TITLE : TECHNICAL SPECIFICATION FOR BOUGHT OUT ITEM FOR ESP

ITEM : SWITCH MODE POWER SUPPLY FOR ESP

PROJECT : M/S NATIONAL THERMAL POWER CORPORATION LTD (NTPC)

NAME		DESIGNATION	SIGNATURE	DATE
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Sl. No.	Specification	Vendor Confirmation (with documents)
1	**Qualifying Requirements**	
1.1	The offered **Switched Mode Power Supply (SMPS)** along with controllers should be from a Manufacturer, who has supplied at least 70KV/1000mA Silicone Oil filled Switched Mode High Frequency Transformer rectifier sets (either Stand Alone or in combination with conventional High Voltage Transformer) in one ESP of 200MW or higher rated coal fired units which is in successful operation for a minimum one (1) year as on 8th January 2013.	
2	**Scope**	
2.1	Design, manufacture, test, pack & supply SMPS for Electrostatic Precipitator (ESP) of 400mm electrode spacing. The system shall be built with suitable high frequency transformer, IGBT based inverter module, control cabinet, controller, operator terminal and necessary accessories to make the system complete. The scope also includes Commissioning Supervision of SMPS unit at Thermal Power Station.	
2.2	The SMPS shall be of **RESONANT** switching type. The switching frequency shall be **10KHz or higher**	
2.3	SMPS unit shall be field-proven, type tested and tropicalized.	
2.4	Special tool & tackles, if any, are to be indicated and included in the scope.	
3	**Project Information**	
3.1	Ambient conditions	
3.1.1	Ambient temperature : 0°C to 50°C	
3.1.2	Humidity : Up to 95%	
3.2	Location : Outdoor, on top of ESP, open and exposed to atmosphere.	
3.3	Altitude from mean sea level : Less than 1000m	
3.4	Quantity & Rating : As per enquiry	
3.5	Environment :The atmosphere will be very dusty, very high Abrasive nature, conducive to fungus growth.	
4	**Applicable Standards**	
	Bidder to comply all applicable latest Indian standards/international standards for the SMPS unit offered. Following standards requirement shall also be taken care	
4.1	EMC conformity : EN 61000-6-4 emission, EN 61000-6-2 Immunity	
4.2	Fast Transient : ANSI/ IEEE C37.90.1-2002/ IEC 60255-22-04-2008	
4.3	Low voltage directive : EN 50178 2006/95/EC	
4.4	Degree of protections, enclosure: IEC 529/1989/2/73,EN 60529	

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4.5	Electronic equipment for use in Power installations : EN 50178	
4.6	Silicone oil shall meet transformer oil fire safety requirement specified in paragraph 450-23 of National Electric Code	
4.7	Transformer shall conform to IS:2026 /IEC60076	
4.8	SMPS shall meet local statutory regulations as applicable.	
5	**Terminal Conditions**	
5.1	Power supply Input :3 Phase, 415V, 50Hz AC	
5.2	Power supply variation	
5.2.1	Voltage: +10% to -10%.	
5.2.2	Frequency: + 3% to - 5%.	
5.2.3	Combined variation of Voltage & Frequency : 10%	
5.3	Any other voltage required for SMPS to be arranged by the vendor	
5.4	Capacitance of precipitator (pF): 200 x Rated output current in mA. (approx.)	
5.5	High voltage Negative Output terminal: Through single horizontal bushing of Porcelain type	
5.6	Rated output voltage, output current and quantity shall be as per Enquiry/PO.	
6	**Design & Operational Requirements**	
6.1	The bidder shall furnish control principle details under non-sparking and sparking mode for review.	
6.2	Soft start shall be provided during initial energization / switch on of the output. The soft start shall be effective till field current reaches set value.	
6.3	The SMPS unit shall be suitable for operation with Intermittent Energization (IE). On-time and Off -time shall be user settable.	
6.4	The precipitator is a dead load. The electrodes inside the Precipitator keep swinging slightly with frequency of 5 to 10 Hz. The unit shall be capable of operating at any secondary current provided the primary current is not exceeded. The unit shall be capable of operating under accidental no load condition. The unit may be subjected to short circuit condition when the ESP Electrodes gets snapped during operation. The SMPS unit shall be suitable for the above operating conditions.	
7	**Major Components of SMPS**	
7.1	The SMPS shall have typically 3 phase input rectifier, capacitor bank, pre-charging circuit, IGBT based inverter and high frequency high voltage rectifier transformer. The above components shall be selected / designed to	

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	meet the specification. Major components shall withstand 150% of rated KW for 60 sec. for every 10minutes. Bidder shall provide all technical datasheets of the above components for our review.	
7.2	The SMPS unit is meant as automatic constant current source of power to the ESP. The SMPS unit shall be suitable for 24 hours a day operation continuously, with frequent sparking in the precipitator load, occasionally having 200 sparks per minute. SMPS is to operate throughout the year in all climatic condition in ESP application.	
7.3	SMPS system shall regulate the output current to the set value within + / - 5 % for any non-Sparking load conditions between 10 to 100% of the rated output current for any / all of the following conditions:	
7.3.1	Variation in impedance of EP load	
7.3.2	Variation in input supply voltage between 415 + 10 % to 415 – 10 %.	
7.3.3	The Unit shall deliver the rated secondary voltage and current with load connected, when the Power supply input voltage is 415V.	
8	**Construction & Design Features of SMPS**	
8.1	Transformer shall be designed for the selected switching frequency. The core and winding material shall be specifically designed for the selected switching frequency.	
8.2	Transformer shall be filled with Silicone oil, nontoxic and shall have high flash point (above 300 Deg. C).Maximum temperature rise is 50 Deg. C above an ambient of 40 Deg. C.	
8.3	SMPS shall have a circuit breaker, contactor and fuses for protection of IGBT's as a minimum.	
8.4	The winding shall be of Electrolytic grade copper.	
8.5.	The core material of the transformer shall be Ferrite or equivalent and the lamination is of high grade Non-aging Cold Rolled Grain Oriented Silicone Sheet Steel type.	
8.6	A suitably rated Radio Frequency Choke shall be located inside the Transformer Tank to protect the SMPS from the sparking that may occur in the ESP.	
8.7	The terminal side of the bushing shall have M10 threading.	
8.8	A suitable metallic duct enclosing the output negative bushing shall be provided with flange for the protection of the Bushing Insulator against adverse condition such as rain and accumulation of dust. An opening to clean the insulator shall be provided in the duct.The flange shall match with the flange provided in the Disconnecting Switch supplied by the buyer. The exact dimensions of the flange will be provided during ordering.	

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8.9	Power connections for LT supply shall be extended with adequate support such that power cables can be terminated vertically without bending the cable cores.	
8.10	There shall be a weather proof Marshaling box mounted on the SMPS unit. The marshaling box shall house current & voltage measurement terminals along with protections, terminations of protection, control and monitoring equipment etc. for safe & reliable operation of the SMPS unit. Interlocking type or colour coded ferrules of proper size shall be used for control and signal wiring.	
8.11	The fixing arrangement of SMPS shall be provided for review and approval.	
8.12	The SMPS unit shall be provided with bi-directional skids, lifting lugs and four jacking pads.	
8.13	The SMPS unit shall be provided with Danger Plate and Name plate.	
8.14	The High Frequency Transformer component of SMPS shall be designed to pass the Double voltage Double frequency testing.	
8.15	The General Arrangement of Components in Transformer unit, lay out inside the enclosure, Electrical power and Control Scheme are subject to BHEL approval.	
8.16	Cutouts as per the sketch indicated in the Annexure 1 shall be provided on the door for mounting a special rotary interlock, (supply & mounting by buyer at site) to de–energize the rectifier when the key of the special interlock is removed. This facility is intended for interlocking of the SMPS with the Precipitator for safety of operating personnel and equipment. Necessary wiring and terminations shall be made to include the NC contact of this key interlock in the Main Power contactor coil circuit without affecting the IP requirement.	
8.17	Anti-vibration pads, if required for the set shall be provided.	
8.18	All controls and instrumentation shall be insensitive to vibration, dust & humidity and shall be fully tropicalized.	
8.19	The bus bar support, if applicable, shall be of molded type, non-hygroscopic, anti-tracking and non- inflammable. The location of power terminals shall be sufficiently above gland plate for ease of cable termination. Bus-bar shall be tinned copper bus suitable to terminate four runs each incoming power & outgoing power cable. All power wiring shall be done with bars of suitable size to withstand 50 KA for 1 Sec.	
8.20	All internal wiring shall be neatly laid out. Ferrule numbering shall be adopted for wiring. Inter component wiring shall be done with extra flexible stranded copper conductor PVC insulated wires. More than two wires shall not be terminated in a terminal block. Each wire shall be provided with a separate lug for termination. Suitable pre-insulated Annealed Tinned Copper	

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	(ATC) lugs and clip on type terminals shall be used in wiring. For CT, shorting link shall be provided. All the wires shall be laid down through cable tray channel. For control and signal wiring, 1 sq mm copper PVC insulated stranded wires to be used.	
8.21	20% spare control terminal blocks shall be provided in the panel for each row / group of terminal. The current rating of terminal blocks shall be at least twice that of terminated wires.	
8.22	SMPS system shall be dust and vermin proof with enclosure meeting IP56 degree of protection as a whole. Neoprene gaskets / natural rubber shall be provided for all metal-to-metal joints. All hard wares such as bolts, nuts and be nickel / cadmium plated / zinc passivated.	
9	**Grounding**	
9.1	There shall be two separate grounding terminals with M12 bolt, nut and washers for Positive grounding of tank. The positive bushing terminal shall be connected by tinned copper strips to the earth terminal, externally. The positive terminal shall also be earthed, internally within the TR set.	
10	**Component Identification and Labeling**:	
10.1	All the components of SMPS shall be identified. Door mounted components shall be identified by fixing anodized Aluminium labels & for components mounted inside the panel / marshaling box shall be identified with Aluminium foil sticker.	
11	**SMPS Controller**	
11.1	The SMPS controller shall be an advanced, latest version with high degree of flexibility, converts the frequency to the required level, monitor, execute algorithms and adjust automatically the output to suit ESP operating conditions. Once programmed by the operator, it shall automatically adjust output without any manual intervention/adjustments. Adequate Alpha-Numeric display shall be provided for operator information/trouble shooting. All parameter setting& editing shall be pass word protected. Controller shall detect failure of any phase. The controller shall have record log of sequence of faults for diagnosis. List of alarms & Trip conditions for trouble free operation of the SMPS shall be provided. It shall be possible to command and control from Remote Terminal Unit (RTU).	
11.2	Following alarms/trip shall be provided as minimum.	
11.2.1	Oil temperature High	
11.2.2	Capacitor bank temperature	
11.2.3	IGBT power pack temperature	
11.2.4	Over load, over voltage	

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11.2.5	AC current High	
11.2.6	Low DC voltage	
11.2.7	High DC voltage	
11.2.8	Management Command Failure	
11.3	Details of SMPS Controller & RTU shall be furnished for our review.	
11.4	The controller shall have analog outputs of 4 to 20 mA corresponding to Rated mA and Maximum DC voltage.	
11.5	It shall be possible to communicate with Controller from Central Computer. Communication interface shall be MODBUS over RS485(2-wire) /Ethernet.	
11.6	User settings are to be retained suitably in memory even after power off condition.	
11.7	Any special communication cable for RTU and Central computer communication (other than 1.5sqmm shielded cable) and all its interfaces like network switch & modem are to be supplied	
12	**Back corona**	
12.1	Detection of Back-corona and optimization of operating parameters based on the VI characteristic/any proven parameter of the field to be provided.	
13	**Type Tests For SMPS**	
13.1	Type test to be conducted as per Contract Quality Requirement(CQR) indicated in Enquiry.	
14	**Painting**	
14.1	**Painting for Transformer**	
14.1.1	The internal and external surfaces including fluids filled chambers and structural steel work of transformer shall be sand blasted / approved equivalent method, to remove all rust, scales or foreign adhering material. All steel surfaces in contact with insulating fluid shall be painted with two coats of heat resistant fluid insoluble in insulating fluid. All sheet steel surfaces exposed to weather shall be given a primary coat of zinc chromate, second coat of weather resistant epoxy paint of colour distinct from primary. Finally two coats of glossy fluid and weather resistant non fading paint of shade RAL 5012 (BLUE) shall be provided. Minimum thickness of paint shall be 50 microns.	
14.1.2	If the transformer tank is made of material other than steel, the same shall be clearly brought out along with the process followed for metal treatment & painting.	

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14.2	**Painting for Controller Unit, Marshaling Box, Enclosure box etc.**	
14.2.1	All sheet steel shall be pretreated in seven tank process in accordance with IS 6005/Equivalent International Standard. Degreasing, de-rusting, phospating (Class C) shall be done for metal treatment. Stove lead oxide primer coating. After primer application, finishing synthetic enamel stoving paint shall be applied. Thickness of paint shall not be less than 50 microns. The final shade shall be RAL 9002 (GREY) in front and rear and RAL 5012 (BLUE) in the extreme end covers of panel. Peelable coating shall be applied on panel after final painting. If the approved drawing calls for any other painting process, then the same shall be followed.	
15	**Makes of Components**	
15.1	The make of components are subject to BHEL review & NTPC approval. Only the Make of components which are approved by NTPC during drawing approval by NTPC shall be used in the supply. There shall not be any commercial implication on account of such approvals.	
16	**Documents to be submitted**	
16.1	**Documents to be submitted along with offer**	
16.1.1	Filled in data sheet forming part of the enquiry.	
16.1.2	Over all General arrangement with dimensions, mounting details, weight, and external clearances required.	
16.1.3	Compliance to the technical specification and list of specific deviations if any. Clarifications will be construed as compliance.	
16.1.4	Brief operation /functioning of SMPS.	
16.1.5	Power and control scheme(Typical)	
16.1.6	Bill of materials of Major components with make & model number.	
16.1.7	List of customers where similar/identical SMPS supplied, year of supply& commissioning, Quantity, country and application like Thermal power /cement etc, Customer feedback on the performance(typical)	
16.2	**Documents to be submitted on placement of Purchase order for BHEL review and NTPC approval:**	
16.2.1	General arrangement of SMPS, controller unit & Marshaling box, inside component layout, Wiring drawing, Bill of material, Power and control scheme, Rating and Diagram plate and technical particulars of High frequency high voltage transformer.	
16.2.2	Detailed calculation for selection / sizing of KVA rating of transformer, RF choke, Diode stack, HV resistor column, IGBT etc. for review/information.	

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16.2.3	Data sheet for transformer, Controller unit, functional/operational write up.	
16.2.4	Interconnection diagram between HVTR and controller unit, Marshaling box, and external equipment interface requirements / other panels.	
16.2.5	Typical test certificate of similar /identical rating and test format for inspection.	
16.2.6	Quality plan with customer check points.	
16.2.7	Packing procedure and drawing.	
16.2.8	Six sets of the above drawings shall be submitted to BHEL for approval, before taking up with manufacture.	
16.2.9	Typical operation and maintenance supplied for identical / similar rating recently to customers.	
17	**O&M Manual**	
17.1	Operation &Maintenance manual in required numbers , as per Enquiry / Purchase order, shall be supplied along with the dispatch of the SMPS. The O&M manual shall be directly sent to BHEL / Ranipet Stores.	
17.2	The O & M manual shall contain the following as minimum requirement. Relevant GA drawings, power & control schemes, operational write up, wiring drawings, Rating and diagram plate, Do's and Don'ts, details on storage, handling, pre commissioning checks, commissioning procedure, Controller operating details, set parameters, trouble shooting, manufacturer's catalogue for various bought out components etc., List of recommended spares for three years trouble free maintenance spares with Quantity.	
17.3	The scheme drawings shall indicate all the components so that trouble shooting can be made easier.	
17.4	Exhaustive Bill of Materials indicating description, rating, quantity, make, model number , datasheet etc., for ordering components at a later date.	
18	**Inspection & Testing**	
18.1	The SMPS shall be tested based on the following documents:	
18.1.1	BHEL Purchase order (PO).	
18.1.2	BHEL Technical specification/ordering specification as finalised &indicated in the PO.	
18.1.3	Quality checklist / Quality Plan as finalised & indicated in the PO.	
18.1.4	Test Procedure TP: 110 (latest revision).	
18.1.5	BHEL/NTPC approved vendor drawings.	
18.1.6	Vendor shall provide specific confirmation to all the individual tests requirements.	

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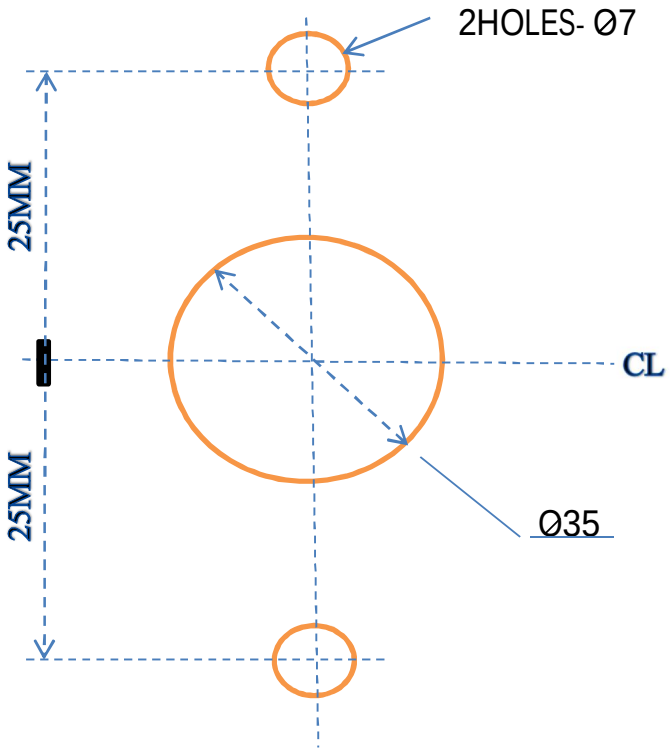
19	**Packing**	
19.1	The equipment shall be properly packed with sea worthy packing to avoid any damage during transit / storage. The packing shall be weather proof and suitable for outdoor storage. Necessary provisions / marks for handling shall be provided. Each packing shall contain a packing slip showing all the components, supplier reference and Name, purchase order number, serial number of equipment, destination address, brief equipment description, one copy of instruction manual and relevant test certificates. Loose components if any, shall be clearly indicated in packing slip.	
19.2	Each SMPS unit shall be packed separately. Loose Items related to each SMPS unit shall be packed along with the SMPS for ease of identification.	
19.3	Each crate shall indicate the Purchase Order number, Name and address of the consignee, approximate weight, Name of equipment (SMPS), Shipping marking etc.	
20	**Commissioning supervision & Training**	
20.l	Commissioning supervision is required for 1 set of SMPS at Thermal Power Station. Training on Commissioning, Operational and Maintenance of SMPS are to be provided during the visit of Commissioning Supervision	
20.2	Additional Commissioning Supervision Charges over and above the first Set of SMPS at Thermal Power Station shall be quoted separately as an optional item. Vendor to note that commissioning of SMPS may take up to 2 years from the date of supply.	

Annexure-I



DRILLING DATA ON PANEL FOR FIXING INTERLOCK

DOCUMENT TITTLE : TEST PROCEDURE FOR BOUGHT OUT ITEMS FOR ELECTROSTATIC PRECIPITATOR

ITEM : SWITCH MODE POWER SUPPLY

PROJECT : BHEL STANDARD

	NAME	DESIGNATION	SIGNATURE	DATE
PREPARED BY	E.ARULSELVI	SR. ENGINEER		04-01-2016
REVIEWED BY	V.S.SURESHKUMAR	DGM		04-01-2016
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ISSUED BY

EDC – C&I

RECORDS OF REVISIONS :

REVISION NUMBER 00 INITIAL RELEASE Dt. 04-01-2016

1. INTRODUCTION:

   This testing procedure describes the procedure for functional testing of SWITCH MODE POWER SUPPLY.

2. OPEN CIRCUIT TEST

   Connect 3-Phase 415V/ 50Hz Power supply with suitable current rating to the input terminals of SMPS. Keep the DC output terminal of SMPS in OPEN condition. Increase the Output DC KV to rated KV from zero. There shall not be any primary current shoot-up during the test for the system to pass. The NO-LOAD loss and current shall be recorded at 0%, -10% and +10% of the rated primary voltage.

3. HIGH VOLTAGE AND INSULATION RESISTANCE TEST

   3.1 INSULATION RESISTANCE (IR) TEST

   Short the Input Power terminals of SMPS. Short the HV DC output terminal of SMPS. Secondary of all transformers (other than High Frequency Transformer) shall be shorted together. Isolate/Remove all electronic components from the system.

   3.1.1 Measure IR at the following terminals using 2000V DC MEGGER

   a. Between DC output and Earth : Minimum 50 Meg Ohm

   3.1.2 Measure IR at the following terminals using 500V DC MEGGER

   a. Between Input Power terminal groups and Earth : Minimum 5 Meg Ohm
   b. Between Input Power Terminal groups and Output Terminal : Minimum 5 Meg Ohm
   c. Between Output Terminal and Earth : Minimum 5 Meg Ohm

   3.2 HIGH VOLTAGE TEST

   The Input power Terminals shall be shorted together. Output DC terminals are shorted. Secondary of all transformers (other than High Frequency Transformer) shall be shorted together. Isolate/Remove all electronic components from the system. Apply High voltage

as given below for 1 minute between the following groups and ensure that all the groups withstand this test.

a. Between Output terminal and earth : 3KV
b. Between Input Power terminal groups and Earth : 2KV

3.3 DOUBLE VOLTAGE DOUBLE FREQUENCY TESTING ON HIGH FREQUENCY TRANSFORMER OF SMPS

With secondary terminals of High Frequency Transformer kept open, apply a power supply having two times the rated transformer primary voltage at twice the rated frequency, for 1 minute, between primary terminals of High Frequency Transformer. The High Frequency Transformer shall withstand this test.

4. RESISTANCE AND CAPACITIVE LOAD TEST FROM 0 TO RATED LOAD

Ensure the following settings.

a. The Set Current is set to Zero.
b. Spark Rate set to 10 (minimum).
c. Maximum Current Limit set to Rated Current.

Connect rated Resistive (R) and rated Capacitive (C) load to SMPS Output terminals

$$\text{The rated Resistive load in M}\Omega = \frac{\text{RATED KV (AVERAGE)}}{\text{RATED mA (AVERAGE)}}$$

The rated capacitive Load in pF = K x (Rated mA (Average)).

(The value of K is between 100 and 200).

The value of the resistance and capacitance shall be recorded. The SMPS shall be tested with R separately and R+C load connected in parallel separately. The test shall be carried out at the Set Currents 0%, 10%, 25%, 50%, 75% & 100%.In all cases, record the primary voltage, primary current ,secondary voltage & secondary current.

5. CURRENT REGUALTION TEST

5.1 LINE REGULATION TEST

Switch off power to SMPS. Apply 373 V at the SMPS input terminals. With the above set up and at 100% Set Current, switch HT ON to switch on power to SMPS. Record the secondary DC current when it reaches the steady value. Secondary DC current value should not deviate more than 5% from Set Current.

Switch off power to SMPS. Apply 457 V at the SMPS input terminals. With the above set up and at 100% set current, switch HT ON to switch on power to SMPS. Record the secondary DC current when it reaches the steady value. Secondary DC current value should not deviate more than 5% from Set Current.

5.2 LOAD REGULATION TEST

With the above set up, switch off supply to SMPS. Connect 10% of rated resistive load and rated capacitance at the secondary of SMPS. Apply 415 V at the input terminals of SMPS. Switch on power to SMPS and set the Set Current at 100%. Then switch HT ON to switch on power to SMPS. When output DC current reaches steady value, record the same. It should not deviate by more than 5% from Set Current.

6.0 PULSE MODE OPERATION

With the above set-up, put SMPS in pulse mode with appropriate settings. Duty cycles shall be kept at 10%, 25%, 50% and 100% of the maximum range. During the test, SMPS shall not trip and no primary current shoot-up shall be observed.

7.0 SPARK RATE CONTROL TEST

Switch off power to SMPS. Connect spark gap across R+C load. Switch on power to controller. Set suitable parameters such that the spark-rate is set as 4/min. Set HT-ON mode in to energize SMPS Output. Spark will appear on load side as current rises. After each spark, verify that the

secondary DC current drops by 25% (approximate) of Rated Current. Also verify that the time between two consecutive sparks is 15 seconds (approximate).

8.0 SPARK TEST

With the above set up, set suitable parameters such that Spark Rate is set to approximately 160 to 180 sparks per minute to appear on the load side of SMPS. Continue this test for 3 minutes and ensure that the SMPS withstand this test without any trip or primary current shoot up.

9.0 SPARK SIMULATION TEST

With the above set up, Set spark rate to 10 Sparks/Min. Keep the DC secondary current 25%, 50%, 75%, and 100% each for 2 minutes, by setting Set Current and observe that no trip occurs.

10.0 FAULT ANNUNCIATION TEST

All the fault annunciations are to be tested. Faults can be simulated by shorting the respective terminals. Records shall be verified for faults, which could not be simulated. The list of all applicable alarms will be referred from approved data-sheet.

11.0 RESISITIVE LOAD TEST FROM 0 TO RATED LOAD

Switch off power to SMPS. Disconnect the capacitive load and spark gap. Keep only

Resistive load connected at the output terminals. Ensure Set Current is kept at 100% of rated value.

Switch on power to SMPS. Set HT-ON mode key to energize SMPS output. Observe that the output DC current rises slowly and record the value when it reaches steady value. This value should not deviate from the rated current by more 2%.

Make Set-Current as 0% of rated value. Now record the output DC current value. This value should not be more than 5% of rated DC current.

12.0 QUANTUM OF TESTS

Test following are the quantum of tests to be conducted on SMPS Sets.

01	OPEN CIRCUIT TEST	100%
02	IR & HV TEST	100%
03	RESISTIVE & CAPACITIBE LOAD TEST	100%
04	CURRENT REGULATION TEST	1/Lot
05	PULSE MODE OPERATION	100%
06	S&T CONTROL TEST	1/Lot
07	SPARK TEST	1/Lot
08	SPARK SIMULATION TEST	1/Lot
09	FAULT ANNUNCIATION TEST	100%
10	RESISTIVE LOAD TEST FROM 0 TO RATED LOAD.	1/Lot