



Space engineering

Structural materials handbook - Part 8: Glossary

Foreword

This Handbook is one document of the series of ECSS Documents intended to be used as supporting material for ECSS Standards in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

This handbook has been prepared by the ECSS-E-HB-32-30 Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Change log

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Introduction

The Structural materials handbook, ECSS-E-HB-32-20, is published in 8 Parts.

A glossary of terms, definitions and abbreviated terms for these handbooks is contained in Part 8.

The parts are as follows:

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1 Glossary

A

A

Aluminium Association, USA

A-BASIS DESIGN ALLOWABLE

A value which at least 99% of the population of values is expected to fall with a confidence of 95%, Ref. [9]; also known as 'A' value and 'A' basis.

A-SCAN

A single point signal describing the ultrasonic response of material immediately beneath the transducer

A-stage

An early stage in the polymerisation reaction of certain thermo-setting resins (especially phenolic) in which the material, after application to the reinforcement, is still soluble in some liquids and is fusible; sometimes called resole. [See also: B STAGE, C STAGE]

'A' value

An 'A' value is one above which at least 99% of the population of values is expected to fall with a confidence of 95%. [See also: ALLOWABLES]

ABLATIVE

Sacrificial material which protects a structure from high-velocity, high-temperature gas streams. It is typically used on leading surfaces for planetary re-entry to protect against frictional atmospheric heating. The surface of the ablative is consumed by reaction, abrasion and evaporation or sublimation and the lost material carries heat away from the underlying structure

AblaDor DO-31-F

Lightweight phenolic ablative

ABM

Apogee Boost Motor

ABS

- 1 Alumino-boro-silicate ceramic
- 2 Acrylonitrile-butadiene-styrene copolymer

ACC

Advanced Carbon-Carbon (NASA) replaced RCC

ACCELERATOR

A material mixed with a catalysed resin to increase the rate of chemical reaction between the catalyst and resin, used in polymerising resins, also known as promoter or curing agent

ACCELEROMETER

A device for measuring acceleration, often used in vibration analysis

ACCEPTANCE

Verification phase with the objective to demonstrate that the flight items are free of workmanship defects and integration errors and ready for operational use, Ref. [1]

ACESA

Advanced composites with embedded sensors and actuator. An American smart technology programme.

ACG

Advanced Composites Group, UK

ACK analysis

Aveston-Cooper-Kelly analysis for modelling the onset of matrix cracking in composite materials (with particular regard to CMC ceramic matrix composites)

ACOUSTIC EMISSION (AE)

An inspection technique where the sound generated by damage formation and propagation (under test stressing or in-service) is monitored using sensitive, high-frequency microphones. Triangulation techniques can be used to locate the damage events within a three dimensional structure. Frequently used to measure the integrity of composite laminates

ACRV

Assured Crew Return Vehicle (NASA/ESA) for emergency return of astronauts from orbiting space stations to earth

ACS

Attitude Control System

ACTEX

Advanced control technology experiment. An American smart technology programme.

ACTIVE COMPENSATION

A device able to change its characteristics in response to an externally triggered signal, e.g. stiffness in response to vibration

ACUSIL I

An ablative foam composed of silicone resin, quartz microballoons, phenolic microballoons and quartz fibre

ACUSIL II

Lower density ablative foam composed of silicone resin, quartz microballoons, phenolic microballoons and quartz fibre. Remains RF transparent during re-entry

ADHEREND

Plate adhesively bonded to another plate, Ref. [10].

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

ADVANCED COMPOSITES

Composite materials with structural properties comparable to or better than those of aluminium; e.g. boron, graphite and aramid composites

AE

See: Acoustic Emission

AECMA

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

AEFIS

Acoustic emission flight instrumentation system. A structural health monitoring system, developed by Boeing.

Aerotiss® 2.5D

Aerospatiale reinforced carbon-carbon (RCC) material with multidirectional fibre architecture

A_f

Austenite finish temperature

AFNOR

Association Française de Normalisation; French national standards organisation

AFRSI

Advanced Flexible Reusable Surface Insulation (Shuttle orbiter)

AFWAL

Air Force Wright Aeronautical Laboratory, USA

AGC

Attitude Gain Control

AGE HARDENING

A thermal treatment used to improve the strength of some metal alloys, e.g. certain aluminium alloys, [See also: Precipitation Hardening].

AGED STRUCTURE

A structure which can have structural degradation or damage as a result of being exposed to the combined effects of the environment

AGEING

General: The process or the effect on materials of exposure to an environment (elevated temperature, ultraviolet radiation, moisture or other hostile environment) for a period of time; also known as 'aging'

1 Material or sample: usually undertaken before testing and applied to simulate the expected service environmental conditions, e.g. exposure to heat and humidity

2 Structure: the progressive change in characteristics owing to exposure to the service conditions, e.g. corrosion, outgassing

3 Processing: a thermal process used to obtain the desired microstructure and properties of metal alloys, e.g. some aluminium alloys

AGGRESSIVE ENVIRONMENT

Any combination of liquid or gaseous media and temperature that alters static or fatigue crack-growth characteristics from 'normal' behaviour associated with an ambient temperature and laboratory air environment, Ref. [5]

AGING

[See: Ageing].

AI

Artificial intelligence

AIAA

American Institute of Astronautics and Aeronautics, USA

AISI

American Iron and Steel Institute

AIT

Assembly, Integration and Test

AIV

Assembly, Integration and Verification

AKM

Apogee Kick Motor

ALFLEX

Automatic Landing Experimental Vehicle

Al-Li

Aluminium-lithium alloy

ALLOTROPY

Existence of a chemical element in two or more physical forms, e.g. carbon as graphite or diamond

ALLOWABLE LOAD

The load that induces the allowable stress in a material, Ref. [5]

ALLOWABLE STRESS

The maximum stress that can be permitted in a material for a given operating environment to prevent rupture, collapse, detrimental deformation or unacceptable crack growth, Ref. [5]

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

AlN

Aluminium nitride

ALS051

Medium-density, silicone-based ablative

ALSCAP

Alternative Low-cost, Short Manufacturing Cycle Assessment Programme

ALUMINA

Aluminium Oxide, Al₂O₃.

ALUMINIDE

Intermetallic compound of another metallic element, or elements, with aluminium, e.g. NiAl, TiAl or FeAl

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

ALUMINIUM-LITHIUM

An aluminium alloy containing typically between 1% and 3% Li, with the objective of increasing mechanical properties over base alloy alone.

Note: Because Li is a low-level alloy addition, Al-Li alloys are classified within the 2XXX, 7XXX and 8XXX wrought alloy designations, plus 2XX casting alloys

ALUMINIUM NITRIDE (AlN)

Ceramic with high thermal conductivity (140 W/mK to 177 W/mK), but is effectively an electrical insulator (volume resistivity 10¹⁰ ohm cm). Can suffer surface oxidation above 700°C, density 3320 kg m⁻³.

ALUMINO-SILICATE

Compound of aluminium and silicon oxides used in ceramics and some types of glasses for composite matrix materials

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

ANALYSIS

A verification method performing theoretical or empirical analysis by accepted analytical methods. The selected techniques can typically include systematics, statistics, qualitative design analysis, modelling and computer simulation, Ref. [1]

ANALYSIS PROCEDURE

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

ANALYSIS REPORT

A document that describes, for each analysis, assumptions, utilised methods, software and results and contains proper evidence that the relevant requirements are satisfied, Ref.[1]

ANALYTICAL LIFE

Life evaluated analytically, i.e. by crack-growth analysis or fatigue analysis, Ref. [5]

ANALYTICAL MODEL

A representation of an item based on mathematical modelling. The modelling is performed on the basis of known mathematical techniques, providing a representation of the item features under investigation, Ref. [1]

ANGLE INTERLOCKED

A triaxial fabric in which all reinforcement fibres are woven at the same time; also known as 'integrally woven'

ANGLE-PLY LAMINATE

Possessing equal plies with positive and negative angles. This bidirectional laminate is simple because it is orthotropic

ANISOTROPIC

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

ANNEALING

A heat treatment process:

- 1 Metals: used to reduce residual stresses.
- 2 Composites: ineffective at reducing residual stresses

ANOXIC

The resistance of a material to thermo-oxidative attack by atomic oxygen

ANTISYMMETRY

Special symmetry with sign change between off-diagonal components, e.g. an unsymmetrical angle-ply laminate

AO

Atomic oxygen; experiments conducted on the Long Duration Exposure Facility (LDEF)

AOCS

Attitude and Orbit Control System, or subsystem

APC

Aromatic polymer composite

AQUEOUS CORROSION

Corrosion by ionic species in water, e.g. chlorides, hydroxides. Includes moisture or humidity trapped or condensed within structures.

AR

Acceptance Review

ARA

Advanced rigid array; a type of ultrasonic transducer assembly

ARALDITE™

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

ARALL™

Aramid fibre-reinforced aluminium laminate. [See: FIBRE METAL LAMINATE]

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

ARAMID/EPOXY

A composite material comprising of an aramid fibre reinforcement in an epoxy matrix

ARC

Austrian Research Centre, Seibersdorf

ARD

Atmospheric Re-entry Demonstrator

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

ARP

Aramid fibre-reinforced plastic, Ref. [10]

ARTIFICIAL INTELLIGENCE (AI)

The property of a machine capable of reason by which it can learn functions normally associated with human intelligence

A_s

Austenite start temperature

ASIFS

Aerial spacecraft interface structure; part of SILEX

ASIP

Aircraft Structural Integrity Program

ASME

American Society of Mechanical Engineers

ASSEMBLED ARTICLE

Any component 'black box' or assembly of components which represents the article to be used in a spacecraft, Ref. [7].

ASSEMBLY

An accumulation of subassemblies and/or equipment that performs specific functions within a subsystem, e.g. water pump package. (Verification level typical of US standard), Ref.[1]

ASTM

American Society for Testing and Materials; USA standards organisation

ASTP

Advanced Systems and Technology Programme; ESA programme

ASTREX

Advanced space structure technology research experiments; an American smart technology programme

ATC

- 1 Active Thermal Control
- 2 Advanced Technical Ceramic

ATOMISATION

Spray technique for producing metal alloy powders with or without a particulate reinforcement. Molten metal is forced through a nozzle into a stream of high-velocity, inert gas. The semi-solid droplets are collected on a substrate. Proprietary processes are OSPREY (un-reinforced alloys) and COSPRAY (particulate reinforced alloys)

ATOX

Atomic Oxygen

AUTOCLAVE

A closed vessel for conducting a chemical reaction or other operation under pressure and heat

AUTOCLAVE MOULDING

After composite lay-up, the entire assembly is placed in steam autoclave at 7 bar to 14 bar and 180°C; additional pressure achieves higher reinforcement loading and improved removal of air

AVCO 5026-39 HCG

Epoxy-novolac, glass fibre honeycomb reinforced material

AVERAGE STRESS CRITERION

A failure criterion in which it is assumed that failure occurs when the average stress over some distance equals the unnotched laminate strength

AWG

American Wire Gauge

AXIAL WINDING

In filament-wound reinforced plastics, a winding with the filaments parallel to the axis

AXISYMMETRY

Symmetry about an axis (in the case of a laminated material it is isotropic in the plane normal to the axis, and this material is called transversely isotropic)

B**B-BASIS DESIGN ALLOWABLE**

A value which at least 90 % of the population of values is expected to fall with a confidence of 95 %, Ref. [9]; also known as 'B' value

B-SCAN

A scanned line response showing features at identifiable depths; nondestructive testing

B-STAGE

An intermediate stage in the reaction of certain thermosetting resins, Ref. [10], in which the material swells when in contact with certain liquids and softens when heated, but cannot dissolve or fuse entirely; sometimes referred to as 'resistol'. The resin in an uncured prepreg or pre-mix is usually in this stage. [See also: A-STAGE, C-STAGE]

'B' VALUE

A 'B' value is that above which at least 90% of the population of values is expected to fall with a confidence of 95%. [See also: ALLOWABLES]

BACKING SHEET

A thin polymer sheet used to protect prepreg and film adhesive surfaces from contamination and damage prior to use. These have to be completely removed during lay-up and are usually coloured to aid this.

BAe

British Aerospace, UK

BAGGING

Process: the enclosing of an uncured composite lay-up in a heat-resistant bag prior removal of the air and subsequent curing

BAKEOUT

Activity of increasing the temperature of hardware to accelerate its outgassing rates with the intent of reducing the content of molecular contaminants within the hardware. Note: Bakeout is usually performed in a vacuum environment but may be done in a controlled atmosphere, Ref. [8].

BALANCED DESIGN

In filament-wound reinforced plastics, a winding pattern so designed that the stresses in all filaments are equal

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

BAM

Bundesanstalt für Materialforschung und prüfung, Federal Institute for Materials Research and Testing, Germany

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

BERYLLIUM (Be)

Metallic element, melting point 1289°C, density 1850 kg m⁻³. Uses: aerospace structural material, with good dimensional stability and moderately high service temperatures.

BIAS

A type of weave for a fabric, [See: BIAS WEAVE]

BIAS WEAVE

The weft picks cross the warp ends at 45° or 60° instead of the normal 90°.

BIAXIAL WINDING

In filament winding, a type of winding in which the helical band is laid in sequence, side by side, with no crossover of fibres

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]

BIG FOOT™

Types of mechanical fasteners that provide a larger footprint, i.e. contact area, than conventional types of fasteners; developed by Monogram

BIOMIMETICS

Synthetic materials which function like natural ones, e.g. artificial tendons and Velcro™

BIOPAN

A multi-user exposure facility, designed for exobiology, radiation biology, radiation dosimetry and material science investigations in space; ESA mission

BIPROPELLANT

Rocket fuel consisting of two chemical components which react on contact in the combustion chamber, e.g. mono-methyl-hydrazine (MMH) and nitrogen tetroxide (NTO)

BISFA

International Bureau for Standardisation of Man-made Fibres

BISMALEIMIDE (BMI)

A type of polyimide that cures by an addition rather than a condensation reaction, thus avoiding problems with volatiles, and which is produced by a vinyl-type polymerisation of a polymer terminated with two maleimide groups. It has intermediate temperature capability between epoxy and polyimide (about 200°C)

BLEED

The removal of excess resin from a prepreg during processing, [See also: CONTROLLED BLEED and ZERO-BLEED]

BLEEDER CLOTH

Non-structural, fibre glass cloth placed adjacent to the composite material part to absorb excess resin during cure, and removed from the part after cure

BLIND

Fasteners: Installed from one side of a component only

BLISK

Turbine disk where the blades and hub are formed as a single piece (Integrally-bladed disk).

BLISTER

Delamination in a distinct local area or areas

BLOX

Laser enhanced oxidation test facility at ONERA, France.

BMI

Bismaleimide. [See: BISMALEIMIDE]

BOND LINE

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

BOND STRENGTH

The amount of adhesion between bonded surfaces; a measure of the stress required to separate a layer of material from the base to which it is bonded. [See also: PEEL STRENGTH]

BONDED JOINT

The general area of contact for a bonded structure. This includes composite to composite and composite to metal adherends and all forms of adhesives including co- and post-cured joints. [See also: ADHEREND, ADHESIVE, CO-CURE, POSTCURE]

BOR-4

A re-entry test vehicle

BORON (B)

Metallic element, melting point 2092°C, density 2340 kg m⁻³. Uses: alloying additions, doping in aluminides to induce ductility. Reinforcing filaments for polymer or metal matrix composites. Mainly within the USA

BORON CARBIDE (B₄C)

Extremely hard ceramic material with a density of 2520 kg m⁻³

BORSIC

Boron filaments for reinforcement made by deposition onto a fine tungsten wire and coated with silicon carbide (SiC)

BPS

Backpack subsystem; part of an extra-vehicular activity space suit

BRAGG GRATING

A diffraction grating constructed by creating a systematic spatial variation of the structure of a material, such as the molecular structure of a crystal or the refractive index of glass, Ref.[4].

BRAIDING

Process: A mechanical weaving of fibres that enables three or more continuous yarns to be progressively crossed in a predetermined pattern and angle to produce a complex network to form a structural shape, such as a tube, square box or U-shaped channel

BRAZING

Joining technique involving the melting of a material with a lower temperature (braze) placed between parts to be joined. The parent metal(s) remain(s) solid during brazing

BREADBOARD

[See: DEVELOPMENT MODEL]

BREATHER

Porous material, such as fabric or mat, placed inside the vacuum bag to facilitate removal of air, moisture and volatiles during cure

BRIDGING

A build-up of solder or conformal coating between parts, component leads and/or base substrate forming an elevated path

BROOMING

The appearance of the end of a failed composite material where the reinforcing fibres are clearly visible, such that it resembles a brush or broom

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 transversely; fibre buckling modes are known as 'extension mode' and 'shear mode'.

BUNDLE

A number of parallel filaments, normally without organic matrix

BUNDLE STRENGTH

Strength obtained from a test on parallel filaments, with or without organic matrix. The bundle test is often used instead of the monofilament test

BURAN

Russian reusable manned spacecraft: resembling the USA STS Space Shuttle Orbiter

BURST PRESSURE

The pressure at which a pressurized system ruptures or collapses, Ref. [5]

BURST STRENGTH

Hydraulic pressure required to burst a vessel of given thickness; commonly used in testing filament-wound composite structures

BVID

Barely visible impact damage

C

C-C

Carbon-carbon. Carbon fibre reinforced, carbon matrix composite

C/SiC

Carbon fibre-reinforced silicon carbide; a ceramic matrix composite (CMC)

C-STAGE

The final stage in the reaction of certain thermosetting resins in which the material is relatively insoluble and infusible; sometimes referred to as resite. The resin in a fully cured thermoset moulding is in this stage. [See also: A-STAGE, B-STAGE]

CABLE

Two or more insulated conductors, solid or stranded, of equal length, contained in a common covering; or two or more insulated conductors, of equal length, twisted or moulded together without common covering; or one insulated conductor with a metallic covering shield or outer conductor (shielded cable or coaxial cable)

CABLED YARN

[Technical textiles] Two or more folded yarns twisted together

CADMIUM (Cd)

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

C/Al

Carbon fibre reinforced aluminium

CAI

Compression after impact

CALIBRATION

The comparison of two instruments or measuring devices, one of which is a standard of known accuracy traceable to national standards, to detect, correlate, report, or eliminate by adjustment any discrepancy in accuracy of the instrument or measuring device being compared with the standard

CANOPY

The fabric portion of a parachute which provides drag, or drag and lift, when inflated

CAPSA

Alenia Spazio ablative TPS design tool computer program

CARBIDE

A binary compound of carbon with an element more electropositive than carbon, (excluding carbon-hydrogen compounds). Compounds often hard and brittle. Uses: external hardening treatment for steels, as hardening agents within alloys; e.g. silicon carbide is a widely used abrasive in particulate form, or as a matrix for ceramic matrix composites. Carbides, important alloying element in steels and superalloys

CARBON (C)

Non-metallic element, melting point $\sim 3550^{\circ}\text{C}$; graphite sublimates at $\sim 3367^{\circ}\text{C}$; density 2200kg m^{-3} . Uses: carbon reinforcement fibres, matrix in C-C composites, silicon, tungsten. [See also: CARBIDE and CARBON FIBRE]

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-CARBON

Carbon fibre-reinforced carbon, produced by resin or pitch pyrolysis of the matrix of a CFRP, or by CVI; infiltration of a fibrous preform. [See: CVI]

CARE

Carbon fibre-reinforced aluminium laminate. [See: FIBRE METAL LAMINATE]

CARINA

Space recovery vehicle, by Alenia Spazio: CApsula di RIentro Non Abitata

CARPET PLOT

A design chart showing the uniaxial stiffness or strength as a function of arbitrary ratios of 0° , 90° and $\pm 45^{\circ}$ plies; used for determination of moduli, strength or thermal expansion coefficients

CARTEC-FT

Study for an Italian scientific payload carrier for re-entry experiments

CAS

Calcium aluminosilicate: a glass-ceramic matrix

CASA

Construcciones Aeronauticas SA, (E); now EADS CASA

CASE

Case describes the whole structure which is necessary for pressure storage. It consists of the pressure vessel, the joint structure and the interface flange providing the connection to the main structure

CASSINI-HUYGENS

NASA Cassini mission to study Saturn, it's rings and moons. The ESA-built Huygens probe is for decent onto Titan, the largest Saturn moon.

CAT

Computer-aided tomography

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

CATASTROPHIC HAZARD

A potential risk situation that can result in loss of life, in life-threatening or permanently disabling injury, in occupational illness, loss of an element of an interfacing manned flight system, loss of launch site facilities or long term detrimental environmental effects.

Note: For payloads of the NASA STS or ISS, the applicable definition is: 'A potential risk situation that can result in personnel injury, loss of the NASA orbiter, ground facilities, or STS equipment'; (LASTS 1700.7, paragraph 302), Ref. [5]

CAUL PLATE

Smooth metallic plate that is placed in contact with the laminate or adhesively bonded assembly to ensure uniform pressure and temperature during cure and a smooth finish afterwards

CBEN

Cantilever beam enclosed notch; a test method used for Mode II fracture toughness

C-C

Carbon-carbon composite material

CCB

Configuration Control Board

CCD

Charge-coupled Device

CCDTV

Charged-couple device television

CCSiC

Carbon-carbon-silicon carbide composite material

CDA

Copper Development Association

CDR

Critical Design Review

CDS

Characteristic damage state

CEN

Comité Européen de Normalisation (European Committee for Standardization)

CERAMIC

Chemical compound or mixture of compounds with high temperature capabilities, often metal (or silicon) oxides, nitrides or carbides

CERAMIC MATRIX COMPOSITE (CMC)

Composite material in which the matrix is a ceramic

CETEX

Ceramic Tile Experiment (on EXPRESS)

CFD

Computational Fluid Dynamics

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]

CFRTP

Carbon fibre-reinforced thermoplastic

CHA

Ceramic Heatshield Assembly

CHAR YIELD

The amount of material remaining after ignition and burning

CHARACTERISTIC DAMAGE STATE (CDS)

A characteristic level at which the amount of cracking induced in a laminate by cyclic loading stabilises

CHEMICAL VAPOUR DEPOSITION (CVD)

Processing method involving the decomposition of a pre-cursor gas rich in the elements required under controlled temperatures and pressures (in a reaction vessel) and deposition onto a component or onto reinforcement fibres. Applicable to metals and ceramic (most common). Uses: coatings and thin section carbon or ceramic matrix composites. Deposition rates are slow, unless substrates are heated (pyrolysis) or laser heat sources (photolysis) are used

CHEMICAL VAPOUR INFILTRATION (CVI)

Same principle as CVD. Term often used to describe the Near-net shape processing method for matrix deposition within fibre preforms. Deposition rates are slow. Proper infiltration of thicker section composites can require thermal gradients or forced flow techniques. Uses: ceramic and carbon matrix composites

[See also: NEAR-NET SHAPE]

CHROMIA

Chromium Oxide (Cr_2O_3)

CHROMIUM (Cr)

Metallic element, melting point $\sim 1863^\circ\text{C}$, density $7180 \text{ kg}\cdot\text{m}^{-3}$, Uses: Addition for corrosion (oxidation) resistance in superalloys, steels, coating systems

CI

Configuration Item Number (as per project definition)

CIRCUIT

In filament winding: (1) One complete traverse of the fibre-feed mechanism of a winding machine. (2) One complete traverse of a winding band from one arbitrary point along the winding path to another point on a plane through the starting point and perpendicular to the axis

CIRCUMFERENTIAL ('CIRC') WINDING

In filament-wound reinforced plastics, a winding with the filaments essentially perpendicular to the axis

CLEANROOM

A room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters, e.g. temperature, humidity, pressure; are controlled as necessary, [BS EN ISO 14644-1:1999 3.1.3], Ref. [8]

CLOTH

A manufactured assembly of fibres or yarns with sufficient mechanical strength to hold the assembly together when handled; a fabric more than 150 mm wide. [See also: FABRIC]

CLRD

Common large reflector dish

CLS

Cracked lap shear; a test method used for mixed fracture toughness modes I and II

CMBR

Cosmic microwave background radiation

CMC

Ceramic matrix composite

CME

See: COEFFICIENT OF MOISTURE EXPANSION

CMR

Creep mismatch ratio. In a composite material, the ratio of the creep rate of the fibres to that of the matrix

CN

Centre notch; a test method used for fracture toughness mode I

CNC

Computer numerical control

COATING

1 A material applied to protect a substrate material or assembly, Ref. [10], e.g. against corrosion, oxidation or diffusion

COBALT (Co)

Metallic element, melting point 1495°C, density 8900 kg.m⁻³, Uses: base element for some superalloys, binder for cemented carbides (tungsten carbide), alloying addition to other superalloys

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

COEFFICIENT OF MOISTURE EXPANSION (CME)

The change in length per unit length produced by the absorption of water (usually by resin matrices or adhesives)

COEFFICIENT OF THERMAL EXPANSION (CTE)

The change in length per unit length produced by a unit rise or decrease in temperature

COHESION

The requirement that the constituent components of the prepreg remain united in the required format for the specified storage and handling conditions. (Specific definition for 'cohesion' in relation to prepreg)

COLLECTED VOLATILE CONDENSABLE MATERIAL (CVCM)

The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific temperature for a specific time, Ref. [8].

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

COMBINED TEST

Test imposing the environments in the logical combination, rather than sequentially, to evaluate the synergistic effects between environments, Ref.[1]

COMED

Constellations and multimedia development and demonstration programme; a DLR (D) telecommunications technology demonstration programme completed in 2004

COMET

Commercial Experiment Transporter (NASA) two function recovery capsule. Free-flyer concept of a pressurised recovery system (intended for 227 kg of recoverable experiments) with a non-pressurised, non-recoverable service module

CO-MINGLING

A process whereby thermoplastic fibres are mixed with reinforcing fibres within a yarn

COMPATIBILITY

The ability of two or more substances combined with each other to form a homogeneous composition with useful plastic properties. (Specific definition for 'compatibility' in relation to composites.)

COMPLIANCE

Measurement of softness as opposed to stiffness of a material. It is the reciprocal of Young's modulus, or an inverse of the stiffness matrix

COMPONENT

A device which performs an electronic, electrical or electromechanical function and consists of one or more elements joined together and which cannot normally be disassembled without destruction. The terms component and part can be interchanged. Typical examples of components are transistors, integrated circuits, hybrids, capacitors

COMPOSITE SANDWICH CONSTRUCTION

A panel 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, Ref. [9]

CONDITION

Metal alloys: a sequence of heat-treatment or mechanical working, which determines the metallurgical structure and hence properties

CONDITIONING

One or more processes applied to samples prior to testing, e.g. to increase or decrease the moisture content, heat treatment, thermal cycling

CONDITION MONITORING

Smart technologies: A diagnostic system which can provide data on the integrity or functioning of machinery, industrial plant or a space subsystem, either continually or periodically

CONDUCTOR

A lead or wire, solid or stranded, or printed-circuit patch serving as an electrical interconnection between terminations

CONFORMAL COATING

Material applied to protect an electronic assembly, Ref. [10]. A thin protective coating which conforms to the configuration of the covered assembly

CONSOLIDATED DECLARED LIST

A prime contractor task which consists of:

- sorting by part, material or process group and merging the items from subcontractors' lists into one project list
- summing up in one item, identical items from different subcontractors,
- negotiating the reduction to one or a few items, where identical functions are performed by an excessive number of parts, [See also: DML, DMPL, DPL]

CONSOLIDATION

A stage in the manufacturing process used to create a composite from either fibres and matrix phases or pre-prepared plies, e.g. thin metal foils, metallised reinforcement fibres or prepregs. Often requires heating and pressure to achieve proper consolidation. Processes can be repeated

CONSTITUENT MATERIALS

Individual materials that make up the composite material; e.g. carbon and epoxy are the constituent materials of a carbon/epoxy composite material

CONTAINMENT

A technique that, if a part fails, prevents the propagation of failure effects beyond the container boundaries, Ref. [5]

CONTAMINATION

Particles, liquids, gases, materials and micro-organisms which by their presence can disturb the performance of an item

CONTINUOUS FILAMENT YARN

Yarn formed by twisting two or more continuous filaments into a single continuous strand

CONTINUOUS REINFORCEMENT

Where reinforcement fibres or filaments pass uninterrupted through the composite

CONTROLLED BLEED

Prepreg materials that contain a resin which is formulated to have flow and gelation characteristics such that excess resin is removed in a controlled manner during consolidation and curing of a composite

CONVENTIONAL METALS

Engineering metals and alloys which do not contain deliberate additions of particulate or fibre reinforcements, i.e. are not considered as composites

COPPER (Cu)

Metallic element, melting point 1085°C, density 8960 kg.m⁻³, Uses: high thermal and electrical conductivity applications

CORE

Sandwich panel: a lightweight material in between the face skins, e.g. honeycomb core, foam. Metallic or composite sheet materials are bonded to the core to form a sandwich panel

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

CORNING DC 235 SILICONE

Commercial silicone-based material produced by Corning

CORROSION

A reaction of the engineering material with its environment with a consequent deterioration in properties of the material, Ref. [9]

Note: The reaction can be chemical or electrochemical

COUNT (Fabrics)

Number of warp and fill yarns per unit length; e.g. a fabric count of 24 x 26 in English units means 24 yarns per inch in the warp, and 26 in the fill

COUPLANT

A substance placed between an ultrasonic transducer and the material under test to ensure a good acoustic path

COUPLING

Linking a side effect to a principal effect. Poisson coupling links the lateral contraction to an axial extension. For composite materials, an anisotropic laminate couples the shear to normal components; an unsymmetric laminate couples curvature with extension. These couplings are unique with composites and provide opportunity to perform extraordinary functions

COUPON

A small test specimen, e.g. usually a flat laminate, for evaluation of basic lamina or laminate properties or properties of generic structural features (e.g. bonded or mechanically fastened joints)

CP

Commercial Purity (Metal alloys, notably Titanium)

CPASB

Coarse pointing areal support bracket; part of SILEX

CPM

Coarse pointing mechanism; part of SILEX

CPN

Corps de Propulseurs à Poudre.

CPS

Chestpack subsystem; part of an extra-vehicular activity space suit

CPU

Central Processing Unit

CR

Commissioning Review

CRACK

1 A defect that behaves like a crack that is initiated, for example, during material production, fabrication or testing or developed during the service life of a component. Note: The term 'crack' in this definition includes flaws, inclusions, pores and other similar defects, Ref. [5]; also known as CRACK-LIKE DEFECT

2 Composite: An actual separation of moulding material visible on opposite surfaces of the part and extending through the thickness; a fracture

CRACK ASPECT RATIO

For a part-through crack, the ratio of crack depth, a , to half crack length, c , i.e. a/c , Ref. [5]

CRACK GROWTH

Rate of propagation of a crack through a material due to a static or dynamic applied load

CRACK GROWTH RATE (da/dN , dc/dN , da/dt or dc/dt)

The rate of change of depth a or length c with respect to the number of load cycles N or time t , Ref. [5]

CRACK GROWTH RETARDATION

The reduction of crack-growth rate due to intermittent overloading of the cracked structural member, Ref. [5]

CRACK-LIKE DEFECT

A defect that behaves like a crack, [See: CRACK]

CRAF

Comet rendezvous and flyby

CRAG

Composite Research Advisory Group, UK

CRAZING

Fine discontinuity which can extend in a network on or under the surface of a plastic material

CREEP

The deformation (permanent change in dimensions) of a material (plastic, metal or ceramic) under constant load over a period of time, not including the initial instantaneous elastic deformation. A process which generally becomes significant at elevated temperatures, at room temperature it is sometimes called cold flow

CREVICE CORROSION

A form of galvanic corrosion occurring within a single phase where a gradient environment exists. [See also: GALVANIC CORROSION]

CRITICAL CRACK

The critical crack size (a_c) defined as the crack size at which the structure fails under limit load, calculated for brittle fracture by:

$$a_c = \frac{(K_c)^2}{\Sigma \pi (F_i S_i)^2}$$

where:

K_c = critical stress intensity factor

S_i = limit stresses†

F_i = stress intensity magnification factors†

†: for different load cases

Note: Factors F_i normally depend on the crack size (a), and is accounted for in the calculations, e.g. by use of an iterative method

CRITICAL FLAW

A flaw of sufficient size and shape to cause unstable growth to occur under the specific operating loads and environment

CRITICAL HAZARD

A potential risk situation that can result in, Ref. [5]:

- temporarily disabling but not life-threatening injury, or temporary occupational illness;
- loss of, or major damage to, flight systems, major flight system elements or ground facilities;
- loss of, or major damage to, public or private property; or short-term detrimental environmental effects

CRITICAL MECHANICAL PART

Mechanical part that requires specific attention or control due to fracture mechanics aspects and limited-life aspects, or with which the Contractor has no previous experience, Ref. [6]

CRITICAL PROCESS

A process is declared critical when it is new or nonvalidated for the application in question or has caused problems during previous use that remain unresolved, Ref. [6]

CRITICAL STRAIN

The strain at the yield point

CRITICAL STRESS-INTENSITY FACTOR (FRACTURE TOUGHNESS)

The value of the stress-intensity factor at the tip of a crack at which unstable propagation of the crack occurs. This value is also called the fracture toughness. The parameter K_{Ic} is the fracture toughness for plane strain and is an inherent property of the material. For stress conditions other than plane strain, the fracture toughness is denoted K_c . In fracture mechanics analyses, failure is assumed to be imminent when the applied stress-intensity factor is equal to or exceeds its critical value, i.e. the fracture toughness, [See Stress intensity factor (K)], Ref. [5]

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

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

CRV

- 1 Crew Return Vehicle
- 2 Crew Rescue Vehicle

CRYOFORMING

Forming (shaping) of metal alloys at very low temperatures, e.g. stainless steels

CRYOGENIC

Very low temperature, generally less than 100 K. Typically the temperature ranges at which the principal atmospheric gases liquify, e.g. Nitrogen: -196°C

CRYOMILLING

Mechanical attrition in liquid nitrogen

CRYOTANK

A tank structure containing a liquid or gas (often fuel) at cryogenic temperatures, [See also: LOX and LH]

CRYSTALLINITY (DEGREE OF)

The volume fraction of crystallites within the polymer

C-SAM

C-scan scanning acoustic microscope; an ultrasonic materials evaluation technique

C-SCAN

The area-scanning of a specimen with ultrasonic acoustic waves. A non-destructive testing technique for finding voids, delaminations and defects in fibre distribution, [See also: A-SCAN and B-SCAN]

CSG

Centre Spatial Guyanais

C-SiC

Carbon-silicon carbide composite material

CSLDV

Continuously Scanning Laser Doppler Vibrometer

CSM

Chopped strand matt; a type of multidirectional, short-fibre reinforcement used for industrial materials rather than high-performance aerospace composites

CT

Computer or computerised tomography

CTE

See: COEFFICIENT OF THERMAL EXPANSION

CTE MISMATCH

- 1 The difference in coefficient of thermal expansion between two or more materials within a specified temperature change, e.g. polymers and metals, Ref. [10].
- 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)

CTP

Cold thermal protection

CTV

Crew Transfer Vehicle

CURE

- 1 To change 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, Ref. [10].
- 2 A chemical reaction during which a liquid resin is transformed to a solid material by the process of cross-linking

CURE CYCLE

- 1 The relationship between time, temperature and pressure required to achieve the required cure and properties of a polymer-based material, e.g. resin, adhesive, coating, Ref. [10].
- 2 The 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. The optimum cure cycle is usually specific to a particular type of prepreg, its lay-up and the component and tool design. Small variations in the prepreg (in particular in the resin) can have a dramatic effect on the cure cycle needed to achieve a satisfactory laminate

CURE STRESS

A residual internal stress produced during the curing cycle of a composite structure

CURIE POINT

The temperature at which a material begins to lose its piezoelectric characteristics. Once lost the process is irreversible, though the material can be recoverable by re-poling

CURING AGENT

Hardener, a catalytic or reactive agent added to a resin to cause polymerisation

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

CVD

Chemical Vapour Deposition

CVI

Chemical Vapour Infiltration

CVI-C/SiC

Carbon-silicon carbide composite material manufactured by MAN Technologie (D), using Chemical Vapour Infiltration process.

CVSR

Comet Nucleus Sample Return mission

CYANATE ESTER

A family of polymer resins, which can contain bisphenol, phenol or novalac within their formulations, that provide a low moisture absorption capability

CYCLE

Processing of composites: The complete, repeating sequence of operations in a process or part of a process. In moulding, the cycle time is the elapsed time between a certain point in one cycle and the same point in the next

CYCLIC LOADING

A fluctuating load (or pressure) characterized by relative degrees of loading and unloading of a structure. Examples are loads due to transient responses, vibroacoustic excitation, flutter and oscillating or reciprocating mechanical equipment, Ref. [5]

D

DADT

Differential absorption distributed thermometry. A fibre-optic-based temperature-measurement method

DAISY

Deployable antenna integral system; an antenna design from Dornier

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 ACCUMULATION

Term used in fatigue testing of MMC and CMC materials where fatigue cracks initiated in the matrix phase propagate and cause debonding at the fibre-to-matrix interface, but do not damage the reinforcement

DAMAGE CRITICAL PARTS

Structural parts or items whose failure, due to the initiation or propagation of flaws or damages can result in loss of the mission or present a catastrophic hazard to personnel

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

A structure is considered to be damage tolerant if the amount of general degradation and/or the size and distribution of local defects expected during operation do not lead to structural degradation below limit-specified performance, Ref. [5]

DAMPING

The parameter which governs the resonant response of a material, component or structure; expressed quantitatively either as an absolute or a relative energy basis

DAMPING (MECHANICAL)

Mechanical damping gives the amount of energy dissipated as heat during the deformation of a material. Perfectly elastic materials have no mechanical damping

DART

Distributed anti-Stokes ratio thermometry. A fibre optic-based temperature measurement system

DASA

Deutsche Arbeitsschutzausstellung, German aerospace organisation; now Deutsche Aerospace Airbus

DBTT

Ductile-to-brittle transition temperature

DCB

Double cantilever beam; a test method used for fracture toughness Mode I (GIC)

DC-XA

Delta-Clipper Advanced Experimental Vehicle. An unmanned and rocket-powered, prototype vertical take-off and landing (VTOL) reusable launch vehicle developed under NASA's SSTO programme by McDonnell-Douglas

DDA

Discontinuous Deformation Analysis

DEBOND

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 skin; caused by contamination or damage to either the film adhesive used to join the face skin laminate to the core, face laminate itself, bond area of the core or mechanical damage to core cell walls, by crushing or more local damage

DEBOND

General: a defective area of an adhesive bond where the adherends are no longer held together

DEBRIS

Accumulation of man-made waste materials in space, usually resulting from launch, deployment and other spacecraft operations

DEBULK

To reduce laminate thickness by application of pressure. The compaction is achieved by removing trapped air, vapour and volatiles between plies

DEBULKING

Process: to remove large volumes of air from prepreg materials during their lay-up on or into a mould, whereby some uncured plies of prepreg are formed to the mould surface using a vacuum bag, further plies added to the stack after the bag is removed. If necessary, it is repeated several times especially for thick laminates: a means of reducing porosity or voids in thick laminates or shaped details, e.g. corners

DECLARED MATERIAL LIST (DML)

Consolidated list of all materials used in a project, [See: CONSOLIDATED DECLARED LIST]

DECLARED MECHANICAL PART LIST (DMPL)

Consolidated list of all parts used in a project, [See: CONSOLIDATED DECLARED LIST]

DECLARED PROCESS LIST (DPL)

Consolidated list of all processes used in a project except for non-critical processes sufficiently described in the declared materials list,
[See: CONSOLIDATED DECLARED LIST]

DEFECT

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

DEFLECTION

Displacement of a structure such as a beam

DEFORMATION

Changes in size and shape of a body resulting from externally applied loads, temperature change, and moisture absorption. Deformation in size is measured by the normal strain components; that in shape, by shear component

DEGRADATION

The alteration of material properties (e.g. mechanical, thermal or optical) that may result from deviations in manufacturing or from repeated loading and/or environmental exposure, Ref. [10]

DELAMINATION

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

DELTA CLIPPER

McDonald Douglas single-stage-to-orbit (SSTO) spacecraft

DEMONSTRATION

A method of verification which consists of a qualitative determination of the properties of the test article. It is made through observation or actual conduct, which verifies characteristics such as human engineering features, and transportability. Note: Typical verification method of US standard. In the European standard Demonstration is part of Test, Ref.[1]

DENIER

A yarn and filament numbering system in which the yarn number is equal numerically to the weight in grams of 30 000 ft (9144 m) (used for continuous filaments). The lower the denier the finer the yarn

DENSIFICATION

The consolidation phase of a composite manufacturing technique in which pores or cracks are closed either by further infiltration or by the application of pressure at a specified temperature.

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 AND DEVELOPMENT PLAN

This document is the master plan for the project Design and Development activities and gives high-level information on how the system design is to be carried out and which are the major guidelines for the system development, Ref.[1]

DESIGN FEATURE

An element or detail of a specific design that is not considered generically applicable to other structures for the purpose of substantiation (e.g. lugs and major joints). Such a design element or detail is qualified by a combination of test and analysis

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

DETAIL

A non-generic structural element of a more complex structural member (e.g. specific design-configured joints, splices, stringer run-outs, or major access holes)

DEVELOPMENT

Verification phase with the objective to support the design feasibility and select options able to satisfy manufacturing and performance requirements. The data acquired during this phase are also used to establish processes, procedures and test levels to support subsequent design, production, verification, maintenance and check-out activities. In principle, development is not used to achieve the formal verification close-out, Ref.[1]

DEVELOPMENT MODEL

Physical model used in support to the verification program during the development phase, mainly to confirm mathematical models and, in general, necessary in the areas of new design or where substantial redesign is required. Note: Development Model is also called Breadboard, Ref.[1]

DHS

Distributed hydrogen sensing. A fibre-optic-based measurement system

DIAL

Differential absorption LIDAR: two laser frequencies are used, with different absorption characteristics by an atmospheric molecule of interest. The measured absorptions of the two then provide atmospheric chemical composition information

DIAPHRAGM MOULDING

A shaping process technique applied to thermoplastic-based composites

DIELECTRIC

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

DIFFERENTIAL SCANNING CALORIMETRY (DSC)

Measurement of the energy absorbed (endothermic) or produced (exothermic) as a resin system is cured. Also permits detection of loss of solvents and other volatiles. DSC provides a means of assessing the cure characteristics of the supplied prepreg batch. Like HPLC, it is an analytical technique providing data on which to base comparisons. It can provide reaction start temperature, heats of polymerisation, temperature at peak maximum heat of polymerisation and glass transition temperature (Tg) of cure prepreg

DIFFUSION BONDING (DB)

Joining method for metals in which heated components are clamped together (in vacuum) enabling interdiffusion across the bond line. For bonds between components of the same material the resulting joint is metallurgically undetectable

DIFFUSION

Process of atomic movement of one element into another. Rate of diffusion increases with temperature. Generally implies solid-state diffusion, but also encompasses diffusion of gaseous species through solids

DIFFUSION COATING

Additional alloying elements introduced into the surface of a material by a process of material diffusion at high temperature, normally with strong, coherent oxide-forming elements such as chromium or aluminium to increase the corrosion resistance

DIMENSIONAL STABILITY

Zero or nearly zero deformation due to changes in temperature and moisture content:

1 Materials: A property of carbon/resin and aramid/resin composite materials that is exploited in the design of high-accuracy components in space, e.g. antennas or telescopes

2 Structures: Those which have to retain their physical shape and dimensions under the cyclic thermal conditions experienced in orbit, between -150°C and +100°C, typically

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

DIRECTIONAL SOLIDIFICATION (DS)

Manufacturing method used to create a directional microstructure in a material, e.g. in superalloy turbine blades where grains are aligned in such a way as to resist the principal loads

DIRECTIONALLY SOLIDIFIED EUTECTIC (DSE)

Eutectic alloy composition which is directionally solidified to achieve the required microstructure; normally superalloys

DISCONTINUOUS REINFORCEMENT

Where the reinforcement phase consists of particles, whiskers or short fibres

DISCREPANCY

A manufacturing anomaly allowed and detected by the planned inspection procedure. It can be created by processing, fabrication or assembly procedures

DISCRETE COMPONENT

Any individually packaged electronic device, either active or passive, e.g. resistors, capacitors, inductors, diodes, transistors

DISLOCATION

An abnormality within a material lattice structure occurring along certain lines in the crystal structure. These take the form of stacking faults in the regular atomic pattern of the crystal. Deformation in metals occurs by the formation and movement of edge or screw dislocations. 'Cold work' - plastic deformation at low temperature - greatly increases the density of dislocations and anchors them to other dislocations, grain boundaries, the surface or other structural features. This pins crystallographic slip planes, so increasing material strength and reducing elongation to failure (work hardening)

DISLOCATION DENSITY

The number of dislocations within a given material volume. [See also: DISLOCATION]

DISPERSION STRENGTHENING

Increase of alloy strength due to a finely dispersed phase created by precipitated alloying constituents. Note: An optimum dispersion size and volume is required to maximise strength; deviation from the prescribed thermal treatment, in service or in manufacture, affects the strength

DISPLACEMENT

Measure of the movement of a point on the surface and in the interior of a body

DISSIMILAR MATERIALS

Materials with widely differing mechanical and physical properties:

1 materials which have different galvanic potentials, such that when they are in contact or joined together under particular environment conditions, e.g. moisture, temperature, there is a possibility of galvanic corrosion

2 materials which possess different thermal expansion characteristics

3 Joints: The coefficient of thermal expansion (CTE) is a critical property of materials to be joined

DLR

[Deutschen Zentrum für Luft- und Raumfahrt](#). German aerospace organisation

DM

Development Model

DMA

Dynamic mechanical analysis, [See: DYNAMIC MECHANICAL ANALYSIS]

DML

Declared Materials List

DMPL

Declared Mechanical Parts List

DoD

Department of Defense, USA

DOME

In a filament winding, the portion of a cylindrical container that forms the integral ends of the container

DOPING

Alternative term for MICRO ALLOYING

DOT

Department of Transportation, USA

DOUBLE CANTILEVER BEAM SPECIMEN

Interlaminar fracture toughness test specimen, frequently used for CFRP materials

DOUBLER

A sheet of material, made of either composite or metal, applied to a composite laminate or metal sheet to locally increase the properties, e.g. Locally built-up reinforcement or repair

DPL

Declared Processes List

DRAFT

The taper or slope of the vertical surfaces of a mould designed to facilitate removal of moulded parts. (Specific definition of 'draft' in relation to moulds.)

DRAFT ANGLE

The angle between the tangent to the surface at that point and the direction of ejection. (Specific definition in relation to moulds)

DRAPE

Ability of woven and non-woven composite materials to conform to a complex curvature surface, e.g. a fabric to a mould

DRD

Document Requirements Definition

DRY LAY-UP

Construction of a laminate by layering pre-impregnated reinforcement (partly cured resin) in a female or male mould, usually followed by bag moulding or autoclave moulding. [See also: PREPREG]

DS

- 1 Directionally Solidified
- 2 Dispersion Strengthened; dispersion of particles in metal alloys

DSC

Differential scanning calorimetry, [See: DIFFERENTIAL SCANNING CALORIMETRY]

DSDCB

Double split double cantilever beam for Mode III

DSE

Directionally solidified eutectic

DSS

1. Distributed strain sensor; A fibre-optic-based strain measurement system
2. Dimensionally stable structure
3. Dimensionally stable structures programme; and ESA programme

DT

Double torsion; a test method used for fracture toughness Mode I

DTA

Differential thermal analysis

DTRC

David Taylor Research Center, USA; a test method

DTS

Distributed temperature sensor or sensing. A fibre optic-based temperature measurement system

DUCTILE-BRITTLE TRANSITION

The temperature at which a metallurgical phase change in a metal alloy occurs and results in a sudden loss of ductility, e.g. tungsten below 400°C

DUCTILITY

A measure of a material's plastic deformation. Often used to indicate maximum deformation prior to fracture

DUPLEX MICROSTRUCTURE

Two distinct phases within a material microstructure

DWELL TIME

Period of time during cure that a laminate is held at elevated temperature prior to application of pressure

DWI

Deviation Work Item

DYNAMIC MECHANICAL ANALYSIS (DMA)

DMA can be used on uncured prepreg and cured laminates to quantify some of their mechanical properties over a range of temperatures. DMA provides a measurement of storage modulus and loss-modulus in a shear or flexural mode. From these it is feasible to judge the cured material for consistency on expected modulus and modulus retention at elevated temperatures. The glass transition temperature (T_g) of cured material can also be determined. [See: LOSS-MODULUS]

DYNAMIC MODULUS

The ratio of stress to strain under vibrator conditions (calculated from data obtained from either free or forced vibration tests, in shear, compression, or elongation). [See also: DMA]

DYNEEMA

A high-performance fibre based on high modulus polyethylene, manufactured by DSM (NL)

E

E-GLASS

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

EAP

Electroactive polymer (EAP) actuators are polymer materials or structures that change volume or shape when electric energy is supplied. Used in smart structures

EB

Electron beam; used in processes such as welding metals and curing resins

EBM

End-burning motor

EB-PVD

Electron Beam Physical Vapour Deposition. A method of depositing surface coatings

EBW

Electron Beam Welding

ECLS

Environmental Control and Life Support

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].

EDM

Electrical discharge machining. Also called: spark eroding

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]

EDT

Edge delamination tension; a test method for mixed Modes I and II

EEE

Electrical, electronic and electromechanical

EFA

European Fighter Aircraft; standards

EFCB

ESA Fracture Control Board

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

EGSE

Electrical Ground Support Equipment

EIT

Electrical Impedance Tomography

ELASTIC MODULUS

Stiffness

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

ELASTIC-PLASTIC FRACTURE MECHANICS (EPFM)

Adaptation of Linear Elastic Fracture Mechanics (LEFM) engineering principle to describe the propagation of a single crack through a material, usually a metal alloy, which assumes that the bulk of the material is behaving elastically, but compensates for plastic behaviour around the crack tip, [See: LEFM]

ELECTRIC POLING

The action of applying a strong electric field to orientate the dipoles within a ferroelectric ceramic as it is cooled through the ferroelectric transformation point. This conditions suitable materials (e.g. PVdF film) to produce piezoelectric effects

ELECTROLYTE

Galvanic corrosion: Any substance that provides an electrically conductive path between two dissimilar materials, e.g. moisture between carbon and aluminium

ELECTRORHEOLOGICAL FLUIDS

A class of fluids, consisting of colloidal dispersions in non-conducting liquids that exhibit a large, reversible change in their rheological behaviour when subjected to an external electric field

ELECTROSTRICTIVE MATERIALS

Solid materials which deform mechanically when subjected to an external electric field

ELECTROSTRICTION

An induced strain deformation that is independent of field polarity. A weaker effect than piezoelectricity. All dielectrics exhibit this behaviour

ELEMENT

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

ELS

End loaded split; a test method

EMA

Electro-mechanical actuator; for X-38 test vehicle

EMAT

Electromagnetic acoustic transducer

EMC

Electromagnetic compatibility

EMF

Electromotive force

EMI

- 1 Electromagnetic interference
- 2 Electro-mechanical impedance

EN

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

ENCAPSULATING COMPOUND

An electrically non-conductive compound used for environmental protection which completely encloses and fills in voids between electrical components

ENCB

End notched cantilever beam; a test method used for thick laminates

END

A strand of roving consisting of a given number of filaments gathered together (the group of filaments is considered an end or strand before twisting and a yarn after twist has been applied); an individual warp yarn, thread, fibre or roving; in fabrics, the tows in the warp direction

ENF

End notch flexure; a test method used for fracture toughness Mode II (GIIC)

ENGINEERING CONSTANTS

Measured directly from uniaxial tensile and compressive, and pure shear tests applied to unidirectional as well as laminated composites. Typical constants are the effective Young's modulus, Poisson's ratio, and shear modulus. Each constant is accompanied by letter or numeric subscripts designating the direction associated with the property. (Specific definition for 'composites')

ENGINEERING MODEL

Physical model flight representative in form, fit and function, without redundancies and 'Hi-rel' parts, used for functional qualification, except redundancy verification, failure survival demonstration and parameter drift checking, Ref.[1]

ENGINEERING QUALIFICATION MODEL

Physical model fully reflecting the design of the flight end item, except for the part standard ('Mil-Grade' parts are allowed, but procured from the same manufacturer of the 'Hi-rel' parts), used for functional performance qualification (including verification of procedures for failure detection, confirmation, isolation and recovery and for redundancy management) and EMC testing, Ref.[1]

ENS

End loaded split; a test method used for Mode II used for thin laminates

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

EOM

End of Mission

EOS

Earth observation satellite

EPDM

Ethylene propylene elastomer

EPFM

Elastic Plastic Fracture Mechanics

EPOXY

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

EQM

Engineering Qualification Model

EQUATOR

In filament winding, the line in a pressure vessel described by the junction of the cylindrical portion and the end dome

EQUIPMENT

It is a functional unit that is viewed as an entity for purposes of analysis, manufacturing, maintenance, e.g. valves, batteries, individual electronic boxes, Ref.[1]. Note: In the US standard it is called Component

EQUIPMENT CATEGORY

Equipment classification on the basis of the qualification status, e.g. off-the-shelf, off-the-shelf with modifications, completely new, Ref.[1]

ER

Electro-rheological (fluid)

ERC

Earth Return Capsule

ERS

Earth resources satellite

ES

Electronic Shearography

ESA

European Space Agency

ESA WLC TSTO

Two-stage-to-orbit spacecraft from ESA Winged Launcher Concept programme

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

ESACRACK

A software package distributed by ESA. The package consists of the load- and stress-spectrum generation program ESALOAD, fracture mechanics analysis NASFLA, stress-intensity factors NASBEM, process crack growth material data NASMAT, fatigue analysis ESAFATIG, [See also: ESALOAD]

ESALOAD

A software programme that generates a load spectrum and a stress spectrum for a payload. The stress spectrum is generated using unit stress values, [See also: ESACRACK]

ESD

Electrostatic discharge

ESH

Equivalent sun hours

ESIS

Energy Standards Information System; test standards

ESOC

European Space Operations Centre, Darmstadt, Germany

ESPI

Electronic speckle pattern interferometry

ESTEC

European Space Research and Technology Centre, Noordwijk, NL

ET

External Tank. Space shuttle main external fuel tank

ETAC

Environmental Technical Applications Center, part of United States Airforce, USA; test standards

ETCO-Odeillo

Test centre, France

ETFE

Ethylene tetrafluoroethylene

EURECA

European Retrievable Carrier

EUTECTIC ALLOY

An alloy of two or more metals that has a single distinct melting point

eV

Electron volt

EVA

Extra-vehicular activity; human activity outside of a spacecraft ('spacewalk')

EXPANSION COEFFICIENT

Measurement of the swelling expansion of composite materials due to temperature change and moisture absorption

EXPERIMENT

An item designed and built to accomplish a specific purpose which can be disassembled and retain its capabilities after re-assembly, Ref. [7]

EXPRESS

Experimental Re-entry Space System

EXTRUSION

A manufacturing method for metals, where a billet is forced through a die of the required shape. Often used to manufacture continuous lengths of materials with constant cross-sectional profiles. Materials can be heated for extrusion to reduce extrusion pressures or refine microstructure

F**FAA**

Federal aviation authority; controlling body for USA aircraft

FABRIC

General: any material of woven construction:

- 1 Reinforcement fabrics: fabrics constructed of reinforcing fibres, e.g. carbon, placed in more than the standard warp and weft fabric directions, e.g. 2-D fabrics; 2.5-D fabrics; 3-D fabrics

- 2 Technical textiles: interwoven fibres (warp and weft) of one or more fibre type In a finished fabric, the warp direction is the longitudinal thread direction, and the weft direction is the transverse thread direction Fabrics are specified by their fibre type, yarn type, knitting or weaving technique, weave style, fibre density, texture, pattern type, condition, length, width, density and thickness
- 3 Tape: a fabric of width less than 150 mm
- 4 Integrally woven: a triaxial fabric where all the reinforcement fibres are woven at the same time; also known as 'angle interlocked'
[See also: WEAVE, CLOTH, WARP, WEFT]

FABRICATING, FABRICATION

The manufacture of plastic products from moulded parts, rods, tubes, sheeting, extrusions, or other form by appropriate operations such as punching, cutting, drilling, and tapping. Fabrication includes fastening plastic parts together or to other parts by mechanical devices, adhesives, heat sealing or other means

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]

FAIL-SAFE

A Potentially Fracture Critical Item (PFCI) is fail-safe if it can be shown by analysis or test that, owing to structural redundancy, the structure remaining after failure of any element of the PFCI can sustain the new higher internal loads without losing limit specified performance. In addition, the failure of the item shall not result in the release of any part or fragment resulting in a catastrophic or critical event. [See also: PFCI]

FAIL-SAFE (STRUCTURE)

A damage-tolerance acceptability category in which the structure is designed with sufficient redundancy to ensure that the failure of one structural element does not cause general failure of the entire structure, Ref. [5]

FAILURE (structural)

The rupture, collapse, seizure, excessive wear or any other phenomenon resulting in an inability to sustain limit loads, pressures and environments, Ref. [5]

FAILURE CRITERION

Empirical description of the failure of composite materials subjected to a complex state of stresses or strains. The most commonly used criteria are the maximum stress, the maximum strain, and the quadratic criteria

FAILURE ENVELOPE

Ultimate limit in combined stress or strain state defined by a failure criterion

FAILURE MODE

The way in which a material degrades such that it can no longer support the applied loads leading ultimately to fracture

- 1 laminates: usually assessed by the behaviour of the individual layers and the interfaces between them, along with the laminate as a whole

FAR

Final Acceptance Review

FASTENER

Any item that joins other structural items and transfers loads from one to the other across a joint, [See: JOINT], Ref. [5]

FATIGUE

- 1 In materials or structures, the cumulative irreversible damage incurred by cyclic application of loads in given environments. Fatigue can initiate and extend cracks, which degrade the strength of materials and structures, Ref.[5]
- 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 LIMIT

The stress below which a material can be stressed cyclically for an infinite number of times without failure

FATIGUE NOTCH FACTOR

The ratio of fatigue strength of un-notched specimens at N cycles to the fatigue strength of notched specimens at N cycles

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 STRENGTH RATIO

The ratio of fatigue strength to static strength

FATIGUE STRESS RATIO

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

FAULT

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

FBH

Flat bottom hole; a standard nondestructive testing calibration procedure

FCI

Fracture Critical Item

FCIL

Fracture Critical Item List

FDEMS

Frequency Dependent Dielectric Measurements

FE

Finite element

FEA

Finite element analysis

FEM

Finite element model or modelling

FEI

Flexible External Insulation; a thermal protection system (TPS)

FEP

Fluorinated ethylene-propylene co-polymer

FERROELECTRICITY

Reorientation of the dielectric dipoles of polar crystals by means of an applied field

FESTIP

Future European Space Transportation Investigations Programme; an ESA programme

FFPI

Fibre-Fabry-Pérot Interferometer

FFT

Fast Fourier Transform. A digital signal analysis technique

FGSE

Fluidic Ground Support Equipment

FIBER

American term for a fibre. [See: FIBRE]

FIBRE

- 1 Technical textiles: a general term for filamentary materials with a finite length at least 100 times their diameter. Also known as Filament or Spin Fibre
- 2 Single filament, rolled or formed in one direction, and used as the principal constituent of woven and non-woven composite materials

FIBRE-COMPOSITE MATERIAL

A material consisting of two or more discrete physical phases, in which a fibrous phase is dispersed in a continuous matrix phase. The fibrous phase can be macro-, micro- or sub-microscopic, but it has to retain its physical identity so that it can conceivably be removed from the matrix intact

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. $0^\circ/\pm 45^\circ/0^\circ/\pm 45^\circ/0^\circ$

FIBRE DIAMETER

The measurement of the diameter of individual filaments, in micrometres

FIBRE/MATRIX INTERFACE

The region separating the fibre and matrix phases, which differs from them chemically, physically, and mechanically. In most composite materials, the interface has a finite thickness (nanometres to thousands of nanometres) because of diffusion or chemical reactions between the fibre and matrix. Thus, the interface can be more properly described by the terms, 'interphase' or 'interfacial zone'. When coatings are applied to the fibres or several chemical phases have well-defined microscopic thicknesses, the interfacial zone can consist of several interphases

FIBRE METAL LAMINATE (FML)

Sheet or laminated material consisting of thin sheets of metal adhesively bonded with layers of fibre-reinforced polymer plies; often with various fibre directions. [See also: ARALL, GLARE and CARE]

FIBRE OPTIC

Pertaining to systems, subsystems, equipment and components in which optical fibres are used, Ref.[4]

For smart technologies: one or more optical fibres used as sensors to measure some parameter of the light travelling within it that can in turn be related to a characteristic of the material to which it is applied to or embedded within, e.g. strain, temperature, hydrogen presence

FIBRE ORIENTATION

Fibre alignment in a non-woven or mat laminate where the majority of fibres are in the same direction, resulting in a higher strength in that direction

FIBRE PATTERN

- 1 Visible fibres on the surface of laminates or mouldings.
- 2 The thread size and weave of glass cloth

FIBRE PREFORMS

A solely fibrous network of reinforcement fibres created by one or more weaving, knitting or braiding process to create a geometrical shape that is then subsequently infiltrated with a matrix phase (polymer, metal or ceramic) to create a three-dimensionally reinforced composite component. The preform is usually rigidised using a matrix-compatible binder before infiltration

FIBRE REINFORCED METAL (MMCf)

A metal alloy containing continuous reinforcement fibres or filaments; often silicon carbide or carbon

FIBRE REINFORCED PLASTIC (FRP)

A fibre-reinforced thermosetting or thermoplastic polymer matrix composite material

FIBRE SURFACE TREATMENT

Carbon fibres are usually given a post-graphitisation surface treatment by either a chemical or an electro-mechanical method. The surface treatment enhances the bond between the fibres and the resin matrix in the cured laminate. This enhanced bond improves the shear and compressive properties of the laminates, but if the surface treatment is over done brittle laminates can result

FICK'S EQUATION

Diffusion equation for moisture migration. This is analogous to Fourier's equation of heat conduction

FILAMENT

- 1 For technical textiles: the smallest unit of a fibrous material. The basic unit formed by drawing and spinning
- 2 A continuous discrete fibre with an effective diameter in the range of:
 - Carbon: 6 μm to 10 μm
 - Glass: 6 μm to 13 μm
 - Aramid: >12 μm
 - Alumina: >20 μm
 - Boron: 100 μm to 200 μm
 - Silicon carbide: 10 μm to 20 μm or 100 μm to 140 μm , depending on the source

Note: The cross-section is not necessarily circular

FILAMENT REINFORCEMENT

Composite material using filaments as the reinforcement phase, [See also: FILAMENT]

FILAMENT WINDING

Automated process of placing filaments or fibres onto a mandrel in prescribed patterns. The resin impregnation can be before or during the winding, known as prepreg or wet winding, respectively. The mandrel can subsequently be removed after curing of the composite material. Filament winding is most advantageous in building pressure vessels, pipes, drive shafts, or any device that is axisymmetrical

FILAMENT WOUND

An item manufactured using a filament winding process

FILAMENT YARN

For technical textiles: one or more continuous filaments, with or without twist

FILL, FILLER

Yarn oriented at right angles to the warp in a woven fabric. [See also: WEFT]

FILLET

A smooth concave build-up of material between two surfaces, e.g. a fillet of adhesive in a bonded joint; a fillet of weld metal between two plates, generally placed at an angle to each other; a fillet of solder between a component lead and a solder pad or terminal, a fillet of conformal coating material between a component and printed-circuit board

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

FINISH

Material and process used to treat fibres to improve the interfacial bond between fibre and matrix. (Definition specific to composites)

FINISHING

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

FIRST

Far infra-red sub millimetre space telescope

FIRST-PLY FAILURE

The initial failure of a laminated or similar multi-layer composite material which can be predicted by an established criterion. Note: The structure can be capable of carrying additional loads after this initial failure, but this has to be substantiated by consideration of the appropriate failure models to establish the LAST-PLY FAILURE

FITTING

Fittings (or 'bosses') are responsible for inlet and outlet of the stored medium and for closing of the vessel at the polar openings. They are also often necessary as part of the mandrel in the manufacture of the vessel

FLAGRO

Fracture mechanics analysis software developed by NASA, [See also: ESACRACK, ESALOAD]

FLAMMABILITY

A measure of the ease with which a material is set on fire.

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]

FLAW (CRITICAL)

A flaw of sufficient size and shape to cause unstable growth to occur under the specific operating loads and environment

FLAW (INITIAL)

A flaw that exists in a composite structure before the application of operating loads and exposure to environment. (Specific definition in relation to composites)

FLEECE

For technical textiles: fibrous webs, e.g. felts, non-woven fabrics, wadding; produced from twisted single textile fibres

FLEXURAL MODULUS

The ratio, within the elastic limit, of the applied stress on a test specimen in flexure to the corresponding strain in the outermost fibres of the specimen. (Specific definition in relation to composites)

FLEXURAL STRENGTH

- 1 The resistance of a material to breakage by bending stresses.
- 2 The strength of material in bending expressed as the tensile stress of the outermost fibres of a bent test sample at the instant of failure. (Specific definition in relation to composites)
- 3 The unit resistance to the maximum load before failure by bending. (Specific definition in relation to composites)

FLIGHT MODEL

The flight end item, which is subjected to formal functional and environmental acceptance testing, Ref.[1]

FLIGHT SPARE

The spare end item for flight, which is subjected to formal acceptance testing, Ref.[1]

FLLI

Fracture Limited Life Item

FLLIL

Fracture Limited Life Items List

FLOCK

For technical textiles: short chopped fibres

FLOW

The movement of resin under pressure, enabling all parts of a mould to be filled; flow or creep is the gradual but continuous distortion of a material under continued load, often at elevated temperatures

FLTP

Future launchers technologies programme; an ESA programme

FLUX

A material which, during welding, brazing or soldering, removes the oxide film, protects the surface from oxidation and permits the filler material to wet the surfaces to be joined

FM

Flight Model

FMCW

Frequency-modulated continuous wave. A fibre optic-based strain measurement system

FMECA

Failure mode effects and criticality analysis

FML

Fibre metal laminate. [See: ARALL, GLARE, CARE]

FOD

Foreign object impact damage

FOLDED YARN

For technical textiles: two or more single yarns twisted together

Note: Folding is synonymous with plying

FOOTPRINT

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

FORCE

- 1 Mechanical load
- 2 The male half of a mould, which enters a cavity, exerting pressure on resin and causing it to flow (also called punch)
- 3 Either part of a compression mould (top force and bottom force)

FOS

Fibre optic sensor; smart technology

FOTON

Un-manned Russian research spacecraft with MIRKA re-entry capsule. [See also: MIRKA]

FOURIER'S EQUATION

Diffusion equation commonly associated with the heat conduction in a body. Fick's equation is a special case, applied to the migration and accumulation of moisture. [See also: FICK'S EQUATION]

FP

Fabry-Pérot

FPF

See: FIRST-PLY FAILURE

FRACTURE

Rupture of the surface without complete separation of laminate

FRACTURE CRITICAL ITEM

A safe-life or fail-safe Potentially Fracture Critical Item (PFCI). [See also: PFCI]

FRACTURE LIMITED LIFE ITEM

Any item that requires periodic reinspection to comply with safe life or fail-safe requirements, [See: SAFE LIFE; FAIL-SAFE (structure)], Ref. [5]

FRACTURE REGION

A term used in the mechanical testing of MMC and CMC materials to describe reinforcement failure, normally continuous fibres or filaments

FRACTURE TOUGHNESS

The resistance of a material to fracture, a measure of the damage tolerance of a material containing initial flaws or cracks. The old term 'Toughness' to describe the resistance of a material to permanent deformation was poorly defined and gave little basis for comparison between materials, particularly under representative service environments. For strong materials such as heat-treated steels, aluminium and titanium alloys: plane strain values of critical stress intensity factor K_{Ic} are valid material properties, independent of specimen thickness, to describe fracture toughness. Materials having appreciable plasticity before fracture are described by the J integral - the critical value of which is a material property in the same way that K_{Ic} is for a linear elastic solid, Ref.[2]. For metals, the Fracture Toughness is usually obtained by measuring the Strain Energy Release Rate of a pre-cracked Crack Opening Displacement (COD) specimen. For materials destined for corrosive service environments, testing can be carried out under representative conditions to give a KISCC value. [See also: CRITICAL STRESS INTENSITY, Ref. [5]]

FRCI

Fibrous Refractory Composite Insulation, e.g. Space Shuttle Orbiter

FREE EXPANSION

Thermal or moisture expansion without external stress

FRF

Frequency Response Function

FRP

Fibre-reinforced plastic

FRS

Fibre-reinforced superalloy

FRSI

Felt reusable surface insulation, TPS system, e.g. Space Shuttle Orbiter

FS

Flight spare

FSE

Flight Support Equipment

FSS

Frequency selective surface

FULL SMART SYSTEM

A system of sensors, interrogation and analysis software and compensators able to monitor and react in a required manner to external influence without human intervention

FUNCTION ORIENTED MODEL

Physical model dedicated to the qualification of particular functional requirements. It is flight representative as necessary for the limited qualification objectives, Ref.[1]

FUNCTIONAL ANALYSIS

Related to the verification of the correct implementation of a required function, Ref.[1]

FUSION JOINING

Joining techniques involving the melting of one or more joint constituent, e.g. welding, brazing, soldering. [See also: WELDING, BRAZING]

FUSION WELDING

Creating a joint where one or more of the joint parts is molten, [See also: WELDING]

FV

Flight Vehicle

FWC

Finite width correction factor

G

G_{1c}

Fracture energy

GALVANIC CORROSION

Corrosion that occurs in aqueous or humid conditions that is driven by electrochemical potential differences between two phases, usually metallic, in electrical contact. It can also occur for a single phase where a gradient environment exists; called crevice corrosion. [See: CREVICE CORROSION]

GAM

Groupe d'Activation Moteur

GARTEUR

Group for Aeronautical Research and Technology in Europe

GAT

Groupe d'Activation Tuyère

GAUGE LENGTH

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

GC

Gas-chromatograph

GCMC

Glass-ceramic matrix composite

GEL COAT

A resin applied to the surface of a mould and gelled before lay-up. The gel coat becomes an integral part of the finished laminate and is usually used to improve surface appearance

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. Resin bleed 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

GEO

Geostationary Earth orbit

GEODESIC

The shortest distance between two points on a curved surface

GEODESIC ISOTENSOID

Constant-stress level in any given filament at all points in its path

GEODESIC OVALOID

A contour for end domes, the fibres forming a geodesic line. The forces exerted by the filaments are proportioned to meet hoop and meridional stresses at any point

GEODESIC-ISOTENSOID CONTOUR

In filament-wound reinforced-plastic pressure vessels, a dome contour in which the filaments are placed on geodesic paths so that under pressure loading the filaments will exhibit uniform tension throughout their length

GFRP

Glass-fibre reinforced plastic

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

GH2

Gaseous hydrogen

GIRL

German Infrared Laboratory

GLARE

Glass fibre-reinforced aluminium laminate. [See: FIBRE METAL LAMINATE]

GLASS CERAMIC MATRIX COMPOSITE (GCMC)

Composite containing a mixture of glass and ceramic phase as a matrix for fibre reinforcement (often SiC or C fibres)

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 FILAMENT

Drawn from molten glass through platinum bushings. The most widely used filament in composite materials. Glass filament can be made into unidirectional plies, woven fabric, mats and short-fibre composites like the sheet moulding compound

GLASS MATRIX COMPOSITE (GMC)

A composite containing a glassy phase as a matrix for fibre reinforcement (often SiC or C fibres)

GLASS TRANSITION TEMPERATURE (T_g)

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

GNC

Guidance, Navigation and Control

GOLD (Au)

Metallic element, melting point 1064°C, density 19300 kg m⁻³. Uses: alloying additions, coatings

GOX

Gaseous Oxygen

GPL

Groove proportional lock-bolt; a type of mechanical fastener

GPR

Ground Penetrating Radar

GPS

Global Positioning System

GRADED STRUCTURE

Material in which the chemical composition or microstructure varies with position. It can be achieved most readily by means of powder metallurgical techniques. In a product graded from pure material A to pure material B, intermediate A+B powder mixture stages can be used to smooth the transition. These materials can be used to reduce mismatch problems in physical, chemical and metallurgical properties, e.g. CTE mismatch

GRAPHITE FIBRE

A fibre made from a precursor by an oxidation, carbonisation and graphitisation process (which provides a graphitic structure). [See also: CARBON FIBRE]

GREEN SHAPE

Ceramic parts that are in an intermediate state of manufacture into a shape that is near that of the finished ceramic product. They exist after the initial consolidation of the blended powders but prior to the high pressure and/or temperature densification processes that give the desired final mechanical properties

GRIST

Grazing incidence solar telescope

GRP

Glass reinforced plastic; an industrial composite not a high-performance structural composite for aerospace applications; sometimes used for tabs on the ends of some composite test specimens

GSE

Ground Support Equipment

GTO

Geostationary Transfer Orbit

H

HAFNIUM (Hf)

Metallic element, melting point 2231°C, density 13310 kg.m⁻³. Uses: carbide former in superalloys, coating material compositions, including diffusion barrier coatings on tungsten reinforcing filaments

HALIDE

Compound formed with an element from Group VII of the periodic table of elements: fluoride, chloride, bromide

HAND LAY-UP

The process of placing (and working) successive plies of reinforcing material or resin-impregnated reinforcement in position on a mould by hand

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]

HARDWARE MATRIX

The matrix identifying for each equipment the related qualification status and the required models, Ref.[1]

HASTELLOY

A nickel-based alloy

HAWT

Horizontal Axis Wind Turbine

HAZ

Heat Affected Zone

HCF

High-cycle Fatigue

HE

[See: HYDROGEN EMBRITTLEMENT]

HEALTH MONITORING

For smart technologies: a diagnostic system which can provide data on the integrity or functioning of structures or structural components, either continually or periodically

HEAT TREATMENT

Metal alloys: thermal conditioning of the material to achieve a desired metallurgical structure and/or properties. Also used to relieve residual stress after or between mechanical working.

[See also: CONDITION]

HEE

[See: HYDROGEN EMBRITTLEMENT ENVIRONMENT]

HEMISPHERICAL EMITTANCE (ϵ_h)

The total energy emitted over a hemisphere above the emitting element for all wavelengths, Ref. [10]

HEO

Highly Elliptical Orbits

HERMES

Manned winged reusable spacecraft; European programme

HETEROGENEITY

- 1 Microscopic level: local variation of constituent materials.
- 2 Macroscopic level: ply-by-ply variation of materials or orientations

HFE

Human Factor Engineering

HHPV

Hydraulic high pressure vessel

HiBi

Highly birefringent. A type of optical fibre used in fibre optic sensor (FOS) smart technologies

HIGH CYCLE FATIGUE (HCF)

Repeated mechanical loading applying low to moderate stresses for a high number of cycles, typically 10^6 to 10^8 or greater

HIGH MODULUS CARBON FIBRES (HM)

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

HIGH-PRESSURE LIQUID CHROMATOGRAPHY (HPLC)

HPLC is an analytical technique for determining the chemical constituents of the prepreg matrix. By testing a batch of prepreg it is possible to take the results and a reference trace (form of fingerprint) for the same prepreg to provide a means of comparison on product consistency

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

HIT RATE

For structural health monitoring or nondestructive testing: the number of acoustic emission events detected in a given time period, [See also: ACOUSTIC EMISSION]

HKM 1650

Fibrous insulation material

HM

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

HOCOSC

Hot-to-cold structure combination

HOMOGENEITY

Material uniformity within a body. In the mechanics of composite materials, micro- and macroscopic homogeneity are achieved by smearing the actual heterogeneity

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

HOOKE

[See: GENERALISED HOOKE'S LAW]

HOOKEAN

[See: GENERALISED HOOKE'S LAW]

HOOP STRENGTH

The circumferential strength of a material of cylindrical form subjected to internal or external pressure

HOOP STRESS

The circumferential stress in a material of cylindrical form subjected to internal or external pressure

HOOP WINDING

The placing of fibres (filament) perpendicular to the longitudinal axis of a cylinder or a pressure vessel

HOPE

H-II Orbiting Plane. Winged man-capable re-entry glider. Japanese programme

HOPE-X

H-II Orbiting Plane – Experimental. Full scale, unmanned prototype of the HOPE winged man-capable re-entry glider. Japanese programme

HORUS

Upper spaceplane stage of SÄNGER

HOT ISOSTATIC PRESSING (HIP)

A consolidation technique consisting of simultaneous high temperature and very high inert gas pressure. Often used as a stage in a powder metallurgical process. Can also be used to eliminate porosity from cast materials

HOT PRESSING

Manufacturing method often used for metal and ceramic powder matrices, but also for pre-impregnated fibre tapes with glass matrices. Effective for closing porosity

HOTOL

Horizontal take-off and landing

HPLC

[See: HIGH PRESSURE LIQUID CHROMATOGRAPHY]

HPV

High pressure vessel

HRE

Hypersonic Research Engine (USA)

HRSI

High-temperature Reusable Surface Insulation, e.g. Space Shuttle Orbiter

HS

High strength; a range of carbon fibres

HST

High speed wind tunnel

HSTS

High stability telescope structures

HUYGENS

An ESA-built probe for descent onto Titan, the largest Saturn moon. Part of the NASA Cassini mission to study Saturn, its rings and moons. [See also: CASSINI-HUYGENS]

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'

HTI

High temperature insulation

HTP

Hot thermal protection

HYBRID

- 1 Composite: containing more than two constituents, e.g. a graphite/glass/epoxy hybrid; an intralaminar hybrid has hybrid plies made from graphite and glass filaments; an interlaminar hybrid has laminates made from two or more different ply materials
- 2 Reinforcing fibre: a mixture of two or more types of fibres, e.g. high strength carbon and high modulus carbon, carbon and aramid
- 3 Fabric: made of more than one type of fibre, e.g. usually combinations of carbon, glass and aramid fibres
- 4 Co-mingled: a mixture of reinforcing fibre and thermoplastic fibre in a fibre tow
- 5 Tank: where a tank thrust structure is enclosed within an aeroshell; a reusable launch vehicle concept
- 6 FML: a fibre metal laminate containing both composite layers and sheet metal

HYBRID PHILOSOPHY

Model philosophy representing a compromise between prototype and protoflight approaches. It is based on a protoflight model on which a partial protoflight qualification test campaign is carried out. Specific qualification tests in the critical areas are carried out on dedicated models. The hybrid model philosophy is used in projects where advanced qualification activities must be performed in areas of new design or having a critical impact on the verification program, Ref.[1]. [See also: PROTOFLIGHT MODEL]

HYBRID POLYMER COMPOSITE

[See: FIBRE METAL LAMINATE (FML)]

HYDROGEN EMBRITTLEMENT (HE)

The degradation of a material's ductility and fracture characteristics when exposed to hydrogen at temperatures up to 600°C, typically. Material sensitivity depends on the composition and the ease of hydrogen transport from the environment, e.g. hydrogen charging. Effects can be catastrophic

HYDROGEN EMBRITTLEMENT ENVIRONMENT (HEE)

Degradation of a material's ductility and fracture characteristics when exposed to hydrogen but without sufficient time to charge the material with hydrogen. Effects can be additional to those described as HE

HYDROLYTIC

Chemical reaction of a substance with water

HYFLEX

Hypersonic Flight Experiment

HYGROSCOPIC

Tending to absorb moisture from the air

HYGROTHERMAL

The combination of moisture and temperature

HYGROTHERMAL EFFECT

Change in properties due to moisture absorption and temperature change

H/W

Hardware

I**IBC**

Individual blade control. A smart technology proposed for helicopter rotor blades

IC

Integrated circuit

ICD

Interface Control Document

ICI

Imperial Chemical Industries, UK

ICMCf

Inorganic ceramic matrix composite with fibrous reinforcement

ICSTM

Imperial College of Science, Technology and Medicine, UK

I/F

Interface

IFBG

In-fibre Bragg grating, [See also: BRAGG GRATING]

IFI

Internal Flexible Insulation; a thermal protection system (TPS)

IITRI

Illinois Institute of Technology Research Institute, USA; a type of mechanical test

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

IMC

Intermetallic matrix composite

IMI

- 1 Internal Multiscreen Insulation; a thermal protection system (TPS)
- 2 Imperial Metal Industries; commonly used alloy designation for titanium-based materials

IMIDE

A family of polymers, including polyimide (PI) and bismaleimide (BMI); used in a resin form as a matrix for high-performance reinforced plastics

IMPACT DAMAGE

A structural anomaly created by the impact of a foreign object

IMPREGNATE

In reinforced plastics, to saturate the reinforcement with a resin

IMQ

Initial material quality. A distribution of microstructural anomalies that might lead to failure

INCONEL

A range of nickel-based alloys

INCREMENTAL FORMING

A process for shaping thermoplastic-based composites

INFILTRATION

Part of composite manufacturing method where the matrix phase (metal, ceramic, glass) is incorporated with the reinforcement. Matrix phase can be in a liquid or gaseous form, e.g. ceramic or glass slurry, molten metal, or silicon carbide rich gas. Note: The infiltration stage is often repeated, [See also: PYROLYSIS]

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

INITIAL CRACK SIZE

The maximum crack size, as defined by non-destructive inspection, that is assumed to exist for the purpose of performing a fracture mechanics evaluation, Ref. [5]

INITIAL FLAW

A flaw that exists in a composite structure before the application of operating loads and exposure to environment. (Specific definition in relation to composites)

INITIAL MATERIAL QUALITY (IMQ)

The distribution of microstructural anomalies that might lead to failure. Term used in the damage tolerance of advanced composite materials in quantifying the effect of defects below the current NDE detection capability

INITIAL MODULUS

[See: MODULUS (of elasticity)]

INORGANIC COMPOSITE

Composite not containing organic polymers

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 fixation device or type of fastener system, commonly used in sandwich panels

IN-SITU FIBRE STRENGTH

The strength of a fibre reinforcement when incorporated into a composite after manufacture. For high-temperature processing methods, the initial fibre strength can be seriously affected by the processing time and temperature, or by chemical reaction with the matrix phase, e.g. molten metals

IN-SITU OXIDISATION

Composite manufacture: methods for producing ceramic (oxide) matrix composites from a metal matrix composites with molten matrix phase. Usually applied to aluminium MMC, of which the LANXIDE PROCESS is a proprietary method

IN-SITU SILICONISING

Processing technique involving infiltration of molten silicon into porous C-C composite and subsequent firing to produce a SiC matrix phase

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, 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, Ref.[1]

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, Ref.[1]

INTEGRATED SUBSYSTEM TEST (ISST)

A performance and functional test having the scope to verify the correct functioning of the integrated subsystem in terms of operating modes, with a particular emphasis on subsystem to subsystem interface verification, Ref.[1]

INTEGRATED SYSTEM CHECK (ISC)

A sub-set of the Integrated System Test (IST), able to involve all major functions, at the maximum extent automatically performed. It has the scope to provide the criteria for judging successful survival of the system/element in a given test environment, with a reasonably high degree of confidence, in a relatively short time, Ref.[1]. [See also: INTEGRATED SYSTEM TEST]

INTEGRATED SYSTEM TEST (IST)

It has the scope to verify that performance of the system/element meets the specification requirements, in terms of correct operation in all operational modes, including back-up modes and all foreseen transients, Ref.[1]. [See also: INTEGRATED SYSTEM CHECK]

INTEGRATION MODEL

Physical model functionally representative of the flight end items in terms of electronic and software, used for functional and interface tests and for failure mode investigations. Commercial parts are utilised, but they must be procured from the same manufacturer of the 'Hi-rel' parts to be used in the flight end item, Ref.[1]

INTEGRATION PROCEDURE

This document provides detailed step-by-step instructions to the integration teams for conducting the integration activities in agreement with the Integration Specification requirements, Ref.[1]. [See also: INTEGRATION SPECIFICATION]

INTEGRATION REPORT

This document describes integration performance, results and conclusions in the light of the integration requirements, Ref.[1]

INTEGRATION SPECIFICATION

This document is prepared for each major integration activity described in the Verification Plan task sheets with the objective to detail the integration requirements

INTEGRATION

The process of assembling and testing hardware and software to obtain a particular configuration. The integration encompasses the verification of the interface compatibility and of the operation of the mated hardware and software to demonstrate the overall end-to-end performance and to ensure that all interfaces meet the specified requirements, Ref.[1]

INTEGRITY CONTROL

A series of actions undertaken to demonstrate the structural integrity of a design. This will take due account of operational conditions and design loads, in conjunction with defined damage tolerance and safety requirements

INTERACTION

Same as coupling. For example, longitudinal tensile strength is affected by the presence of transverse stress. Similar interaction exists between the longitudinal buckling stress and the transverse or shear stress. As a rule, the interaction effects for composite materials are greater than for the conventional isotropic material. All anticipated stresses are considered simultaneously

INTERFACE

Composite materials: Boundary or transition zone between constituent materials, such as the fibre-matrix interface, or the boundary between plies of a laminate. Debond at the microscopic or fibre-matrix interface can lead to fibre breakage and matrix cracking. Debond at the macroscopic or interlaminar interface can lead to delamination

INTERFEROMETER

A device where light from a source is split into two or more beams, which are subsequently reunited after travelling over different paths and interfere.

Note: Several versions exist for interrogation of FIBRE OPTIC signals

INTERLAMINAR SHEAR STRENGTH (ILSS)

The shear strength existing between layers of a laminated material

INTERLAMINAR STRESSES

The stress between two or more adjacent plies in a laminated composite structure; three stress components associated with the thickness direction of a plate. The remaining three are the in-plane components of the plate. Interlaminar stresses are significant only if the thickness is greater than 10% of the length or width of the plate. These stresses can also be significant in areas of concentrated loads, and abrupt change in material and geometry. The effects of these stresses are not easy to assess because three-dimensional stress analysis and failure criteria are not well understood

INTERLAYER

A material C, placed between two materials A and B which are to be joined, to reduce physical or chemical incompatibilities between A and B. Often used in diffusion-bonded joints.

Interlayers are generally very thin shims

INTERMEDIATE MODULUS CARBON FIBRES (IM)

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

INTERMETALLIC COMPOUND

Stoichiometric chemical compound formed between two or more metallic elements

INTERMETALLIC MATRIX COMPOSITE (IMC)

Composite using an intermetallic compound as the matrix material. [See also: ALUMINIDE]

INTESPACE

Test centre, France

INTRALAMINAR STRESSES

The stresses in the plane of a ply

INVAR

A nickel-based alloy

INVARIANT

Constant values for all orientations of the co-ordinate axes. Components of stress, strain, stiffness and compliance all have linear and quadratic invariants. For composite materials, they represent directionally independent properties and the bounds of stiffness and strength of multidirectional laminates

INVESTMENT CASTING

A casting method designed to achieve high dimensional accuracy, usually for small components. Moulds are joint free. Established production technique for high-temperature metal alloys, e.g. aero engine parts. Variant process: lost-wax casting

IONISABLE CONTAMINANT

Process residues, such as flux activators, fingerprints, etching and plating salts, that exist as ions and when dissolved, increase electrical conductivity

IOSIPESCU

A test method using a double V-notched specimen; developed by the University of Wyoming

IP TML

In-phase thermo-mechanical fatigue

IR

Infra Red

IRAS

Infra-red astronomical satellite

IRIDIUM

Metallic element, melting point 1538°C, density 7310 kg m⁻³. Uses: electronics and coatings

IRIS

Italian Research Interim Stage

IRON (Fe)

Metallic element, melting point 156.63°C, density 7870 kg m⁻³. Uses: base element for steels, iron-based superalloys, alloying additions

IRRADIATION

The bombardment of a composite material with a variety of subatomic particles, usually alpha-, beta- or gamma-rays, to bring about changes in the material's physical and mechanical properties

ISAS

Institute of Space and Astronautical Science; Japan's national space research centre

ISC

Integrated system check

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

ISOTROPY

[See: ISOTROPIC]

ISS

- 1 International space station
- 2 Internal stress superplasticity

ISST

Integrated subsystem test

IST

Integrated system test

ITE

Integral throat and entrance; Rocket nozzles

ITEC

Integral throat exit cone; Rocket nozzles

ITEM

The lowest subdivision of a subassembly in which each item is a separate and distinct element not normally separated into further subdivisions or disassembly without destruction of designed use

ITO

Indium tin oxide

IUS

Inertial upper stage

J

JIG

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

JIS

Japanese Institute of Standards

JOINT

- 1 General: Any element that connects other structural elements and transfers loads from one to the other across a connection, Ref. [5].
- 2 Bonded: The location at which two adherends are held together with a layer of adhesive; the general area of contact for a bonded structure. Common bonded types are:
 - Butt Joint: The edge faces of the two adherends are at right angles to the other faces of the adherends.
 - Scarf Joint: A joint made by cutting away similar angular segments of two adherends and bonding them with the cut areas fitted together.
 - Lap Joint: A joint made by placing one adherend partly over another and bonding together the overlapped portions

JOINT EFFICIENCY

Parachutes: the strength of a stitched joint as a percentage of that of the bulk broadloom fabric

JOINT STRUCTURE

Pressure vessels have to be connected to the surrounding main structure. This is performed by a joint structure. A cylindrical joint structure (or 'skirt') is used to attach isotensoid-shaped vessels in their cylindrical area. Brackets are used to attach spherical vessels at the poles. These joint structures have to be so designed as to respect all load cases

K

K

Karlak

K49

Kevlar™ 49

KDF

Knock-down factor

KEVLAR®

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

KFRP

Kevlar-fibre reinforced plastic

K_{IC}

Plane strain fracture toughness, [See also: CRITICAL STRESS INTENSITY FACTOR; FRACTURE TOUGHNESS]

KINK

A distortion in the direction of the reinforcing fibres within a prepreg; often a localised effect but can be considered as a defect

K_{ISCC}

Threshold stress-intensity factor for stress-corrosion cracking. The maximum value of the stress-intensity factor for a given material at which no environmentally induced crack growth occurs at sustained load for the specified environment, Ref.[5]. [See also: FRACTURE TOUGHNESS]

ΔK_{th} or K_{th}

Threshold stress-intensity factor for dynamic loading. The stress-intensity range below which crack growth will not occur under cyclic loading

L

L2K

Plasma arc wind tunnel test

LACIS

Large area composite inspection system

LAM

Liquid Apogee Motor

LAMINA

[See: PLY]

LAMINA-LEVEL MATERIAL PROPERTIES

Established from test data for a single-ply or multi-ply, single-direction-oriented lamina lay-up

LAMINATE FAMILY

Laminates sharing the same ply number and angles

LAMINATE

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

LAMINATED PLATE MODEL

Mathematical model derived to describe behaviour of anisotropic materials of laminar construction, best suited to continuous fibre composites with unidirectional plies

LAMINATED-PLATE THEORY

The most common method for the analysis and design of composite laminates. Each ply or ply group is treated as a quasi-homogeneous material. Linear strain across the thickness is assumed. Note: Also called the lamination theory

LAMINATE-LEVEL DESIGN ALLOWABLE

Established from multiply laminate test data or from test data at the lamina level and then confirmed at the laminate level by test-validated analytical methods.

[See also: ALLOWABLES, DESIGN VALUES]

LAMINATE-LEVEL DESIGN VALUE

[See: LAMINATE-LEVEL DESIGN ALLOWABLE]

LANXIDE

A ceramic composite consisting of an aluminium oxide network with pores filled with aluminium (Lanxide Corp.)

LAP

In filament winding, the amount of overlay between successive windings, usually intended to minimise gapping

LAP JOINT

Joining or fusing of two overlapping surfaces, [See: JOINT]

LaRC or LARC

- 1 NASA Langley Research Center, USA.
- 2 A polyimide resin developed by NASA Langley Research Center, USA

LAS

Lithium-Alumino-Silicate. A family of glass-ceramic matrix materials with different levels of ZrO_2 and BaO

LAST PLY FAILURE

The failure of the ply or ply group in a multidirectional laminate that occurs at last. The load corresponding to this failure can be the ultimate load

LAYER

[See: PLY]

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

LAW OF MIXTURES

An externally applied strain (in tension, compression or shear) is equal to the strains in all the phases present, i.e. reinforcement and matrix. The contribution of each phase is therefore directly dependent on its volume fraction within the composite. Note: This relies on all phases being elastic. For MMC and CMC materials: It can predict stiffness values of but only to very low strain levels. For unidirectional composites: It can provide reasonably accurate tensile strength values, provided that fibre degradation has not occurred. For multidirectional MMC and CMC materials: it is inappropriate and predicts high, inaccurate strength values

LBB

Leak Before Burst; pressure vessels

LBU

Laser-based ultrasonics

LCCD

Linear charge cord device

LCF

Low-cycle Fatigue

LCP

Liquid crystal polymer

LDEF

Long Duration Exposure Facility

LDR

Large deployable reflector

LDV

Laser Doppler vibrometer

LEAD (Pb)

Metallic element, melting point 328°C , density 11350 kg m^{-3} . Uses: alloying additions

LEAK BEFORE BURST

Fracture mechanics design concept in which it is shown that any initial defect grows through the wall of a pressurized system and cause leakage prior to burst (catastrophic failure) at maximum design pressure (MDP), [See: MAXIMUM DESIGN PRESSURE (MDP)], Ref. [5]

LEFM

Linear elastic fracture mechanics

LEO

Low Earth Orbit

LH

Liquid hydrogen

LH2

Liquid Hydrogen

LID

Liquid-interface-diffusion (NASA): a technique for joining dimpled metal foils in Multiwall thermal protection systems

LIDAR

Light detection and ranging: This operates on the same principles as RADAR but uses light instead of radio frequencies. The transmitted light interacts with, and is changed by, the target. Some of this light is reflected or scattered back to the instrument where it is analysed. The change in the properties of the light enables some property of the target to be determined. The time for the light to travel out to the target and back to the lidar can be used to determine the range. Differential absorption lidar (DIAL) uses two different laser frequencies to provide atmospheric chemical composition information

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)

LIMIT LOAD

[See: LOADS]

LIMIT LOAD OR STRESS

The maximum load or stress assumed to act on a structure in the expected operating environments, Ref. [5]; [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

LINER

In a filament-wound pressure vessel, this is the continuous, usually flexible, coating on the inside surface of the vessel used to protect the laminate from chemical attack or to prevent leakage. The evaluation of the material for the liner depends on the stored medium and the pressure level. For lower-pressure application, a rubber liner can be sufficient. For high-pressure application, a steel or titanium load-carrying liner is necessary

LIQUID METAL PRESSURE FORMING

[See: LIQUID PRESSURE FORMING]

LIQUID PHASE PROCESSING

Usually applied to joining techniques where one or more of the constituent parts are melted during the processing, e.g. welding, brazing

LIQUID PRESSURE FORMING

Types of melt infiltration techniques for MMC production conducted in a pressure vessel. A development of low-pressure die casting

LITHIUM (Li)

Metallic element, melting point 181°C, density 534 kg.m⁻³. Uses: aluminium-lithium alloys

LLD

Launch locking devices; part of SILEX

LLV

Lockheed launcher vehicle

LOADING EVENT

A condition, phenomenon, environment or mission phase to which the payload is exposed and which induces loads in the payload structure, Ref. [5]

LOADING PATH

Locus of increasing load in stress or strain space

LOAD SPECTRUM (HISTORY)

A representation of the cumulative static and dynamic loadings anticipated for a structural element during its service life, Ref. [5]

LOADS

Strength requirements are specified in terms of:

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

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-STRAIN CURVE

A graphical representation of the extension of a material under an applied load

LONGITUDINAL MODULUS

Elastic constant along the fibre direction in a unidirectional composite, [See also: YOUNG'S and SHEAR MODULUS]

LOSS FACTOR η

Damping: a well established fundamental ratio with which to assess damping on a relative energy basis

LOSS FACTOR (tan δ)

Electrical: a power factor, values usually quoted at a particular frequency

LOSS MODULUS

A damping term describing the dissipation of energy into heat when a material is deformed

LOW CYCLE FATIGUE (LCF)

Repeated mechanical loading, applying high stresses for a low number of cycles, typically 10⁴ to 10⁶

LOW-STRAINED STRUCTURE

A composite structural component which is designed to a reduced strain level so that catastrophic failure will not occur even in the presence of flaws or damage

LOX

Liquid Oxygen

LPARL

Lockheed Palo Alto Research Laboratory, USA

LPI

1 Liquid-phase infiltration

2 Low pressure infiltration. Processes for manufacturing ceramic matrix composites, developed by [MAN Technologie](#) (D)

LPI-C/SiC

Carbon-silicon carbide composite, produced by LPI process by [MAN Technologie](#), (D)

LPF

[See: LIQUID PRESSURE FORMING]

LRR

Launch Readiness Review

LRSI

Low-temperature Reusable Surface Insulation, e.g. Space Shuttle Orbiter

LST

Large space telescope

LTM

Low temperature moulding; a class of prepreg

LTPP

Long Term Space Transportation Systems Preparatory Programme; an ESA program

LUIS

Laser ultrasonic inspection system

LVDT

Linear variable differential transformers. A type of displacement sensor

LWT

Light-weight tank. The Space Shuttle external main fuel tank; superseded by SLWT super light-weight tank

M

MA

Mechanically alloyed; a powder metallurgy technique for producing a dispersion of particles within an alloy

MACHINING

The removal of material in a controlled manner by one or more mechanical, electrical or chemical methods, e.g. turning, milling, drilling, electro-chemical discharge, ultrasonic, Ref. [10]

MACROMECHANICS

The study of structural behaviour of composite laminates using the laminated plate theory. The fibre and matrix within each ply are smeared and no longer identifiable

MAGE

Moteur d'apogée géostationnaire européenne

MAGNESIUM (Mg)

Metallic element, melting point 650°C, density 1740 kg.m⁻³. Uses: lightweight wrought and cast magnesium alloys; cast alloys can be composite matrices; alloying addition to other base systems

MAGNETOSTRICTIVE

A solid material which mechanically deforms when subjected to a magnetic field

MANDREL

The core around which impregnated paper, fabric, or resin-impregnated fibre is wound to form pipes, tubes, or vessels

MANGANESE (Mn)

Metallic element, melting point 1246°C, density 7210 kg m⁻³. Uses: alloying additions

MAN-MT

Part of the German MAN Technologie company

MARGIN OF SAFETY

Ratio of excess strength to the required (calculated) strength

MARSNET

Multiple-lander ESA Mars mission

MAS

Magnesium aluminosilicate. A glass ceramic matrix

Note: Variant containing higher levels of BaO is called BMAS

MASS FRACTION

[See: WEIGHT FRACTION]

MAT

- 1 A fibrous material for reinforced plastic consisting of randomly oriented chopped filaments or swirled filaments with a binder, available in various widths, weights, and lengths
- 2 For technical textiles: fibrous material consisting of randomly oriented chopped filaments, short fibres or swirled filaments, loosely held together with a binder

MATERIAL

A raw or semi-finished product or compound (gaseous, liquid, solid) of specific characteristics, which is processed to form a part or a finished product, Ref. [6]

MATERIAL DESIGN ALLOWABLE

A 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, Ref. [9]

MATERIAL IDENTIFICATION CARD (MIC)

Accompanies a material sample supplied to ESA or any test house. It states all required information about the material batch

MATERIAL REVIEW BOARD

This board has the responsibility to process, in line with the applicable Product Assurance requirements, all Non-conformance Reports arising during verification activities

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, Ref.[1]

MATRIX

- 1 A material that binds a reinforcement, e.g. thermoplastic or thermosetting resin in fibre-reinforced composites, metal alloy in MMCs, Ref. [10]. Note: The most common matrices for organic composites are polyester, epoxy and polyimide; for metal-matrix composites, aluminium
- 2 Mathematical entity, consisting of rows and columns of numbers. In two dimensions, stress and strain are 1 x 3 matrices; and stiffness and compliance, 3 x 3 matrices

MATRIX-CONTROLLED

A laminate lay-up where the properties are largely determined by those of the matrix, e.g. +45°-45°

MATRIX FAILURE

Gradual accumulation of fatigue crack or other damage distributed only within the matrix phase and without causing fibre damage. Applicable to MMC, C-C and CMC materials

MATRIX INVERSION

Algebraic operation to obtain compliance matrix from stiffness matrix, or vice versa. It is analogous to obtaining the reciprocal of a number

MATRIX TRANSFER MOULDING

Manufacturing method used for glass or glass-ceramic composites where molten matrix is added to a mould containing reinforcement fibres. Usually restricted to matrix materials with moderate melting temperatures, e.g. not ceramics. Detrimental fibre/matrix reactions can occur as a result of the high process temperatures

MAUS

Mobile automated ultrasonic scanner

MAXIMUM DESIGN PRESSURE (MDP)

For a pressurized system, maximum design pressure is the highest possible pressure occurring from maximum relief pressure, maximum regulator pressure, maximum temperature or transient pressure excursions. Factors of safety apply to MDP, Ref. [5]

MAXIMUM STRAIN

Failure criterion based on the maximum strains

MAXIMUM STRESS

Failure criterion based on the maximum stresses

MBB Ottobrunn

Part of the German MBB aerospace organisation

MBSA

Main body structural assembly; part of the Mars Observer Camera

MCrAlY

A range of corrosion-resistant coating alloys, where 'M' can be nickel, cobalt or a combination of both

MD

Multidirectional

MDA

Methylene dianiline amine; a known carcinogenic substance used in some polyimide resin formulations, e.g. PMR-15

MDP

Maximum Design Pressure [Pressure systems, including pressure vessels]

MDSSC

McDonnell Douglas Space Systems Co., USA

MEASURAND

A characteristic or property to be measured

MECHANICAL ALLOYING

A processing method originally invented to manufacture oxide dispersion strengthened nickel alloys. A high energy ball milling process, where alloying is the result of repeated fracture and cold welding of the component particles. The process can also induce chemical reactions, [See also: ODS ALLOYS]

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 a way that it can be evaluated as a whole against expected performance requirements and cannot be disassembled without destroying this capability, Ref. [6]

MELT INFILTRATION

Processing methods for incorporating a matrix phase with the reinforcement by means of capillary action. It can be assisted by positive pressure or vacuum

MELT REFINING

Technique proposed for manufacture of graded materials or structures, where a narrow molten zone is moved through the material to modify the microstructure, often by segregation mechanisms. Also known as ZONE REFINING

MELT SPINNING

A fibre-forming polymer is melted for extrusion through spinnerets and then directly solidified by cooling. Nylon and polyester fibres are produced in this way

MELT STIRRING

Process for forming and distributing oxide particles in molten metal alloys. Some variants use ultrasonic agitation of the melt

MEMORY ALLOY

A class of metal alloy which, after deformation whilst in one metallurgical state, regains its original shape after heating or cooling through a specific temperature. Also known as 'Shape Memory' effect, Ref. [10]

MEMS

Micro electro-mechanical systems

MEOP

Maximum expected operating pressure; pressure vessels

METAL FIBRES

A range of speciality fibres ranging in diameter from 2 μm to 80 μm , typically, that can be co-woven with carbon fibres for inclusion in a composite for certain applications, e.g. stainless steel, Inconel, Hastelloy, titanium.

METALLIZED FIBRES

A range of speciality fibres that are coated with a fine metallic layer, primarily to enhance electrical properties in composites

METAL MATRIX COMPOSITE (MMC)

Composite material in which the matrix is a metal alloy

METCAN

Metal Matrix Composite Analyser (Laminated plate model for fibre-reinforced metals)

M_f

Martensite finish temperature

MFG

Manufacturing

MGSE

Mechanical Ground Support Equipment

METHOD OF MIXTURES

also known as 'Law of Mixtures', [See: LAW OF MIXTURES]

MIC

Material identification card

MICRO-ALLOYING

Alloying additions in the low atomic percent levels, e.g. boron additions to aluminides, to modify mechanical properties. Often to increase ductility over base alloy system. Also known as DOPING

MICROCRACKING

- 1 Cracks formed in composites when thermally created stresses locally exceed the strength of the matrix. (The effect is complex and can be associated with a combination of residual curing stress and stresses induced by thermal cycling.)
- 2 Progressive effect where the matrix phase in a composite material forms a network of small cracks, when residual stresses in the matrix exceed the strength of the matrix or that of the matrix-to-fibre interface; occurs mainly during cooling of a component after cure and is caused by the differential contraction between the high positive CTE of the matrix and the low, negative axial fibre CTE. Also occurs in service where thermal cycling or low temperatures can instigate and promote microcracking

MICROMECHANICS

Calculation of the effective ply properties as functions of the fibre and matrix properties. Some numerical approaches also provide the stress and strain with each constituent and those at the interface

MICROMETEORIOD

Debris accumulated in space from natural sources, e.g. comets, asteroids, the moon and planets

MICROSENSOR

Small devices (micro-technology) produced by micro-machining of Silicon. (Extension of IC technology.) They are capable of being embedded or bonded to a structure or mechanism without altering the overall characteristics of the host component, and can monitor conditions such as pressure, vibration acceleration

MICROSTRUCTURE

The structure of a material as seen with a microscope. Used normally to describe the grain structure, form and any other features which determine or influence the material behaviour

MICRO-YIELD

An applied force to produce a residual strain of 1×10^{-6} m/m along the tensile or compression loading direction, Ref. [9]

MID-PLANE

Centre of a laminate; usually the $z = 0$ plane

MIG

Metal Inert Gas; a fusion welding process

MIP

Mandatory Inspection Point

MIRKA

Mikro Rückkehr Kapsel

MISP

Mismatch induced superplasticity

MIXTURE

A fibre tow that contains both reinforcement fibres and polymer filaments, [See: COMINGLED]

ML

Mar and Lin; a fracture model

MLI

Multi-layer insulation, e.g. that used in the gloves of extra-vehicular activity space suits

MMC

Metal Matrix Composite

MMCF

Metal Matrix Composite, where the reinforcement phase is fibrous

MMCP

Metal Matrix Composite, where the reinforcement phase is particulate

MMH

Mono-methyl-hydrazine. A constituent of certain bipropellant rocket fuels, [See also: NTO]

MMU

Manned manoeuvring unit

MOC

Mars Observer Camera

MOCK-UP

Physical model used in support of design definition for overall architecture analyses, configuration design and assessment, interface control and definition, human factors assessment, operational procedures evaluation, layout optimisation, Ref.[1]

Mod-EIT

Modified Electrical Impedance Tomography

MODEL PHILOSOPHY

Definition of the optimum number of physical models required to achieve a high confidence in the product verification with the shortest planning and a suitable weighting of costs and risks, Ref.[1]

MODULE

It can be made up of directly functionally related equipment or of equipment from various subsystems. A module can be a flight element or can be a major portion of a flight element, e.g. Service Module, Payload Module. Note: Verification level typical of US standard, Ref.[1]

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

MODULUS MISMATCH

The difference in stiffness between a fibre and a matrix, or coating and substrate

MOI

Momentum of Inertia

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

MOISTURE DISTRIBUTION

Transient moisture profile changes very slowly with time. For temperature, a steady-state distribution can be attained in a short time. But for moisture concentration, only the first few plies from the exposed surface can change significantly with time. For the interior plies, months if not years elapse before a change takes place. This non-uniform distribution is considered in the assessment of the effect of moisture on the properties of composite materials

MOISTURISED

Samples, materials and structures that have been subjected to moisture, usually as a conditioning process prior to testing

MOLECULAR COMPOSITE

A combination of two molecular polymer groups where one is a rigid phase that provides a reinforcing effect in the other, flexible, phase

MOLYBDENUM (Mo)

Refractory metallic element, melting point 2623°C, density 10220 kg.m⁻³. Uses: alloying additions

MONITORING

For smart technologies: a diagnostic system which can provide data on the integrity or functioning of machinery or structures, either continually or periodically, but without any reactive elements. [See also: CONDITION MONITORING, HEALTH MONITORING, STRUCTURAL HEALTH MONITORING]

MONEL

A nickel-based alloy

MONOFILAMENT REINFORCEMENT

A reinforcement material used in composites which consists of a single 'wire', unlike the filamentary construction of fibres, e.g. boron filaments, tungsten filaments and some SiC reinforcements. Filaments often consist of layers of various materials deposited onto a carrier fibre core, the external layer being often designed to act as a diffusion coating or barrier. Normally for metal or ceramic matrix materials

MONOFILAMENT YARN

For technical textiles: a single filament

MONOLITHIC CERAMIC

A ceramic material which does not contain any deliberately introduced reinforcing phase, e.g. whiskers or fibres. Normally brittle, they are prone to catastrophic failure if over stressed, especially in tension. Common engineering uses include coatings, insulators, electronic substrates, refractory linings etc. [See also: CERAMIC]

MONOPROPELLANT

Single chemical component rocket fuel which spontaneously decomposes in the presence a catalyst material [See also: BIPROPELLANT]

MOS

Metal-oxide Semiconductor

MoS₂

Molybdenum disulphide

MOULD

- 1 The cavity or matrix in or on which the plastic composition is placed and from which it takes its form.
- 2 To shape plastic parts or finished articles by heat and pressure.
- 3 The assembly of all the parts that function collectively in the moulding process

MOULD RELEASE AGENT

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

MOULDING

The shaping of a plastic composition in or on a mould, normally accomplished under heat and pressure, sometimes used to denote the finished part

MOULDING, PRESSURE-BAG

[See: PRESSURE-BAG MOULDING]

MPCS

Mobile part carrier structure; part of SILEX

MRB

Material Review Board

M.S

Margin of safety

M_s

Martensite start temperature

MS

Mass-spectrometer

MSG

Meteosat second-generation

MSTP

Manned Space Transportation Programme

MU

Mock-Up

MULTIDIRECTIONAL

- 1 Having multiple ply orientations in a laminate
- 2 Composite laminates in which the properties are controlled by the orientation of the reinforcement fibres, i.e. fibre-controlled

MULTIFILAMENT YARN

Multiple fine, continuous filaments (often 5 to 100), usually with some twist in the yarn to facilitate handling. Sizes range from 5 to 10 denier up to a few hundred denier. Individual filaments in a multifilament yarn are usually about 1 to 5 denier. [See also: DENIER]

MULTIPLE-WOUND YARN

For technical textiles: two or more yarns wound, but not twisted, together

MW

Multiwall, e.g. titanium multiwall construction; a type of thermal protection system

MW_t

Molecular weight

MZ

Mach-Zehnder. A type of interferometer for high-resolution phase analysis used in structural health monitoring systems

N**N₂O₄**

Nitrogen tetroxide; also known as NTO

NaCl

Sodium chloride; salt

NANOTECHNOLOGY

The ability to manufacture and control devices (sensory, reactive or combined) in the nanometre range, i.e. smaller than current micrometer size devices

NASA

National Aeronautics and Space Administration

NASA FLAGRO

Fracture mechanics analysis software developed by NASA

NASA MESUR

Network Mars lander

NASP

National aerospace plane; designated X-30 under the USA X-programme vehicles

NBR

Nitrile butyl rubber; a material used for seals

NBS

United States National Bureau of Standards, USA

NCR

Non-conformance report

NDC

Nondestructive characterisation, [See: NONDESTRUCTIVE]

NDE

Nondestructive evaluation, [See: NONDESTRUCTIVE]

NDI

Nondestructive inspection, [See: NONDESTRUCTIVE]

NDT

Nondestructive testing, [See: NONDESTRUCTIVE]

NEAR-NET SHAPE

Component produced with very little finishing required after the major manufacturing operation; also described as 'net-shape'

NETTING ANALYSIS

The analysis of filament-wound structures which assumes that the stresses induced in the structure are carried entirely by the filaments, the strength of the resin being neglected, and that the filaments possess no bending or shearing stiffness, carrying only the axial tensile loads

NEURAL NETWORK

Computer science terminology. Objective to build computer systems which function in a similar manner to biological nervous systems. Able to be trained and operate at high speeds

NF

Norme Française; French national standard

NICALON[®]

A family of continuous multi-filament silicon carbide fibres derived from the conversion of an organic silicone polymer, polycarbosilane (PCS). Produced by Nippon Carbon Co.

NICKEL (Ni)

Metallic element, melting point 1455°C, density 8900 kg.m⁻³. Uses: most common superalloy base element; high temperature engine components; alloying addition to many other systems

NICKEL ALUMINIDE (Ni₃Al)

High-strength, brittle intermetallic material, used as coatings or as the matrix in intermetallic matrix composites

NIST

National Institute of Standards and Technology, USA; standards

NiTi

A family of shape memory alloys based on nickel and titanium, [See also: SHAPE MEMORY]

NITINOL[®]

A proprietary shape memory alloy with a NiTi chemical composition

NITRIDE

Compound of nitrogen and a metal, often very hard and brittle. Often used as an external hardening treatment for steels, as hardening agents within alloys, e.g. silicon nitride is a widely used ceramic, with or without reinforcement

NLR

Nationaal Lucht-en Ruimtevaartlaboratorium; Dutch national aerospace laboratory

NMR

Nuclear magnetic resonance

NO GROWTH CRITERION

Comprehensively demonstrated condition under which an anomaly or damage does not grow to an extent where the mechanical properties are down-graded so as to impair the residual strength or stiffness of the structure. (The residual strength of the structure is equal to or greater than the strength required for the specified design loads and the stiffness is maintained at the level required for all operating conditions)

NOL

Naval Ordnance Laboratory

NOMEX®

An aramid fibre blend from Dupont

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 CONFORMANCE

An apparent or proven condition of any item or documentation that does not conform to specified requirements or which could lead to incorrect operation or performance of the item or mission. The term nonconformance is also used for, e.g. failure, discrepancy, defect, anomaly, malfunction, deficiency

NON-CRITICAL MECHANICAL PART

Any mechanical part that does not fall under the critical mechanical part definition [See: CRITICAL MECHANICAL PART]

NON-CRITICAL PROCESS

Any process part that does not fall under the critical process part definition [See: CRITICAL PROCESS]

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. Nondestructive 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

NON-DESTRUCTIVE INSPECTION (NDI)

- 1 General: [See: NONDESTRUCTIVE]
- 2 Inspection techniques that do not cause physical or chemical changes to the item being inspected or otherwise impair its adequacy for operational service, and that are applied to materials and structures to verify required integrity and detect and characterise cracks. NDI method refers to the specific technique used, such as dye penetrant, X-ray. NDI level refers to the degree of resolution of the technique

- 3 Special Nondestructive Inspection: The formal inspection of items using non-destructive procedures involving the use of techniques or equipment that exceed common industrial standards
- 4 Standard Nondestructive Inspection: The formal inspection of items using non-destructive procedures consistent with common industrial standards. These include standard dye-penetrant, eddy-current, ultrasonic and X-ray procedures

NON-HOOKEAN

A material that does not behave according to Hooke's Law, i.e. non-elastically, [See: GENERALISED HOOKE'S LAW]

NON-MECHANICAL STRESS

Originated from curing and hygrothermal stress

NON-WOVEN TEXTILE

- 1 For technical textiles: fibrous sheet-materials, [See also: FLEECE]
- 2 Space applications: it can be used in the core of a flexible external insulation system. [See also: FEI]

NOTCH

Testing: a specimen that contains a feature to simulate a stress raiser, e.g. a hole or slit

NOTCH FACTOR

Ratio of the resilience determined on a plain specimen, to the resilience determined on a notched specimen

NOTCH SENSITIVITY

The extent to which the sensitivity of a material to fracture is increased by the presence of a surface inhomogeneity such as a notch, a sudden change in section, a crack, or a scratch. Low notch sensitivity is usually associated with ductile materials and high notch sensitivity with brittle materials

NOTCHED STRENGTH

The effective strength of a plate with such stress-raisers as holes, notches and cracks

NOTCHED TENSILE

Tensile stress test of a specimen containing a deliberately introduced flaw. Many standard test specimens with a variety of machined 'defects' exist in an attempt to model 'real' defects

NRB

Non conformance review board

NTO

Nitrogen tetroxide. A constituent of some bipropellant rocket fuels, [See also: MMH]

NSTS

The National Space Transportation System (US Space Shuttle)

O

OA

Optical assembly; part of SILEX

OASIS

On-line alerting of structural integrity and safety

OASPL

Overall acoustic sound pressure level

OBDH

On Board data handling

OCDP

Optical coherence domain polarimetry. A fibre optic-based temperature measurement system

ODS

Oxide dispersion strengthened (metal alloys)

OFBG

Optical fibre Bragg grating, [See also: BRAGG GRATING]

OFF-AXIS

Not coincident with the axis of symmetry. Note: Also called off-angle

OFFES

Outer fabric for European space suit

OFFGASSED PRODUCT

An organic or inorganic compound evolved from a material or assembled article or experiment or rack, Ref. [7]

OFFGASSING

- 1 General: Depending on the application, there are restrictions on the gaseous products released from materials or finished articles in operational vacuum conditions that can:
 - contaminate other equipment, [See also: OUTGASSING]
 - contaminate the air during preparatory or operational conditions for manned spacecraft.
- 2 The evolution of gaseous products for an assembled article subjected to slight radiant heat in the specified test atmosphere, Ref. [7]. Note: It applies to materials and assembled articles to be used in a manned space vehicle crew compartment

OFT

Orbital flight test

OGSE

Optical ground support equipment

OHB

Optical head bench; part of SILEX

OHTH

Optical head thermal hood; part of SILEX

OMS

Orbital manoeuvring system or subsystem

OREX

Orbital re-entry experiment

ON-AXIS

Coincident with the axis of symmetry; also known as 'on-angle', [See: ORTHOTROPIC]

ONERA

[Office National d'Etudes et de Recherches Aérospatiales](#). French national aerospace research organisation

ON-ORBIT

Verification phase valid for projects whose characteristics, e.g. mission, on-orbit operations, etc. require on-orbit verification. The on-orbit phase has the objective to supplement ground testing by providing operating conditions which cannot be fully or cost effectively duplicated or simulated on the ground, Ref.[1]

OPS

Oxidation-protection system; a coating system for carbon-carbon composites

OPTICAL FIBRE

- 1 General: A single discrete filament-shaped transparent dielectric material, usually made of glass or plastic, which guides light. It normally has a cylindrical core with one or more external cladding materials applied. The cladding materials have a refractive index higher than that of the core in order to ensure that light propagates within the core, Ref.[4]
- 2 Smart technologies: A specially manufactured glass optical fibre device usually with some sensory function that can relay light signals usually over long distances. Depending on the precise structure, many signals can be sent and received at the same time, [See also: FIBRE OPTIC]

OPTIMUM LAMINATE

Having the highest stiffness or strength per unit mass or cost

OP TML

Out-of-phase thermo-mechanical fatigue

ORFEUS

Orbiting and retrievable far and extreme ultraviolet spectrometer

ORTHOTROPIC

A description of material symmetry where the x-axis and y-axis of a laminate coincide with the longitudinal and transverse directions of the material; also know as 'on axis'

ORTHOTROPY

Having three mutually perpendicular planes of symmetry. Unidirectional plies, fabric, cross-ply and angle-ply laminates are all orthotropic

ORS

Part of Austrian Aerospace GmbH, since 1997

ORTHOGONAL WEAVE

A fabric in which the warp and weft directions are 90° to each other

ORU

Orbital Replaceable Unit

OSR

Optical Solar Reflector

OTA

Optical Telescope Assembly

OTDR

Optical Time Domain Reflectometry

OTV

Orbital Transfer Vehicle

OUTGASSING

- 1 General: Depending on the application, there are restrictions on the gaseous products released from materials or finished articles in operational vacuum conditions that can:
 - contaminate other equipment (outgassing)
 - contaminate the air during preparatory or operational conditions for manned spacecraft, [See: OFFGASSING]
- 2 Release of gaseous species from a specimen under high vacuum conditions, Ref. [8]

OVERLAP

A simple adhesive joint, in which the surface of one adherend extends past the leading edge of another

OVERLAY COATING

Coating applied to the surface of a component. Often containing inert, oxide materials, acting as a physical barrier to corrosion, temperature or erosion. Common formulae are based on MCrAlY, where M=Ni, Co or Fe. Silicon Carbide coatings are also used

OXIDATION

- 1 Process of attack by oxygen, usually at elevated temperature.
- 2 Oxide coatings on ceramics, [See: CVD]
- 3 Oxide coatings on metals, [See: DIFFUSION COATINGS]

OXIDATION RESISTANCE

A measure of the ability of a material not to degrade or deteriorate under conditions where oxygen is present, usually at elevated temperatures, for a particular time

OXIDE DISPERSION STRENGTHENING (ODS)

The generation of very fine, sub-micrometre particles of oxides and their addition to a metal with the objective of modifying the base material's deformation properties. Normally achieved by powder attrition techniques, [See also: MECHANICAL ALLOYING]

P

P/L

Payload

PA

Product Assurance

PAET

Planetary Aerothermal Experiment Test

PAI

Polyamide-imide; a polymer

PALLADIUM

Metallic element, melting point 1555°C, density 12020 kg m⁻³. Uses: constituent of high-temperature brazing alloys

PAM

Payload Assist Module

PAN

- 1 Polyacrylnitrile; a range of carbon fibres
- 2 Process of producing carbon fibres in which a chain of carbon atoms is separated from polyacrylnitrile through heating and oxidation. The other process for producing carbon fibres uses 'pitch' as the precursor material

PAO

Anti-oxidation coating system for carbon-carbon composites

PAP

Propulseurs d'appoint à poudre

PART

- 1 A component usually manufactured using one or more processes, e.g. a laminated sheet
- 2 A mechanical part, Ref. [6]

PARTICULATE

- 1 A material in which the aspect ratio is small; a discontinuous reinforcement
- 2 Powder or fine grit, usually ceramic, used for reinforcement phase in metal alloys, [See also: PARTICULATE REINFORCED METAL (MMC_p)]

PARTICULATE REINFORCED METAL (MMC_p)

Metal matrix composite produced by introducing a finely dispersed, hard, brittle powder phase into a metal alloy. These particulate materials are often carbides or oxides. This is usually achieved either with molten metal (casting) or by mixing with powdered metals (powder metallurgy). Particulate sizes are typically between $3\mu\text{m}$ and $20\mu\text{m}$, i.e. much larger than those for oxide dispersion strengthened (ODS) alloys

PASSIVATION

The treatment of metal surfaces, often with acid solutions (or pastes), to remove contaminants and promote the formation of a stable oxide film

PASTE

Adhesive: a single- or two-component adhesive that often includes a thickening agent, such as microballoons, that behaves as a viscous liquid

PAYLOAD ASSIST MODULE (PAM)

Concept using a large solid-rocket motor as a perigee injection stage incorporated as part of the user's payload rather than as part of the launch vehicle system, e.g. PAM-A: Atlas-sized, PAM-D: Delta-sized

PAYLOAD

Any equipment or material carried by the launcher that is not considered part of the basic launcher itself. It therefore includes items such as free-flying automated spacecraft, individual experiments and instruments, Ref. [5]

PBI

Polybenzimidazole; a type of fibre from Celanese

PC

Personal computer

PCB

Printed circuit board

PDR

Preliminary Design Review

P-E

Pulse-echo; an ultrasonic testing process using one transducer placed on one side of the material under test; also known as 'pitch-catch'

PECVD

Plasma Enhanced Chemical Vapour Deposition

PEEK

Poly-ether-ether-ketone: a linear aromatic crystalline thermoplastic. [See also: THERMOPLASTIC]

PEEL PLY

Sacrificial sheets of material, usually a fabric, applied to the external surfaces of composites; after processing peel plies are removed to provide a clean, contaminant-free surface

PEEL STRENGTH

Bond strength, obtained by peeling the layer

PEI

Polyetherimide

PERFLUORONATED

Containing fluorine; usually applied to polymers, e.g. Teflon™

PERFORMANCE FACTOR

The efficiency of a pressure case is given by the performance factor:

$$k = \frac{v \cdot p}{m}$$

where:

v : volume of the vessel,

p : burst pressure,

m : weight of the structure.

Note: Dimension of k is km

PES

Polyethersulfone thermoplastic. [See also: THERMOPLASTIC]

PFCI

Potential Fracture-critical Item

PFCIL

Potential Fracture-critical Item List

PFM

Protoflight Model

PHENOLIC RESIN

Thermosetting resin for elevated temperature use produced by the condensation of an aromatic alcohol with an -aldehyde, particularly of phenol with formaldehyde

PHENOLIN RESIN

[See: PHENOLIC RESIN]

PHPV

Pneumatic high pressure vessel

PHYSICAL VAPOUR DEPOSITION (PVD)

Coating manufacturing technique in which metal atoms or ions are transferred from a donor material to a substrate whilst under vacuum. Variants to the basic method are electron beam (EB-PVD), sputtering, ion plating and sputter ion plating (SIP)

PI

Polyimide; resin for elevated temperature. [See also: POLYIMIDE]

PICK

Tows in the weft direction of a fabric

PID

Process Identification Document

PIEZOCERAMIC

A ceramic-based material which exhibits the piezoelectric effect, such as lithium niobate (LiNbO₃), single crystals of quartz (SiO₂); ferroelectric ceramics, such as barium titanate (BaTiO₃) and lead zirconate titanate (PZT). Applications include sensors for smart technologies and inspection systems, e.g. ultrasonic and acoustic emission, [See also: PIEZOELECTRIC]

PIEZOELECTRIC

A class of materials which develop voltages across them when loaded or a mechanical force when a voltage is applied. [See also: PIEZOCERAMIC and PVdF]

PILE

A discontinuous fibre in the through-thickness direction of a fabric; a type of triaxial fabric; also known as quasi-3-D or 2.5-D fabrics

PIN HOLE

A small hole

PIP

A repeated resin infiltration and pyrolysis process, developed by Dornier for manufacturing ceramic matrix composites (CMC)

PITCH FIBRE

Carbon fibre made from pitch. The other process for producing carbon fibres uses Polyacrylonitrile (PAN) as the precursor material

PLAIN

A type of weave for a fabric, [See: PLAIN WEAVE]

PLAIN WEAVE

A fabric in which each warp and weft thread passes over one end (or pick) and under the next; also known as 'Square' weave

PLANAR FLOW CASTING

A continuous casting process for the production of rapidly solidified amorphous and microcrystalline metal alloy sheets

PLANAR HELIX WINDING

A winding in which the filament path on each dome lies in a plane which intersects the dome, while a helical path over the cylindrical section is connected to the dome paths

PLANAR WINDING

A winding in which a filament path lies in a plane intersecting the winding surface

PLANE STRAIN FRACTURE TOUGHNESS (K_{Ic})

[See: CRITICAL STRESS INTENSITY FACTOR]

PLANCK

CFRP satellite mirror structure. The ESA Planck Surveyor mission studied the cosmic microwave background radiation (CMBR)

PLASMA SPRAYING

Processing methods for depositing metal, ceramic or mixtures of the two onto a substrate from powder or wire feed-stock. Variants to basic method are vacuum, low-pressure (LPPS) and RF. Uses: coatings, matrix deposition onto fibre-reinforcement (MMC ply manufacture), matrix foils and particulate reinforced MMC

PLASTIC

A material that contains as an essential ingredient an organic substance of high molecular weight, is solid in its finished state, and at some stage in its manufacture or processing into finished articles can be shaped by flow; made of plastic

PLATINUM (Pt)

Metallic element, melting point 1769°C, density 21450 kg.m⁻³. Uses: alloying additions, coatings

PLM

Payload Module

PLY

A single layer of a laminated stack of composite material (or a single pass for a filament-wound configuration)

PLY DROP

The position inside a laminate where a ply is terminated, e.g. to create a tapered thickness

PLY GROUP

Group formed by contiguous plies with the same angle

PLYING

For technical textiles: [See: FOLDED YARN]

PLY STRAIN

Those components in a ply which, according to the laminated plate theory, are the same as those of the laminate

PLY STRESS

Those components in a ply that vary from ply to ply, depending on the materials and angles in the laminate

PMN

Lead-magnesium-niobate. A piezoceramic and thermo-electrostrictive material

PMP

Parts, Materials and Processes

POD

Probability of detection

POINT STRESS CRITERION

A failure criterion where it is assumed that failure occurs when the stress over some distance away from the discontinuity is equal to or greater than the strength of the unnotched laminate

POISSON'S RATIO

(1) Ratio of lateral strain to axial strain in an axial loaded specimen:

$$\nu = \frac{-\epsilon_y}{\epsilon_x}$$

where: ν is Poisson's ratio; ϵ_y is strain normal to direction of loading (lateral strain); ϵ_x is strain in the direction of loading (axial strain)

(2) Poisson's ratio is the constant that relates modulus of rigidity to Young's modulus in the equation:

$$E = 2G(\nu + 1)$$

where: E is Young's modulus; G , modulus of rigidity; and ν , Poisson's ratio.

The formula is valid only within the elastic limit of a material. A method for determining Poisson's ratio is given in ASTM E-132

POLAR WINDING

A winding in which the filament path passes tangent to the polar opening at one end of the chamber and tangent to the opposite side of the polar opening at the other end. A one-circuit pattern is inherent in the system

POLYAMIDE

A polymer in which the structural units are linked by amide or thio-amide grouping; many polyamides are fibre-forming

POLYESTERS

Thermosetting resins produced by dissolving unsaturated, generally linear alkyd resins in a vinyl active monomer, e.g. styrene, methyl styrene, or diallyl phthalate

POLYIMIDE

A polymer produced by reacting an aromatic dianhydride with an aromatic diamine; used for the matrix phase of composites; highly heat-resistant resin above 315°C typically

POLYMER

A high molecular weight organic compound, natural or synthetic, with a structure that can be represented by a repeated small unit, the mer, e.g. polyethylene, rubber and cellulose, Ref. [9].
Note: Synthetic polymers are formed by addition or condensation polymerisation of monomers. Some polymers are elastomers, some plastics

POLYMERISATION

A chemical reaction in which the molecules of a monomer are linked together to form large molecules whose molecular weight is a multiple of that of the original substance

POLYVINYLIDENE DIFLUORIDE (PVdF)

A polymer material which exhibits piezoelectric characteristics, [See: PIEZOELECTRIC]

POROSITY

Voids remaining in a material or component after manufacture, e.g. gas bubbles in fibre-reinforced resin products, gas or vacuum voids in metal castings. The porosity of a material is normally expressed as the ratio of the volume of air or void contained within the boundaries of a material to the total volume (solid material plus air or void), expressed as a percentage; also known as 'voidage' and 'void content'

POST TEST REVIEW

The objective is to review the preliminary results declaring the test completion, Ref.[1]

POSTCURE

An additional elevated-temperature cure, usually without pressure, to improve final properties or complete the cure. Complete cure and ultimate mechanical properties of certain resins are attained only by exposure of the cured resin to higher temperatures than those of curing

POST-LANDING

Verification phase valid for multi-mission projects. The post-landing phase has the objective to verify recycled hardware and software between missions, hardware and software needed for next flight and not previously verified, an article which has been modified since last usage and functional paths (at periodical intervals) during storage periods, Ref.[1]

POT LIFE

The length of time a catalysed resin system retains a viscosity low enough to be used in processing; also called 'Working Life', Ref. [10]

POTENTIALLY FRACTURE CRITICAL ITEM (PFCI)

A structural detail, structural element or structural assembly that is judged to be potentially fracture critical because of the potential critical reduction in flight residual strength or critical loss of structural function that is a consequence of its failure

POTTING COMPOUND

A polymer resin that usually contains a thickening agent to modify the viscosity and flow characteristics; used for retaining inserts in sandwich panels

POWDER METALLURGY (PM)

The forming of components from elemental, alloy or compound precursor materials in powder form. There are many process variants but the basic method consists of: blending of powders, shaping and pressing, heat treatment to consolidate component and remove porosity. In some variants these can be carried out simultaneously. PM allows good control of microstructure and can produce components to very high dimensional tolerance

POWDER PROCESSING

Techniques applicable to materials in a powder form. [See also: POWDER METALLURGY (PM)]

PPL

Preferred Parts List

ppm

Parts per million

PPS

Polyphenylenesulphide

PRECIOUS METAL

Metallic elements which are relatively scarce, often difficult to extract and hence have a high market price, e.g. gold, platinum

PRECIPITATION HARDENING

Strengthening mechanism for some metal alloys. Alloy is solution heat-treated to retain alloying elements in a solid solution. Subsequent, lower temperature heat treatment enables controlled growth of finely dispersed second phase precipitates. Greatest strength is usually achieved by stopping short of true precipitates, retaining a continuous, but strained, crystal lattice through the 'enrichment zones'

PREFORM

Fibres arranged, often woven, into a shape prior to manufacture of a composite, e.g. by matrix infiltration.

- 1 A pre-shaped fibrous reinforcement formed by distribution of chopped fibres by air, water flotation, or vacuum over the surface of a perforated screen to the approximate contour and thickness desired in the finished part
- 2 A pre-shaped fibrous reinforcement of mat or cloth formed to the desired shape on a mandrel or mock-up before being placed in a mould press

PRE-LAUNCH

Verification phase with the objective to verify that the flight article is properly configured for launch and, to the extent practical, it is capable to function as planned for launch. In the mean time, the Ground Support Equipment readiness to support launch is verified, Ref.[1]

PREPREG

Abbreviation of 'pre-impregnated'; a woven or unidirectional ply or roving impregnated with a resin, usually advanced to B-stage, ready for lay-up or winding, Ref. [10]. [See also: B-STAGE, TAPE]

prEN

Provisional or draft EN standard

PRESS CLAVING

A process method for thermoplastic-based composites; a thermoforming technique

PRESS MOULDING

A process for manufacturing composite materials

PRESSURE INFILTRATION CASTING

Types of melt infiltration techniques for MMC production conducted in a pressure vessel

PRESSURE LEVELS

Three pressure levels determine the design of a pressure vessel:

- 1 MEOP: The maximum expected operational pressure level during the lifetime of the vessel
- 2 Proof Level: The pressure level which has to be proven for acceptance of a case. This level is normally higher than the MEOP level. The distance between these two levels is dependent on the application. For low- or medium-pressure application the difference is about 5%; for high-pressure application, a difference of 50% is normally requested. At proof level, no failures that influence the behaviour of the case during its lifetime are allowed
- 3 Burst Level: Requested minimum value before failure of the structure, with requested reliability. The difference between this and MEOP is about 25% for low- or medium-pressure application and about 100% for high-pressure application

Note: For vessels with a load-carrying metallic liner, a fourth pressure level has to be taken into account. It is then required that the yield strength of the liner be reached at a pressure level significantly higher than the proof level (about 75% higher than the MEOP) for higher-pressure application

PRESSURE VESSEL

A pressurised container which:

- 1 contains stored energy of 19310 joules (14240 foot-pounds) or more, the amount being based on the adiabatic expansion of a perfect gas, or
- 2 contains a gas or liquid which will create a hazard if released, or
- 3 experiences a design limit pressure greater than 0.69 MPa (100 psi)

PRESSURE-BAG MOULDING

A process for moulding reinforced plastics, in which a tailored flexible bag is placed over the contact lay-up on the mould, sealed, and clamped in place. Fluid pressure, usually compressed air, is exerted on the bag, and the part is cured

PRIMER

A coating applied to a surface before the application of an adhesive, lacquer, paint, enamel or the like to improve the performance of the bond

PRINCIPAL DIRECTION

Orientation of the specific co-ordinate axes when stress and strain components reach maximum and minimum for the normal components, and zero for the shear

PROCESS

Set of inter-related resources and activities which transforms a material or semi-finished product into a semi-finished product or final product, Ref. [6]

PROCESS VALIDATION

[See: VALIDATION OF PROCESSES]

PROOF STRESS (PS)

Stress at which permanent (non-elastic) deformation occurs in a material. Normally expressed as the stress required to produce a certain amount of permanent deformation, e.g. 0.2% proof stress, the stress to produce 0.2% permanent deformation

PROOF TEST

The test of a flight structure at a proof load or pressure that gives evidence of satisfactory workmanship and material quality or establishes the initial crack sizes in the structure, Ref. [5]

PROTECTION SYSTEM

A number of materials applied, often to components, designed to resist the operational environment, e.g. aluminising of superalloys or glassy layers on carbon-carbon composites

PROTOFLIGHT MODEL

The flight end item on which a partial or complete protoflight qualification test campaign is performed before flight, Ref.[1]

PROTOFLIGHT PHILOSOPHY

Model philosophy based on a single model (Protoflight Model) to be flown after it has been subjected to a protoflight qualification and acceptance test campaign. Typical philosophy for projects with no technology-critical design and compromise permitted to reduce cost, accepting a medium risk, Ref.[1]. [See also: PROTOFLIGHT MODEL]

PROTOTYPE PHILOSOPHY

Model philosophy making an extensive use of physical models to cover verification necessities. Typical for projects for which all affordable measures are taken to achieve minimum risk, Ref.[1]

PRR

Preliminary Requirement Review

PRT

Placement of Relaxed Fibre Technique

PS

1 Polysulfone; a high-temperature-resistant thermoplastic polymer. [See also: THERMOPLASTIC]

2 Poe and Sova; a fracture model

psi

Pounds per square inch

PSI

Polysiloxane-etherimide; a polymer

PSI/PAI

A molecular composite comprising of both polysiloxane-etherimide and polyamide-imide polymers, [See: MOLECULAR COMPOSITE]

PSS

Procedures, specifications and standards; previous ESA documentation classification system under going transfer to ECSS

PTC

Passive Thermal Control

PTFE

Polytetrafluoroethylene

PTR

Post Test Review

PULTRUSION

Reversed extrusion of resin-impregnated roving in the manufacture of rods, tubes and structural shapes of a permanent cross section. After passing through the resin dip-tank, the roving is drawn through a die to form the desired cross section

PVA

Polyvinyl acetate

PVC

Polyvinylchloride

PVD

Physical vapour deposition

PVDF or PVdF

Polyvinylidene fluoride. A piezoelectric polymer material used in smart technologies and sensors

PVS

Procedure Variation Sheet

PWG

Pipes, Wetherhold and Gillespie; a fracture model

PYROELECTRICITY

Development of electrical polarisation in special classes of crystals that are subjected to a temperature change

PYROLYSED, PYROLYSATION

[See: PYROLYSIS]

PYROLYSIS

A high-temperature processing method often used to convert a precursor infiltrated liquid (carbon-rich) to a composite matrix phase, e.g. carbon. Note: The process is often repeated after subsequent infiltrations, [See also: IN-SITU SILICONISING]

PZT

Lead-zirconate-titanate. A piezoceramic material

Q

QA

Quality assurance

QCM

Quartz crystal microbalance

QM

Qualification model

QNDE

Quantitative non-destructive evaluation

QPL

Qualified parts list

QR

Qualification review

QRR

Qualification review report

QUALIFICATION

Verification phase with the objective to demonstrate that the design meets the applicable requirements including proper margins, Ref.[1]

QUALIFICATION ANALYSIS

This is performed where it is required to demonstrate that, Ref.[1]:

- the as-designed system implements features that are additional to the system functions, performances and interfaces, and
- system architectural features and operational interactions on ground and in-orbit are to be implemented

QUALIFICATION MARGIN

An increase in the environmental range used for qualification testing in order to, Ref.[1]:

- avoid qualification test levels that are less severe than the flight ones,
- accommodate differences among qualification and flight units due to variations in parts, materials, processes, manufacturing and degradation during usage, and
- assure against fatigue failures due to repeated testing and operational use, e.g. acceptance and flight

QUALIFICATION MODEL

Physical model fully reflecting the flight end item design in all aspects, used for full level functional and environmental qualification tests, Ref.[1]

QUARTZ

Silica; silicon dioxide

QUARTZ CRYSTAL MICROBALANCE (QCM)

A device for measuring small quantities of mass deposited on a quartz crystal using the properties of a crystal oscillator, Ref. [8]

QUASI-ISOTROPIC LAMINATE

A laminate approximating isotropy by orientation of plies in several or more directions

R**R**

The ratio of the minimum stress to maximum stress, Ref. [5]

R - CURVE

Graphical representation of fracture energy against crack length

RACK

Structure where different experiments will take place during a manned mission, Ref. [7]

RAM

The direction of spacecraft motion

RAMJET

A type of combustion engine requiring no turbine parts. High velocity air entering the engine is used to pressurise the fuel and air combustion mixture, [See also: SCRAMJET]

RAMP-UP

Cure cycle: the increase of temperature to the process temperature

RANKING

Ordering of laminates by strength, stiffness or other properties

RAPIDLY SOLIDIFIED POWDER (RSP)

Powder metallurgy technique involving very fast cooling for producing highly alloyed (supersaturated) powder or very fine grain structures

RARE EARTH METAL

Group of chemical elements with atomic numbers 58 to 71, e.g. cerium, erbium. Used in alloying, or as thin films

RCC

Reinforced Carbon-Carbon (NASA) replaced by ACC

RCG

Reaction Cured Glass

RCS

Reaction Control System

REACTION BONDING

A manufacturing process similar in principle to sintering for ceramic or MMC production, where a gas or reactive elemental powder is used to chemically bond the constituents, e.g. nitrogen gas for silicon nitride production

RECOVERED MASS LOSS (RML)

The total mass loss of the specimen itself without the absorbed water ($RML = TML - WVR$). Note: The RML is introduced because water is not always seen as a critical contaminant in spacecraft materials, Ref. [8]

RECRYSTALLISATION

Heat treatment of metal alloys; heating to a temperature where a new, strain free, crystal structure develops, removing any previous strain-hardening of the material. Strength decreases and ductility increases. Heating above the recrystallisation temperature leads to a progressive increase in grain size

REFRACTORY FIBRES

Reinforcement fibres made of boron, silicon carbide and alumina; used for metal and ceramic matrix composites

REFRACTORY METAL

Group of metal or alloys, including W, Re, Ta and Mo, which possess high-temperature stability, e.g. high melting point although some have poor oxidation resistance at high temperatures

REI

Rigid External Insulation

REINFORCED PLASTIC

A plastic with strength properties greatly superior to those of the base resin, resulting from the presence of reinforcements embedded in the composition

REINFORCEMENT

A strong inert material bonded into a plastic, metal or ceramic to improve its strength, stiffness and impact resistance. Reinforcements are usually long fibres of glass, boron, graphite or aramid, in woven or non woven form. To be effective, the reinforcing material must form a strong adhesive bond with the matrix

Note: 'Reinforcement' is not synonymous with 'filler'

RELATIVE DIELECTRIC CONSTANT (ϵ)

A measure of the electrical properties of a material; varies for different polymer resins, [See also: DIELECTRIC]

RELATIVE HUMIDITY (RH)

A measure of the moisture content of an atmosphere with respect to the fully saturated atmosphere at the same temperature and pressure; expressed as a percentage

RELAXATION

A change in shape resulting from exposure to continuous loading or temperature

RELEASE AGENT

A material which is applied in a thin film to the surface of a mould to keep the resin from bonding to it

RELEASE FILM

A thin sheet of material applied to a composite surface to enable its removal from a mould; used in autoclave processing

REPAIR

Operations performed on a non-conforming item to place it in usable and acceptable condition according to an authorised repair procedure/standard. Repair is distinguished from rework.

Note: Repair can consist of a component change with all its associated connections including the fixing down of a lifted pad or track

REQUEST FOR APPROVAL (RFA)

Document with which the supplier or user asks the competent body for permission to use a critical material, part or process, Ref. [6]

REQUIREMENT

Within this handbook: a property of a material or a function of a component or structure that is defined as a result of the application within a particular service environment or mission, e.g. mechanical loads, temperature, dimensional stability, galvanic corrosion

REQUIREMENT CATEGORY

A requirement category identifies a homogeneous set of requirements for which is possible to define a common verification strategy, Ref.[1]

RESIDUAL FATIGUE STRENGTH

The retention of static strength by a laminate that has been subjected to a certain fatigue-load history

RESIDUAL STRAIN

Coatings: a strain which remains locked into a material after processing. Further loading can result in coating fracture

RESIDUAL STRENGTH

The retention of static strength by a laminate that has been subjected to a load history or environment

RESIDUAL STRESS

- 1 A stress that remains in the material or structure, owing to processing, fabrication or prior loading
- 2 Composites: Resulting from cool-down after cure and change in moisture content. On the micromechanical level, stress is tensile in the resin and compressive in the fibre.
On the macro-mechanical level, it is tensile in the transverse direction to the unidirectional fibres, and compressive in the longitudinal direction, resulting in a lowered first-ply-failure load. Moisture absorption offsets this detrimental thermal effect at both micro and macro levels
- 3 Metals: Usually arises from heat treatment or mechanical working

RESIN

A solid, semi-solid, or pseudo-solid organic material which has an indefinite (often high) molecular weight, exhibits a tendency to flow when subjected to stress, usually has a softening or melting range, and usually fractures conchoidally. Most resins are polymers. In reinforced plastics, the material used to bind together the reinforcement material, the matrix. [See also: POLYMER]

RESIN CONTENT

The amount of resin in a laminate expressed as a percent of total weight or total volume

RESIN FLOW

A measure of the amount of resin exuded from the prepreg during cure processing. Resin flow is a measure of the transient reduction in viscosity that takes place in thermosetting systems as the temperature is increased, prior to gelling. Resin flow has an important effect on the production process and varies widely from system to system

RESIN TRANSFER MOULDING (RTM)

A technique for infiltrating a fibre preform, held in a mould, with a range of thermosetting resins. Infiltration can be pressure and/or vacuum assisted. Resin cure can be achieved quickly. Uses: production technique for large batch polymer (thermoset) composites. Preliminary process method usually for thick-section C and SiC matrix composites

RESIN-RICH AREA

Where local resin content is higher than the average of a laminate owing to improper compaction or curing. It can be detrimental because any resin-rich area can mean a resin-starved area somewhere else

RESIN-STARVED AREA

Where local resin content is lower than the average. It has a dry appearance where the setting of filaments or fabric is not complete. It is probably more detrimental than the resin-rich area

REVERSE HELICAL WINDING

In filament winding, as the fibre-delivery arm traverses one circuit, a continuous helix is laid down, reversing direction at the polar ends; contrasted to biaxial, compact, or sequential winding in that the fibres cross each other at definite equators, the number depending on the helix. The minimum cross-over would be three

REVIEW OF DESIGN PROCEDURE

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

REVIEW OF DESIGN REPORT

This document describes each verification activity performed reviewing documentation during program design reviews and contains proper evidence that the relevant requirements are satisfied, Ref.[1]

REVIEW OF DESIGN

A verification method using validation of previous records or evidence of validated design documents, when approved design reports, technical descriptions, engineering drawings, etc., unambiguously show that the requirement is met, Ref.[1]

Note: In US standard: Review of Design = Validation of Records

REWORK

Reprocessing of a non-conforming item to make it conform to drawing, specification or contract

RF

Radio frequency

R.F.

Reserve factor

RFA

Request for approval

RFCP

Reduced Fracture-control Programme

RFW

Request for waiver

R-GLASS

A high-strength grade of glass fibre, [See also: GLASS FIBRE]

RH

Relative humidity

RHENIUM (Re)

Refractory metallic element, melting point 3186°C, density 21020 kg m⁻³. Uses: alloying additions, coatings

RIG

A fixture or tool that retains a material, sample or structure, e.g. for testing and processing; also known as 'jig'

RIGGING LINE

Any cord or tape attached to a parachute canopy that transmits the forces on the canopy to the suspended load via lift webs or strops

RIM

Resin injection moulding

RLV

Re-useable launch vehicle

RML

Recovered mass loss

RMS

Root mean square

ROC

Receiver operating characteristic; an ultrasonic testing calibration procedure

ROD

Review of design

ROSETTA

ESA comet rendezvous mission

ROTATING MACHINERY

Any rotating mechanical assembly that has a kinetic energy of 19 300 joules or more, the amount being based on $0.5 I\omega^2$, where I is the moment of inertia (kg.m^2) and ω is the angular velocity (rad/s), Ref. [5]

ROVING

For technical textiles: a number of yarns, strands, tows collected into a parallel bundle with little or no twist. Roving can be impregnated for use in filament winding, in braiding, and in unidirectional tapes

ROUND ROBIN

An evaluation process whereby the same subject of interest is assessed using the same principles by several different organisations; often used for material evaluation tests to provide a measure of the variability to be expected within the results

RSBN

Reaction bonded silicon nitride. [See also: REACTION BONDING]

RSI

Reusable surface insulation (Shuttle Orbiter)

RT

Room temperature

RTM

Resin transfer moulding

RTV

Room-temperature vulcanising, e.g. silicone adhesives

RULE OF MIXTURES

Linear volume fraction relation between the composite and the corresponding constituent properties; also known as 'Law of Mixtures'

e.g. For modulus of a composite E_c , the rule of mixtures equation is:

$$E_c = E_f V_f + E_m V_m$$

where:

E_f = modulus of the fibre; V_f = volume fraction of fibre in the composite; E_m = modulus of the matrix; V_m = volume fraction of the matrix

RUS

Resonant ultrasound spectroscopy

S

SACMA

Suppliers of Advanced Composite Materials Association, USA

SADM

Solar array drive mechanism

SAE

Society of Automotive Engineers, USA

SAFE LIFE

- 1 A fracture-control acceptability category which requires that the largest undetected crack that can exist in the part will not grow to failure when subjected to the cyclic and sustained loads and environments encountered in the service life, Ref. [5]
- 2 A potentially fracture critical item (PFCI) is a safe-life item if it can be shown that the largest defect in the part will not grow to an extent where the minimum specified performance (e.g. limit load capability or no leak) is no longer assured within a safe life interval. [See: PFCI]

SAFETY FACTOR

[See: FACTOR OF SAFETY, LOADS]

SAFFIL LD and HD

Proprietary types of alumina fibre; LD: low density, HD: high density

SAM

Scanning acoustic microscope; an ultrasonic materials evaluation technique

SANDWICH

- 1 Construction: An assembly 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, Ref.[9], [See also: FACE SHEET]
- 2 Panel: A sandwich construction of a specified dimensions.
Note: The honeycomb and face skins can be made of composite material or metal alloy.

SÄNGER

German-designed, two-stage, reusable launch vehicle technology programme

SAR

Synthetic aperture radar

SAS

Solar Array System

SASW

Spectral Analysis of Surface Waves

SATELLITE

An unmanned spacecraft generally oriented to scientific, telecommunication, earth observation missions, Ref.[1]

SATIN

A type of weave for a fabric, [See: SATIN WEAVE; SATIN 8 WEAVE]

SATIN WEAVE

Each warp end and weft pick floats over N and under one crossing thread. The weave is described by (N+1), e.g. an 8 harness (8 shaft) satin SATIN 8 in which the weft pick passes over 7 and under one warp end

SATIN 8 WEAVE

A type of fabric weave, 8 harness (8 shaft) satin in which the weft pick passes over 7 and under one warp end

SAW

Surface Acoustic Wave

SAXS

Small angle X-ray scattering

SBSS

Short beam shear strength; a test method

SCARF JOINT

[See: JOINT]

SCC

Stress Corrosion Cracking

SCEF

Stress Corrosion Evaluation Form

SCISSION

The breaking of molecular chains; a degradation effect of polymer resins exposed to penetrating radiation (alpha and beta particles)

SCRAMJET

Supersonic combustion ramjet. A type of combustion engine requiring no turbine parts. High velocity air entering the engine is used to pressurise the fuel/air combustion mixture. Differs from a RAMJET in that combustion takes place at supersonic air velocities through the engine

SDI

Strategic defense initiative. American space defence programme

SDR

System Design Review

SEAM

For technical textiles: a series of stitches or different stitch types, applied to one or more thicknesses of textile, normally a fabric, in order to join them together

SECANT MODULUS

Idealised Young's modulus derived from a secant drawn between the origin and any point on a non-linear stress/strain curve.

Tangent modulus is the other idealised Young's modulus derived from the tangent to the stress/strain curve

SECONDARY BONDING

A process whereby manufactured component parts are joined by an adhesive; can be applied to composite parts that have already been cured or metal parts or combinations thereof. Note: This is different from co-curing, [See also: CO-CURING]

SELF-DESTRUCT

Temperature and moisture level that will cause failure without externally applied stress

SELF-SIMILAR DAMAGE GROWTH

The propagation of a crack through both reinforcement and matrix within a composite, usually caused by excessive bonding between fibre and matrix, resulting in no crack stopping, or crack deviation at the interface. Also known as single crack failures. Applicable to MMC and CMC materials

SEM

Scanning electron microscope

SENB

Single-edged notched beam test specimen, used to generate 'R' curves - fracture energy against crack length

SEP

French company: Société Européenne de Propulsion

SEPCORE®

A thermal protection system (TPS) heat shield concept from SEP comprising of an ablative layer on a C-SiC structure which protects fibrous insulation.

SERIOUS CONSEQUENCE

A potential risk situation that can result in:

- temporarily disabling but not life-threatening injury, or temporary occupational illness;
- loss of, or major damage to, flight systems, major flight system elements or ground facilities;
- loss of, or major damage to, public or private property; or
- long-term detrimental environmental effects

SERR

Strain energy release rate

SERVICE CONDITIONS

The combination of mechanical loading and environmental effects experienced by a material, component or structure in operation over its intended life

SERVICE LIFE

The interval beginning with an item's inspection after manufacture and ending with completion of its specified life, Ref. [5]

SES

Suit enclosure subsystem; part of an extra-vehicular activity space suit

SEVIRI

Spinning enhanced visible and infra red imager instrument

S-GLASS

A magnesia-alumina-silicate glass, especially designed to provide filaments with very high tensile strength

SHAKEDOWN STRESS

Term used in tensile testing of MMC materials where a small irrecoverable deformation occurs at low strains, or during the first few load cycles, at a threshold stress

SHAPE MEMORY ALLOY (SMA)

A metal alloy which, after mechanical deformation in a particular temperature range, will regain its original shape after heating or cooling through a specific temperature. These alloys are used in actuators and in some latching and joining devices

Note: The trigger temperature is alloy dependent

SHAPE MEMORY EFFECT (SME)

A reversible shape change in certain metal alloys arising from a transformation to and from a martensitic structure. Mechanical deformation in the working temperature range for the alloy gives rise to regions of martensite within the crystal structure which, having a different volume, accommodate the shape change. Subsequent heating reverses this effect and so returns the material to its original shape

SHEAR LAG MODEL

Mathematical model derived to describe behaviour of anisotropic materials, best suited to aligned, short-fibre composites

SHEAR MODULUS RATIO

Ratio of the shear modulus of the core material to that of the face material in a sandwich construction

SHEET MOULDING COMPOUND (SMC)

Manufacturing technique using short fibre-reinforced composites

SHEET

Prepreg of any width, supplied as flat sheet in the form of cut lengths. (Specific definition for 'composites')

SHELF LIFE

- 1 The stated time period in which the manufacturer guarantees the properties or characteristics of a product for the stated storage conditions, Ref. [10].
- 2 Prepreg: The period of time during which a prepreg retains the specified flow, tack and cure characteristics when stored under specified conditions. Most prepreps require refrigerated storage in order to achieve useful shelf lives

SHM

Structural health monitoring

SHMS

Structural health monitoring system

SHOP LIFE

The shop life of a prepreg is that period following removal from the specified storage conditions and attaining shop-floor temperature for which the prepreg remains workable in terms of tack, and flow and cure characteristics

SHORT-TRANSVERSE (S-T) DIRECTION

Equivalent to the through-the-thickness direction of sheet or plate material. For anisotropic materials the short-transverse direction general shows the poorest mechanical properties

SHRINKAGE

Contraction of a moulded part during and after cure. Parts can meet dimensional tolerance if the dimensional changes due to temperature of the part and the mould are properly considered

SI

The international system of units, published by the International Standards Organisation (ISO)

SIALON

Fine-grained non-porous silicon nitride ceramic with a small amount of added aluminium oxide. Approximate properties: Density 3240 kg m⁻³, Elastic modulus 288 GPa, Flexural strength 760 MPa, Fracture toughness K_{IC} 6.0 MPa m^{1/2} to 7.5 MPa m^{1/2}, Thermal conductivity 15 W/m °K to 20 W/m °K, Maximum use temperature (no load) 1200°C

SIAT

Semi-Integrated Aeroshell TPS - Co-operative programme between Dassault-Aviation and DASA/Dornier, covered the activities from 1994 to 1996 on the design of future Mars landing probe aeroshell and thermal protection concepts

SiC

Silicon carbide

SiCf

Silicon carbide fibre reinforcement

SiCp

Silicon carbide particulate reinforcement

SiC-SiC

Silicon carbide fibre-reinforced silicon carbide; a ceramic matrix composite

SiC/Ti

Silicon carbide reinforced titanium

SILEX

Semiconductor laser inter-satellite link experiment

SILICA

Silicon dioxide (SiO₂)

SILICON (Si)

Non-metallic element, melting point 1414°C, density 2330 kg m⁻³. Uses: alloying additions.
[See also: SILICON CARBIDE (SiC)]

SILICON CARBIDE (SiC)

High strength ceramic material with a density of approximately 3100 kg m⁻³. Approximate properties: Elastic modulus 410 GPa, Flexural strength 550 MPa, Compressive strength 3900 MPa, Fracture toughness K_{IC} 4.6 MPa.m^{1/2}, Thermal conductivity 120 W/m °K, Maximum use temperature (no load) 1650°C

SILVER (Ag)

Metallic element, melting point 962°C, density 10500 kg.m⁻³. Uses: alloying additions, coatings

SIMILARITY

A verification method used if it can be shown that the article is similar to another article that has already been qualified to equivalent or more stringent criteria. Note: In the European standard similarity is part of Analysis, Ref.[1]

SIMOUN

Plasma jet test facility at Aerospatiale (Aquitaine), France

SINGLE CRYSTAL (SC)

A component formed from a single alloy crystal - hence with no internal grain boundaries where high temperature damage processes such as creep, recrystallisation and precipitation are normally most active, [See also CREEP]

SINGLE YARN

For technical textiles: a yarn that can be composed of either spun, filament, monofilament or multifilament yarn

SINTERING

A consolidation technique for metal and ceramic compounds by solid phase diffusion or where a constituent has a lower melting point than the others and is molten during the processing. Note: A variant of this process is REACTION BONDING

SiO₂

Silicon oxide

SIP

Strain Isolation Pad

SIS

Support and interface subsystem; the interface between a space vehicle and an extra-vehicular activity space suit

SIZE

A material often added to fibre tow (in the case of carbon, after surface treatment). This size improves the handling characteristics of the tow and reduces filament damage during subsequent processing, e.g. weaving or prepreg manufacture. When a prepreg with an epoxy-resin matrix is to be manufactured, an epoxy-resin size containing no curing agents is usually specified. Size content with respect to the tow is frequently in the range 0.5% to 1.0% by weight. (Definition specific to 'composite')

SIZING

- 1 Applying a material on a surface in order to fill pores and thus reduce the absorption of the subsequently applied adhesive or coating.
- 2 Modifying the surface properties of the substrate to improve adhesion.
- 3 Selecting by design the ply number and angles of a laminate subjected to one or more sets of applied stresses

SLA-561

low density silicone ablator

SLAM

Scanning laser acoustic microscope; a nondestructive materials evaluation technique

SLURRY

Powdered materials suspended in a liquid phase

SLURRY INFILTRATION

Also known as colloidal infiltration or slip casting (un-reinforced ceramics). The slurry consisting of the matrix phase (final form or elemental powders), binders, solvents and wetting agent(s) is infiltrated into the reinforcement, dried and fired. Process can also incorporate

REACTION BONDING**SM**

Structural Model

SMA

[See: SHAPE MEMORY ALLOY]

SMAC

Spacecraft Maximum Allowable Concentration

SMART

In the context of this handbook: applications in space programmes where the principal requirements are for smart systems with a self inspection (or sensory) capability, with or without an inherent adaptive response

SMART STRUCTURE

A structure or mechanism with sensory and reactive elements incorporated which, when activated, will monitor or modify the structure or mechanism characteristics

SMART TECHNOLOGIES

[See: SMART]

SMC

[See: SHEET MOULDING COMPOUND]

SME

[See: SHAPE MEMORY EFFECT]

SMH

Structural materials handbook; ECSS-E-30-04

SMSA

Secondary mirror support assembly; part of the Mars Observer Camera

S-N CURVE

Stress per number of cycles to failure; a graph used to display fatigue testing results

SNELL'S LAW

When a light ray passes into a higher refractive index medium, its path is deviated toward the normal to the surface at the point of incidence, i.e. the refraction angle is less than the incidence angle. When passing into a lower refractive index medium, the refraction angle is greater than the incidence angle, Ref. [4]

SOLAR ABSORPTANCE (α_s)

The relationship between the absorptance of a test item irradiated with a solar simulator to the absorptance the test item would experience from the sun

SOLDERING

As for brazing, but where the braze (solder) has a very much lower melting temperature. Common solders are often Sn- or Pb-based alloys used for electrical and electronic connections. Note: Special solders exist for use in space

SOLELY REACTIVE SMART SYSTEM

A structure or mechanism which contains one or more devices for controlling its condition, e.g. shape, stiffness

SOLELY SENSORY SMART SYSTEM

A structure or mechanism which contains one or more devices for monitoring its condition, e.g. temperature, strain

SOL-GEL

(Silica impregnation process) A chemical solution containing the ceramic matrix phase constituents in gel form. In sol-gel processing, the gel is infiltrated into the reinforcement, dried and subsequently fired to produce the composite matrix phase

SPA

Surface Protected Ablator

SPACECRAFT

A space system which could be either manned or unmanned and could have any type of mission objectives, i.e. telecommunications, transportation, earth observation, interplanetary exploration, Ref.[1]

SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATION (SMAC)

The maximum concentration of a volatile offgassed product that is allowed in the spacecraft atmosphere for a specified flight duration, Ref. [7]

SPACE-PROVEN MATERIAL OR MECHANICAL PART

One whose properties are well understood and that is produced by means of a stable process, usually confirmed by a history of continuous or frequent production runs. It must be compliant with a recognised set of specifications. It will have been used in space applications, or will have successfully completed an appropriate evaluation process

SPALL

- 1 The loss of a material or some part of that material, e.g. as the result of impact
- 2 The loss of a material or substance from a substrate; often as a result of thermal cycling, e.g. coatings

SPAS

Shuttle palette satellite

SPATE

Stress pattern analysis by thermoelastic emission; a nondestructive testing technique

SPECIAL NONDESTRUCTIVE INSPECTION

[See: NONDESTRUCTIVE]

SPECIAL PROCESS

A process where quality cannot be completely ensured by inspection of the end article only, Ref. [6]

SPECIFIC ENERGY ΔU

Damping: the energy dissipated per unit volume of material during one cycle of vibration at a given stress amplitude; defined in absolute terms

SPECIFIC GRAVITY (SG)

A dimensionless quantity also known as Relative Density. Ratio between the density of a material and that of water under standard conditions

SPECIFIC STIFFNESS

The measure of the stiffness of a material with respect to its density

SPECIFIC STRENGTH

The measure of the strength of a material with respect to its density

SPELDA

Structure Porteuse pour Lancement Double Ariane

SPF

Superplastic forming

SPF/DB

Superplastic forming/Diffusion bonding; the combined metal sheet forming and joining process with particular relevance to titanium alloys

SPLAT COOLING

Very high cooling rate process for producing metal powders. The alloy is melted and liquid droplets are sprayed or dropped onto a chilled surface with high thermal conductivity, e.g. a internally water-cooled copper wheel. The resultant splat particulate is removed from the rotating wheel to allow subsequent droplets to contact the bare, chilled surface

SPLIT MOULD

A mould in which the cavity is formed of two or more components known as splits, held together by an outer case

SPRAY-UP

Techniques with a spray gun as the processing tool. In reinforced plastics, for example, glass fibre and resin can be simultaneously deposited in a mould. In essence, roving is fed through a chopper, ejected into a resin stream, and is directed at the mould by either of two spray systems

SPRINGBACK

Shape distortion of sheet metal after forming resulting from the recovery and equalisation of elastic deformation strain

SPUN YARN

For technical textiles: a number of discontinuous fibres held together by twist

SQUARE

A type of weave for a fabric, [See: SQUARE WEAVE]

SQUARE WEAVE

A type of fabric in which each warp and weft thread passes over one end (or pick) and under the next; also known as 'Plain' weave

SQUEEZE CASTING

Melt infiltration technique for MMC production using high pressures. Other variants have been developed to reduce damage to reinforcements during processing

SRD

System Requirement Document

SRM

Solid rocket motor

SRR

System Requirement Review

SSM

Second surface mirror

SSME

Space shuttle main engine

S/S

Subsystem

SST

Supersonic wind tunnel

SSTO

Single stage to orbit

STACKING ORDER or SEQUENCE

Ply ordering in a laminate. Stacking sequence does not affect the in-plane properties of a symmetric laminate. Only the ply number and angles are important. But stacking sequence becomes critical for the flexural properties, and the interlaminar stresses for any laminate, symmetric or not; also known as 'lay-up'

STAGNATION POINT

The point where an impinging gas flow separates around an object

STAINLESS STEEL

A range of metal alloys containing at least 11% to 12% of chromium, a low percentage of carbon, and often some other elements, notably nickel and molybdenum

STAMP

Study on Technology of Aerobraking for Mars Penetrators

STANDARD NON DESTRUCTIVE INSPECTION

[See: NONDESTRUCTIVE]

STANDARD OR ESTABLISHED PROCESS

One that is well documented, has a previous history of use, is well understood and for which standard inspection procedures exist. Such a process would generally be covered by ESA specifications or other international or national documents

STARVED AREA

An area in a plastic part which has an insufficient resin to wet out the reinforcement completely. This condition can be due to improper wetting or impregnation or excessive moulding pressure

STARVED JOINT

An adhesive joint which has been deprived of the proper film thickness of adhesive, owing to insufficient adhesive spreading or application of excessive pressure during lamination

STATIC FATIGUE

Failure of a part under continued static load; analogous to creep-rupture failure in metal testing, but often the result of ageing accelerated by stress

STATIC LOAD (STRESS)

A load (stress) of constant magnitude and direction with respect to the structure, Ref. [5]

STE

Special Test Equipment

STICKING COEFFICIENT

The probability that a molecule, colliding with a surface, stays on that surface before thermal re-evaporation of that molecule occurs, Ref. [8]

STIFFNESS

Ratio between the applied stress and the resulting strain. Young's modulus is the stiffness of a material subjected to uniaxial stress; shear modulus to shear stress. For composite materials, stiffness and other properties are dependent on the orientation of the material. [See: MODULUS]

STM

Structural Thermal Model

STOICHIOMETRIC

Chemical composition with fixed atomic ratios of constituent elements

STORAGE LIFE

The length of time that a material can be kept under predetermined conditions and not degrade, e.g. Prepreg: usually -18°C for thermosetting resin systems, with subsequent factory floor operations at room temperature, [See also: SHELF LIFE]

STRAIN GAUGE

Widely used device for point measurement of strain. Usually thin film metals which, when strained, change in electrical resistance.

Note: Require calibration and temperature compensation

STRAIN RELAXATION

[See: CREEP]

STRAIN TO FAILURE

Total strain experienced by a material before catastrophic failure

STRAND

For technical textiles: usually an untwisted bundle of continuous filaments used as a unit. Occasionally a single fibre or filament is referred to as a strand

STRENGTH PARAMETER

Strength coefficient of a quadratic failure criterion in stress or strain space

STRENGTH RATIO or STRENGTH/STRESS RATIO

Measure related to MARGIN OF SAFETY. Failure occurs when the ratio is unity; safety is assured for example by a factor of 2 if the ratio is 2. The ratio is particularly easy to obtain if the quadratic failure criterion is used

STRENGTH

Maximum stress that a material can sustain. Like the stiffness of a composite material, this is highly dependent on the direction as well as the sign of the applied stress; e.g. axial tensile, transverse compressive, and others

STRESS AMPLITUDE (R)

Fatigue test: the range of stresses induced in a laminate when a cyclic load is applied, [See also: R]

STRESS CONCENTRATION

A localised increase in the stress within a material, component or structure compared with the average stress. These occur as a result of the presence of a design feature or defect, e.g. hole, cut-out or notch, crack, delamination:

- 1 Micromechanical level: Concentration occurs at the fibre/matrix interface
- 2 Macro-mechanical level: Concentration occurs at, e.g. holes, notches; ply termination or drop-off points, joints, defects

STRESS CONCENTRATION FACTOR

The ratio of the maximum stress in the region of a stress concentrator to the stress in a similar strained area without a stress concentrator

STRESS CORROSION

the combined action of sustained tensile stress and corrosion that can lead to the premature failure of materials

STRESS-CORROSION CRACKING (SCC)

The initiation and/or propagation of cracks, owing to the combined action of applied sustained stresses, material properties and aggressive environmental effects, Ref. [5]. Usually experienced by metal alloys as pit formation or intergranular attack in aqueous solutions.
Note: Composites and plastics can also suffer from stress corrosion cracking

STRESS CRACK

External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength. The stresses which cause cracking can be present internally or externally or can be combinations of these stresses, [See also: CRAZING]

STRESS CRACKING

The formation of cracks owing to the combined effects of an aggressive environment and internal or external stresses in a polymer; can result in a rapid failure

STRESS INTENSITY FACTOR (K)

A calculated quantity that is used in fracture mechanics analyses as a measure of the stress-field intensity near the tip of an idealised crack. Calculated for a specific crack size, applied stress level and part geometry. [See: CRITICAL STRESS-INTENSITY FACTOR; FRACTURE TOUGHNESS], Ref. [5]

STRESS RELAXATION

The decrease in stress under sustained constant strain, also called stress decay

STRESS

Intensity of forces within a body. The normal components induce length or volume change; the shear component, shape change. The numerical value of each component changes as the reference co-ordinate system rotates. For every stress state there exists a principal direction, a unique direction when the normal components reach maximum and minimum, and the shear component vanishes

STRESS-STRAIN CURVE

A graphical representation of a material's response to increasing load. Often used to depict relationships between stress(load) and strain (elongation), e.g. stiffness, strength(s)and strain to failure

STRESS-STRAIN RELATION

A linear relation is usually assumed for calculating stress from strain, or strain from stress. For multidirectional laminates, it can be generalised to include in-plane stress-strain, and flexural stress-strain relations. All anisotropic relations are simple extensions of the isotropic relation

STRUCTURAL COMPONENT

A major section of the structure (e.g. wing, body, fin, horizontal stabiliser) that can be tested as a complete unit to qualify the structure

STRUCTURAL FAILURE

[See: FAILURE (STRUCTURAL)]

STRUCTURAL HEALTH MONITORING

For smart technologies: a diagnostic system which can provide data on the integrity or functioning of structures or structural components, normally continually

STRUCTURAL MODEL

Physical model fully representative of the flight end item in all mechanical aspects, used for qualification of the structural design and for mathematical models correlation, Ref.[1]

STRUCTURAL SUBCOMPONENT

A major three-dimensional structure that can provide complete structural representation of a section of the full structure (e.g. stub-box, section of spar, wing panel, wing rib, body panel or frames)

STRUCTURAL-THERMAL MODEL

Physical model combining the Structural Model and Thermal Model objectives, Ref.[1]. [See also: STRUCTURAL MODEL and THERMAL MODEL]

STRUCTURE

All items and assemblies designed to sustain loads or pressures, provide stiffness and stability, or provide support or containment

STS

Space Transportation System (US Space Shuttle)

SUBASSEMBLY

A subdivision of an assembly consisting of two or more items

Note: Verification level typical of US standard, Ref.[1]

SUBGRAIN

A term used to describe phases within a microstructural grain of a material, usually metal or ceramic, often caused by dislocations or the presence of reinforcement

SUBSYSTEM

1 A functional subdivision of a payload consisting of two or more items

2 A set of functionally related equipment, connected to each other, that performs a single category of functions, e.g. structure, power, attitude control, thermal control, Ref.[1]

SUITCASE

Physical model designed to simulate functional performance both in terms of data handling (telecommand and telemetry as formats, bit rates, packet type, etc.) and radio frequency, Ref.[1]

SUPERALLOY

A series of alloys with very high operational temperatures with respect to their melting point, e.g. 0.9 Tm. The three groups are Nickel-based, Cobalt-based and Iron-based.

SUPERPLASTIC FORMING (SPF)

Manufacturing method using materials with superplastic characteristics. Normally a slow process owing to the low strain rates used. Applied to aluminium and titanium alloys and often combined with diffusion bonding to produce 'finished' components

SUPERPLASTICITY

The ability of heat softened material to undergo very large plastic deformation, e.g. in excess of several 100%, without fracture

SURFACE TREATMENT

A material applied to fibres during the forming operation or in subsequent processes. [See: SIZE, FINISH or FIBRE SURFACE TREATMENT]

SVF

Software Validation Facility

SVM

Service Module

S/W

Software

SWARF

Waste material, usually metallic, produced during machining processes

SWELLING

Increase in volume due to rise in temperature or absorption of moisture

1 Laminates: a change of dimension owing to the absorption of moisture, usually by the matrix

SWF

Stress wave factor

SWRI

South West Research Institute, USA; standards

SXT

Soft X-ray telescope

SYLDA

Système de Lanceur Double Ariane 5 (Ariane 5 double launch system)

SYMMETRIC LAMINATE

Possessing mid-plane symmetry. This is the most common construction, because the curing stresses are also symmetric. The laminate does not twist when the temperature and moisture content change. An unsymmetrical laminate on the other hand twists on cooling down and untwists after absorbing moisture

SYSTEM

The composite of elements, skills and techniques capable of performing the operational roles. A system includes all operational equipment, related facilities, materials, software, services and personnel required for its operation, e.g. launch system, on-orbit system, Ref.[1]

T

T

Toxic hazard index

TAB

A material, usually fixed to each end of a test specimen, which enables load to be transferred to the test specimen without causing damage to the test specimen; composite test specimens often have light-alloy or glass-fibre based composite tabs adhesively bonded to the test specimen

TACK

Stickiness of a prepreg or film adhesive; an important handling characteristic

TAFA

Thermal acoustic fatigue apparatus. A test facility at NASA Langley, USA

TANGENT MODULUS

Idealised Young's modulus derived from the tangent drawn at the origin or any point on a non linear stress-strain curve. Secant modulus is the other idealised Young's modulus between the origin and same point on the stress-strain curve

TANGENTIAL STRESS

The normal stress along the tangent of the opening

TANTALUM (Ta)

Refractory metallic element, melting point 3020°C, density 16650 kg m⁻³. Uses: alloying additions

TAPE

- 1 Unidirectional prepreg of a continuous length including tape splices in the fibre direction (whose position must be indicated by the tape supplier) and of any width, supplied on a reel, [See also: PREPREG]
- 2 Fabric: widths less than 150 mm

TAPE-LAYING

A process whereby a tape of material is layed-up to form a composite; often using a computer-controlled machine

TBC

Thermal barrier coating

TBE

Tetrabromoethane

TC

Thermal Control

TCL

Test Configuration List

TEAR RESISTANCE

For textiles: the ability of the fabric to resist the propagation of a cut under nominal lo-ads

TECHNOLOGY ANALYSIS

Related to the assessment of the adequacy of the selected materials, with respect to the required properties, Ref.[1]

TEM

Transmission electron microscope

TEMPER

Normally a heat-treatment or prescribed sequence of treatments used on metal alloys which determines their microstructure and properties. [See also: CONDITION]

TEMPLATE

Pattern used as a guide for cutting and laying plies

TERBIUM

Metallic element, melting point 1356°C, density 8229 kg.m⁻³, atomic number 65. Terbium-Iron alloy is a magnetostrictive material with potential for smart technologies

TEOS

Tetra-ortho-ethyl-silicate

TEST

A verification method wherein requirements are verified by measurement of performance relative to functional, electrical, mechanical and thermal parameters. These measurement can require the use of special equipment, instrumentation and simulation techniques, Ref.[1]

TEST ACCURACY

Measurement precision based on instrument characteristics.

Note: Test accuracy shall be better than related test tolerance: at least one third, Ref.[1]

TEST EFFECTIVENESS

The number of failures per spacecraft found in the test of interest divided by the total number of failures which are possible to be found in all the acceptance test campaign and during the first 45 days of flight, Ref.[1]

TEST FAILURE QUESTIONNAIRE

Form dedicated to the collection of project statistical verification information about occurred failures and to eventually feed a dedicated verification historical data base, Ref.[1]

TEST LEVEL

The environmental level utilised for testing an item. It could be qualification or acceptance test level, Ref.[1]

TEST PROCEDURE

A document which provides detailed step-by-step instructions to the Test teams for conducting the test activities in agreement with the Test Specification requirements, Ref.[1]

TEST READINESS REVIEW

The objective of this review is to declare the readiness for the test authorising the start of the test, Ref.[1]

TEST REPORT

A document which describes Test performance, results and conclusions in the light of the test requirements, Ref.[1]

TEST REQUIREMENT SPECIFICATION

This document is a system support specification applicable to all verification levels containing the general test requirements in terms of type of tests, sequences, margins, durations, tolerances, screening policy and methodology, Ref.[1]

TEST SPECIFICATION

A document prepared for each major test activity described in the Verification Plan task sheets with the objective to detail the test requirements, Ref.[1]

TEST TOLERANCE

The maximum range within which the test level can vary, Ref.[1]

TETRA

Technologien für zukünftige Raumtransportsysteme; German programme

TEX

For technical textiles: the linear density, i.e. the mass per unit length. Also known as TITER

TEXTILE

For technical textiles: these can be woven, knitted or braided, or nonwoven products, [See also: WOVEN TEXTILE and NONWOVEN TEXTILE]

TEXTURE

Metal alloys: the influence of mechanical working on the microstructure of a metal, e.g. often seen as elongated directional grain structure

TFE

Tetrafluoroethylene

TFRS

Tungsten fibre reinforced superalloy

T_g

Glass transition temperature; the temperature at which a material changes from a glassy to ductile state, giving a steep increase in free volume

THERMAL BARRIER COATING (TBC)

Ceramic coating (often modified zirconia, circa. 0.4mm thick) applied locally to component areas experiencing high thermal flux and gas wash, e.g. turbine blade edges. TBCs are usually applied over an overlay (bond coat) on the substrate

THERMAL CONDUCTIVITY

Ability of material to conduct heat; the physical constant for quantity of heat that passes through a unit cube of a substance in unit time when the difference in temperature of two faces is 1 degree

THERMAL CYCLING

The repeated change of temperature experienced by a material, component or structure; the maximum and minimum temperatures are normally those associated with orbiting the Earth

THERMAL EXPANSION

[See: COEFFICIENT OF THERMAL EXPANSION]

THERMAL LOAD (STRESS)

1 The structural load (or stress) arising from temperature gradients and differential thermal expansion between structural elements, assemblies, subassemblies or items,

Ref. [5]

2 Polymer composites: One component of the hygrothermal load. The difference between cure and operating temperatures gives rise to in-plane thermal load for symmetric laminates, and to both in-plane and flexural thermal loads for unsymmetric laminates. The presence of the flexural load causes twisting of unsymmetric laminates after cure

THERMAL MODEL

Physical model fully representative of the flight end item in all thermal aspects, used for the qualification of the Thermal Design and for mathematical models correlation, Ref.[1]

THERMAL SHOCK

Sudden and rapid change in temperature, usually over a large temperature range

THERMAL SOAK

A period of time that a material, component or structure is exposed to an elevated temperature, e.g. structures underneath thermal protection systems

THERMOCOUPLE

Device for measuring temperature consisting of two dissimilar conductors joined at their ends which, when heated, develop a characteristic EMF. The temperature is indicative of that of the junction of the pair in the thermocouple, i.e. a point measurement device.

Note: Calibration and compensation are required

THERMOFORMING

Processes that use heat and pressure to shape a composite component, e.g. applied to thermoplastic matrix composites

THERMO-MECHANICAL

An indication of the performance of a material under the combined conditions of elevated temperature and load

THERMO-MECHANICAL FATIGUE (TMF)

Mechanical and thermal cyclic loading experienced by a material or component.

Note: Thermal and loading cycles can be in or out of phase with each other

THERMO-OXIDATIVE

Combined conditions of elevated temperature and oxygen

THERMOPLASTIC

Organic material, the stiffness of which can be reversibly changed by temperature change. One unique property of this material is its large strain capability, e.g. PEEK. On the other hand, processing requires higher temperatures and pressures than those for thermosetting plastics

THERMOSETTING

Organic material that can be converted to a solid body by cross-linking, accelerated by heat, catalyst, ultraviolet light, and others. This is the most popular matrix material for composite materials. [See also: EPOXY PLASTICS]

THICKNESS OF PREPREG

Usually specified as a nominal value in the cured laminate, when the latter has been cured to a particular value (often 60%) of fibre volume fraction in the laminate. Common unidirectional carbon-fibre prepreg thicknesses are: 50µm, 100µm, 125 µm and 250µm. Fabric-based prepreps vary in thickness over the range of 50 µm to 450µm, depending on tow size and weave type. The thinner prepreps are more difficult to manufacture and require low-filament-count tow; they are therefore usually more expensive

THORIA

[See: THORIUM OXIDE]

THORIATED TUNGSTEN

Thorium oxide dispersion strengthened tungsten alloy. Used in some lamp filaments and welding electrodes

THORIUM (Th)

Metallic element, melting point 1755°C, density 11720 kg m⁻³. Uses: alloying additions

THORIUM OXIDE (ThO₂)

Also called Thoria. Ceramic oxide used as dispersed particle reinforcement and as diffusion barrier coatings

THRESHOLD STRAIN

The value of strain level, below which catastrophic failure of the composite structure does not occur in the presence of flaws or damage

THRESHOLD STRESS INTENSITY FACTOR

[See: K_{ISCC} (Stress Corrosion) or ΔK_{th} (Dynamic)]

TiAl

Titanium aluminide; an intermetallic material

TiC

Titanium carbide

TIG

Tungsten Inert Gas; a fusion welding process

TIME-OF-FLIGHT

The time taken by a propagating wave, such as light or sound, to travel a known distance through a given medium

TIN (Sn)

Metallic element, melting point 232°C, density 7310 kg m⁻³. Uses: alloying additions and soldering alloys

TiO

Titanium oxide

TITAN

Largest moon of Saturn

TITANIUM (Ti)

Metallic element, melting point 1670°C, density 4540 kg m⁻³. Uses: alloying additions, class of aluminide. Matrix alloy for composites, structural materials for aerospace uses generally where operational temperatures exceed those possible with aluminium. Manufacture of structural shapes with superplastic forming/diffusion bonding technique, [See also: SPF/DB]. Extremely difficult to cast. Sensitive to presence of hydrogen and oxygen

TITANIUM ALUMINIDE (Ti₃Al, TiAl)

Intermetallic material

TITER

For technical textiles: the linear density, i.e. the mass per unit length. Also known as TEX

T_m

Melting temperature at which the material changes from the solid state to the molten state, in °C

TM

Thermal model

TMC

Titanium matrix composite

TMF

Thermo-mechanical fatigue

TML

Total mass loss. [See also: OFFGASSING, OUTGASSING]

TORLON™

Polyamide-imide

TOTAL MASS LOSS (TML)

The total mass loss of material outgassed from a specimen that is maintained at a specific constant temperature and operating pressure for a specified time, Ref. [8]

Note: TML is calculated from the mass of the specimen as measured before and after the test and is expressed as a percentage of the initial specimen mass

TOUGHNESS

The energy required to break a material, equal to the area under the stress-strain curve

TOW

A loose, untwisted bundle of individual filaments, usually identified by fibre type (in terms of fibre tensile strength and elastic modulus) and the number of individual filaments, often in terms of thousands of filaments

TOXIC

Substances causing serious, acute or chronic effects, even death, when inhaled, swallowed or absorbed through the skin, Ref. [10]

TOXIC HAZARD INDEX (T)

The T value is determined by calculating the ratio of the projected concentration of each offgassed product to its SMAC 'Spacecraft Maximum Allowable Concentration' value and summing the ratios for all offgassed products without separation into toxicological categories, Ref. [7]

TOXICITY

[See: TOXIC]

TPS

Thermal Protection System (or Subsystem)

TRACEABILITY

The ability to trace the history, application, use and location of an item through the use of recorded identification numbers

TRAMP ELEMENT

Low level contaminant in metal alloys

TRANSITION TEMPERATURE

The temperature at which the properties of a material change. [See also: GLASS TRANSITION TEMPERATURE]

TRANSITION ZONE

Joints: the region between the parent parts in which the composition within the joint varies, e.g. between dissimilar materials in graded structures. The zone is of banded composition and often several mm thick to alleviate mechanical and thermal stress concentrations

TRANSVERSE CRACK

Matrix and interfacial failure caused by excessive tensile stress applied transversely to the fibres in a unidirectional ply of a laminate. This cracking is normally the source of the first-ply failure, [See: FIRST PLY FAILURE]

TRANSVERSE ISOTROPY

Material symmetry that possesses an isotropic plane; e.g. a unidirectional composite

TRIAXIAL FABRIC

Reinforcement fibres comprising of layers of biaxial fabrics which are 'joined' together by continuous yarns

TRR

Test Readiness Review

TsAGI

Testing facility (Russia)

TSNIIMASH

Plasmatron test facility (Russia)

TSTO

Two-stage-to-orbit

T-T

Through transmission; an ultrasonic testing process using two transducers where one is placed on each side of the material under test

TUNGSTEN (W)

Refractory metallic element, melting point 3422°C, density 19300 kg m⁻³, Uses: strength to extreme temperatures, reinforcement filaments in high temperature composites, alloying element in superalloys, tungsten carbide for tooling and high wear applications

TVBO

Thermoviscosity Theory Based on Overstress. Model for the analysis of fibre reinforced metals (MMCs)

TVT

Thermal Vacuum Test

TWARON®

Aramid fibre produced by Teijin Twaron

TWILL

A type of weave for a fabric, [See: TWILL WEAVE]

TWILL WEAVE

A type of fabric, generally 2x2 or 4x4, in which each warp end and weft pick floats over two or four crossing threads

TWIST

For technical textiles: direction and number of turns per metre

TZM

A commercial molybdenum alloy; typical composition Mo-0.02C-0.5Ti-0.1Zr

U**UD**

Unidirectional

UHM

Ultra-high modulus; a range of carbon fibres

UK

United Kingdom

ULE

Ultra low expansion (ceramic or glass material)

ULSM

Ultra lightweight scanning mirror; part of SEVRI on MSG

ULTIMATE ELONGATION

The elongation at rupture

ULTIMATE LOAD

[See: LOADS]

ULTIMATE STRENGTH

The strength corresponding to the maximum load or stress that an unflawed structure or material can withstand without incurring rupture or collapse, Ref. [5]

ULTIMATE TENSILE STRENGTH (UTS)

Highest stress sustained by a material before catastrophic failure. The ultimate or final stress sustained by a specimen in a tension test; the stress at moment of rupture

ULTIMATE TENSILE STRESS

[See: ULTIMATE TENSILE STRENGTH]

ULTRA HIGH MODULUS CARBON FIBRES (UHM)

A range of carbon fibres in which the tensile modulus exceeds 395 GPa, typically

ULTRAVIOLET (UV)

Zone of invisible radiation beyond the violet end of the spectrum of visible radiation. Since ultraviolet wavelengths are shorter than the visible, their photons have more energy, enough to initiate some chemical reactions and to degrade most plastics

UMA

Unfurlable mesh antenna; an antenna design from MBB

UNAIDED EYE

Normal Snellen 20/20 vision including eye glasses required to correct defective vision to 20/20 equivalent. Does not include microscopes, eye loupes or any other magnifying device

UNDERAGEING

A condition of a metal alloy stopping short of peak precipitation hardening

UNDERCURING

An incorrect process in which there is insufficient time or temperature to enable full and proper curing of an adhesive or resin

UNIDIRECTIONAL COMPOSITE

A composite having only parallel fibres

UNNOTCHED STRENGTH

The strength of a laminate without an opening

UNSYMMETRIC LAMINATE

A laminate without mid-plane symmetry

USA

United States of America; also denoted as US

USAF

United States Air Force

USS

Unique support structure; from Spacelab D1 mission

UTS

Ultimate Tensile Strength or Stress; [See: ULTIMATE TENSILE STRENGTH, ULTIMATE TENSILE STRESS]

UV

[See: ULTRAVIOLET]

V

VACUUM-BAG MOULDING

A process for moulding reinforced plastics, in which a sheet of flexible transparent material is placed over the lay-up on the mould and sealed. A vacuum is applied between the sheet and the lay-up. The entrapped air is mechanically worked out of the lay-up and removed by the vacuum, and the part is cured. Note: Compare with PRESSURE-BAG MOULDING

VADR

Vehicle Analysis Recording System; X-38 vehicle

VALIDATION OF PROCESSES

A set of data (and/or experiments performed) to demonstrate that a process performs as intended (technical requirements) and that sufficient confidence can be placed on the outcome (quality assurance requirements). Process validation is approved by the final contractor

VAMAS

Versailles project on advanced materials and standards

VANADIUM (V)

Metallic element, melting point 1910°C, density 6110 kg m⁻³. Uses: alloying additions

VANISHING FIBRE DIAMETER (VFD)

Model for the analysis of fibre reinforced metals (MMCs)

VARIABLE AMPLITUDE SPECTRUM

A load spectrum or history whose amplitude varies with time, Ref. [5]

VAT-1104

Plasmatron at TsAGI test facility (Russia)

VAWT

Vertical Axis Wind Turbine

VCB

Verification Control Board

VCD

Verification Control Document

VCM

Volatile Condensable Material

VDA

Vacuum Deposited Aluminium

VELCRO®

A textile-based hook and loop fastener. Registered trademark of Velcro Industries B.V.

Venture Star

An X-33 reusable launch vehicle demonstrator; from NASA/Lockheed Martin. [See also: X-PROGRAMME]

VERIFICATION

The verification is a process oriented to demonstrate that the system design meets the applicable requirements and is capable of sustaining its operational role along the project life cycle, Ref.[1]

VERIFICATION CONTROL BOARD

This board has the objective to assess/approve the status of the verification process including the approval of the verification close-out through the Verification Control Document, Ref.[1]

VERIFICATION CONTROL DOCUMENT

This document lists all the requirements to be verified with the selected methods in the applicable phases at the defined levels and traces during the phase C/D, how and when each requirement is planned to be verified and is actually verified, Ref.[1]

VERIFICATION DOCUMENTATION

Documentation associated to the verification process for verification requirement definition, planning, reporting and close-out, Ref.[1]

VERIFICATION MATRIX

Matrix associating to each requirement the selected verification methods for the different verification levels in the applicable verification phases, Ref.[1]

VERIFICATION PLAN

This document is the master plan for the project verification process and demonstrates how the requirements will be verified by a coherent implementation approach, Ref.[1]

VERIFICATION PLANNING

Planning phasing the verification activities with the project milestones and programmatic constraints, Ref.[1]

VERIFICATION REPORT

This document is prepared in case than more than one of the defined verification methods are utilised to verify a requirement or a specific set of requirements. It explains the approach followed and how the verification methods were combined to achieve the verification objectives, Ref.[1]

VERIFICATION STRATEGY

The verification strategy identifies, for each requirement category, the applicable verification methods at each level, together with the models involved in the verification activities. It assures consistency between the several verification activities at the different levels avoiding duplications or gaps in the entire verification process, Ref.[1]

VERIFICATION TEAM

Dedicated team, within the project organisation, responsible of the verification process particularly in terms of co-ordination and results, Ref.[1]

VERIFICATION TOOLS

Tools utilised in support to verification implementation, e.g. Ground Support Equipment, Software Validation Facility, Special Tools, Simulators, Analytical Tools, Integration and Test Equipment/Facilities, Ref.[1]

VERY HIGH STRENGTH CARBON FIBRES (VHS)

A range of carbon fibres in which the tensile strength exceeds 3500 MPa, typically

V_f

Volume fraction of reinforcement fibres within a composite material, expressed as a percentage

VFD

Vanishing fibre diameter. Model for the analysis of fibre reinforced metals (MMCs)

VHS

Very high strength carbon fibres

VISCOSITY

1 A measure of the fluidity of a liquid, in comparison with that of a standard oil, based on the time of outflow through a certain orifice under specified conditions, Ref. [10]

- 2 The property of resistance to flow exhibited within the body of a material, expressed in terms of relationship between applied shearing stress and resulting rate of strain in shear

VOID

Air or gas trapped in composite materials during cure

VOID CONTENT

Volume percentage of voids, usually less than 1%. The experimental determination is, however, only indirect; e.g. calculated from the measured density of a cured composite and the 'theoretical' density of the starting material. Such determination also implies that voids are uniformly distributed throughout the body

VOLATILE CONTENT

A measure of the mass loss from a sample subjected to prescribed test conditions. The volatile loss is an indication of the solvent content of the prepreg remaining from either the resin-compounding process or a solution prepregging operation. Prepregs with a high volatile content tend to produce heavily voided laminates, owing to the vaporisation of the usually low-boiling-point solvent within the resin constituent during cure

VOLATILES

Materials in a sizing or a resin formulation capable of being driven off as a vapour at room temperature or slightly above

VOLUME FRACTION

Fraction of a constituent material based on its volume; a measure of the quantity of one phase in a composite material, usually the reinforcement fibre content, e.g. denoted as V_f and expressed as a percentage

VULCAIN

Ariane 5 main cryogenic engine

VUV

Vacuum ultraviolet

W**WAISTED**

A type of test specimen or coupon where the gauge length is not parallel for the entire length

WAKE

Behind the direction of spacecraft motion

WARP

- 1 The yarn running lengthwise in a woven fabric; a group of yarns in long lengths and approximately parallel, put on beams or warp reels for further textile processing, including weaving
- 2 A change in shape or dimension of a cured laminate from its original moulded shape

WASA

Wide-angle support assembly; part of the Mars Observer Camera

WASPALLOY

Nickel-based, chromium, cobalt and titanium containing, high-temperature alloy (UNS alloy designation N07001)

WATER ABSORPTION

Ratio of the weight of water absorbed by a material upon immersion to the weight of the dry material. [See also: MOISTURE ABSORPTION]

WATER VAPOUR REGAINED (WVR)

Mass of the water vapour regained by the specimen after the optional reconditioning step.

Note: WVR is calculated from the differences in the specimen mass determined after the test for TML and CVCM and again after exposure to atmospheric conditions and 65% relative humidity at room temperature (22 ± 3)°C, Ref. [8]

WAVE SOLDERING

A process wherein printed-circuit boards are brought in contact with a gently overflowing wave of liquid solder which is circulated by a pump in an appropriately designed solder pot reservoir. The prime functions of the molten wave are to serve as a heat source and heat-transfer medium and to supply solder to the joint area

WAXS

Wide angle X-ray scattering

WEAG

Western European Armament Group

WEATHERING

The exposure of plastics outdoors. In artificial weathering, plastics are exposed to cyclic laboratory conditions of high and low temperatures, high and low relative humidities, and ultraviolet radiant energy, with or without direct water spray, in an attempt to produce changes in their properties similar to those observed on long continuous exposure outdoors. Laboratory exposure conditions are usually intensified beyond those in actual outdoor exposure to achieve an accelerated effect

WEAVE

The particular manner in which a fabric is formed by interlacing yarns and usually assigned a style number, [See also: PLAIN WEAVE; SQUARE WEAVE; TWILL WEAVE; SATIN WEAVE; BIAS WEAVE]

WEB

A textile fabric, paper, or a thin metal sheet of continuous length handled in roll form, as contrasted with the same material cut into sheets

WEFT

The transverse threads or fibres in a woven fabric; fibres running perpendicular to the warp. Note: Also called fill, filler, filler yarn, woof. [See also: FILL, FILLER]

WEK

Waddoups, Eisenmann and Kaminski; a fracture model

WELDING

A fusion joining technique involving the melting of both joint materials, often with the addition of a third (filler) material

WET

Having absorbed moisture. Like the presence of voids, a uniform moisture distribution is implied which is unlikely to exist in reality. Most absorbed moisture is located near the exposed surface. Interpretation of the effect of being wet must take into account the realistic, highly non-uniform moisture distribution

WET LAY-UP

The reinforced plastic which is liquid resin applied as the reinforcement is laid up; the opposite of dry lay-up or prepreg. [See also: DRY LAY-UP, PREPREG]

WETTING

Flow and adhesion of a liquid to a solid surface, characterised by smooth, even edges and low contact angle

WHISKER

Reinforcement in the form of very short fibres, usually crystalline

WHORL

Coils of reinforcement fibre that form in a prepreg sheet; usually occurring at the end of production prepreg runs

WINDING ANGLE

In filament winding, the angular measure between fibre (filament) direction and a reference axis (longitudinal axis or axis of rotation of a cylinder or a pressure vessel)

WLC

Winged Launcher Configurations

WLE

Wing Leading Edge

WN

Whitney and Nuismer; a fracture model

WÖHLER CURVES

A graphical representation of the fatigue properties of a material, where stress is plotted against the number of load cycles to failure

WOVEN FABRICS

Fabrics produced by interlacing strands more or less at right angles

WOVEN ROVING

Cloth or fabric containing reinforcing fibres

WOVEN TEXTILE

For technical textiles: these are fabrics constructed from visually identifiable, compacted bundles of fibres known as yarns, [See also: YARN]

WRINKLE

- 1 A surface imperfection in laminated plastics that has the appearance of a crease in one or more outer sheets of the paper, fabric, or other base which has been pressed in
- 2 Sandwich panels: deformation of the face skins; a potential failure mode

WROUGHT METAL PRODUCT

Metallic stock material, e.g. in the form of sheet and strip, plate, bar, which is produced by methods involving large amounts of plastic deformation (such as forging, rolling, extrusion) that results in a material with a wrought microstructure, often with some level of anisotropy

Wt%

Weight percent

WVR

Water Vapour Regained

X**X-30**

National aerospace plane (NASP)

X-33

Venture Star. A half-scale, sub-orbital experimental flight-test vehicle designed to demonstrate key design and operational aspects of a single-stage-to-orbit (SSTO) and reusable launch vehicle (RLV) rocket system; from NASA - Lockheed Martin, (USA)

X-34

The reusable launch vehicle (RLV) technology demonstrator vehicle: small, fully reusable vehicle from Orbital Sciences Corp. (USA)

X-37

Future-X Pathfinder. An unpiloted reusable vehicle, carried by Space Shuttle, for both orbital and re-entry technology tests

X-38

The re-entry demonstrator Crew Transfer Vehicle (CTV). A forerunner of the Crew Return Vehicle (CRV) for the International Space Station (ISS) of which European participation is through the German TETRA/X-38 technology programme

X-40A

Space Manoeuvre Vehicle. 90% scale model, free-flight tests

X-43

Hyper-X Scramjet Demonstrator. Test vehicle(s) for single-flight missions at Mach 7 to Mach 10

XMM

X-ray multi-mirror telescope

X-programme

The US programme covering future reusable space-vehicle concepts, i.e. potential Space Shuttle replacements

X-vehicle

A series of experimental vehicles designed as ground and flight test beds for proving technologies required for future reusable space-vehicle concepts; under the US-instigated X-programme

Y**YARN**

For technical textiles: a continuous assembly of twisted filaments, fibres or strands (natural or artificial), suitable for processing to form a textile, e.g. by weaving or knitting

YIELD STRENGTH

The strength corresponding to the maximum load or stress that an unflawed structure or material can withstand without incurring permanent deformation, Ref. [5]

YIELD STRESS (YS)

Stress at which permanent deformation commences in a material. The limit of reversible elastic behaviour, [See also: PROOF STRESS]

YOUNG'S MODULUS

The ratio of a material's simple tensile stress, within elastic limits, to the resulting strain parallel to the direction of the tensile stress

YTTRIA

Yttrium oxide (Y_2O_3)

YTTRIUM (Y)

Metallic element, melting point 1522°C, density 4470 kg m⁻³. Uses: alloying additions, ceramic compounds

Z**ZERO-BLEED**

Prepreg materials that contain resins with viscosity and gelation characteristics optimised to avoid excessive resin flow during processing, [See also CONTROLLED BLEED]

ZINC (Zn)

Metallic element, melting point 420°C, density 7130 kg m⁻³. Uses: alloying additions

ZIRCONIA

Zirconium oxide

ZIRCONIUM (Zr)

Metallic element, melting point 1855°C, density 6510 kg m⁻³. Uses: alloying additions

ZnO

Zinc oxide

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