EUROPEAN POWER SUPPLY MANUFACTURERS ASSOCIATION
(Visit the EPSMA website at www.epsma.org)

Safety Approvals for Railway Applications

Guidelines to the standard EN50124-1 and EN50155

Revision Date: 10th Nov 2008

This document gives an overview of design issues, definitions and useable standards currently used in AC/DC power supplies for railway applications. It aims to provide a common understanding of which safety rules and certifications should be used depending on the final application of the standard.

Furthermore this document provides a general interpretation of how different standards - requirements are in practice realized in power supplies.

Paper prepared by the EPSMA Technical Committee. Special thanks and acknowledgements to Matthias Emerson (Delta Energy Systems), for his contribution to this document.

The European Power Supply Manufacturers Association was established in 1995, to represent the European power supply industry.

This report was supported by
Bureau Veritas E&E Product Services GmbH,
Türkheim, Germany

Content:

1. Introduction

The requirements for components and electronic equipment used in railway applications is harmonised within the European Union. It therefore makes sense to produce a general railway approval of components such as power supplies, shipped for use in these applications in Europe.

This application note is intended for equipment used in stationary and rolling stock railway applications.

2. Applicable Standards

When we talk about applications for railway, we have to differentiate between rolling stock and stationary equipment.
Stationary equipment will be investigated according to:

- IEC50155, IEC60950 are excellent base standards for product safety for railway in combination with spacing in accordance to EN50124-1. (IEC60950 is more severe compared to EN50124-1 for pollution degree II and over voltage category II).
- EMC as agreed with the customer (e.g. EN50121-3-2)
- MTBF calculation in accordance to IEC61709 / SN29500 and reliability requirements according IEC60605
- Environmental and ambient testing as agreed with the client. (e.g. vibration to EN61373)
- EN50126 Railway application – The specification and demonstration of Reliability, Availability, Maintainability and Safety

Note - some of the national railways offices accept test reports and technical documentation in their native language only. For example the German Railway Office (www.**eisenbahn-bundesamt**.de) accept test reports in German language only.

3. Power Supplies approved according to EN50155 –RAILWAY APPLICATIONS- Electronic equipment used on rolling stock

This above mentioned standard covers the following topics:
(clauses refer to (prEN50155:2006))

- Chapter 4 – Normal Operating Conditions - These environmental conditions have to be defined carefully between client and power supply manufacturers. They include altitude, ambient, shock- and vibration, relative humidity, special operating conditions, atmospheric pollutants.
- Chapter 5- Electrical Operating Conditions – Conditions of the supply such as nominal voltages of accumulator batteries, variation of voltage supply, interruption of voltage supply, variation of voltage supply for rolling stock powered by thermal engines, DC ripple factor, supply by a static converter rotating set, supply change over, supply with overhead line and third rail, supply over voltages, installation, surges, burst
    - Chapter 5.5 Electromagnetic Compatibility (EN50121-3-2)

- Chapter 6 Reliability, Maintainability and Expected Useful Life
- Chapter 7 – Design for quality (quality management, life-cycle, interfacing, fault protection) interchange ability, Inrush currents,
    - Chapter 7.3 – Software (EN29000-3 shall be used for the application of EN ISO9001 software)
- Chapter 8 – Components – Procurement, application, second source.
- Chapter 9 – Construction, Socket and connectors, component mounting, layout, fixing, component terminations, pre-set control, testability, PCB boards
- Chapter 10 – Safety, (refer to EN50126, EN50128, EN50129)
- Chapter 11 – Documentation
- Chapter 12 – Testing (Type, routine, investigation tests)

3.1. Steps to approval

Product Safety Testing is performed in accordance to IEC60950 with creepage and clearance in accordance to EN60124 and in addition, the tests required in chapter 12. The report format is enclosed in this document.

Environmental testing:
Shock and vibration test is mandatory only if unit is non-potted. This environmental test is often done as part of the end product evaluation and not done at the power supply build stage.

Components to be verified to the specification versus application and to the requirement of EN50155. In Specific second source is mandatory.

Quality system audit according to EN50155. Appendix the test protocol about quality. ISO900x certification will be accepted.

Temperature cycle test for potted components (Power Supplies)

EMC test reports will be accepted from accredited EMC test houses.

Documentation to be verified to Chapter 11guidelines.

MTBF calculation to IEC61709 / SN29000-1, -2, - 3 , -4

Certification : GS mark and additional approval to EN50155.

Routine test to be performed for each unit in production:

(Clause 12.2)

Visual inspection
Performance test (function)
Insulation test (consists out of dielectric and insulation resistance)
Requirement according to EN50116 (protective earth resistance) has to be tested in addition.

4. Requirements for Approval

The following tables list the requirements that are provided by the safety approval agency for approval of the power supply:

Requirement which enables the test house to do the approval:	
Three samples of the P/S. In case of a series two samples of the lowest and highest output voltage, and one from each output voltage in between will be required.	
Type label	
Layout and layout with the marked potentials (primary, secondary)	
Circuit diagram	
Component placement	
Transformer winding description	
Price parts list with vendors and types	
Specification	
Manual	
Two unpotted transformers	
Connectors if required	

Information required for the component verification to chapter 8				
Component	Is used for	Rating	Specific.	Vendor, Type

5. Creepage and Clearance distances according EN50124

This information will help with the proof for creepage distances and clearances for railway applications.
This standard is based on IEC60664 which gives important information on the rating of clearance.
EN50124-1 is supplemented with relation of the over voltage category for railway applications.

<u>Field of application and purpose.</u>
The whole document handles the isolation coordination for railways .It is useful for electrical operational equipment for the operation in railway signal constructions, trains and local railway constructions up to 2000m height above sea level.

<u>This part does not treat “distances through fixed and liquid insulation”. For voltages up to 1000 V IEC60950 is used. For higher voltages a partial-discharge test is used.</u>

The following rough formula may be used to calculate thickness of isolation:
Distance spacing through isolation is...(value of working voltage – 1000)*0,0004 mm +0,4 mm.

Example: 3000 V working voltage yields 3000 – 1000 = 2000.
2000 * 0,004 = 0,8 mm
Thickness of isolation should be 0,8 + 0,4 = 1,2 mm.

<u>Functional insulation</u> is different to IEC60950. The possibility to prove the conformity through short circuits is not part of EN50124-1.

<u>Basics of the insulation coordination.</u>

It is important to consider the following:

Voltages which can appear in the system;
Voltages which are produced through electrical equipment;
Graduate of expected availability.
Function security of control and protection systems
Induced voltages in cables which are installed along the railway embankment.
Form of the insulating surfaces
Location and mounting position of creepage distance.

5.1 Determination of the necessary clearance in air

The voltage of the isolation will be measured: (“working voltage measurement”
Furthermore, the over voltage will be determined by the application

- OV1:electric circuits, which are protected by external and internal over voltage and in which small over voltages are appearing.
- OV2: as OV1; however with stricter over voltage terms and higher standards relating to protection and reliability.
- OV3; as OV4; however with less strict over voltage terms and with less standards relating to protection and reliability.
- OV4: electric circuits, which are not protected against internal and external over voltage.

Furthermore, there is a difference if systems are connected directly with the traction system or not. Depending on this there are various tables to use. (Table A1,A2; EN50124-1)

Normally, there are stated seven standards on pollution severities (PD1; PD2; - PD7; EN50124-1).

Functional Isolation:
The lower limiting value from clearance in air of functional isolation will be measured for rating withstand voltage according to table A3 (or proved through tests).
There is an essential difference to IEC60950. There is also the possibility to cover up with lacquer.

5.2 Dimensioning of creepage distances.

The standards distinguish between functional isolation, base and additional insulation. Regarding the dimensionality - pollution severity, working voltage and material condition CTI must be considered.

Example:

Power adaptor will not be operated out of the contact line. (single-phase; OV2; CTI = III; PD2; working voltage 320 Vrms)

From table A1 the rated impulse voltage will be determined. A rated impulse voltage of 4,0 KV, is the result of the working voltage.
With table A3 the clearance in air of 3,0 mm will be determined primary to secondary.

Creepage distance:

According to table A5 there are 1, 6 mm creepage distance on the conductor map and according to A6 there are 3, 2 mm for other materials.

	Clearance in air	creepage distance
L to N Functional	0,5 mm	1,6 mm (*)
L and N to PE	0,5 mm	1,6 mm
Primary to Secondary PCB	3,0 mm	3,2 mm
Primary to SecondaryTransformer	3,0 mm	6,4 mm

A voltage of 240V was applied because the high working voltage flowing out of the transformer was not impressed.

For the distance on the PCB, on which the distances for functional isolation are lower there must be an insulation test performed according to table A8 (EN50124-1) Furthermore it is allowed to cover up with liquor or casting compound.

6. Test Report

The following pages show an example of a typical test report.

TEST REPORT **DIN EN50155** **Safety Approval of Power Supplies for Railway Applications**		
Report reference No ....:		
Tested by (printed name and signature) ....:		....
Approved by (printed name and signature) ....:		....
Date of issue ....:		
Testing Laboratory Name ....:		
Address ....:		
Testing location ....:		
Address ....:		
Applicant's Name ....:		
Address ....:		
Test specification		
Standard ....:	DIN EN50155	
Test procedure ....:		
Non-standard test method ....:		
Test Report Form No...........................:		
TRF originator . ...:		
Master TRF ....:		
Test item description ....:		
Trademark ....:		
Manufacturer ....:		
Model and/or type reference ....:		
Serial number ....:		
Rating(s) ....:		

Copy of marking plate
Enclosures to this report Photographic documentation Documentation of the manufacturer: schematic diagram layout, specification, description of transformer, unit list, MTBF and calculation of endurance. Documents quality protection system

History Sheet			
		Initial report was written	Rev. 0

Summary of the results

This assembly has been tested according to EN50155 and passed the tests

6.1 List of tests required according EN50155

List of tests			
1	10.2.1	Visual inspection	
2	10.2.2	Performance test	
3	10.2.3	Cold test / Low temperature test	
4	10.2.4	Dry heat test,	
5	10.2.5	Damp heat test, cyclic	N/A
6	10.2.6	Supply overvoltages / ESD	
7	10.2.7	Surges, electrostatic discharge and transient burst susceptibility tests	
8	10.2.8	Radio interference test	
9	10.2.9	Insulation test	
10	10.2.10	Salt mist test	
11	10.2.11	Vibration, shock and bump test	
12	10.2.12	Water tightness test	
13	10.2.13	Equipment stress screening	
14	10.2.14	Low temperature storage test	

Particulars: test item vs. test requirements	
Equipment mobility:	e.g. table top or wall mounting unit.
Operating condition	e.g. Continuous Operation
Mains supply tolerance (%)	
Tested for IT power systems:	
IT testing, phase-phase voltage (V):	
Class of equipment:	e.g. Class I
Mass of equipment (kg):	
Protection against ingress of water:	
Test case verdicts	
Test case does not apply to the test object:	N/A
Test item does meet the requirement:	P(ass)
Test item does not meet the requirement:	F(ail)
Testing	
Date of receipt of test item:	
Date(s) of performance of test:	

General remarks –

The test result presented in this report relate only to the object(s) tested.

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This report shall not be reproduced, except in full, without the written approval of the Applicant.

This report contains following documents:

1. Test Report
2. National Differences – Enclosure No. 1 –
3. Additional Test Data – Enclosure No. 2 –
4. Pictures – Enclosure No. 3 –
5. Schematics, Layouts, Transformer data - Enclosure No. 4 –
6. Datasheets of Safety critical components (if required) – Enclosure No. 5 –
7. Test Equipment list – Enclosure No. 6 -

General product information:
Tests required for the unit test: Input to Output minimum requirements: 1500 Vac. or 2200 Vdc

Test Report			
Clause-	Requirement – Test	Result	Verdict
1	Scope		
2	Normative reference		
3	Definitions		
3.1	PWB		
3.2	Mounted PWB		
3.3	Plug-in unit		
3.4	Sub-rack		
3.5	Rack		
3.6	Cubicle (enclosure)		
3.7	Line replaceable unit		
3.8	Performance check		
3.9	Control system voltage supply		
3.10	Vehicle wiring		
3.11	Supply overvoltage		
3.12	Surge		
3.13	Burst		
3.14	Failure		
3.15	Damage		
3.16	Useful life		
4	Environmental operating conditions of operation		
4.1	Normal operating conditions		
4.1.1	Altitude		
4.1.2	Ambient temperature		
4.1.3	Shock Vibration		
4.1.4	Relative humidity		
4.2	Special operating conditions		
4.2.1	Atmospheric pollutants		
5	Electrical operating conditions		
5.1	Power supply		
5.1.1	Supply from accumulator battery		
5.1.1.1	Variations of voltage supply		
5.1.1.2	Interruption of the supply voltage		
5.1.1.3	Variations of voltage supplies for rolling stock powered by thermal engines		
5.1.1.4	DC current ripple factor		
5.1.2	Supply by a static converter or a rotating set		
5.1.3	Supply change over		

Test Report			
Clause-	Requirement – Test	Result	Verdict
5.1.4	Supply with overhead line or third rail		
5.2	Voltage impact caused by supply voltage		
5.3	Installation		
5.4	Surged, electrostatic discharge and transient burst susceptibility tests		
5.5	Electromagnetic compatibility		
6	Reliability, maintainability and expected useful life		
6.1	Equipment reliability		
6.1.1	Predicted reliability		
6.1.2	Proof of reliability		
6.2	Useful life		
6.3	Maintainability		
6.4	Maintenance levels		
6.4.1	On-vehicle diagnosis		
6.4.2	Off-vehicle diagnosis and repair		
6.5	Built-in diagnostics		
6.6	Automatic test equipment		
6.7	Alternative methods for fault diagnosis		
6.8	purpose built test equipment and special tools		
7	Design		
7.1	General		
7.1.1	Quality management		
7.1.2	Life cycle		
7.2	Detailed practices/Hardware		
7.2.1	Interfacing		
7.2.2	Fault protection		
7.2.3	Referencing power supplies		
7.2.4	Interchange ability		
7.2.5	Reduction of supply voltage		
7.2.6	Polarity reversal		
7.2.7	Inrush currents		
7.2.8	Spare capacity		
7.3.	Detailed practices/Software		
7.3.1	General		
7.3.2	Software design measures		
7.3.2.1	Modular approach		
7.3.2.2	– Translator proven in use		
7.3.2.3	Recording		
7.3.2.4	Structured methodology		
7.3.2.5	Design and code methods		

Test Report			
Clause-	Requirement – Test	Result	Verdict
7.3.2.6	Structured programming and analysis		
7.3.2.7	Programming language		
7.3.2.8	Proven techniques		
7.4	Equipment features		
7.4.1	Memory checking		
7.4.2	Self test		
7.4.3	Watchdog / control function		
7.4.4	Error indication		
7.4.5	Recovery		
8.	Components		
8.1	Procurement		
8.1.1	Component specification		
8.1.2	Quality system		
8.1.3	Corresponding to the standards		
8.1.4	Multiple sources		
8.1.5	Single source		
8.1.7	ASIC description		
8.2	Application		
8.2.1	Quality of components		
8.2.2	Not approved components		
8.2.3	Use		
8.2.4	Temperature range		
9	Construction		
9.1	Equipment construction		
9.1.1	Mechanical protection		
9.1.2	Polarisation or coding		
9.1.3	Dimensional requirements		
9.1.4	Sockets and connectors		
9.2	Component mounting		
9.2.1	Layout		
9.2.2	Fixing		
9.2.3	Component terminations		
9.2.4	pre-set control		
9.2.5	Selection on test (SOT) components		
9.3	Electrical connections		
9.3.1	Soldered connections		
9.3.2	Crimped connections		
9.3.3	wire wrap connections		
9.3.4	Other connections		

Test Report			
Clause-	Requirement – Test	Result	Verdict
9.4	Internal flexible wiring (electrical and optical)		
9.5	Flexible printed wiring		
9.6	Printed boards (flexible and rigid)		
9.6.1	character of PWBs		
9.6.2	Procurement		
9.6.3	Layout		
9.6.4	Materials		
9.7	Protective coatings for printed board assemblies		
9.8	Identification		
9.8.1	Bare printed board identification		
9.8.2	Identification of sub-racks and printed board assemblies		
9.8.3	Mounting position of sub-racks and printed board assemblies		
9.8.4	Fuse and battery identification		
9.9	Mounting		
9.10	Cooling and ventilation		
9.11	Materials and finishes		
10	Safety		
10.1	General		
10.2	Functional safety		
10.3	Personnel safety		
11	Documentation		
11.1	Supply and storage of documentation		
11.2	Hardware and software documentation		
11.2.1	Hardware documentation		
11.2.2	Software documentation		
11.3	Documentation requirements		
11.3.1	Documents		
11.3.2	Circuit diagrams		
11.3.3	Component lists		
11.3.4	Component layout		
11.3.5	Block diagrams		
11.3.6	wiring plans		
11.3.7	Interconnection diagrams		
11.3.8	Equipment drawings		
12	Testing		
12.1	Categories of tests		
12.1.1	Type tests		
12.1.2	Routine tests		

Test Report			
Clause-	Requirement – Test	Result	Verdict
12.1.3	Investigation tests		
12.2	List of tests		
12.2.1	Visual inspection		
12.2.2	Performance test		
12.2.3	Cooling test Cold temperature test		
12.2.4	Dry heat test		
12.2.5	Damp heat test		
12.2.6	Supply overvoltage test		
12.2.7	surges, electrostatic discharge (ESD) and transient burst susceptibility test		
12.2.8	Radio interference test		
12.2.9	Insulation test		
12.2.10	Salt mist test		
12.2.11	Vibration, shock and bump test		
12.2.12	Water-tightness test		
12.2.13	Equipment stress screening		
12.2.14	Low temperature storage test		

4. MTBF and Useful Life

Example of MTBF calculation according IEC61709 / SN29500:

MTBF-Berechnung nach Siemens-Norm SN29500

$T_{amb,calc}$	70°C
$T_{amb,mean}$	19°C
Σ FIT: 3843	
MTBF: 260.238h	

Kunde:	
Projekt:	
Datum:	27.06.01

Bezeichnung	Anzahl	RefDes	U_{Rated}	U_{Op}	T_{Mean}	ΔT	T	λ/part	λ	FIT / Σ
D-FORMAT 5X20 (G-SICHERUNGSEINSÄTZE)	1	F1	250V	0V	40°C	21,0K	91°C	0,100	**0,100**	0,0%
SONSTIGE KONDENSATOREN (Z.B. X2-, Y-KONDENSATOREN)	2	C1, C11	275V	264V	47°C	28,0K	98°C	188,427	**376,854**	9,8%
Varistor	1	R14	250V	264V	45°C	26,0K	96°C	48,429	**48,429**	1,3%
Induktivitäten f. EMV, < 3 A	1	L1	250V	264V	50°C	31,0K	101°C	6,497	**6,497**	0,2%
BRÜCKENGLEICHRICHTER	1	V11	600V	370V	40°C	21,0K	91°C	12,383	**12,383**	0,3%
BOBBIN CORE-INDUKTIVITÄTEN (STAB-,ROLLEN-,ROHRKERN)	2	L5, L6	3V	3V	45°C	26,0K	96°C	4,678	**9,357**	0,2%
Elko, Aluminium, flüssig	2	C15, C16	400V	150V	42°C	23,0K	93°C	95,602	**191,204**	5,0%
Hochspannungsgleichrichterdiode	3	V1, V2, V3	600V	150V	43°C	24,0K	94°C	274,870	**824,609**	21,5%
C, Metallfolie, Polycarbonat	2	C2, C7	400V	300V	45°C	26,0K	96°C	338,582	**677,164**	17,6%
SONSTIGE KONDENSATOREN (Z.B. X2-, Y-KONDENSATOREN)	2	C13	2500V	200V	47°C	28,0K	98°C	12,808	**25,615**	0,7%
Optokoppler mit bipolarem Ausgang (SFH610, CNY17, 6N136)	1	V9	5000V	200V	45°C	26,0K	96°C	107,090	**107,090**	2,8%
MOSFET, Leistung (TO3, TO220, D-Pak ...)	1	V10	800V	600V	62°C	43,0K	113°C	201,299	**201,299**	5,2%
OPV, Komparatoren, Spg-Überwachung, CMOS (Transistoren: <31)	1	U2	10V	10V	40°C	21,0K	91°C	40,015	**40,015**	1,0%
METALLSCHICHTWIDERSTÄNDE	3	R2, R3, R4	150V	70V	50°C	31,0K	101°C	0,291	**0,874**	0,0%
THERMISTOREN (NTC, PTC)	1	R6	250V	5V	80°C	61,0K	131°C	5,000	**5,000**	0,1%
Elko, Tantal, fest	1	C10	16V	10V	43°C	24,0K	94°C	20,774	**20,774**	0,5%
Gleichrichterdiode, Leistung	1	V12	60V	40V	63°C	44,0K	114°C	9,317	**9,317**	0,2%
Hochspannungsgleichrichterdiode	1	V13	800V	500V	70°C	51,0K	121°C	653,977	**653,977**	17,0%
E-CORE-TRAFO'S (E-, EC-, EF-, EI-, EP-KERN) bis 16kVA	1	W1	3000V	0V	50°C	31,0K	101°C	24,592	**24,592**	0,6%
Elko, Aluminium, flüssig	1	C4	16V	10V	52°C	33,0K	103°C	263,918	**263,918**	6,9%
Elko, Aluminium, flüssig	1	C6	100V	30V	47°C	28,0K	98°C	121,085	**121,085**	3,2%
C, Keramik, HDK (X7R, Z5U ...)	3	C3, C8, C14	25V	15V	40°C	21,0K	91°C	18,381	**55,144**	1,4%
METALLSCHICHTWIDERSTÄNDE	12	R9, R21, R5, R15, R25, R27,R26, R8, R10, R11, R12, R20	150V	15V	40°C	21,0K	91°C	0,230	**2,763**	0,1%
C, Keramik, HDK (X7R, Z5U ...)	1	C12	100V	50V	45°C	26,0K	96°C	14,333	**14,333**	0,4%
Universaldiode	2	V4, V5	75V	15V	40°C	21,0K	91°C	4,054	**8,108**	0,2%
BOBBIN CORE-INDUKTIVITÄTEN (STAB-,ROLLEN-,ROHRKERN)	1	L4	100V	10V	45°C	26,0K	96°C	4,678	**4,678**	0,1%
C, Keramik, HDK (X7R, Z5U ...)	1	C9	500V	200V	50°C	31,0K	101°C	11,131	**11,131**	0,3%
Spg.-Referenzen	1	V23	18V	12V	40°C	21,0K	91°C	124,832	**124,832**	3,2%
ISOLATED WIRES (ISOLIERTE LEITUNGEN,SCHALTDRÄHTE U. -LITZEN)	5	X1, X2,X3, X4, X5	0V	0V	30°C	11,0K	81°C	0,100	**0,500**	0,0%
SINGLE POLE CONNECTORS (EINPOLIGE STECKVERB.)	5	X1, X2,X3, X4, X6	0V	0V	30°C	11,0K	81°C	0,200	**1,000**	0,0%

5. Development – Information quality system

Extract of the Quality Assurance System, ISO Certificate

6. Construction elements

6.	TABLE: Components	

object/part No.	Use for	manufacturer/ trademark	type/model	technical data	Measured data	standard	mark(s) of conformity[1])

1) an asterisk indicates a mark which assures the agreed level of surveillance
2) + indicates that components from other vendor and other model number, but with the same rating and equivalent approvals are accepted.

Enclosure No. 2

Additional test data

	TABLE: maximum temperatures on components						P
	test voltage (V) .... :	90	264	90	264	264	—
		Horizontal		Wall mounted		Horiz.	
	t_{amb1} (°C) .... :	23,6	24,1	20,8	20,7	22,9	—
	t_{amb2} (°C) .... :	40,0	40,0	40,0	40,0	40,0	—

maximum temperature T of part/at::	T (°C)					allowed T_{max} (°C)
Component x						----
Component y						80
						80
						80

10.2.1 Visual inspection

10.2.1	TABLE: clearance and creepage distance measurements					P
clearance cl and creepage distance dcr at/of:	Up (V)	U r.m.s. (V)	required cl (mm)	cl (mm)	required dcr (mm)	dcr (mm)
Input primary L to N	340	240	1,5		2,5	
Input primary to groung	340	240	2,0		2,5	
Input primary to secondary	340	240	4,0		5,0	
Secondary to ground	30	30	0,7		1,2	

	TABLE: ball pressure test of thermoplastic parts		P
	allowed impression diameter (mm) ....:	≤ 2 mm	—
Part		test temperature (°C)	impression diameter (mm)
e.g. Connector X		125 °C	1,1 mm

	TABLE: resistance to fire				P
Part	manufacturer of material	type of material	thickness (mm)	flammability class	
e.g. Enclosure					

	TABLE: distance through insulation measurements				N/A
distance through insulation at/of:		Up (V)	test voltage (V)	required di (mm)	di (mm)

	TABLE: Steady force test (internal spacings push test)	P

Components and parts, other than parts serving as an enclosure, are subjected to a steady force of 10 N ± 1 N.

Parts of an enclosure located in Operator Access Area, which are protected by a cover or door, are subjected to a steady force of 30 N ± 3 N for a period of 5 s, applied by means of a straight un-jointed version of the test finger, to the part on or within the equipment.
External enclosures are subjected to a steady force of 250 N ± 10 N for a period of 5 s, applied in turn to the top, bottom and sides of the enclosure fitted to the equipment, by means of a suitable test tool providing contact over a circular plane surface 30 mm in diameter. However, this test is not applied to the bottom of an enclosure of equipment having a mass of more than 18 kg.

Part	Thickness	Force	Observation
Componets 10 N		10 N	Basic and reinforced isolation are not shorted
Enclosures 250 N		250 N	Enclosure remains undemaged

Comments:

10.2.2 Performance test

1.6.2	TABLE: electrical data (in normal conditions)					P
fuse #	Irated (A)	U (V)	P (W)	I (A)	Ifuse (mA)	condition/status
	0,8	90	54,0	0,59		Rated load
	0,8	100	53,8	0,53		Rated load
	0,8	240	52,4	0,241		Rated load
	0,8	264	52,5	0,230		Rated load

Numbers are for example only

	TABLE: fault condition tests					
	ambient temperature (°C) ....:				20,5 °C	—
	model/type of power supply:					—
	manufacturer of power supply :					—
						—
component No.	Fault	test voltage (Vdc)	test time	fuse No.	fuse current (A)	Result
Output	Short Circuit	264 Vac	10 min			Observations e.g. max. output current, breaking of fuses, …
Output	Overload	90 Vac	3 h			Observations e.g. max. output current, temperature of critical components such as transformer, …
Output	normal condition	0 Vac	30 min			Observations. e.g. deep discharge protection, …
Supplementary information						

	TABLE: Energy hazards			P
The sample was connected to 72 V dc. With the unit operating normally, a variable resistor was connected across the points noted beside. The current through the resistor and voltage across the resistor were monitored using suitable meters. The resistance was adjusted to obtain maximum VA at a voltage exceeding 2 V.				
Model	Test Point	Volts	Amps (A)	Max. VA
Comments: E.g.: The output power is less than 240W and generates no risky energy hazards				

	TABLE: Discharge of capacitors in the primary circuit			P
The unit was connected to 264.V a.c. , 50 Hz. A storage oscilloscope was connected across the external point of disconnection of the mains supply. With all switches in the unit initially set to the off position, the unit was disconnected from the supply source. The voltage at the time of disconnection, Vo, and the voltage Vtc at 1 second was recorded.				
Model	Location	Time Constant	Measured voltage after 1 sec.	Condition
	Input L – N	< 1 Sec	0	with and without external load
Comments:				

	TABLE: Voltages under normal conditions			N/A
The unit was connected to ____ V ac , and 50 Hz. The output were loaded to the rated value. The voltage at each secondary winding was recorded. If the voltage exceeded 42.4 Vpk or 60 V dc, the measurement were taken again after the next component in series with the secondary until the voltage measured was less 42.4 Vpk or 60 Vdc.				
Model	Transformer Designation	Location	Maximum Voltage (Vpk/dc)	Voltage Limiting Component
Comments:				

	TABLE: Limited current circuit	N/A
The unit was connected to _________ Vac, ______ Hz. A 2000 Ohms non-inductive resistor and a switch were connected between the user accessible part of a limited current circuit and either pole of the limited current circuit or earth. A storage oscilloscope was connected across the points under consideration. The switch was closed and voltages on resistor were measured.		
Limit values		
Circuit(s) tested		
Measured working voltage:		
Measured frequency		
Measured current through 2000□		
Measured capacitance		

	TABLE: Resistance of earthing conductors and their terminations			N/A
Using a maximum 12 V dc power source, a current of 30 A was passed between the equipment earthing terminal and the part in the equipment that is required by 2.6.1 to be earthed listed below for a period of 120 s. The voltage drop from the earthing terminal to the accessible metal part required to be earthed was recorded and the resistance was calculated.				
Model	Location	Test Current in A	Measured Voltage in (mV)	Calculated Resistance (mΩ)
Comments:				

	Table: working voltage measurement			N/A
Location	RMS voltage	Peak voltage	Comments	
Power transformer				
Input voltage / Test Condition: .				

	TABLE: Touch current and protective conductor current – Berührstrom			P
Parts tested	Input	Measured voltage (U2)	Calculated current	Comments/ Verdict
Enclosure	264 Vac Phase	0,183	0,36	P
	264 Vac Neutral	0,184	0,37	P
	264 Vac Phase	0,217	0,43	P
	264 Vac Neutral	0,216	0,42	P
Comments:				

10.2.3 Cold temperature test

10.2.4 Dry heat test

10.2.5 Damp heat test

10.2.6 Supply overvoltage

10.2.7 Surges, electrostatic discharge and transient burst susceptibility

10.2.8 Radio interference test

10.2.9.Iinsulation test

5.2	TABLE: electric strength tests, impulse tests and voltage surge tests	P
test voltage applied between:	test voltage (V) a.c. / d.c.	Breakdown Yes / No
Input to Output	4250 Vdc	
Input to enclosure (with aluminium foil wrapped around)	4250 Vdc	
Input Primary to ground	1500 Vac	
supplementary information:		

10.2.10 Salt mist test

10.2.11 Vibration, shock and bump test

10.2.12 Watertightness test

10.12.13 Equipment stress screening

10.12.14 Low temperature storage test

Enclosure No. 3

Pictures of the unit

Enclosure No. 4

Schematics, layouts and transformer drawings