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ACCELERATION FORCES ROAD - RAIL - AIR - SEA

ROAD

Fg = Weight load

RAIL
Forward/Backward: 4 G.
Sideways: 0,5 G.

AIR
Forward/backward: 1,5 G.
Sideways: 1,5 G.
Vertical: 3 G.
Summary of ship movement

<table>
<thead>
<tr>
<th>Significant wave height in sea area</th>
<th>Securing in</th>
<th>Acceleration coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Longitudinally (cx)</td>
</tr>
<tr>
<td>A  Hs &lt; 8 m</td>
<td>Longitudinal direction</td>
<td>0.3</td>
</tr>
<tr>
<td>A</td>
<td>Transverse direction</td>
<td>-</td>
</tr>
<tr>
<td>B  8 m &lt; Hs &lt; 12 m</td>
<td>Longitudinal direction</td>
<td>0.3</td>
</tr>
<tr>
<td>B</td>
<td>Transverse direction</td>
<td>-</td>
</tr>
<tr>
<td>C  Hs &gt; 12 m</td>
<td>Longitudinal direction</td>
<td>0.4</td>
</tr>
<tr>
<td>C</td>
<td>Transverse direction</td>
<td>-</td>
</tr>
</tbody>
</table>
The friction coefficient is expressed in $\mu$.

Some friction coefficients:

- Cardboard on wood pallet : 0,35
- Bigbag on wood pallet : 0,35
- Wood on steelplate : 0,30
- Oiled metal on oiled metal : 0,10
- Steel pallet on flat multiplex : 0,20
- Steel pallet on rought multiplex : 0,25
- Paper roll on steel : 0,30
- Plastic crate on wood pallet : 0,30
- Non-sliprubber : 0,60

Lashing seafreight: **MSL** (Maximum Securing Load): means the maximum assumable force in securing element for securing purposes. It is comparable to Safe Working Load (SWL) or WLL (Working Load Limit) for cargo lifting but has a lesser safety factor against the breaking load than factors used for lifting gear.

<table>
<thead>
<tr>
<th>Material</th>
<th>MSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>shackles, rings, deck eyes, turnbuckles of mild steel</td>
<td>50% of breaking strength</td>
</tr>
<tr>
<td>fibre ropes</td>
<td>33% of breaking strength</td>
</tr>
<tr>
<td>web lashings</td>
<td>50% of breaking strength</td>
</tr>
<tr>
<td>wire rope (single use)</td>
<td>80% of breaking strength</td>
</tr>
<tr>
<td>wire rope (re-useable)</td>
<td>30% of breaking strength</td>
</tr>
<tr>
<td>steel band (single use)</td>
<td>70% of breaking strength</td>
</tr>
<tr>
<td>chains of high tensile steel</td>
<td>50% of breaking strength</td>
</tr>
</tbody>
</table>

**Calculation strength CS** (for assessment only) = **MSL** / 1.5
LASHING EQUIPMENT

Ratchet strap

CHAINS
STABILITY

A load is stable when:

1. In forward direction: $B_z / H_z > 0.8$
2. Sideways: $B_z / H_z > 0.7$
3. To the back: $B_z / H_z > 0.5$

---

Centre of gravity

Tipping point

Hz

Bz
METHODS OF LASHING

Lashing against tipping

To avoid tipping of instable cargo, lashing is of course necessary. Mostly done by direct lashing. But pushing down is also an option, but is not preferred.

Important:
• Pushing down: use ratchet straps.
• Direct lashing: use lashing chains or ratchet straps.
Diagonal lashing

Inclined lashing

Pushing down - Direct lashing

Direct lashing

HEADLASHING
DIRECT LASHING ON LIFTING TRUNNIONS
Head – sideway - combined

Various head lashings

Sideway

Combination sideway / headlashing
**LASHING CONTAINER / FLATTRACK**

**Forces on container/flatrack floor**

- 20 ft container: 4.5 ton per linear meter.
- 40 ft container: 3 ton per linear meter.
- Flatrack: full loadspreading. Small but heavy: check with shipping line.
- Loadspreading 20 ft ctr. Wood min. 10 cm wide with minimum space between the wood of 80 cm.
- Loadspreading 40 ft ctr. Wood min. 15 cm wide with minimum space between the wood of 80 cm.

In general: use all support beams of container.

**Containers & Flattracks**

Lashing lug container: max. 1 to. (~1000 daN.)
Lashing lug flatrack: max. 5 to. (~5000 daN)
If you don’t know for sure: rule of thumb: diam. x diam. x 10 = cap. lashing.
Example: 10 mm x 10 mm x 10 = 1000 daN = ~1 to.

**Cargo securing components in the container.**

1. Lashing bars (corner posts)
2. Lashing bars (side rail)
3. Corner posts
4. Lashing rings
5. Wooden floor

**Centre of gravity cargo in container/flatrack**

- 20 ft:
  - longitudinal max. 60 cm from middle of container.
  - width: middle.
  - height: middle or lower.
- 40 ft:
  - longitudinal max. 90 cm from middle of container.
  - width: middle.
  - height: middle or lower.

**Blocking with wood (timber shore):**
If surface between a en b is 100 cm². In general: securing force: 3000 daN:
1 cm² = 30 daN.
LASHING PROJECT CARGO

Regulations from IMO

Cargo securing concepts

Sliding prevention by welded stoppers
Blocking by timber shoring

Sliding and tipping prevention by wire rope lashings
Sliding and tipping prevention by chain lashings

Sliding and tipping prevention by web lashings
In the previous Tables (1, 2 and 3) the basic values are used in the calculations for project cargo (CSS Code by IMO).

In the calculation for project cargo following values are used for the use of timber shores and welded stoppers:

Timber shores: Max. 0.3 kN/cm². Up to 0.5 kn/cm² is possible. Both vertical to to fibre. For safety reasons the decreased value of 0.3 kN/cm² is used.

Welded stoppers: because of the wide variety in stoppers (H beam horizontal, vertical, plate stopper etc.) the rule of thumb is applicable: the MSL in kN = 4 times the total length of the welded seams in cm. Seam: min. 6 mm. Height of attack of MSL max. 5 cm above welded seam.