INTERNATIONAL STANDARD

ISO 11995

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Aircraft — Stability requirements for loading and servicing equipment

Aéronefs — Exigences de stabilité des matériels de chargement et de service

Reference number
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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11995 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

Annex A of this International Standard is for information only.

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Introduction

Throughout this International Standard, the minimum essential criteria are identified by the use of the key word "shall". Recommended criteria are identified by the use of the key word "should", and while not mandatory are considered to be of primary importance in providing safe equipment. Deviation from the recommended criteria should occur only after careful consideration, extensive testing, and thorough service evaluation have shown alternate methods to be satisfactory.

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Aircraft — Stability requirements for loading and servicing equipment

1 Scope

1.1 This International Standard specifies:

a) the criteria to be used to determine stability of aircraft loading and servicing equipment, including wind loads;

b) the classification of systems recommended to achieve stability;

c) the formula to be used for calculating steady-state wind stability;

d) the recommended test methods applicable to equipment.

1.2 The intent of this International Standard is not to specify equipment design, but rather to define uniform criteria, calculation and testing methods in order to provide a safe work environment under all predictable circumstances for the users of aircraft loading and servicing equipment.

1.3 This International Standard specifies the worldwide requirements recognized by aircraft and equipment manufacturers as well as airlines and handling agencies.

In addition, it shall be applied with due reference to national governmental regulations of the country where the equipment is to be operated.

1.4 This International Standard applies to aircraft loading and servicing equipment, typically but not exclusively defined as follows:

— container and pallet loaders (see ISO 6967 and ISO 6968);

— catering trucks (see ISO 10841);

— passenger stairs (see ISO 12056);

— maintenance and fueling access platforms,

when operated in a static position on an aircraft.

1.5 This International Standard does not apply to:

— forklifts;

— aircraft de-icers;

— any equipment with rotating booms,

and more generally any equipment the normal mode of operation of which includes moving in the elevated position.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6966:1993, *Aircraft — Basic requirements for aircraft loading equipment.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 wind: Movement of air which causes a force imposed on surfaces of aircraft loading and servicing equipment.

NOTE 1 Wind in this context includes

— steady-state natural wind;

— wind gusts (temporary peak intensities);

— the effect of jet blast from other aircraft's engines.

3.2 stabilizers: Structural devices capable of supporting the weight of the equipment and any additional forces resulting from wind or other sources, used to reduce the lateral deflection of vehicles, when extended within the outer planview envelope of the vehicle.

NOTE 2 Stabilizers will normally eliminate or reduce the part of the vehicle's weight supported by tyres and suspensions.

3.3 outriggers: Stabilizers which, when extended, project outside the outer planview envelope of the vehicle.

NOTE 3 Outriggers enlarge the supporting base of the vehicle.

3.4 tip point: Condition where the vehicle center of gravity has been rotated by the combined effect of load distribution, ramp slope, structural deformation if any, and the force of wind up to a point directly above the vehicle's pivot point.

3.5 pivot point: That point of the vehicle in contact with the ground located farthest out on the most heavily loaded side or the side opposite to that to which the force of wind is applied.

3.6 stability: Condition where

— the laden or unladen vehicle's center of gravity is located within the outer support perimeter, i.e. inward of the tip point; and

— the vehicle's weight as well as the force of wind and any other forces are entirely supported by rigid structural elements.

NOTE 4 Where all or part of the vehicle's weight and additional forces are supported by elastic elements such as tyres, suspension springs, etc., a dynamic condition may be created that can exceed static and wind stability conditions as defined in 3.6.1 and 3.6.2. In such a case, appropriate additional safety margins should be determined to take into account possible dynamic effects resulting from support elasticity.

3.6.1 static stability: Stability achieved in a condition where, there being no wind or other additional forces, the vehicle's tipping risk is determined only by load distribution (i.e. center of gravity location) and ramp slope.

3.6.2 wind stability: Stability achieved in a condition where the force of wind constitutes the predominant factor of the vehicle's tipping risk.

4 Objectives

4.1 The static stability objective for any piece of aircraft loading and servicing equipment shall be for the vehicle to remain stable as defined in 3.6 when

a) the vehicle is at maximum elevation, and

b) the maximum allowable payload is concentrated on only one half side of the vehicle (all on the same side of the vehicle's centre line), and

c) the vehicle, with stabilizers or outriggers extended when applicable, is standing on a surface at a slope of 3° (5 %) perpendicular to the vehicle's centre line and sloping on the loaded side of the vehicle.

4.2 The wind stability objective for any piece of aircraft loading and servicing equipment shall be for the vehicle to remain stable as defined in 3.6 when the vehicle

a) is at maximum elevation, and

b) is empty, and

c) is standing on a horizontal surface, with stabilizers or outriggers extended when applicable, and

d) is subjected to a steady-state wind of 120 km/h (65 kn), perpendicular to one long side of the vehicle.

4.3 The objectives for combined static and wind stabilities shall be as follows.

a) The vehicle shall remain stable in the following conditions based on those defined for static stability in 4.1:

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a) the vehicle is at maximum elevation, and

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c) is standing on a horizontal surface, with stabilizers or outriggers extended when applicable, and

d) is subjected to a steady-state wind of 120 km/h (65 kn), perpendicular to one long side of the vehicle.

4.3 The objectives for combined static and wind stabilities shall be as follows.

a) The vehicle shall remain stable in the following conditions based on those defined for static stability in 4.1:

— maximum elevation allowed with or without stabilizers/outriggers;

— maximum payload asymmetry, or empty, whichever is the worst case;

— 3° (5 %) ramp slope,

when simultaneously subjected to a steady-state wind of 75 km/h (40 kn), perpendicular to one long side of the vehicle in the same direction as payload asymmetry and ramp slope.

b) The vehicle shall remain stable in the following conditions:

— maximum elevation;

— symmetrical payload, or empty, whichever is the worst case;

— 1,5° (2,5 %) ramp slope,

when simultaneously subjected to a steady-state wind of 110 km/h (60 kn), perpendicular to one long side of the vehicle in the same direction as the ramp slope.

NOTE 5 The objectives retained for combined static and wind stabilities are based on the following assumptions:

— aircraft manufacturers generally specify that the doors of a civil transport aircraft may not be opened or closed by a wind exceeding 75 km/h (40 kn), or remain open by a wind exceeding 110 km/h (60 kn) or 120 km/h (65 kn) depending on the aircraft type;

— operators therefore need to keep equipment fully functional by steady-state winds up to 75 km/h (40 kn), still allowing for momentary wind gusts up to a maximum of 110 km/h (60 kn) without affecting safety. Operations on aircraft have to be stopped whenever gusts may exceed the latter value;

— any operation through wind gusts exceeding 75 km/h (40 kn) requires careful assessment of the weather forecasts at the airport, and specific operating rules to be issued and carefully applied. Such rules should include avoiding any payload asymmetry in the downwind direction — or, on the contrary, deliberately maintaining a load asymmetry in the upwind direction — and prohibiting the use of any aircraft stands with major slopes in the downwind direction. 1,5° (2,5 %) was determined to be the maximum normal ramp slope at international airports, excluding exceptional cases.

5 Systems classification

Systems recommended to achieve the required stability are as follows, in order of increasing effectiveness.

A combination of some of the systems mentioned in 5.1 to 5.3 may be utilized to gain the desired stability. The choice of these systems is left up to the manufacturer because every vehicle is different in design and function. See ISO 6966 for general requirements.

5.1 Integral vehicle chassis methods

a) Heavy-duty springs and auxiliary overload springs. These produce a harder ride, but provide increased side movement stability and assist in levelling off-centre loads when the vehicle is moving or stationary.

b) Heavy-duty shock absorbers. These produce a harder ride but provide increased side movement stability while the vehicle is moving.

c) Tyre pressure. High tyre pressure on a vehicle increases the overall stability of either a slow moving or stationary vehicle, but produces a harder ride.

d) Stabilizer bar systems. These increase stability by taking out chassis movement through a rigid bar or spring and can be applied in several areas of the chassis. These systems do not adversely affect the ride of the vehicle as much as those defined in a), b), c) and e).

e) Spring lockout systems. These block out the chassis springs against the axle and improve the stationary stability of a vehicle. Spring lockouts should not be engaged while a vehicle is moving as this produces an extra hard ride and transmits all road shocks directly into the vehicle structure.

5.2 Stabilizer systems

These systems generally utilize hydraulic cylinders with self-levelling foot pads that press against the ground within the envelope of the vehicle. These systems stabilize the vehicle chassis when it is stationary by blocking out chassis movement on the springs and tyres. Usually stabilizers are used in tandem (one on each side of the vehicle) and placed at various key positions along the length of the vehicle. Two or more should be used as required.

5.3 Outrigger systems

These systems generally utilize hydraulic cylinders that extend self-levelling foot pads to the ground beyond the normal envelope of the vehicle, with heavy structural members that are connected to the chassis. The farther out from the chassis that these foot pads are extended, the greater the resistance to tipping.

NOTE 6 Outriggers may result in interference with adjacent aircraft handling equipment, and hence should preferably be used only when stabilizers as described in 5.2 remaining within the equipment planview envelope, are proven not to be sufficient to meet the stability objectives of clause 4.

6 Calculation formula

6.1 The following formula should be used for calculating the steady-state wind stability (tip point) of aircraft loading and servicing equipment.

6.2 The formula is based on the following assumptions.

a) The formula is applicable to the vehicle's projected areas in its worst operating condition where stability is involved. This generally occurs when vehicle is at full extension and is unloaded.

b) The air density is assumed to be 1,2 kg/m^3 (0,075 3 lb/ft^3), at standard temperature of 20 °C (68 °F) and atmospheric pressure of 101,3 kPa (14,7 lb/in^2). If extreme temperatures and pressures (e.g. airport altitude) must be allowed for, the wind force should be corrected in proportion to the density.

c) Wind velocity is considered as a steady-state wind condition. Aircraft jet blasts are also considered as a steady-state wind condition, however they are likely to produce higher effective forces on the vehicle due to their dynamic (gust) nature.

6.3 The standard formula for calculating the tip point of the vehicle is

$$M_{\text{O}} = M_{\text{R}}$$

where

M_{O} is the total overturning moment, in newton metres, as defined in 6.4;

M_{R} is the total restoring moment, in newton metres, as defined in 6.5.

6.4 The overturning moment formula is

$$M_{\text{O}} = 0{,}048\ 4\ v^2 \left[\sum_{i=1}^{n} S_i\, h_i\, C_i \right]$$

where

M_{O} is the total overturning moment, in newton metres;

v is the wind velocity, in kilometres per hour;

S_i is the area of the ith element, in square metres;

h_i is the height from ground level of the centre of the area of the ith element, in metres (see figure 1);

C_i is the shape factor of the ith element based on the aspect ratio in figure 2;

n is the number of elements of the sail area with wind loading (i.e. vehicle chassis, vehicle scissor lift system, etc.).

NOTE 7 The corresponding formula in imperial units is

$$M_{\text{O}} = 0{,}002\ 52\ v^2 \left[\sum_{i=1}^{n} S_i\, h_i\, C_i \right]$$

where

M_{O} is expressed in feet pounds-force;

v is expressed in miles per hour;

S_i is expressed in square feet;

h_i is expressed in feet.

6.5 The restoring moment formula is

$$M_{\text{R}} = Wd$$

where

M_{R} is the total restoring moment, in newton metres;

W is the total weight of the vehicle, in newtons;

d is the distance, in metres, from the centre of gravity of the vehicle to the pivot point of the vehicle as in figure 3. As a wind force is applied to the side of a vehicle, the vehicle's centre of gravity is caused to move in the direction of the wind force. For this reason d' should be used as shown in figure 3 b). (The centre of gravity will move due to spring deflection, tyre deflection unless rigid stabilizers are used, and structural deflection if any.)

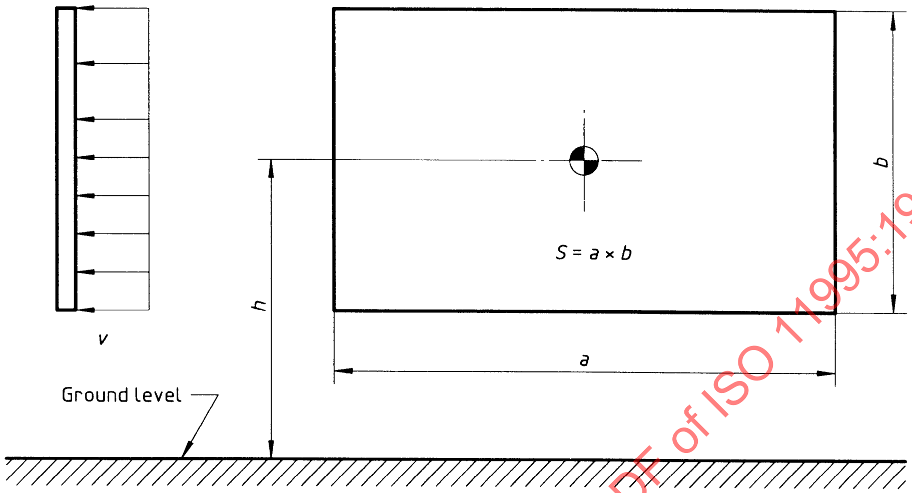

Figure 1 — Representation of some parameters

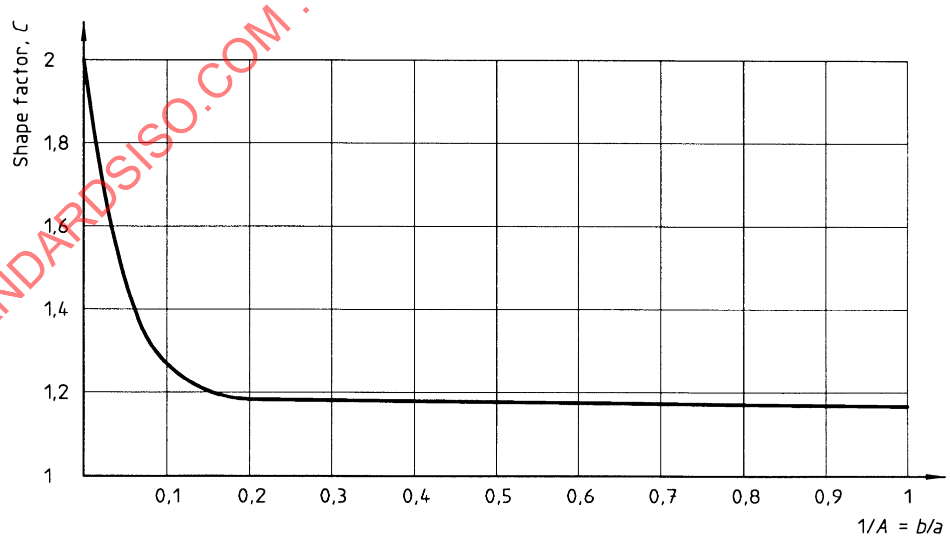

Figure 2 — Variation of "shape factor" with aspect ratio for rectangular plates perpendicular to the flow

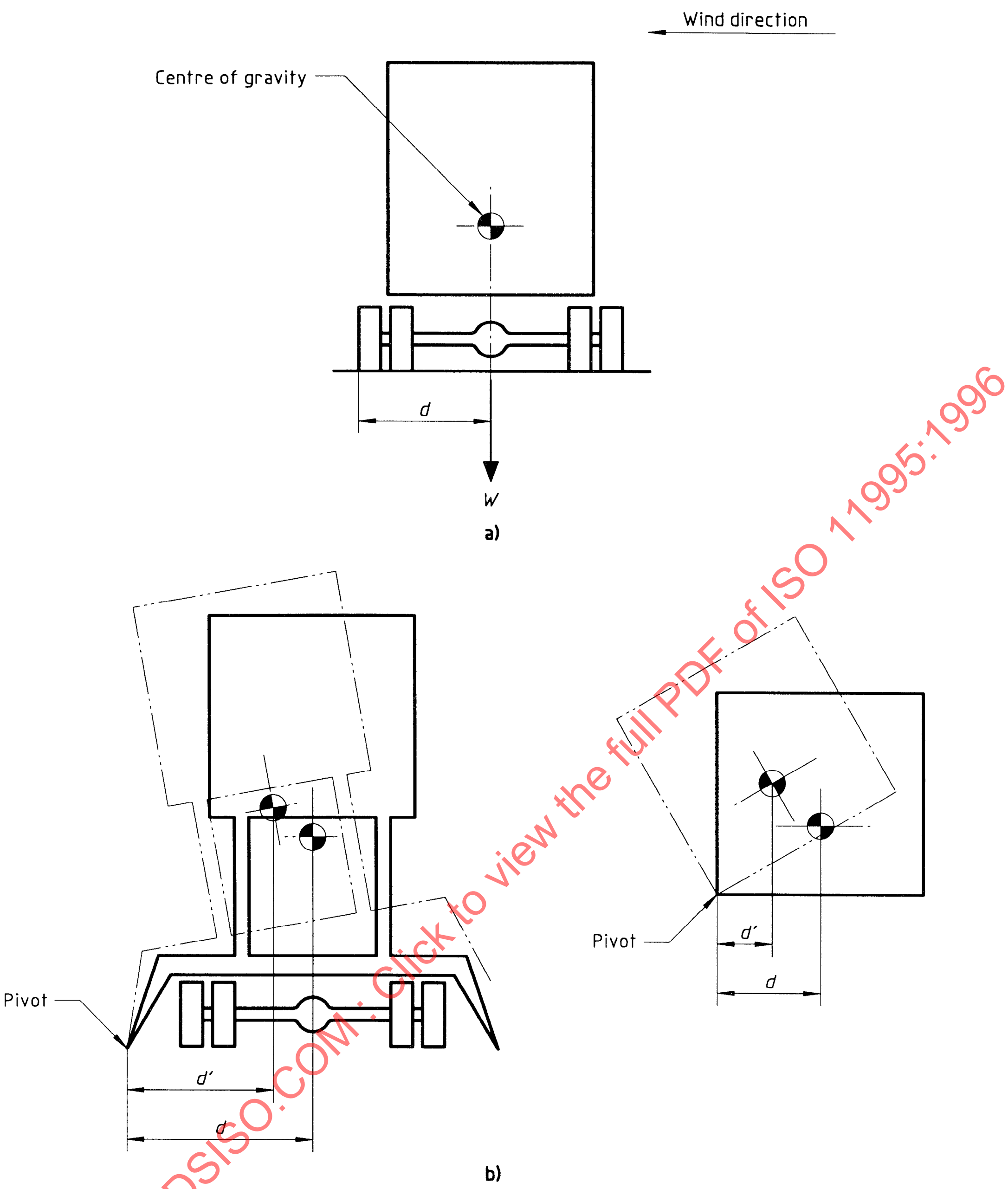

Figure 3 — Determination of the distance from the centre of gravity to the pivot point

6.6 Since

$$M_O = M_R$$

then the tip point formula is

$$0{,}048\,4\, v^2 \left[\sum_{i=1}^{n} S_i\, h_i\, C_i \right] = Wd$$

The shape factors so obtained apply to full scale for structures with sharp edges whose principal resistance is due to the pressure forces. For bodies that do not have any sharp edges perpendicular to the flow, such as spheres or stream-lined bodies, the factor C is not constant. For such bodies, the law for variation of the shape factor C must be determined experimentally before safe predictions of full-scale forces can be made from model measurements. The force F normal to a flat plate depends upon the aspect ratio $A =$ (length)/(width) of the plate. Writing $F = CqS$, the coefficient C varies from about 1,18 to 2 as shown in figure 2. About 70 % of the normal force on the plate is due to the large underpressures existing over the rear surface.

7 Test methods

One of the test methods described in 7.1 and 7.2 should be used when required to test vehicle stability (tip point) and confirm calculations.

7.1 Application of a chain or cable pulling horizontally at approximately the centre of wind pressure of the vehicle. The maximum restoring moment can be determined by measuring the cable tension and multiplying that value by the height of application above ground level.

7.2 An air bag can be applied between the vehicle and a solid fixed structure, to simulate the effect of wind loading. The restoring moment can be determined by measuring the static pressure in the air bag, multiplying by the vertical area in contact with the bag, and the height of the centre of pressure above ground level.

Annex A
(informative)

Bibliography

[1] ISO 6967:1994, *Aircraft — Wide body aircraft main deck container/pallet loader — Functional requirements*.

[2] ISO 6968:1994, *Aircraft — Wide body aircraft lower deck container/pallet loader — Functional requirements*.

[3] ISO 10841:1996, *Aircraft — Catering vehicle for large capacity aircraft — Functional requirements*.

[4] ISO 12056:1996, *Aircraft — Self-propelled passenger stairs for large capacity aircraft — Functional requirements*.

[5] SAE Aerospace Recommended Practice ARP 1328A, *Aircraft ground support equipment vehicle stability analysis*.[1)]

[6] ANSI/SIA (Scaffold Industry Association) American National Standard A92.7-1990, *Airline Ground Support Vehicle-Mounted Vertical Lift Devices*.[2)]

1) ARP 1328A can be obtained from:

Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

2) National Standard A92.7 can be obtained from:

American National Standards Institute, 11 West 42nd Street, New York, NY 10036, USA.