

Rules for Classification and Construction

I Ship Technology

1 Seagoing Ships



20 Stowage and Lashing of Containers

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Alterations to the preceding Edition are marked by beams at the text margin.

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Section 1 General Definitions

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A Application

A.1 Ships classed with Germanischer Lloyd

A.1.1 Parts of the container stowage and lashing system, which are welded to the ship's hull and thereby may affect its strength, as well as connections of these parts to the hull and their substructures are subject to classification of the ship in accordance with Rules for [Hull Structures \(I-1-1\)](#) and [Structural Rules for Container Ships \(I-1-5\)](#) of Germanischer Lloyd (GL). These systems shall be dimensioned according to the loads given in [Section 3](#). Corresponding drawings indicating locations of connections and material properties are to be submitted for approval.

A.1.2 For other parts of stowage and lashing systems, such as loose lashing elements and removable guide structures, associated documents (drawings, calculation reports, etc.) will be examined within the approval of the entire stowage and lashing system in accordance with Rules for Stowage and Lashing of Containers. These other parts shall be fabricated in conformity with provisions laid down in [Section 4](#), and they shall be subjected to strength tests according to [Annex B](#).

A.1.3 The exclusive use of onboard container stowage and lashing systems, approved and tested by GL in accordance with [Section 4](#) and [Annex A](#) of these Rules, as well as the GL approved container securing arrangement plan are mandatory for ships assigned the class notations **CONTAINER SHIP** or **EQUIPED FOR CARRIAGE OF CONTAINERS** (see GL Rules for [Classification and Surveys \(I-0\)](#)).

Certificates of the container stowage and lashing fittings used onboard the ship shall be kept on board. The container securing arrangement plan has to contain a parts list with the following specification of the container stowage and lashing equipment:

- number of parts with position number
- designation (type)
- manufacturer and
- breaking load and working load

In the Class Certificate of the ship a notation will be entered to this effect.

The manufacturer of the approved stowage and lashing system has to ensure that clear instructions for the safe operation of all components of the system are available to the ship's crew.

Responsibility for compliance with these requirements rests with the owner of the ship.

GL surveyors will examine the compliance with the conditions for granting the class notation during periodical class surveys.

A.1.4 A container securing arrangement plan for unrestricted service approved by GL is to be kept on board as part of the cargo securing manual and is to be made available to the GL Surveyor on request.

If route specific container stowage is planned, a GL approved route specific container stowage manual is to be kept on board. The route specific container stowage manual shall include route specifications according to Annex K and excerpts of the route specific container securing arrangement plans for deck and hold stowage of 20ft and 40ft containers for three different longitudinal ship positions for each route.

A.1.5 If the container stowage and lashing equipment is to be modified or removed, GL shall be informed accordingly.

The owners and/or the shipyard charged with the conversion have to submit relevant drawings to GL for approval.

This refers also to modifications of the stowage arrangement caused by an increased number of containers stowed on the weather deck and on hatch covers including, for instance, the arrangement of additional container layers, increased stack weights and modified container weights in individual container layers.

A.1.6 GL grants type approval of loose and fixed stowage and lashing fittings fabricated in series. The approval procedure comprises examination of drawings as well as load tests and serves as a basis for individual approvals in connection with the assignment of class (A.1.2).

If the load test shows satisfactory results, a Type Certificate will be issued.

Note

Where container stowage and lashing elements are intended for use as loose gear - e.g., lifting pots or lifting foundations on hatch covers – Guidelines for Construction and Survey of Lifting Appliances" are to be applied.

A.1.7 Use of a lashing computer on board with lashing software approved by GL as given in Annex D is mandatory.

A.2 Ships classed with other Classification Societies

For ships other than covered by A.1.1, compliance with these Rules can be certified by GL upon request for container stowage and lashing systems after the corresponding examination.

A.3 Cargo securing manual

According to IMO requirements, all ships subject to SOLAS have to be equipped with an approved cargo securing manual. Exempted are ships carrying liquid cargo and bulk cargo and fishing vessels and off-shore units. The cargo securing manual will be certified by GL upon request, provided authorisation by the Flag Administration has been obtained.

Section 2 Requirements on Container Securing Arrangement and Construction

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A General

A.1 Container stowage

These Rules apply to stowage of containers designed according to ISO Standard Series 1 ISO 1496-1. For weights, dimensions and tolerances of standard containers see [Annex E](#).

Containers shall be stowed aboard the ship in the fore-to-aft direction.

Requirements according to [Hull Structures \(I-1-1\)](#), [Section 21, H](#), and [Structural Rules for Container Ships \(I-1-5\)](#), [Section 21, H](#), are to be considered.

Requirements according to IMO CSS-Code Annex 14 are to be considered. Under specific conditions, operational walkways can be permitted below deck.

A.2 Container foundations

A.2.1 Transmission of forces on foundations

Sufficient size of transmission surface for vertical forces from the twistlock and/or from the stacking cone acting on the foundation shall be provided. Thus, if vertical loads exceeds 600 kN (700 kN max. pressure for a twistlock at the first tier top and higher), the minimum surface for direct pressure transmission of the twistlock (i.e., the web surface of a corner fitting covered by the twistlock foundation plate) is to be 25 cm².

Note

At twistlock foundations with elongated ISO holes an even larger base is recommended to achieve a longer lifetime.

Load transition into the deck and into longitudinal coamings etc. shall be sufficiently smooth to avoid stress concentrations.

A.2.2 Foundation tolerances

A.2.2.1 Height tolerances

The following tolerances for the height of container resting levels are recommended by GL (see [Annex H](#)).

Transversely:

One point is zero (reference point), the other ± 3 mm

Longitudinally:

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

A.2.2.2 Distance tolerances

The following tolerances for transverse and longitudinal distances of aperture centrelines of container foundations are recommended by GL.

Transversely:

± 3 mm for 20ft and 40ft containers

Longitudinally:

± 3 mm for 20ft containers and

± 4 mm for 40ft containers

For other container sizes, accordingly (see also ISO 668).

B On-Deck Stowage of Containers

B.1 Container seating

B.1.1 Seating conditions

A check shall be made whether hull deformations may cause relative shifting of seating points of a container or a container stack. This may be the case, for instance, aboard ships having large hatch openings, where a container rests partly on a hatch cover and partly on a container stanchion situated adjacent to the hatchway. Relative dislocations of container seating points shall also be taken into account when the container rests on two adjacent hatch covers.

Where necessary, the alignment steps (cones) at the container's seating points shall be used to prevent damages of the container itself or of fittings and foundations caused by forces induced by relative dislocations of the seating points. Sliding plates or foundations with elongated apertures may be provided, for instance. Except for the aperture length, the shape of elongated apertures shall be in compliance with Standard ISO 1161 apertures.

Where container stanchions situated adjacent to hatchways are relieved of transverse forces by the use of, e.g., sliding plates, suitable devices shall be used to transmit the transverse forces into the hatch covers.

B.1.2 Linear seating of containers

B.1.2.1 If containers are stowed with linear seating in several layers, the total weight of the containers above the first layer shall not exceed the following values:

- 0.8G for 40ft containers and
- 1.0G for 20ft containers

where G is the container's maximum gross weight according to [Annex E](#).

This kind of seating may be set up by arranging continuous steel or wooden dunnages below the longitudinal bottom rails of the containers or by directly seating these bottom rails on the hatch covers or the decks, with sunk-in pockets being arranged below the container corners.

The arrangement of short steel pads serving as dunnage placed on the girders of short hatch covers shall be avoided.

B.1.2.2 Equipment used to obtain a linear seating shall be configured to leave a sufficient clearance (about 5 mm) between corner fittings of the container and hatch covers or decks. For ISO standard containers, a protruding depth of their corner fittings of 4 to 17.5 mm from their bottom longitudinal rails and of 11 to 17.5 mm from the bottom transverse girders may be assumed. Special container types may require additional dunnage for their transportation.

Linearly seated containers shall be secured against shifting by locking devices arranged on the hatch covers and/or the deck.

B.2 On-deck stowage without lashing and lateral support

B.2.1 Containers in one layer

Containers carried in one layer shall be secured against tilting and shifting by locking devices arranged at their lower corner fittings.

Where containers are coupled to container blocks by dual cone adapters or equivalent devices and bridge fittings, it is sufficient to lock the two outer containers at least at three corner fittings.

B.2.2 Containers in several layers

B.2.2.1 If containers are stowed in several layers, locking devices shall be arranged between the container layers. Containers located in the lowermost layer shall be locked at their lower corner fittings.

B.2.2.2 If four or more container layers are arranged, bridge fitting should be provided athwartships on the uppermost layer if possible. Tension pressure bridge fittings should be used, which can be inserted into variable gaps between containers.

B.2.3 Dunnage

Placing containers on dunnage without lashing them is only permissible if effective securing devices can be arranged to prevent them from shifting and tilting (see B.2.1), see also B.1.2.

B.3 On-deck stowage with lashing (without lateral support)

B.3.1 Lashing of containers

B.3.1.1 If lashings of containers are used, pretension of lashings shall be kept as small as possible.

B.3.1.2 To improve the efficiency of lashings, lashing bridges can be arranged. In this case, corresponding drawings of lashing bridges and force diagrams of the abutment loads are to be submitted for examination.

B.3.1.3 All front-ends and all door-ends of containers shall be stowed in the same direction. If this requirement is not met, the stack in question shall be examined separately.

B.3.1.4 For single lashings lashing elements, such as lashing rods, are to be fitted to the containers' bottom corner castings.

B.3.1.5 For vertical lashings, lashing shall be "loose" to equalize the clearance in the twistlock. This equalization may also be achieved by spring elements.

B.3.1.6 Generally, internal lashings shall be used if containers are stowed with lashings. For individual cases, after consultation with GL and appropriate verification, approval may be granted for external lashings (see Fig. 2.1).

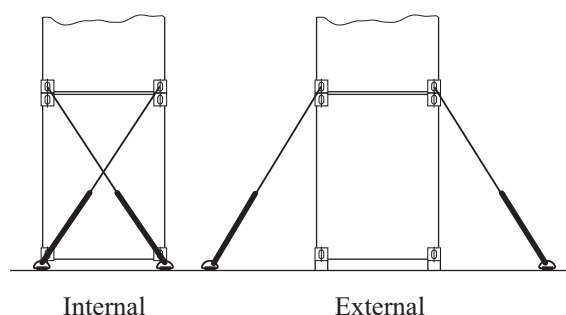


Fig. 2.1 Internal and external lashings

B.3.2 Containers in one layer

Lashing is required only if locking devices are arranged at lower corner fittings of containers. Lashings shall be arranged vertically.

B.3.3 Containers in several layers

B.3.3.1 Container stacks of several layers may be lashed as shown in Fig. 2.2 or in a similar way.

B.3.3.2 Locking devices shall be arranged between container layers.

B.3.3.3 Container stacks shall be secured against horizontal displacements by cones, locking devices or alignment steps arranged on hatch covers and/or on deck.

B.3.3.4 If container stacks of four or more layers are lashed only at one end, e.g., if 20ft containers are stowed on 40ft stowing places with an inaccessible 20ft gap, the use of bridge fittings on the uppermost layer at the unlashed end is recommended, according to [B.2.2.2](#).

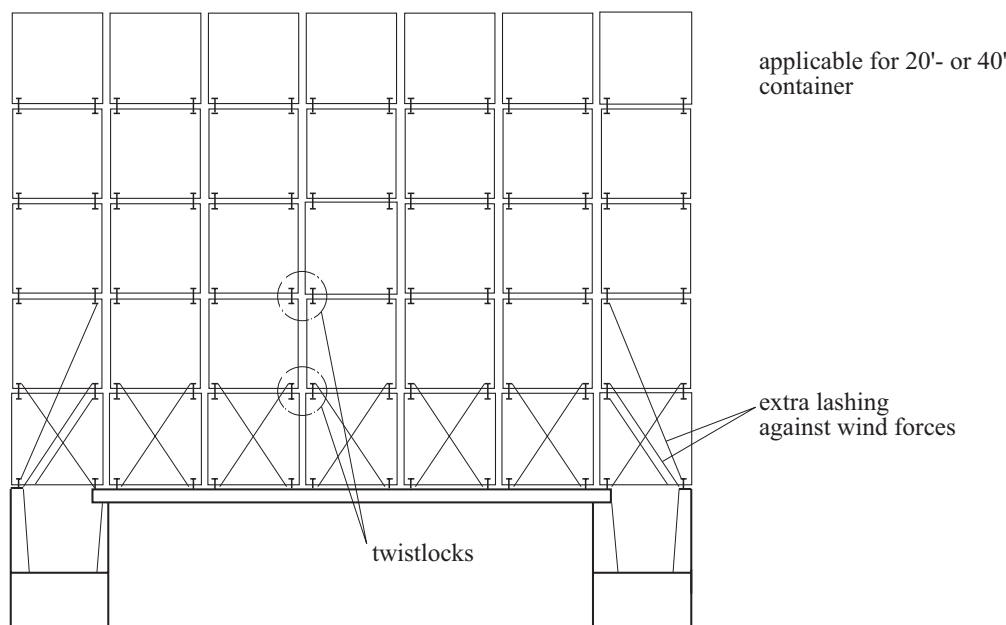


Fig. 2.2 Basic arrangement of lashings

B.4 On-deck stowage with lateral support

B.4.1 Buttress system stowage

B.4.1.1 Instead of being lashed, containers may also be secured against sideward shifting and/or tilting by means of buttress structures placed on deck (if necessary, on hatchways) or by a system consisting of buttress structures and cone adapters.

B.4.1.2 Containers shall be shored by buttress structures in such a way that inadmissible deformations of the container framework are prevented and the permissible container racking loads are not exceeded.

B.4.2 Cell guides on deck

Containers stowed above the height of cell guides are to be sufficiently secured against racking and lifting forces. Vertical lashings are recommended. This also holds for containers whose upper part exceeds the height of cell guides.

The 20ft containers can be stowed in 40ft cell guides according to [C.1.6](#). However, outer stacks shall be additionally secured against green water loads, including buoyancy and wind forces, by suitable devices.

B.5 Containers endangered by green water loads

Containers stowed in positions especially endangered by green water loads and by buoyancy forces of incoming water have to be additionally secured by locking devices, by container foundations of increased height and/or by reinforced lashings. For smaller ships, a buoyancy force, based on the entire volume of the container, shall be considered acting on the lowermost container.

C Below-Deck Stowage of Containers

C.1 Stowage in cell guide structures

C.1.1 General requirements

C.1.1.1 Cell guide structures for containers may be welded to the ship's hull or be arranged in a detachable manner (screwed connections, suspended structures).

C.1.1.2 Doubling plates or, for ships fitted with an inner bottom ceiling, other suitable means shall be provided at lower ends of guide rails to reinforce the container supporting area, see GL Rules for [Hull Structures \(I-1-1\), Section 21, H](#), and [Structural Rules for Container Ships \(I-1-5\), Section 21, H](#).

C.1.2 Vertical guide rails

C.1.2.1 Vertical guide rails consist, in general, of equal-sided steel angles. On account of abrasion and local forces, e.g., due to jamming occurring when hoisting and lowering of containers, the flange thickness of steel angles should be at least 12 mm.

C.1.2.2 Horizontal forces from containers are transmitted as point loads through the container corners to the guide rails.

Where vertical guide rails consist of several steel angles, steel angles should be connected to each other by horizontal web plates arranged at least at the level of container corners and, additionally, halfway between them.

C.1.2.3 Guide heads

Top ends of guide rails shall be fitted with sufficiently strong guide heads, according to operating conditions.

To minimise the impact on fatigue strength, it is recommended to support guide heads in way of hatch corners horizontally against transverse bulkhead only. A vertical support may be fitted to the longitudinal or transverse bulkhead.

It is recommended to provide a vertical connection to the transverse bulkhead in way of the guide heads, to transfer shear forces caused by loading and off-loading.

C.1.2.4 Self-supporting guide rails

Self-supporting guide rails in the cargo hold shall be sufficiently secured by, e.g., transverse ties. The ties shall be fitted, if possible, at the level of the container corners.

Guide rails may consist of main girders (e.g., I-beams) to which steel guide angles are attached.

C.1.2.5 Guide rails at bulkheads

Vertical guide rails at transverse or longitudinal bulkheads shall be connected to the bulkhead plating or to bulkhead stiffeners by horizontal web plates or other elements that resist shear and bending loads. A connection as free from notches as possible shall be aimed at, especially for tank bulkheads.

C.1.3 Cross ties

Depending on the construction of the cell guide system, cross ties support the guide rails athwartships by distributing local loads to all rails. If possible, they shall be arranged at the level of the container corner fittings to allow a direct absorption of horizontal forces. Sufficiently dimensioned cross ties may also absorb longitudinal forces.

C.1.4 Longitudinal ties

Where cross ties are not designed to absorb longitudinal forces, longitudinal ties shall be provided to support the vertical guide rails.

When steel wire pendants are used for longitudinal ties, they shall be provided with adjusting devices. Where bars are used, their end connections shall be constructed to exclude compressive stressing.

C.1.5 Clearances

C.1.5.1 Clearance of standard containers in guide rails shall not exceed 25 mm athwartships and 38 mm in the fore-to-aft direction. Maximum clearance in the fore-to-aft direction includes the deformation of the cell-guide system itself. Where containers are stowed in less than six layers, larger clearances can be permitted, provided container strength has been proven to be sufficient.

C.1.5.2 Transverse spacing of the cell guide system shall be sufficient to prevent damage to longitudinal supports of cell guide structures and to containers by loading and off-loading of containers with deformed side walls.

C.1.6 Stowage of 20ft containers in 40ft cell guides

C.1.6.1 Stowage with lateral support in 20ft gap

If 20ft containers are stowed in 40ft cell guides, in general, container ends in the 20ft gap shall be secured, analogous to C.2.1, that is:

Containers placed side by side shall be coupled in the 20ft gap by dual cone adapters or equivalent devices. Containers in the lowermost layer shall be secured against shifting. Outer containers shall be laterally supported in the 20ft gap, according to C.2.1.

C.1.6.2 Longitudinal stowage system

For a longitudinal stowage system, i.e., linkage of two 20ft containers by longitudinal tension/pressure adapter cones to a 40ft unit, lateral support of containers in the 20ft gap is not required. The maximum permissible stack weight is 120 t. The lowermost container shall have space for shifting.

C.1.6.3 Mixed stowage

The 20ft containers may be stowed in 40ft cell guides without lateral support, provided they are secured by single cones at least at both bottom corners in the 20ft gap of each container layer. The lowermost layer shall be secured against shifting in the 20ft gap. This is possible for up to 12 tiers. The maximum permissible stack weights, listed in Table 2.1, depend, first, on transverse container accelerations at their respective location and, second, on the number of tiers.

If a 20ft stack is topped by one or more 40ft containers (also linked by single cones), higher stack weights are permissible, as listed in Table 2.2 for different transverse container accelerations and different numbers of tiers.

Table 2.1 Depending on the containers' transverse acceleration, permissible total weight of 20ft containers stowed in 40ft cells not topped by 40ft containers, according to C1.6.3

tiers \bar{b}_q	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

Section 2 Requirements on Container Securing Arrangement and Construction

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

Section 2 Requirements on Container Securing Arrangement and Construction

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

Permissible 20ft container stackweights [t] for stowage in hold cell guides.
 Shown container stack weights are not to be exceeded. Inside the container stack the single container weights may differ from each other. Calculated acceleration factors are to be rounded up to two decimal places maximum.

Table 2.2 Depending on the containers' transverse acceleration, permissible total weight of 20ft containers stowed in 40ft cell guides and topped by at least one 40ft container, according to C.1.6.3

tiers \bar{b}_q	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

Section 2 Requirements on Container Securing Arrangement and Construction

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

Permissible 20ft container stackweights [t] for stowage in hold cell guides.

Shown container stack weights are not to be exceeded. Inside the container stack the single container weights may differ from each other. Calculated acceleration factors are to be rounded up to two decimal places maximum.

C.2 Stowage without cell guide structures

C.2.1 Stowage without lashings

C.2.1.1 Container securing

Container stacks placed side by side are to be coupled by dual cone adapters or equivalent devices to form container blocks. For container blocks extending over the hold width, bridge fittings for compression shall be provided on the uppermost layer of containers if there is a lateral shoring point at this level. If containers are separated into two blocks, bridge fittings for tension and compression are to be arranged at the level of the shoring points.

In the lowest container layer each container shall be secured against shifting at all four corner castings.

Each container block shall be laterally supported at its container corner fittings. Support is to be provided by sufficiently strong structural elements of the ship, such as decks and web frames.

C.2.1.2 Shoring forces

The number of lateral shoring points shall be determined so that the corner fitting loads and container racking loads will not be exceeded (see [Section 3](#)).

Where necessary, the force at a shoring point can be distributed to the two adjacent corner fittings by a special design of the shoring element.

Shoring forces can also be reduced by dividing the containers to be shored into two separate container blocks (see [C.2.1.1](#)), thus splitting up the transverse container forces into compressive shoring forces on one side and tensile shoring forces on the other side of the hold.

C.2.1.3 Shoring element construction

Shoring elements shall be constructed to transmit compressive loads or, where necessary, compressive and tensile loads. Shoring elements can be of fixed or removable configuration. Both kinds shall ensure that the clearance between their contact faces and the container corner fittings is as small as possible.

Wedges shall be sufficiently secured against their inadvertent loosening (e.g., on account of vibrations).

Shoring elements shall be easily accessible. Their weight and the associated number of loose parts shall be restricted to a minimum.

C.2.2 Stowage with lashing in cargo hold

Instead of or in combination with shoring systems described in [C.2.1](#), cargo hold containers can also be secured by lashings. If this is the case, provisions in [B.3](#) apply analogously.

Section 3 Dimensioning of Container Securing Systems

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B	Container stowage without lateral support.....	3-5
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A Wind and Sea Induced Loads on Containers

A.1 General

A.1.1 Transverse, longitudinal and vertical loads on containers given below are to be understood as forces aligned in the ship's coordinate axes. They include static gravity loads, dynamic loads caused by the ship's pitch, heave, yaw, sway and roll motions, as well as wind loads.

A.1.2 The following values for minimum and maximum gross weights of containers are to be assumed for subsequent calculations (see also [Annex E](#)):

20ft	minimum	2.5 tons
	maximum	30.5 tons
40ft	minimum	3.5 tons
	maximum	30.5 tons
45ft	minimum	4.5 tons
	maximum	32.5 tons

Other container sizes correspondingly.

A.1.3 The height of the centre of gravity of the container and its cargo is assumed at 45 % of container height.

A.2 Transverse forces on containers

A.2.1 The transverse force, F_q , acting on a container parallel to the deck is to be calculated as follows:

$$F_q = G \cdot b_q \cdot 9.81 + F_w \quad [\text{kN}]$$

G : container's gross weight [t]

b_q : transverse acceleration factor, see [A.2.2](#) and [A.2.3](#)

F_w : lateral wind load on the container, see [A.2.4](#)

Where containers or container stacks placed side by side are coupled to form container blocks, transverse loads acting on containers, such as wind loads on outer container stacks, shall be equally distributed over a maximum of three stacks.

A.2.2 Transverse acceleration factor for unrestricted service

A.2.2.1 The transverse acceleration factor, b_q , includes combined effects of the ship's pitch, heave, yaw, sway and roll motions:

$$b_q = (1 + b_v) \cdot \sin(\varphi) + b_h \cdot \cos(\varphi) + \frac{1}{9.81 \cdot \frac{m}{s^2}} \cdot \left(\frac{2 \cdot \pi}{T_{Roll}} \right)^2 \cdot \varphi \cdot (z_{cont} - z_{Roll})$$

b_v : dimensionless acceleration in the global vertical direction due to pitch and heave

b_h : dimensionless acceleration in the global horizontal direction due to yaw and sway

φ : ship's roll angle

T_{Roll} : roll period [s]

z_{Roll} : height of roll axis above base [m]

z_{cont} : height of container's centre of gravity above base [m]

In the formula above, values of b_v , b_h and φ represent simultaneously acting accelerations and roll angle of the ship. They are to be determined from the respective design values $b_{v,D}$, $b_{h,D}$ and φ_D , i.e., the extreme values occurring once in 20 years operation of the ship, such that b_q attains its maximum value and

$$\left(\frac{b_v}{b_{v,D}} \right)^2 + \left(\frac{b_h}{b_{h,D}} \right)^2 + \left(\frac{\varphi}{\varphi_D} \right)^2 = 1$$

A.2.2.2 The transverse acceleration factor, b_q , is to be determined using the software GL-StowLash, distributed free of charge upon request by e-mail to ptp-stowage@gl-group.com. A software development kit for integration of the acceleration calculation into other lashing software can also be provided upon request.

GL-StowLash calculates b_q -values for unrestricted service based on approximation formulae, which are derived from a statistical evaluation of ship motions for an operating period of 20 years in a wave climate represented by the IACS Rec. 34 wave scatter diagram. In addition to the dynamic roll angle, a static heeling angle caused by wind on cargo and ship structure is included in the calculation of b_q .

Main input parameters to calculate b_q are:

B : ship's moulded breadth

L_{pp} : ship's length between perpendiculars

C_B : ship's block coefficient

v_0 : maximum service speed

T_{act} : ship's draught in actual loading condition

GM_0 : initial metacentric height

x : longitudinal distance from AP to stack's middle

z : vertical distance from base to stack's bottom

If the actual value is not known for C_B , a standard C_B -value will be used in GL-StowLash.

A.2.2.3 For ships with unusual form and design regarding, e.g., stern and bow shape, GL may require determination of the transverse acceleration factors by an alternative calculation method.

A.2.2.4 The container securing arrangement plan submitted for approval shall be based on b_q -values for unrestricted service and the initial metacentric height, GM_0 :

$$GM_0 = 0.04 \cdot B^2/Z$$

B : ship's moulded breadth [m]

Section 3 Dimensioning of Container Securing Systems

$$Z = h_{\text{cont}} + H_{\text{st}} \text{ [m]}$$

h_{cont} : maximum number of container tiers (n_{tiers}) in the stack on the hatch covers or on the weather deck, as specified in the container securing arrangement plan, multiplied by 1.05

$$h_{\text{cont}} = n_{\text{tiers}} \cdot 1.05 \text{ [m]}$$

H_{st} : vertical distance between designed waterline and lower edge of container stack considered.

A.2.2.5 The dimensioning of cell guide structures shall be based on b_q -values for unrestricted service and the initial metacentric height, $GM_{0,\text{max}}$, to be determined as follows:

$$B \leq 32.2 \text{ m} \quad GM_{0,\text{max}} = 0.04 \cdot B^2/Z$$

$$32.2 \text{ m} < B \leq 40 \text{ m} \quad GM_{0,\text{max}} = (B-25.96)/156 \cdot B^2/Z$$

$$B > 40 \text{ m} \quad GM_{0,\text{max}} = 0.09 \cdot B^2/Z$$

In general, this is the maximum allowable initial metacentric height for container stowage systems approved according to these Rules. Other $GM_{0,\text{max}}$ -values require special considerations.

A.2.3 Transverse acceleration factor for route specific container stowage

A.2.3.1 For route specific container stowage, loads on containers and container securing equipment shall be determined based on transverse acceleration factors b_q according to [A.2.2](#), reduced by route specific reduction factors f_{route} .

A.2.3.2 For standard routes according to [Annex K](#), the reduction factors f_{route} are given in [Table 3.1](#).

A.2.3.3 For an individual route according to [Annex K](#), GL will determine a reduction factor, f_{route} , by statistical evaluation of ship motions, assuming the operation period on this route to be 20 years. For this purpose, an individual wave scatter diagram will be generated by GL for each specified route, based on wave statistics of recognised weather bureaus.

Table 3.1

Standard route according to Annex K	Reduction factor f_{route}
Asia-Europe service	0.88
Pacific-Atlantic service	0.94
Pacific service	0.94
North Sea-Mediterranean Short Sea service	0.93
North Atlantic service	0.97

A.2.4 Wind loads

In general, lateral wind loads, F_w , on exposed side walls of containers according to [Table 3.2](#) shall be considered.

Wind loads are not to be considered for containers the side walls of which are exposed to wind over a height of less than $0.33 \times 8' 6''$.

If inside positioned stacks form a gap larger than $1/2B$ for $B > 16 \text{ m}$ or more than three rows wide for $B \leq 16 \text{ m}$ (for B see [A.2.2.2](#)), free standing stacks are to be imposed with wind loads according to [Table 3.2](#) reduced by a factor of 0.33.

Section 3 Dimensioning of Container Securing Systems

Table 3.2

Wind load F_w per container [kN]		
	container type	
	20ft	40ft
1st tier ¹	30	60
2nd tier and higher	15	30
¹ The load F_w for the first tier accounts additionally for green water loads on outer stacks. The green water loads do not need to be accounted for in case of open holds of hatchcoverless ships. ² The stated values are valid for 8' 6" high containers. For other container heights and lengths, the wind force has to be adjusted according their side wall area.		

A.3 Longitudinal forces on containers

The longitudinal force, F_ℓ , acting on a container parallel to the deck is to be calculated as follows:

$$F_\ell = G \cdot b_\ell \cdot 9.81 \text{ [kN]}$$

b_ℓ : longitudinal acceleration factor, see [Table 3.3](#)

The b_ℓ -values for containers located between the lowermost layer in the cargo hold and the lowermost layer on deck shall be determined by interpolation; for containers above the first layer on deck, by linear extrapolation.

Table 3.3 Longitudinal acceleration factor b_ℓ

for lowermost container in cargo hold	for lowermost container on deck
$L \leq 120 \text{ m} : b_\ell = \left(0.22 - \frac{L}{1710} \right)$ $L > 120 \text{ m} : b_\ell = 0.15$	For any length of the ship: $b_\ell = \left(0.35 - \frac{L}{1000} \right)$ $\min b_\ell = 0.15$

A.4 Vertical forces on containers

The vertical force F_v acting downwards on a container or container stack is to be calculated as follows:

$$F_v = \sum_{i=1}^n G_i \cdot (1+a_v) \cdot 9.81 \text{ [kN]}$$

n : number of tiers in container stack

a_v : acceleration factor according to [I-1-1, Sec.4](#) and [I-1-5, Sec.4](#).

B Container Stowage without Lateral Support

B.1 Calculation of forces

B.1.1 Container stowage without lashings

B.1.1.1 The transverse racking force, RF_T , on each container end frame in the i^{th} tier is:

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

F_q : transverse container force according to [A.2](#)

B.1.1.2 The longitudinal racking force, RF_L , on each container side frame in the i^{th} tier is:

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

F_{ℓ} : longitudinal container force according to [A.3](#)

B.1.1.3 The corner post force, CPL, on the upper corner casting of a container in the i^{th} tier is:

$$CPL_i = CPL_{i+1} + RF_{T,i+1} \cdot \frac{H_{c,i+1}}{B_c} + \frac{1}{4} \cdot G_{i+1} \cdot b_t \cdot 9.81 \cdot \cos 30^\circ$$

B_c : 2.260 m for ISO-containers (8' width)

H_c : container height [m]

The container position correction factor, b_t , shall be calculated as follows:

$$b_t = 1.15 + \frac{80.5 - 0.75 \cdot x - 105 \cdot \frac{x}{L_{pp}}}{L_{pp} + 70} \quad \text{for AP to 0.2L}$$

$$b_t = 1 + \frac{70}{L_{pp} + 70} \quad \text{for 0.2L to 0.6L}$$

$$b_t = 0.55 + \frac{38.5 + 0.75 \cdot x + 105 \cdot \frac{x}{L_{pp}}}{L_{pp} + 70} \quad \text{for 0.6L to FP}$$

x : distance of the container's centre of gravity from A.P. [m]

L : ship's length [m]

B.1.1.4 The lifting force, LF, on the bottom corner casting of a container in the i^{th} tier is:

$$LF_i = LF_{i+1} + RF_{T,i} \cdot \frac{H_{c,i}}{B_c} - \frac{1}{4} \cdot G_i \cdot b_t \cdot 9.81 \cdot \cos 30^\circ$$

B.1.1.5 The vertical forces on each foundation point of a container or container stack are:

$$CPL_{\text{found}} = CPL_1 + RF_{T,1} \cdot \frac{H_{c,1}}{B_c} + \frac{1}{4} \cdot G_1 \cdot b_t \cdot 9.81 \cdot \cos 30^\circ \quad \text{at stack's compressed side}$$

$$LF_{\text{found}} = LF_1 \quad \text{at stack's tensioned side}$$

B.1.1.6 The transverse force on a foundation point is:

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

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

Section 3 Dimensioning of Container Securing Systems

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 is to be calculated as a friction force resulting from the vertical compressive force, CPL_{found} , acting on this foundation point:

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

μ : 0.25 for cast steel combinations; 0.5 for steel-steel combinations; other combinations upon agreement with GL

The horizontal force need not be taken greater than the force causing the stanchion's transverse deflection which is equal to the transverse clearance of the bottom locking device (usually, abt. 10 mm). In case of major deformations of hatches - e.g., with long hatches - they are to be taken into account in connection with the container's horizontal shift.

B.1.1.7 The longitudinal force on container's foundation is:

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

B.1.2 Container stowage with lashings

B.1.2.1 The transverse racking force, RF_T , on a container in the i^{th} tier is to be calculated according to [B.1.1.1](#), additionally taking into account transverse components of lashing forces, if any, on top of this container and on bottom of the container above as follows:

$$RF_{T,i} = RF_{T,i+1} + 0.275 \cdot F_{q,i+1} + 0.225 \cdot F_{q,i} - Z_{top,i} \cdot \sin \alpha_{top,i} - Z_{bottom,i+1} \cdot \sin \alpha_{bottom,i+1}$$

Z : total lashing force [kN]

α : lashing angle

The transverse racking forces acting on container end frames and the lashing forces on these frames are to be calculated by solving the system of linear equations based on compatibility of deflections of container corners and lashing elements at their corresponding positions.

Where the arrangement of container stacks is such that tilting may occur, forces induced in the lashing elements are to be specially considered.

In general, static forces caused by pretension of lashings are neglected. If these forces represent a significant portion of the total loads on containers and container securing equipment, special consideration is required.

A load increase on some lashing elements caused by horizontal shifting of containers owing to clearance at, e.g., cone adapters and lower shifting locks is, in general, to be taken into account as follows:

A transverse displacement of containers in the first and second layers of 4 mm each is to be considered for the stack's door end. For the front end, in general, a transverse displacement of containers shall not be considered. If more than three container stacks placed side by side are coupled by double cone adapters to a container block, it is assumed that containers will not shift horizontally.

Lashing forces are to be calculated by taking into account deformations of lashing bridges of 10 mm and 25 mm in the direction of the lashing force for one-tier and two-tier high bridges, respectively. For higher lashing bridges, the lashing bridge deformation is to be determined upon consultation with GL

For calculation of the lashing forces according to B.1.2, the following values of overall modulus of elasticity can be assumed for steel lashing rods (including tensioning device and eyes) depending on their design:

$$E_z = 1.4 \cdot 10^4 \div 1.9 \cdot 10^4 \quad [\text{kN/cm}^2]$$

In general, lashing computations shall be based on standard values according to Table 3.4. In case of significant deviations from these standard values, actual values are to be submitted.

Section 3 Dimensioning of Container Securing Systems

Table 3.4

Lashing to	Length of lashing l [cm] ¹	Angle of lashing α ¹	E-module of lashing rope E _z [kN/cm ²]
1 st tier top	354	43°	1.4 · 10 ⁴
2 nd tier bottom	365	41°	
2 nd tier top	560	24°	1.75 · 10 ⁴
3 rd tier bottom	575	22°	
3 rd tier top	710	19°	1.9 · 10 ⁴
4 th tier bottom	725	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 have to be adjusted accordingly.

For calculation of lashing forces, where the racking resilience values of the container end frames are unknown, the following mean values can be used for steel frame containers:

	Door frame	Front wall frame
Racking resilience c _c [cm/kN]	2.7 · 10 ⁻²	0.60 · 10 ⁻²

For aluminium containers values of c_c are to be specially agreed.

Determination of transverse racking forces and lashing forces is demonstrated below by means of a simple example for a container stack consisting of two tiers lashed to the bottom of the second tier (see Fig.3.1). A further calculation example is given in Annex L.

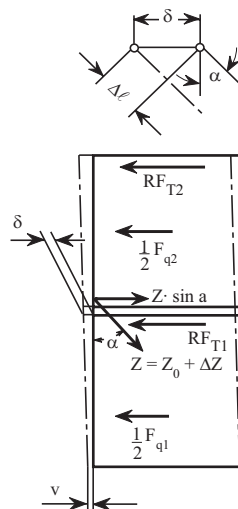


Fig. 3.1

Racking force on top of upper tier:

$$RF_{T,2} = 0.225 \cdot F_{q,2}$$

Racking force on top of lower tier:

$$RF_{T,1} = RF_{T,2} + 0.275 \cdot F_{q,2} + 0.225 \cdot F_{q,1} - Z \cdot \sin \alpha$$

Total lashing force:

$$Z = Z_0 + \Delta Z$$

$$\Delta Z = c_z \cdot \Delta \ell$$

$$c_z = \frac{E_z \cdot A}{\ell}$$

$$\Delta \ell = \delta \cdot \sin \alpha$$

Z_0 : pretension force [kN]

ΔZ : increase of lashing force [kN]

c_z : tension stiffness of lashing element [kN/cm]

ℓ : length of lashing [cm]

$\Delta \ell$: elongation of lashing element [cm]

A : effective cross-section of lashing [cm²]

E_z : overall modulus of elasticity of lashing [kN/cm²]

Transverse deflection of lashed container corner:

$$\delta = c_c \cdot RF_{T,1} + v$$

c_c : racking resilience of the container's transverse frame [cm/kN]

v : transverse offset caused by shifting of bottom container [cm]

B.1.2.2 The longitudinal racking force, RF_L , on a container's side frames is to be calculated according to [B.1.1.2](#).

B.1.2.3 The corner post force, CPL, on the upper corner casting of a container in the i^{th} tier is to be calculated according to [B.1.1.3](#), additionally taking into account vertical components of lashing forces, if any, on top of this container and on bottom of the container located above as follows:

$$CPL_i = CPL_{i+1} + RF_{T,i+1} \cdot \frac{H_{c,i+1}}{B_c} + \frac{1}{4} \cdot G_{i+1} \cdot b_t \cdot 9.81 \cdot \cos 30^\circ + Z_{\text{top},i} \cdot \cos \alpha_{\text{top},i} + Z_{\text{bottom},i+1} \cdot \cos \alpha_{\text{bottom},i+1}$$

B.1.2.4 The lifting force, LF, on the bottom corner casting of a container in the i^{th} tier is to be calculated according to [B.1.1.4](#).

B.1.2.5 The vertical force on each foundation point of a container or container stack at the compressed side is to be calculated according to [B.1.1.5](#), additionally taking into account the vertical component of the lashing force, if any, acting on top of the lowermost container as follows:

$$CPL_{\text{found}} = CPL_1 + RF_{T,1} \cdot \frac{H_{c,1}}{B_c} + \frac{1}{4} \cdot G_1 \cdot b_t \cdot 9.81 \cdot \cos 30^\circ + Z_{\text{top},1} \cdot \cos \alpha_{\text{top},1}$$

The vertical force on each foundation point of a container or container stack at the tensioned side is to be calculated according to [B.1.1.5](#).

B.1.2.6 The transverse force on a foundation point is to be calculated according to [B.1.1.6](#).

B.1.2.7 The longitudinal force on container's foundation is to be calculated according to [B.1.1.7](#).

B.2 Design loads

B.2.1 Design loads on container frameworks and corner castings

Design values for transverse and longitudinal container racking forces, corner post forces, lifting forces and, where applicable, lashing forces calculated according to [B.1](#) are to be used for dimensioning container securing systems without lateral supports.

B.2.2 Design loads on lashing gear

For container stowage with internal lashings, container lashings are to be dimensioned based on the lashing forces calculated according to [B.1.2](#), taking also into account the load assumptions given below.

Dimensioning of external lashings requires special consideration.

B.2.3 Design loads for lashing bridges

B.2.3.1 Dimensioning of the lashing bridge shall be based on the lashing case of the container securing arrangement plan which produces the highest lashing forces. Alternatively, a force of 230 kN per lashing acting in the lashing direction can be applied. The global system of the individual lashing bridge shall be loaded with 61 % of these forces only. The lashing forces have to be applied according to their x-, y- and z-components.

B.2.3.2 The individual lashing plates and their substructures have to be dimensioned based on the lashings' maximum Safe Working Loads (SWL), see [Annex C](#).

B.2.4 Design loads for container stanchions and substructures

B.2.4.1 In general, for container stowage without lateral support, container stanchions and substructures are to be dimensioned based on the most adverse simultaneously acting transverse forces, $F_{T,found}$, and vertical forces, CPL_{found} and LF_{found} , acting on foundation points calculated according to [B.1](#).

If the bending strength of container stanchions is smaller in the longitudinal than in the transverse direction, the vertical forces on the foundation points at the stanchion are to be considered as acting simultaneously with the longitudinal force, $F_{L,found}$, according to [B.1](#), instead of the transverse forces, $F_{T,found}$.

B.2.4.2 Where lashings are arranged at the stanchions, the stanchions are to be dimensioned also considering the most adverse vertical and horizontal loads resulting from lashing forces calculated according to [B.1.2](#).

B.2.4.3 To dimension container stanchions, the most unfavourable eccentricity of the vertical compressive forces, CPL_{found} , acting on foundation points is to be assumed.

B.2.4.4 Detached stanchions are to be designed to safely absorb shocks occurring during normal loading operations.

B.2.4.5 Under major hatch deformations, containers situated on stanchions and hatch covers shall not transmit shifting forces (see [Section 2, B.1](#)).

B.2.5 Design loads for container foundations

B.2.5.1 Container foundations welded on and/or welded into the ship structure have to be dimensioned taking into account simultaneously acting horizontal and vertical forces, according to [B.2.4](#).

B.2.5.2 To dimension foundations welded in to the ship's longitudinal main structures (strength deck, inner bottom, etc.), stresses resulting from the ship's global loads are also to be considered.

B.2.5.3 Substructures for container foundations are to be dimensioned according to GL Rules for [Hull Structures \(I-1-1\)](#) and [Structural Rules for Container Ships \(I-1-5\)](#).

C Container Stowage with Lateral Support

C.1 Dimensioning of cell guide structures

C.1.1 General

C.1.1.1 Load assumptions

Cell guide structures are to be dimensioned for the maximum number of container layers and for the maximum permitted container gross weight in each layer. Combinations of different container heights in a stack, yielding the most adverse stresses in cell guide structures, are to be considered.

Calculations of resulting forces and stresses in structural members, such as ties and guide rails, may be carried out with suitable computer programs. In this case, the computer model, the boundary conditions and load cases are to be agreed upon with GL. The calculation documents are to be submitted, including input and output documentation.

C.1.1.2 Transverse loads on cell guide structures

To dimension cell guide structures, the transverse load on each container is to be taken into account as follows:

$$F_q = G_{\max} \cdot b_q \cdot 9.81 + F_w$$

G_{\max} = maximum permitted container gross weight [t]

F_w = wind load according to [A.2.4](#)

b_q = transverse acceleration factor for unrestricted service and for the metacentric height $GM_{0,\max}$ according to [A.2.2](#)

Transverse loads on cell guides are to be considered for stowage of both 40ft containers and 20ft containers as follows:

For stowage of 40ft containers in cell guides, it is to be assumed that one-quarter of F_q is transmitted to the cell guide structure at each of the four corner fittings of one longitudinal side wall of the container.

For stowage of 20ft containers in 40ft cell guides, it is to be assumed that a share of 1/3 of F_q is transmitted to the cell guide structure at each of the two corner fittings of one longitudinal side wall at the container end placed in the cell guide.

C.1.1.3 Longitudinal loads on cell guide structures

The longitudinal load, F_ℓ , on each container is to be taken into account according to [A.3](#), assuming the maximum permitted gross weight, G_{\max} , of the container.

It may be assumed that a share of one-quarter of F_ℓ is transmitted to the cell guide structure at each of the four corner fittings of the container's front end or door end. A Force reduction in calculations due to friction between container layers is not permissible.

C.1.1.4 Vertical loads on cell guide structures

Vertical design loads on vertical guide rails supporting hatch covers, decks or similar parts loaded with containers shall be determined, including the vertical acceleration factor, a_v , according to GL Rules for [Hull Structures \(I-1-1\), Section 4](#) and [Structural Rules for Container Ships \(I-1-5\), Section 4](#). The scantlings resulting for the corresponding structural members shall not be taken less than those obtained according to GL Rules for [Hull Structures \(I-1-1\), Section 10, C](#) and [Structural Rules for Container Ships \(I-1-5\), Section 10, C](#).

C.1.1.5 Where parts of the cell guide structures are to be considered as components of the ship's hull, GL Rules for [Hull Structures \(I-1-1\)](#) and [Structural Rules for Container Ships \(I-1-5\)](#) shall be taken into consideration as well.

C.1.2 Dimensioning of cross ties

C.1.2.1 In general, forces acting on cross ties shall be calculated as indicated in C.1.1.1, based on the transverse container loads according to C.1.1.2. Where necessary, additional compressive or tensile loads on the cross ties caused by transverse deformations of the ship's hull shall be taken into account.

The resulting tensile and compressive stresses in cross ties shall not exceed permissible values given in D.

Where longitudinal ties are not arranged, also bending and shear stresses in cross ties induced by longitudinal container loads according to C.1.1.3 shall not exceed permissible stresses given in D. The distribution of longitudinal loads on cross ties follows from the arrangement of vertical guide rails and may be determined as indicated in C.1.1.1. Alternatively, a load distribution throughout the length of the cross tie may be assumed, as shown in Fig. 3.2.

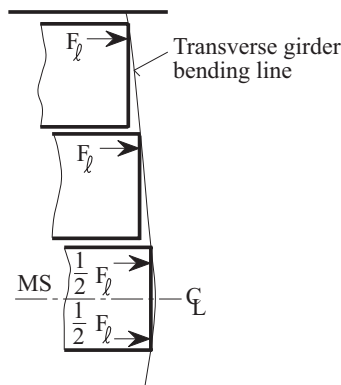


Fig. 3.2 Load distribution throughout cross tie

C.1.2.2 For cross ties not directly connected to the hull, the minimum required sectional area, $A_{s\text{ req}}$, of the cross tie bar subject to the compressive load, P_s , is:

$$A_{s\text{ req}} = 10 \cdot \frac{P_s}{\sigma_p} \quad [\text{cm}^2]$$

σ_p : permissible compressive stress [N/mm²]

$$\frac{\kappa}{S} \cdot R_{eH}$$

P_s : compressive tie bar load [kN]

κ : reduction factor

$$\frac{1}{\phi + \sqrt{\phi^2 - \lambda_s^2}}$$

ϕ : $0.5 [1 + n_p (\lambda_s - 0.2) + \lambda_s^2]$

0.34 for tubular and rectangular profiles

0.49 for open sections

λ_s : degree of slenderness of the tie bar

$$\frac{\ell_s}{i_s \cdot \pi} \cdot \sqrt{\frac{R_{eH}}{E}} \geq 0.2$$

ℓ_s : length of the tie bar [cm]

E : modulus of elasticity [N/mm²]

i_s : radius of gyration of the tie bar

$$: \sqrt{\frac{I_s}{A_s}} \text{ [cm]}$$

I_s : smallest moment of inertia of tie bar cross section [cm⁴]

S : safety factor

: 1.4 for $\lambda_s \leq 1$

: 1.65 for $\lambda_s > 1$

C.1.2.3 For cross ties rigidly connected to the hull, the slenderness ratio of tie bars is required to be $\lambda_s \leq 250$. The slenderness, λ_s , is to be calculated according to C.1.2.2, where the effective (buckling) length, s_K , is used instead of the tie bar length, ℓ_s :

$s_K = 0.7 \cdot \ell_s$ for welded connections

$s_K = \ell_s$ for screw connections and suspended structures

C.1.3 Dimensioning of longitudinal ties

Compressive and tensile loads on longitudinal ties shall be calculated as indicated in C.1.1.1, based on longitudinal container loads according to C.1.1.3 and the number and arrangement of longitudinal ties. Resulting stresses shall not exceed the permissible values given in D.

For longitudinal ties subject to compressive forces, the slenderness ratio, λ_s , according to C.1.2.1 shall not exceed 250.

Longitudinal ties shall be connected to the ship's hull in a manner to not absorb compressive and tensile stresses resulting from the ship's global deformations.

C.1.4 Dimensioning of vertical guide rails

C.1.4.1 To dimension non-displaceable end and intermediate shoring points (see Fig. 3.3), rails shall be considered as continuous girders simply supported at both ends. For a system shown in Fig. 3.3, the total transverse load acting at each cross tie level is distributed among the vertical guide rails according to their rigidity values

$$k_i = \frac{I_i}{\ell_i^3}$$

I_i : moment of inertia of rail cross section [cm⁴]

ℓ_i : length of the guide rail [cm] (In the example, Fig. 3.3, all the lengths ℓ_i would be the same.)

Load on each rail at the cross tie level:

$$P_i = \sum P_q \cdot \frac{k_i}{\sum k} \text{ [kN]}$$

$\sum P_q$: total transverse force at the cross tie level

$\sum k$: sum of the rigidity values of all vertical guide rails

Resulting stresses shall not exceed the permissible values given in D.

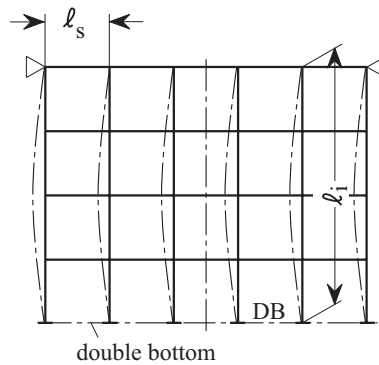


Fig. 3.3: Deformation of vertical guide rails caused by transverse loads

C.1.4.2 Where vertical guide rails support hatch covers, decks or similar parts loaded with containers, vertical loads on these guide rails shall be based on vertical accelerations including factor, a_v , according to GL Rules for [Hull Structures \(I-1-1\), Section 4](#) and [Structural Rules for Container Ships \(I-1-5\), Section 4](#). Resulting stresses shall not exceed the permissible values given in [D](#). The resulting scantlings for the corresponding structural members shall not be taken less than those obtained following GL Rules for [Hull Structures \(I-1-1\), Section 10, C](#) and [Structural Rules for Container Ships \(I-1-5\), Section 10, C](#).

C.1.5 Dimensioning lateral supporting rails

The shoring forces according to [C.2](#) shall be used for dimensioning these rails. Resulting stresses shall not exceed the permissible values given in [D](#).

C.2 Design loads for shoring of containers in cargo hold

C.2.1.1 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 is to be assumed to be completely distributed between these supports. The total transverse load is to 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 is to be assumed to be distributed according to the vertical distance of these supports from the centre of the total transverse load:

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

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

$F_{\text{shore},j}$: transverse shoring force on a support point at support level j

d_j : vertical distance of centre of the total transverse load from support level j

$F_{q,\text{total}}$: sum of transverse loads F_g according to [A.2](#) 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 [Fig. 3.4](#). In this example, the same transverse load, F_g , (see [A.2](#)) is assumed for each container in the container block.

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

The total transverse load from the two uppermost container layers induces the following shoring force on each support point of the upper and the lower supports:

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

Section 3 Dimensioning of Container Securing Systems

The lower support is additionally loaded with the proportional share from the three lower container layers. Thus, each of the lower supports are loaded with

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

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

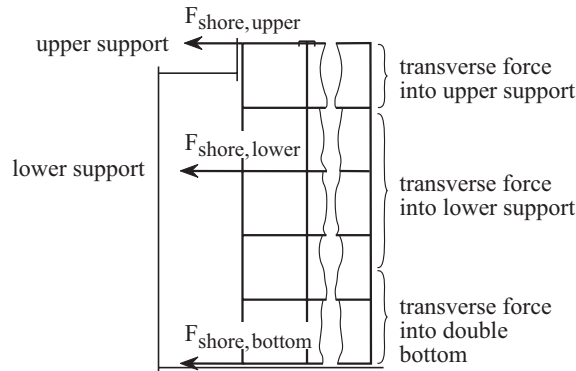


Fig. 3.4

C.2.1.2 Where the number of stacks in the container block is greater than four, the transverse shoring forces calculated according to B.2.1.1 may be reduced by the following factor f_r :

$$\text{if } (n - m) \leq 4, \text{ the factor } f_r = 1 - \frac{(n - 4)^2}{2 \cdot n \cdot m}$$

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

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 , are to 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 are to be neglected.

Tank steps still existing are not considered.

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

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

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

G_{aver} : average gross weight of containers to be supported by support point under consideration [t]

C.3 Stackability

According to ISO 1496-1, the lowermost container in the hold may be overstowed with 192 000 kg, taking into account a vertical acceleration of 1.8 g. This can be converted to the maximum allowable stack mass stowed on top of the first layer in accordance with the vertical acceleration $(1+a_v) \cdot g$, where a_v is obtained according to A.4, when considering a safety factor of 1.2. The number of tiers is not limited.

D Permissible Loads

D.1 Permissible forces

D.1.1 Transverse racking force

The maximum permissible transverse racking force acting on the container's end frame is, in general, 150 kN.

For container stowage in cell guides with only one container end in the guide, the maximum permissible transverse racking force on the lowermost container is 185 kN and 170 kN for 30ft and 40ft containers, respectively.

D.1.2 Longitudinal racking force

The maximum permissible longitudinal racking force acting on the side wall frame of a container is 125 kN each.

D.1.3 Corner post force

The maximum permissible corner post force acting on the upper corner casting of the container is, in general, 848 kN.

If 45' containers are stowed on top of 40ft containers, the corner posts may be loaded with 270 kN maximum. This may be applied for 48ft, 49ft and 53ft long containers.

D.1.4 Lashing forces

For lashing angles between 40° and 45°, the maximum permissible lashing force is, in general, 230 kN.

For lashing angles between 20° and 25°, the maximum permissible lashing force is, in general, 270 kN for lashing to the lower corner casting and 175 kN for lashing to the upper corner casting.

For vertical lashing, the maximum permissible lashing force is, in general, 300 kN for lashing to the lower corner casting and 125 kN for lashing to the upper corner casting (see Annex I).

If suitable technical proof is given, a lashing force of up to 300 kN may be permitted for other lashing angles.

D.1.5 Shoring forces on corner fittings

The maximum permissible transverse shoring forces for tension and compression are, in general, 250 kN for upper corner fittings and 400 kN for lower corner fittings.

Where containers are stowed which may not withstand the loads mentioned above due to their type of construction, the maximum transverse shoring forces shall be adequately reduced (see also ISO 1496/I).

The maximum permissible longitudinal shoring forces for tension and compression on upper corner fittings are 125 kN for closed type containers, so-called box containers, and 75 kN for tank containers, open top containers, open-side containers and platform-based containers. The maximum permissible longitudinal shoring forces on lower corner fittings equate to container weight.

D.1.6 Lifting forces

The lifting force acting on a twistlock may not exceed the twistlock's maximum SWL and the maximum permissible tensile force on a container corner casting (in general 250 kN).

For vertical lashings according to [Section 2](#), which are not accounted for in the model to calculate container and lashing forces, a calculated lifting force of up to 375 kN is permissible, in general.

D.2 Permissible stresses

The maximum permissible stresses for container supports, foundations, lashing bridges, etc. are:

$$\sigma_N = \frac{R_{eH}}{1.25}$$

$$\tau = \frac{R_{eH}}{2.5}$$

$$\sigma_v = \sqrt{\sigma_N^2 + 3\tau^2} = \frac{R_{eH}}{1.13}$$

σ_N : perm. normal stress [N/mm²] (tension, compression, bending)

τ : perm. shear stress [N/mm²]

σ_v : perm. equivalent stress [N/mm²]

R_{eH} : reference yield stress of the material used [N/mm²]

Section 4 Materials, Welding and Tests

A	Materials and Constructional Parts.....	4-1
B	Welding	4-4

A Materials and Constructional Parts

A.1 Manufacture and testing

A.1.1 Works approval

Materials and constructional parts for cell guides and lashing elements may only be supplied by manufacturers approved by GL in this respect. Approval shall be applied for in writing to GL and will be granted, as a rule, on basis of an inspection of the works and approval tests of the products. The scope of testing will be laid down in this respect from case to case.

A.1.2 Requirements for the materials, quality evidence

All materials and constructional parts decisive for the strength of the buttress and cell guide structures as well as lashing elements shall satisfy, in respect of their quality characteristics, the GL Rules for [Steel and Iron Materials \(II-1-2\)](#), be tested in the presence of a Surveyor and be certified by GL according to the GL Rules for [Principles and Test Procedures \(II-1-1\)](#), [Section 1, H.1.2](#) and [A.3.1](#) respectively.

Where parts not welded to the ship's hull or not relevant for the ship's strength are concerned, testing by the manufacturer with a certificate according to the GL Rules for [Principles and Test Procedures \(II-1-1\)](#), [Section 1, H.1.2](#), e.g. an acceptance test certificate 3.1 as to EN 10204, may be consented ¹.

The material records shall contain specific details on the manufacturing procedure, composition, heat treatment mechanical properties and marking.

Relevant equivalent certificates can be recognized.

Inspection of constructional parts:

All parts shall be made available to the Surveyor for an inspection of their surface condition and a dimensional check. The dimensional checks and - in case of piece numbers above 100 - also the visual inspection will be carried out at random. On request of the Surveyor non-destructive tests are to be carried out, e.g. ultrasonic, x-ray or surface crack indication tests.

A.1.3 Retests

Where no or insufficient material records are furnished for the materials and/or individual parts or if the association with the test certificates is insufficient, GL may call for retests to be carried out under their supervision. The kind and scope of the tests will be laid down from case to case in conformity with the GL Rules for Materials.

A.1.4 Selection and materials

The selection of materials shall be done taking all qualities into account, a confirmation of GL is done normally by the drawings approval.

A.1.5 Marking

Materials and fittings shall be marked by the manufacturer in such a way that an unobjectionable identification can be done by the material certificates. Materials tested by GL are stamped additionally according to the GL Rules for [Principles and Test Procedures \(II-1-1\)](#), [Section 1, F](#).

¹ Lashing elements welded on hull are in general of minor importance to ship's strength and are normally sufficiently certified by a material certificate 3.1 according to EN 10204 .

Cast steel and forged pieces are to be marked with the manufacturer's ident, short ident of the kind of cast and a marking respect. ident-no. for the charge (i.e. last three numbers of the charge number). Additional markings can be agreed between manufacturer and customer.

A.2 Approved materials

A.2.1 Materials for cell guides, blind frames and similar structures

Plates, sections, bars and pipes for cell guides and blind frames, container stanchions and similar structures shall be in accordance with the GL Rules for [Steel and Iron Materials \(II-1-2\)](#), Section 1.

The materials shall fulfil the requirements of the minimum impact strength of the rules mentioned before.

Table 4.1 furnishes a summary of permissible GL-shipbuilding steels and comparable steels acc. to EN 10025-2. Steels from other norms may be used if equivalent to those listed in the Table, if it can be proved that they are suitable for welding and if they meet the requirements of the GL Rules for [Steel and Iron Materials \(II-1-2\)](#), Section 1, C.2.3.

Table 4.1 Materials for cell guides, container stanchions and similar structures (excerpt of properties required)

Hull structural steels ¹			Comparable structural steels ²			
Grade	Min. yield point [N/mm ²]	Tensile strength [N/mm ²]	Steel quality acc. to EN 10025-2 and EN 10025-3	A.2.1.1 Min. yield point R _{eH} ³ [N/mm ²]		Tensile ³ strength R _m [N/mm ²]
				t ≤ 16 mm	16 < t ≤ 40 mm	
GL-A	235	400 – 520	S 235 JR S 275 JR	235 275	225 265	360 – 510 410 – 560
GL-B			S 235 J0 S 275 J0	235 275	225 265	360 – 510 410 – 560
GL-D			S 235 J2 S 275 J2	235 275	225 265	360 – 510 410 – 560
GL-E			S 275 NL	275	265	370 – 510
GL-A 36			355	490 – 630	S 355 J2	355
GL-D 36	S 355 K2 S 355 N					
GL-E 36	S 355 NL					

¹ For more requirements, see GL-Rules for [Steel and Iron Materials \(II-1-2\)](#), Section 1, B.
² Extract from the standards EN 10025-2 and EN 10025-3 respectively.
³ When dimensioning the components, possibly, the lower yield points or tensile strengths – depending on steel quality and/or thickness of products – have to be considered by increasing the cross sections accordingly.

A.2.2 Materials for stowage- and lashing fittings above or below weather deck

The steels shall fulfil following requirements:

- The steels shall be killed and fine grain treated.
- All products shall be heat treated, that means normalised or quenched and tempered.
- The steels shall fulfil the requirements for impact strength mentioned in the Standards and approved specifications respectively, at least fulfil the requirements mentioned in Table 4.2.

Section 4 Materials, Welding and Tests

- Unalloyed steels intended for welding shall not have a higher carbon content than 0.22 % (ladle analysis)
- If the type of product requires it, additional non destructive test can be required.

Proof of impact energy is to be given for the temperatures at ISO-V specimen.

Table 4.3 gives an overview of the materials to be used for stowage- and lashing fittings.

Use of the grades GL-A, GL-B and S235JR, S235J0, S275JR, S275J0, S355JR respectively and S355J0 (EN 10025-2) according to the GL Rules for [Steel and Iron Materials \(II-1-2\), Section 1, B and C](#) is not permitted.

If stowage and lashing fittings are fabricated from materials according to EN 10025-2 and EN 10025-3 by hot forming, the requirements as regards chemical composition of the GL Rules for [Steel and Iron Materials \(II-1-2\), Section 1, C.2.3.1](#) are to be observed.

If an impact strength of 14 (11) Joule at – 20 °C is proofed for nodular cast iron of grade EN-GJS-400-18-LT, it can be used for fittings for service above and below deck. Nodular cast iron shall not be used for dynamically high loaded fittings (bottom twistlocks, midlocks etc.).

The temperature at which the necessary impact strength values are proofed is to be chosen with –20 °C for above-deck and with 0 °C for below-deck service.

A.2.3 Materials for lashing chains

For manufacture of lashing chains preferably fully killed steels (e.g. 21 Mn 5, 27 Mn Si 5) according to DIN 17115 or equivalent steels shall be used. The grade RSt 35-2 may be used after special approval.

Where the material grade and the welding procedure so require, the chains are to be properly heat treated.

Table 4.2 Minimum values of impact energy for stowage and lashing fittings above and below the weather deck

Product from	Impact energy		Test temperature for materials with usage above weather deck [°C]	Test temperature for materials with usage below weather deck [°C]
	longitudinal	transverse		
Rolled products ² R _{emin} ≥ 235 N/mm ²	27 (19)	20 (14)	– 20	± 0
Rolled products ² R _{emin} ≥ 355 N/mm ²	34 (24)	24 (17)		
Forged steels	27 (19)			
Cast steels	27 (19)			
Nodular cast iron	14 (11)			

¹ Obtained from ISO-V-specimens as an average value from three tests. One of these values may occur as the lowest individual value; see data indicated in brackets.

² Plate, section, bar

Table 4.3 Materials for stowage and lashing fittings

Type of product, standard	Steel- or casting grade
Structural steels acc. to rules for materials of Germanischer Lloyd	GL-D, GL-D 32 GL-D 36, GL-E GL-E 32, GL-E 36
General steels EN 10025-2	S 235 J2 +N S 275 J2 +N S 355 J2 +N
Fine grain steels suitable for welding acc. to EN 10025-3	basic qualities (N) tough at sub-zero temperatures (NL)
Cast steel DIN 1681 DIN 17182	GS-38 GS-45 GS-52 GS-16Mn5 GS-20Mn5
High temperature steel castings DIN 17245	GS-C 25
Low-temperature steel castings SEW 685	GS-21Mn5 GS-26CrMo4
Quenched temperature steel castings EN 10083	41Cr4 42CrMo4
Nodular cast iron EN 1563	EN-GJS-400-18-LT

B Welding

The following summarises the most important quality assurance measures to be observed and/or to be taken during welding. The scope of quality assurance measures is to be brought into conformity with the production. For any additional requirements having to be imposed the GL Rules for Welding (II-3) and for [Hull Structures \(I-1-1\)](#), [Section 19](#) apply analogously.

B.1 Conditions in respect of workshops

B.1.1 Works' approval

Works and shops, subsidiaries and also sub-contractors intending to carry out welding work on container lashing elements shall be approved by GL in this respect. The approval is to be applied for at GL head office with the following statements and particulars:

- description of the workshop
- materials used
- welding procedure and consumables
- welding personnel
- test equipment as far as available

B.1.2 Facilities

The works and shops shall avail themselves of the necessary facilities permitting expert and perfect weldings. Such facilities are, inter alia, working places protected against atmospheric influences, machinery and equipment for an expert preparation of the welding joints, reliable welding machinery and equipment, stationary or portable drying spaces or cabinets for storing the welding filler metals and consumables.

B.1.3 Welding jigs

For assembly and welding, it is recommendable to use jigs in order to ensure correct dimensions of the structural parts. The jigs shall be of such a configuration that the weld seams are easily accessible and can be welded in the most favourable position possible (cf. i.a. also [B.5.1](#) and [B.6.5](#)). Tack or temporary weldings shall be avoided wherever possible.

B.2 Welders, welding supervision

B.2.1 Welder's qualification test

All welding work on container lashing elements may only be carried out by GL-recognized welders examined in connection with the welding process in question. For manual arc welding and semi-mechanized gas-shielded welding on stowage- or lashing fittings as well as on the hull only welders are permitted, who have qualified according to EN 287 respect. ISO 9606 and, additionally, fulfil the GL Rules [General Requirements, Proof of Qualifications, Approvals \(II-3-1\), Section 3](#).

Welders to be employed for special grade structural steels shall have qualified by analogy with the GL Rules [General Requirements, Proof of Qualifications, Approvals \(II-3-1\), Section 3](#) or in a corresponding qualification group as to EN 287 and ISO 9606 respectively. Equivalent welder's qualification tests on the basis of other rules or standards may be recognized.

B.2.2 Welding supervisors

Each workshop carrying out welding work shall have in its employ a welding supervisor whose professional qualification shall be evidenced. Depending on the type and scope of the welding work to be carried out, welding supervision may be effected by, e.g., a welding specialist or a graduate welding engineer. Changes in respect of the welding supervisors shall be communicated to GL without any prior request to do so. The welding supervisor(s) shall responsibly supervise the preparation for, and execution of, the welding work.

B.3 Welding processes, procedure tests

B.3.1 Evidence of suitability

Only welding processes shall be used the suitability of which has been proved in a procedure test.

As to welding procedure tests for the flash butt welding and friction welding see [Annex B](#)

B.3.2 Application, execution

The execution of a procedure test in order to extend the approval according to [B.1.1](#) is to be applied for at GL head office with the following statements and particulars:

- description of the procedure and the equipment (if possible also pictures, leaflets or similar)
- particulars of the procedure (preparation of seams, welding data, etc.)
- materials to be welded and dimensions of the parts to be connected
- welding consumables to be used and auxiliaries
- subsequent works, if applicable
- subsequent heat treatment data, if applicable
- intended testing during manufacture
- place and time of procedure testing

Welding of samples and testing is to be done under supervision of GL.

B.3.3 Scope of testing, requirements, welders

The scope of testing, test pieces and specimens, and requirements will be laid down, by analogy with the GL Rules for [Welding in the Various Fields of Application \(II-3-3\), Section 1](#) from case to case in accordance with the application range applied for. Welders employed in procedure tests are considered qualified in the welding technique concerned and/or for the respective materials, provided that the procedure tests have been successfully completed. Where further welders or operator groups are to be employed with the procedure application range enlarged later on, the welders or operator groups shall be adequately trained and tested.

B.4 Welding filler metals and consumables

B.4.1 Approval and range of application

All welding filler metals and consumables (such as rod electrodes, shielded-gas welding wires etc.) shall have been approved by GL in accordance with the GL Rules [General Requirements, Proof of Qualifications, Approvals \(II-3-1\), Section 5](#). The required quality grade depends on the base materials to be welded.

B.5 Design of weld joints

B.5.1 General principles

The weld joints shall be designed from the beginning in such a way that they be easily accessible during manufacture and can be made in the most favourable welding sequence and welding position possible (cf. also [B.6.5](#)), care being taken that only the least possible residual welding stresses and distortions will remain in the constructional components after manufacture. Small distances of the welded joints from one another and local accumulations of welds shall be avoided.

B.5.2 Weld shapes

Butt weld joints (such as I, V or X seams) and corner or cross joints (such as single-bevel butt joints) shall be designed in such a way that the full plate or shape cross section is fused. In order to achieve this, the constructional components shall be prepared with adequately chosen weld shapes as to the standards being given a sufficient angle between the planes of the fusion faces, a sufficient air gap, and the smallest possible depth of the root faces in accordance with the plate thickness. Special weld shapes require GL approval; where necessary, the weld shapes are laid down in connection with a procedure test.

B.5.3 Fillet welds

Fillet welds shall, in zones of high local stress (i.e. load introductory zones), whenever possible, be so designed as to be continuous on both sides. Only fillets continuous on both sides or intermittent fillets shall be provided at especially corrosion endangered parts (i.e. exposed to sea water) where the fillets being led around the stiffener or scallop ends to seal them. The fillet throat depends on the stressing in each case, and proof calculations of its sufficiency shall be furnished in cases of doubt. The "a" dimension (throat thickness) shall not exceed $0.7 t$ (t = thickness of the thinner part) nor be less than 3.0 mm.

B.5.4 Overlapped welds

Overlapped weld joints (instead of butt-seam connections) shall only be used in connection with structural parts subject to small loads and only be arranged, wherever possible, in parallel to the direction of the main stress. The overlap width shall be at least $1.5 t + 15$ mm, as t being the thickness of the thinner plate. The fillets shall be made in accordance with [B.5.3](#).

B.6 Manufacture and testing

B.6.1 Welding preparation

The constructional components shall be dry and clean in way of the weld. Any scale, rust, flame cutting slag, grease, paint (with the exception of permitted over-weldable production coatings), and dirt shall be thoroughly removed prior to welding.

Where plates, shapes or constructional components are provided with a corrosion-reducing production coating (shop-primer) prior to welding, this coating shall not affect the quality of the welded joints.

B.6.2 Assembly

When preparing and fitting together the constructional parts, care shall be taken to meet the specified weld shapes and gap widths (air gaps). Where the permissible gap width is slightly exceeded, the same may be reduced by deposit welding on the fusion faces of the joint. Filling pieces or wires shall not be welded in.

B.6.3 Alignment of constructional components

Plates and shapes shall be accurately aligned, in particular in structures interrupted by crossing members. A displacement of the edges relative to one another of more than 15 % of the plate or shape thickness, but maximum 3 mm, the lesser figure being applicable, is not acceptable.

B.6.4 Protection against atmospheric influences

During welding operations, the area where work is carried out shall be protected against atmospheric influences. In cold air (below 0 °C), suitable measures shall be taken (covering, heating the constructional components) to ensure satisfactory execution of the weld joints. Welding shall cease at temperatures below – 10 °C. Any rapid cooling - in particular in the welding of thickwalled parts or steels susceptible to hardening - shall be avoided.

B.6.5 Welding position and sequence

Welding work shall be carried out in the most favourable welding position possible. Welding in vertical downward position shall be avoided wherever possible and shall not be applied to connecting load-bearing components, not even after a procedure test for vertical downward welding in general and irrespective of the approval of welding consumables. A suitable welding sequence shall be chosen to ensure the least possible restriction of the weld seam shrinkage.

B.6.6 Workmanship

In welding operations, care shall be taken to achieve uniform penetration, perfect fusion down to the root, and uniform, not excessively convex weld surfaces. In multi-pass welding, slag having originated from the preceding runs shall be thoroughly removed. Cracks (including broken tack welds), larger pores or slag inclusions etc. are not to be welded over but shall be gouged out.

B.6.7 Repair of defects

The repair of major workmanship defects may only be carried out after consent of GL has been obtained.

B.6.8 In-shop control

Workmanlike, perfect and complete execution of the welding work shall be ensured by a close control by the works or shop concerned. GL will check the welds at random during fabrication and, where necessary, during the final inspection after completion. GL is entitled to reject insufficiently checked constructional components and require their being tendered a new for inspection after successful in-shop control and completion of any repairs necessary.

B.6.9 Weld seam testing

GL is entitled to demand additional non-destructive tests to furnish evidence of a satisfactory weld quality, to be carried out on important structural parts. The type and scope of the tests will be laid down by GL from case to case.

Annex A Instruction for the Performance of Inspections of Container Lashing Elements

A Performance of InspectionsA-1

A Performance of Inspections

A.1 General

A.1.1 All components for container stowage and lashing elements are in principle subject to testings in accordance with the following requirements. The testings and inspections required are to be carried out at manufacturers', prior to delivery.

A.1.2 The scope and type of testings shall comply with the requirements of items [A.1](#), [A.2](#) and [A.3](#) below. Where deemed necessary, deviations therefrom may be admitted upon agreement with GL.

A.1.3 In general, proofs of materials as defined in item [A.2](#) below are to be furnished for the components presented for testing. Where such proof cannot be presented, in agreement with Germanischer Lloyd head office, a subsequent material test is to be carried out. To this effect, the relevant components are to be marked unmistakably.

A.1.4 Generally with the test the drawings approved by head office have to be presented to the surveyor.

A.1.5 All components exposed to tension/compression are to be subjected to load tests, see [A.3](#). For this purpose, at least 2 % of the items delivered are to be selected and subjected to the test load prescribed to which the component shall be able to resist without cracks or permanent deformations occurring. If the test reveals any deficiencies, the Surveyor may extend the scope of testing at his own discretion. Any deficient parts are to be eliminated.

Where a series consists of less than 50 parts, at least one of them is to be load tested. Where a manufacturer repeatedly produces minor series of equal parts at certain intervals, proof of quality is to be furnished by load testing of each individual series.

A.1.6 The parts to be subjected to the test load to be arranged on/clamped into the test bench in a manner corresponding to onboard conditions.

For fittings which have to be welded-in for the purpose of testing and which therefore cannot be used anymore after testing, the scope of testing may be reduced. For this an acceptance test is to be presented, not older than 12 month. Furthermore a type Certificate of GL shall be presented for these fittings.

A.1.7 Where a lashing element is composed of several components (e.g. turnbuckles, twistlocks) supplied by different manufacturers, testing has to be carried out upon final assembly. For components not subject to load testing, only proofs of materials as defined in item [A.2](#) below are to be furnished by the subcontractors.

A.1.8 In case of doubt, the Surveyor is entitled to have testings carried out beyond the prescribed scope, e.g., additional materials tests.

A.1.9 Break-load-tests are carried out in conjunction with the type test (see [A.3](#)). Break-load-test are to be repeated depending on production numbers upon agreement with the surveyor, however, latest after 5 years.

A.1.10 Kinds of testings

A.1.10.1 Testing on a lot basis

In general, testing is carried out by lots, combining into one testing unit elements manufactured by the same process, from the same material and in the same form. The Surveyor will select not less than 2 % of the parts of each lot and check these for their surface finish and accuracy to size and tolerances.

A.1.10.2 Testing on a piece basis

Where testing on a piece basis is required, e.g. on account of the kind of element, special agreements will have to be reached between manufacturers and GL.

A.2 Special test

A.2.1 Cell guides are to be controlled for measurements after installation. A function test has to be done as a random check with containers or a corresponding pattern.

A.2.2 Generally a material-test certificate of a neutral institution of the maker has to be presented with the test. Welded-in lashing elements, that are welded into ship structures which are important for ships strength, require a GL certificate. The welded-in plates shall reach at least the characteristic values of the plates where they are welded into. Exceptions have to be agreed upon with GL Head Office.

A.2.3 Welded fittings have to be randomly checked for welding thicknesses aside of the normal welding seam examination (especially with container foundations).

A.2.4 Welding-in foundations (pots)

All welding-in pots have to be checked for tightness (proof by makers certificate). GL reserves the right to be present at this test. Exceptions shall be arranged with GL head office.

A.3 Load tests (type test)

In general, following safety factors v_{Br} apply for container lashing elements and rigid fittings:

safety factor in general : $v_{Br} = 2.0$

for lashing ropes applies factor : $v_{Br} = 2.25$

for lashing chains applies factor : $v_{Br} = 2.50$

$$v_{Br} = \frac{BL}{WL}$$

BR : minimum breaking load [kN]

WL : working load [kN]

The table in [Annex C](#) shows working load, test load and breaking load for the most frequent fittings, as well as the test arrangement for the load tests. The stated values are applicable in case the materials which are usual for the specific fitting are used. The test loads are calculated in accordance with the values of the table below and are to be transmitted correspondingly onto other fittings.

Container lashing fittings are also approved and tested for lower safe working loads as long as it fits into the system

The number of necessary test- and breaking load tests for the type-test (-approval) will be stated for each fitting with the drawings approval by the GL head office. For standard elements, however, at least three pieces are to be tested with break load.

On completion of the load test, an operational test shall be carried out.

Under the test load no permanent deformations or incipient cracks may occur.

The successfully carried out type test will be certified with a type-certificate by GL Head Office (sample see [Annex C](#)).

A load test plus an operational test may be required for lashing appliances consisting of several individual parts the joint performance of which has not yet been proven.

For common designs of fully automatic locks, an operational test is required as described in [Annex C](#). For novel concepts for fully automatic locks, details of the operational test will be individually laid down by GL Head Office.

A.4 Marking of components

A.4.1 General

The marking of the fittings is to be done in such a way that an identification on account of the material certificates to be presented is possible. The stamping by the surveyor is done after examination of the material certificates, after visual inspection of the finished product and, if need be, the successful practical testing. In order to avoid damages to the component, the method of fixing the marking may have to be agreed upon with the Surveyor (see [A.4.3.5](#) below).

A.4.2 Marking by GL stamp

A.4.2.1 Testing on a lot basis

Materials and components tested on a lot basis, which met the test conditions are provided with the GL stamp



A.4.2.2 Testing on a piece basis

Materials and components tested or inspected individually in accordance with the Rules and meeting their requirements will be provided with the stamp



A.4.2.3 Extent of stamping

At random checks all examined fittings are stamped (2 % of the delivery). With individual inspection all parts are stamped.

A.4.3 Examples for marking of individual parts

A.4.3.1 Castings are to be provided by manufacturers at least with their symbol and with a marking showing the charge or heat treatment batch. In addition, parts are to be marked as defined in [A.4.2](#).

A.4.3.2 Forgings are to be provided with the manufacturer's symbol and a marking showing the charge, production or heat treatment batch. In addition, parts are to be marked as defined in [A.4.2](#).

A.4.3.3 Parts made of rolled steels

Stamping is to be done in accordance with [A.4.2](#).

A.4.3.4 Lashing bars

Following the tensile test according to [A.4.2](#) each testal lashing bar is to be stamped.

A.4.3.5 Lashing chains

Following the tensile test each chain is to be stamped at one end according to [A.4.2](#). In addition, following testing in accordance with the standards applicable to chains, each chain is to be stamped by manufacturers with their symbol (or identification character) as well as with the grade characteristic of the chain material employed (see DIN 685). In principle, stamping is to be effected on the unwelded side of the chain link and shall not create any deterioration of the link.

A.4.3.6 Lashing ropes

For marking the nominal strength of the wires, lashing ropes are to be provided with coloured spun in identification threads, as follows:

- nominal strength 1570 N/mm²: red
- nominal strength 1770 N/mm²: green

Ropes tested by approved manufacturers or dealers independently and supplied with GL approved Works Test Certificates shall additionally be provided with a spun in identification thread carrying the manufacturer's symbol or the identification No. designated by GL.

Ropes tested in the Surveyor's presence are marked by a lead seal carrying the stamp:



Annex B Welding Procedure Qualification Test Flash Butt Welding or Friction Welding of Container Lashing Elements

A Procedure Qualification Flash Butt Welding B-1

A Procedure Qualification Flash Butt Welding

A.1 Scope and purpose

The present working sheet applies to welding procedure qualification tests for flash butt welding or friction welding of Container lashing elements. It supplements the GL Rules for Welding (II-3) as well as the "Rules for Stowage and Lashing of Containers aboard Ships" and describes the special test pieces, test specimens and requirements for proof of unobjectionable workmanship and adequate mechanical properties of the welding joints.

A.2 Types of joints, materials, requirements

In accordance with the state of technology and application the above procedures are mainly employed for joining lashing bars, including their end fittings, such as hooks, eyes etc., made from quenched and tempered steels 41 Cr 4 (Mat.-No. 1.7035), 25 Cr Mo 4 (Mat.-No. 1.7218) and 42 Cr Mo 4 (Mat.-No. 1.7225). As a rule their diameters are approx. 25 mm.

In most cases these steels are used in quenched and tempered condition and owing to their chemical composition are relatively susceptible to hardening. Particularly in the case of flash butt welding embattlement of the weld area is to be reckoned with, which can only be compensated by subsequent systematic heat treatment. Therefore, apart from furnishing proof of strength, the main purpose of the procedure test is to furnish proof of adequate toughness (ductility). The welding and, where applicable, annealing data shall be capable of being reproduced.

A.3 Test pieces and specimens

The test pieces are to be welded from known steels, for which proofs are available. If different materials are employed, the different steels are to be welded to each other and/or welded to each other in the envisaged combination. All welding and annealing data, if any, including the pertinent machine adjustment characteristics, are to be recorded. The length of the test pieces is to be taken such as to enable them to be perfectly clamped, to exclude heat accumulation and to enable sampling as required. The minimum length of test specimens is 300 mm.

For each kind and/or combination of material(s) in the presence of a GL representative at least six equal test pieces are to be welded, from which following a magnetic particle or dye penetration test for surfaces flaws the following specimens are to be taken:

- 1 round tensile test specimen according to DIN 50120 Part 2 (diameter of test specimen $d_0 = 20$ mm)
- 3 transverse bending test specimens according to DIN 50121 Part 2 (cross-section of test specimen \approx cross section of component)
- 1 notched transverse bending test specimen analogously to DIN 50121 Part 2 (cross-section of test specimen \approx cross-section of component)
- 1 macro-etching (longitudinally) with hardness measurements (1 \times at specimen centre, 1 \times near surface of specimen)

In particular cases GL may stipulate other supplementary examinations (e.g. ultrasonic test) or testings (e.g. of notch impact bending test specimens); in that case the number of test specimens will have to be increased accordingly.

A.4 Testing and requirements

Testing is to be effected in the presence of a GL representative subject to the standards mentioned. The tensile strength is to be at least equal to the values fixed for the quenched and tempered condition in the materials' standards for the material concerned. In the transverse bending tests using a mandrel diameter of $4 \times$ specimen thickness, a minimum bending angle of 60° shall be reached. The bending elongation (measuring length $l_0 = 2 \times$ specimen thickness) is to be reported.

The notched transverse bending test specimen shall not show any welding flaws, such as pores, inclusions, cracks and the like in the broken section. The same applies to macro-etchings. The hardness survey shall be as even as possible and shall not show any pre-eminent hardness peaks. The requirements for possible additional testings will be fixed from case to case.

A.5 Recording of results

During the test weldings all parameters essential for the constancy and quality of the weld connections are to be recorded.

In the case of flash butt welding these include:

- Welding machine (kind, manufacturer, type, output, steering mechanism, control devices, etc.)
- Basic material (kind, shape and dimensions)
- Workpiece preparation (clamping and abutting surfaces)
- Length tolerance (overlength) and clamping length
- Clamping jaws (shape and material)
- Clamping force
- Upsetting force and upsetting pressure
- Welding current and platen speed
- Welding time
- Axial reduction of parts length
- Post-heating current and time
- Removal of welding burrs

It is advisable to this effect to equip the welding machine with a device for recording the time curve of current, distance and force.

In the case of friction welding these include:

- Welding machine (kind, manufacture, type, output, steering mechanism, control devices etc.)
- Basic material (kind, shape and dimensions)
- Workpiece preparation (clamping and abutting surfaces)
- Length tolerance (overlength) and clamping length
- Speed (number of revolutions)
- Contact pressure
- Welding time
- Axial reduction of parts length
- Removal of welding burrs

Here, too, it is advisable to record the time curve of relative speed and contact pressure and under all circumstances to equip the machine with relevant control devices.

During the tests the shapes of test specimens and their dimensions, mechanical properties achieved, findings of tests (flaws) are to be recorded and the hardness curves are to be represented graphically. The protocols are to be countersigned by the Surveyor.

A.6 Literature (selection)

The following technical guides of the DVS (German Welding Society) are German editions only.

DVS 2901-1

DVS 2909-1

DVS 2909-2

DVS 2909-3

DVS 2909-4

DVS 2909-5

DVS 2922

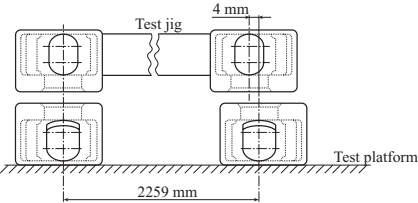
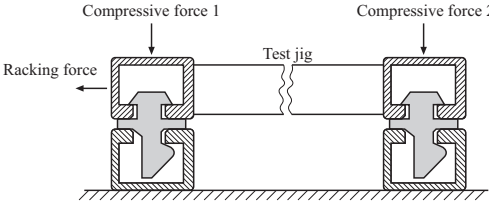
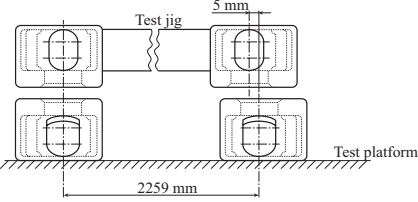
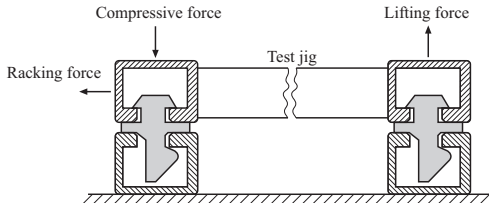
Annex C Container Lashing Fittings

A Loads for Container Stowage- and Lashing Fittings.....C-1
 B Operational Tests for Fully Automatic LocksC-2

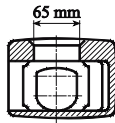
A Loads for Container Stowage- and Lashing Fittings

Type	Test arrangement		WL Usual Working Load [kN]	TL Test Load [kN]	min. BL Breaking Load [kN]
Lashing rod			230	288	460
Lashing chain			80	100	200
Lashing steel wire rope			200	250	450
Turnbuckle			230	288	460
Twistlock (single)/ Midlock ¹			210	263	420
Twistlock (single)/ Midlock ¹			250	313	500
Stacker			210	263	420
Doublestacker		Deck	200	250	400
		Hold	560	620	730
Flush socket			250	313	500
Pedestal socket			250	313	500
Pedestal socket			210	263	420
"D"- Ring			230	288	460
Lashing plate			230	288	460
Penguin hook			230	288	460
TP Bridge fitting			210	263	420
Buttress		betw. tiers	650	715	850
		Top tier	250	275	325
Dove tail Twistlock		Tensile	200	250	400
		Shear	210	263	420
Linkage plate			150	188	300
General note:		Deck	WL	1,25 WL	2,0 WL
		Hold	WL	1,1 WL	1,33 WL
The loads above are valid for Ro-Ro lashing elements also. Lashing belts are also tested with factor 2,0 BL/SWL.					
¹ For fully automatic locks, additional operational tests are required. Details of the operational tests are defined in Table B.					
² Pedestal sockets shall be tested additionally for an SWL of 1000 kN pressure.					

B Operational Tests for Fully Automatic Locks

Type	Test arrangement and loading scenario	Test Load [kN]	
Fully automatic locks	<p>Test setup:</p> <ul style="list-style-type: none"> The distance between center lines of the corner casting apertures on the test jig is to be 4 mm less than distance between center lines of the corner casting apertures on the test platform.  <p>Loading scenario:</p> <ul style="list-style-type: none"> First, the test jig is to be shifted in the direction of racking force as far as possible within the clearance of the locks. Subsequently, test forces are to be applied in the following sequence: <ol style="list-style-type: none"> Compressive forces 1 and 2 Racking force 	Compressive force 1	96
		Compressive force 2	35
		Racking force	210
Fully automatic locks	<p>Test setup:</p> <ul style="list-style-type: none"> The distance between center lines of the corner casting apertures on the test jig is to be 5 mm less than distance between center lines of the corner casting apertures on the test platform.  <p>Loading scenario:</p> <ul style="list-style-type: none"> First, the test jig is to be shifted in the direction of racking force as far as possible within the clearance of the locks. Subsequently, test forces are to be applied in the following sequence: <ol style="list-style-type: none"> Compressive force Racking force Lifting force 	Compressive force	350
		Racking force	150
		Lifting force	275

- Notes:
1. Two ISO top corner fittings in mint condition are to be fixed on the test platform.
 2. A stiff test jig, linking two ISO bottom corner fittings in mint condition, is to be used.
 3. The top and bottom apertures of all ISO corner fittings are to be exactly 65 mm wide.



4. The orientation of the racking force is to be always opposite to the nose of the fully automatic lock.
5. During the sequential application of test forces, the previously applied forces are to be kept constant.
6. Devices for application of test forces shall not laterally jam the test jig.
7. Permanent deformations, incipient cracks, or failure of the lock as such will not be accepted.
8. At least three randomly selected fully automatic locks are to be tested.

Annex D Approvals of Computer Software for Determination of Forces in the Lashing System

A	Approval of Lashing Computers/Software	D-1
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A Approval of Lashing Computers/Software

A.1 General remarks

A lashing calculation program is computer-based software for calculation and control of container securing arrangements in compliance with the applicable strength requirements. A GL approved lashing calculation program is to be used onboard each ship carrying containers.

GL examines and approves calculation programs on test condition basis. This examinations and the corresponding approval are done in relation to a specific ship.

GL recommends using the lashing program on a GL type approved hardware only. If it is not the case, the program shall be installed on two nominated computers.

A.2 General requirements

For each ship the printouts of the test conditions of different bays for unrestricted service (see [Section 3, A.2](#)), a copy of the program and a user's manual have to be submitted for examination. For ships intended to be assigned the notation **RSCS** for route specific container stowage, additional printouts of test conditions of bays according to route specific container stowage manual (see [Section 1, A.1.1.4](#)) have to be submitted for examination. Test conditions shall include the following cases:

- twistlocks only
- complete lashing
- with exceeding of stack weight
- with exceeding of lashing load
- with exceeding of lifting force
- an example with outboard stacks missing
- one example, where 20' and 40' containers are arranged in mixed stowed
- typical stowage in hold

The software has to be user-friendly, with a graphic presentation of the container arrangement. It has to reject input errors from user. For example negative weight input, container positioned outside or lashings, which are not possible on board are not to be accepted. The software and the stored characteristic data are to be protected against any erroneous use.

For Class Notation **RSCS**, an option shall be available in the software to choose between accelerations for unrestricted service and for specified routes. The chosen acceleration basis shall be visible on the screen as well as in printouts.

GL has to be informed immediately about any modifications which may affect the approved lashing program installed on board of the ship. GL will decide about a re-approval case by case. Failure to advice of any modifications will annul the issued certificate.

The following details have to be given for each container arrangement in addition to the GM Value of the ship:

- position of each stack
- container weight
- actual stack weights

- permissible stack weights
- lashing arrangement
- transverse acceleration of each stack
- racking forces
- lifting forces
- lashing forces
- corner post loads
- pressure loads at bottom
- percentage of exceeding
- a warning has to be given if any of the strength limit is exceeded

The lashing program certificate, the approved test conditions and the user's manual have to be kept on board.

Annex E Weights, Measurements and Tolerances

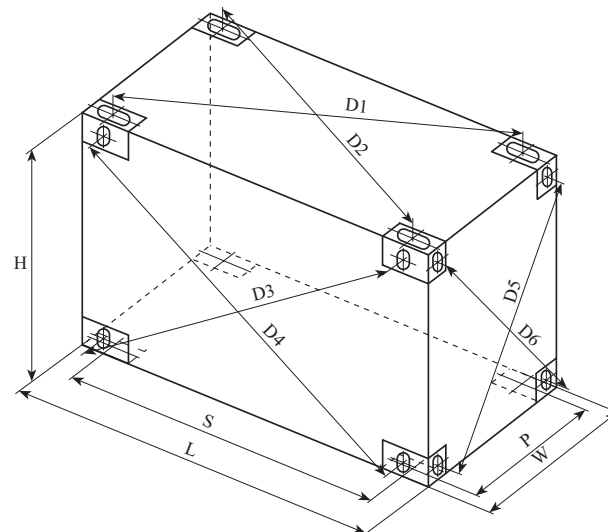
Table E.1 Weights, measurements and tolerances

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	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
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 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.

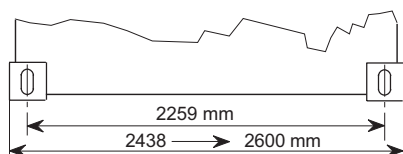
** In certain countries there are legal limitations to the overall height of vehicle and load.



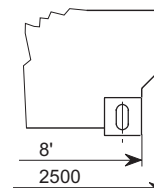
Annex F Container-Dimensions

Größe	Länge (Seitenansicht)	Breite	Höhe
53' (16150 mm)		8' 6" (2591 mm)	9' 6 1/2"
49' (14935 mm)		2600 mm	9' 6" 2896 mm
2x24 1/2' (2x7442 mm)		2600 mm	9' 6" 2896 mm
48' (14630 mm)		8' 6" (2591 mm)	9' 6 1/2"
45' (13720 mm)		8' (2438 mm)	9' 6" 9' 6 1/2"
43' (13103 mm)		8' (2438 mm)	
40' ISO (12192 mm)		8' (2438 mm)	8' 9" 8' 6" 9' 6"
40' EURO (12192 mm)		2500 mm	8' 6" 9' 6"
40' Bell Lines (12192 mm)		2500 mm	
35' (10660 mm)		8' (2438 mm)	8' 6"
30' (9125 mm)		8' (2438 mm)	8' 8' 6"
24' (Matson) (7430 mm)		8' od. 8' 6" (2438 mm or 2591 mm)	8' 6" 9' 6"
2x20' (2x6058 mm)		8' (2438mm)	8' 9' 6" 8' 6"

Common for all containers in the transverse measure from center to center point of the holes of corner castings = 2259 mm

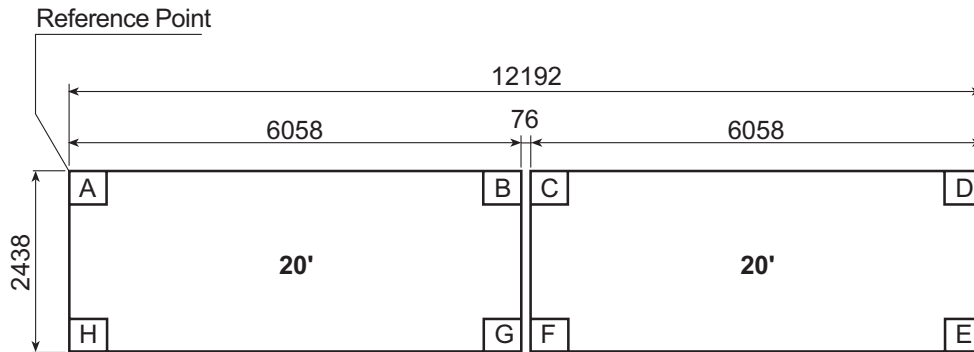


* to EURO-/ "Bell Lines"-Container view on top



The dimensions of the non-ISO-standardized containersizes are preliminary.

Annex H Height Tolerances of Container Foundations

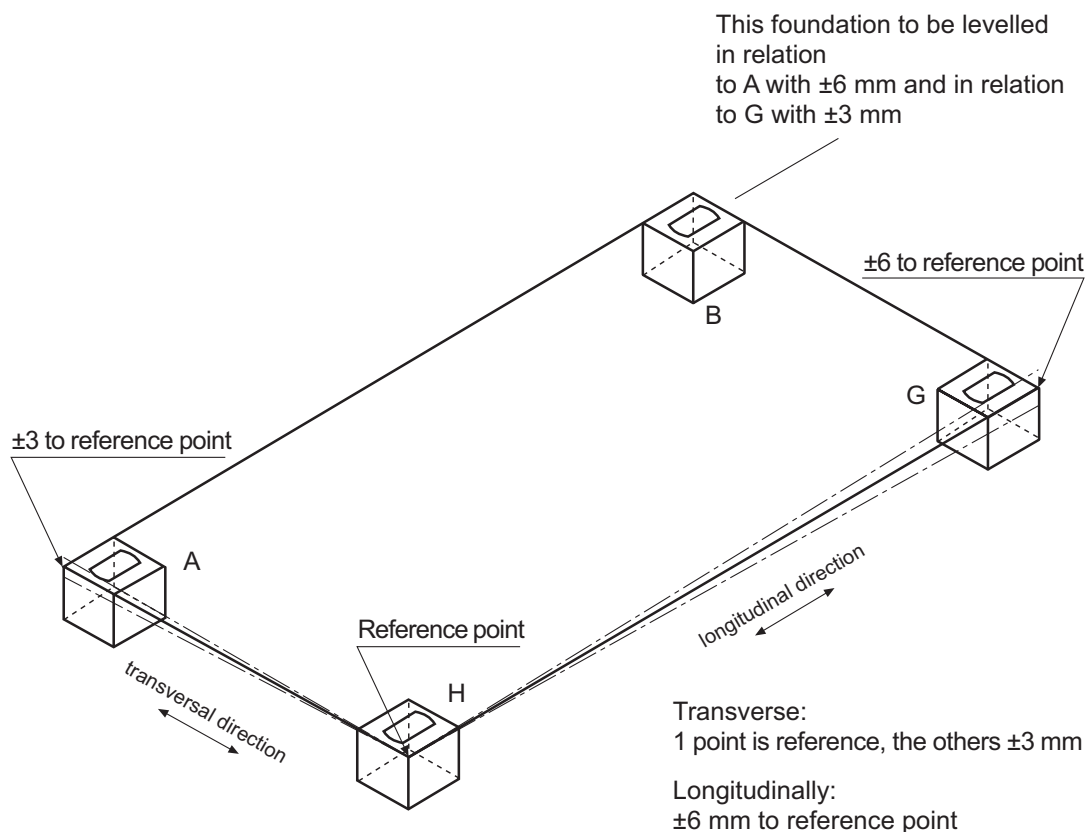


Example in mm

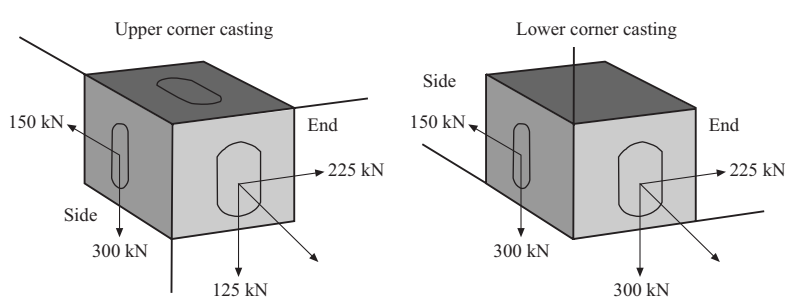
- A = 0
- B + C = -3
- D = -6
- E = -9
- F + G = -6
- H = -3

in general the following tolerances have to be kept

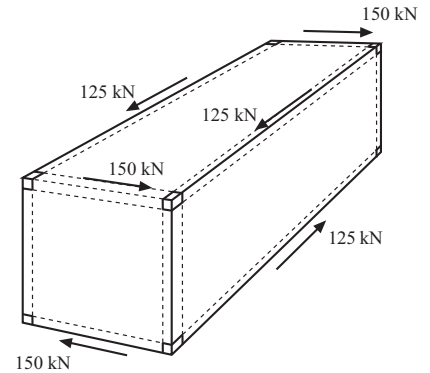
in longitudinal not more than ± 6	in transversal not more than ± 3
A to B	A to H
C to D	B to G
A to D	C to F
H to G	D to E
F to E	
H to E	



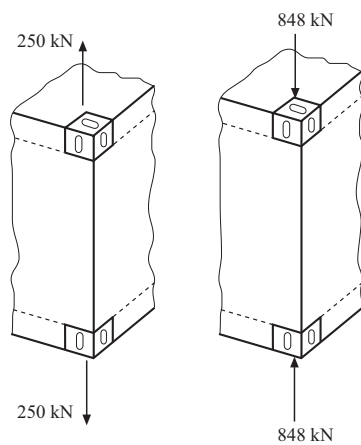
Annex I Maximum Allowable Forces on ISO-Container



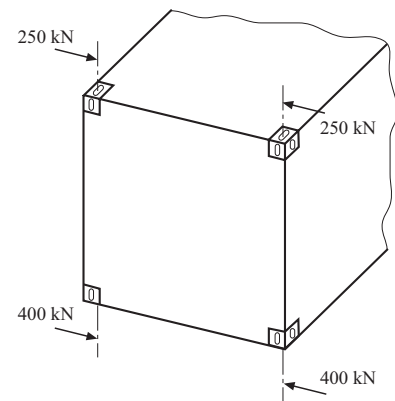
a) Corner casting lashing loads



b) Racking Loads



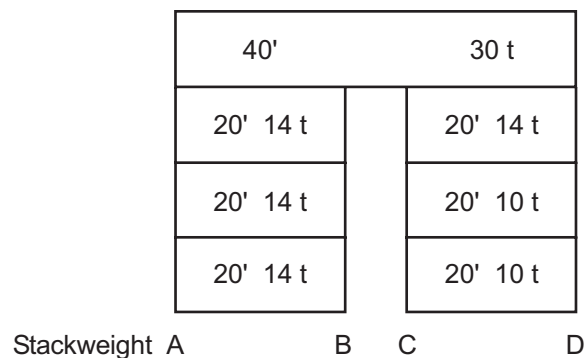
c) Max. vertical corner lifting and compressive forces



d) Transverse compressive forces

Annex J Determination of the Existing Stack Weight for Mixed Stowage (20' and 40' Container) for the Individual Foundation Points

Example:



$$A = 14 \times 3 + 30 = 72 \text{ t}$$

$$B = 14 \times 3 = 42 \text{ t}$$

$$C = 2 \times 10 + 14 = 34 \text{ t}$$

$$D = 2 \times 10 + 14 + 30 = 64$$

At foundation A and D we get the existing stackweight for 40' Container, at foundation B and C the stackweight for 20' Container.

Annex K Specification of Standard and Individual Routes for Route specific Container Stowage

A Specification of RoutesK-1

A Specification of Routes

A.1 Standard routes

Standard routes for Asia-Europe service (AE), Pacific service (PX), Pacific-Atlantic service (PAX), North Sea-Mediterranean Short Sea service (NMED) and North Atlantic service (NA) are defined for route specific container stowage.

Route specification is based upon the sea areas defined in BMT's Global Wave Statistics (www.globalwavestatisticsonline.com). Standard routes are illustrated in Figs.K.1 to K.5, including a map of sea area subdivisions according to BMT. Standard routes are characterized by travelled sea areas and time portions of the voyage in these sea areas as listed in Tables K.1 to K.5. Coordinates of area boundaries according to BMT are listed in [Table K.6](#).

An actual route of a ship is considered equivalent to one standard route unless significant deviations from the voyage path and the voyage of this standard route occur.

Table K.1 Specification of the standard route for Asia-Europe service

AE Service	
Area No. acc. to BMT	Time Portion
11	6 %
16	3 %
17	3 %
25	3 %
26	9 %
27	10 %
37	11 %
38	1 %
39	5 %
40	12 %
41	3 %
50	11 %
60	4 %
61	11 %
62	8 %

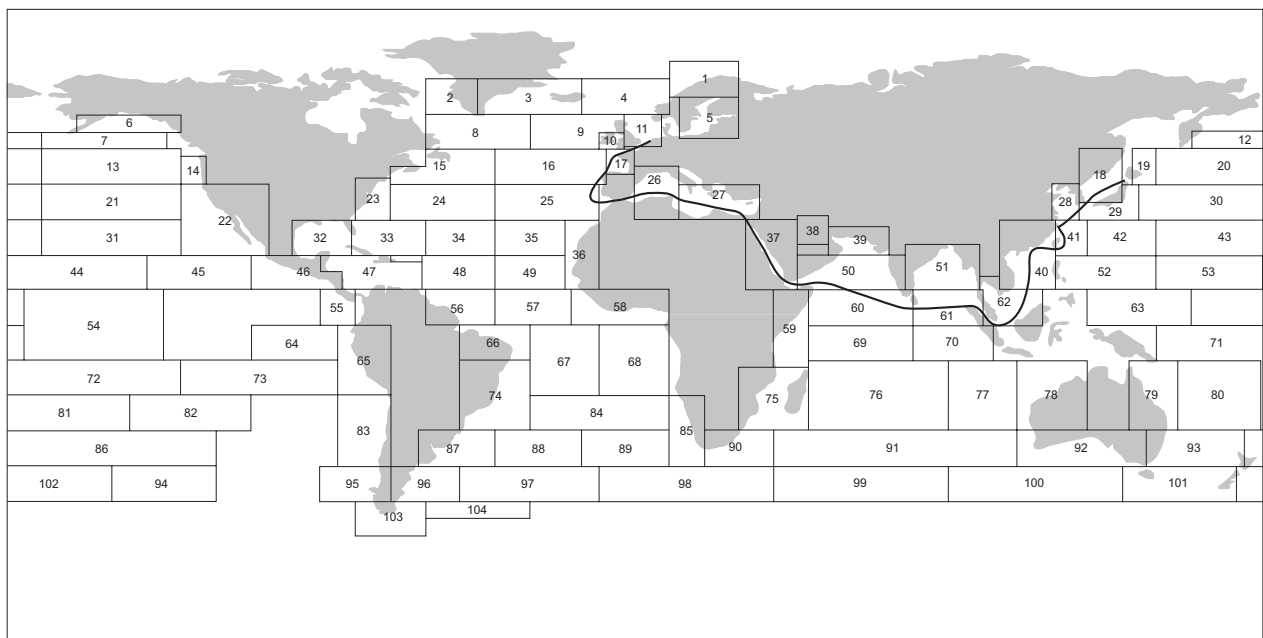


Fig. K.1 Standard route for Asia-Europe service

Table K.2 Specification of the standard route for Pacific service

PX Service	
Area No. acc. to BMT	Time Portion
7	10%
12	9%
13	10%
14	7%
18	1%
19	2%
20	11%
21	3%
22	13%
29	13%
30	5%
40	7%
41	5%
42	1%
62	3%

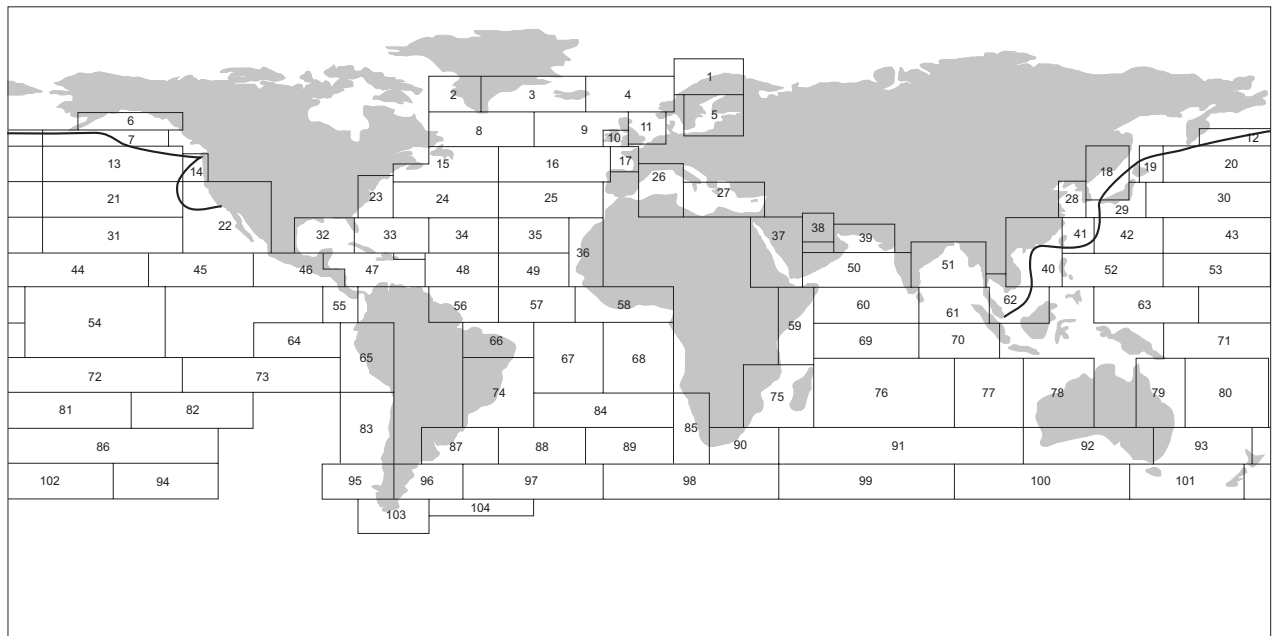


Fig. K.2 Standard route for Pacific service

Table K.3 Specification of the standard route for Pacific-Atlantic service

PAX Service	
Area No. acc. to BMT	Time Portion
7	4 %
8	1 %
9	3 %
11	6 %
12	3 %
13	4 %
14	2 %
15	10 %
16	6 %
17	2 %
19	1 %
20	4 %
21	1 %
22	9 %
23	12 %
29	4 %
30	2 %
32	1 %
33	4 %
40	2 %
41	2 %
46	7 %
47	5 %
55	5 %

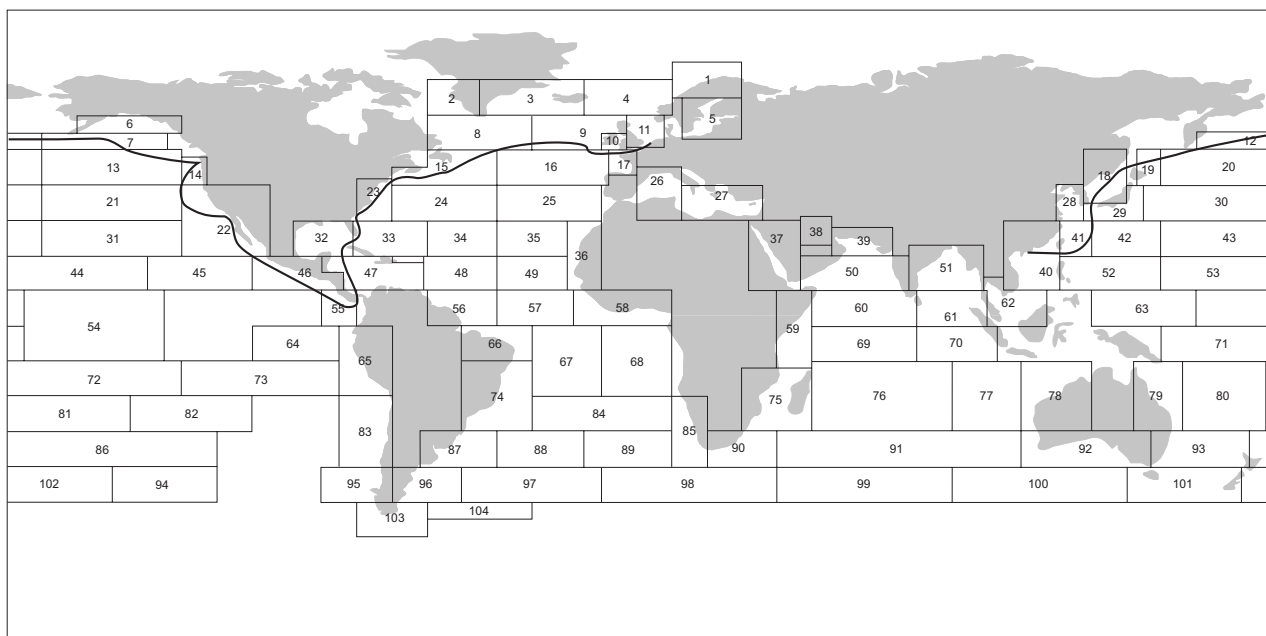


Fig. K.3 Standard route for Pacific-Atlantic service

Table K.4 Specification of the standard route for North Sea - Mediterranean Short Sea service

NMED Service	
Area No. acc. to BMT	Time Portion
11	17 %
16	9 %
17	9 %
25	10 %
26	26 %
27	29 %

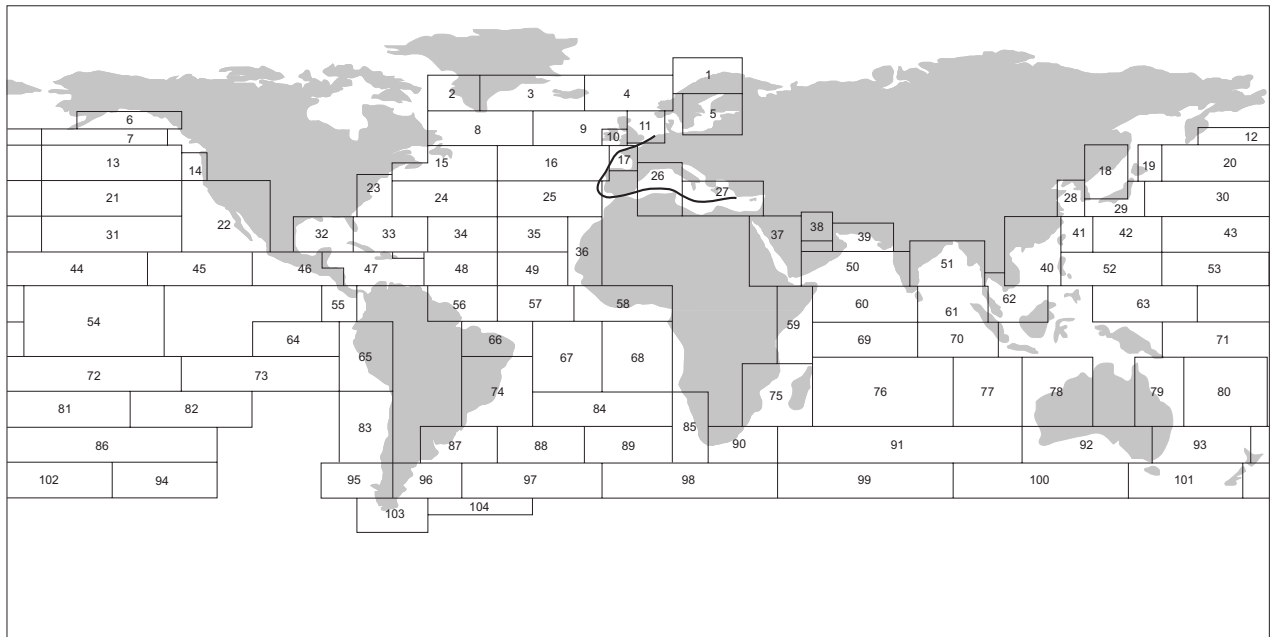


Fig. K.4 Standard route for North Sea-Mediterranean Short Sea service

Table K.5 Specification of the standard route for North Atlantic service

NA Service	
Area No. acc. to BMT	Time Portion
8	3 %
9	8 %
10	1 %
11	14 %
15	24 %
16	15 %
17	4 %
23	27 %
33	4 %

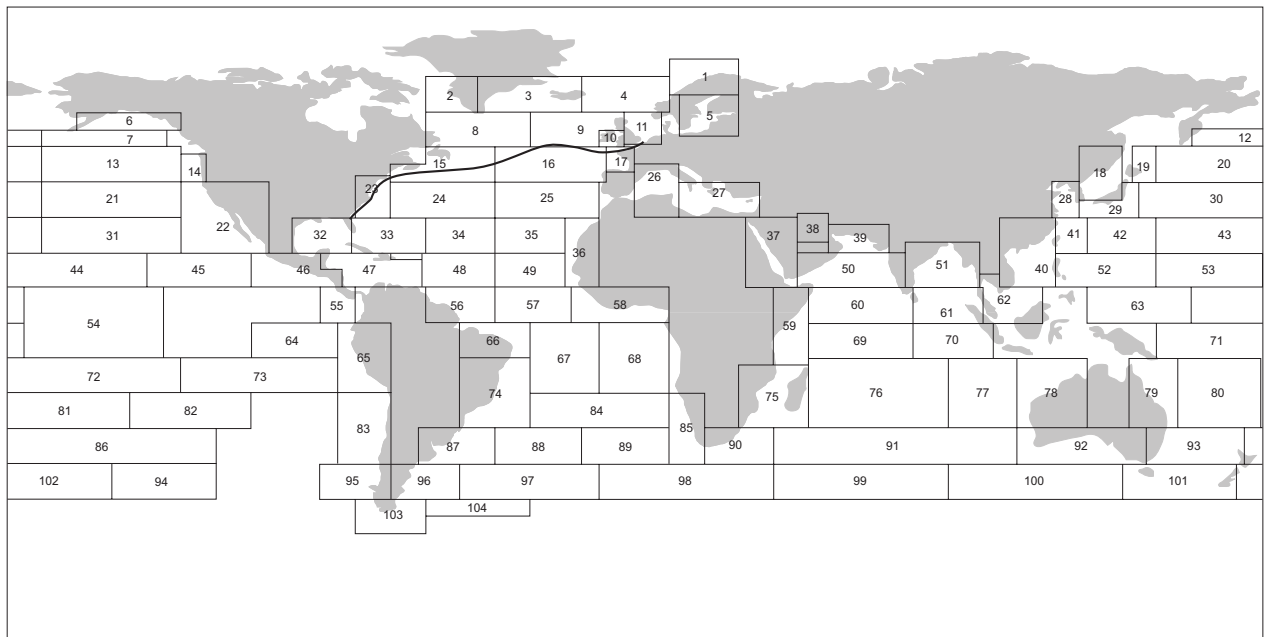


Fig. K.5 Standard route for North Atlantic service

Table K.6 Coordinates of area boundaries according to BMT

AREA NO.	LATITUDE RANGE	LONGITUDE RANGE	AREA NO.	LATITUDE RANGE	LONGITUDE RANGE
1	65°N-75°N	10°E-30°E	27	30°N-40°N	13°E-36°E
2	60°N-70°N	45°W-60°W	28	30°N-40°N	120°E-128°E
3	60°N-70°N	15°W-45°W	29	30°N-40°N	128°E-145°E
4	60°N-70°N	10°E-15°W		-35°N-40°N	128°E-140°E
5	53°N-65°N	13°E-30°E	30	30°N-40°N	145°E-170°W
6	55°N-60°N	130°W-160°W	31	20°N-30°N	130°W-170°W
7	50°N-55°N	134°W-170°W	32	20°N-30°N	81°W-98°W
8	50°N-60°N	30°W-60°W	33	20°N-30°N	60°W-81°W
9	50°N-60°N	3°W-30°W	34	20°N-30°N	40°W-60°W
	-50°N-55°N	3°W-10°W	35	20°N-30°N	20°W-40°W
10	50°N-55°N	3°W-10°W	36	10°N-30°N	10°W-20°W
11	51°N-60°N	3°W-8°W	37	10°N-30°N	32°E-47°E
12	50°N-55°N	160°E-170°W	38	23°N-31°N	47°E-56°E
13	40°N-50°N	130°W-170°W	39	20°N-28°N	56°E-73°E
14	40°N-48°N	123°W-130°W	40	10°N-30°N	105°E-121°E
15	40°N-50°N	40°W-70°W	41	20°N-30°N	121°E-130°E
	-45°N-50°N	60°W-70°W	42	20°N-30°N	130°E-150°E
16	40°N-50°N	8°W-40°W	43	20°N-30°N	150°E-170°W
17	43°N-50°N	0°-8°W	44	10°N-20°N	140°W-180°W
18	35°N-50°N	128°E-140°E	45	10°N-20°N	110°W-140°W
19	40°N-50°N	143°E-150°E	46	10°N-20°N	84°W-110°W
20	40°N-50°N	150°E-170°W		-15°N-20°N	84°W-90°W
21	30°N-40°N	130°W-170°W	47	10°N-20°N	61°W-90°W
22	20°N-40°N	105°W-130°W		-10°N-15°N	84°W-90°W
23	30°N-42°N	70°W-80°W		-18°N-20°N	61°W-70°W
24	30°N-40°N	40°W-70°W	48	10°N-20°N	40°W-61°W
25	30°N-40°N	10°W-40°W	49	10°N-20°N	20°W-40°W
26	30°N-45°N	0°-13°E	50	10°N-20°N	47°E-78°E

AREA NO.	LATITUDE RANGE	LONGITUDE RANGE	AREA NO.	LATITUDE RANGE	LONGITUDE RANGE
51	10°N-23°N	78°E-99°E	77	10°S-30°S	90°E-110°E
52	10°N-20°N	121°E-150°E	78	10°S-30°S	110°E-130°E
53	10°N-20°N	150°E-180°E	79	10°S-30°S	142°E-156°E
54	10°S-20°N	135°W-175°W	80	10°S-30°S	156°E-180°E
55	0° -10°N	80°W-90°W	81	20°S-30°S	145°W-180°W
56	0° -10°N	40°W-60°W	82	20°S-30°S	110°W-145°W
57	0° -10°N	18°W-40°W	83	20°S-40°S	70°W-85°W
58	0° -10°N	10°E-18°W	84	20°S-30°S	10°E-30°W
59	12°S-10°N	40°E-50°E	85	20°S-40°S	10°E-20°E
60	0° -10°N	50°E-80°E	86	30°S-40°S	175°E-120°W
61	0° -10°N	80°E-100°E	87	30°S-40°S	40°W-62°W
62	0° -14°N	99°E-117°E	88	30°S-40°S	15°W-40°W
	-10°N-14°N	105°E-117°E	89	30°S-40°S	10°E-15°W
	-0° -10°N	99°E-100°E	90	30°S-40°S	20°E-40°E
63	0° -10°N	130°E-160°E	91	30°S-40°S	40°E-110°E
64	0° -10°S	85°W-110°W	92	30°S-40°S	110°E-147°E
65	0° -20°S	70°W-85°W	93	30°S-40°S	147°E-175°E
66	0° -10°S	30°W-50°W	94	40°S-50°S	120°W-150°W
67	0° -20°S	10°W-30°W	95	40°S-50°S	70°W-90°W
68	0° -20°S	10°E-10°W	96	40°S-50°S	50°W-70°W
69	0° -10°S	50°E-80°E	97	40°S-50°S	10°W-50°W
70	0° -10°S	80°E-103°E	98	40°S-50°S	40°E-10°W
71	0° -10°S	150°E-175°W	99	40°S-50°S	40°E-90°E
72	10°S-20°S	130°W-180°W	100	40°S-50°S	90°E-140°E
73	10°S-20°S	85°W-130°W	101	40°S-50°S	140°E-173°E
74	10°S-30°S	30°W-50°W	102	40°S-50°S	173°E-150°W
75	12°S-30°S	30°E-50°E	103	50°S-60°S	60°W-80°W
76	10°S-30°S	50°E-90°E	104	50°S-55°S	30°W-60°W

A.2 Individual routes

On request of the owner individual routes may be considered for route specific container stowage. An individual route is to be specified by the owner in terms of a series of latitude and longitude coordinates describing discrete route points for a voyage. For each involved sea area according to BMT (see Table K.6), at least one point is to be specified. The route specified in this form is to be representative regarding possible scattering of the actual route. Alternatively, an individual route may be specified by the owner in terms of a sequence of port calls and, if applicable, canal passages.

Annex L Calculation of a 5 Tiers Stack on Deck

A Calculation Example L-1

A Calculation Example

The determination of deformations respect. lashing and racking forces is done according to [Section 3, A](#)

A.1 Determination of transverse components F_{qi}

- L : 187.00 [m] (= L_{pp})
 x : 128.90 [m] from AP
 B : 37.32 m
 T_{Sc} : 12.5 m
 T_D : 11 m
 v : 22.5 kn
 Z_{bottom} : 21.5 m
 max. tiers : 6

Acceleration according to GL StowLash for above mentioned vessel.

The transverse components F_{qi} are stated without additional wind forces.

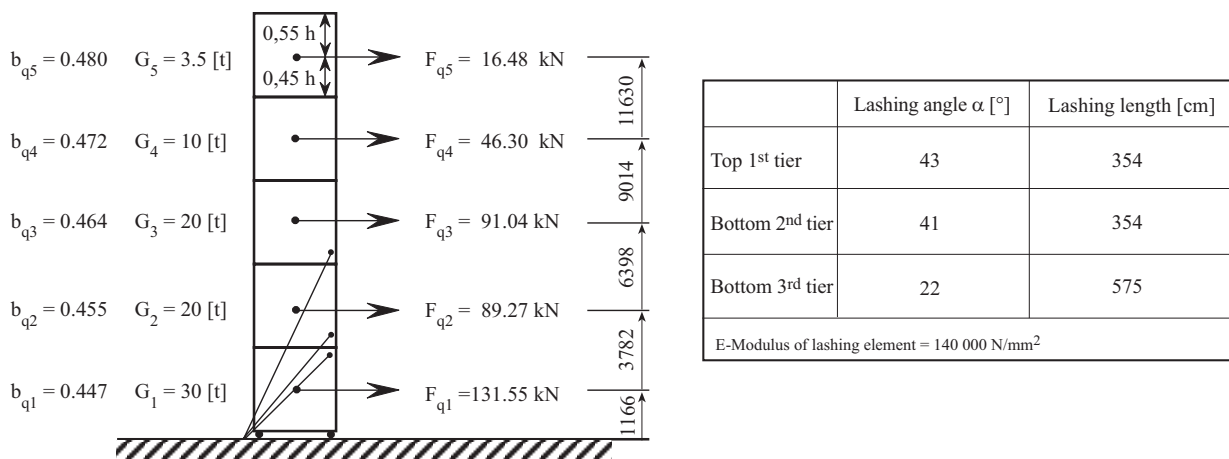


Fig. L.1 transverse components F_{qi}

A.2 Determination of transverse dislocations (door side)

The dislocations are determined according to [Section 3, A](#) With the standard values specified therein for length, angle and module of elasticity and a given lashing bar diameter of $d = 26$ mm, the horizontal stiffnesses of the lashings assigned can be calculated.

$$C_{Z,hor} = \frac{A \cdot E_z \cdot \sin^2 \alpha}{\ell}$$

- d : 2.6 cm
 A : 5.309 [cm²]

Annex L Calculation of a 5 Tiers Stack on Deck

1. tier top: $C_{Z,hor} (1o) = 97.657 \text{ [kN/cm]}$
2. tier bottom: $C_{Z,hor} (2u) = 87.646 \text{ [kN/cm]}$
3. tier bottom: $C_{Z,hor} (3u) = 22.674 \text{ [kN/cm]}$

The horizontal supporting force from lashings Z_{hor1} and Z_{hor2} result as follows:

$$Z_{hor1} = \delta_1 \cdot [C_{Z,hor} (1o) + C_{Z,hor} (2u)] = \delta_1 \cdot 185.303$$

$$Z_{hor2} = \delta_2 \cdot C_{Z,hor} (3u) = \delta_2 \cdot 22.674$$

From this result two systems of equations for door and front side of the stack considered with the unknown deformations δ_1 and δ_2 following statement:

I. $\delta_1 = c_c \cdot RF_{T1} + v_0$

with

$$\delta_2 = c_c \cdot RF_{T1} + v_0 + c_c \cdot RF_{T2} + v_1$$

you get:

II. $\delta_2 - \delta_1 = c_c \cdot RF_{T2} + v_1$

δ_1, δ_2 : total dislocation of the containers at top level 1. respect 2. tier

v_0, v_1 : taken dislocations between the foundation and container corner casting respect between the corner castings

c_c : resilience of the container transverse frame (see [Section 3](#))

RF_{T1}, RF_{T2} : resulting racking forces in container transverse frame

In the present case RF_{T1} and RF_{T2} are determined as follows:

$$RF_{T1} = \frac{1}{2} (F_{q2} + F_{q3} + F_{q4} + F_{q5}) + 0.225 \cdot F_{q1} - Z_{hor1} - Z_{hor2} \text{ [kN]}$$

$$= 151.14 - Z_{hor1} - Z_{hor2}$$

$$RF_{T1} = \frac{1}{2} (F_{q3} + F_{q4} + F_{q5}) + 0.225 \cdot F_{q2} - Z_{hor2} \text{ [kN]}$$

$$= 97.00 - Z_{hor2}$$

Front side:

I. $\delta_1 = 0.006 [151.14 - \delta_1 \cdot 185.303 - \delta_2 \cdot 22.674]$

II. $\delta_2 - \delta_1 = 0.006 [97.00 - \delta_2 \cdot 22.674]$

$$\Rightarrow \delta_1 = 0.537 \text{ [cm]}, \delta_2 = 1.251 \text{ [cm]}$$

Door side:

I. $\delta_1 = 0.027 [151.14 - \delta_1 \cdot 185.303 - \delta_2 \cdot 22.674] + 0.4$

II. $\delta_2 - \delta_1 = 0.027 [97.00 - \delta_2 \cdot 22.674] + 0.4$

$$\Rightarrow \delta_1 = 0.522 \text{ [cm]}, \delta_2 = 2.197 \text{ [cm]}$$

In the following the racking-, lashing, lifting and pressure forces of the stack are calculated exemplarily for the door side.

A.3 Determination of racking forces (door side):

$$RF_{T1} = \frac{\delta_1 - v_0}{c_c} = \frac{0.522 - 0,4}{0.027} = 4.52 \text{ [kN]}$$

$$RF_{T2} = \frac{\delta_2 - \delta_1 - v_1}{c_c} = \frac{2.197 - 0.522 - 0,4}{0,027} = 47.22 \text{ [kN]}$$

A.4 Determination of lashing forces (door side):

In the model (idealization) of a lashed container stack two "parallel" lashing bars (i.e. at 1. tier top plus 2. tier bottom or 2. tier top plus 3. tier bottom) are taken calculatory via the addition of the horizontal stiffnesses as one lashing. The details of the parallel bars can be determined through the relations of the individual horizontal stiffness.

A.4.1 Lashing forces 2. tier bottom – Z (2u) 1. tier top – Z (1o)

$$C_{Z,hor} (1o + 2u) = 185.303 \text{ [kN/cm]}$$

$$Z_{hor1} = 0.522 \cdot 185.303 = 96.73 \text{ [kN]}$$

$$\frac{C_{Z,hor} (1o)}{C_{Z,hor} (1o + 2u)} = \frac{97.657}{185.303} = 0.527$$

$$\frac{C_{Z,hor} (1o)}{C_{Z,hor} (1o + 2u)} = \frac{87.646}{185.303} = 0.473$$

$$Z (1o) = \frac{Z_{hor1} \cdot 0.527}{\sin 43^\circ} = \frac{96.73 \cdot 0,527}{\sin 43^\circ} = 74.75 \text{ [kN]}$$

$$Z (2u) = \frac{Z_{hor1} \cdot 0.473}{\sin 41^\circ} = \frac{96.73 \cdot 0,473}{\sin 41^\circ} = 96.74 \text{ [kN]}$$

A.4.2 Lashing forces 3. tier bottom – Z (3u)

$$Z_{hor2} = 2.197 \cdot 22.674 = 49.81 \text{ [kN]}$$

$$Z (3u) = \frac{Z_{hor2}}{\sin 22^\circ} = \frac{49.81}{\sin 22^\circ} = 132.97 \text{ [kN]}$$

A.5 Determination of the lifting force and pressure force at lower level of 1. tier, LF_{found} and CPL_{found} (door side):

A.5.1 Without influence of the lashing

Forces, according to formula in [Section 3](#):

$$b_t = 1 + \frac{70}{217.28 + 70} = 1.2437$$

$$CPL_{found} = 372.11 + 220.57 = 592.68$$

$$LF_{found} = 372.11 - 220.57 = 151.54$$

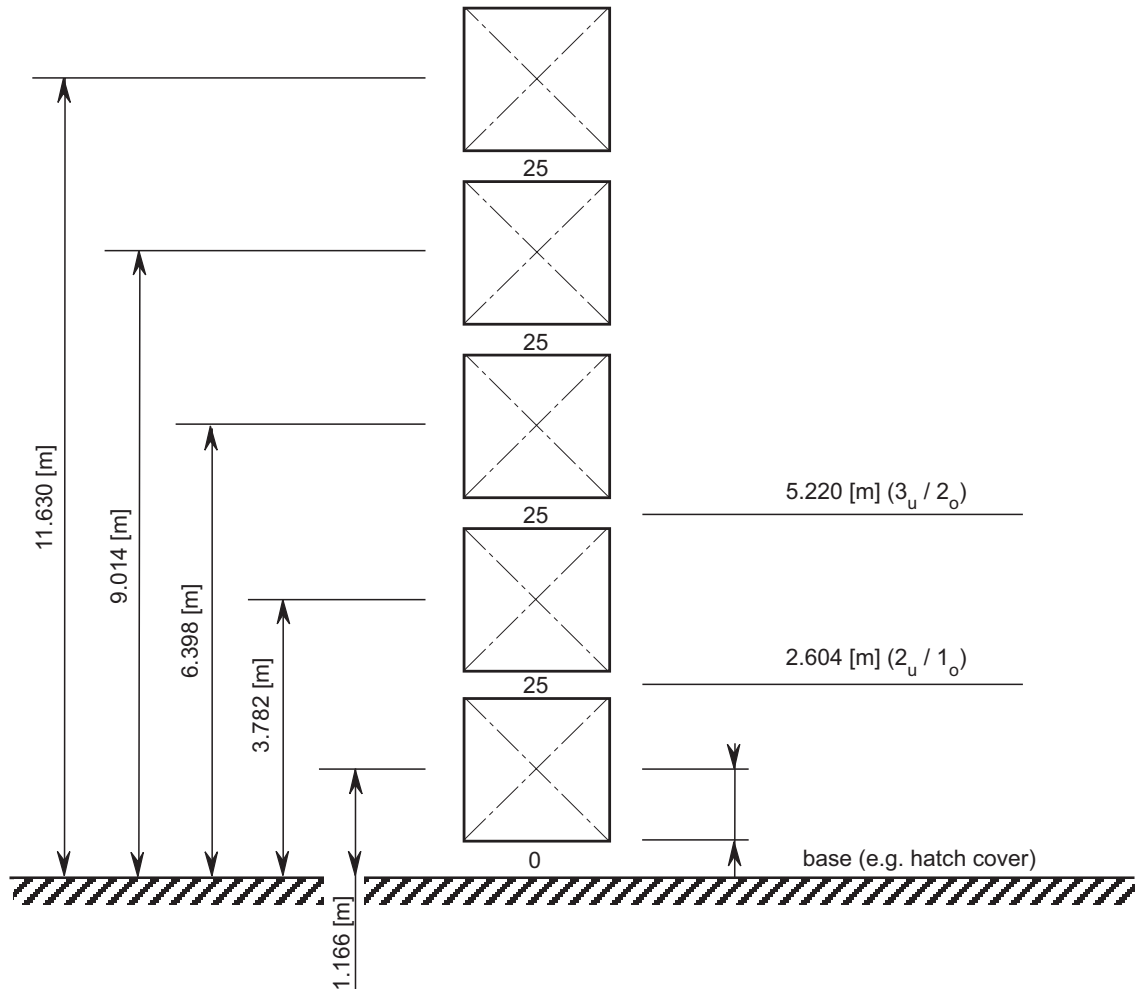


Fig. L.2 lever arms and heights of the application points of lashing in the stack (for Containers with 8.5" = 2.591 [m] height)

base : 50 [mm] below lower edge 1. tier
 twistlock height : 25 [mm]
 centre of gravity of container : VCG 45 % = 1.166 [m] above lower level container (8' 6")

A.5.2 Influence of lashing forces on LF_{found} and CPL_{found} (door side):

A.5.2.1 Lashing 1. tier top:

$$Z(1o) = 74.75 \text{ [kN]}$$

$$Z(1o/hor.) = Z(1o) \cdot \sin 43^\circ = 50.98 \text{ [kN]}$$

$$Z(1o/vert.) = Z(1o) \cdot \cos 43^\circ = 54.67 \text{ [kN]}$$

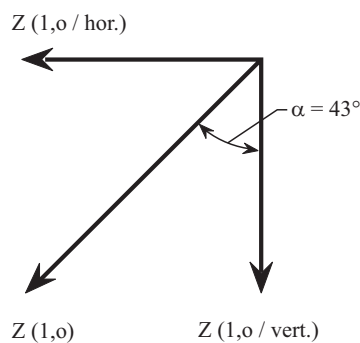


Fig. L.3

A.5.2.2 Lashing 2. tier bottom:

$$Z(2u) = 69.74 \text{ [kN]}$$

$$Z(2u/\text{hor.}) = Z(2u) \cdot \sin 41^\circ = 45.75 \text{ [kN]}$$

$$Z(2u/\text{vert.}) = Z(2u) \cdot \cos 41^\circ = 52.63 \text{ [kN]}$$

A.5.2.3 Lashing 3. tier bottom:

$$Z(3u) = 132.97 \text{ [kN]}$$

$$Z(3u/\text{hor.}) = Z(3u) \cdot \sin 22^\circ = 49.81 \text{ [kN]}$$

$$Z(3u/\text{vert.}) = Z(3u) \cdot \cos 22^\circ = 123.29 \text{ [kN]}$$

A.5.2.4 Resulting lifting force LF_{found} :

$$LF_{\text{found}}(\text{res.}) = 151.54 - \frac{2.604}{2.260} (50.98 + 45.75) -$$

$$- \frac{5.220}{2.260} \cdot 49.81 = 151.54 - 218.74$$

$$= -63.20 \text{ [kN]} \text{ (compressive force)}$$

A.5.2.5 Resulting pressure forces CPL_{found} :

$$CPL_{\text{found}}(\text{res.}) = 592.68 - 218.74 + 54.67 + 52.63 +$$

$$+ 123.29 = 609.53 \text{ [kN]} \text{ (pressure force)}$$

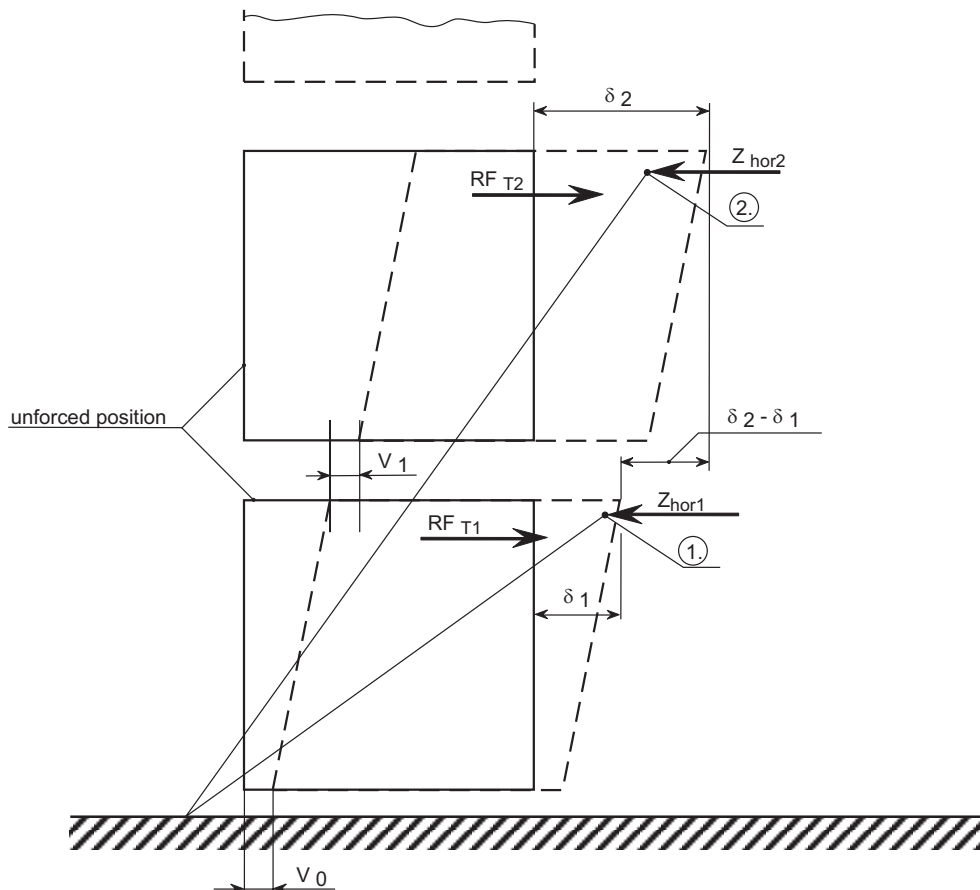


Fig. L.4 dislocations and deformations in container stacks

Given dislocations between the tiers:

Door side:

$$v_o = 0.4 \text{ cm}$$

$$v_1 = 0.4 \text{ cm}$$

Front side:

$$v_o = 0.0 \text{ cm}$$

$$v_1 = 0.0 \text{ cm}$$

Given points of application for lashings for the lashing force calculation at:

1. lashing bars at 1. tier top **and** 2. tier bottom
2. lashing bars at 2. tier top **and** 3. tier bottom