DNV·GL

CLASS GUIDELINE

DNVGL-CG-0060 Edition May 2019

Container securing

DNV GL AS

FOREWORD

DNV GL class guidelines contain methods, technical requirements, principles and acceptance criteria related to classed objects as referred to from the rules.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

This document supersedes the October 2015 edition of DNVGL-CG-0060.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or subsection, normally only the title will be in red colour.

Changes May 2019

<table>
<tr><th>Topic</th><th>Reference</th><th>Description</th></tr>
<tr><td rowspan="9">Revised method for determination of maximum permissible cargo masses of deck containers</td><td>Sec.1 [5.1]</td><td rowspan="2">Class notation RSCS replaced with new class notation RSCS+.</td></tr>
<tr><td>Sec.2 [2.1]</td></tr>
<tr><td>Sec.2 [2.2]</td><td>Correction of reference for wind loads.</td></tr>
<tr><td>Sec.2 [3.1]</td><td>Table 1 replaced with reference to DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8.</td></tr>
<tr><td>Sec.4</td><td>Completely revised, except for:
— Sec.4 [2.1.3.2] overall modulus of elasticity of steel lashing rods (old Sec.4 [3.1.4])
— Sec.4 [2.1.3.5] (old Sec.4 [3.1.3]) deflection of lashing bridges
— Sec.4 [4.1] (old Sec.4 [2.6]) transverse force in way of container foundation
— Sec.4 [4.2] (old Sec.4 [2.7]) longitudinal force in way of container foundation
— Sec.4 [4.3] (old Sec.4 [2.2]) longitudinal racking force.</td></tr>
<tr><td>Sec.5 [2.1.2]</td><td>Correction of formula for vertical compression force acting on the lowermost container in stack.</td></tr>
<tr><td>Sec.6 [3.2]</td><td>Reference to certification standard is replaced with reference to DNVGL-CP-0068.</td></tr>
<tr><td>App.G</td><td>Deleted.</td></tr>
</table>

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.

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SECTION 1 GENERAL

1 Objective

The purpose of this publication is to serve as an aid to those responsible for the planning and strength evaluation of securing arrangements for cargo containers on board ships.

2 Scope

This publication explains procedures for calculating of forces acting on container securing systems on board ships. Acceptable assumptions and calculation procedures supplementing the general requirements stated in the rules for classification of ships are given.

3 Application

For ships assigned the ship type class notation **Container ship** or additional class notation **Container**, DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 requires that strength evaluation of container securing arrangements shall be carried out. This class guideline includes calculation methods for strength evaluation of container securing arrangements acceptable to the Society.

4 Procedure

To determine loads in the container lashing system, calculation methods according to Sec.4 to Sec.6 shall be applied depending on the arrangement and type of the lashing system. Input data are container gross weights, dimensionless acceleration factors and wind loads according to DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8, as well as parameters of the lashing system.

The results shall be checked against strength limits for ISO-containers or safe working load (SWL) of the lashing fittings in accordance with Sec.3.

5 Symbols and definitions

5.1 Symbols

For symbols not defined in this class guideline, see DNVGL-RU-SHIP Pt.3 Ch.1 Sec.4 [2].

α	=	angle of lashing, in degrees, measured to vertical axis of ship's coordination system
A	=	minimum effective gross area, in cm^2, of lashings
b_l	=	longitudinal dimensionless acceleration factor defined in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.4.2]
b_q	=	transverse dimensionless acceleration factor defined in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3.2]
	=	for ships assigned the additional class notation **RSCS+** the transverse dimensionless acceleration factor, b_q, shall be reduced by a route reduction factor, f_{route}, defined in DNVGL-RU-SHIP Pt.6 Ch.4 Sec.10
b_v	=	vertical dimensionless acceleration factor defined in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.5.3]
CPL_{found}	=	vertical support force, in kN, acting at bottom of a specific tier of container
CPL_i	=	calculated compressive force, in kN, in container post, equal to CPL_{found}, calculated at top of the container for which the container post is under investigation
E_Z	=	overall Young's modulus, in kN/cm^2, of lashings including turnbuckle
F_q	=	horizontal force, in kN, acting per container

$F_{q,i}$ = transverse container force, in kN, acting at level *i*, as given in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3]

$F_{\ell,i}$ = longitudinal container force, in kN, acting at level *i*, as given in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.4]

$F_{t,found}$ = calculated transverse force, in kN, acting on foundation at bottom of the stack

G = container's gross mass, in ton, as given in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.2]

l = length, in cm, of lashing

= in case the rule length is not available, length between perpendiculars L_{PP} as defined in DNVGL-RU-SHIP Pt.3 Ch.1 Sec.4 Table 2 may be applied

LF = calculated tension force, in kN, in container post, calculated at bottom of the container

LF_i = calculated tension force, in kN, in container post, calculated at bottom of the container for which the container post is under investigation

μ = friction coefficient

= 0.25 for cast steel combinations

= 0.5 for steel-steel combinations

= other combinations will be considered on a case-by-case basis

$RF_{t,i}$ = horizontal support force, in kN, acting at level *i*

Z_i = lashing force, in kN

$RF_{l,i}$ = longitudinal racking force, in kN.

5.2 Definitions

For definitions not defined in this class guideline, see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.1 [1.5] and DNVGL-RU-SHIP Pt.3 Ch.1 Sec.4 [3].

6 Assumptions

6.1 Hull support structures

Hull support structures are normally assumed rigid. In special cases, e.g. shoring forces at ship sides, it may be necessary to consider non-rigid supports.

6.2 Strength and stiffness of containers

Calculations assume that containers have at least normal strength and stiffness, i.e. closed boxes, open-top boxes, tank containers.

6.3 Orientation of containers

For default calculations all containers in a stack or block are placed in the same directions, i.e. all containers have the doorless end facing the same direction.

6.4 Friction

Friction effects are not taken into account.

6.5 Pre-tensioning of lashings

Pre-tensioning of lashings is not considered.

SECTION 2 DESIGN LOAD COMBINATIONS FOR CONTAINER SECURING ARRANGEMENTS

1 General

Container lashing calculations as given in this publication shall be carried out with the design load combinations as given in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [5], which are further detailed in the followings.

2 Design loads

2.1 Sea induced accelerations

Accelerations related to ship's motion shall be calculated in accordance with DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3] to DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.5]. For ships assigned the additional class notation **RSCS+**, accelerations related to ship's motion for the specific routes shall be calculated additionally in accordance with DNVGL-RU-SHIP Pt.6 Ch.4 Sec.10.

2.2 Wind loads

Wind loads shall be applied in accordance with DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8.

3 Design load combinations

3.1 General

Applicable design load combinations are listed in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 Table 4. In the subsequent sections the relevant design load combinations are described in some more detail.

3.2 Transverse loading (LC1)

3.2.1 Forces in the lashing system shall be calculated by applying the transverse dimensionless acceleration factor, b_q, in accordance with DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3].

3.2.2 For deck stowage extreme transverse accelerations are combined with the vertical component of acceleration of gravity acting downwards.

Wind loads shall be added to wind exposed containers.

See also Figure 1.

3.2.3 For hold stowage extreme transverse accelerations are combined with the vertical component of acceleration of gravity acting downwards.

See also Figure 1.

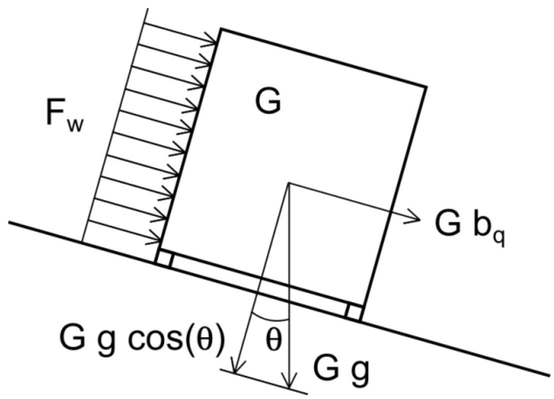


Figure 1 LC1

3.3 Longitudinal/vertical loading (LC2)

3.3.1 Longitudinal dimensionless accelerations factor, b_l, in accordance with DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.4] shall be applied combined with vertical dimensionless acceleration factor, b_v, in accordance with DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.5].

3.3.2 For deck/hold stowage extreme longitudinal accelerations are combined with the vertical acceleration b_v and gravity acting downwards.

See also Figure 2.

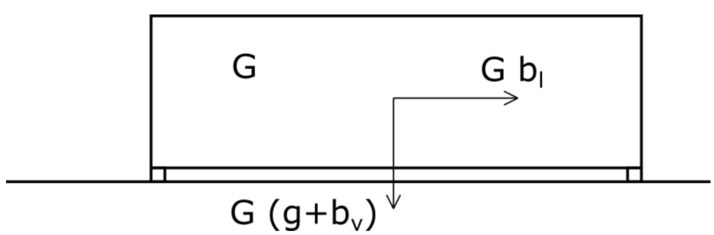


Figure 2 LC2

SECTION 3 ACCEPTANCE CRITERIA

1 General

Container strength limits shall be in accordance with recognized standards. In [2] strength limits for ISO containers are given.

Allowable forces in the container securing devices shall be taken as the certified safe working load (SWL). In [3] typical SWL for selected container securing devices are shown.

2 Acceptance criteria for ISO containers

Container strength limits and container corner casting strength limits shall be in accordance with required minimum (tested) strength values and capabilities given in recognized standards, e.g., ISO 1496-1 and ISO 1161.

Strength limits for ISO containers are given in Table 1.

Table 1 Strength limits for ISO containers, in kN

Racking force (door frame / front wall frame) (RF_t)			150
Racking force side walls (RF_l)			150 (75[1)])
Corner post compression (*CPL*)			848 (942[2)])
Vertical tension in upper corner (from locking device) (*LF*)			250
Vertical tension in lower corner (from locking device) (*LF*)			250
Allowable values for lashing loads in corner casting (Z)			
Type of lashing	Lashing angle	Lower corner	Upper corner
Vertical lashing	$0° \le \alpha \le 10°$	300	125
Long lashing	$10° < \alpha \le 35°$	270	175
Short lashing	$35° < \alpha \le 60°$	245	245
Horizontal lashing	$60° < \alpha \le 90°$	225	225
Horizontal shoring forces on corners (F_{shore})			
Lower corner, tension/compression		400	
Upper corner, tension/compression		250	

1) for non-closed box containers

2) For containers stowed with both ends in cell guides, a corner post load of 942 kN may be applied, provided the containers in lowermost tier are certified for this load in accordance with ISO 1496-2.

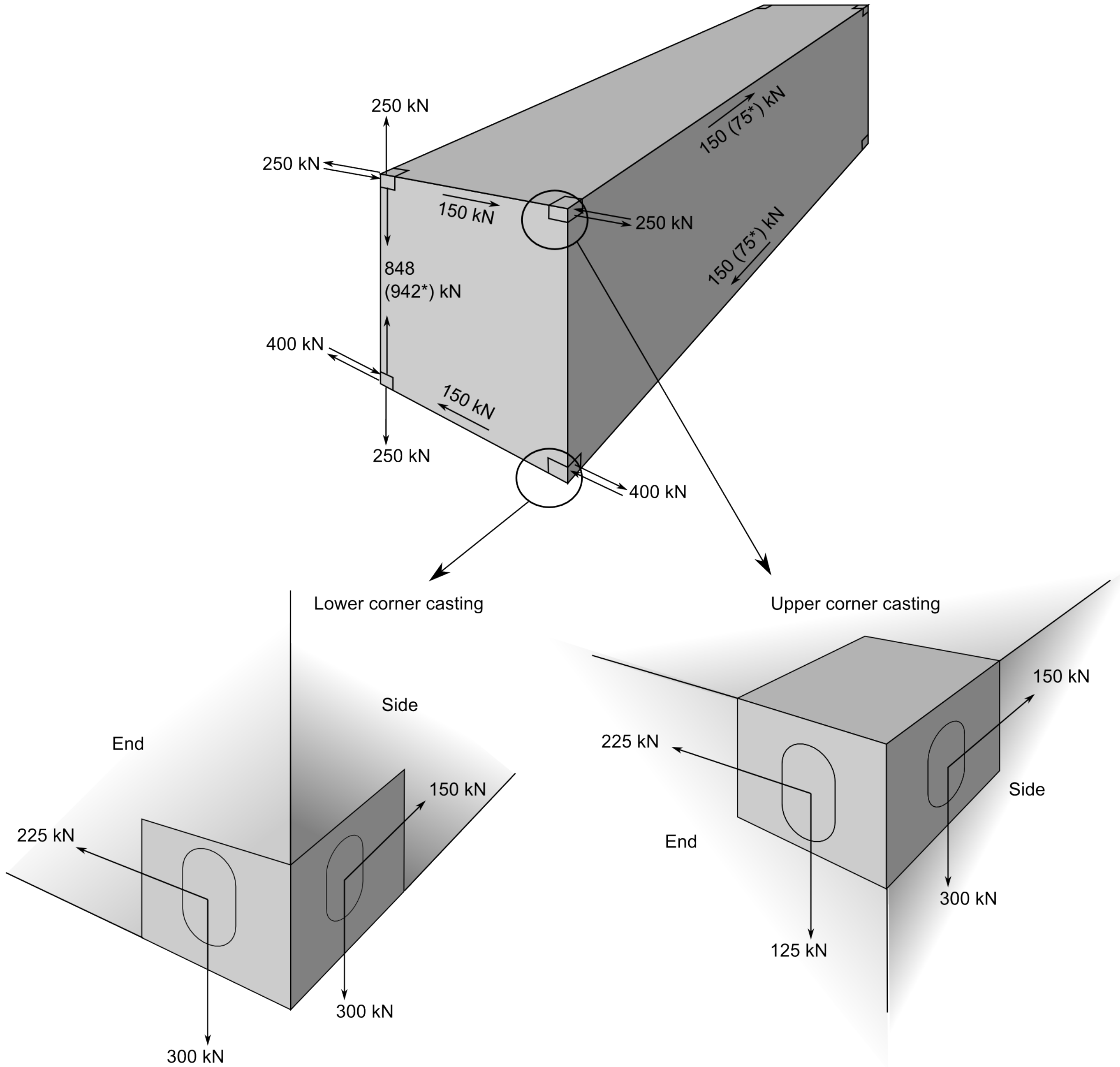
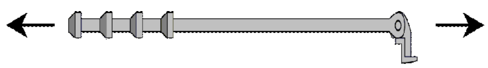
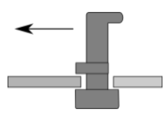
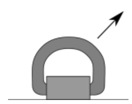
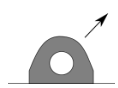
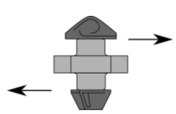


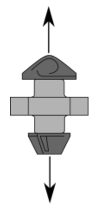
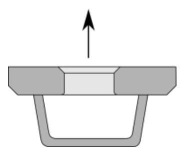
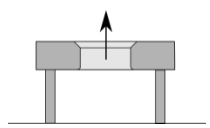
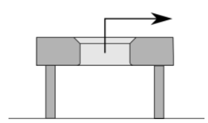
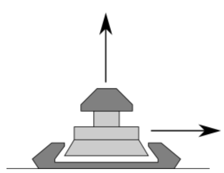
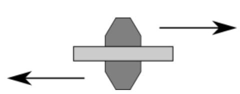
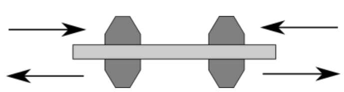
Figure 1 Strength limits for ISO containers

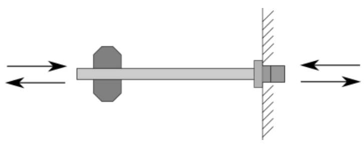
3 Typical SWL for container securing devices

In Table 2, safe working load (SWL) values are shown as typical values for selected types of the container securing devices. For container securing calculation purposes, SWL values as given in the product certificates of actual devices shall be used as allowable limits.

Table 2 Typical SWL values for container securing devices

Item	*Type*	*Figure*	*Safe Working Load (SWL), in kN*	*Proof Load (PL)), in kN*	*Min. Breaking Load (BL)), in kN*
General note:		Deck	SWL	1.25 SWL	2.0 SWL
		Hold	SWL	1.1 SWL	1.33 SWL
		Lashings			
1.1	Lashing rod		245	307	490
1.2	Lashing chain		80	100	200
1.3	Lashing steel wire rope		200	250	450
2	Turnbuckle		245	307	490
3	Penguin Hook		245	307	490
4	D-Ring		245	307	490
5	Lashing plate		245	307	490
		Twist locks and deck connections			
6	Twist lock (single)		210	263	420

Item	*Type*	*Figure*		*Safe Working Load (SWL), in kN*	*Proof Load (PL)), in kN*	*Min. Breaking Load (BL)), in kN*
				250	313	500
7	Flush ISO socket			250	313	500
8	Pedestal ISO socket			250	313	500
				210	263	420
9	Dove tail socket with twist lock		Tension	250	313	500
			Shear	210	263	420
Hold and block stowage						
10	Stacker (single)			210	263	420
11	Stacker (double)			560	620	730

<table>
<tr><th>Item</th><th>Type</th><th colspan="2">Figure</th><th>Safe Working Load (SWL), in kN</th><th>Proof Load (PL)), in kN</th><th>Min. Breaking Load (BL)), in kN</th></tr>
<tr><td>12</td><td>Linkage plate</td><td colspan="2"></td><td>150</td><td>188</td><td>300</td></tr>
<tr><td>13</td><td>TP Bridge fitting</td><td colspan="2"></td><td>210</td><td>263</td><td>420</td></tr>
<tr><td rowspan="2">14</td><td rowspan="2">Buttress</td><td rowspan="2"></td><td>Between tiers</td><td>650</td><td>715</td><td>850</td></tr>
<tr><td>Top tier</td><td>250</td><td>275</td><td>325</td></tr>
</table>

SECTION 4 STRENGTH EVALUATION OF CONTAINER SECURING ARRANGEMENTS WITH LATERAL NON-RIGID SUPPORT

1 General

This section provides guidance on how to perform finite element analysis for container lashing arrangements.

The procedure described below represents the method used by the DNV GL software STOWLASH 3D.

Container stacks secured with twistlocks, with or without lashings, are considered as container securing arrangements with lateral non-rigid support.

2 Calculation method

The strength evaluation shall be carried out applying the design load combinations given in Sec.2.

Each stack shall be analyzed separately unless there are horizontal connections between the stacks such as double stackers or bridge fittings, in which case the whole block should be analysed.

Calculation models for container stacks shall fulfill the requirements in this section. The models of containers shall be 3-dimensional. The stiffness and response behaviour of the container shall be considered as described in [2.1.1].

Twistlock elements shall be modelled with clearances, as real twistocks have clearances. In case of a container stack tipping, the twistlock will open until the clearance is reached. Until the twistlock clearance is reached, no vertical forces can be transferred, but the kinetic energy is increasing. When the twistlock connection is closed, vertical forces will be transferred. The kinetic energy of the containers above will contribute to a dynamic force component that increases the static vertical force. The above mentioned effects shall be considered in the calculation method.

The transverse deformation of container stacks can basically be described by the deformation of the containers themselves, by racking deformation, and additionally transverse deformations resulting from opening of twistlocks. The centre of gravity of the container stack will shift transversely causing a change of the vertical forces. The calculation method shall take into account this non-linearity.

2.1 Modelling of geometry

2.1.1 Container stiffness

Sea going dry freight containers are 3-dimensional steel constructions. Containers consist of a framing system, which transfers loads in vertical, lateral and longitudinal direction. Racking forces are transferred by side walls, end walls and, specifically on the door side, by doors.

Loads are basically transferred to other containers by the container corner castings.

The end frames of containers have a racking stiffness, which is different for the wall side and the door side. Also the side walls of containers have a racking stiffness.

The frames will also have compressive and tensile strain under load.

A very important property of containers is torsional stiffness. Due to the torsional stiffness, forces will be transmitted from the door side to the wall side and vice versa, depending on the forces.

Container calculation models shall be modelled taking into account all the factors described above.

2.1.2 Twistlocks

Twistlocks shall be modelled as 1-dimensional elements, e.g. beam elements. The section area of the twistlock elements shall be sufficiently large to enable realistic tensile deformations.

Twistlocks shall be modelled with a hinge at one end to avoid transfer of bending moments between the containers, as shown in Figure 1.

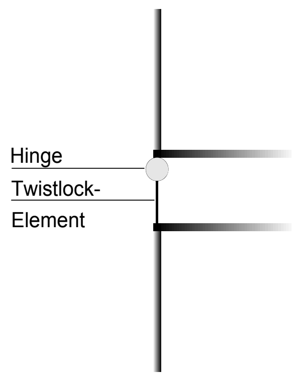


Figure 1 Model of twistlock

Clearance is an important aspect of twistlocks. Tensile forces will be transferred only if the clearance is reached. The elements, which describe the behaviour of twistlocks, shall be able to display this property. That means, twistlock elements shall be able to open without transferring tensile forces. When the clearance is reached, tensile forces shall be transmitted. Twistlock elements shall also be able to transfer compressive forces. A force displacement diagram is shown in Figure 2 below.

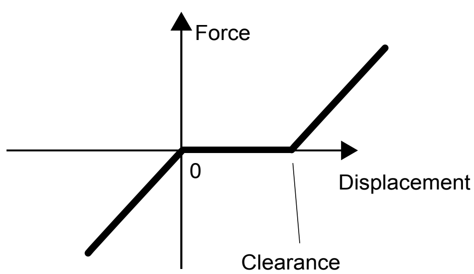


Figure 2 Schematic force displacement diagram of twistlock

The amount of vertical clearances for twistlocks is defined in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [2.3.6].

2.1.3 Lashing rods

For lashing units with one turnbuckle, the lashings shall be modelled as 1-dimensional elements, e.g. beam elements with Young's modulus according to Table 1 using the minimum effective cross area *A*, in cm^2, of the lashing rods. The lashing elements shall be fitted with hinges at corner fitting ends to avoid transfer of bending moments, as shown in Figure 3.

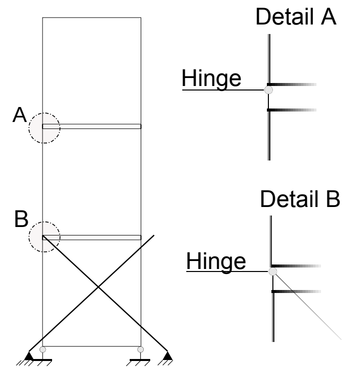


Figure 3 Lashing rods

The elements shall transfer only tension forces. The minimum force which such elements shall transfer is 0 kN. It shall not be negative. A diagram is shown in Figure 4.

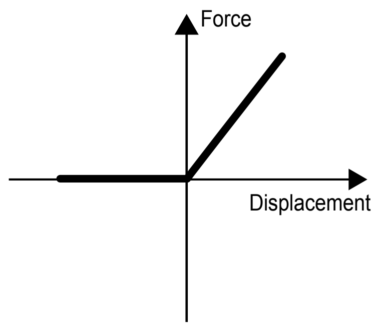


Figure 4 Force displacement diagram of lashing element

2.1.3.1 Geometry of lashings

The geometry of lashings shall be modelled considering their x-, y- and z length component of the lashing. The x-component of a lashing may be neglected, if the x-distance is less than 300 mm.

2.1.3.2 Overall Young's modulus of steel rods

The characteristics of lashing arrangements shall be determined with their actual geometry. For calculation of lashing forces the values of Young's modulus, as given below, shall be applied for steel lashing rods (including tensioning device and eyes) depending on their design:

- 1.40 x 10^4 kN/cm^2 for lashings with a length of lashing l less than 500 cm
- 1.75 x 10^4 kN/cm^2 for lashings with a length of lashing l less than 700 cm
- 1.90 x 10^4 kN/cm^2 for lashings with a length of lashing l more than 700 cm

Alternatively for standard lashing arrangements the values given in Table 1 may be applied.

Table 1 Design values for lash parameters

Lashing to	*Length of lashing l, in cm* [1)]	*Angle of lashing α, in deg* [1)]	*Young's modulus of lashing rod E_z, in kN/cm^2*
1st tier top	354	43°	$1.4 \cdot 10^4$
2nd tier bottom	365	41°	
2nd tier top	560	24°	$1.75 \cdot 10^4$
3rd tier bottom	575	22°	
3rd tier top [2)]	810	19°	$1.9 \cdot 10^4$
4th tier bottom [2)]	825	18°	

[1)] The stated standard values for the length and the angle of lashing are valid for 8' 6" high containers. For other container heights, these values shall be adjusted accordingly.

[2)] These long lashings are not permitted according to IMO Res. A.714 *Code of Safe Practice for Cargo Stowage and Securing Annex 14*.

In case of unusual characteristics of the lashing arrangement, Young's modulus for calculation of lashing forces shall be obtained by a separate test of the lashing configuration including turnbuckle. The test results shall be submitted to the Society for acceptance.

2.1.3.3 Container stacks with external lashings and internal lashings

For container stacks under lateral loads, the tripping moment induced by lateral loads will result in vertical reaction forces on container posts i.e. compression forces on one side and tension forces on the other side. For internal lashing, the acting lashing bars are fixed to the corner casting on the post with compression reaction forces. For external lashing, the acting lashing bars are fixed to the corner casting on the corner post where tension reaction forces occur. See illustrations in Figure 5.

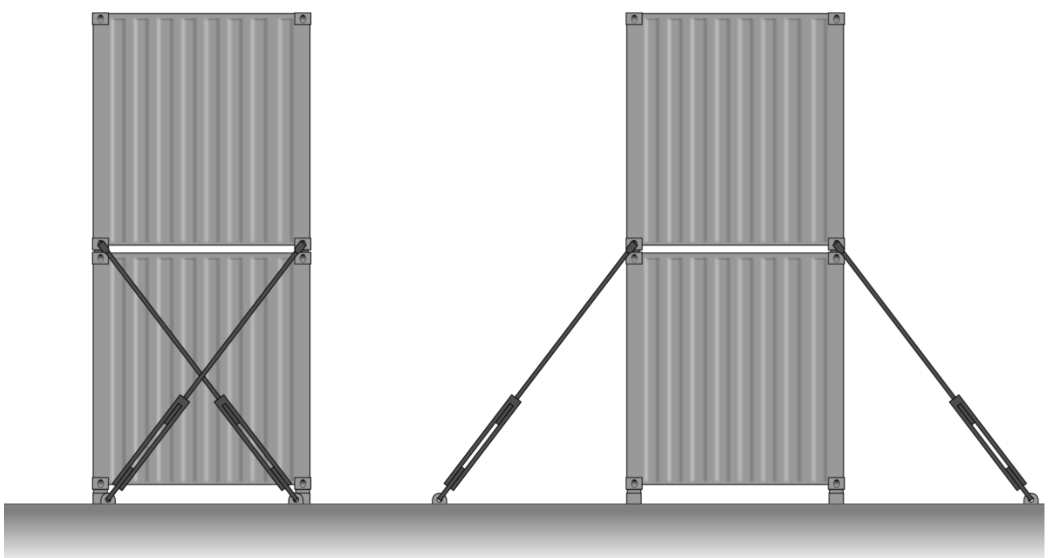


Figure 5 Internal lashing (left) and external lashing

For container stacks secured by external lashing, when the corner casting (where the acting lashing bar is secured to) is under tension force, the twistlock will not bear the loads before the clearance between twistlock cones and corner casting is closed. In such a case, the acting lashing bar will take more loads when considering additional deformation due to closing of the clearance. This phenomenon shall be taken into consideration during container securing calculations for external lashing system.

2.1.3.4 Container stacks with vertical lashing

For container stowage where vertical lashings are applied (lashing bar angle 0° ≤ α ≤ 10°) with spring element to equalise clearance between twistlocks and corner castings, the strength limits given in Sec.3 [2] shall be complied with, applying the following exception: for all twistlocks below the vertical lashing, the combined force of vertical tension force *LF*, and the lashing force *Z*, of the vertical lashing shall not exceed 375 kN.

2.1.3.5 Deflection of lashing bridges

Lashing forces shall be calculated by taking into account maximum deformations of lashing bridges. The maximum deformations of the lashing bridges in ship's transverse direction are given in DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [2.2.2].

If strength evaluation of lashing bridges results in greater deformations, these shall be applied in the strength evaluation of the container stacks, see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [1.2].

3 Boundary conditions

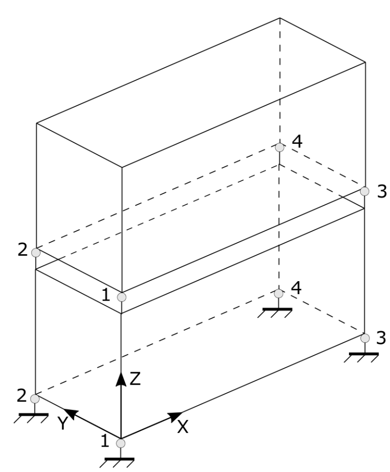
3.1 Boundary conditions at ship structure

The boundary nodes of twistlock elements attached to the ship structure or hatch cover shall be fixed against displacements in all directions.

An example of boundary conditions is summarized in Table 2.

Table 2 Example for boundary conditions

Position	Direction of support
1	*x*, *y*, *z*
2	*z*
3	*y*, *z*
4	*z*



3.2 Boundary conditions between containers

The nodes of twistlock elements between containers shall transfer forces in vertical direction.

Transfer of horizontal forces shall be carried in a way that no constraint forces occur in the container models. For example, one node shall transfer forces in both horizontal directions, and one node shall transfer forces in transverse direction.

3.3 Boundary conditions between containers mixed stowage

The nodes of twistlock elements of the 20 ft container models shall transfer forces in vertical direction.

Transfer of horizontal forces shall be carried in a way that no constraint forces occur in the container models. For example, one bottom node shall transfer forces in both horizontal directions and one node shall transfer forces in transverse direction.

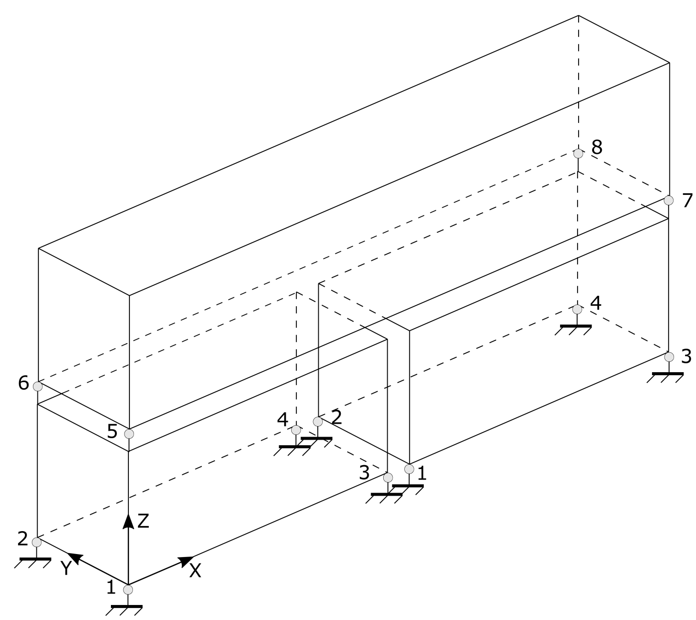
The bottom nodes of the 40 ft container model, which is on top of the 20 ft container models, shall additionally transfer forces in longitudinal direction to achieve a statically determined coupling between the containers.

Container models above this 40 ft container model will be constrained as described in [3.2].

An example of boundary conditions of mixed stowage is summarized in Table 3.

Table 3 Example for boundary conditions of mixed stowage

Position	Direction of support
1	*x, y, z*
2	*z*
3	*y, z*
4	*z*
5	*x, y, z*
6	*x, z*
7	*x, y, z*
8	*x, z*



4 Loading conditions

The vertical and horizontal forces shall be applied to the nodes of the container. This is illustrated in Figure 6 as an example.

The transverse forces in the example are calculated for a vertical centre of gravity (VCG) of 45% of the container height, see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.1.3].

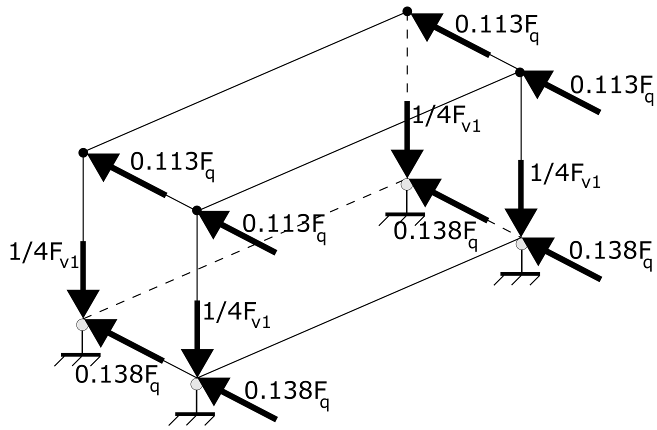


Figure 6 Example of forces on container

4.1 Transverse force in way of container foundation

The transverse force, $F_{t,\, found}$, in kN, on a foundation point shall be taken as:

$$F_{t, found} = RF_{t,1} + 0.275 \cdot F_{q,1}$$

If this force is not determined separately, a maximum value of 210 kN shall be assumed.

For container stanchions provided with a sliding plate or an athwartships arranged "dove tail base", the transverse force, $F_{t,\, found}$, on a foundation point shall be calculated as a friction force resulting from the vertical compressive force, CPL_{found}, acting on this foundation point and shall be taken as:

$$F_{t, found} = \mu \cdot CPL_{found}$$

The horizontal force is not required to be taken greater than the force causing the transverse deflection equal to the transverse clearance of the bottom locking device (usually about 10 mm). In case of significant deformation of hatches, e.g. with long hatches, these shall be taken into account with the container's horizontal shift.

4.2 Longitudinal force in way of container foundation

The longitudinal force, $F_{l, found}$ in kN, on container's foundation shall be taken as:

$$F_{l, found} = \sum_{i=1}^{n} F_{l,i}$$

4.3 Longitudinal racking force

The longitudinal racking force, RF_l in kN, on each container side frame in the i[th] tier shall be taken as:

$$RF_{l,i} = RF_{l,i+1} + 0.275 \cdot F_{l,i+1} + 0.225 \cdot F_{l,i}$$

The longitudinal racking force shall be compared with the strength limit of the container.

5 Results

Forces shall be extracted from the model to confirm that the loads in the securing devices between the containers and in the containers themselves do not exceed the maximum securing load (MSL) of the securing devices or the container strength criteria, according to Sec.3 [2]. In addition the reaction forces in the ship structure shall be considered.

At least the following forces shall be extracted and compared with the strength criteria:

— racking force of each container tier, $RF_{t,i}$
— loads at bottom of container stack, CPL_{found}
— container post load of each container tier, CPL_i
— lifting force between each container tier, LF_i
— lashing forces of all lashing elements, Z_i
— forces in connecting elements, if applicable.

SECTION 5 STRENGTH EVALUATION OF CONTAINER SECURING ARRANGEMENTS WITH LATERAL RIGID SUPPORT

1 General

Cell guides, buttress and similar are considered as container securing structures with lateral rigid support for container stacks. Strength evaluations of such container securing structures are given in:

— container stacks with cell guides: [2]
— forces for shoring of containers in cargo holds without cell guides: [3].

For containers secured with different methods at the two ends, e.g., one end with cell guide and the other end with stackers, or one end with lashings and the other end with twist locks, strength evaluation shall be carried out for both ends respectively.

2 Container stacks with cell guides

2.1 Containers stacks with both ends supported by cell guides

For container stacks with both ends supported by cell guides, strength evaluation for containers and relevant container securing devices shall be checked based on design load combination 2 given in Sec.2.

2.1.1 Longitudinal force transferred into cell guides

The longitudinal forces due to pitching motions are transferred by compression of the container's corner castings against the cell guide rails. Each container corner casting will transfer:

$$F_{CG,long} = \frac{F_{L,i}}{4}$$

2.1.2 Vertical compression of lower most container in stack

The vertical compression force acting on the lowermost container in the stack due to pitching motions shall not exceed maximum permissible corner post compression. Each container corner post load shall be calculated as:

$$CPL_1 = \frac{\left(\sum_{i=2}^{n} G_i\right) \cdot g \cdot \left(1 + b_v\right)}{4}$$

where:

G = gross mass of containers, in tons, of containers stowed on top of lowermost tier.

2.2 Containers stacks with one end only supported by cell guides

For 20' container stacks stowed in 40' container cell guides permissible stack weights shall be established in accordance with [2.3].

For 30' and 40' container stacks with one end only supported by cell guides, the calculation methods given in Sec.6 [2] apply.

2.3 Stowage of 20’ containers in 40’ cell guides

2.3.1 Stowage with lateral support in 20’-gap

Where 20’ containers are stowed in 40’ cell guides, in general, container ends in the 20’ gap shall be secured against shifting in the lowermost tier on both sides of the stacks. For the lowermost tier, the 20’ container bottom shall also be secured by single cones at cell guide ends.

For other tiers above, the 20’ containers shall be secured to each other by single stackers at the gap end.

2.3.2 Stowage of 20’ containers without lateral support in 20’-gap not topped by 40’ containers

For stowage of 20’ containers not topped by 40’ containers, the maximum permissible stack weights are listed in Table 1.

Table 1 Permissible stack weight, in tons, of 20’ containers not topped by 40’ containers

$\bar{b}_q$	*tiers*										
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.30	61.0	91.4	121.9	152.4	165.3	166.3	167.0	167.5	168.1	168.6	169.0
0.31	61.0	91.4	121.9	152.4	159.9	160.8	161.5	162.1	162.6	163.1	163.5
0.32	61.0	91.4	121.9	152.4	154.8	155.7	156.4	156.9	157.4	157.9	158.3
0.33	61.0	91.4	121.9	148.8	150.1	150.9	151.6	152.1	152.6	153.0	153.4
0.34	61.0	91.4	121.9	144.3	145.6	146.4	147.1	147.6	148.0	148.4	148.8
0.35	61.0	91.4	121.9	140.2	141.4	142.2	142.8	143.3	143.7	144.1	144.5
0.36	61.0	91.4	121.9	136.2	137.4	138.2	138.8	139.3	139.7	140.1	140.4
0.37	61.0	91.4	121.9	132.5	133.6	134.4	135.0	135.4	135.8	136.2	136.6
0.38	61.0	91.4	121.9	129.0	130.1	130.8	131.4	131.8	132.2	132.6	132.9
0.39	61.0	91.4	121.9	125.6	126.7	127.4	128.0	128.4	128.8	129.1	129.5
0.40	61.0	91.4	121.8	123.2	124.3	125.2	125.8	126.2	126.5	126.9	127.2
0.41	61.0	91.4	119.1	120.4	121.5	122.3	122.9	123.3	123.7	124.0	124.3
0.42	61.0	91.4	116.3	117.6	118.7	119.5	120.1	120.5	120.8	121.2	121.5
0.43	61.0	91.4	113.6	114.9	115.9	116.7	117.3	117.7	118.0	118.3	118.6
0.44	61.0	91.4	110.9	112.1	113.1	113.9	114.4	114.8	115.1	115.4	115.7
0.45	61.0	91.4	108.1	109.3	110.4	111.1	111.6	112.0	112.3	112.6	112.9
0.46	61.0	91.4	105.9	107.1	108.1	108.8	109.3	109.7	110.0	110.3	110.6
0.47	61.0	91.4	103.7	104.9	105.9	106.6	107.1	107.4	107.7	108.0	108.3
0.48	61.0	91.4	101.5	102.6	103.6	104.3	104.8	105.2	105.4	105.7	106.0
0.49	61.0	91.4	99.3	100.4	101.4	102.0	102.5	102.9	103.2	103.4	103.7
0.50	61.0	91.4	97.1	98.2	99.1	99.8	100.3	100.6	100.9	101.1	101.4
0.51	61.0	90.5	95.3	96.4	97.3	98.0	98.4	98.8	99.0	99.3	99.5

$\bar{b}_q$	*tiers*										
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.52	61.0	89.5	93.6	94.6	95.5	96.1	96.6	96.9	97.2	97.4	97.6
0.53	61.0	88.5	91.8	92.8	93.7	94.3	94.7	95.1	95.3	95.5	95.8
0.54	61.0	87.5	90.0	91.0	91.9	92.5	92.9	93.2	93.5	93.7	93.9
0.55	61.0	86.6	88.2	89.2	90.0	90.6	91.1	91.4	91.6	91.8	92.0
0.56	61.0	85.1	86.7	87.7	88.5	89.1	89.5	89.8	90.1	90.3	90.5
0.57	61.0	83.6	85.3	86.2	87.0	87.6	88.0	88.3	88.5	88.7	88.9
0.58	61.0	82.2	83.8	84.7	85.5	86.1	86.5	86.8	87.0	87.2	87.4
0.59	61.0	80.7	82.3	83.2	84.0	84.5	84.9	85.2	85.5	85.6	85.8
0.60	61.0	79.3	80.8	81.7	82.5	83.0	83.4	83.7	83.9	84.1	84.3
0.61	61.0	78.0	79.6	80.4	81.2	81.7	82.1	82.4	82.6	82.8	83.0
0.62	61.0	76.8	78.3	79.2	79.9	80.4	80.8	81.1	81.3	81.5	81.7
0.63	61.0	75.6	77.0	77.9	78.6	79.2	79.5	79.8	80.0	80.2	80.4
0.64	61.0	74.4	75.8	76.6	77.4	77.9	78.2	78.5	78.7	78.9	79.1
0.65	61.0	73.1	74.5	75.4	76.1	76.6	76.9	77.2	77.4	77.6	77.7
0.66	61.0	72.1	73.5	74.3	75.0	75.5	75.8	76.1	76.3	76.4	76.6
0.67	61.0	71.0	72.4	73.2	73.9	74.4	74.7	75.0	75.2	75.3	75.5
0.68	61.0	70.0	71.3	72.1	72.8	73.3	73.6	73.9	74.1	74.2	74.4
0.69	61.0	68.9	70.3	71.0	71.7	72.2	72.5	72.8	72.9	73.1	73.3
0.70	61.0	67.9	69.2	70.0	70.6	71.1	71.4	71.6	71.8	72.0	72.1
0.71	61.0	66.9	68.3	69.0	69.7	70.1	70.4	70.7	70.9	71.0	71.2
0.72	61.0	66.0	67.3	68.1	68.7	69.2	69.5	69.7	69.9	70.0	70.2
0.73	61.0	65.1	66.4	67.1	67.8	68.2	68.5	68.8	68.9	69.1	69.2
0.74	61.0	64.2	65.5	66.2	66.8	67.3	67.6	67.8	68.0	68.1	68.3
0.75	61.0	63.3	64.5	65.3	65.9	66.3	66.6	66.8	67.0	67.1	67.3
0.76	60.2	62.5	63.7	64.4	65.0	65.5	65.8	66.0	66.2	66.3	66.4
0.77	59.4	61.7	62.9	63.6	64.2	64.6	64.9	65.2	65.3	65.5	65.6
0.78	58.7	60.9	62.1	62.8	63.4	63.8	64.1	64.3	64.5	64.6	64.7
0.79	57.9	60.1	61.3	62.0	62.5	63.0	63.3	63.5	63.6	63.8	63.9
0.80	57.2	59.3	60.5	61.2	61.7	62.1	62.4	62.6	62.8	62.9	63.1

$\bar{b}_q$ = transverse acceleration factor calculated for the middle of stack height (see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3]).

$\bar{b}_q$	tiers										
	2	3	4	5	6	7	8	9	10	11	12

Note:

1) In the container stack the single container weights may differ from each other.

2) Calculated transverse acceleration factor $\bar{b}_q$ shall be rounded up to two decimal places.

Stowage of 20' containers without lateral support in 20'-gap topped by 40' containers

2.3.3 For stowage of 20' containers topped by 40' containers, the maximum permissible stack weights are listed in Table 2.

Table 2 Permissible stack weight, in tons, of 20' containers topped by 40' containers

$\bar{b}_q$	tiers										
	2	3	4	5	6	7	8	9	10	11	12
0.30	61.0	91.4	121.9	152.4	182.9	213.4	243.8	238.4	227.3	218.3	210.7
0.31	61.0	91.4	121.9	152.4	182.9	213.4	240.7	237.8	226.6	217.5	209.9
0.32	61.0	91.4	121.9	152.4	182.9	213.4	233.2	237.1	225.9	216.7	209.1
0.33	61.0	91.4	121.9	152.4	182.9	213.4	226.2	232.0	225.2	216.0	208.3
0.34	61.0	91.4	121.9	152.4	182.9	213.0	219.6	225.2	224.6	215.2	207.5
0.35	61.0	91.4	121.9	152.4	182.9	206.9	213.3	218.8	223.5	214.5	206.7
0.36	61.0	91.4	121.9	152.4	182.9	201.2	207.4	212.7	217.4	213.8	205.9
0.37	61.0	91.4	121.9	152.4	182.9	195.8	201.8	207.0	211.5	213.0	205.2
0.38	61.0	91.4	121.9	152.4	182.9	190.6	196.5	201.6	206.0	209.8	204.4
0.39	61.0	91.4	121.9	152.4	179.4	185.8	191.5	196.4	200.7	204.5	203.6
0.40	61.0	91.4	121.9	152.4	176.3	182.6	188.3	193.2	197.5	200.3	203.5
0.41	61.0	91.4	121.9	151.9	172.4	178.6	184.2	188.9	193.0	196.1	199.2
0.42	61.0	91.4	121.9	151.5	168.5	174.5	180.0	184.5	188.5	191.8	194.9
0.43	61.0	91.4	121.9	151.0	164.6	170.5	175.8	180.1	184.0	187.5	190.6
0.44	61.0	91.4	121.9	150.6	160.7	166.5	171.6	175.7	179.5	183.2	186.3
0.45	61.0	91.4	121.9	150.1	156.8	162.4	167.5	171.3	174.9	179.0	182.0
0.46	61.0	91.4	121.9	147.1	153.7	159.2	164.1	167.9	171.4	175.2	178.1
0.47	61.0	91.4	121.9	144.2	150.6	155.9	160.8	164.5	168.0	171.5	174.3
0.48	61.0	91.4	121.9	141.2	147.5	152.7	157.4	161.1	164.5	167.8	170.5
0.49	61.0	91.4	121.9	138.2	144.3	149.5	154.1	157.7	161.0	164.1	166.7
0.50	61.0	91.4	121.9	135.2	141.2	146.2	150.7	154.3	157.5	160.3	162.9
0.51	61.0	91.4	120.8	132.8	138.7	143.6	148.0	151.5	154.6	157.4	159.9
0.52	61.0	91.4	119.7	130.4	136.1	140.9	145.3	148.7	151.8	154.5	156.9

$\bar{b}_q$	tiers										
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.53	61.0	91.4	118.6	127.9	133.6	138.3	142.5	145.9	148.9	151.6	154.0
0.54	61.0	91.4	117.5	125.5	131.0	135.7	139.8	143.1	146.0	148.7	151.0
0.55	61.0	91.4	116.4	123.1	128.5	133.0	137.1	140.3	143.2	145.8	148.1
0.56	61.0	91.4	114.5	121.0	126.4	130.8	134.8	137.9	140.8	143.3	145.6
0.57	61.0	91.4	112.6	119.0	124.2	128.6	132.5	135.6	138.4	140.9	143.1
0.58	61.0	91.4	110.6	116.9	122.1	126.4	130.2	133.3	136.0	138.5	140.6
0.59	61.0	91.4	108.7	114.9	120.0	124.2	127.9	130.9	133.6	136.0	138.2
0.60	61.0	91.4	106.8	112.9	117.9	122.0	125.6	128.6	131.3	133.6	135.7
0.61	61.0	91.4	105.2	111.2	116.0	120.1	123.7	126.6	129.2	131.6	133.6
0.62	61.0	91.4	103.5	109.4	114.2	118.3	121.8	124.6	127.2	129.5	131.5
0.63	61.0	91.4	101.9	107.7	112.4	116.4	119.9	122.7	125.2	127.4	129.4
0.64	61.0	91.4	100.3	106.0	110.6	114.5	117.9	120.7	123.2	125.4	127.3
0.65	61.0	91.4	98.7	104.3	108.8	112.7	116.0	118.7	121.2	123.3	125.2
0.66	61.0	90.2	97.3	102.8	107.3	111.1	114.3	117.0	119.4	121.6	123.4
0.67	61.0	88.9	95.9	101.3	105.8	109.5	112.7	115.3	117.7	119.8	121.7
0.68	61.0	87.6	94.5	99.8	104.2	107.9	111.0	113.6	116.0	118.0	119.9
0.69	61.0	86.4	93.1	98.4	102.7	106.3	109.4	111.9	114.3	116.3	118.1
0.70	61.0	85.1	91.7	96.9	101.1	104.7	107.7	110.3	112.5	114.5	116.3
0.71	61.0	84.0	90.5	95.6	99.8	103.3	106.3	108.8	111.0	113.0	114.7
0.72	61.0	82.9	89.3	94.3	98.4	101.9	104.8	107.3	109.5	111.5	113.2
0.73	61.0	81.7	88.0	93.0	97.1	100.5	103.4	105.8	108.0	109.9	111.6
0.74	61.0	80.6	86.8	91.7	95.8	99.1	102.0	104.4	106.5	108.4	110.1
0.75	61.0	79.5	85.6	90.5	94.4	97.7	100.5	102.9	105.0	106.9	108.5
0.76	61.0	78.5	84.5	89.3	93.2	96.5	99.3	101.6	103.7	105.5	107.2
0.77	61.0	77.5	83.5	88.2	92.1	95.3	98.0	100.3	102.4	104.2	105.8
0.78	61.0	76.5	82.4	87.1	90.9	94.1	96.8	99.1	101.1	102.9	104.4
0.79	61.0	75.5	81.4	86.0	89.7	92.8	95.5	97.8	99.8	101.5	103.1
0.80	61.0	74.6	80.3	84.9	88.6	91.6	94.3	96.5	98.5	100.2	101.7

$\bar{b}_q$ = transverse acceleration factor calculated for the middle of stack height (see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3]).

$\bar{b}_q$	tiers										
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Note: 1) In the container stack the single container weights may differ from each other. 2) Calculated transverse acceleration factor $\bar{b}_q$ shall be rounded up to two decimal places.											

3 Forces for shoring of containers in cargo holds without cell guides

3.1 General

Where a largely rigid shoring of a container block may be assumed on account of the ship's construction, the transverse shoring forces on lateral supports and corner castings at corresponding positions may be determined, with sufficient accuracy, as given below. Hull deformations, if significant, shall also be taken into account.

The total transverse load on container layers positioned between two support levels shall be assumed to be completely distributed between these supports. The total transverse load is shall be assumed to be equally distributed in the longitudinal direction, i.e., between supports at the container ends. In the vertical direction, i.e., between both support levels, the total transverse load shall be assumed to be distributed according to the vertical distance of these supports from the centre of the total transverse load:

$$F_{shore,1} = \frac{1}{2} \cdot F_{q,total} \cdot \frac{d_2}{d_1 + d_2}$$

$$F_{shore,2} = \frac{1}{2} \cdot F_{q,total} \cdot \frac{d_1}{d_1 + d_2}$$

where:

$F_{shore,j}$ = transverse shoring force, in kN, on a support point at support level j
d_j = vertical distance, in m, of centre of the total transverse load from support level j
$F_{q,total}$ = sum of transverse loads, F_q, in kN, according to DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3] on containers in layers between both support levels.

In the following, the determination of shoring forces is demonstrated for a simple example, considering a container block with two supports consisting of five layers and n stacks as shown in Figure 1. In this example, the same transverse load, F_g, (see DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 [4.3]) is assumed for each container in the container block.

The load from the container layers shall be distributed ideally to the supports.

The total transverse load from the two uppermost container layers, $F_{shore,\ upper}$, in kN, induces the following shoring force on each support point of the upper and the lower supports:

$$F_{shore,upper} = \frac{2 \cdot n}{4} \cdot F_q$$

The lower support, $F_{shore,\ lower}$, in kN, is additionally loaded with the proportional share from the three lower container layers. Thus, each of the lower supports is loaded with:

$$F_{shore,lower} = \frac{5 \cdot n}{4} \cdot F_q$$

The remaining share of the total transverse load is transmitted into the double bottom.

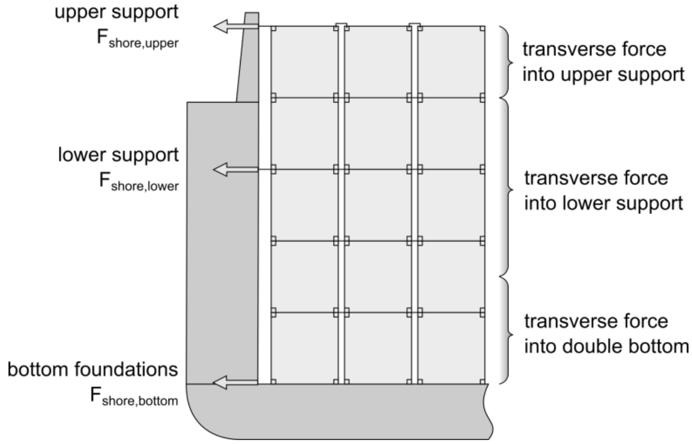


Figure 1 Example for determination of shoring forces

3.2 Reduction in transverse shoring forces for block with more than four stacks

Where the number of stacks in the container block is greater than four, the transverse shoring forces calculated according to [3.1] may be reduced by the following factor f_r:

$$f_r = 1 - \frac{(n-4)^2}{2 \cdot n \cdot m} \qquad (n\text{-}m) \le 4$$

$$f_r = \frac{8+m}{2 \cdot n} \qquad (n\text{-}m) > 4$$

where:

m = number of container layers

n = number of container stacks to be supported at the respective shoring point.

Where two opposite shoring points are designed to act simultaneously in tension and compression, *n* shall be taken as half the number of stacks.

If the container block is not complete, e.g., due to the container bench structures in holds, the number of container layers, m, and the number of container stacks, n, shall be determined as follows:

Number of layers m:

1) maximum number of layers of the considered block / 3 = A (whole numbers, not rounded)
2) original total number of layers to be reduced by A.

The layers having fewer rows than A are not considered.

This gives the corrected number of layers.

Number of stacks n:

1) corrected number of layers (see above) / 2 = B (whole number, not rounded)
2) Stacks for which number of layers is smaller or equal to B shall be neglected. Tank steps still existing are not considered.

The corrected number of layers and stacks shall be inserted into the formula for the reduction factor, f_r, as described above.

The reduction is admissible, provided the following requirement is met:

$$0.3 \cdot m \cdot G_{aver} \cdot 9.81 \cdot \left(1 - f_r\right) \leq 150 \text{ kN}$$

where:

G_{aver} = average gross weight, in tons, of containers to be supported by support point under consideration.

SECTION 6 SPECIAL CONTAINER SECURING ARRANGEMENTS

1 General

Calculation procedure for typical container securing arrangements is given in Sec.4 and Sec.5.

Calculation procedures for container securing arrangements other than those in Sec.4 and Sec.5 are described in this section.

2 Stowage of 30’ and 40’ containers with one end only supported by cell guides

For container stacks with one end only supported by cell guides, strength for containers and relevant container securing devices shall be checked in accordance with Sec.5 [2.1] for the end with cell guide. The other end with lateral non-rigid support shall be checked in accordance with Sec.4.

For container stowage with one end only supported by cell guides, the acceptance criteria as given in Sec.3 [2] shall be complied with, applying the following exception:

— the maximum permissible transverse racking force on the lowermost container is 185 kN and 170 kN for 30’ and 40’ containers, respectively.

3 Mixed stacks of 45' containers and 40' containers

3.1 Acceptance criteria

For container stowage where 45' containers are stowed on top of 40’ containers or vice versa, the acceptance criteria given in Sec.3 [2] shall be complied with, applying the following exception:

— for all 45' containers, which are stowed on top of 40' containers, the container post compression shall not exceed 404 kN, for illustration see Figure 1.

— for all 40' containers, which are stowed on top of 45' containers, the container post compression shall not exceed 270 kN, for illustration see Figure 2.

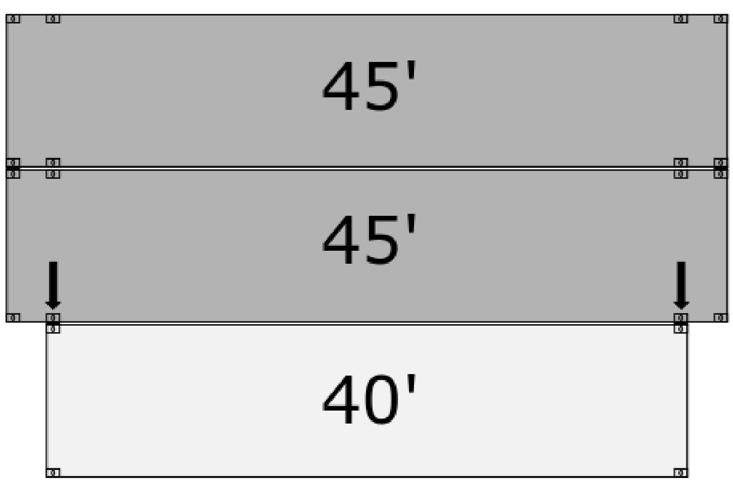


Figure 1 Example of 45' containers stowed on top of 40' container

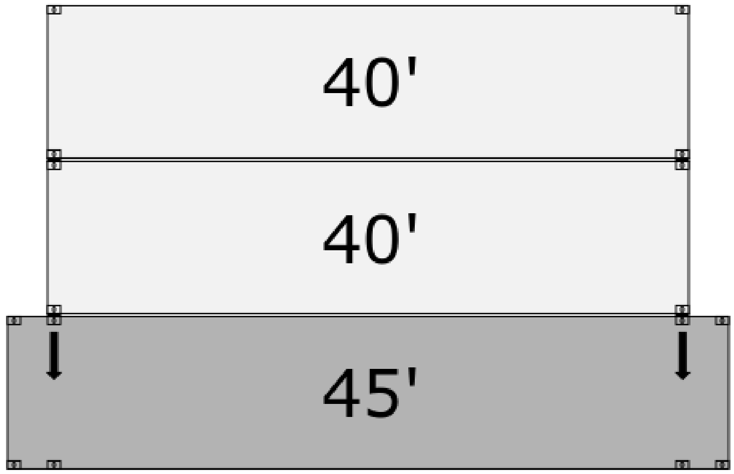


Figure 2 Example of 40' containers stowed on top of 45' container

This may be applied for 48’, 49’ and 53’ containers similarly, provided that the 48’, 49’ and 53’ containers are certified equal to strength limits for 45’ ISO containers.

3.2 Adaptive frames

In case adaptive frames are used for stowage of 48’, 49’ and 53’ containers, these frames shall be certified according to DNVGL-CP-0068. Each adaptive frame should be placed on top of one 40’ container and designated deck area. It should be avoided to position any adaptive frame on different hatches or locations where relative deformations are expected.

APPENDIX A ALTERATION OF CONTAINER SECURING ARRANGEMENTS

1 Applicable rule edition

All measures given below are considered as alterations and not conversions. For a further definition of alterations and conversions, see DNVGL-RU-SHIP Pt.1 Ch.1 Sec.3 [2.6].

2 Documentation requirements and class approval scope

Documentation requirements and class approval scope for typical alterations of container securing arrangements are given in Table 1.

Table 1 Alteration of container securing arrangements - documentation requirements and class approval scope

	Measure	*Rules for Ships and Class Guideline references*	*DocReq[1)]*
1	Additional GM values		
1.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
2	Strength evaluation of container securing arrangement based on specific routes		
2.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
2.2	Lashing computer system	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H084[5)]
3	Increasing nominal container capacity by higher stacks		
3.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
3.2	IMO visibility line	DNVGL-RU-SHIP Pt.6 Ch.8 Sec.2	N020[10)]
3.3	Trim & stability booklet (including longitudinal strength)	DNVGL-RU-SHIP Pt.3	B120[3)] H110[4)]
3.4	Loading computer system	DNVGL-RU-SHIP Pt.3 and DNVGL-RU-SHIP Pt.5 Ch.2	H084[5)]
4	Alterations in lashing arrangement		
4.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
4.2	Cargo Securing Manual (if 4.3 and 4.4 are applicable)	MSC.1/Circ.1353 (as required by SOLAS Reg. VI/5 and VII/5)	H180[9)]
4.3	Additional loose container securing devices	DNVGL-CP-0068	Z270
4.4	Additional fixed container securing devices	DNVGL-CP-0068	Z270
4.4	Supporting structures of additional fixed container securing devices	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.9	C030

Measure		*Rules for Ships and Class Guideline references*	*DocReq*[1)]
5	Modifications to lashing bridge		
5.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
5.2	Structure modification	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H080[5)] H050[6)]
6	Increased stack weights on hatch covers[8)]		
6.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
6.2	Hatch cover strength	DNVGL-RU-SHIP Pt.3	H080[5), 7)] H050[6)]
6.3	Strength of hatch cover stoppers including supporting structure	DNVGL-RU-SHIP Pt.3	H080[5)] H050[6)]
6.4	Lashing bridge strength (if fitted)	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H080[5)] H050[6)]
6.5	Supporting structures of fixed container securing devices	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.9	C030[6)]
7	Increased stack weights in holds[8)]		
7.1	Container Securing Arrangement	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8 and CG 0060	H190
7.2	Strength of cell guides	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.8	C030[6)]
7.3	Supporting structures of fixed container securing devices	DNVGL-RU-SHIP Pt.5 Ch.2 Sec.9	C030[6)]

1) For a full definition of documentation requirements, see DNVGL-RU-GEN-0550.
2) Applies only to ships contracted for construction from 1. January 2007. If only wind area is increased by higher stacks on deck, then equipment letter normally remains unchanged as the wind profile area has limited impact on the equipment letter. Upon request will, the Society may update the equipment number calculation and check if the equipment letter remains unchanged.
3) Revised T&S booklet may not be required to be submitted. Initially, print-outs and stored data from the loading instrument may be provided and reviewed by the Society. Depending on ship's stability characteristics and existing and new container distribution on deck, this may be sufficient to document that the loading instrument can be used for loading conditions with additional container stack height. Where requirements given in DNVGL-RU-SHIP Pt.3 Ch.15 Sec.1 [4.2] (weather criteria dependent on wind profile) is the most critical criteria, additional documentation may be required.
4) Not required for ships installed with a certified loading computer system for longitudinal strength.
5) Revised structural drawing(s) only needed to be submitted if strength analysis identifies need for strengthening.
6) Review limited to strength analysis of increased container loads only. Sea pressures etc. need not to be considered.
7) If resulting in increased draught applicable approval scope is specified in DNVGL-CG-0156 *Conversion of Ships*.
8) Only relevant if additional container securing devices; sufficient to submit updated inventory list only.
9) If the higher stacks do not interfere with the existing field of vision line it is sufficient to document this by providing print-outs from the loading instrument.

APPENDIX B WEIGHTS, MEASUREMENTS AND TOLERANCES

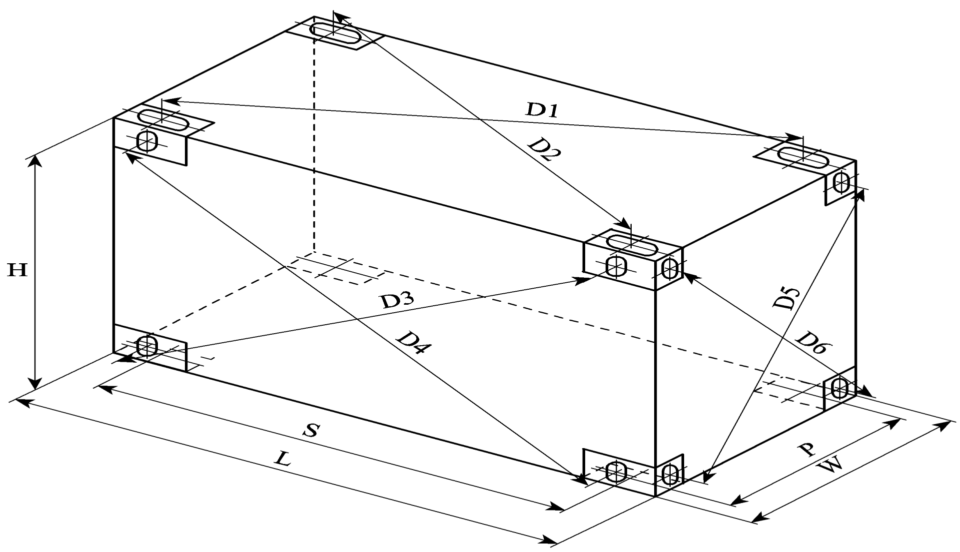
Table 1 Weights, measurements and tolerances

ISO designation of container	Max. permitted gross weight [kg]	External dimensions			Distance between centres of holes in corner fittings			
		Length L [mm]	Height H [mm]	Width W [mm]	Longitudinally S [mm]	crosswise P [mm]	Permitted difference d [1] of diagonals [mm]	Permitted difference d [2] of diagonals [mm]
1 AAA 1 AA 1 A 1 AX	30.480	12.192^{0}_{-10}	2.896^{0**}_{-5} 2.591^{0}_{-5} 2.438^{0}_{-5} < 2.438	2.438^{0}_{-5}	11.990^{0}_{-10}	2.259^{0}_{-4}	19	10
1 BBB 1 BB 1 B 1 BX	25.400	9.125^{0}_{-10}	2.896^{0**}_{-5} 2.591^{0}_{-5} 2.438^{0}_{-5} < 2.438	2.438^{0}_{-5}	8.923^{0}_{-10}	2.259^{0}_{-4}	16	10
1 CC 1 C 1 CX	24.000 (30.480)[3]	6.058^{0}_{-6}	2.591^{0}_{-5} 2.438^{0}_{-5} < 2.438	2.438^{0}_{-5}	5.854^{0}_{-6}	2.259^{0}_{-4}	13	10

ISO designation of container	Max. permitted gross weight [kg]	External dimensions			Distance between centres of holes in corner fittings			
		Length L [mm]	Height H [mm]	Width W [mm]	Longitudinally S [mm]	crosswise P [mm]	Permitted difference $d^{1)}$ of diagonals [mm]	Permitted difference $d^{2)}$ of diagonals [mm]
1 DD 1 D 1 DX	10.160	2.991^{0}_{-5}	2.591^{0}_{-5} 2.438^{0}_{-5} < 2.438	2.438^{0}_{-5}	2.788^{0}_{-5}	2.259^{0}_{-4}	10	10
1 EEE 1 EE	30.480	13.716^{0}_{-10}	2.896^{0}_{-5} 2.591^{0}_{-5}	2.438^{0}_{-5}	13.509^{+4}_{-6}	2.259^{0}_{-5}	19	10

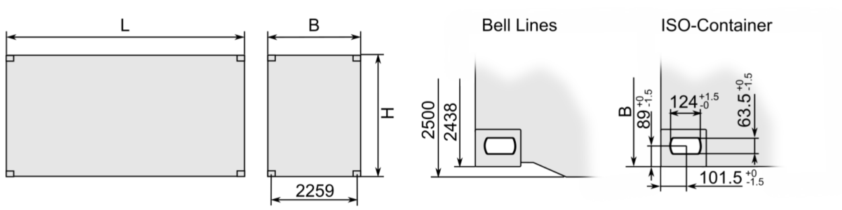
1) allowable difference of the diagonals of whole center of the corner castings of bottom and roof areas and side walls
2) allowable difference of the diagonals of hole center of the corner castings of front walls, see following sketch
3) This max. gross weight can be used in lashing calculations except for lineload stowage of containers see class notation **Container**DNVGL-RU-SHIP Pt.6 Ch.5 Sec.1.

**In certain countries there are legal limitations to the overall height of vehicle and load.



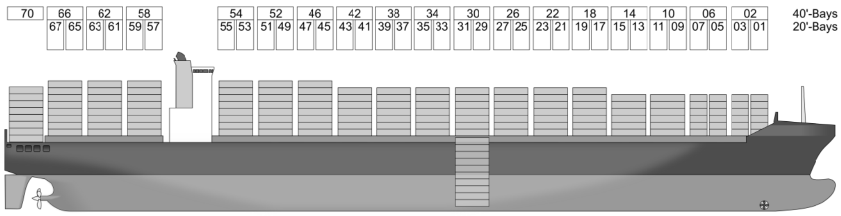
APPENDIX C CONTAINER-DIMENSIONS

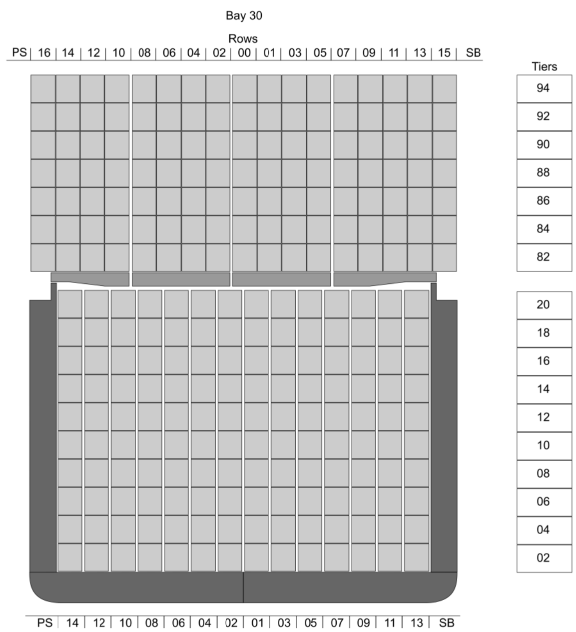
Table 1 Typical Dimensions of Containers



Type side view	L ft	L mm	B ft	B mm	H ft	H mm	Weight (max. gross) t
53'	53'	16150	8'6"	2591	9'6½"	2908	30.48
49'	49'	14935		2600	9'6"	2896	30.48
24½' 24½' 51mm	2x 24½'	2x 7430		2600	9'6"	2896	30.48
48'	48'	14630	8'6"	2591	9'6½"	2908	30.48
45' ISO	45'	13716	8'	2438	8'6" 9'6"	2591 2896	32.50
43'	43'	13103	8'	2438	8'6"	2591	30.48
40' ISO	40'	12192	8'	2438	8' 8'6" 9' 9'6"	2438 2591 2743 2896	30.48
40' EURO 40' Bell	40'	12192		2500	8'6" 9' 9'6"	2591 2743 2896	30.48
30' ISO	30'	9125	8'	2438	8' 8'6"	2438 2591	30.48 (25.40*)
24' Matson	24'	7430	8' 8'6"	2438 2591	8'6" 9'6"	2438 2896	24.00
20' ISO 20' ISO 76mm	2x 20'	2x 6058	8'	2438	8' 8'6" 9'6"	2438 2591 2896	30.48 (24.00*)
Tolerances	20'-24.5': +0mm - 6mm	30'-53': +0mm - 10mm	+0mm - 5mm		+0mm - 5mm		*old values

APPENDIX D CODE OF CONTAINER POSITION





APPENDIX E HEIGHT TOLERANCES OF CONTAINER FOUNDATIONS

For ISO 1496 container types, following tolerances are recommended in order to distribute loads evenly as much as practical to container foundations.

a) height tolerances of container resting levels

- transversely:

  one point is zero (reference point), the other ± 3 mm
- longitudinally:

  one point is zero (reference point), the other ± 6 mm

b) distance tolerances for transverse and longitudinal distances of aperture centrelines of container foundations

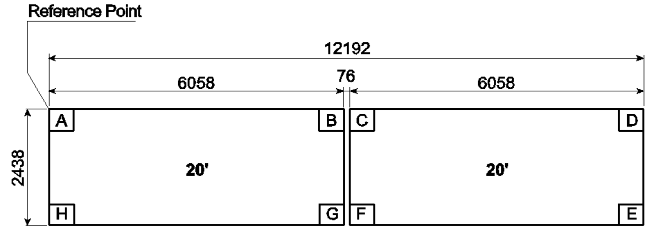
- transversely:

  ± 3 mm for 20’ and 40’ containers
- longitudinally:

  ± 3 mm for 20’ containers and

  ± 4 mm for 40’ containers.

For other container types, the tolerance may be obtained by linear interpolation based on container length (see also ISO 668).

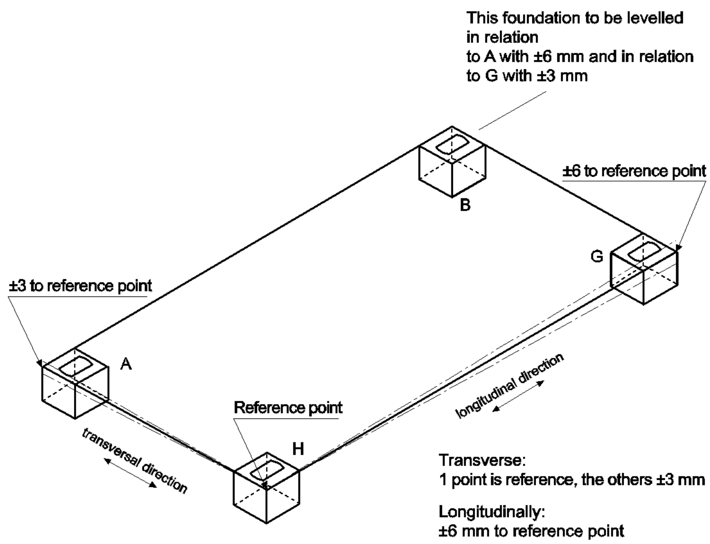


Example in mm

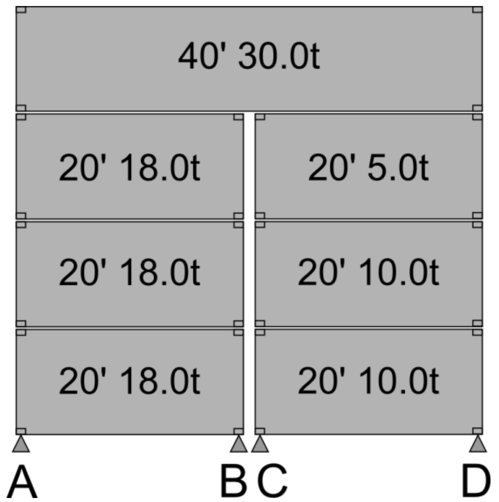
A = 0
B + C = -3
D = -6
E = -9
F + G = -6
H = -3

in general the following tolerances have to be kept

in longitudinal not more than ± 6	in transversal not more than ± 3
A to B	A to H
C to D	B to G
A to D	C to F
H to G	D to E
F to E	
H to E	



APPENDIX F DETERMINATION OF THE EXISTING STACK WEIGHT FOR MIXED STOWAGE (20' AND 40' CONTAINER) FOR THE INDIVIDUAL FOUNDATION POINTS



$$A = 18.0 \cdot 3 + 30.0 = 84.0 \cdot t$$
$$B = 18.0 \cdot 3 = 54.0 \cdot t$$
$$C = 10.0 \cdot 2 + 5.0 = 25.0 \cdot t$$
$$D = 10.0 \cdot 2 + 5.0 + 30.0 = 55.0 \cdot t$$

At foundation A and D, the stackweight at 40’-ends of the bay are calculated whereas results for B and C show 20’-stackweight only.

CHANGES – HISTORIC

February 2016 edition

Amendments February 2016

• General

— Only editorial corrections have been made.

October 2015 edition

There are currenlty no historical changes for this document

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