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Space engineering - High voltage engineering and design handbook

Raumfahrttechnik - Handbuch für Hochspannungstechnik und Design

Ingénierie spatiale - Manuel d'ingénierie et de conception haute tension

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Raumfahrttechnik - Handbuch für
Hochspannungstechnik und Design

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

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Table of contents

European Foreword	10
Introduction	11
1 Scope	12
2 References	13
3 Terms, definitions and abbreviated terms	17
3.1 Terms from other documents.....	17
3.2 Terms specific to the present document	17
3.3 Abbreviated terms.....	21
4 High voltage design considerations	23
4.1 Environment	23
4.1.1 Impact of environment.....	23
4.1.2 Pressure	23
4.1.3 Temperature	25
4.1.4 Energetic Particle Radiation	26
4.1.5 Space Debris and Micrometeoroids	27
4.1.6 Plasma.....	27
4.1.7 Mechanical.....	28
4.2 Electrical insulation	28
4.2.1 Categories of insulation.....	28
4.2.2 Gaseous insulation.....	28
4.2.3 Liquid insulation	31
4.2.4 Solid insulation.....	32
4.2.5 Vacuum insulation.....	35
4.2.6 Composites.....	36
4.3 Life limiting factors	36
4.3.1 Perspective	36
4.3.2 Electrical breakdown	37
4.3.3 Partial discharges	43
4.3.4 Paschen breakdown.....	46

4.3.5	Ageing.....	48
4.4	Typical applications	54
4.4.1	DC-DC High voltage power conditioners	54
4.4.2	Electronic power conditioners for TWTA	56
4.4.3	Electric propulsion.....	63
4.4.4	Microwave tubes	70
4.4.5	Scientific instruments and experiments	73
5	High voltage design principles.....	75
5.1	Basic design principles	75
5.1.1	Control of voltage	75
5.1.2	Control of electrical field strengths	76
5.1.3	Control of electrical field distribution	87
5.1.4	Control of insulation properties.....	89
5.1.5	Control of surface properties	92
5.1.6	Control of partial discharges.....	93
5.1.7	Control of corona effects	95
5.1.8	Control of Paschen breakdown	95
5.1.9	Control of triple junction effects	98
5.1.10	Control of creepage path.....	99
5.1.11	Control of surface charging	100
5.1.12	Control of interferences.....	102
5.2	High voltage assemblies	105
5.2.1	Solid insulation: potted modules.....	105
5.2.2	Solid insulation: others	125
5.2.3	Gaseous insulation.....	127
5.2.4	Liquid insulation (Oil).....	132
5.2.5	Space vacuum insulation	133
5.3	High voltage components	141
5.3.1	Transformers and inductors	141
5.3.2	Capacitors.....	144
5.3.3	Resistors.....	147
5.3.4	Semiconductors	149
5.3.5	Wires and cables	149
5.3.6	Connectors	154
5.3.7	Interconnections.....	155
5.3.8	Insulators and spacers	157
5.3.9	Feedthroughs.....	158

FprCEN/CLC/TR 17603-20-05:2021 (E)

5.3.10	Printed circuit boards	159
5.3.11	Other components.....	161
6	High voltage testing	162
6.1	Non-Destructive Testing	162
6.1.1	Insulation Resistance Test (INR).....	162
6.1.2	Bulk Resistance Measurement (BRM).....	163
6.1.3	Surface Resistance Measurement (SRM)	164
6.1.4	Polarisation and Depolarisation Current Measurement (PDC).....	165
6.1.5	Dielectric Loss Factor Test (DLF).....	166
6.1.6	Partial Discharge Test (PDT)	167
6.1.7	Dielectric Withstanding Voltage Test (DWV)	173
6.1.8	Triple Junction Test (TRJ).....	175
6.1.9	Critical pressure testing/Corona testing (CPT)	177
6.1.10	Life testing (LIT).....	180
6.1.11	Accelerated life testing (ALT)	181
6.1.12	Burn-in testing (BIT).....	182
6.2	Destructive Testing.....	183
6.2.1	Breakdown Voltage Test (BVT).....	183
6.2.2	Lifetime evaluation testing (LET).....	184
6.3	Supplementary Methods.....	185
6.4	Testing strategy.....	186
7	High voltage product aspects	189
7.1.1	Best practice for materials and processes selection	189
7.1.2	Best practice for design.....	191
7.1.3	Best practice for qualification	193
7.1.4	Best practice for flight acceptance.....	194
7.1.5	Best practice for verification	195
7.1.6	PID.....	196
7.1.7	Evaluation Plan	197
8	Specific problem areas	198
8.1.1	High voltage converters	198
8.1.2	Electric propulsion.....	200
8.1.3	Electron devices (tubes).....	205
8.1.4	Scientific instruments and experiments	205
8.1.5	EMC aspects.....	205
9	Hazards and safety.....	207

9.1 Hazards	207
9.2 Safety	207
Annex A High Voltage Field Calculation Tables	208
A.1 Principles of field efficiency factors for spheres and cylindrical geometries ..	208
A.2 Spherical geometries	209
A.3 Cylindrical geometries	210
Annex B Best Practice References	212
B.1 High Voltage Evaluation Plan	212
B.1.1 Evaluation Activities	212
B.1.2 Evaluation Plan	212
B.1.3 Manufacturing of Evaluation Samples	213
B.1.4 Test and Characterisation	213
B.1.5 Evaluation Review.....	213
B.2 Materials Evaluation	214
B.3 PID – Process Identification Document.....	218
iTeh STANDARD PREVIEW (standards.iteh.ai)	
Figures	
Figure 4-1: Arc Caused by Particle Bridge.....	27
Figure 4-2: Discharge (breakdown) development in a gas volume between two electrodes by electron avalanche process.....	38
Figure 4-3: Electrical strengths of a liquid insulation (here: transformer oil in 2,5 mm gap) in relation to voltage exposure time and assumed breakdown mechanism	40
Figure 4-4: Vacuum breakdown phenomena.....	42
Figure 4-5: Typical partial discharge configurations.....	44
Figure 4-6: Electrical model of partial discharges for a gas-bubble in a solid	45
Figure 4-7: Breakdown voltage of gases vs. the product of pressure times gap spacing	47
Figure 4-8: Electrical treeing caused by partial discharges	50
Figure 4-9: Example: Fatigue (thermo-mechanical stress-related) failures in assemblies expressed as stress (ΔT – temperature cycle amplitude) over number of thermal cycles.....	51
Figure 4-10: Example: Fatigue (thermo-mechanical stress-related) failures in assemblies expressed as stress (ΔT – temperature cycle amplitude) over number of thermal cycles	52
Figure 4-11: Electrical field strengths over time curve according to the Crine model ...	54
Figure 4-12: DC/DC power conversion chains for high voltage of an EPC.....	55
Figure 4-13: Topologies of electronic power conditioners	56
Figure 4-14: Functional block diagram of an EPC.....	57

FprCEN/CLC/TR 17603-20-05:2021 (E)

Figure 4-15: Example for a high voltage generation of an EPC59

Figure 4-16: Example of a high voltage transformer for an EPC60

Figure 4-17: Example of a FEM calculation result: Equipotential Lines for a Plane-to-Plane configuration with spherical edges of the upper plane62

Figure 4-18: Principle of Electrical Propulsion vs. Chemical Propulsion.....63

Figure 4-19: FEEP Ion Emitter Principle65

Figure 4-20: FEEP Ion Emitter Load – Equivalent Circuit65

Figure 4-21: Hall Effect Thruster Principle66

Figure 4-22: HEMP Thruster Principle67

Figure 4-23: Ion Thruster Principle (Kaufmann)68

Figure 4-24: Radio Frequency Ion Thruster (RIT) Principle70

Figure 4-25: Schematic layout of a TWT71

Figure 4-26: Principle of the electron gun of a TWT72

Figure 4-27: Principle of the collector stage of a TWT72

Figure 5-1: Electrical field strength depending on voltage and geometrical parameters (Examples)78

Figure 5-2: Uniform electrical field for indefinite parallel planes79

Figure 5-3: Sphere-inside-sphere electrical field80

Figure 5-4: Examples for practical use of field equations for spheres81

Figure 5-5: Examples for practical connections of wires by using spherical solder joints82

Figure 5-6: Cylinder-inside-cylinder electrical field82

Figure 5-7: Space charge formation on an isolating surface84

Figure 5-8: Space charge formation on sharp-edged structures in various environments85

Figure 5-9: Surface charging of an isolator85

Figure 5-10: Correct meshing of shapes87

Figure 5-11: General: E-Field and voltage for a three-dimensional path87

Figure 5-12: E-Field and voltage for gap lengths (straight path)88

Figure 5-13: Control of electrical field distribution - Examples.....89

Figure 5-14: Avoiding fibre bridging effect in liquid insulation90

Figure 5-15: Optimum design of interfaces between materials w.r.t. the electrical field92

Figure 5-16: Limit critical Paschen breakdown pressure range by limitation of maximum gap96

Figure 5-17: Paschen discharge in a gap between solid insulation and ground97

Figure 5-18: Triggered Paschen discharge in a gap between solid insulation and ground97

Figure 5-19: Critical triple-junction point/area in an interface between solid - gaseous/liquid/vacuum insulation - metal conductor98

Figure 5-20: Methods to reduce the influence of the triple junction zone by design99

Figure 5-21: Impact of creepage path on electrical field distribution	99
Figure 5-22: Designs to reduce impact of creepage path on electric insulation.....	100
Figure 5-23: Designs to reduce impact of surface charging on electric insulation	101
Figure 5-24: Segmenting of insulator to influence surface charging.....	102
Figure 5-25: Implementation of design measures minimizing interference problems for a typical high voltage power conditioner (regulated DC-DC converter for high voltage as an example)	104
Figure 5-26: Designs example: potting of embedded aluminium structure, i.e. an HV terminal.....	110
Figure 5-27: Designs example: potting of embedded aluminium structure, i.e. HV terminal.....	112
Figure 5-28: Shielding necessary to avoid exposure of an electronic part to excessive electrical field stress.....	113
Figure 5-29: Potting of PCB`s: typical design aspects	115
Figure 5-30: Transformer with rectifier and filter designed as two separate modules using open terminals for interconnecting HV harness	117
Figure 5-31: Transformer and rectifier filter designed as two separate modules using potted terminals for interconnecting HV harness	118
Figure 5-32: Transformer and rectifier filter designed as one combined module potted in (a) one or (b) two and more sequential potting processes	118
Figure 5-33: Designs example: Spherical solder ball.....	119
Figure 5-34: Fitting a potted assembly to partial discharge testing (Example of a potted transformer winding).....	122
Figure 5-35: Examples for thermal drains embedded in potted modules	123
Figure 5-36: Relative Dielectric Strength of a SF ₆ -N ₂ -Mixture versus Composition of the Mixture.....	129
Figure 5-37: Surface flashover process in a vacuum environment.....	134
Figure 5-38: Surface shapes for insulators	136
Figure 5-39: Arrangement of cylindrically layers of windings	141
Figure 5-40: Arrangement of windings in discs of a bobbin.....	143
Figure 5-41: Partial discharge test aspects of a high voltage transformer	144
Figure 5-42: Critical electrical field stress in the surrounding of high voltage capacitors and proposed measures	146
Figure 5-43: Basic high voltage resistor design variants	147
Figure 5-44: High voltage resistor design aspects	148
Figure 5-45: Suitable partial discharge test setup for high voltage wires.....	150
Figure 5-46: Critical stress cases for high voltage wires	151
Figure 5-47: Critical stress cases for high voltage wires terminations	152
Figure 5-48: Interconnection of high voltage harness via soldering or crimping/bolting at terminals	156
Figure 5-49: Flying lead interconnections	157

FprCEN/CLC/TR 17603-20-05:2021 (E)

Figure 5-50: Suitable insulator design variants	158
Figure 5-51: Suitable feedthrough design variants.....	159
Figure 6-1: Guard ring test set-up for bulk resistance measurement.....	163
Figure 6-2: Partial discharge test set-up	169
Figure 6-3: Typical partial discharge test flow	170
Figure 6-4: Partial discharge testing aspects. Example: High voltage transformer	171
Figure 6-5: Dielectric Withstand Voltage Test Electrical Schematic	174
Figure 6-6: Triple Junction Test Electrical Schematic	176
Figure 6-7: Critical Pressure Test Electrical Schematic	178
Figure 6-8: Breakdown Voltage Test Electrical Schematic.....	183
Figure 8-1: High voltage conditioner with grounding at converter – load floating	199
Figure 8-2: High voltage conditioner with grounding at load side – including a clamping device at the conditioner	199
Figure 8-3: High voltage conditioner with grounding at load side – including a clamping device at the conditioner and triax HV cable for load connection.....	200
Figure A-1 : Field efficiency factors (Schwaiger factors) η as a function of geometry parameter p for spheres.....	209
Figure A-2 : Field efficiency factors (Schwaiger factors) η as a function of geometry parameter p for cylinders	211
Figure A-3 : Field efficiency factors (Schwaiger factors) η as a function of geometry parameter p for cylinders	211
Figure B-1 : Typical material evaluation flow	216
Figure B-2 : Potted Rogowsky-profile electrodes	217
Figure B-3 : Crossed wire electrode	217
Figure B-4 : Material disk between electrodes	217

Tables

Table 4-1: Course Classification of the potential impact to electrical insulations by environmental type.....	23
Table 4-2: Properties of gaseous insulations	30
Table 4-3: Properties of liquid insulations	31
Table 4-4: Properties of EP, PUR and SI.....	33
Table 4-5: Properties of various polymers	34
Table 4-6: Properties of porcelain and alumina	35
Table 4-7: Paschen Minimum for various gases	48
Table 4-8: Overview on Electrical Propulsion Principles, Thruster Type and Electrical Physical Parameters	64
Table 5-1: Critical “thresholds” for high voltage	75
Table 5-2: Orientation “map” for maximum electrical field strengths in electrical insulation	77

Table 5-3: Orientation values (examples) for selection sphere structures to limit the maximum electrical field of a high voltage assembly	81
Table 5-4: Dew point of SF ₆ -N ₂ -mixtures versus pressure and depending of composition.....	130
Table 5-5: Surface shapes for insulators in combination with selected materials comparing the relative surface flashover strengths of +/- 45 degree cone insulators for various voltage waveforms w.r.t pure cylindrical shapes..	137
Table 5-6: Theoretical predictions and experimental consequences of methods to improve the surface flashover strengths in vacuum.....	138
Table 5-7: Application matrix for PCB with high voltage.....	160
Table 6-1: Test methods, levels and acceptance criteria for partial discharge testing	172
Table 6-2: Assessment of test methods w.r.t. its application.....	186
Table 7-1: Typical material properties and reference test methods for high voltage insulation materials	189
Table 7-2: Best practice of verification for high voltage design aspects	196
Table A-1 : Sphere geometries.....	209
Table A-2 : Cylinder-parallel-to-a-cylinder geometries	210
Table A-3 : Cylinder-inside-a-cylinder geometries	210
Table B-1 : Product categories according to heritage (Ref.: ECSS-E-ST-10-02)	214

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European Foreword

This document (FprCEN/CLC/TR 17603-20-05:2021) has been prepared by Technical Committee CEN/CLC/JTC 5 "Space", the secretariat of which is held by DIN.

This document is currently submitted to the Vote on TR.

It is highlighted that this technical report does not contain any requirement but only collection of data or descriptions and guidelines about how to organize and perform the work in support of EN 16603-20-05.

This Technical report (FprCEN/CLC/TR 17603-20-05:2021) originates from ECSS-E-HB-20-05A.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any TR covering the same scope but with a wider domain of applicability (e.g.: aerospace).

This document is currently submitted to the CEN CONSULTATION.

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Introduction

The subject of high voltage engineering and design has been part of the spacecraft design process since the early times of spaceflight.

This was due to need for high voltage power conditioners being a key element of communication links. The relate expertise was built up in Europe in the decade of the 1980 with the support of the development of modern Electronic Power Conditioners (EPC's), to operate Travelling Wave Tube Amplifiers for telecommunication satellites and for high power radar applications.

In 1989 ESA launched its first high power radar for earth observation onboard the ERS-1 (European Remote Sensing Satellite), achieving a technology for 15 kV – 17 kV in space.

Today typically between some ten and over hundred EPC's with operating voltages of 5 kV - 8 kV are placed on many of the telecommunications satellites.

Several space borne radars with travelling wave tubes and klystrons are in orbit using voltage up to 20 kV. Various detectors for various kind of space environment with voltage between a few hundred volts and up to 30 kV are used in many missions, high power lasers up to 150 kV were studied, and even some experiments onboard the International Space Station using fancy high voltage sources.

The latest trend is the increasing use of electric propulsion for satellites dealing with supply voltage in the range between a few hundred volts and above 10 kV. High voltage related anomalies have been observed only a few times, some in the early years of building up experience, some also later, especially when new developments were done with new teams inexperienced in the field.

A need was identified for a standard already in the early years of the space flight, the US air force and NASA presented a series design and test handbook in the 1970's and 1980's. In Europe, ESA started discussing a draft standard with industry: the PSS-02-303 draft 2 from 1992 "Requirements for High Voltage Transformer and Components used in Electronic Power Conditioners for ESA Space Systems" this became a quasi standard reference in many space projects, even if it was never formally released. The growing diversity of high voltage application gave finally the urgency to make a new approach for standardization. The discussion started in 2007 with ECSS who led to the conclusion, that a standard would not satisfy the immediate needs for projects, as it would be too wide to cover the diverse applications and also would not be suitable to transfer the "know-how" of high voltage engineering and design. Therefore it was decided to produce a handbook to give a broad scope of knowledge and recommendations for design and test of high voltage equipment and components.

This document aims to satisfy these needs and provides a detailed view of high voltage knowledge aspects as well as giving a guideline to identify suitable design rules.

Proper design of high voltage effects of these processes is part of the system engineering process as defined in ECSS-E-ST-20, where only a small subset of high voltage requirements is given.

For new projects involving high voltage equipment and design it is useful to provide this handbook as a reference to generate suitable requirements specific to the targeted high voltage application.

Chapter 7 of this document gives some "best practice" statements.

Only a smart answer can be given to the definition of the range of voltages which should be considered as high voltages: The ECSS-E-ST-20C states for the definition of a high voltage "AC or DC voltage at which partial discharges, corona, arcing or high electrical fields can occur". For space environment this can occur ". This in fact can already appear at 60 V – 80 V if a low pressure environment in an inert gas provides a critical pressure for "Paschen Breakdown". Under air (N₂/O₂ mixtures) this can occur for voltage of above 300 V.

1

Scope

This Handbook establishes guidelines to ensure a reliable design, manufacturing and testing of high voltage electronic equipment and covers:

- Design
- Manufacturing
- Verification/Testing

of equipment generating, carrying or consuming high voltage, like: high voltage power conditioner, high voltage distribution (cables and connectors).

This Handbook is dedicated to all parties involved at all levels in the realization of space segment hardware and its interface with high voltage for which ECSS-E-ST-20C is applicable.

This handbook sets out to:

- summarize most relevant aspects and data of high voltage insulation
- provide design guidelines for high voltage insulation
- provide design guidelines for high voltage electronic equipment
- give an overview of appropriate high voltage test methods
- establish a set of recommendations for generation design and verification rules and methods
- provide best practices

Applicability is mainly focused on power conditioning equipment but may be also applicable for all other high voltage electric and electronic power equipment used on space missions, except items of experimental nature.

References

EN Reference	Reference in text	Title
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EN 16603-10-02	ECSS-E-ST-10-02	Space engineering - Verification
EN 16603-10-03	ECSS-E-ST-10-03	Space engineering - Testing
EN 16603-10-04	ECSS-E-ST-10-04	Space engineering - Space environment
EN 16603-20	ECSS-E-ST-20	Space engineering - Electrical and electronic
EN 16603-20-01	ECSS-E-ST-20-01	Space engineering - Multipactor design and test
EN 16603-20-06	ECSS-E-ST-20-06	Space engineering - Spacecraft charging
EN 16603-32	ECSS-E-ST-32	Space engineering - Structural general requirements
EN 16602-30-11	ECSS-Q-ST-30-11	Space product assurance - Derating – EEE components
EN 16602-70-10	ECSS-Q-ST-70-10	Space product assurance - Qualification of printed circuit boards
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