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BSI Standards Publication

Aircraft ground equipment — De-icers — Functional requirements

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National foreword

This British Standard is the UK implementation of ISO 11077:2014. It supersedes BS M 77:1994 which is withdrawn.

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Aircraft ground equipment — De-icers — Functional requirements

Matériel au sol pour aéronefs — Dégivreuses — Exigences fonctionnelles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

This second edition cancels and replaces the first edition (ISO 11077:1993),which has been technically revised.

Introduction

This International Standard specifies the functional and personnel safety requirements to be taken into account by manufacturers for the design of aircraft de-icing and anti-icing vehicles (de-icers).

The requirements of this International Standard were determined based on generally recognized assumptions as to

a) the normally intended use of aircraft ground support equipment on the ramp of international civil airports in order to handle, service, or maintain civil transport aircraft, or

b) the environmental (surface, slope, weather, lighting, operating rules, staff qualification, etc.) conditions prevailing on the ramp area of the majority of international civil airports. In addition to customary environment conditions in this context, it is to be assumed that de-icers will be operated on snowy, icy, muddy, or slushed ramp surfaces and under freezing precipitation conditions.

It is assumed that the manufacturers of de-icers define in the relevant documentation the specifically intended conditions of use and environment for their equipment, and the purchasers systematically review their own specific conditions of use and environment in order to determine whether those stated are adequate or negotiate with the manufacturer appropriate modifications to ensure they are.

NOTE Negotiation between manufacturer and purchaser/user is considered essential to establish or verify the adequate conditions of use and design parameters.

The requirements of this International Standard are expressed in the applicable SI units, with approximate inch-pound unit conversion between brackets for convenience in those countries using that system. Where it is deemed necessary to use exact values, the SI unit ones are to be used.

Aircraft ground equipment — De-icers — Functional requirements

1 Scope

This International Standard specifies the general functional, performance, and safety requirements for a self-propelled vehicle equipped with a boom type aerial device and aircraft de-icing/anti-icing fluid (ADF) spraying systems, hereinafter designated as “de-icer”.

This International Standard does not specify a comprehensive set of technical design criteria for aircraft de-icing/anti-icing vehicles, but only those relating to the main functional, safety, and performance requirements.

This International Standard is not applicable to stationary equipment, e.g. gantries, cranes, used to perform de-icing/anti-icing operations on aircraft.

Throughout this International Standard, the minimum essential criteria are identified by use of the key word “shall”. Recommended criteria are identified by use of the key word “should” and, while not mandatory, are considered to be of primary importance in providing safe, economical, and usable aircraft de-icers. Deviation from recommended criteria should only occur after careful consideration and thorough service evaluation have shown alternate methods to provide an equivalent level of safety.

2 Normative references

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

ISO 6966-1, *Aircraft ground equipment — Basic requirements — Part 1: General design requirements*

ISO 6966-2, *Aircraft ground equipment — Basic requirements — Part 2: Safety requirements*

ISO 7000, *Graphical symbols for use on equipment — Registered symbols*

ISO 10254, *Air cargo and ground equipment — Vocabulary*

ISO 11075, *Aircraft — De-icing/anti-icing fluids — ISO type I*

ISO 11076, *Aircraft — De-icing/anti-icing methods on the ground*

ISO 11078, *Aircraft — De-icing/anti-icing fluids — ISO types II, III and IV*

ISO 11532, *Aircraft ground equipment — Graphical symbols*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

EN 1915-2, *Aircraft ground support equipment — General requirements — Part 2: Stability and strength requirements, calculations and test methods*

EN 12312-6, *Aircraft ground support equipment — Specific requirements — Part 6: De-icers and de-icing/anti-icing equipment*

DIN 51130:2010, *Testing of floor coverings — Determination of the anti-slip property — Workrooms and fields of activities with slip danger, walking method — Ramp test*

NOTE DIN 51130 can be obtained from Deutsches Institut für Normen, Burggrafenstrasse 6, D-10787 Berlin, Germany.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10254 and the following apply.

3.1
de-icer
self-propelled mobile unit, used to perform de-icing or anti-icing operations by means of fluids spraying on aircraft on the ground

Note 1 to entry: It is fitted with an operator cabin or basket mounted on a boom in order to raise the operator at the height of aircraft surfaces to be sprayed.

3.2
driver
person located in the cabin (driving station) of a de-icer's chassis and driving the vehicle around the aircraft

3.3
operator
person(s) located in the boom mounted operator's cabin or basket, operating its movements relative to the de-icer's chassis as well as the fluid spraying system(s)

3.4
cabin (operator's)
completely enclosed work station at the end of the de-icer's boom, where the operator is located to perform de-icing/anti-icing operations on the aircraft

3.5
basket (operator's)
non-enclosed work station at the end of the boom where the operator stands alternatively to a cabin

3.6
boom
structural element supporting the operator's cabin or basket at a height

Note 1 to entry: Not to be mistaken for "spraying boom", an element extending from the operator's station to support spraying hoses and brings the nozzles as close as possible to the aircraft being de-iced, which does not support persons.

4 Requirements

4.1 General

4.1.1 The de-icer's design and construction shall meet the applicable requirements of ISO 6966-1 and ISO 6966-2, and the requirements stated hereafter. Where these requirements are in excess of those in the general aircraft ground equipment standards, they shall take precedence.

NOTE For operation in Europe, the EU Machinery Directive essential safety requirements legally apply. They can be met by complying with the requirements of the following European Standards (see Clause 2 and Bibliography):

— EN 1915-1, *Aircraft ground support equipment — General requirements — Part 1: Basic safety requirements*

— EN 1915-2, *Aircraft ground support equipment — General requirements — Part 2: Stability and strength requirements, calculations and test methods*

— EN 1915-3, *Aircraft ground support equipment — General requirements — Part 3: Vibration measurement methods and reduction*

— EN 1915-4, *Aircraft ground support equipment — General requirements — Part 4: Noise measurement methods and reduction*

— EN 12312-6, *Aircraft ground support equipment — General requirements — Part 6: De-icers and de-icing equipment*

4.1.2 The de-icer's structural strength shall meet the applicable stability and strength requirements of EN 1915-2 and EN 12312-6 and be demonstrated by testing in accordance with them.

4.1.3 Particular attention shall be paid to the fatigue strength requirements for the boom and attachments thereto, which shall be based on minimum 2×10^4 stress cycles or 10 000 h operating life expectancy, whichever is highest.

NOTE Consultation between manufacturer and purchaser is required to substantiate a realistic life expectancy, stress cycle definition, and fatigue spectrum.

4.1.4 The de-icer and all associated systems shall be designed and constructed to operate satisfactorily between temperatures of −30 °C and 50 °C (−20 °F and 120 °F) and in continuous relative humidity of up to 95 % or as stipulated between purchaser and manufacturer.

NOTE Lower temperatures, requiring special design and operating measures, can be agreed between manufacturer and purchaser. See Note in the Introduction.

4.2 Functions

4.2.1 The primary function of the de-icer shall be to apply heated de-icing/anti-icing fluid from a variable height boom to the surfaces of stationary aircraft while traversing their perimeter. A hose shall also be fitted for ground use. The vehicle shall be acceptable for use around terminal gate areas, airport service roads, and aircraft service ramps.

NOTE A secondary function can also be to provide access when required to high elevation parts of the aircraft.

4.2.2 The maximum width and overall height with the boom in the stowed position shall be kept to a minimum. The maximum overall width should be minimum compatible with stability objectives, and the overall height in the stowed position shall not exceed 4,0 m (13 ft, 1 in). Overall turning radius in this position should not exceed 12 m (40 ft), though maximum possible manoeuvrability is recommended.

NOTE Over the road regulations in a majority of states allow a maximum width of 2,5 m (8 ft 2 1/2 in). A number of states allow 2,6 m (8 ½ ft) width. Conversely, some local road traffic regulations can require narrower widths. Depending on the airport of use, a lower height can also be necessary. See Note in the Introduction.

4.2.3 On an appropriate self-propelled chassis with an enclosed driver's cabin, meeting the requirements of 4.3, the de-icer shall provide

a) an aerial device with operator's cabin or basket, including safe access means from the ground in the stowed position, meeting the requirements of 4.4,

b) (a) fluid storage and supply tank(s), large enough to accommodate the fluid capacity necessary for servicing standard-body and/or wide-body or large capacity aircraft as required by the purchaser, meeting the requirements of 4.5.2, and

c) fluid pumping systems for applying heated de-icing fluid and heated or unheated anti-icing fluid to aircraft surfaces, meeting the requirements of 4.5.1.

See Clause 6 for optional features.

4.2.4 A two-way vocal communication system shall be installed between the operator's cabin or basket and the driver's cabin, if separate. The operator's cabin or basket headset, if applicable, shall be integrated or compatible with protective ear mufflers, and its wiring's routing shall be ergonomically designed in order to avoid any hazard or entanglement.

4.2.5 De-icers are intended to spray aircraft under freezing conditions with the following appropriate fluids mixed with water (if applicable) and heated as necessary, in order to enable operators to de-ice/anti-ice aircraft in accordance with the detailed methods stated in ISO 11076:

a) ISO type I de-icing/anti-icing fluid (see ISO 11075);

b) ISO type II, III, or IV de-icing/anti-icing fluid (see ISO 11078).

4.2.6 De-icers can also be used, without spraying, as a means of technical staff access to elevated parts of aircraft, e.g. for maintenance. Reduced performance requirements can apply in such a case where identified in the present International Standard, but personnel safety requirements remain applicable.

4.3 Vehicle

4.3.1 The de-icer shall be based on a chassis rated and approved by the chassis manufacturer for the maximum intended loads and speeds of the de-icer. Alternately, a custom built chassis is allowable under the manufacturer's responsibility and shall substantiate loads and speeds ratings in an at least equivalent manner.

4.3.2 The de-icer with operator's cabin or basket in the stowed position should be capable of being driven at normal road speeds in accordance with applicable local airport regulations, or at least 32 km·h^{-1} (20 mph). When the operator's cabin or basket is lifted from the stowed position, maximum speed shall be limited to no more than 1,7 m·s^{-1} (6 km·h^{-1}, 4 mph) or, if lower, local safety regulations. Where this is ensured by interlocking, the corresponding safety device shall ensure a performance level "b" in accordance with ISO 13849-1.

4.3.3 The drive train of the vehicle shall be designed for as smooth and jerk free driving as possible. It is further recommended to consider manoeuvring close to the aircraft. For this purpose, the possibility of driving with an inching/creeping speed should be considered.

4.3.4 An enclosed heated cabin for the driver, and optionally a passenger, shall be provided. The cabin shall be fitted with windshield wipers and a defroster/heater system. The design of the vehicle shall be such that no de-icing/anti-icing vapours can enter the chassis cabin (with windows closed) under any weather conditions. The cabin shall, as a minimum, be equipped with a mechanical filter on the air intake, for removal of aerosols produced. All seats shall be fitted with automotive type 3 points inertia reel safety belts.

4.3.5 The driver's position shall have maximum unobstructed visibility, including of the operator's cabin or basket under all operating conditions. This requires at least a large overhead transparent panel fitted with wipers and defrosting.

NOTE Where blind spots are unavoidable by design, e.g. at the rear of the vehicle, indirect means of vision such as mirrors or closed circuit television (CCTV) can be used to provide the driver with visibility in those areas.

4.3.6 Power steering as well as a power-assisted dual circuit service braking system and a parking brake shall be provided.

4.3.7 Mud/snow tires shall be provided on drive wheels. Drive wheels tire clearances shall be adequate for the installation and operation of snow chains. Any vulnerable components shall be suitably protected against projections of snow or ice.

4.3.8 The fuel tank(s) shall be located for protection against collision damage, and so that any overflow during filling, or any leakage from the tank, fuel lines, or fittings, will not impinge on engines exhaust system, electrical system, or other ignition sources, or enter the driver's cabin.

4.3.9 Tow hooks shall be installed on the chassis structure, with at least one at the front and one at the rear. The tow hooks shall be usable with the operators' cabin or basket in any position.

4.3.10 Storage electrical batteries shall be of the heavy duty type, and alternators shall be dimensioned bearing in mind that de-icing units often operates in engine idle condition but with all electrical consumers switched on.

4.4 Aerial device

4.4.1 The de-icer shall provide an aerial device including a supporting boom, to which shall be attached either an enclosed operator's cabin fitted with windshield wipers and a defroster/heater system, or (see Note in the Introduction) an open operator's basket entirely surrounded by full guard-rails up to a height of at least 1,1 m (43 in) over its floor. Cabin or basket shall be rated for a minimum of two persons (minimum load capacity of 204 kg/450 lb), to provide for operators training and possible visual de-icing control by a separate qualified person. Where these objectives are not retained, a cabin or basket intended for a single person shall be rated for a minimum load capacity of 160 kg (350 lb).

4.4.2 The operator's cabin or basket and its supporting boom shall be designed to position an operator to effectively apply de-icing/anti-icing fluid to the upper areas of aircraft control surfaces, wings, vertical and horizontal stabilizers, and fuselage. Consideration shall be given to the height of these surfaces on aircraft types intended to be serviced while designing or selecting any de-icer type.

4.4.3 The operator's cabin or basket shall have a self-adjusting mechanism to maintain a vertical operating attitude for all boom positions.

4.4.4 The operator's cabin or basket shall allow safe access from the ground in the stowed position, and provide for safe and easy entry and exit. The cabin door or basket gate shall not fold or open outwards, and shall be constructed to either be automatically self-closing and latching, or boom movements, including lifting from the stowed position, be prohibited unless the cabin door or basket gate is closed and fully latched. Where this is ensured by interlocking, the corresponding safety device shall ensure a performance level "c" in accordance with ISO 13849-1.

4.4.5 The design of the operator's cabin shall be such as to strictly minimize, in as much as possible, entry of de-icing/anti-icing fluids aerosols (with windows closed). See Annex A for toxicological hazards. The cabin shall, as a minimum, be equipped with a mechanical filter on the air intake, for removal of aerosols produced.

4.4.6 The cabin's inner operator envelope shall take into account the likeliness of operators wearing heavy winter clothing, boots, and gloves. The cabin, unless fitted with seats with safety belts for all occupants, or basket shall be fitted with harness anchorage points for personal protective equipment (PPE) harness(es). If provided, operator seat(s) shall be fitted with automotive type 3 points inertia reel safety belts.

4.4.7 (A) lighting projector(s), adjustable from the operator's cabin or basket, shall be provided to illuminate the spraying area for night operation. The minimum total luminous flux shall be 1000 lm (equivalent to approximately 100 W incandescent lamp power).

4.4.8 The structural and fatigue strength of the cabin or basket, its attachment to the boom, the boom itself, and its attachment to the chassis shall be in accordance with the requirements of 4.1.2 and 4.1.3. The aerial device, including the cabin, the boom, and its attachment to the chassis shall be designed in such a manner that periodic structural inspection can readily be carried out without major disassembly.

4.4.9 All steps and platforms shall have a self-draining surface, durably slip-resistant with a minimum R11 slip resistance classification in accordance with Table 3 of DIN 51130:2010 (see ISO 6966-2).

4.5 Fluids system

4.5.1 General

4.5.1.1 The vehicle's fluids handling system shall be designed to be compatible with the appropriate ISO de-icing/anti-icing fluids (ISO 11075 type I and/or ISO 11078 types II, III, or IV). Special fluid circuit design requirements shall be met to avoid degrading the fluid's viscosity, which can be adversely affected by pumping, heating, and spraying, or by too high storage temperatures. The fluid manufacturers' recommendations shall be observed.

4.5.1.2 The de-icing fluids systems and all their components shall withstand fluids temperatures from –20 °C (–4 °F) to 96 °C (205 °F), or as stipulated between purchaser and manufacturer.

4.5.2 Tanks

4.5.2.1 The fluid tank(s) shall be made of non-corrosive material and adequately baffled to prevent undue fluid motion and starving of the fluid pump during manoeuvring. Suitable vents, overflows, manual fills, and liquid level gauges and drains shall be provided. A manhole or equivalent with cover shall be provided and allow easy and safe inspection/cleaning of the tank.

4.5.2.2 De-icing fluid tanks shall be optimally insulated.

4.5.2.3 If fluid tanks are provided with filling couplings, these shall be of different types or have different sizes, for each individual tank to avoid filling with a wrong fluid.

4.5.3 Spraying

4.5.3.1 The de-icing fluid system shall be capable of delivery rate at the spray nozzle of at least 150 $l \cdot mn^{-1}$ [40 gal (US)/min] at a pre nozzle discharging pressure of 700 kPa (100 psi) at any spraying height.

4.5.3.2 Where a separate anti-icing fluid system is provided, it shall be designed so as to spray the fluid at a rate between 45 $l \cdot mn^{-1}$ [12 gal (US)/min] and 95 $l \cdot mn^{-1}$ [25 gal (US)/min] at any spraying height.

4.5.3.3 The spray pattern shall be able to vary from a fan-shaped spray to a solid stream as selected by the operator. The operator shall have full control of fluid flow by means of an open/close function and a rate-of-flow adjustment mechanism.

4.5.3.4 Controls of hand-held spray guns shall be of the hold to run type.

4.5.3.5 Fixed spray guns shall be prevented from spraying directly towards the operator's position.

4.5.3.6 In the event of spray gun failure, it shall be possible to stop the fluid flow by means of an additional shut-off valve.

4.6 Controls

4.6.1 All controls necessary for the safe operation of the vehicle and aerial device with operator's cabin or basket shall be provided at the driver's/operator's position as applicable.

4.6.2 The operator's cabin or basket shall be equipped with a full set of controls allowing the operator to safely move the boom and cabin or basket through any of their motions. Boom handling controls shall provide as smooth as possible movements to avoid jerks or sudden starts and stops.

4.6.3 All control levers shall directionally agree with boom movement, be of the hold to run type and shall be large and separated from each other enough for grasping with a gloved hand. They shall be identified with permanent graphic symbols in accordance with ISO 11532 or, where not available therein, ISO 7000.

4.6.4 Controls shall be protected from fluid spray and risks of inadvertent snagging or interference from lines or hoses.

4.6.5 Lighting shall be provided to illuminate the control panels for night operation. Illumination of controls shall be of anti-glare and non-reflecting quality.

4.6.6 For emergency purposes, controls shall also be provided at a location readily accessible to the driver (preferred) or in the vicinity of the boom base. A selector control shall be provided at this lower station (next to the duplicate controls) to permit selection of the operating station between either the operator's cabin or basket or the lower location. The lower controls, if selected, shall override the operator's cabin or basket controls in any configuration.

4.7 Mobility and stability

4.7.1 The unit shall provide safe and stable manoeuvring around the aircraft, with the boom in any possible position at maximum rated load in operator's cabin or basket, at speeds up to 1,7 m·s^{-1} (6 km·h^{-1}, 4 mph), with wind from any direction at speeds up to 21 m·s^{-1} (75 km·h^{-1}, 40 kn, 47 mph), and fluid tanks at any level.

4.7.2 Higher wind speeds can be agreed between manufacturer and purchaser/user (see Note in the Introduction), under the requirement that they be substantiated by calculation then actual testing. Where intended use includes de-icing/anti-icing with aircraft engines running, the additional forces resulting there from shall be taken into account in the same manner.

4.7.3 Determination of stability shall be performed in accordance with the requirements of EN 1915-2, simultaneously taking into account in the worst direction all dynamic forces generated during de-icer movement, e.g. acceleration, emergency braking, turning moments, fluid surges in incompletely filled tanks, de-icer centre of gravity shifts, recoil from spray guns, etc. A ramp slope in the worst direction of 1,5° (2,5 %) shall be assumed. The tipping line in each direction shall be determined as shown in Annex A of ISO 4305.

NOTE ISO 11995 does not apply to the stability of de-icers.

4.7.4 Stability in the worst intended conditions shall be demonstrated by actual testing in accordance with EN 1915-2. In addition, the following tests shall be performed for stresses measurement in accordance with EN 12312-6, in order to verify adequacy of structural strength and expected fatigue life.

a) driving the de-icer at maximum allowable speed (1,7 m·s^{-1}, 6 km·h^{-1}) in the forward then reverse direction and suddenly applying brakes at full force to simulate emergency (panic) stops;

b) driving the de-icer over a test fixture at maximum allowable speed (1,7 m·s^{-1}, 6 km·h^{-1}) in the forward then reverse directions. The wheels driving over the test fixture shall be the ones giving the highest stress in the boom structure. The test fixture shall be made of wood or similar material, measuring 100 mm (4 in) high, 150 mm (6 in) wide, and 600 mm (24 in) long. The top corners shall be symmetrically cut at 45° angles along the longitudinal length of the member providing a top flat surface measuring 50 mm (2 in) in width.

4.7.5 Both tests shall incorporate the boom position and orientation and the fluid levels in tanks which generate the maximum stress on the structural boom components. The operator’s cabin or basket shall be loaded at maximum rated capacity. In addition to these loads, the wind load shall be incorporated by calculation. During both tests, the stress level shall be measured using strain gauges or equivalent measuring technique. How and where to mount the strain gauges shall be in accordance with relevant industry practices.

4.7.6 The design of the de-icer shall not need stabilizers to ensure stability. Where chassis spring locks, torsion bars, stabilizer bars, or equivalent devices are used, they shall automatically be engaged when the operators’ cabin or basket is moved out of its stowed position.

4.8 Personnel protection

4.8.1 All applicable general personnel safety requirements in accordance with ISO 6966-2 shall be met.

4.8.2 All de-icer specific personnel safety requirements in accordance with EN 12312-6 shall be met.

4.8.3 The A weighted noise level in the chassis cabin and the operator’s cabin shall meet local regulatory requirements and should not exceed 80 dB(A) while all de-icer systems are operating, exclusive from noise emitted by outside sources.

NOTE Methods for noise measurement and reduction are contained in EN 1915–4 (see Bibliography).

4.8.4 All efforts shall be made to minimize the vibration levels the driver and operator(s) are submitted to while the de-icer is operating. Measures to achieve this goal include, e.g. seats designed so as to avoid damage to the human body taking into account duration and conditions of use and adjustable to size and weight of the driver or operator.

NOTE Methods for vibration measurement and reduction are contained in EN 1915–3 (see Bibliography).

4.9 Emergency

4.9.1 Emergency stop buttons shall be provided, as a minimum, in the operator’s cabin or basket and the driver’s cabin. It is recommended (see ISO 6966-2) that other ones be provided on the outside of the de-icer, readily accessible from ground level, e.g. on each longitudinal side. Emergency stops shall stop all boom movements, shut down the fluid pump and heater if installed, and apply parking brakes. Emergency stops shall not impede the back-up lowering function (see 4.9.2), stop the function of communication systems, switch off working lights nor shut down fire extinguisher systems (where applicable).

4.9.2 A back-up lowering system shall be provided to enable the aerial device and loaded operator’s cabin or basket to be manoeuvred and lowered for staff evacuation and de-icer towing away in the event of any system malfunction or engine shut-down.

4.9.3 The vehicle shall be equipped with devices to automatically shut down systems when a hazardous or self-destruction condition arises while the fluid pumping or heating systems are operating, but which still allow the vehicle to be driven away from the aircraft.

4.9.4 Driver’s station and operator’s station shall, as minimum, provide space for a fire extinguisher of suitable type and capacity. See 6.5 for optional integrated fire extinguisher system.

5 Information for use

5.1 Manufacturer’s instructions

The vehicle shall be accompanied by detailed manufacturer’s instructions including at least

a) intended use of the de-icer,

b) any limitations (speeds, weights, wind, other),

c) de-icing/anti-icing fluids the de-icer is intended to be used with, as specified by purchaser/user, or

d) necessary instructions for operating and maintaining the unit in a safe manner.

5.2 Markings

5.2.1 The following shall be legibly marked at prominent locations on the de-icer:

a) manufacturer data plate with type and serial number (also see 5.2.3);

b) intended fluid types (adjacent to each replenishment point), as specified by the purchaser/user;

c) vehicle limitations (maximum weight, maximum height in stowed position, speeds if applicable, wind, other), adjacent to the driver’s cabin;

d) maximum allowable weight in operator’s cabin/basket, adjacent to the cabin/basket access point;

e) any servicing indications contributing to safety (e.g. tires pressure, etc.).

5.2.2 All controls, instruments, fluid filling points, electrical switches, access points for operation or maintenance actions, caution signs, and operating instructions shall be marked adjacent to each, preferably by using permanent graphic symbols in accordance with ISO 11532 or, where not available therein, ISO 7000.

5.2.3 For de-icers intended to be operated at an EU or E.F.T.A. airport, the .CE. conformity marking, under the manufacturer’s responsibility, is also required on the manufacturer’s data plate or in its immediate vicinity.

6 Options

6.1 General

The following optional features can be considered and, if retained, shall meet the defined requirements.

6.2 Fluid heater

6.2.1 If a fuel heating system for heating the de-icing fluid is installed, this shall be capable of raising the temperature of the de-icing fluid tank’s capacity from 5 °C to 85 ° C (41 °F to 185 °F) within 1 h.

6.2.2 If installed, the fluid heater shall be suitable for continuous operation at the airport and during operation of the de-icer in motion when de-icing/anti-icing aircraft, unless it is a fluid pre-heat type requiring external energy. Open flame fuel burners are not permitted.

6.2.3 If installed, the fluid heater shall be equipped with appropriate safety devices to prevent the occurrence of conditions which might damage the equipment or create an unsafe condition. The safety devices/systems shall not prevent the unit from driving (e.g. away from an aircraft).

6.2.4 If installed, the fluid heater can, as a further option, allow when desired heating up only part of the tanks capacity for faster heating and reduced energy consumption.

6.3 Fluid mixing system

An on-board fluid mixing system can be installed to enable the unit to spray a controlled mixture of water and type I, II, III, or IV fluid. The mixing system shall be fast responding, accurate, shall allow the selection of preset mixtures of various ratios of de-/anti-icing fluid and water to be delivered at the nozzle, and shall produce a homogeneous fluid mix, so that no areas of the aircraft are covered with a too lean mixture. The tolerance of the actual mix percentage out-of-nozzle shall not be below the value shown at the unit's selection system, and an adequate buffer shall be applied by the manufacturer in order to ensure this.

NOTE Any mixing system should be accompanied by a reliable fluid type/ratio indication at the operator's cabin or basket.

6.4 Spraying boom

A boom, extending from the operator's cabin or basket, can be installed to support fluid hoses and bring fluid spraying nozzles (as opposed to hand-held spraying guns) as close as possible to the aircraft part being de-iced. Controls for spraying boom and nozzle movement shall be provided in the operator's cabin or basket.

6.5 Fire extinguishing system

An integrated fire detection and/or extinguishing system can be installed within the de-icer. It shall aim at protecting any areas identified as potentially subject to combustible fluids leakage and/or fire. If the system's activation is intended to be automatic, audible and visual warnings shall be provided both at driver's station and in the operator's cabin or basket. Hand-held fire extinguishers shall be maintained at the driver's station and in the operator's cabin or basket to cater for any external occurrences.

6.6 One person operation

Full driving, steering and braking controls can be provided in the operator's cabin or basket to allow a one-person operation from that position, with or without maintaining the chassis driver's cabin. Appropriate specific risk analysis and safety precautions additional to this International Standard are required.

7 Quality assurance

7.1 Manufacturer's quality assurance

7.1.1 General

The manufacturer's design, development and construction processes should be performed under a continuous quality control program meeting the requirements of ISO 9001 (see Bibliography).

The manufacturer shall provide to the purchaser upon request a technical file containing the data and test results necessary to ascertain the de-icer's safety in the stated intended conditions of use.

NOTE This information can be proprietary and require prior non-disclosure agreement.

7.1.2 Structural integrity

The manufacturer's technical file (see 7.1.1) shall include the main features (conditions of use assumptions, parameters, safety coefficients used) of strength, fatigue life and stability calculations, and test reports for at least the stability verification and stress measurement tests specified in 4.7.4.

7.1.3 Functions and safety safeguards

The manufacturer's technical file (see 7.1.1) shall include confirmation that all functions and safety safeguards were satisfactorily tested on each delivered unit.

7.2 User's quality assurance

7.2.1 The manufacturer's technical file should, upon purchaser's request, include insurance that the de-icing and anti-icing fluid type(s) intended by the purchaser/user is (are) not degraded, after being sprayed by the de-icer, beyond the tolerances specified by this (these) fluid(s)' manufacturer(s).

7.2.2 Each user shall maintain the unit in a condition that ensures continuous proper application of the ISO 11078 types II, III, or IV fluid(s) used, and verify it by regularly applying the fluid checking procedures specified in ISO 11076 (AEA guidelines), as required therein.

Annex A
(informative)

Toxicological aspects of using de-icing/anti-icing equipment

A.1 General

The aim of this annex is to highlight toxicological problems, arising from the use of fluids for de-icing/anti-icing aircraft. The annex concentrates on the use of glycol itself and not on the effect of any additives for increasing viscosity, reducing flammability and preventing corrosion.

A.1 covers the general aspect of using glycol for de-icing/anti-icing, A.2 describes how to minimize and overcome these problems, A.3 contains a description of the effects on humans, and finally, recommendations for minimizing these effects are given in A.4

ISO has specified two types of de-icing/anti-icing fluids. Among other things, the specification states the minimum glycol content of the fluids as follows:

— Newtonian fluid (de-icing) shall contain at least 80 % by weight of glycols;

— non-Newtonian (pseudoplastic) fluid (anti-icing) shall contain at least 50 % by weight of glycols.

There is no requirement for the type of glycol used. The commonly used glycols in Europe are mono propylene glycol and diethylene glycol. In other parts of the world, e.g. North America, mono ethylene glycol is also used.

The main constituents of de-icing/anti-icing fluids are one or more glycols and water. Furthermore the fluids contain minor amounts of proprietary additives, neutralizers, inhibitors, and thickeners (in anti-icing fluids).

The use of de-icing/anti-icing fluids results in environmental exposure (water and soil) as well as exposure of personnel. The degree of environmental exposure depends on the environmental protection measures taken. Personnel exposure depends on the way of application and the personal protection measures taken.

A.2 Systems and training of operators

A.2.1 General

In order to ensure personnel and environmental protection, various aspects of the de-icing procedure should be carefully considered. The involved components/structures should then be designed or adapted with the goal of: minimizing the consumption of de-icing and anti-icing fluids while having flight safety in mind. The goal can be achieved through emphasis on the following:

— dedicated low fluid consuming spraying equipment;

— well-trained de-icing staff.

A.2.2 Design of the spraying equipment

A.2.2.1 Short spraying distance

For the most effective environmental protection, the de-icing equipment should provide a short spraying distance. This is important for the following reasons:

— temperature loss caused by long spray distances is minimized;

— the physical effect of the spray jet is optimized;

— loss of fluid through wind effects is minimized.

A short spraying distance makes it possible to minimize the fluid consumption and by that, the exposure of glycol to the environment.

A.2.2.2 Mixing systems

The fluid system of the de-icing equipment should give the operator the possibility of selecting a glycol/water mix precisely suited to the prevailing weather conditions and which includes the necessary temperature buffer. This means glycol concentration can be optimized within the limits of safety. The nozzle should be able to provide a concentrated spray stream for de-icing (removal of frozen precipitation) and a flared spray stream for anti-icing (applying a film to protect against new ice build-up). Dedicated fluid lines to the nozzle, e.g. for 100 % non-Newtonian (pseudoplastic) fluid, will limit fluid loss when switching between the fluid selections. A print out containing data similar to that mentioned in A.2.3.4 could be helpful for documentation and statistics.

A.2.3 Training of operators

A.2.3.1 Theoretical training

Theoretical training, mandatory for aeronautical purposes (see EU-OPS 1 345 and associated material, or equivalent) should include a basic understanding of the reasons for de-icing and recommendations for de-icing procedures. Operators should be aware of the crucial de-icing points in order to give them an understanding of how and where to apply de-icing fluid. This ensures that sufficient fluid is used on critical areas and that fluid is economized on non-critical areas.

A.2.3.2 Practical training

Practical training should be of such a duration that the operator feels “as one” with the de-icing equipment. Total familiarization enables the operator to understand the concept of the equipment and optimally exploit the benefits of its design, thereby minimizing fluid consumption.

A.2.3.3 Composition of the de-icing staff

Optimizing the number of de-icing staff means finding a balance that keeps it small enough to ensure that each operator performs a large number of de-icing operations thereby maximizing experience, while at the same time ensuring that the staff numbers are large enough to cope with absences. It is recommended that the specialized personnel are permanent, thereby maintaining the accumulated skills year after year.

A.2.3.4 Recording operation data (statistics)

To enable useful evaluation and follow-up of operator training/performance, a system for recording and controlling operations should be established. The details fed into the system (e.g. flight no., aircraft type, duration of operation, volume and type of fluid used, weather conditions etc.) will depend on the level of detail desired from the analysis. Data such as the above could provide a basis for comparing actual performance with ideal figures.

A.3 Effects on humans

A.3.1 Toxicity of glycols

Glycols are hygroscopic. In prolonged contact with glycols, skin and mucosae can dry up resulting in irritation of skin, eyes, and mucosae in the respiratory tract. Mono ethylene glycol and mono propylene glycol are readily taken up through the skin whereas diethylene glycol is only taken up upon prolonged skin contact.

Mono ethylene glycol (MEG)

In the body, mono ethylene glycol is metabolized to oxalic acid, which binds calcium ions. Calcium oxalate crystals ("stones") can form in the kidney and in the bladder, possibly giving rise to bladder cancer in the case of many years exposure to relatively high concentrations. Prolonged skin contact has resulted in a few rare cases of allergic eczema. Large doses of mono ethylene glycol can be toxic to the kidneys and to the central nervous system. An oral dose of approximately 100 g can cause death in man.

Mono propylene glycol (MPG)

Mono propylene glycol is metabolized in the body to lactic acid and pyruvic acid, which are normal constituents of the glycolysis, normal metabolic pathways in the body. Mono propylene glycol is practically non-toxic. It is allowed in cosmetics and in medicine for cutaneous application. Prolonged skin contact has resulted in a few rare cases of allergic eczema.

Diethylene glycol (DEG)

Diethylene glycol is metabolized in the body to 2-hydroxyethoxyacetic acid, which is eliminated via the urine. Large doses can be toxic to the kidneys and the central nervous system. An oral dose of approximately 75 g can cause death in man.

The three glycols are rather harmless to experimental animals having LD50-values ranging from 6 g/kg body weight to 33 g/kg body weight depending on glycol and species. However, mono ethylene glycol and diethylene glycol appear to be toxic to humans and to the same degree, but only mono ethylene glycol is classified in the EU as a dangerous substance. Mono propylene glycol is regarded as non-toxic.

Table A.1 — Acute toxicity of glycols and EU classification

	MEG	DEG	MPG
LD_{50} (humans) (animals)	6 - 19 (g/kg bw[a]) 1,5 (g/kg bw[a])	9 - 26 (g/kg bw[a]) 1,0 (g/kg bw[a])	10 - 33 (g/kg bw[a]) [b]
EU-classification	Xn: R22; S2	—	—

[a] bw means body weight.

[b] No values found.

A.3.2 Work environment considerations

Due to the glycol content, the de-icing/anti-icing fluids are irritating to skin, eyes, and mucosae. Furthermore, mono ethylene glycol and diethylene glycol are rather toxic to humans. However, the toxicity of diethylene glycol is only recognized by Scandinavian work environment authorities, see Table A.2. During the de-icing/anti-icing process, aerosols (fog, mist) are produced in rather high concentrations. Inhalation of these aerosols can cause adverse effects in the lungs.

Table A.2 — Some occupational exposure limits for glycols

	MEG	DEG	MPG
Denmark 1992			
(vapour)	50×10^{-6} (ppm)[a]	50×10^{-6} (ppm)[a]	—
(aerosol)	10 mg/m^3 [a]	10 mg/m^3 [a]	—
Sweden 1993			
(vapour)	10 ppm S	10 mg/m^3 [a]	—
(aerosol)	25 mg/m^3 S	45 mg/m^3 [a]	—
USA (TLV 1992/93)			
(vapour)	50 ppm[a]	—	—
(aerosol)	127 mg/m^3 [a]	—	—

[a] Ceiling value S skin.

Personnel exposure to de-icing/anti-icing fluids should be minimized as much as possible. In the case of exposure, personnel should wear a protective suit with hood, gloves, face shield and respirator. The respirator shall protect against wet aerosols, e.g. class FFP2SL or FFP3SL of EN 143:2000 or equivalent.

A.3.3 Aircraft internal environment considerations

Persons inside the aircraft can be exposed to de-icing/anti-icing fluids and their pyrolysis products formed in the engines/auxiliary power unit (APU) entering the aircraft via the ventilation system. To avoid adverse health effects, the aircraft ventilation system shall be shut off during the de-icing/anti-icing process, (see ISO 11076).

A.4 Recommendations

Summarizing this Annex, the following recommendations are given:

— The de-icing/anti-icing process should be mechanized to minimize personnel exposure.

— Personnel working with de-icing/anti-icing procedures should be suitably protected.

— Aircraft ventilation systems shall be shut off during de-icing/anti-icing process (see ISO 11076).

Annex B
(informative)

Environmental aspect of de-icing/anti-icing at airports

B.1 General

The aim of this annex is to highlight environmental problems, arising from the use of fluids for de-icing/anti-icing aircraft, inflicted on airport surroundings. The purpose is to point out ways in which users can overcome these problems. The annex concentrates on the use of glycol itself and not on the effect of any additives for increasing viscosity, reducing flammability, and preventing corrosion.

Glycols can be utilized by microorganisms as a source of carbon and energy, whereby the glycols ultimately are transformed into water and carbon dioxide. This process requires oxygen which is absorbed from the environment, possibly resulting in oxygen deficiency.

This oxygen consumption is considered the biggest environmental problem in connection with de-icing of aircraft today. Theoretically, glycols require the following amounts of oxygen for complete transformation:

Table B.1 — Oxygen demand for transformation of glycol

Glycol	Oxygen demand	Oxygen/glycol kg
Mono ethylene glycol	5 atoms oxygen per molecule	1,3
Mono propylene glycol	8 atoms oxygen per molecule	1,7
Diethylene glycol	10 atoms oxygen per molecule	1,5

Table B.1 shows that a diethylene glycol molecule needs the highest number of oxygen atoms to degrade to water and carbon dioxide; but due to the difference in mol weight, mono propylene glycol, however, requires more oxygen if calculated by weight.

The oxygen content in normal sea water is dependent on many factors (e.g. temperature, daily or seasonal variations etc.), but a theoretical value of 10 mg/kg can realistically be used for the sake of this calculation. This necessitates the oxygen from approximately 170 m^3 of water to degrade 1 kg mono propylene glycol. For additional information about different types of glycol see also A.3.1.

B.2 Environmental protection

B.2.1 General

De-icing on dedicated pads close to the runway allows for a reduction in the amount of glycol consumed, because less hold-over time is needed. Therefore, it is possible to either use a weaker Newtonian solution or eliminate the need for non-Newtonian (pseudoplastic) fluid. No matter how efficient the de-icing system (i.e. de-icing equipment, de-icing pads, operators) is, glycol residue is unavoidable. This residue means that two tasks should be performed:

— collection of used glycol (see B.2.2);

— treatment of the collected glycol (see B.2.3).

B.2.2 Collection of glycol

B.2.2.1 General

When collecting used glycol, two different methods are most common:

— mobile collection;

— central collection.

The goal should be to collect glycol in a concentrated form as possible. This means that the following treatment is as simple as possible and that the required capacity of collection tanks is reduced.

B.2.2.2 Mobile collection

The used glycol can be collected by special vehicles, by means of suction or absorption. This is a time consuming process which closes the area for a period, thereby reducing de-icing capacity, while collection takes place. The suction vehicles are normally redesigned mobile vacuum street cleaners.

The absorption vehicle is a mobile roller sponge fluid collector. This vehicle will usually have the greatest application in airports where de-icing is performed at the gate and where the glycol cannot be isolated in the draining system.

It is strongly recommended that removal of glycol is performed immediately after aircraft de-icing is completed. In this way most of glycol will be captured before it is diffused and diluted.

B.2.2.3 Central collection

At airports where de-icing can be performed in dedicated areas (central or remote de-icing), the used glycol can be guided from collecting pads into a drainage system in the ground. There are various points to be considered when designing both elements of the dedicated area.

Collecting pad

The surface of the pad should be designed in such a way that fluid is not blown away when the aircraft uses break-away power. A grooved surface will for example prevent fluid from being blown away. The grooves shall be perpendicular to the aircraft. The surface material which can be concrete or rubber mats, should prevent fluid seeping away. Even when exposed to non-Newtonian (pseudoplastic) fluid, the material shall retain the necessary friction for aircraft and vehicles. It is vital that the grooved surface is resistant to the environment and treatments to which it is exposed. Break down of the surface reduces friction and increases the risk of foreign object damage (FOD) to aircraft engines.

Drainage system

It is very important that the system has a by-pass facility in order that non-contaminated water can be diverted back to the usual waste water system. This means avoiding unnecessarily large tanks in the system. Retention time of fluid in the collection system should be short, meaning that fluid should pass quickly from the collecting pad to the storage tank or waste water system respectively.

B.2.3 Treatment of glycol

B.2.3.1 General

The collected glycol can be treated in three different ways:

— recycling;

— destruction;

— decomposition.

B.2.3.2 Recycling

In order to decide whether recycling is the optimal way to treat glycol, many conditions should be considered. These conditions are variable as no two airports operate precisely under the same circumstances. The sum of the variables will provide a basis on which to conclude whether recycling is cost-effective from an environmental and economical point of view. Some of the variables are as follows:

— average and total glycol consumption at the airport;

— average and total precipitation at the airport, and estimated volume of collected fluid;

— average, minimum, and maximum glycol concentration in collected fluid;

— quality of collected glycol: matters in the surrounding environment that affect the size of the cleaning step in the recycling process (e.g. metal ions, runway de-icing fluid, spillage of oil and lubricants from aircraft and vehicles, etc.);

— total energy demand for recycling of glycol:

  — energy for the distillation process and for other necessary additional equipment;

  — realistic utilization of excess heat from distillation process;

— necessary capacity of buffer tanks, both collecting and ready tanks;

— recycled glycol shall have the same quality as new glycol;

— total costs for recycled glycol (including investments in facilities, cost of operations and maintenance, etc.) compared with the costs of using new glycol (including the cost of “used glycol treatment”);

— environmental consequences of the recycling process, compared to treating used glycol in other ways;

— treatment of the collected fluid with a low glycol content which has by-passed the recycling system.

The design of the system should pay attention to the required size of the buffer tank. A distillation unit will have a certain capacity, but the amount of fluid used in any given period will vary in accordance with factors such as weather conditions and flight activity. In certain circumstances, much glycol will have to be stored in the buffer tank and allowances should be made for this.

B.2.3.3 Destruction

Burning glycol is very energy consuming due to the content of water, despite the burning value of the glycol itself. The environmental consequences of burning should also be investigated.

B.2.3.4 Decomposition

The last method mentioned here is decomposition of glycol, by means of aerobic microorganisms. By leading the glycol to a public sewage plant the process can be controlled and thus the oxygen consumption regulated. This means avoiding the problems created through disturbing the oxygen content of natural recipients.

The microorganisms for decomposition cannot live from glycol and oxygen alone, but need to “eat” other essential matters in order to sustain their vital life functions. All these matters are normally present at a public sewage plant which makes glycol decomposition possible there.

The decomposition rate of glycol varies greatly with the ambient temperature. The inlet of glycol should therefore be regulated in accordance herewith.

The sewage plant will have a fixed capacity, but its work load will differ due to daily peaks and seasonal variations. The inlet of glycol should therefore also be regulated with regard to these variations. This means that the considerations when determining adequate buffer tank size are the same as those in connection with recycling of glycol. Furthermore, it is important that the capacity of an available sewage plant is compatible with the size of the airport in question.

B.2.3.5 Summary

It should be pointed out that there is not one single way to optimally remove glycol. Each airport is a unique case and many factors will have influence when choosing the best method, for example:

— economy;

— amount of glycol;

— topography and urbanisation of the surroundings;

— local health, safety and environmental regulations;

— meteorological conditions;

— special environmental and ecological conditions.

B.3 Environmental effects of de-icing/anti-icing fluids

B.3.1 General

The following describes the environmental effects, including the toxicological aspects, on surrounding environment:

— effects on aquatic environment (see B.3.2);

— effects on soil environment (see B.3.3);

— effects on humans (see A.3).

Additional safety information can be found in material safety data sheets in accordance with 91/155/EEC.

B.3.2 Effects on aquatic environment

B.3.2.1 Biodegradation

The glycols are readily biodegraded in aquatic environment including waste water and sludge. The biodegradability depends on the temperature, the lower the temperature, the slower the biodegradation rates. Mono ethylene glycol and mono propylene glycol are fully degraded, mono propylene glycol at the fastest rate, whereas diethylene glycol is degraded to a lesser extent, possibly due to the ether-bond.

B.3.2.2 Toxicity

The toxicity of glycols to water organisms is low or absent, diethylene glycol being the most toxic and mono propylene glycol being the least toxic to bacteria, fish, and mammals.

B.3.3 Effects on soil environment

B.3.3.1 Biodegradation

In soil, all three glycols are readily biodegraded. As in water, biodegradation in soil depends on the temperature, as can be seen from Table B.2.

Table B.2 — Mean biodegradation rates of glycol in soil

Mean biodegradation rates in soil mg glycol/(kg soil × day)			
	−2 °C	**8 °C**	**20 °C**
Mono ethylene glycol	3,0	19,7	66,3
Mono propylene glycol	2,3	22,7	83,5
Diethylene glycol	4,5	27,0	93,3
NOTE Source: Klecka GM, Carpenter CL, Landenberger BD. Biodegradation of aircraft de-icing fluids in soil at low temperatures.			

B.3.3.2 Toxicity

The degradation takes place over a wide range of concentrations indicating that glycols do not inhibit the growth of soil microorganisms, i.e. they are probably not toxic to these.

B.3.4 Recommendations

Summarizing this annex, the following recommendations are given:

— de-icing/anti-icing procedures should be organized so that as little as possible de-icing/anti-icing fluids are used within the limits of safe de-icing;

— de-icing/anti-icing procedures should be carried out in locations constructed for reception of residual de-icing/anti-icing fluid in order to avoid environmental pollution. The collected fluids should subsequently be treated by, e.g. recycling, controlled feeding to a biological purifying plant or proper destruction.

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[1] ISO 4305, *Mobile cranes — Determination of stability*

[2] ISO 9001, *Quality management systems — Requirements*

[3] EN 1915-1, *Aircraft ground support equipment — General requirements — Part 1: Basic safety requirements.* [1] [2]

[4] EN 1915-3, *Aircraft ground support equipment — General requirements — Part 3: Vibration measurement methods and reduction*

[5] EN 1915-4, *Aircraft ground support equipment — General requirements — Part 4: Noise measurement methods and reduction*

[6] SAE/ARP 1971, *Aircraft De-icing Vehicle — Self-propelled*[3]

[7] SAE/ARP 5058, *Enclosed Operator's Cabin for Aircraft ground De-icing Equipment*

[8] IATA AHM 975, *Functional Specification for Self-propelled Aircraft De-icing / Anti-icing Unit*[4]

1) Same scope as ISO 6966-2 but more detailed, contains the personnel safety requirements for compliance with the E.U. Machinery Directive.

2) EN standards can be obtained from: Comité Européen de Normalisation, Avenue Marnix 17, B-1000 Brussels, Belgium, or any of the European national standardization institutes, members of C.E.N.

3) SAE documents can be obtained from: Society of Automotive Engineers, 400, Commonwealth Drive, Warrendale PA 15096-0001, USA.

4) IATA publications can be obtained from: International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113, Montréal, Québec, Canada H4Z 1M1.

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