

TECHNICAL  
REPORT

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**Series 1 freight containers — Rationale for  
structural test criteria**

**iTeh STANDARD PREVIEW**  
*Conteneurs de la série 1 — Fondements des critères de résistance*  
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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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

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- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
  - type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
  - type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard (“state of the art”, for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 15070, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 104, *Freight containers*, Subcommittee SC 1, *General purpose containers*.

## Introduction

The tests specified in ISO 1496, relative to the ISO series 1 container, were established in the earliest days of the development of containerization in the 1960s. They have proved appropriate ever since and are quoted extensively in subsequent standards. In particular, the development of European Standards (EN) for swap bodies relies on the quality of the work of ISO/TC 104, the Technical Committee charged by ISO with the development and the maintenance of standards for freight containers.

At publication of this Technical Report, there are nearly 8,4 million twenty-foot equivalent units (TEU) of containers in free circulation in the world.

ISO/TC 104 is concerned that all who operate ISO containers are aware of the principles which govern the tests included in ISO 1496.

These principles were established in the early stages of the standards' development by engineers who are now retiring or have already retired.

This Technical Report has been prepared for use as a concise reference. Included, in annex A, is a reference list detailing the source documents, some 30 years old, where the avid reader will find additional information.

ISO/TC 104/SC 1/WG 1 has issued this Technical Report retaining the tests concerning ISO series 1 containers as described in ISO 1496-1.

It is intended that this Technical Report be updated and completed to include the tests for other general purpose containers and specific purpose containers as specified in ISO 1496-2, in ISO 1496-3, in ISO 1496-4 and in ISO 1496-5, which may, because of the nature and utilisation of these containers, be different in some respects.

# Series 1 freight containers — Rationale for structural test criteria

## 1 Scope

This Technical Report gives the rationale for the structural test criteria for ISO series 1 freight containers, based on the tests specified in ISO 1496-1.

## 2 References

ISO 1161:1984, *Series 1 freight containers — Corner fittings — Specification.*

ISO 1496-1:1990, *Series 1 freight containers — Specification and testing — Part 1: General cargo containers for general purposes.*

ISO 1496-2:1996, *Series 1 freight containers — Specification and testing — Part 2: Thermal containers.*

ISO 1496-3:1995, *Series 1 freight containers — Specification and testing — Part 3: Tank containers for liquids, gases and pressurized dry bulk.*

ISO 1496-4:1991, *Series 1 freight containers — Specification and testing — Part 4: Non-pressurized containers for dry bulk.*

ISO 1496-5:1991, *Series 1 freight containers — Specification and testing — Part 5: Platform and platform-based containers.*

ISO 3874:1988, *Series 1 freight containers — Handling and securing.*

## 3 Explanatory notes on test procedures

### 3.1 General

The test procedures and tests specified in ISO 1496-1:

- a) concern IAAA, IAA, IA, IBBB, IBB, IB, ICC, IC and 1D containers;
- b) are based on the assumption that all containers are stowed longitudinally and lashed athwartship;
- c) are intended to demonstrate:
  - 1) the ability of a container to withstand, without failure of any kind during its service life, the loads encountered under the dynamic and normal operating conditions of various forms of intermodal transportation;

- 2) the operational interchangeability of containers;
- d) shall be carried out on all new containers intended for international use (see 3.3.1);
- e) are intended to simulate the dynamic stresses exerted on containers during the various modes of transportation employed in use. For reasons of reproducibility and ease of handling, all tests are carried out in the static mode. They shall be carried out individually, at the frequency detailed in ISO 1496-1, and independently from each other (see.3.3.2).

### 3.2 Test loads

The test criteria, in particular for maximum gross mass,  $R$ , are the recommended minimum for testing and the maximum allowable for operation.

### 3.3 Remarks

**3.3.1** The actual design specification of the containers shall include the capability to withstand these loads. The ISO test loads include a safety factor to account for fatigue, corrosion and damage to which the container may be subjected during its expected operational life.

**3.3.2** The test loads are based on the assumption that there is no synergistic combination of dynamic forces due to handling or the effects of any transportation mode.

**3.3.3** Attention needs to be paid to the order of tests only when so noted in the standard specific to each type of container.

**3.3.4** All the tests assume a homogeneous cargo and an even weight distribution. Particularly dense cargoes may cause concentrated loads. This should be borne in mind when stowing and lashing the cargoes.

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## 4 Tests

### 4.1 Test No. 1 – Stacking

#### 4.1.1 General

This test is carried out to prove the ability of a fully loaded container to support a superimposed mass of containers, taking into account the conditions aboard ships at sea and the relative eccentricities between superimposed containers.

#### 4.1.2 Purpose and requirements

##### 4.1.2.1 History and evolution

In the initial version of ISO 1496-1 the test was conducted to prove the ability of a container to withstand five superimposed containers of the same dimensions, each with a load of  $1,8R$ .

##### 4.1.2.1.1 Load eccentricities

The eccentricity requirements are based on the fact that a minimum of play is needed to allow for proper operation of the containers when being lowered in or lifted out of the ship's cell guides.

The maximum values of the eccentricity as required by the test procedure are:

laterally: 25,4 mm, i.e. 1 in;

longitudinally: 38 mm, i.e. 1,5 in.

The actual in-service values are derived from the data in table 1.

**Table 1**

Characteristics	Dimension	Nominal length of container	
		20 ft	40 ft
Usual cell guide dimensions of container ships	Width	2 460 mm	2 460 mm
	Length	6 091 mm	12 234 mm
Container dimensions and tolerances	Width	2 438 mm $\begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$ mm	2 438 mm $\begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$ mm
	Length	6 058 mm $\begin{smallmatrix} 0 \\ -6 \end{smallmatrix}$ mm	12 192 mm $\begin{smallmatrix} 0 \\ -10 \end{smallmatrix}$ mm
Container dimensions at mean construction tolerances	Width	2 435,5 mm	2 435,5 mm
	Length	6 055 mm	12 187 mm
Actual play for containers at mean construction tolerances	Width	24,5 mm <sup>1)</sup>	24,5 mm <sup>1)</sup>
	Length	36 mm <sup>2)</sup>	47 mm <sup>3)</sup>
1) In general, the actual play is close to this value.			
2) In general, the actual play is less than this value.			
3) In general, the actual play is greater than this value (see 4.1.3.1).			

#### 4.1.2.1.2 Conditions on board ship

According to studies made in 1964 and the acceleration measured on board ships under the worst sea and wind conditions (Beaufort 11), a load factor of 1,8 represents an average which is perfectly adapted to the requirements for container testing. Subsequent studies have shown the continued validity of this value despite evolving vessel design, regardless of its capacity<sup>[2]</sup>.

#### 4.1.2.2 Current practice in testing

In order to promote uniform end-frame design for containers of 40 ft, 30 ft and 20 ft nominal capacity and considering the current operations with such containers in a nine-high stack aboard ship, a stacking load based on eight containers, superimposed on a ninth, each loaded to 24 000 kg, was adopted in ISO 1496-1:1990. This decision led to the adoption of a corner-post stacking test load of 86 400 kg regardless of container dimensions (see ISO 1496-1:1990, note in table 3).

The total load on the bottom container is equal to  $24\ 000\ \text{N} \times 9,81 \times 8 \times 1,8 = 3\ 390\ \text{kN}$ . The force on each end is thus 1 695 kN, and the total load for this test is  $24\ 000 \times 8 = 192\ 000\ \text{kg}$ .

#### 4.1.2.3 Operation

Observations of actual operating conditions show that the average actual gross mass of 40 ft and 20 ft containers stowed aboard ship rarely reaches the average value of 24 000 kg. Furthermore,

for stability requirements of the ship, lighter containers are stowed in the upper levels. Therefore an average value of 24 000 kg represents a maximum that is never reached in normal situations.

### 4.1.3 Possible changes for future needs

#### 4.1.3.1 Load eccentricities

— The load eccentricities are sufficient to cover the actual eccentricity of 20 ft containers when stacked in 20 ft cells;

— Although the data in 4.1.2.1.1 indicate that the load eccentricities are not sufficient to cover the actual eccentricity of 40 ft containers when stacked in 40 ft cells, practical experience has shown that this is not a problem.

#### 4.1.3.2 Forces applied during stacking test

Although there is a tendency to increase the value of the maximum gross mass for 20 ft containers, there is no need to change the present test requirements because

— the average actual gross mass will in practice be less than the permissible maximum;

— the actual gross mass of containers has not so far been limited due to road regulations;

— acceleration values of 1,8g are still considered a valid upper limit by shipbuilders. Containers tested for this acceleration value can be stacked on new-generation container vessels which have higher stacking capability but whose overall dimensions limit in-service vertical acceleration to below 1,8g.

## 4.2 Test No. 2 — Lifting from the four top corner fittings

### 4.2.1 General

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This test is carried out to prove the ability of a container, whether in a loaded or empty condition, to withstand being lifted vertically using its top corner fittings. It demonstrates the lifting capability not only of the top frame but also of the entire container frame and floor structure of the container.

### 4.2.2 Purpose and requirements

#### 4.2.2.1 History and evolution

The test conditions, unchanged since the publication of the original requirements<sup>[4][7]</sup>, are the following:

- a) the container is loaded to a combined tare and payload mass equal to  $2R$ ;
- b) lifting is accomplished via twistlocks or other fittings engaging the four top corner fittings;
- c) the direction of application of the lifting force is vertical, except for 10 ft containers;
- d) in the case of a 10 ft container being lifted by use of slings connected to a single point above the top of the container, the direction of application of the lifting force is at least  $60^\circ$  above the horizontal;



- e) the minimum acceleration or deceleration in lifting should be applied;
- f) the base of the container is free to deflect;
- g) the container is suspended for at least 5 min.

#### 4.2.2.2 Current practice

Generally, containers are lifted vertically using the methods described in 4.2.2.1.

##### 4.2.2.2.1 Testing

The test requirements have remained the same in all editions of ISO 1496-1.

##### 4.2.2.2.2 Construction

The use of separate corner castings welded to posts and rails has remained constant and standard in the industry. The use of fittings or apertures complying with the design requirements of ISO 1161, but integral to the post, is also acceptable.

#### 4.2.2.3 Operations

Vertical lifting through the upper apertures of the four top corner fittings is the preferred method of lifting containers. As far as is known, no problems concerning vertical top lifting have been reported to ISO/TC 104. Moreover, tests conducted on forces imposed on containers during crane operation show maximum acceleration values that remain within the present ISO test criteria<sup>[12]</sup>.

#### 4.2.3 Possible changes for future needs

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The current test is quite satisfactory, provided the container is lifted cleanly and vertically by all four corner fittings. If the vertical load on any corner fitting exceeds 150 kN, resulting from an increase in maximum gross mass above 30 480 kg or from other operational changes, the design, construction and test requirements must be reviewed.

### 4.3 Test No. 3 — Lifting from the four bottom corner fittings

#### 4.3.1 General

This test is carried out to prove the ability of a container, whether in a loaded or empty condition, to withstand being lifted using the bottom corner fittings, in accordance with ISO 1161, via slings which transmit the lifting force from the bottom corner fittings obliquely to a single transverse spreader beam.

#### 4.3.2 Purpose and requirements

##### 4.3.2.1 History and evolution

The test conditions, unchanged since the publication of the original requirements<sup>[4][7]</sup>, are the following:

- a) the container is loaded to a combined tare and payload mass equal to  $2R$ ;
- b) lifting is accomplished via fittings engaging the lateral aperture of the four bottom corner fittings;

- c) the lifting force originates from a single point, and is transmitted via a transverse spreader beam to slings attached from either side of the beam to bottom corner fittings on the respective sides of the container;
- d) the slings are situated vertically in the transverse plane, at a maximum of 38 mm (1,5 in) from the sides of the container, in order to avoid overloading the lateral face of the corner fittings around the opening;
- e) slings on the same side are placed in the same longitudinal plane, at the following minimum angles from the horizontal:
  - 30° for 40 ft containers;
  - 37° for 30 ft containers;
  - 45° for 20 ft containers;
  - 60° for 10 ft containers.

The arrangements given in a) to e) lead to a comparable loading pattern of the bottom corner fittings of containers of different length:

- negligible acceleration or deceleration in lifting is detected;
- the base of the container is free to deflect;
- the container is suspended for at least 5 min and then lowered to the ground.

#### 4.3.2.2 Current practice

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While containers are generally lifted using the top corner fittings, the lifting method using the bottom corner fittings may be used.

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#### 4.3.2.2.1 Testing

The test requirements have remained the same in all editions of ISO 1496-1.

#### 4.3.2.2.2 Construction

The use of separate corner castings welded to the posts and rails has remained constant and standard in the industry. The use of fittings or apertures complying with the design requirements of ISO 1161, but integral to the post, is also acceptable.

#### 4.3.2.3 Operations

This is the only recognized method of using slings connected to the bottom corner fittings to lift ISO containers. It is rarely used. As far as is known, no problems concerning bottom lifting have been reported to ISO/TC 104.

Care must be taken that the maximum offset of 38 mm and the minimum angle of the slings are not exceeded.

#### 4.3.3 Possible changes for future needs

No changes are envisaged.

## 4.4 Test No. 4 — Longitudinal external restraint

### 4.4.1 General

This test is carried out to prove the ability of a container to withstand longitudinal external restraint under dynamic conditions of railway operations.

### 4.4.2 Purpose and requirements

#### 4.4.2.1 History and evolution

The longitudinal restraint test was developed assuming an acceleration of  $2g$ .

From the beginning of the standardization process, longitudinal accelerations and decelerations of  $2g$  have been accepted as satisfactorily representing common practice.

During the test, the container was subjected to a uniformly distributed load of  $R$ , but for the calculation of the restraint force a design load factor of 1,25 was used.

In the initial Recommendation<sup>[7]</sup>, the restraint force was specified as  $2,5R$  (i.e. a force equivalent to a load of  $2,5R$ ). In the International Standard which replaced it<sup>[8]</sup>, the restraint force was reduced to  $2R$ .

#### 4.4.2.2 Current practice

The practice has not subsequently changed, as there has been no indication that damage occurs due to the design load factor or the value of the acceleration/deceleration used.

##### 4.4.2.2.1 Testing

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The test requirements have remained the same in all editions of ISO 1496-1.

##### 4.4.2.2.2 Construction

The use of separate corner castings welded to posts and rails has remained constant and standard in the industry. The use of fittings or apertures complying with the design requirements of ISO 1161, but integral to the post, is also acceptable.

##### 4.4.2.3 Operations

As far as is known, no problems have ever been reported to ISO/TC 104 by European or American railways concerning normal operating conditions.

### 4.4.3 Possible changes for future requirements

As containers are very seldom transported as single wagon loads, but usually in unit trains, shocks to the cars and the containers have been reduced. The speed of container unit trains will doubtless increase in the years to come, but because of these opposing trends, it is recommended that no changes be undertaken.

## 4.5 Test No. 5 — Strength of end walls

### 4.5.1 General

This test is carried out to prove the ability of the end walls of a container to withstand the forces caused by the cargo under the dynamic conditions of railway operations.