mm | 1 | 10.1 | 3 |

(e) One no. socket box (water tight) for remote positive sensing in Helicopter starter and arranged to take following cables.

| S.No. | Cable Part No. | Cable size | No. of cables | OD (mm) | Gland Size |
|---|---|---|---|---|---|
| (i) | 521-6828 | 2 x 1 sq.mm | 1 | 9.1 | 2 |

(f) One no. start/service switch in watertight housing and arranged to take following cables.

| S.No. | Cable Part No. | Cable size | No. of cables | OD (mm) | Gland Size |
|---|---|---|---|---|---|
| (i) | 521-6913 | 4 pair x 1 sq.mm | 1 | 16.1 | 4 |

(g) Power panel with MCB type:-

(i) 126C (60A) 1 No.
(ii) 113C (30A) 1 No.
(iii) 115 C (40 A) 2 Nos.

(h) Bench Power Outlet Box - 05 nos.

(j) Switch Socket 15 amps DC- 12 nos.

0902. **AC System.** The frequency converters should be supplied with the following equipment and accessories:-

(i) One in number squirrel cage induction motor with soft/star delta starter for input supply of 415 V, 50 HZ, 3 pH 3 Wire suitable for continuous operation.

(ii) One in number 30 KVA 200 V, 400 HZ, 3 pH - 3 Wire at 0.8 P.F. synchronous generator, brushless, electrically controlled, self ventilated suitable for continuous operation. (***For INS Jalashwa :- For 30 KVA, READ 75 KVA***)

(iii) One in number control panel.

(iv) One in number hand voltage regulator (for voltage adjustment) is to be supplied separately for installation in hangar control panel.

(v) One in number auto voltage regulator is to be incorporated in the control panel or it may be mounted on converter.

(vi) Shock mounts for the frequency converter and control panel conforming to NSS-II. The manufacturer shall provide details and make of the S/V mounts.

(vii) Thermisters for the converter.

(viii) Cable glands of suitable size conforming to DGS/EED/VI/1535/R6 be supplied by the equipment manufacturer.

(ix) Contactor Box AC system- 1 no.

(x) Control Box AC system- 1 no.

(xi) Overload box AC system- 1 no.

(xii) Hanger Socket Box- 2 nos.

(xiii) Flight Deck Socket Box 6 pole, 200V 400 Hz, 1 KVA 3 Phase 4 wire water tight complete with matching plug- 6 nos.

(xiv) Power panel for helo starting and servicing supplies 200V, 400Hz, 3 phase 4 wire- 1 no.

0903. **Flexible Cable Assemblies (portable).** The detailed technical requirements of various types of cable assemblies (DC/ AC) for starting and servicing aircraft onboard ships are stipulated in the data sheet and table-1 of NES 642 and to be strictly adhered to. The cable assemblies are to be duel extrusion insulated, manufactured and tested in accordance with NES 526. Termination of cable cores within the moulded connectors is to be arranged so as to minimise breakage of the smaller control cores when assemblies/connectors are bent or flexed. The portable cable end connector at helicopter end should be compatible with NATO type connector on the helicopter. Complete assemblies are to be tested for end-to-end continuity and are to meet the following requirement when tested between sockets and earth:

(a) 1.5 KV rms. 40-62 Hz for 5 minutes.

(b) 400 megohms per Km at 20 ° C at 500 Volts DC.

## SECTION –X

## INSPECTION AND TESTING

1001.. **Inspection / Classification**

(a) For design : Directorate of Electrical Engineering (DEE) of Indian Navy.
(b) For ship trials : ETMA of Indian Navy
(c) For QC : DQA(WP) & DQA(N) of DGQA

1002. **INSPECTION AGENCY** : Director of Quality Assurance (Naval)/(WP)

1003. **Testing.** The equipment shall be tested in accordance with this specification in conjunction with NES 537 for rectifier and NES 629 for converters.

1004. The product offered by the manufacturers should conform to Standard Engineering practices. The equipment will be subject to stage inspection and final test and trials by the Naval Inspection Agencies as mutually agreed with the equipment manufactures. By and large, the equipment should have components of indigenous make. In case of replacement of any components is done in subsequent orders, the manufacturer shall inform the customer and the equipment will have to be type tested again. Any deviation from the mentioned specifications will have to be brought to the notice of Naval Headquarters and approval to be taken for the same. All defects observed or developed during the inspection/ testing are to be rectified free of cost before dispatch to shipyard.

1005. The first of each type of equipment is to be type tested and each successive unit is to be production tested at the manufacturer’s works. In addition, extended endurance testing of prototype equipment is required to be carried out before approval for their use can be granted. The supplier should also furnish data/information about the methods/measurements carried out in evaluating the performance of the equipment during the trials.

1006. During workshop tests, all the supplied equipment is to be installed on the test bed and operated in the same way as it will be on board the vessel. Any correction applied for different environmental and installation conditions shall be duly notified to concerned Naval Agencies, seeking their approval.

1007. The testing installation shall provide for a mounting arrangement of better or equal stiffness than the expected one for the ship structure where the unit will be installed.

1008. The schedule for inspection, test & trials should be drawn up in such a way that all inspections including component level inspection, trials of subassemblies, etc., should be, as far as practicable performed at the

corresponding stage of manufacturing. Detailed measurements should be carried out at the appropriate stage of manufacturing.

1009. Testing requirements at sea shall be defined in the trial programme for each ship. The major machinery elements shall be subject to post tests inspections. All tests required are to be carried out as specified in this specification.

**RECTIFIERS**

1010. Each rectifier is to be subjected to one of the following tests:-

(a) **Type Testing.** The first rectifier of a new design is to be subjected to type test in accordance with clause 0602 of NES 537. In addition, it is the responsibility of the main contactor to arrange for the equipment to be tested as a complete installation with all its ancillaries including fans, heat exchangers, control switches etc. as applicable. Rectifier and associated equipment is to be submitted for type testing within three months of the placement of order if not tested earlier by Director of Quality Assurance (Navy).

(b) **Routine Acceptance Tests on new Rectifiers.** All new Rectifiers are to undergo the following Routine Acceptance Test (to be incorporated in the GRAQS) as per procedures given in section-VI of NES 537:-

(i) Endurance Test.
(ii) Temperature Rise test.
(iii) Measurement of Insulation resistance.
(iv) Steady State output Characteristic.
(v) Transient Voltage response Test.
(vi) Output ripple test.
(vii) Efficiency
(viii) Operation of protective device.
(ix) Voltage modulation.
(x) Effect of supply Interruptions

(c) **Post Repair/Refit Testing of Rectifiers.** The helo starting rectifier shall be subjected to following tests (as per procedure given in section-VI of NES 537) post major repairs /overhauls/post refits:-

(i) Endurance Test.
(ii) Heat Run Test.
(iii) Insulation Measurement test.
(iv) Steady State output Characteristic.
(v)Transient Voltage response Test.
(vi) Output ripple test.
(vii) Operation of protective device.

(d) All new rectifiers will be subjected to performance tests at the firm's premise. The test parameters will be recorded in an on-line oscilloscope with graphic recorder to obtain real time performance data. The output parameters will be recorded at the load end connected with all specified

cables and associated sockets/connectors which will be delivered with the main equipment for use onboard ship for helicopter starting. All required tools/test equipment including configurable load bank of 1200 amps capacity for these tests are to be provided by the OEM. Tests set up and procedures are mentioned at appendix "F" to the EED-Q-267(R4). The results of the tests are to be complied in a test report and be forwarded to NSM for analysis. Details of performance tests are as follows:-

(i) Input Voltage measurement.

(ii) Maximum output voltage drop and recovery period during transient load state.
(iii) Starting cycle output voltage and current envelope.
(iv) Output ground servicing/compressor washing
(v) Output ripple voltage at all load conditions
(vi) Output voltage setting range
(vii) Transient voltage and current
(viii) DC output under voltage and over voltage protection trip
(ix) Overload protection.

**ROTARY FREQUENCY CONVERTER AND ASSOCIATED CONTROL PANEL.**

1011. Each equipment is to be subjected to one of the following tests:-

(a) **Type Testing.** The first equipment of a new design is to be subjected to type test in accordance with section – iv & viii of NES 629 tabulated at Appendix-'D'. In addition, it is the responsibility of the main contractor to arrange for the equipment to be tested as a complete installation with all its ancillaries including fans, heat exchangers, control switches etc. as applicable. Converter and associated equipment is to be submitted for type testing within three months of the placement of order if not tested earlier by Director of Quality Assurance (Navy).

(b) **Routine Acceptance Tests on New Rectifiers.** All new Rotary converters not subjected Type tests must undergo the Routine Acceptance Test (to be incorporated in the GRAQS) in accordance with section viii of NES 629 as tabulated at Appendix- 'D''.

(c) **Post Repair/Refit Testing of Rectifiers.** Routine Tests as per table at Appendix-'D'.

**ENVIRONMENTAL TESTS**

1012. **Limited Environmental Tests.** A list of limited environmental tests (which do not drive the equipment to yellow banding) shall be carried out on the complete equipment as per the table given at appendix- 'E' and report submitted to NSM for approval.

1013. All tests (except shock tests) are to be carried out by manufacturer at his own works, in the presence of an inspecting authority, prior to dispatching the equipment to the customer.

1014. The inspecting authority shall call for repetition of tests if he is not satisfied till the representation of the normal performance of the equipment.

1015. The manufacturer shall be responsible for the satisfactory performance during warranty period and would have to undertake any repair if found necessary.

1016. **Tilt Test.** As per environmental conditions. The equipment is to be run for one hour with 20 ° tilt in each direction. All parameters are to be checked after 45 minutes.

1017. **Environmental Stress Screening (ESS) tests.** All the PCBs and electronic modules fitted in the Helo Starting Rectifier will be subjected to ESS tests as per MIL STD 2164 mentioned below:-

(a) Thermal Shock. Temperature: - 40˚C (MIL grade components) / 0˚C (for commercial grade components) to 70 ˚C.

No. of cycles : 06
Dwell time : 90 min.
Change over : 5 min.

(b) Thermal Cycling. Sub- units/equipment with power on:-

Temperature : -30 ˚C to + 55˚C change @ 1˚C /min.
No. of cycles : 03
Dwell time up to 20 Kg : 2 hours
20-40 kg : 3 hours
Above 40 kg : 4 hours

(c) Random Vibration Tests:- The vibration test will be carried out on X,Y & Z axis at 20-2000 Hz, 0.02 $g^2$ /Hz for 10 minutes.

(d) Burn in Test. The equipment with PCBs in place will be switched on at room temperature for 168 hours. OR for 48 hours at full load at 55 ˚C. The test will comprise of:-

(i) Sinusoidal vibration 10-150 Hz sweep 2-5 min. in each of the three mutually perpendicular directions.

(ii) 300 bump 40g of 6 milliseconds in one axis only.

## SECTION-XI

## Drawings And Documents.

1101. **Drawings.** The manufacturers shall submit approval and As made drawings sufficiently detailed to show the manner of construction and operation, the method of assembly and dismantling. The drawings prepared in accordance with JSS 0251-1 containing following details be forwarded to IHQ MOD (N)/DEE and DQAN: -

(a) A layout drawing where more than one cubicle or other auxiliary is involved.
(b) Main view of the individual cubicles, with part section.
(c) Detailed drawing of principal sub-assemblies.
(d) Circuit diagram, wiring diagrams, wiring schedules and terminal connection
details
(e) Overall dimensions of the equipment.

Each drawing shall have cross-reference to the other drawings of the series and to the drawings of the associated apparatus, such as contactor box, motors and starters etc.

1102. **Documents.** The format and content of documentation being provided should be as per JSS 0251-01. Following draft documents shall be presented for approval of Indian Navy.

(a) Technical and Operating Instruction Manual.
(b) Onboard Maintenance Manual.
(c) Field and Depot Maintenance Manual.
(d) Installation and Testing Manual.
(e) Parts and Tools Catalogue.
(f) Installation Drawings.
(g) As fitted Drawings.
(h) Conformation of Standards Specified.
(j) Test Procedure and Documentation.
(k) Certified Test Report

## SECTION –XII

## SPARES AND PRODUCT SUPPORT

1201. **Spare Gear.** The onboard spares, Base & Depot spares and test equipment is to be recommended by the supplier. Such recommendations are to be commensurate with the reliability of critical components and component used in the system. Special tools and test equipment is to be supplied for onboard maintenance.

1202. **On Board Spares.** As per section 11 of NES 636 a itemised list of OBS, special tool and special test equipment, which will be supplied with the main equipment, is to be furnished along with the quotation for the main equipment. The OBS and special tool are to cater for all of the ships' staff onboard maintenance routines and possible repair requirements. The OBS and tools should include following: -

i) All spares required for exploitation up to 2 years.
ii) One set of important assemblies to effect "repair by replacement".
iii) One set of general-purpose maintenance tools along with each converter.

1203. **Five-Year Base & Depot Spares / Comprehensive Part Lists.** Base spares recommendation is to cover maintenance / overhaul requirements for 5 years including two refits. Recommendations for insurance holding of long lead items are also to be indicated. Itemised cost of B&D spares are to be forwarded with the main offer.

1204. **Installation.** The supplier shall supply one set of installation and commissioning spares. The manufacturer is required to provide the necessary representative(s) to assist in carrying out inspection and supervise the work that is done on the equipment, during the following phases:

i) On-board erection and connections
ii) Setting to work
iii) Harbour and sea trials
iv) Final machinery trials
v) Inspections on completion of CSTs

1205. **Warranty** : The equipment with associated controls/instrumentation is to be guaranteed for stipulated performance for 24 months after commissioning. The equipment supplied shall be warranted from defects, manufacturer and performance for the said period and cover all the defects arising from malfunction through design faults, inappropriate material, bad production and non- conformance to specifications. Any expense on account of repair/supply of spares against guarantee defects is to be borne by the supplier.

**Appendix-'D'**

## TESTS ON ROTARY FREQUENCY CONVERTERS

The requirement of various tests and their abbreviations used in this table are T- Type Test, R- Routine Test, L – Test at electrical Maker's work and C – Combined Equipment Test

| TEST | AC MOTORS | | MOTOR GENERATORS | |
|---|---|---|---|---|
| | **L** | **C** | **L** | **C** |
| | | | | |
| Winding Resistance | TR | | | TR |
| Temperature Rise | TR | T | | TR |
| Hot Spot Sensing | T | | | T |
| Dry and damp heat | | | | T |
| Withstand Voltage | TR | | | TR |
| Insulation Resistance | TR | TR | | TR |
| Efficiency | T | | | T |
| Voltage Balance | | | | TR |
| Ripple, harmonic content modulation | | | | T |
| Voltage Range | | | | TR |
| Effectiveness of enclosure | T | | | T |
| Measurement of air gaps | TR | | | TR |
| Bearing grease relief | T | | | T |
| Self induced airborne noise and vibration<br>(i) Type Test<br><br>(ii) Production Test | <br><br>T<br><br>R | | | <br><br>T<br><br>R |
| Commutators and Slip rings | | | | TR |
| Operation of protective devices | | | | TR |
| Motor starting current and run-up time | T | T | T | T |
| No Load | TR | | | |
| Speed Regulation | TR | T | | |
| Locked rotor torque | T | | | |
| Pull out torque | T | | | |
| Over speed | TR | | | TR |
| Protective devices thermistors | TR | | | |
| Machine characteristics and constants | | | T | |
| Short circuit performance tests | | | | T |
| Voltage regulation and control | | | | TR |
| Parallel Operation | | | | T |
| Over voltage | | | | T |
| Hand voltage regulator | | | | TR |
| Steady state voltage regulation | | | | TR |
| Frequency regulator | | | | TR |

| | | | | |
|---|---|---|---|---|
| No-Break motor generator | | | | TR |
| Hand/Auto Control | | | | TR |
| Motor Thermal Protection Unit(MTPU) | | | | TR |

**Appendix- 'E'**

## TABLE OF ENVIRONMENTAL TESTS

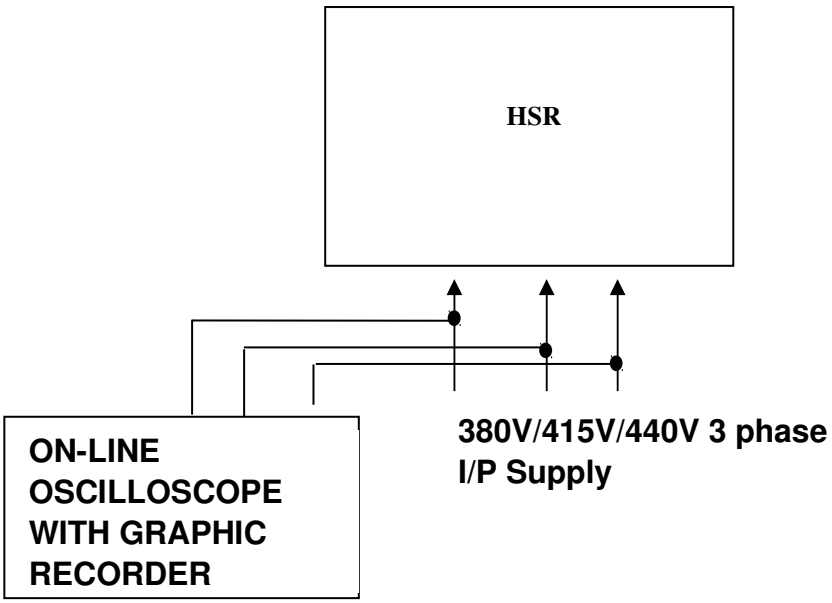
| SL | TEST | SPECIFICATION | TEST CONDITION/SEVERITY |
|---|---|---|---|
| 1 | Vibration | JSS 55555 – Test 28 | 5 – 33 Hz |
| 2 | High Temperature | JSS 55555 – Test 17 | 55 deg C for 16 Hrs. Procedure 5,<br>Test Condition 'G' |
| 3 | Damp heat | JSS 55555 – Test 10 | 40 deg C – 95 deg C RH for 16 Hrs |
| 4 | Drip proof | JSS 55555 – Test 11 | Vertical Water drip<br>1 m height for 15 min |
| 5 | Mould growth | JSS 55555 – Test 21 | 29 ° C 90 % RH mould growth chamber for 28 days |
| 6 | Bump | JSS 55555 – Test 5 | 1000 bumps – 40 G, 6 m/sec |
| 7 | Shock / Impact | JSS 55555 – Test 24 | As per laid down Specifications |
| 8 | Inclination/ Tilt | CL 0563 Sec 19 | |
| 9 | Ship Motion | | |
| 10 | EMI/EMC | MIL-STD 461 C | |
| 11 | Magnetic field effects | NWS 1000 | |

**Appendix- 'F'**

## SETTING UP OF HELO STARTING RECTIFIER FOR PERFORMANCE TEST

**TEST SPECIFICATION.**

**TEST NO.(i) Input Voltage Measurement**




**Test Procedure:** An online oscilloscope with graphic recorder be connected up with the Helo starting Rectifier mains input supply and measurements of 3 Ph input power supply be recorded.

**TEST SPECIFICATION.**

**TEST NOs.**

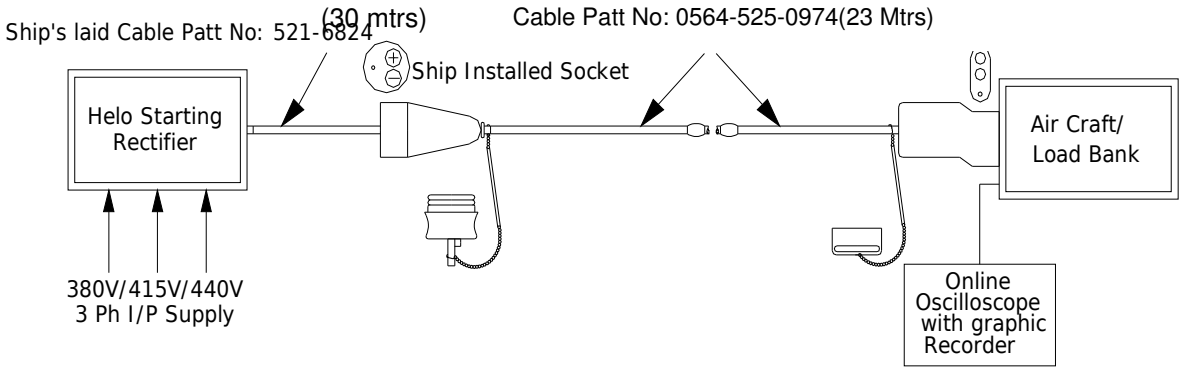
**(ii) Max. output voltage drop during transient state and recovery period.**

**(iii) Starting cycle output voltage and current envelope.**

**(iv) Output ground servicing/compressor washing**

**(v) Output Peak to Peak ripple voltage at all load conditions**

**(vii) Transient output voltage and current**




Cable Patt No: 521-6824
Single Core Silicone Rubber Insulated, CSP sheathed (Power)

| | | | |
|---|---|---|---|
| Strands | 61/2.52mm | X | 0.11 |
| D | 22.68mm | LD | 250 Mtrs |
| OD IC | 25.5mm | W | 3196 Kg/Km |
| Cable OD | 31 mm | V | 440 |
| R | 0.059 Ohms | A | 660 |
| Rac | 0.08 Ohms/Km | | |

**Test procedure Test No. (ii)** The Helo starting Rectifier is to be connected to load with 30 mtrs long specified cable. Using an on-line graphic Oscilloscope at the load end, the maximum drop in output voltage and its recovery time within specified values be recorded during transient load state.

(a) High frequency filter of oscilloscope to be in "OFF" condition

(b) AC box of Chetak helo lead to be connected will domestic load. Relay fitted in AC box should not trip.

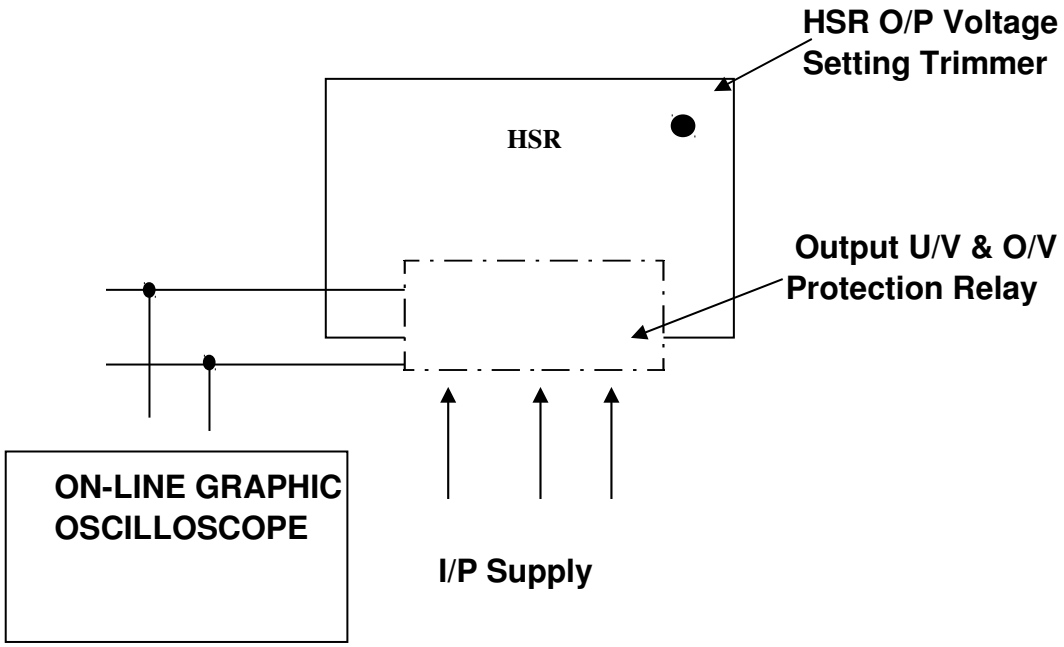
**Test Procedure Test No. (iii),(v) &(vii)** The Helo Starting Rectifier to be connected to a 30 mtrs long specified cable as shown above. Using an on-line Oscillograph the test parameters are to be recorded at load terminal. Tests No. (iii) & (iv) are to be conducted for the complete starting envelope of the Helo Starting Rectifier. Test No.(vii) be conducted for minimum duration of 10 sec to obtain significant transient parameters on graph.

**Test Procedure Test No. (iv)** The Rectifier output voltage & current be recorded at load terminal as shown in Figure above for a duration of 20 sec. for Helicopter servicing/ compressor washing.

**TEST SPECIFICATION.**

**TEST NO. (vi) Output voltage setting range**

**TEST NO. (viii) DC output U/V and O/V protection trip**



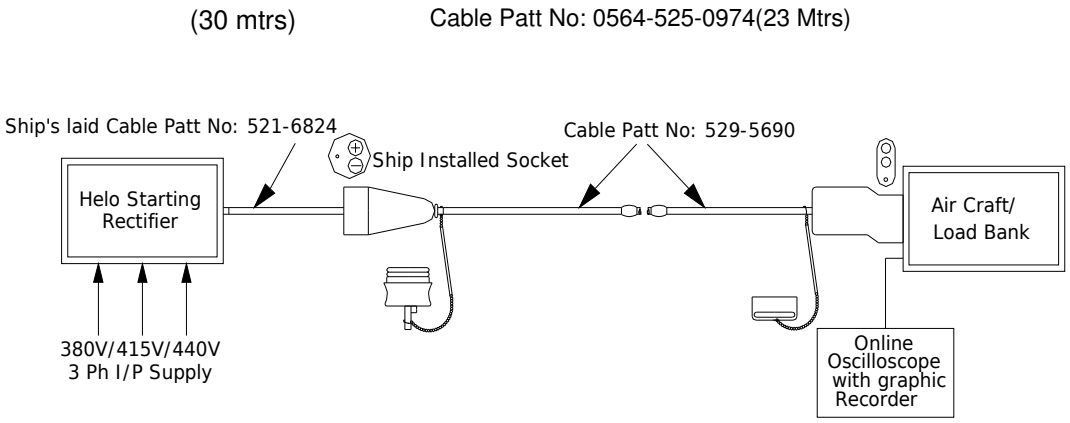

**Test Procedure Test No. (vi)** On-line graphic oscilloscope be connected at the output terminals of the rectifier. Switch on the rectifier

and using the output voltage trimmer, increase and decrease the output voltage to record the regulation.

**Test Procedure Test No. (ix)** On-line graphic oscilloscope be connected at the output terminals of the rectifier. Switch on the rectifier and using the output voltage trimmer decrease the output voltage of rectifier to operate the U/V trip of the rectifier. Similarly, using the voltage trimmer increase the rectifier output to operate the O/V trip. Operation of both U/V and O/V relays be on-line recorded.

## TEST SPECIFICATION.

**TEST NO. (ix) Overload Protection**.




Cable Patt No: 521-6824
Single Core Silicone Rubber Insulated, CSP sheathed (Power)

| | | | |
|---|---|---|---|
| Strands | 61/2.52mm | X | 0.11 |
| D | 22.68mm | LD | 250 Mtrs |
| OD IC | 25.5mm | W | 3196 Kg/Km |
| Cable OD | 31 mm | V | 440 |
| R | 0.059 Ohms | A | 660 |
| Rac | 0.08 Ohms/Km | | |

**Test Procedure.** The Helo Starting Rectifier to be connected to a 30 mtrs long specified cable as shown above. An On-line graphic Oscilloscope be connected at the load terminals and the overload on Rectifier be gradually increased to 125% of the peak load of 1200 Amps. The overload trip should cut off the Rectifier output within 1Sec. of occurrence of overload.