SLOVENSKI STANDARD

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Aerospace series - Cables, electrical, aircraft use - Test methods - Part 706: Laser markability

Luft- und Raumfahrt - Elektrische Leitungen für Luftfahrtverwendung - Prüfverfahren - Teil 706: UV-Laser-Markierung

Série aérospatiale - Câbles électriques à usage aéronautique - Méthodes d'essais - Partie 706 : Marquabilité laser UV

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Aerospace series - Cables, electrical, aircraft use - Test methods - Part 706: Laser markability

Série aérospatiale - Câbles électriques à usage aéronautique - Méthodes d'essais - Partie 706 : Marquabilité laser UV

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This European Standard was approved by CEN on 12 September 2005.

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Foreword

This European Standard (EN 3475-706:2005) has been prepared by the European Association of Aerospace Manufacturers - Standardization (AECMA-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of AECMA, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2006, and conflicting national standards shall be withdrawn at the latest by April 2006.

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

UV laser wire marking is the aerospace industry standard method for marking identification codes on to the surface of electrical wires or cables. UV laser wire marking was developed in 1987 to provide a safe, permanent means of marking thin wall insulations in particular, as an alternative to hot stamp wire marking, which is considered to be an aggressive process.

1 Scope

This standard specifies the test method to establish the ultra violet (UV) laser marking performance of aerospace wire and cable for use in conjunction with UV laser wire marking systems in accordance with TR 4543 "UV laser wire marking systems for aircraft wire and cable identification" and EN 3475-100 "Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General".

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 3838, *Aerospace series — Requirements and tests on user-applied markings on aircraft electrical cables.* 1)

EN 3475-100, *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General.*

EN 3475-705, *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 705: Contrast measurement.*

TR 4543, *UV laser wire marking systems for aircraft wire and cable identification.* 2)

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
laser
laser is an acronym for Light Amplification by the Stimulated Emission of Radiation. Lasers are a source of intense monochromatic light in the ultraviolet, visible or infrared region of the spectrum. The "active" or lasing medium may be a solid, liquid or gas. The laser beam is generated by energising the active medium using an external power source, which is most commonly electrical or optical.

3.2
ultraviolet (abbreviation UV)
electromagnetic radiation in a wavelength range from approximately 200 nm to 400 nm

1) Published as AECMA Prestandard at the date of publication of this standard.

2) In preparation at the date of publication of this standard.

3.3
UV laser
a laser that produces a beam of UV radiation

3.4
fluence
the energy density, measured in J cm^{-2} (Joules per square cm) of a single pulse of the laser beam, which, for the purposes of this document, is at the surface of the wire insulation or cable jacket

3.5
pulse length
the time interval between the laser energy crossing half the maximum energy on the rising and the falling edges of the pulse; referred to as FWHM — full width half maximum. Pulse lengths are measured in nanoseconds, ns. 1 ns = 10^{-9} s.

3.6
wavelength (λ)
wavelength is measured in nanometres, nm. 1 nm = 10^{-9} m. $\lambda = c/f$ where c is the velocity of light and f is the frequency

3.7
damage
for the purpose of this document, damage is defined as an unacceptable reduction in the mechanical or electrical properties of a wire's insulation, i.e. specifically a measurable reduction in the performance of the wire which is outside of its defined and acceptable specification

Wire surface defects that are visible only through × 10 magnification or greater, such as bubbles or flakes, should not be considered as damage unless they would affect marking performance (contrast, legibility, or other behaviour according to EN 3838) or other properties of the wire insulation.

3.8
Nd (neodymium)
neodymium is an elemental metal that forms the active laser material in the most common type of solid state laser. The neodymium is held in an optically transparent solid "host" material, and is energised by optical input, either from a flash lamp or from the optical output from a diode laser. The host material does not play a direct role, but can slightly influence the laser wavelength. Typical host materials are specialised crystal materials, such as Yttrium Aluminium Garnet (YAG) and Yttrium Lithium Fluoride (YLF). These lasers are commonly referred to as Nd:YAG or Nd:YLF respectively. The primary wavelength of Nd solid state lasers is in the infrared (IR) at a wavelength of approximately 1 064 nm. The IR output of such lasers can be conveniently reduced to lower wavelengths suitable for wire marking by use of harmonic generation (see 3.10).

3.9
excimer
a gas laser deriving its name from the term "excited dimer". The laser is energised by means of a gas discharge. Excimer lasers are available operating at a number of discrete wavelengths throughout the UV, the most common of which are 193 nm, 248 nm, 308 nm and 351 nm. The wavelength is dependant only on the gas mix used; 308 nm is commonly used for UV laser wire marking.

3.10
harmonic generation
the use of non-linear optical processes to change the wavelength of a laser by frequency conversion. This enables the output of an infrared laser to be converted to shorter wavelengths. In the case of Nd lasers this results in a frequency doubled output at 532 nm in the green and a frequency tripled output at 355 nm in the UV, which is used for wire marking.

4 Requirements

4.1 General

4.1.1 Preparation of wire samples

Take a sample of the wire for marking. Before marking the wire ensure that the wire surface is clean and dry and free from dust and dirt. For initial production it should only be necessary to clean the wire with a dry cloth. However, in some situations, for instance if the wire is contaminated with oil or is very dirty, it may be necessary to wipe it clean using Propan-2-ol (Isopropyl alcohol).

4.1.2 Laser marking system

A suitable laser must be used to mark the wire samples. Based on commonly used laser sources employed in UV laser wire marking systems within the aerospace industry, it is recommended that either one of the ultra violet (UV) laser types listed in the following Table 1 is used for marking the wire samples. These are pulsed lasers that provide the very short pulse lengths and intense, high power pulses of UV light required for creating marks on aerospace wire insulation. The laser pulse length shall be within the range of 1 ns to 30 ns.

Table 1

Laser type	Wavelength nm	Pulse length [a] ns
Frequency tripled Q-switched Neodymium YAG, (Nd:YAG), solid state laser	355	4 to 20
Xenon chloride (XeCl) excimer gas laser	308	10 to 30

[a] The pulse length ranges quoted are typical of commercially available lasers.

IMPORTANT — Other laser types may only be employed provided they comply with the requirements of TR 4543.

To measure the marking performance of the wire it is necessary to measure the contrast of the mark made by the UV laser beam. The mark should be made using a laser and optical beam delivery system that incorporates a mask with a suitable cut out, e.g. in the shape of a square or rectangle, so that a clearly defined mark can be made on the wire surface for measurement. See Figure 1. To enable the mark contrast to be accurately measured, a well-formed mark with minimum dimensions of (1 × 1) mm is required, subject to the wire gauge being large enough to accommodate this. See Figure 2.

It is important that the intensity of that part of the laser beam used for marking the samples and subsequent contrast measurement should be uniform to within ± 10 % when projected on to a flat surface at the focal point of the beam delivery system. This is to ensure that fluctuations in the mark contrast due to changes in the laser intensity within the marking field are kept to a minimum. To ensure that this is the case suitable, purpose designed test equipment must be used for the laser marking, or alternatively, appropriate diagnostic equipment must be used to confirm that the laser beam intensity is within the required limits. Figure 3 shows an acceptable laser beam profile.

IMPORTANT — The contrast achieved may vary for certain combinations of wire types and lasers, in particular wires with ethylenetetrafluoroethylene extruded insulations, whether cross linked or non-cross linked, are likely to exhibit a higher contrast with 355 nm Nd:YAG lasers than with 308 nm excimer lasers. It is therefore important to record the type of laser used in the tests. In general, wires with insulations made from polytetrafluoroethylene are unlikely to exhibit this tendency.

4.1.3 Laser marking fluence

Marking should be carried out as follows:

A marking fluence of (0,9 ± 0,1) J cm^{-2} should be used **unless** the wire type under test is specified for marking at a different fluence. This fluence level has been determined to be satisfactory for achieving the maximum contrast, or satisfactory contrast levels, on all common aerospace wire and cable types and is representative of the majority of equipment in use, albeit that some equipment does function with higher fluence levels. It should be noted that the fluence is specified here for the purposes of defining the requirements for determining the laser markability of the wire only.

The system used must ensure that the laser fluence delivered to the wire remains within the specified range for all markings.

NOTE For marking on the smallest gauge wires in production situations, e.g. 24 and 26 gauge, it may be necessary with some wire types and equipment to utilise higher fluences at the wire centre. This is to ensure that the fluence at the edge of the mark remains above the minimum required to achieve the desired contrast while accommodating the geometric affects of the wire curvature, which reduces the fluence as the laser beam rolls off at the edges.

WARNING — Care must be taken that maximum permissible fluence is not exceeded in such cases: refer to the appropriate product or other specification.

4.1.4 Determination of laser fluence

The laser fluence should be determined by first measuring the laser beam energy after it has passed through the mask aperture (see Figure 1) using a suitable calibrated laser energy calorimeter. The area of the laser beam should be determined by making a mark on a suitable piece of flat plastic material held at the focal point of the laser system. NB when marking wire samples, take care to ensure that the top centre of the wires are positioned in the same plane as the flat plastic sample to ensure that the marking is carried out at the same fluence.

After making a mark on the flat plastic material the area of the laser beam should be determined by measuring the mark dimensions using a suitable microscope and graticule. The fluence may be calculated by dividing the laser beam energy by the mark area.

4.2 Sample marking

Take the sample of wire and mark it according to the above instructions at appropriate intervals along the length of the wire. It is important to ensure that the laser marks do not overlap when doing this. Make sure that the laser beam is centralised on the wire axis to ensure accurate marking.

For the purposes of determining the laser markability of a batch of wire during manufacture, samples of wire should be marked taken from the wire at both the start and the end of a run.

4.3 Sample measurement

4.3.1 Contrast measurement

After marking the wire measure the contrast of the resulting marks on the wire insulation using a suitable contrast measurement system in accordance with EN 3475-705 "Aerospace series — Cables, electrical, aircraft use — Test methods — Part 705: Contrast measurement".

4.3.2 Sample area

When measuring the contrast of the marks ensure that measurements are made on the marked and unmarked areas about the central axis of the wire and just either side within a band equal to ± 20 % of the diameter of the wire or cable, to ensure that the most uniform part of the mark is measured so that errors are not introduced caused by changes in the laser fluence resulting from the curvature of the wire. See Figure 2.