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Space product assurance

Termination of optical fibres

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Foreword

This document is one of the series of ECSS Technical Memoranda. Its Technical Memorandum status indicates that it is a non-normative document providing useful information to the space systems developers' community on a specific subject. **It is made available to record and present non-normative data, which are not relevant for a Standard or a Handbook.** Note that these data are non-normative even if expressed in the language normally used for requirements.

Therefore, a Technical Memorandum is not considered by ECSS as suitable for direct use in Invitation To Tender (ITT) or business agreements for space systems development.

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Change log

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Introduction

The objective of this Technical Memorandum is to ensure a successful manufacturing testing and installation of fibre optic based harness in spacecrafts. Part of this Technical Memorandum has been compiled from the recommendations of the National Aeronautics and Space Administration (NASA), European aerospace standards and International Standardization Organization (ISO). The specific requirements of the European space community for scientific and applications satellites have been included. The methods and workmanship contained in this document are approved for normal spacecraft requirements.

1
Scope

This Standard defines the technical requirements and quality assurance provisions for optical fibre terminations, fibre optic terminations, cable assemblies and installation for use in spacecraft and associated equipment.

The rigorous standards set by this specification ensure the high reliability of optical fibre and fibre optic connections intended to withstand both normal terrestrial conditions and the vibrational G-loads and environment imposed by space flight.

The proper tools and equipment, correct materials, design and workmanship are covered by this Standard. Acceptance and rejection criteria are stated and some workmanship standards are included to aid discrimination between acceptable and unacceptable.

The requirements for optical fibre based sensors and health monitoring systems that require specific treatments along the optical core such as metal deposition or Bragg grating are not part of this Standard.

The repair of fibre optic cables requires the development of a specific repair process procedure by the supplier that is related to the cable and its use. Repair procedures are not covered by this Standard.

This Technical Memorandum may be referred for the specific characteristics and constrains of a space project in conformance with ECSS-S-ST-00.

2
Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Technical Memorandum. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Technical Memorandum are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

ECSS-ST-S-00-01	ECSS system – Glossary of terms
ECSS-Q-ST-10-09	Space product assurance – Nonconformance control system
ECSS-Q-ST-20	Space product assurance - Quality assurance
ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes
ECSS-Q-ST-70-01	Space product assurance – Cleanliness and contamination control
ECSS-Q-ST-70-02	Space product assurance – Thermal vacuum outgassing test for the screening of space materials
ECSS-Q-ST-70-21	Space product assurance – Flammability testing for the screening of space materials
ECSS-Q-ST-70-22	Space product assurance – Control of limited shelf-life materials
ECSS-Q-ST-70-29	Space product assurance – Determination of offgassing products for materials and assembled articles to be used in a manned space vehicle crew compartment
ECSS-Q-70-71A rev.1	Space product assurance – Data for selection of space materials and processes
EN 100015-1	Basic Specification: Protection of Electrostatic Sensitive Devices Part 1: General Requirements

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Technical Memorandum, the terms and definitions from ECSS-ST-00-01 and ECSS-Q-ST-70 apply, in particular for the following terms:

acceptance

calibration

certificate

customer

equipment

supplier

3.2 Terms specific to the present Technical Memorandum

3.2.1 armour

component applied to a fibre optic cable that protects the component parts of the cable from damage from hostile external environments

NOTE 1 An armour is made of a steel or aluminium tape wrapped over the inner jacket, and is usually covered by an outer jacket.

NOTE 2 An "overarmour" is an additional cover, jacket (sheath) placed over a fibre optic cable to provide additional strength and protection against harsh environments.

3.2.2 attenuation

decrease in field strength, i.e. decrease in irradiance, caused by the absorption of energy by the medium; by the scattering caused by the scattering centres of the material medium, but not by the reduction caused by geometric spreading, i.e. the inverse square of distance effect for irradiance

NOTE 1 In optical fibres, attenuation occurs as a result of absorption, reflection, scattering, deflection, dispersion or diffusion rather than by geometric spreading.

NOTE 2 Attenuation is usually expressed in terms of "attenuation rate".

3.2.3 attenuation rate

Rate of decrease of average power with respect to distance along a transmission path.

NOTE The attenuation rate is usually expressed in the units decibels (dB) per kilometre (km).

3.2.4 back-lit (light)

method of illuminating the optical fibre endface by transmitting incoherent light through the opposite end of the fibre core

3.2.5 bend

curvature of the optical path in optical fibres

NOTE Bends can be microbends that occur along the core-cladding interface, causing incidence angles to occur that are greater than the critical angle for total internal reflection, or macrobends with radii of curvature less than the critical radius, in which evanescent waves can no longer remain coupled to bound modes and hence radiate laterally away from the fibre, i.e. evanescent waves that cannot maintain a constant phase relation with the wave inside the fibre, thus they become uncoupled (unbound) and radiate away from the fibre.

3.2.6 bend radii (minimum)

minimum radii of curvatures that an optical waveguide device can sustain under specific conditions

NOTE 1 The value of the bend radius depends on the type of stress the optical device sustains.

NOTE 2 The minimum bend radius is a function of tensile stresses; such as occur when the optical fibre or cable is bent around a capstan or sheave, particularly when the fibre or cable is under tension.

NOTE 3 The minimum bend radius varies with different fibres and cables. The manufacturers' specification states the radius below which cables should not be bent (often two or three times the minimum bend radius), for both short-term (installation) and long-term (operation).

3.2.7 bend radius (long-term)

minimum radius to which a cable can be bent for its lifetime, while under maximum installation load, without causing broken fibres, localized weakening of the fibres, or a permanent increase in attenuation

3.2.8 bend radius (short term)

minimum radius to which a cable can be bent during hardware mounting, while under maximum installation load, without causing broken fibres, localized weakening of the fibres, or a permanent increase in attenuation

3.2.9 buffer (optical fibre)

component used to encapsulate an optical fibre to provide mechanical isolation and protection from physical damage

NOTE 1 The buffer is designed to

- preserve fibre strength;
- inhibit cable losses;
- protect against mechanical damage (microbends, macrobends, during cabling and spooling);
- environmental protection (moisture and corrosive conditions);
- provide compatibility with fibre and cable manufacturing processes (dipping, extrusion, spraying and electrostatic processes).

NOTE 2 Fibre optic cable buffers include cushioning material, such as aramid fibre, and tubes in which the optical fibre is loose or in a gel. Buffer materials include proprietary fluoropolymers, polyurethane and several others.

3.2.10 cable (fibre optic)

cable that has one or more optical fibres that are used as a propagation medium for lightwaves; is capable of transmitting optical signals over long distances; usually consists of optical fibres that are surrounded by buffers, strength members and jackets (for protection, stiffness and strength), and does not require the use of metals

3.2.11 cable assembly (fibre optic)

cable that is terminated with fibre optic connectors and that is ready for installation

3.2.12 chemical splice

mechanical splice where the fibre end faces are held in place with an adhesive

NOTE See also: mechanical splice

3.2.13 cladding (optical fibre)

one or more layers of material of lower refractive index in intimate contact with a core material of higher refractive index

[Adapted from ATIS telecom Glossary 2000 www.atis.org/tg2k/]

3.2.14 cleave (optical fibre)

break that is deliberate and controlled, has a smooth, flat endface perpendicular to that of the fibre axis, and is produced using cleaving tools and processes

3.2.15 cleaving

processes used to produce an acceptable cleave, with a smooth, flat endface perpendicular to the fibre axis, in an optical fibre

NOTE 1 A nick or groove (microscopic fracture) is made in the fibre with an appropriate cleaving tool that has a sharp blade of a hard material (diamond, sapphire, tungsten carbide etc.) and a force is applied, either by the cleaving tool or manually at or after the nick is made, to propagate the fracture through the cross section of the optical fibre.

NOTE 2 A good cleave is required for a successful low-attenuation joint made by a splice or connector.

NOTE 3 Some connectors do not require the use of abrasives and polishing media for the endface because they use a cleaving technique that trims the fibre to the correct length and produces an endface of the required quality.

3.2.16 connector (fibre optic)

device that transfers optical power between two optical fibres, groups of optical fibres, or fibre optic bundles

NOTE A fibre optic connector can be repeatedly connected and disconnected, and usually consists of two, fully intermateable or demateable parts, one attached to each end of a fibre optic cable, to equipment or to components to allow connection and disconnection of fibre optic cables.

3.2.17 core (optical fibre)

central region along an optical fibre axis that is surrounded by cladding, and has a refractive index higher than the cladding that surrounds it

3.2.18 coupler (fibre optic)

device in which an optical fibre transfers optical power to other optical fibres, between a light source and an optical fibre, or between an optical fibre and a photodetector without the use of splices or connectors

3.2.19 device (fibre optic)

device or equipment in which an optical fibre is used

NOTE 1 Fibre optic devices can be used, for example, for transmission, delay, illumination or sensing.

NOTE 2 Fibre optic cables, couplers, transmitters, receivers, transceivers, repeaters, sensors, endoscopes, boroscopes, light guides.

3.2.20 endface (optical fibre)

surface that is at either end of an optical fibre, is usually perpendicular to the optical axis, and through which light waves are launched into, or exit from, the optical fibre

3.2.21 fibre axis

longitudinal centre of symmetry of an optical fibre

NOTE The axis of an optical fibre with a circular cross section is the locus of all points at the centres of cross-sectional circles, i.e. the central longitudinal axis of the core.

3.2.22 ferrule

mechanical fixture, generally a rigid tube, used to confine the stripped end of a cable

NOTE 1 It is used to hold the stripped end of an optical fibre or fibre optic bundle consisting of individual optical fibres cemented together.

NOTE 2 It has a diameter designed to hold the fibre(s) firmly with a maximum packing fraction.

NOTE 3 It can be made of non-rigid material, such as shrink tubing.

NOTE 4 It usually provides a means of positioning within a connector by performing the function of a bushing.

NOTE 5 Ferrules can be made of plastics, metals or ceramics.

3.2.23 fibre optics

branch of optical technology concerned with the transmission of optical radiation through fibres made of transparent materials

NOTE Fibres can be made out of glass, fused silica, or plastic.

3.2.24 fusion splice

splice that is accomplished by the application of sufficient heat to melt, fuse, and so join two lengths of optical fibre together forming a single, continuous optical fibre

NOTE If properly made, it results in a continuous optical fibre with low or no discontinuities at the splice and a near-zero insertion loss (i.e. without attenuation) across the splice. It is usually made by commercial fusion splicing equipment.

3.2.25 hackle (optical fibre)

surface irregularity characterized by a rippled or stepped break in the fibre, usually due to improper cleaving

3.2.26 index of refraction

See: Refractive index

3.2.27 insertion loss

the increase in the total optical attenuation caused by the insertion of an optical component into an optical transmission path

[from IEC Glossary]

NOTE 1 Insertion loss is expressed as the ratio of the signal power delivered to that part of the line following the device to the signal power delivered to that same part before insertion. When ratio is lower than unity, there is an insertion loss.

NOTE 2 The value is usually expressed in dB, in such case there is a loss when ratio is negative.

NOTE 3 Insertion losses can be attributed to many causes (such as absorption, scattering diffusion, leaky waves, dispersion, microbends and macrobends, reflection and lateral radiation).

3.2.28 installation load (maximum)

maximum load that can be applied along the axis of a fibre optic cable during installation without breaking fibres or causing a permanent increase in the cable attenuation

NOTE Sometimes called a 'pull-load'. It is usually specified by the cable manufacturer.

3.2.29 interference

Interaction of two or more coherent or partially coherent waves, which interaction produces a resultant wave that differs from the original waves in phase, amplitude, or both.

[Adapted from ATIS telecom Glossary 2000 www.atis.org/tg2k/]

NOTE Coherent interference can be constructive (increase the field strength in the original direction) or destructive (reduced the field

strength in the original direction and increases lateral emanations and absorption).

3.2.30 interference (in signal transmission systems)

energy that is extraneous, from natural or man-made sources that interferes with the reception of desired signals

NOTE Interference produces a loss in performance, misinterpretation or loss of information that can otherwise be extracted in the absence of such unwanted energy.

3.2.31 jacket (cable)

tough, usually fluid-resistant, layer of a flexible material that is applied over a propagation medium for protection during spooling, storage, shipping and payout, installation and in-service;

NOTE 1 The flexible material can be of plastic or impregnated fabric.

NOTE 2 It can be applied in several separate layers, such as is common in communications cables.

NOTE 3 Fibre optic cables often have an inner jacket surrounded by armour or strength members over which a second (outer) jacket is applied.

3.2.32 jacket (optical fibre)

material that covers the buffered, or unbuffered, optical fibre

3.2.33 junction (optical fibre)

interface surface formed by butting two optical fibre endfaces together to allow direct fibre-to-fibre optical transmission

3.2.34 loose splice tube

tube with a square hole containing a material with a refractive index matching the optical fibres into which two optical fibres are introduced for splicing

NOTE The device provides alignment and support of the two optical fibres until the cure of the splicing material (optical adhesive) is complete, so forming a low loss butt joint (butt coupling).

3.2.35 mechanical splice

splice in which the fibre ends are held together in a permanent or separable manner by means other than fusion

[IEC Glossary]

NOTE 1 Index matching material can be applied between the two fibre ends.

NOTE 2 A splice made using an optical adhesive can be called "chemical splice".

3.2.36 optical fibre

single discrete filament-shaped transparent dielectric material that guides light

NOTE An optical fibre consists of glass or plastic; has a cylindrical core and one or more claddings on the outside; has a round cross section, and can have a special-purpose noncircular cross section, such as an elliptical, rectangular, planar or slotted cross section.

3.2.37 optical time domain reflectometry (backscattering method)

test method for characterizing an optical fibre whereby an optical pulse is transmitted through the optical fibre and the optical power of the resulting light scattered and reflected back to the input is measured as a function of time

NOTE The backscattering method is useful for estimating the attenuation coefficient for uniform fibres, and identifying and localising defects and other localised losses.

[Adapted from IEC Glossary]

3.2.38 pistoning

axial movement of an optical fibre within a connector or connector ferrule

3.2.39 reflection

abrupt change in direction of a wavefront at an interface surface between two dissimilar propagation media, so that a finite proportion of the incident wave remains in the medium of which it is incident

NOTE Reflection can be specular (smooth, polished surface) or diffuse (rough surfaces).

3.2.40 refractive index

ratio of the velocity of propagation of an electromagnetic wave in vacuum to the velocity of propagation of the wave in the medium

3.2.41 sliver

part of an optical fibre bared by coating removal, normally jutting-out of the ferrule before cleaving

3.2.42 splice

joint that is made between two fibre optic cables, or two optical fibres

NOTE 1 A splice is generally mounted within a protective housing (such as a tube or sheath), provides for minimal power loss at the junction (joint), and is used to couple optical signal power between optical fibres or cables.

NOTE 2 Cable splices are used to complete a cable span or to repair a damaged cable.

See: Chemical splice, fusion splice, mechanical splice.

3.2.43 splice enclosure (cable)

portion of the cable splice that covers the fibre optic splice, seals against the outer jackets of joined cables, provides environmental protection, and provides mechanical strength to the joint

3.2.44 spooling

winding and unwinding of fibre optic cables from their supporting spools or reels

3.2.45 strength member

component of a cable that protects the elements of the cable from excessive stresses during installation and while in service

3.3 Abbreviated terms

For the purpose of this Technical Memorandum, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
ATIS	Alliance for Telecommunications Industry Solutions
CME	Coefficient of Moisture Expansion
CTE	Coefficient of Thermal Expansion
FIA	Fibreoptic Industry Association
IEC	International Electrotechnical Commission
OTDR	Optical Time Domain Reflectometer

4
Principles of fibre cable assemblies

Using optical fibre to transmit data implies that the light emitted at one end of a cable assembly is transmitted to the other extremity with an acceptable level of disturbance. Proper signal transmission can be achieved if the sources of signal loss are minimized. These losses are mainly generated at the locations where the signal can be reflected, connectors, splices, bends. In addition, improper handling of an assembly can result in optical fibre breakage and a complete loss of signal.

This Technical Memorandum applies to assemblies designed to operate within the temperature limits from -55°C to +150°C.

5
Fibre optic cable assemblies

5.1 Specific equipment and environmental conditions

5.1.1 Facilities

a. The work area shall be clean, located in a controlled environment room or, preferably in a clean room.

b. Air used for ventilation shall be filtered to prevent contamination by moisture, oil or dust.

c. Unless classified as a clean room, the areas in which terminations or assemblies are carried out shall be kept free of loose material

NOTE Dirt, dust, particles, oils, waste and scrap materials can cause contamination of the connection.

d. Furniture in the work areas shall be arranged to allow easy and thorough cleaning of the floor.

e. The environment shall fulfil the most recent requirements of national health regulations.

f. Easy access of personnel to washing facilities shall be provided to prevent the spreading of contamination and waste materials.

5.1.2 Work-bench

a. Working surfaces shall be covered with an easily cleaned hard top or have a replaceable surface of clean, non-corrosive silicone-free paper.

b. The lighting intensity shall be a minimum of 1080 Lux on the work surface with at least 90% of the work area being shadowless and without severe reflections.

c. Where devices, susceptible to static charges are present, the requirements of EN 100015-1."Basic Specification: Protection of Electrostatic Sensitive Devices Part 1: General Requirements" shall be met.

d. Individual protective equipment shall be used according to the most recent national health regulations.

e. The following specific additional safety equipment shall be provided for operators and inspectors of optical fibre and fibre optic assemblies to

prevent bare optical fibres and fragments of optical fibre penetrating the eye or skin:

1. Surgical latex talc-free gloves to protect against the penetration of bare fibres and slivers.
2. Goggles (wrap-around style) for eye protection against fragments and debris
3. Eye protection: that conforms to the requirements for exposure to high-radiation lasers or exposure to the wavelengths of radiation encountered during assembly, testing and inspection procedures.
4. Protection against exposure to process residues (such as airborne debris from grinding and polishing operations), process chemicals and materials used in component parts of the fibre optic assembly and in assembly processes.

f. Optical fibre fragments and bare fibre scraps shall be collected and disposed according to requirements of acknowledged standards for the disposal of hazardous optic fibre materials, e.g. FIA-TSD-2000-5-3 "optic fibre – disposal of waste".

g. All the tools necessary to perform the assembly of optical devices shall be readily available on the work-bench before starting the assembly.

NOTE 1 Often the transmitted radiation is in the non-visible part of the electromagnetic spectrum, so it is not immediately apparent to operators that optical fibres are energized.

NOTE 2 Some fibre optic cables contain caustic fire-retardant materials.

5.2 Materials and parts selection

5.2.1 General

a. All materials shall be selected in accordance with ECSS-Q-70-71A rev.1.

b. Materials used in vacuum or low pressure compartments shall conform to the requirements of ECSS-Q-ST-70-02.

c. Materials used in habitable areas of spacecraft, stowed equipment and experiments shall conform to the requirements of ECSS-Q-ST-70-21 and ECSS-Q-ST-70-29.

d. Materials shall be selected according to ECSS-Q-ST-70-01 to fulfil the project contamination requirements taking into account the process documentation and the service environment.

e. Combinations of materials potentially releasing acid or alkaline compounds by their chemical interaction shall not be used.

NOTE A flow chart showing the main steps for manufacturing and verification of fibre optic cable assembly is shown in Annex F.

5.2.2 Fibre optic cable materials

5.2.2.1 Introduction

A fibre optic cable assembly consist of the optical fibre, coating(s), cladding(s), buffer layer(s), strength member(s) and jacket. An example of the components of a fibre optic cable is given in Annex D. This optic cable is terminated by connectors in which the optical fibre is inserted and maintained.

5.2.2.2 Material selection and compatibility

a. The successive concentric layers of the optical fibres and its surrounding protective layers and their positioning in the optic cable shall be specified in the technical specification of the optic cable.

b. The differential expansion due to CTE of individual layers shall not induce power losses above project requirements when selecting the combination of the materials for an optic cable.

c. The differential expansion due to CME of individual layers shall not induce power losses above the project requirements when selecting the combination of materials for an optic cable.

d. The radiation resistance shall be taken into account when selecting the optic cable materials.

e. Fibre optic cable shall be identified differently from other cables.

NOTE Identification methods include labels, colour codes, marking.

5.2.3 Fibre optic connectors

a. The selection of connectors shall be specified in the project documentation.

b. Connectors shall be selected, as a minimum, on their conformance to

1. space requirements,
2. project requirements,
3. environmental resistance,
4. temperature resistance,
5. fluid resistance (if applicable),
6. resistance to vibration, and
7. optical performances

c. Connector boot suitable to sustain the space environment shall be used for protecting the transition of the fibre into the connector.

d. All connectors shall be keyed to prevent incorrect mating with identical connector shells.

NOTE 1 Connectors are oriented by keys and key-inserts or pins..

NOTE 2 Keying applies to individual fibres when inserted into a multi-fibre connector and also to the multi-fibre connector case.

e. Different types of connectors shall be selected to prevent accidental cross-connection, for cable harness systems, comprising a great number of fibre optic cables.

f. Connectors shall be selected according to their capability to sustain the vibrational load to which they are exposed.

NOTE Connectors that can be used for connections subjected to high and sustained vibrational loads are

- threaded-coupling type and preferably the self-locking type, or
- wire-locked connector, using a stainless steel wire

g. Dust caps made of vinyl shall not be used for flight applications.

NOTE 1 Fibre optic cable manufacturers often recommend connector types compatible with their cables.

NOTE 2 Fibre optic connectors that can be locked after coupling to prevent any uncontrolled decoupling and re-coupling are preferred.

5.2.4 Solvents

a. The solvents used for the removal of grease, oil, dirt and residues shall:

1. be non-conductive,
2. be non-corrosive,
3. not dissolve or degrade the quality of parts or materials, and
4. not remove the identification markings.

b. Solvents shall be labelled and maintained in a clean and uncontaminated condition.

c. Solvents shall not be used in any manner which carry dissolved residue onto contact surfaces of optical fibre end-faces or connectors.

d. All solvents shall be selected such that they can be completely dried.

5.2.5 Adhesives

a. All optical adhesives and adhesive materials shall conform to the requirements for “limited life” materials (storage, marking and control) as per ECSS-Q-ST-70-22, clause 4.1.2

b. The adhesive selected shall be compatible with the mission requirements and anticipated service environment,

NOTE This compatibility is demonstrated through e.g. temperature range, outgassing rate and radiation resistance characteristics.

c. The adhesive curing cycle shall be compatible with the thermal limitations of the hardware.

d. Shrinkage of adhesive during curing, repair and in-service conditions shall not degrade the optical fibre.

e. Compounds that emit acetic acid, ammonia, amines, hydrochloric acid and other acids shall not be used.

5.3 Equipment and tools

5.3.1 General

a. The supplier shall define the parts, tools, equipment, and procedures used in preparing the fibre optic cable for termination.

b. All parts, materials, tools and equipment shall be verified visually prior to assembly operations; the calibration status of the tools and equipment is part of this verification.

5.3.2 Fibre optic cable preparation tools

a. Tools used to prepare fibre optic cables shall be capable of cutting, slicing, or stripping a cable component (jacket, strength member) without causing damage (cuts, nicks, grooves) to adjacent parts of the cable

NOTE Examples of fibre preparation tools are given in Annex D.

b. Only the tools defined in the manufacturing procedure shall be used for each of these operations.

c. Cutting edges of tools shall be checked regularly for damage and maintained in a sharp condition.

d. Operators and inspectors shall make use of the equipment detailed in 5.1.2.

e. Waste materials (optical fibre, adhesives, process chemicals and materials) shall be collected, controlled and disposed of immediately.

NOTE See also5.1.2f.

5.3.3 Fibre optic cable finishing tools

a. Tools used to finish the fibre optic cables assembly termination shall be capable of scribing, cleaving, cutting and lapping optical fibre without causing damage.

NOTE Examples of fibre preparation tools are given in Annex D.

b. The tools used to hold the terminated connectors shall not damage the adjacent parts of the optic cable.

c. The setting verification of automatic lapping equipment shall be performed prior to using it on the terminated cable assemblies.

d. Only the tools defined in the manufacturing procedure shall be used for each finishing operations.

5.3.4 Fibre optical inspection tools

a. Visual aids tools shall be available for in-process inspection and quality inspection of the fibre end-face; with the following features:

1. be suitable to illuminate the fibre end using normal and back lighting without touching the fibre extremity;
2. have a 200x magnification available.

5.3.5 Tools for adhesive dispenser

a. The following tools for preparing, dispensing and curing the adhesive shall be available on the work-bench:

b. scale able to weigh the adhesive compounds for multi-component adhesives,

1. tools allowing mixing of the adhesive without inducing contamination,
2. solvents to clean all the parts to be in contact with the adhesive,
3. equipment allowing the removal of the entrapped gas bubbles from the adhesive,
4. adhesive dispenser (e.g. syringe) capable to release the amount of adhesive required,
5. controlled curing device onto which the termination to be bonded can be mounted, without stresses on the fibre and the connector.

5.4 Fibre optic cable preparation

5.4.1 General

a. Any deviation from the connector manufacturer's termination specification shall be justified.

5.4.2 Fibre optic cable preconditioning

a. Preconditioning shall be performed

1. on all optic cables, unless it is demonstrated that the optic cable is not susceptible to differential shrinkage;

2. before the inclusion of the optical fibre in the cable, unless not possible.

b. Preconditioning shall not be performed

1. on a cable equipped with connectors, even if only one end is terminated to a connector;

2. on a partly prepared cable (e.g. connected or crimped) even if only one end is partly prepared.

c. The entire cable shall be placed in the thermal cycling arrangement.

d. The differential shrinkage per thermal cycle shall tend toward zero at the end of the pre-conditioning treatment.

NOTE 1 The following preconditioning heat treatment process is most of the time suitable:

- Upper temperatures: 140 °C
- Lower temperature: -50 °C
- Heating / cooling rate: 5 °C/min maximum
- Dwell time: 1 minute
- Number of cycles: 6

NOTE 2 Some thermal-cycling induced shrinkage can occur in the different concentric layers from which the cable is made of (e.g. extrusion process can leave stresses in the fluoro-polymer materials). On a terminated assembly, the differential shrinkage can induce micro-bending in the optical fibre(s) and lower the signal transmission.

5.4.3 Visual inspection

a. Fibre optic cable shall be visually inspected before starting the assembly.

b. The outer surface of the cables shall be circular, exempt of blisters, swollen or strained parts, pits and pores.

c. The successive concentric layers of the fibre optic cable shall all visible, as described by the engineering drawings of the connector manufacturer at the prepared cable extremities.

5.4.4 Fibre optic cable stripping

a. Cables shall be prepared for termination by exposing the optical fibre without causing damage (chips, nicks, scratches) or contamination.

b. The coating on an optical fibre shall be removed, unless stated otherwise in the optical fibre manufacturer's stripping procedure.

c. Each protective material shall be removed to the dimensions specified in the connector manufacturer's fibre installation procedure using dedicated tools and techniques.

NOTE Following are examples of the various tools and techniques:

- Mechanical strippers with fixed fibre diameter tools to remove the coating from one specific optical fibre diameter.
- Mechanical strippers with variable fibre diameter tools (with interchangeable dies for different fibre diameters) to remove the coating from a range of fibre diameters.
- Chemical stripping media compatible with the optical fibre, all component parts of the termination and the fibre optic cable..
- Thermal stripper compatible with the optical fibre, all component parts of the termination and the fibre optic cable. Overheating of fibres and cable components can result in damage such as delamination of layers allowing localized bending of the optical fibre outside the specified limits.

d. Immediately after removing a buffer layer requiring chemical (solvent) stripping, the cable extremity under preparation shall be cleaned to remove any solvent residues or buffer materials and then dried.

e. The optical fibre to be adhesively bonded shall be cleaned with solvents and dried before the application of the adhesive.

f. The exposed optical fibre shall be prepared in accordance with the procedure (removal of any coating materials) as specified by the fibre manufacturer.

g. The connection process shall not be interrupted when the glass fibre is bare.

NOTE Bare glass fibres are prone to accidental damage and moisture ingress.

5.5 Connector preparation

a. Each connector shall be visually inspected to verify that it:

1. is not stained,
2. does not present rust particles,
3. is clean, and
4. the aperture in the ferule is not obstructed.

b. The connectors shall be disassembled to allow the application of the adhesive and the insertion of the optical fibre in the ferrule according to connector manufacturer engineering documentation

c. The connector shall be cleaned with solvent and dried just before the application of the adhesive.

5.6 Adhesive preparation and usage

a. The adhesive shall be conditioned and processed according to the adhesive manufacturer specification.

NOTE The two main types of adhesives are:

- deep-frozen adhesive, and
- multi-component adhesive

b. All parts and equipment that come in contact with the adhesive shall be cleaned and dried just before use.

c. The potentially entrapped gases shall be removed from the adhesive (by e.g. centrifugation or vacuum degassing) before it is applied on the parts to be bonded.

d. The curing device shall be set-up and its settings verified before starting the cable assembly.

e. The cure cycle specified by the adhesive supplier shall be followed

NOTE Deviation from the specified curing cycle can have adverse effects and reduce the performance of the adhesive.

5.7 Cable assembly procedure and verification

a. The assembly of the optic cable to the connector's manufacturing engineering specifications.

b. When positioning the connector into which the optical fibre has been inserted in the curing device care shall be taken to avoid stresses on the assembly

c. A droplet of cured adhesive shall be present at the extremity of the ferrule after curing.

d. The bare optical fibre shall protrude from the cured adhesive droplet.

e. Wicking of the strength member by the cured adhesive shall not be excessive; it shall not extend more than 2 centimetres from the exit of the connector body.

NOTE A typical sequence for connector to cable assembly is:

- filling up the connector with the adhesive,
- inserting the bare optical fibre end into the ferrule,
- securing the connector on the optic cable,
- inserting the connector in the curing oven until the adhesive is cured.

5.8 Optical end-face finishing

a. Any excess optical fibre protruding from the connector end shall be cleaved to the correct length by scribing the fibre with a scribing tool and cleaving the excessive fibre length, as described in the fibre assembly specification.

b. The cleaved end-face shall be polished by using the successive polishing media and tools specified in the fibre assembly specification.

c. The polished optical fibre end shall be cleaned to remove polishing residues and dried.

d. The polished and cleaned optical fibre end shall be visually inspected for acceptability by a trained inspector.

e. A protective cap shall be placed on the connector immediately after inspection of the terminated fibre-end connection acceptance.

NOTE Manual polishing is not recommended for single mode fibres due to the difficulty of achieving the required end-face profile.

5.9 Optic cable storage and handling

a. Components for optic cable shall be kept in their original packaging until the cable assembly.

b. Spools of optic cable and optical fibre shall be kept in a dry atmosphere – desiccant may be used.

c. Terminated cables shall be packed individually and kept in a dry atmosphere desiccant may be used.

d. Terminated cables shall be laid on flat surface and shall not be stacked.

e. Disconnected connectors shall be protected with their specific protection cap.

f. Cable shall not be twisted or nicked during cable preparation, cable assembly and cable inspection and testing.

g. The limitations given by the cable manufacture specification during handling shall not be exceeded.

NOTE For example, the maximum tensile load or the minimum long and short term bend radii.

h. The end-face shall be inspected using an inspection microscope and cleaned if not visibly clean after every decoupling of a fibre optic connector.

i. All connectors shall be provided with a dust cap when disconnected and labelled to indicate that it is a fibre optic cable connector.

5.10 Fibre optical assembly evaluation and qualification report

a. The supplier shall provide the complete results of the qualification and evaluation of the fibre optical assembly

NOTE This folder include evidences of records for materials (e.g. test reports), for processes (e.g. audit or inspection reports, certificate of compliance) and for parts.

b. The supplier shall provide the fibre optical assembly report that conforms to the DRD in Annex A.

6
Fibre optic cable routing and layout

6.1 General

a. The routing, layout and installation procedure of the optical fibres and fibre optic cables shall take into account the physical limitations of the materials.

b. The supplier shall ensure that the data transmission performances of the optical fibres is not lowered due to mishandling of the terminated optic cables.

6.2 Routing of fibre optic cables

a. The supplier shall specify the maximum installation tensile load, the maximum use tensile load, and the maximum vertical rise for cable assemblies according to the cable manufacturer's specification.

b. The minimum long-term bend radius of the routed fibre optic cables shall conform to the cable manufacturer specification.

c. The fibre optic fibre shall not be routed over sharp edges or corners without additional mechanical protection conforming to the long term minimum bend radius requirements.

d. Conduits should be used to route optic fibre cables through areas where access is limited or restricted.

e. Supports (such as conduits) that provide mechanical and abrasion resistance shall be used for cables routed through structural members

6.3 Installation of fibre optic cables

a. During installation, fibre optic cable assemblies shall not be subject to axial load higher than that indicated in the cable manufacturer specification

b. The fibre optic cable installation procedures shall ensure that the cable radius of curvature remains above the minimum short-term bend radius of the fibre provided in the cable manufacturer specification.

c. Bend radii restrictors shall be used to ensure that bends in cables are higher than the minimum short term bend radius

d. Fibre optic connectors shall be tightened to the value specified in the connector's manufacturer documentation or as specified by the project.

6.4 Layout of fibre optic cables

a. The fibre optic cables shall be supported as a minimum at 20 cm intervals along their length, unless otherwise stated in the installation documentation.

NOTE Support can be lacing cords or cable supports such as "P-clips".

b. Cable supports shall be designed to support the size and cross section of cable and have a temperature rating higher than that of the optical cable.

c. Cable supports shall be tightened to keep cables in position, but shall not:

1. pinch, deform, kink or otherwise stress the fibre optic cable assemblies,

2. restrict slight movements due to the thermal expansion and contraction.

NOTE Overtight cable supports can cause microbending of the optical fibre and affect the optical performance or reliability.

d. Cable supports shall not be attached to adjacent cables or cable harnesses.

e. Conformal coating shall not be applied to stack fibre optic cables unless specified in the project documentation.

f. Bend radii restrictors shall be used, in addition to cable supports ,to ensure that bends in cables conform to the specified long term bend radius

6.5 Evaluation and verification report

a. The supplier shall provide the evaluation report for the routing, the installation and the layout of the fibre optical cables that conforms to the DRD in Annex B.

7 Verification, testing and acceptance criteria

7.1 Preassembly in-process inspection

a. Prepared fibre optic cables shall be subject to in-process inspection by a trained inspector for the following:

   1. correct cable stripping dimensions;
   2. absence of strength member damage;
   3. absence of cracks, nicks, cuts or other damage in the termination area of all cable components, including damage to the optical fibre(s);
   4. absence of chemical strip wicking or damage;
   5. cleanliness.

b. Fibre optic connector parts shall be subject to in-process inspection by the operator or a trained inspector for the following:

   1. connector endface profile;
   2. absence of blockage in the internal fibre channel;
   3. absence of cracks, defects or deformation of the connector ferrule;
   4. cleanliness.

      NOTE The prepared fibre cannot be used to check for blockage.

c. Other requirements (e.g. shrink sleeve dimensions or crimp sleeve requirements) shall be inspected by the operator or a trained inspector for conformance with the connector's manufacturer specification.

7.2 Post assembly inspection

7.2.1 Connector assembly inspection

a. Completed connector assemblies shall be inspected by a trained inspector for the following:

1. strength member uniformly distributed and securely attached to the connector;
2. shrink tubing or crimp sleeve positioned correctly;
3. end-face geometry compliant with the connector's manufacturer requirements;
4. ferrule length compliant with the connector's manufacturer requirements;
5. absence of optical fibre pistoning;
6. concentricity of fibre in connector
7. endface inspection for unacceptable defects using normal and backlighting under a 400x magnification microscope

   NOTE Annex E shows examples of typical satisfactory and unsatisfactory endfaces.
8. for single mode fibre, compliance to endface profile requirements is verified using an appropriate method.
9. proper positioning and attachment of the strain relief device (e.g. connector boot) as per connector's manufacturer requirements;
10. cleanliness;
11. absence of nicks exposing underlying cable components (jacket, strength member, armour, optical fibre);
12. absence of kinks or twists.

b. Unless stated otherwise, the axial alignment with the connector within 5 cm of the termination shall be inspected, in order to minimize bending which causes stress in the fibre or higher level assemblies.

c. If cracks in a flight fibre optic cable end-face are found, the cable shall be re-prepared and re-terminated, or scrapped.

d. End-faces of flight hardware fibre optic cables shall not be re-polished to remove cracks.

7.2.2 Fibre optic cable assembly inspection

a. To ensure high reliability of fibre optic assemblies, all the finished assemblies shall be tested by a qualified inspector.

b. The mean value and variance of the insertion loss shall be measured.

c. Fibre optic cables shall be tested by techniques that measure the optical signal between the optical signal insertion point end the termination point (e.g. over the whole cable length).

d. Terminated cables shall be proof-tested according to the project requirements to ensure proper manufacturing

   NOTE Single fibre proof-test load is typically 50 N

e. Any fibre optic cable and connector terminations that do not conform to the optical signal requirements shall be re-terminated, re-tested or scrapped.

7.3 Verification and tests on layout cables

a. Upon inspection of installed fibre optic cables, the following characteristics shall be general criteria, for cable rejection:

1. missing or incorrectly installed component parts and devices;
2. absent or incorrect cable supports at specified intervals: cable clips and clamps, splice enclosures, conduits;
3. loose cable supports;
4. deformation of the cable (twists, bends, crushing) due to incorrect installation of cable supports;
5. nonconformance to minimum bend radii;
6. absence of or incorrect permanent marking (cable or connector).

8
Quality assurance

8.1 General

a. For the quality assurance requirements ECSS-Q-ST-20 shall apply.

8.2 Data

a. The quality records (e.g. logbooks) shall be retained for at least ten years unless otherwise stated by project requirements, and contain as a minimum the following:

1. copy of final inspection documentation;
2. index of limited-life articles and their use times;
3. nonconformance reports and corrective actions;
4. copy of the inspection and test results with reference to the relevant procedure, personnel, tools, equipment and baths;
5. an event log which is a chronological history of process operations and parameters, inspections and tests;
6. details of failure mode (if applicable).

8.3 Nonconformance

a. ECSS-Q-ST-10-09 shall apply.

8.4 Calibration

a. Each reference standard and piece of measuring equipment shall be calibrated.

b. Any suspected or actual equipment failure shall be recorded as a project nonconformance report so that previous results can be examined to ascertain whether re-inspection and re-testing is required.

c. The customer shall be notified of the nonconformance details.

8.5 Traceability

a. Traceability shall be maintained throughout the process from incoming inspection to final test, including details of test equipment and personnel employed in performing the task.

8.6 Operator and Inspector training and qualification

a. Personnel trained in conformance with clause 5.1.2 of ECSS-Q-ST-20 shall be employed for all operations and inspections related to the fibre optic assembly, their inspection and verification testing of their performances.

b. Records shall be maintained of the training and qualification status of the operators and inspection personnel.

c. The supplier shall have a documented programme that includes procedures for the training, certification, maintenance of certified status, re-certification and revocation of certified status for assembly and inspection personnel.

d. The supplier may prepare and have readily available workmanship standards consisting of satisfactory work samples or visual aids.

9
Fibre splicing

9.1 General

a. By design, the number of splices shall be minimized.

b. The project documentation shall define the specific regions of the cable where splices cannot be made (e.g. fire-resistance, fire-zones, cables used in "vital circuits" and position subject to flexing at hinge points, doors, access panels)

c. For flight hardware, only fusion splicing shall be used.

d. For flight hardware repairing, splicing shall not be performed unless cable replacement is not possible.

e. For testing and installation, mechanical and chemical splices may be used.

NOTE 1 Splices are used to:

- lengthen a fibre optic cable;
- make a permanent junction (joint);
- repair a damaged cable.

NOTE 2 Splices can lower the performances of a fibre optic cable assembly and are used when necessary.

9.2 Requirements for optical fibre splicing

a. Splices shall not change the cross-section of the optical fibre path.

b. Splices shall be visually inspected by an inspector before the splice is recoated or a splice protector is installed.

c. Splices shall be contained in a splice enclosure to prevent mechanical stressing of the optical fibre and shall be sealed.

d. If splice enclosure cannot be used, the mechanical and environmental protection of the optical fibre shall be ensured (e.g. by additional loose splice tube component).

e. Splices shall be positioned so that they can be inspected after installation by inspectors, i.e. not located under cable supports.

9.3 Splice assembly

9.3.1 Equipment and tools for splicing

a. Clause 5.3.1 of this Technical Memorandum shall apply.

b. Clauses 5.3.2 of this Technical Memorandum shall apply.

c. Clauses 5.3.4 of this Technical Memorandum shall apply.

d. For chemical splicing, clause 5.3.5 of the present Technical Memorandum shall apply.

e. For fusion splicing, the set-up of the splicing tools shall be verified by the operator on blank samples prior to performing the splice on the optical fibre.

f. The blank splices samples shall be verified by an inspector as per sub clause 9.2 9.2b of this Technical Memorandum.

9.3.2 Splice procedure and verifications

a. Fibre optic cables shall be prepared for splicing in accordance with clause 5.4.4 of this Technical Memorandum.

b. The prepared optical fibres shall be inspected by the operator before splicing to ensure there is no contamination on the end-faces, unacceptable defects or other non-conformances with project's specific requirements.

c. Completed splices shall be protected from mechanical stresses and environmental conditions by e.g. a splice protector or re-coating, re-jacketing the optic cable.

NOTE A typical sequence for fusion splicing is:

- insert both prepared optical fibre extremities in the splicing equipment,
- apply power to locally fuse the optical materials,
- inspect the splice,
- apply protective layers (e.g. re-jacket).

d. Stress on the fibre at splice location shall be minimised by using a mechanical protector to prevent local bending

e. Splice should always be mechanically protected even if recoated and rejacketed.

NOTE Because the fibre at this location is substantially weaker than in other locations.

9.4 Verification testing and acceptance criteria for splices

9.4.1 Fusion splicing in process inspection

a. Prepared fibre optic cables shall be subject to in-process inspection in accordance with 7.1 7.1a.

b. The cleaved end-face geometry shall comply with the requirements of the fusion splicing equipment documentation.

c. Before applying protective layers on the splice, fused optical fibre zone shall be inspected by a trained inspector using both illuminated and non illuminated fibres for:

   1. low angular misalignment of the two spliced end-faces;
   2. absence of core diameter mismatch;
   3. low lateral offset of the two spliced end-faces;
   4. absence of a boundary layer or diffraction zone;
   5. absence of pores or bubbles in the splice.

d. Correct positioning of the protective layers and splice enclosure shall be verified by trained inspector.

9.4.2 Fusion splicing post process inspection

a. All cables containing splices shall be tested by a qualified inspector in accordance with Clause 7.2.2.

b. All splices shall be verified by certified inspector using Optical Time Domain Reflectometry (OTDR) or another test procedure for the measurement of attenuation loss.

c. Fusion splices shall be subjected to a pull-test

d. Unless stated otherwise in project documentation, splices shall withstand a minimum 10 Newton pull-test.

9.5 Splice layout

a. Splice trays shall be supported in such a way that they do not move during vibration and the fibre shall be loose enough to avoid thermal stresses.

b. Splices not protected by a splice tray shall be supported in such way that they do not move during vibration.

c. Splices shall be marked in such a way that they can be identified without touching them.

9.6 Quality assurance

a. All splices that are not documented in the project documentation shall be recorded and this record shall as a minimum, contain the following information:

   1. location;
   2. cable identification (number, circuit or other);
   3. cable size and type;
   4. manufacturers' name, part number and type of splice;
   5. attenuation loss.

b. The supplier shall provide the evaluation report for the splicing that conforms to the DRD in Annex C.

Annex A (normative)
Report on fibre optic cable assembly - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called by ECSS-Q-TM-70-51, requirement 5.10b.

A.1.2 Purpose and objective

The purpose of this DRD is to provide in a single document all information on materials, parts, processes, testing and inspections used during a fibre optic cable assembly. This document is applicable to the fibre optic cable assembly prior to its installation in a spacecraft or space equipment

A.2 Expected response

A.2.1 Scope and content

<1> Originator

a. The report shall contain the name, organization and address of the originator.

<2> System / Subsystem

a. The report shall contain the name of the system/subsystem on which the optical fibre assembly is used.

<3> Project

a. The report shall contain the name of the project for which the assembly is manufactured.

<4> Manufacturer

a. The report shall contain the name of the manufacturer of the assembly

<5> Use and location

a. The report on fibre optic cable assembly shall contain the use and location foreseen for the part.

<6> Engineering drawings

a. The report shall contain or refer to the engineering drawings of the fibre optical cable cross section

b. The report shall contain or refer to the engineering drawings of the connectors to be mounted

c. The report shall contain or refer to the engineering drawing of the fibre optic cable assembly

<7> Applicable documents

a. The report shall contain the applicable document list and the reference document list including the list of procedures to be applied and of standard to comply with

<8> Assembly list

a. The report shall identify or refer to the assembly list detailing all the elements constituting this assembly.

NOTE Elements can be materials, processes and parts.

b. The report shall identify all the fibre optic cable constituents.

c. The report shall identify the selected connectors.

d. The report shall identify the selected optical adhesive, its expiry date and its curing cycle.

<9> Pre-conditioning

a. The report shall contain, at least, the following preconditioning information related to the fibre optic cable:

1. minimum cycling temperature,
2. maximum cycling temperature,
3. heating and cooling rates,
4. dwell time at extreme temperatures,
5. number of cycles, and
6. evidence of the evolution of dl/l VS number of cycles for each of the layers composing the optical cable.

NOTE In case pre-conditioning is not performed the above pre-conditioning information can be replaced by a reference to the documents stating that the fibre is not susceptible to differential shrinkage.

<10> Processes

a. The report shall contain all the information related to the operations and associated controls performed when connecting the connectors to the fibre optic cable, including as a minimum the following:

1. results of the visual inspection of the fibre,
2. photographic evidence of the correctness of the cable layout,
3. correctness of the fibre stripping,
4. absence of defects in the connectors,
5. curing equipment verification results,
6. curing parameters,
7. verifications post curing on the connectors and on the assembly, and
8. traceability of the operators and inspectors who performed the activities.

NOTE All the above information can be collected in the traveller sheet accompanying the fibre optic cable

<11> Verification and testing

a. The report shall contain all the information related to the operations and associated controls performed when connecting the connectors to the fibre optic cable, including as a minimum the following:

1. photograph of the polished fibre end-faces using an x 200 magnification as a minimum with and without back-lightning, and
2. test reports of the terminated fibre optic cable assembly including the mean and variance of the optical insertion loss and pull test results.

<12> Storage packaging

a. The report shall contain all the information related to the storage conditions and packaging of the fibre optic cable starting from the incoming inspection until delivery to the customer.

NOTE The customer is in this case the entity installing the optic fibre cable in the system / subsystem.

A.2.2 Special remarks

None.

Annex B (normative) Report on fibre optic cable routing and layout - DRD

B.1 DRD identification

B.1.1 Requirement identification and source document

This DRD is called by ECSS-Q-TM-70-51, requirement 6.5a.

B.1.2 Purpose and objective

The purpose of this DRD is to provide in a single document all information on materials, parts, processes, testing and inspections used during a fibre optic cable routing and layout. This document is applicable to installation of the fibre optic cable in a spacecraft or space equipment

B.2 Expected response

B.2.1 Scope and content

<1> Originator

a. The report shall contain the name, organization and address of the originator.

<2> System / Subsystem

a. The report shall contain the name of the system/subsystem on which the optical fibre assembly is used.

<3> Project

a. The report shall contain the name of the project for which the optic fibre cable is layed-up.

<4> Manufacturer

a. The report shall contain the name of the manufacturer of the fibre optic cable assembly.

<5> Identification

a. The report shall contain all information allowing identifying unambiguously the optic fibre cable.

NOTE This can include the use and location foreseen for the part, the colour of the armour, the type of connector, the diameter or the bar-code.

<6> Cable specifications

a. The report shall contain or refer to the cable allowable and its physical limitations.

<7> Engineering drawings

a. The report shall contain or refer to the engineering drawings of the fibre optic cable routing path.

b. The report shall contain or refer to the engineering drawings and procedures of the special measures used to ensure that the fibre optic cable is not subjected to conditions above the physical allowable.

c. The report shall contain or refer to the engineering drawing and or procedures for supporting and tightening the optic fibre cable

<8> Verification and testing

a. The report shall contain all the information related to the operations and associated controls performed while routing the fibre optic cable, including as a minimum the following:

1. traceability of the operators and inspectors who performed the activities,

NOTE All the above information can be collected in the traveller sheet accompanying the fibre optic cable during layout.

2. photograph of the routed fibre optic cable, and
3. photograph of the connected connectors.

B.2.2 Special remarks

None.

Annex C (normative)
Report on fibre optic cable splicing - DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-TM-70-51, requirement 9.6b.

C.1.2 Purpose and objective

The purpose of this DRD is to provide in a single document all information on materials, parts, processes, testing and inspections used during a fibre optic cable splicing. This document is applicable to fibre optic cable assemblies installed in a spacecraft or space equipment

C.2 Expected response

C.2.1 Scope and content

<1> Originator

a. The report shall contain the name, organization and address of the originator.

<2> System / Subsystem

a. The report shall contain the name of the system/subsystem on which the optical fibre assembly is used.

<3> Project

a. The report shall contain the name of the project for which the splice is done.

<4> Manufacturer

a. The report shall contain the name of the manufacturer of the assembly

<5> Use and location

a. The report on fibre optic cable assembly shall contain the use and location foreseen for the part.

<6> Engineering drawings

b. The report shall contain or refer to the engineering drawings of the fibre optical cable cross section.

c. The report shall contain or refer to the engineering drawings of the fibre optic cable layout.

d. The report shall contain or refer to the engineering drawings of the terminated splice including splice mechanical protection.

<7> Applicable documents

a. The report shall contain the applicable document list and the reference document list including the:

1. NCR or other document providing the rationale for performing splicing,
2. documents related to the qualification of the repair method,
3. list of procedures to be applied,
4. list of standards to comply with.

<8> Processes

a. The report shall contain all the information related to the operations and associated controls performed when performing the splicing, including as a minimum the following:

1. photographic evidence of the correctness of the splice location with respect to the cable layout,
2. verification of the set-up of the splicing tool with photographic evidence of the correctness of the blank samples,
3. correctness of the fibre stripping,
4. photographic evidence of the correctness of the splice with and without illumination of the fibre for low angular misalignment, absence of core mismatch, low lateral offset of the two end faces, absence of a boundary layer or diffraction zone and absence of pores or bubbles in the splice,
5. photographic evidence of the correctness of the installation of the protection layers or splice enclosure.
6. traceability of the operators and inspectors who performed the activities

NOTE All the above information can be collected in the traveller sheet accompanying the fibre optic cable splice.

<9> Verification and testing

a. The report shall contain all the information related to the operations and associated controls performed when testing the performances of the splice, including as a minimum the following:

   1. pull test result on the splice or, on the blank samples protected as the splice,
   2. test reports of the OTDR performed from both ends of the spliced optic fibre, and
   3. test report of the signal loss of the spliced fibre optic cable assembly including the minimum and maximum signal losses measured.

C.2.2 Special remarks

None.

Annex D (informative)
Examples of fibre, connector and tooling

The illustrations in this annex depict typical tooling and hardware encountered in optical fibre assembly.

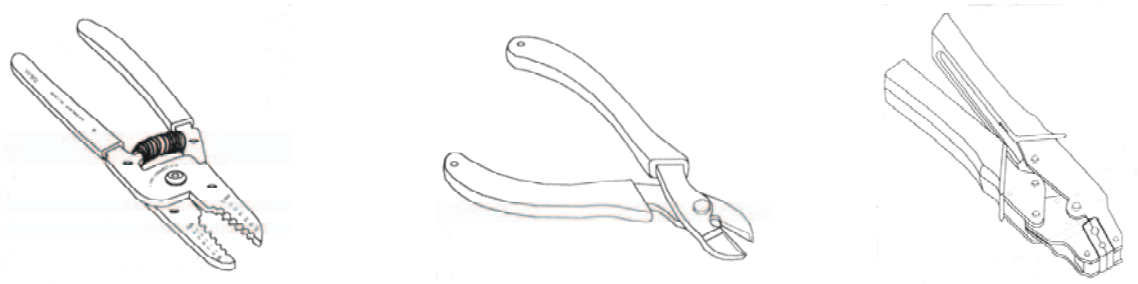


Figure D-1: Examples of commercially available tools for fibre optic cable preparation

Figure D-2: Example of commercially available scribing tool

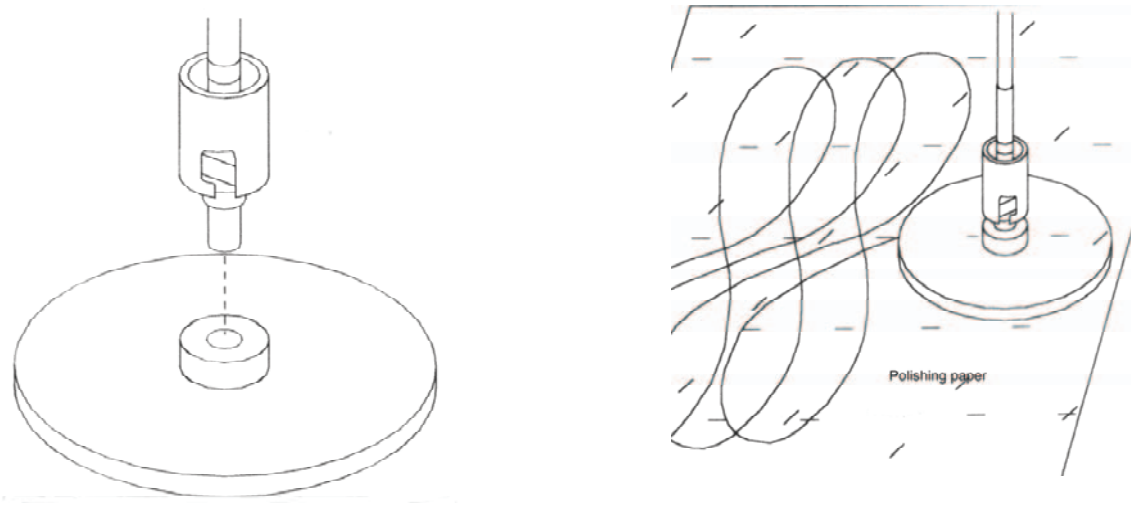


Figure D-3: Example of commercially available polishing jig

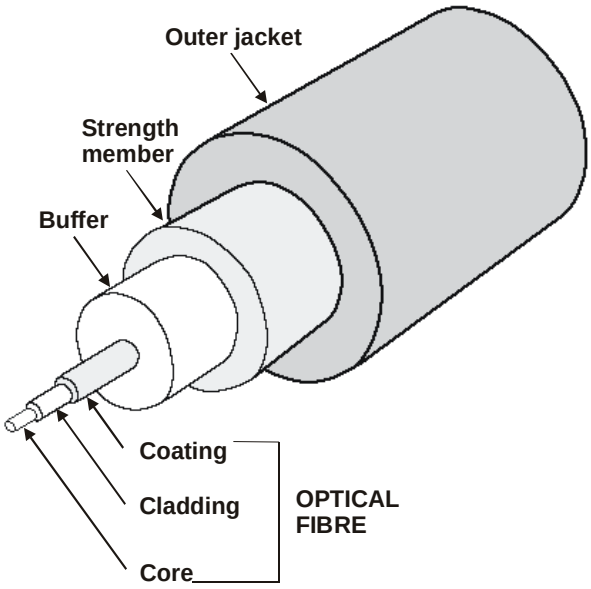


Figure D-4: Example of the component parts of a fibre optic cable

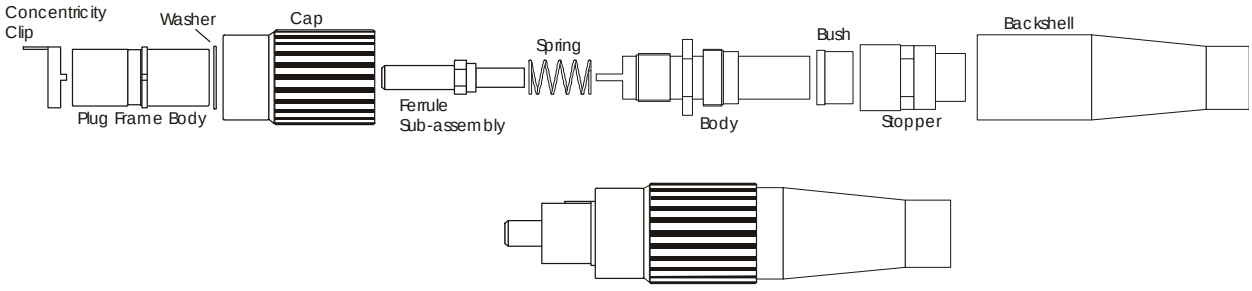
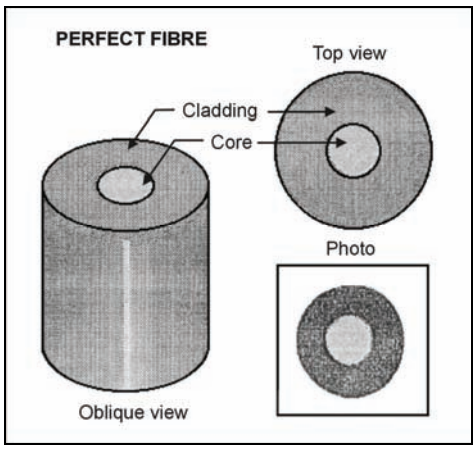
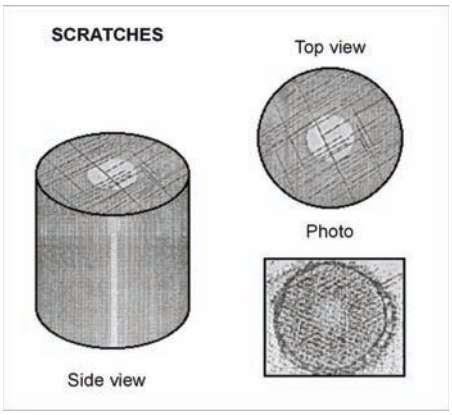


Figure D-5: Example of commercially available fibre optic connector.
Top - exploded view, Bottom – assembled view

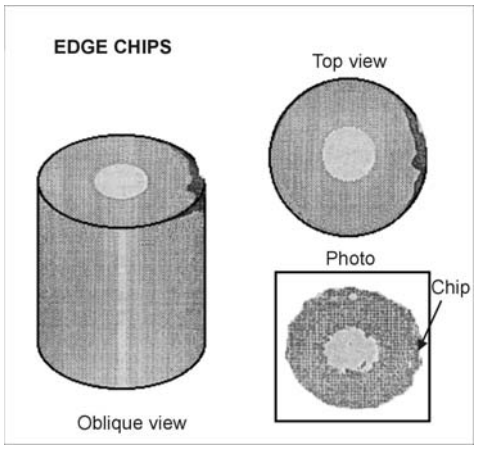
Annex E (informative) Workmanship standards: typical satisfactory and unsatisfactory optical fibre end faces

The illustrations in this annex depict typical satisfactory and unsatisfactory prepared and polished optical fibre endfaces and shall be used as visual workmanship standards

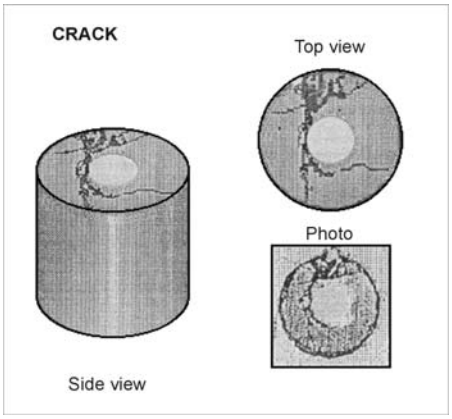




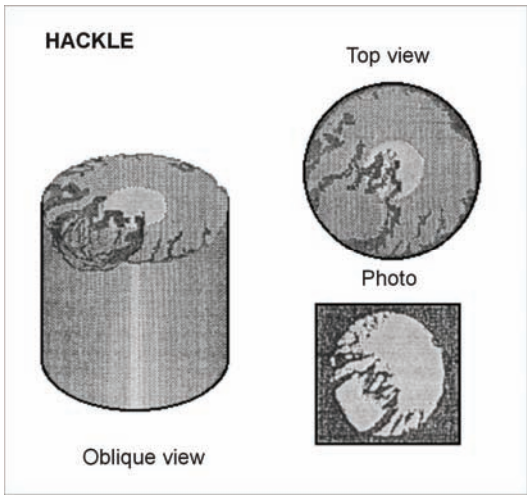
SCRATCHES: UNACCEPTABLE



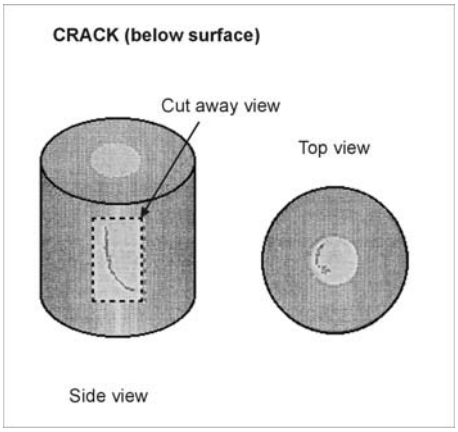
EDGE CHIPS: UNACCEPTABLE



CRACK (surface): UNACCEPTABLE

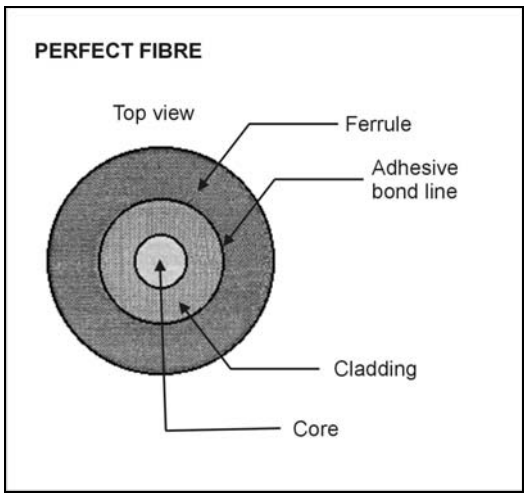


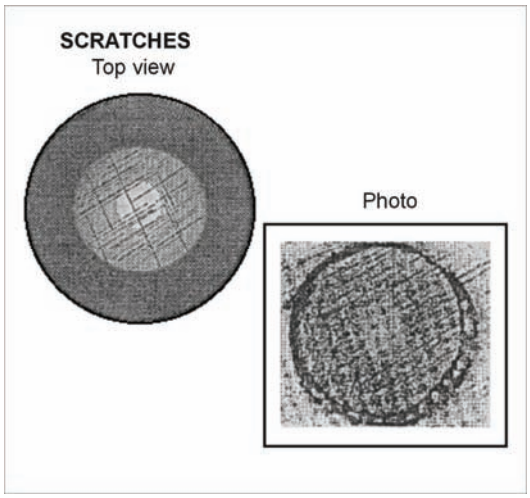
HACKLE: UNACCEPTABLE



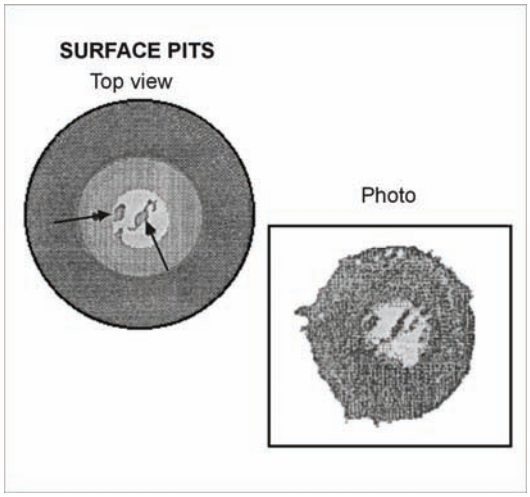
CRACK (subsurface): UNACCEPTABLE

Figure E-1: Bare optical fibre (backlit)

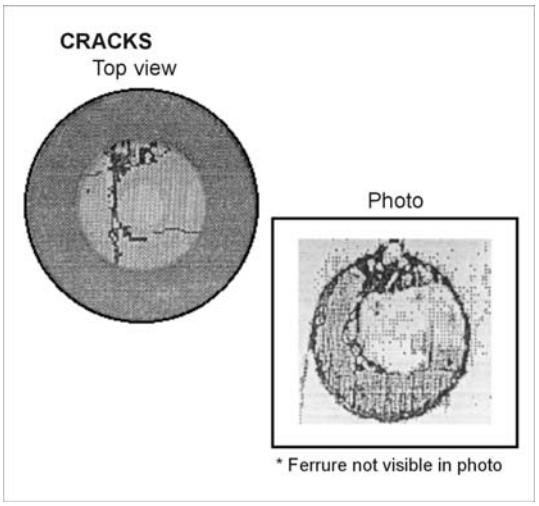




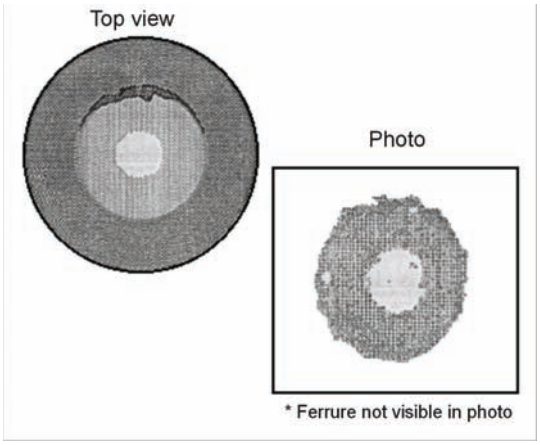
SCRATCHES: UNACCEPTABLE



SURFACE PITTING: UNACCEPTABLE

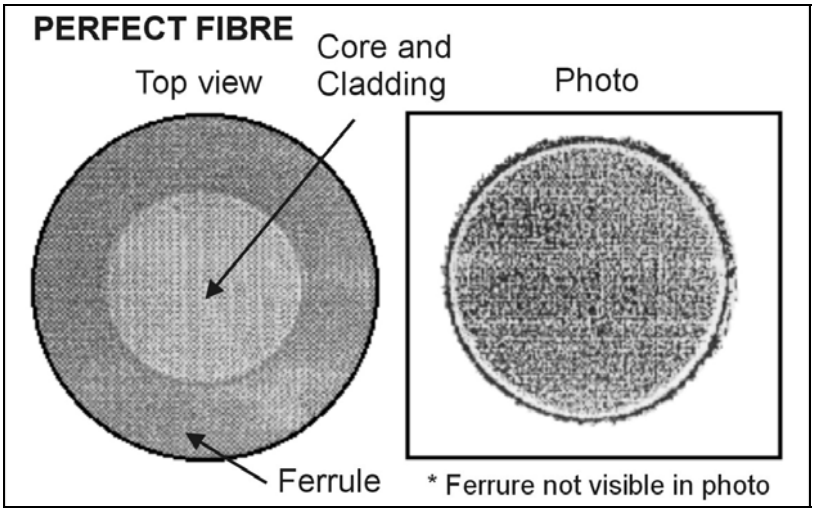


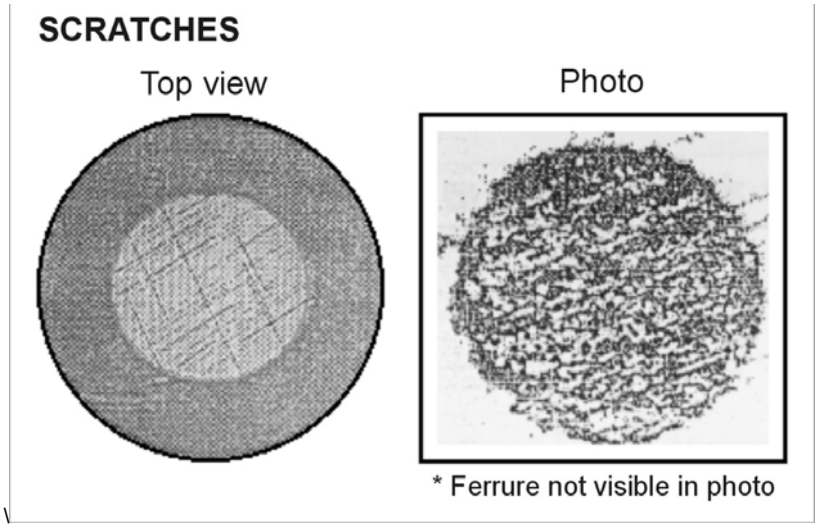
CRACKS: UNACCEPTABLE



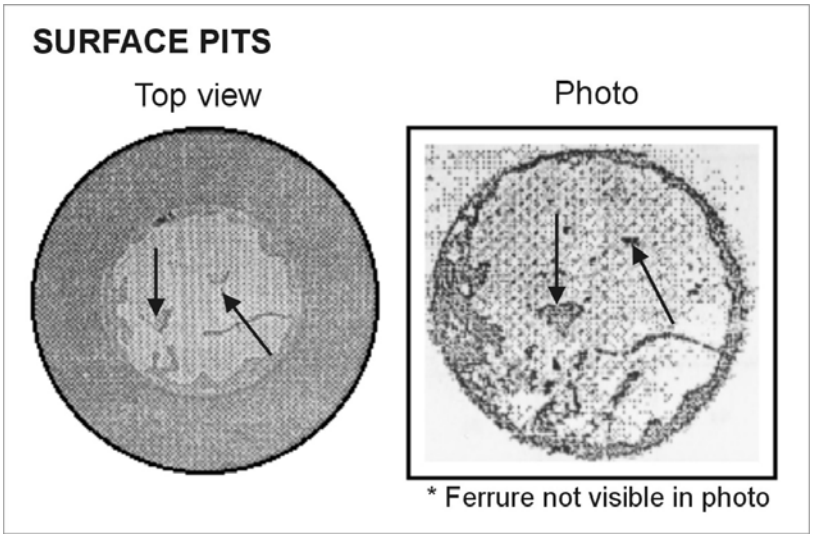
EDGE CHIPS: UNACCEPTABLE

Figure E-2: Mounted optical fibre (backlit)





SCRATCHES: UNACCEPTABLE



SURFACE PITS: UNACCEPTABLE

Figure E-3: Mounted optical fibre (direct lit)

Annex F (informative) Manufacturing and verification flow chart for fibre optic cable assembly

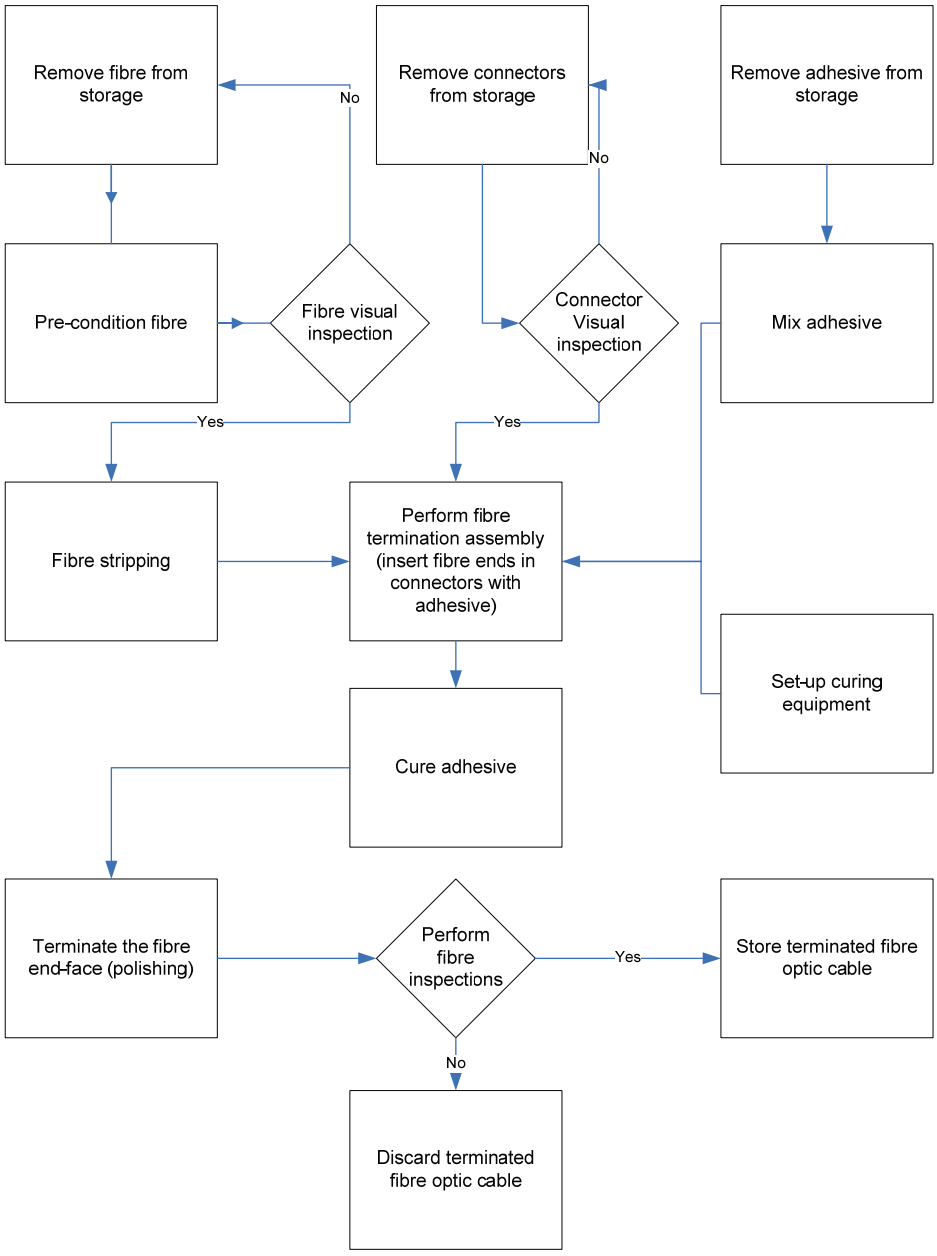


Figure F-1: Manufacturing and verification flow chart for fibre optic cable assembly

Bibliography

ECSS-S-ST-00 ECSS system – Description, implementation and general requirements