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Space engineering — Insert design handbook

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The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

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Published by BSI Standards Limited 2022

ISBN 978 0 539 20827 6

ICS 49.030.99; 49.140

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 August 2022.

Amendments/corrigenda issued since publication

Date	Text affected

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TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 17603-32-22

June 2022

ICS 49.030.99; 49.140

English version

Space engineering - Insert design handbook

Ingénierie spatiale - Manuel de conception d'inserts

Raumfahrttechnik - Handbuch zu Einsätzen

This Technical Report was approved by CEN on 17 May 2022. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

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European Foreword

This document (CEN/TR 17603-32-22:2022) has been prepared by Technical Committee CEN/CLC/JTC 5 “Space”, the secretariat of which is held by DIN.

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 16603-32.

This Technical report (CEN/TR 17603-32-22:2022) originates from ECSS-E-HB-32-22A.

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).

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1 Scope

The document recommends engineering inserts and practices for European programs and projects. It may be cited in contracts and program documents as a reference for guidance to meet specific program/project needs.

The target users of this handbook are engineers involved in the design, analysis and verification of launchers and spacecraft in relation to insert usage. The current know-how is documented in this handbook in order to make expertise to all European developers of space systems.

It is a guidelines document, therefore it includes advisory information rather than requirements.

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2 References

Due to the structure of the document, each clause at its end contains the list of reference called upon.

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3 Terms, definitions and abbreviated terms

The following provides an explanation of the terms, acronyms and abbreviations used in this handbook; they are not definitions. Terms are listed in alphabetical order and interposed with explanations of the acronyms and abbreviations used in the handbook.

A

AA

Aluminium Association, USA

A-BASIS DESIGN ALLOWABLE (A-value)

mechanical property value above which at least 99 % of the population of values is expected to fall, with a confidence level of 95 %

[ECSS-E-ST-32]

ADHEREND

Plate adhesively bonded to another plate

[ECSS-Q-70-71]

ADHESION

The state in which two surfaces are held together at an interface by forces or the interlocking action of an adhesive or both

ADHESIVE

A substance capable of holding two surfaces together

NOTE: Used to retain carbon-fibre tube inserts in sandwich panels instead of the conventional potting compounds used for standard-types of inserts

ADHESIVE (FILM)

A synthetic resin adhesive, usually of the thermosetting type in the form of a thin film of resin with or without a fibrous carrier or support; used for bonding the face sheets of sandwich panels to the core

NOTE: Film adhesives usually have some tack to enable their placement during assembly.

ADHESIVE (FOAMING)

A synthetic resin adhesive, usually of the thermosetting type which when cured produces a foam-like material. [See: ADHESIVE (SYNTACTIC)]

ADHESIVE (SYNTACTIC)

A synthetic resin adhesive, usually of the thermosetting type that contains a hollow filler material, often in the form of small glass microballoons, which when cured produces a foam-like material

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NOTE: These types of materials are widely used as a potting compound for retaining inserts in sandwich panels.

AECMA

Association Européen des Constructeurs Matériel Aérospatiale; European Association of Aerospace Industries

AFNOR

Association Français de Normalisation; French national standards organisation

AIR

French standards organisation

AISI

American Iron and Steel Institute, USA

ALLOWABLE LOAD

maximum load that can be permitted in a structural part for a given operating environment to prevent rupture, collapse, detrimental deformation or unacceptable crack growth [ECSS-P-001]]]

ALLOWABLE STRESS

The maximum stress that can be permitted in a structural part for a given operating environment to prevent rupture, collapse, detrimental deformation or unacceptable crack growth [ECSS-P-001]

ALLOWABLES

Material values that are determined from test data at the laminate or lamina level on a probability basis (e.g. 'A' or 'B' values), following ASTM or other test standards accepted by the final customer. [See also: A-BASIS DESIGN ALLOWABLE; B-BASIS DESIGN ALLOWABLE; 'A' VALUE, 'B' VALUE]

ALLOY

Mixture of a base metallic element with one or more other metallic or non-metallic elements

ALODINE®

A proprietory chemical oxidising process, i.e. a non-electrolytic process, for surface treatment which results in an electrically conductive, chromated (mixed-metal, chromium-oxide) film, typically less than 1µm thick

ALUMINIUM (Al)

Metallic element, melting point 660°C, density 2700 kg m-3. Uses: ubiquitous aerospace alloy base, important component in oxidation resistant alloys and coatings and as part of basic strengthening mechanism for nickel-based superalloys

AMBIENT

1 The surrounding environmental conditions, e.g. pressure, temperature or relative humidity

2 usual work place temperature and humidity environmental conditions, e.g. room temperature

ANISOTROPIC

Having mechanical or physical properties which vary in direction relative to natural reference axes in the material

ARALDITE™

A range of epoxy-based structural adhesives; developed by Ciba Geigy, now Vantico

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ARAMID

A type of highly oriented aromatic polymer material. Used primarily as a high-strength reinforcing fibre, of which Kevlar™ 49 and Twaron™ HM are most commonly used in aerospace applications

AREAL WEIGHT

A measurement of the weight per unit area of a fabric or fabric prepreg; expressed as g/m²

ARIANE

Family of European launch vehicles

ASTM

American Society for Testing and Materials; USA standards organisation

B

B-BASIS DESIGN ALLOWABLE (B-value)

mechanical property value above which at least 90 % of the population of values is expected to fall, with a confidence level of 95 %

[ECSS-E-ST-32]

BALANCED LAMINATE

Where plies with positive angles are balanced by equal plies with negative angles. While angle-ply laminates have only one pair of matched angles, balanced laminates can have many pairs, plus 0 and 90 degrees. A balanced laminate is orthotropic in in-plane behaviour, but anisotropic in flexural behaviour

BATCH

Materials produced during a unique sequence:

1. Fibre: The amount which is produced by the conversion of a number of precursor tows under standard, controlled, processing-plant conditions in one continuous operation, including any surface treatment and sizing of the fibre

2. Prepreg: A quantity, irrespective of width, that is produced under 'no-change conditions' in one continuous operation of the impregnating plant from one batch of resin mix and one batch of fibre. A batch is expected to conform to a fixed manufacturing process and to have homogeneous properties within prescribed tolerances over its whole width and length. A maximum allowable length for a prepreg batch is sometimes specified

3. Resin: A quantity of resin in either film or liquid form produced from one mix of resins, resin modifiers and curing agents

BIDIRECTIONAL LAMINATE

A reinforced plastic laminate with the fibres oriented in two directions in the plane of the laminate; a cross laminate. [See also: UNIDIRECTIONAL LAMINATE]

BLIND

Fasteners: Installed from one side of a component only

BOND LINE

The area between two materials that have been adhesively bonded; includes the layer of adhesive between the adherends

BORE HOLE

A hole machined in a sandwich panel of a suitable size to accept an insert

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BS

British standard, controlled by the British Standards Institute (BSI)

BSI

British Standards Institute, UK

BUCKLING

1 Unstable displacement of a structural part, such as a panel, caused by excessive compression or shear. Micro-buckling of fibres in a composite material can also occur under axial compression

2 Fibre: a failure mechanism which occurs under compressive loads where the reinforcing fibres in a composite are displaced transversly; fibre buckling modes are known as 'extension mode' and 'shear mode'.

C

CADMIUM (Cd)

Metallic element, melting point 321 °C, density 8650 kg m-3, Uses: alloying additions, protective coatings: NOT FOR SPACE USE

CARBON/EPOXY

A composite material comprising of a carbon fibre reinforcement in an epoxy polymer matrix

CARBON FIBRE

Fibre produced by the pyrolysis of organic precursor fibres, such as rayon, polyacrylonitrile (PAN) and pitch, in an inert environment. The term is often used interchangeably with the term graphite; carbon fibres and graphite fibres do, however, differ. The basic differences lie in the temperature at which the fibres are made and heat-treated, and in the amount of elemental carbon produced. Carbon fibres typically are carbonised in the region of 1315°C and assay at 93 to 95% carbon, while graphite fibres are graphitised at 1900°C to 2480°C and assay at more than 99% elemental carbon

CARBON-FIBRE TUBE INSERT

A non-standard type of insert developed by DLR for the Rosetta Lander project, [See also: A.03; F.06]

CASA

Construcciones Aeronauticas SA, (E); now EADS CASA

CATALYST

A substance that changes the rate of a chemical reaction without itself undergoing permanent change in its composition; a substance that markedly speeds up the cure of a compound when added in a quantity small compared with the amounts of primary reactants

CEN

Comité Européen de Normalisation (European Committee for Standardization)

CFRP

Carbon fibre-reinforced plastic. Letter G in this handbook stands for Glass, whereas in American publications it is used for graphite. [See also: GFRP]

CIS

standards organisation, Russia

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CO-CURE

Simultaneous curing and bonding of a composite laminate to another material or parts, such as honeycomb core or stiffeners, either by using the adhesive properties of the composite resin or by incorporating an adhesive into the composite lay-up

COLLECTED VOLATILE CONDENSABLE MATERIAL (CVCM)

quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific temperature for a specific time

NOTE: CVCM is expressed as a percentage of the initial specimen mass and is calculated from the condensate mass determined from the difference in mass of the collector plate before and after the test.

[ECSS-Q-ST-70-02]

COMPOSITE SANDWICH CONSTRUCTION

panels composed of a lightweight core material, such as honeycomb, foamed plastic, and so forth, to which two relatively thin, dense, high-strength or high-stiffness faces or skins are adhered

[ECSS-E-ST-32-08]

CORE

1 A lightweight material in between the face sheets of a sandwich panel, e.g. honeycomb core, foam. Metallic or composite sheet materials are bonded to the core to form a sandwich panel

2 Cores are often classed as either metallic or non-metallic and are commercially-available in a wide range of materials and configurations, e.g. honeycomb with a range of cell sizes and foil thicknesses, with or without perforations

CORE (HEXAGONAL)

A core material in which the shape of the individual cells is hexagonal

CORE (METALLIC)

Any core that is made of metal, e.g. often made of an aluminium alloy

CORE (NON-METALLIC)

Any core that is made of a material other than metal; usually made of glass-reinforced plastic (GFRP) or Nomex® for space applications

CORE (NON-PERFORATED)

A core material in which each of the cells is not connected to its neighbours; air trapped with the cells of a sandwich panel cannot be vented easily when placed in vacuum

CORE (PERFORATED)

A core material in which each of the cells is connected to its neighbours by one or more small holes in the cell walls; enables the removal of air trapped with the cells of a sandwich panel when placed in vacuum

CORE SPLICE

A joint or the process of joining one type of core to another; usually achieved by adhesive bonding using an adhesive with gap-filling properties

CROSS-LINKING

1 Applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible super-molecule of all the chains

2 The chemical reaction that occurs in thermosetting polymers due to the heat applied during the cure

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CROSS-PLY

Composites containing plies of material, normally prepreg, at angles of 0° and 90°

CROSS-PLY LAMINATE

Special laminate that contains only 0° and 90° plies. This bidirectional laminate is orthotropic and has nearly zero Poisson's ratio. The other simple bidirectional laminate is the angle-ply, which possesses one pair of balanced off-axis plies

CTE

See: COEFFICIENT OF THERMAL EXPANSION

CTE MISMATCH

1 difference in coefficient of thermal expansion between two or more materials within a specified temperature change, e.g. polymers and metals. [ECSS-Q-70-71]

2 The difference in coefficient of thermal expansion between a reinforcement and the matrix or a coating and substrate within a specified temperature rise, e.g. carbon fibre (low/zero CTE) and Al alloy (large +ve CTE)

CURE

1 changing the properties of a polymer-based material by chemical reaction accomplished by heat or catalyst (or both) and with or without pressure, e.g. resin, adhesive, coating. [ECSS-Q-70-71]

2 chemical reaction during which a liquid resin is transformed to a solid material by the process of cross-linking

CURE CYCLE

1 period with a distinctive time, temperature and pressure profile to obtain specific

properties of a polymer-based material , e.g. resin, adhesive, or coating. [ECSS-Q-70-71]

2 he cure cycle can include defined heat-up and cool-down rates, isothermal holds for specified periods and application and removal of negative or positive pressures at defined times or temperatures

3 potting compounds: Depends on the chemical formulation of the resin used for potting and if the resin or assembly can be cured at elevated temperature without causing damage; a typical cure cycle for potted inserts, using a two-part epoxy-based resin system, is several hours at room temperature

CURING TEMPERATURE

Temperature at which a cast, moulded or extruded product, a resin-impregnated reinforcement or an adhesive is subjected to curing

CURING TIME

The length of time a part is subjected to heat or pressure, or both, to cure the resin; interval of time between the instant relative movement between the moving parts of a mould ceases and the instant pressure is released

NOTE: Further cure can take place after removal of the assembly from the conditions of heat or pressure.[See: POST CURE]

CVCM

Collected Volatile Condensable Matter

CYCLIC LOADING

fluctuating load (or pressure) characterized by relative degrees of loading and unloading of a structure

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NOTE For example, loads due to transient responses, vibro-acoustic excitation, flutter, pressure cycling and oscillating or reciprocating mechanical equipment.

[ECSS-E-ST-32-01]

D

DAMAGE

A structural degradation or anomaly caused by service conditions or by abnormal operation, e.g. impact damage caused by dropped tools or other foreign objects

DAMAGE TOLERANCE

The ability of a material, component or structure to retain an acceptable level of structural or environmental resistance properties under the effects of operational conditions, without risk of failing in a catastrophic manner, [See: DAMAGE TOLERANT]

DAMAGE TOLERANCE CONTROL

The application of design methodology, material and processing control, manufacturing technology, and quality assurance procedures to prevent premature structural failure due to the initiation or propagation of flaw or damage during fabrication, testing and service life

DAMAGE TOLERANT

characteristic of a structure for which the amount of general degradation or the size and distribution of local defects expected during operation, or both, do not lead to structural degradation below specified performance

ECSS-E-ST-32-01]

DAN

Deutsche Airbus-Norm; German Airbus standard

DEBOND

General: a defective area of an adhesive bond where the adherends are no longer held together. An area of separation within or between plies in a laminate, or within a bonded joint, caused by contamination, improper adhesion during processing, or damaging interlaminar stresses [See also: DELAMINATION]:

1 Adhesive bond: a delamination between the adherends

2 Sandwich panel: a delamination that occurs between the core and the face sheet; caused by contamination or damage to either the film adhesive used to join the face sheet laminate to the core, face sheet laminate itself, bond area of the core or mechanical damage to core cell walls, by crushing or more local damage

DEFECT

A manufacturing anomaly (crack, void, delamination) created by processing, fabrication or assembly procedures. [See also: FLAW]

DEGRADATION

reduction of material properties (e.g. mechanical, thermal or optical) that can result from deviations in manufacturing or from repeated loading or environmental exposure. [ECSS-Q-70-71]

DELAMINATION

Physical separation or loss of bond of the layers of material in a laminate; locally or over a wide area

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DESIGN ALLOWABLE

Material values that are determined from test data at the laminate or lamina level on a probability basis (e.g. 'A' or 'B' values), following ASTM or other test standards accepted by the final customer. [See also: A-BASIS DESIGN ALLOWABLE; B-BASIS DESIGN ALLOWABLE; 'A' VALUE, 'B' VALUE]

DESIGN VALUES/ PROPERTIES

Material, structural-element and structural detail properties that have been determined from test data and chosen to assure a high degree of confidence in the integrity of the completed structure

DIELECTRIC

A material in which the electrical conductivity is zero or near zero

DIMPLING

Sandwich panels: the displacement under load of the face skins between the cellular structure of a honeycomb core

DIN

Deutsches Institut für Normung; German national standards organisation

DLR

Deutschen Zentrum für Luft- und Raumfahrt. German aerospace organisation

E

E-GLASS

Electrical glass; a grade of glass fibre. A borosilicate glass containing less than 1% alkali (combined sodium and potassium oxides); the type most used for glass fibres for reinforced plastics; suitable for electrical laminates because of its high resistivity

ECSS

European Cooperation for Space Standardization. A cooperative effort of the European Space Agency, National Space Agencies and European industry associations for the purpose of developing and maintaining common standards, [See: ECSS website: www.ecss.nl)

EDGE CLOSE-OUT

[See: EDGE CLOSURE]

EDGE CLOSURE

Sandwich panels: Protects the core from accidental damage, serves as a moisture seal and provides edge reinforcement to enable transfer and distribution of edge attachment loads; also known as ‘edge close-out’ and ‘edge member’

EDGE MEMBER

[See: EDGE CLOSURE]

EDGE DISTANCE

The distance between an insert, or more precisely the centre line of the potting, and the edge of a sandwich panel

ELASTIC MODULUS

Stiffness

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ELASTIC RELATION

Fully reversible, single-value, stress-strain relation. Loading and unloading follow the same path; there is no hysteresis, or residual strain. Although non-linear relation is admissible, the relation for composite materials is essentially linear

ELEMENT

1 A part of a more complex structural member, e.g. skin, stringers, shear panels, sandwich panels, joints or splices, Glossary Ref.[Ref-1]

2 A composite of subsystems, capable of performing an operational role only in conjunction with other elements, e.g. Space Vehicle, Ground Segment, Space Station Pressurised Module, Glossary Ref.[Ref-1]

ELONGATION

Deformation caused by stretching; the fractional increase in length of a material stressed in tension. (When expressed as percentage of the original gauge length, it is called percentage elongation)

EM ATV Cargo Carrier

Engineering model, Automated transfer vehicle integrated cargo carrier for ISS; International Space Station

EN

Euro Norme (European standard), [See: CEN]

ENN

ERNO-Norm; standard developed by MBB-ERNO (Bremen), now Astrium GmbH

ENVIRONMENT

External, non-accidental conditions (excluding mechanical loading), separately or in combination, that can be expected in service life and that can affect the structure, e.g. temperature, moisture, UV radiation and fuel

ENVISAT

Polar Platform ESA Polar Platform satellite to carry the Envisat-1 Earth-observation instruments. Designed to launch on Ariane-5 and use ESA's Data Relay Satellite system for the transmission of data to Earth.

EOS

Earth observation satellite

EPOXY

1 General: A family of thermosetting resins made by polymerisation of epoxides or oxiranes with other materials such as amines, alcohols, phenols, carboxylic acids, acid anhydrides, and unsaturated compounds; used for the matrix phase of composites and structural adhesives

2 Potting compounds: usually two-part epoxy resin systems combined with a suitable filler that, when cured, produces a foam-like material, [See also: ADHESIVE (SYNTACTIC)]

ESACOMP®

A software package for the analysis and design of composite laminates and laminated structural elements; developed for ESA/ESTEC by Helsinki University and distributed by Componeering Inc

ESTEC

European Space Research and Technology Centre, Noordwijk, NL

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EXOTHERMIC

A type of chemical reaction that produces heat, e.g. can occur during the cross-linking, or curing, of polymer-based resins, such as epoxy

F

FABRIC

Any material of woven construction

FACE

1 Outer ply of a laminate.

2 Covering sheets of a sandwich panel

FACE SHEET

A composite laminate or metal sheet that forms the external surfaces of a sandwich panel

FACING

A sheet material, usually thin and made of composite or metal, that is attached to a core material to form a sandwich panel; also known as 'face sheet'

FACTOR OF SAFETY

The ratio of the design or ultimate loads to the limit or applied loads. [See: LOADS]

FAILURE (STRUCTURAL)

The rupture, collapse, seizure, excessive wear or any other phenomenon resulting in an inability to sustain limit loads, pressures and environments

[ECSS-E-ST-32]

FASTENER

item that joins other structural items and transfers loads from one to the other across a joint

[ECSS-E-ST-32-01]

FATIGUE

1 cumulative irreversible damage incurred by cyclic application of loads to materials and structures

NOTE 1 Fatigue can initiate and extend cracks, which degrade the strength of materials and structures.

NOTE 2 Examples of factors influencing fatigue behaviour of the material are the environment, surface condition and part dimensions.

[ECSS-E-ST-32-01]

2 Progressive cracking mechanism caused by alternating stress

FATIGUE LIFE

The number of cycles of deformation required to bring about failure of the test specimen under a given set of oscillating conditions

FATIGUE STRENGTH

1 The maximum cyclic stress a material can withstand for a given number of cycles before failure occurs

2 The residual strength of a material that has been subjected to fatigue

FATIGUE STRESS RATIO

The ratio of the minimum to the maximum fatigue stress, usually denoted by R

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FAULT

Manufacturing: an error or departure from the intended specified process which results in a defective material or structure

FE

Finite element

FEA

Finite element analysis

FEM

Finite element model or modelling

FEDERAL

An American specification

FIBRE CONTENT

Percent volume of fibre in a composite material. Most common composites in use today have a fibre content between 45 volume % and 70 volume %. Percent weight of mass of fibre is also used

FIBRE-CONTROLLED

A laminate lay-up where the properties are largely determined by those of the fibre, e.g. 0°/±45°/0°/±45°/0°

FIBRE REINFORCED PLASTIC (FRP)

A fibre-reinforced thermosetting or thermoplastic polymer matrix composite material

FILLER

1 Fabric: Yarn oriented at right angles to the warp in a woven fabric; also known as fill, [See also: WEFT]

2 A material incorporated into a synthetic resin to modify the inherent viscosity and flow characteristics, e.g. usually in the form of glass microballoons for potting compounds used to embed inserts in sandwich panels

FILM ADHESIVE

A synthetic resin adhesive, usually of the thermosetting type in the form of a thin film of resin with or without a fibrous carrier or support.

NOTE: Film adhesives usually have some tack to enable their placement during assembly

FINISHING

Final manufacturing processes which result in a component ready for assembly. Often used to describe minor machining or cleaning operations

FLAW

A local discontinuity in a composite structure such as; a scratch, notch, crack, void, delamination, or debonding.

NOTE: Some fracture models also define a notch as a flaw, e.g. WEK [See also: DEFECT]

FLOW

1 The movement of resin under pressure, enabling all parts of a mould or cavity to be filled, e.g. flow of potting compound around an insert when injected into a bore hole.

2 Flow or creep is the gradual but continuous distortion of a material under continued load, often at elevated temperatures.

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FLUSH (MOUNTED) INSERT

The positioning of an insert such that the upper surface of the insert is level, or flush, with the surface of the upper face sheet

FOAMING ADHESIVE

A synthetic resin adhesive, usually of the thermosetting type which when cured produces a foam-like material. [See: ADHESIVE (SYNTACTIC)]

FOOTPRINT

The area of the nut, collar or tail of an installed mechanical fastener that is in contact with the substrate material; bearing surface

FRP

Fibre-reinforced plastic

FULL POTTING

The maximum possible potting height is identical to the core height, c; also known as blind or 'borne'

FULLY POTTED INSERT

An insert in which the potting material is in contact with the inside of the bottom face sheet,

G

GAUGE LENGTH

Part of a test specimen in which the characteristics of the material are determined; often instrumented with strain gauges, extensometers

GEL POINT

The stage at which a liquid begins to exhibit pseudo-elastic properties, also conveniently observed from the inflection point on a viscosity versus time plot

NOTE: Also called GEL TIME

GEL TIME

The exposure period required at a prescribed temperature to convert the resin from a fluid to a defined partial-cure stage

NOTE: Resin flow during cure can only occur substantially before gelling

GENERALISED HOOKE'S LAW

The most general linear elastic stress-strain relation for an anisotropic material from which materials with various types of symmetries can be derived

GFRP

Glass-fibre reinforced plastic

NOTE: In this handbook G = glass, but in US publications G = graphite. [See also: CFRP]

GLASS FIBRE

Reinforcement fibres of which E-, R- and S- grades are normally used in composites for aerospace applications

NOTE: E-glass: electrical grade; R and S: high-strength grades

GLASS TRANSITION TEMPERATURE (Tg)

The temperature at which increased molecular mobility results in significant changes in the properties of a cured resin system

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GRP

Glass reinforced plastic; an industrial composite not a high-performance structural composite for aerospace applications, [See: GFRP]. Sometimes used for tabs on the ends of some composite test specimens

H

HARDENER

1 A substance or mixture added to a plastic composition to promote or control the curing action by taking part in it

2 A substance added to control the degree of hardness of the cured film [See also: CATALYST]

HEXAGONAL CORE

A core material in which the shape of the individual cells is hexagonal, e.g. aluminium honeycomb core

HIGH MODULUS CARBON FIBRES (HM)

A range of carbon fibres which have a tensile moduli greater than 310 GPa, typically

HIGH STRENGTH CARBON FIBRES (HS)

A range of carbon fibres which have tensile strengths up to 3500 MPa and tensile moduli in the range of 200 GPa to 255 GPa, typically

HIGH TENACITY CARBON FIBRES (HT)

A range of carbon fibres which includes HS high strength fibres and VHS very high strength fibres

HM

High modulus; a range of carbon fibres that also includes UHM ultra high modulus fibres

HONEYCOMB

Manufactured product of resin-impregnated sheet material (paper, glass or aramid-based fabric) or sheet metal formed into hexagonal-shaped cells; used as a core material in sandwich construction; also known as NIDA in Europe

HONEYCOMB SANDWICH

A sandwich construction in which the core material between the face sheets has a hexagonal cellular form that resembles honeycomb

HRG

'Haute Résolution Géométrique', the main payload of the SPOT 5 earth observation satellite

NOTE: The structure is similar to HRV and HRV-IR on SPOT 3 and SPOT 4, respectively.

HS

High strength; a range of carbon fibres

HT

High tenacity (high strength/high strain); a range of carbon fibres which includes HS high strength fibres and VHS very high strength fibres; also known as 'high tension'

HYGROSCOPIC

Tending to absorb moisture from the air

HYGROTHERMAL

The combination of moisture and temperature

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I

IATP

Insert allowable test programme, conducted in two stages IATP-1 and IATP-2; an ESA-funded study

IDH

Insert design handbook

ILSS

Interlaminar shear strength

IM

1 Intermediate modulus; a range of carbon fibres that have tensile moduli in the range of 255 GPa to 310 GPa, typically

2 Integration Model

IN-HOUSE

A process or test standard created and used within a particular organisation; often considered as confidential and so not disclosed to other parties

INSERT

1 An integral part of a plastic moulding, consisting of metal or other material which can be moulded into position or pressed into the moulding after the moulding is complete

2 A fixing device or type of fastener system, commonly used in sandwich panels

INSERT (FLUSH)

An insert positioned such that its surface is level with that of the face sheet

INSERT (FLUSH-MOUNTED)

An insert positioned in a sandwich panel such that the upper surface of the insert is level, or flush, with the surface of the upper face sheet

INSERT (OVER-FLUSH)

An insert positioned above the surface of the face sheet; also known as ‘protruding’ insert

INSERT (PROTRUDING)

An insert positioned such that the end of the insert extends beyond the surface of the sandwich panel; also known as ‘proud’ or ‘over-flush’

INSERT (SUB-FLUSH)

An insert positioned such that the end of the insert is below the surface of the face sheet; also known as ‘recessed’ insert

INSERT (THROUGH-THE-THICKNESS)

An insert which passes through the entire sandwich panel thickness also known as transverse, double-sided or spool.

INSERT (TYPE)

The various types of inserts can be grouped by the means that they are embedded into a sandwich panel:

(A) for simultaneous bonding during sandwich production, also known as ‘co-cure’;

(B) for an existing sandwich using either a thermosetting resin (usual potting process of standard inserts) or for non-standards inserts by an equivalent bonding process, e.g. carbon fibre tube inserts;

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(C) for mechanical clamping or screwing into an existing sandwich.

INSPECTION

A verification method for physical characteristics that determines compliance with requirement without the use of special laboratory equipment, procedures, items or services. Inspection makes use of standard methods to verify requirements for construction features, document and drawing compliance, workmanship, physical conditions, Glossary Ref.[Ref-1]

INSPECTION PROCEDURE

This document lists all the requirements to be verified by Inspection, grouping them in categories detailing the Verification Plan activity sheets, with planning of the execution and a definition of the associated procedures, Glossary Ref.[Ref-1]

INSPECTION REPORT

This document describes each verification activity performed when inspecting hardware during manufacturing/integration and contains proper evidence that the relevant requirements are satisfied and the indication of any deviation, Glossary Ref.[Ref-1]

INTERLAMINAR SHEAR STRENGTH (ILSS)

The shear strength existing between layers of a laminated material

INTERMEDIATE MODULUS CARBON FIBRES (IM)

A range of carbon fibres with tensile moduli in the range of 255 GPa to 310 GPa, typically

IR

Infra Red

ISO

International standards organization

ISOTROPIC

Property that is not directionally dependent. [Having the same physical or mechanical properties in all material directions]. Metals are often assumed to be isotropic. This is normally not the case, but they do generally show considerably less anisotropy than fibre-reinforced composites

ISOTROP

[See: ISOTROPIC]

J

JIG

A fixture or tool that retains a material, sample or structure, e.g. for testing or during processing; also known as ‘rig’ or ‘fixture’

JIS

Japanese Institute of Standards

K

K49

Kevlar™ 49

KEVLAR®

A grade of aramid fibre from E.I. Du Pont de Nemours [See also: ARAMID]

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KFRP
Kevlar-fibre reinforced plastic

L

LAMINA
[See: PLY]

LAMINATE
Plate consisting of layers of uni- or multidirectional plies of one or more composite materials

LAY-UP
1 Hand- or machine-operated process of ply-by-ply laying of a multidirectional laminate

2 Ply-stacking sequence or ply orientations of a laminate

LIGHT ALLOY
General term for metal alloys of low density, e.g. aluminium, magnesium, which usually have high specific strengths (ratio of strength to density)

LIMITED SHELF LIFE
A period of time, usually stated by the manufacturer or supplier, that when elapsed means that a material can no longer be processed to produce consistently stable final properties, [See also: SHELF LIFE]

LIMIT LOAD
[See: LOADS]

LIMIT LOAD (LL)
maximum load(s), which a structure is expected to experience with a given probability, during the performance of specified missions in specified environments.

[ECSS-E-ST-32]

[See also: LOADS]

LIMIT STRESS
[See: LIMIT LOAD]

LINEAR ELASTIC FRACTURE MECHANICS (LEFM)
Engineering principle to describe the propagation of a single crack through a material, usually a metal alloy, in which it is assumed that all the material is behaving elastically

LN
Luft-Norm; a German standard

LOADS
Strength requirements are specified in terms of:

1 Limit Loads: The maximum external loads to be expected during operational use

2 Ultimate Loads: Limit loads multiplied by prescribed FACTORS OF SAFETY, e.g. the ultimate loads are often established by applying a factor of safety of 1,5 on limit loads

LOAD-DEFLECTION CURVE
A graphical representation of the extension of a material under an applied load; often recorded during the mechanical testing of a sample

LOAD-STRAIN CURVE
A graphical representation of the extension of a material under an applied load

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M

MACHINING

removal of material in a controlled manner by one or more mechanical, electrical or chemical methods, e.g. turning, milling, drilling, electro-chemical discharge, and ultrasonic. [ECSS-Q-70-71]

MAN-MT

Part of the German MAN Technologie company

MARGIN OF SAFETY

Ratio of excess strength to the required (calculated) strength

MASS (of insert system)

Calculated by (potting mass + mass of insert components) – (mass of face sheet removed + mass of core removed)

MASS (of potting)

Describes the volume of cured potting compound used to retain a potted insert within a sandwich panel; also known as 'potting mass'

MATERIAL

raw, semi-finished or finished purchased item (gaseous, liquid, solid) of given characteristics from which processing into a functional element of the product is undertaken

[ECSS-P-001]

MATERIAL DESIGN ALLOWABLE

material property that has been determined from test data on a probability basis and has been chosen to assure a high degree of confidence in the integrity of the completed structure

[ECSS-E-ST-32-08]

MATHEMATICAL MODELLING

Analytical verification based on mathematical modelling of the system. Modelling is performed on the basis of known mathematical techniques, providing a representation of the system features under investigation, Glossary Ref.[Ref-1]

MBB ERNO

Part of the German MBB aerospace organisation located in Bremen. Original authors of the insert design handbook; now part of Astrium GmbH

MD

Multidirectional

MECHANICAL LOAD

Mechanically applied load, distinguished from cure or environment-induced load

MECHANICAL PART

piece of hardware which is not electrical, electronic or electromechanical, and which performs a simple elementary function or part of a function in such away that it can be evaluated as a whole against expected requirements of performance and cannot be disassembled without destroying this capability

[ECSS-P-001]

METALLIC CORE

Any core that is made of metal, e.g. often made of an aluminium alloy

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MICROBALLOONS

A filler material made of very small, hollow glass spheres that is mixed into synthetic resins to modify the flow and viscosity characteristics of the resulting potting compounds; also known as 'microspheres'

MIL-A-81596

Aluminum foil for sandwich construction; USA specification

MIL-A-8625

Anodic coatings for aluminium and aluminium alloys; describes anodising processes for inserts; USA specification

MIL-C-5541

Chemical conversion processes on aluminium alloys; describes chromating processes for inserts; USA specification

MIL-C-7438

Core material - aluminum, for sandwich construction; USA specification

MIL-C-81986

Core Material - plastic honeycomb: nylon paper base for aircraft structural applications; USA specification

MIL-HDBK-17

Composite Materials Handbook; USA specification

MIL-HDBK-23

Structural Sandwich Composites; USA specification.

NOTE: MIL-HDBK 23 is under review for partial incorporation as Volume 6 of MIL-HDBK-17

MIL-HDBK-5

Metallic Materials and Elements for Aerospace Vehicle Structures; USA specification

MIL-standards and specifications

Information regarding current MIL-designation specifications (http://store.mil-standards.com/)

MODULUS

An elastic constant defined as the ratio between the applied stress and the related deformation, such as Young's modulus, shear modulus, or stiffness moduli in general

MOISTURE ABSORPTION

Moisture absorption causes the properties of epoxy to change; it can be detrimental in causing the glassy temperature of the epoxy to be suppressed, and beneficial by counteracting swelling during stresses

MOISTURE CONTENT

The amount of moisture in a material determined under prescribed conditions and usually expressed as a percentage of the mass of the moist specimen, i.e. the mass of the dry substance plus the moisture present

MOULD RELEASE AGENT

Lubricant applied to mould surfaces to facilitate release of the moulded part

M.S

Margin of safety

MULTIDIRECTIONAL

1 Having multiple ply orientations in a laminate

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2 Composite laminates in which the properties are controlled by the orientation of the reinforcement fibres, i.e. fibre-controlled

N

NAS
National Aerospace standard

NDI
Non-destructive inspection, [See: NON DESTRUCTIVE]

NDT
Non-destructive testing, [See: NON DESTRUCTIVE]

NF
Norme Française; French national standard

NIDA
European term for 'honeycomb'; a type of core used in sandwich panels

NOMEX®
An aramid fibre blend from E.I. Dupont de Nemours. Used as the reinforcement material in non-metallic honeycomb cores for sandwich constructions

NON-ASSESSED PROCESS
A process that has no history of previous use in the space environment, and for which no or insufficient data are available relevant to the required project application

NON-METALLIC (CORE)
Any core material that is not made of metal. Core materials of sandwich panels used for space applications are normally made of Nomex® or glass-fibre reinforced plastic

NON DESTRUCTIVE
Techniques used to qualitatively evaluate or quantitatively measure properties or detect defects in materials, structural components or whole structures which do not cause a permanent change to the item under test, e.g. ultrasound, holography, eddy current. The terms NDI (inspection), NDT (testing), NDC (characterisation) and NDE (evaluation) tend to be interchangeable. Non-destructive inspection systems can be manually interpreted or automated to some extent. All require calibration, and the detection limit for each technique varies.

NOTE: No one technique is capable of detecting all types of defects.

NSA
Normalisation Sud Aviation; French standard

O

OFF-AXIS
Not coincident with the axis of symmetry

NOTE: Also called off-angle

OFFGASSING PRODUCT
organic or inorganic compound evolved from a material or assembled article or experiment or rack

[ECSS-Q-ST-70-29]

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