Resolutions from the 17th Session of the Assembly of IMO, November 1991, as amended

CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING

CARGO STOWAGE AND SECURING

ANNEX 13.

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CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING

See Contents for this Code.

ANNEX 13.

Methods to assess the efficiency of securing arrangements for non-standardized cargo.

1. SCOPE OF APPLICATION.

The methods described in this annex should be applied to non-standardized cargo, but not to containers on containerships.

Very heavy units as carried under the provisions of Chapter 1.8 of the Code of Safe Practice for Cargo Stowage and Securing (the Code) and those items for which exhaustive advice on stowage and securing is given in the annexes to the Code should be excluded.

All lashing assemblies used in the application of the methods described in this annex must be attached to fixed securing points or strong supporting structures marked on the cargo unit or advised as being suitable, or taken as a loop around the unit with both ends secured to the same side as shown in Annex 5, Figure 2 of the Code. Lashings going over the top of the cargo unit, which have no defined securing direction but only act to increase friction by their pre-tension, cannot be credited in the evaluation of securing arrangements under this annex.

Nothing in this annex should be read to exclude the use of computer software, provided the output achieves design parameters which meet the minimum safety factors applied in this annex.

The application of the methods described in this annex are supplementary to the principles of good seamanship and shall not preplace experience in stowage and securing practice.

2. PURPOSE OF THE METHODS

The methods should:

1. provide guidance for the preparation of the Cargo Securing Manuals and the examples therein;

2. assist ship`s staff in assessing the securing of cargo units not covered by the Cargo Securing Manual;

3. assist qualified shore personnel in assessing the securing of cargo units not covered by the Cargo Securing Manual; and

4. serve as a reference for maritime and port related education and training.

3. PRESENTATION OF THE METHODS

The methods are presented in a universally applicable and flexible way. It is recommended that designers of Cargo Securing Manuals convert this presentation into a form suiting the particular ship, its securing equipment and the cargo which it carries. This form may consist of applicable diagrams, tables or calculated examples.

4. STRENGTH OF SECURING EQUIPMENT

4.1 Manufacturers of securing equipment should at least supply information on the nominal breaking strength of the equipment in kilo-Newton (kN) *1).

(*1) 1 kN equals almost 100 kg.

4.2 «Maximum Securing Load» (MSL) is a term used to define the load capacity for a device used to secure cargo to a ship. Safe Working Load (SWL) may be substituted for MSL for securing purposes, provided this is equal to or exceeds the strength defined by MSL.

The MSL for different securing devices are given in table 1 if not given under 4.3.

The MSL of timber should be taken as 0.3 kN/cm^2 normal to the grain.

Table 1: Determination of MSL from breaking strength.

Material	**MSL**
Shackles, rings, deckeyes, turnbuckles of mild steel	50 % of breaking strength
Fibre rope	33 % of breaking strength
Web lashing	50% of breaking strength
Wire rope (single use)	80 % of breaking strength
Wire rope (re – usable)	30 % of breaking strength
Steel band (single use)	70 % of breaking strength
Chains	50 % of breaking strength

4.3 For particular securing devices (e.g. fiber straps with tensioners or special equipment for securing containers) a permissible working load may be prescribed and marked by authority. This should be taken as the MSL.

4.4 When the components of a lashing device are connected in series, for example, a wire to a shackle to a deck eye, the minimum MSL in the series shall apply to that device.

5. **RULE-OF-THUMB METHOD**

5.1 The total of MSL values of the securing devices on each side of a unit of cargo (port as well as starboard) should equal the weight of the unit *2)

(*1) kN ≈100 kg.

(*2) The weight of the unit should be taken in kN.

5.2 This method, which implies a transverse acceleration of 1 g (9.81 m/sek^2), applies to nearly any size of ships regardless of the location of stowage, stability and loading conditions, season and area of operation.
The method however, neither takes into account the adverse effects of lashing angles and non-homogeneous distribution of forces among the securing devices nor the favorable effect of friction.

5.3 Transverse lashing angles to the deck should not be greater than 60° and it is important that adequate friction is provided by the use of suitable material. Additional lashings at angles of greater than 60° may be desirable to prevent tipping but are not to be counted in the number of lashings under the rule-of-thumb.

6. SAFETY FACTOR.

When using balance calculation methods for assessing the strength of the securing devices, a safety factor is used to take account of the possibility of uneven distribution of forces among the devices or reduced capability due to the improper assembly of the devices or other reasons. This safety factor is used in the formula to derive the calculated strength (CS) from the MSL and shown in the relevant method used.

$$\text{CS} = \frac{\text{MSL}}{Safety\ factor}$$

Notwithstanding the introduction of such a safety factor, care should be taken to use securing elements of similar material and length in order to provide a uniform elastic behavior within the arrangement.

7. ADVANCES CALCULATION METHOD.

7.1 Assumption of external forces

External forces to a cargo unit in longitudinal, transverse and vertical direction should be obtained using the formula:

$$F_{(x,y,z)} = m \cdot a_{(x,y,z)} + F_{w\,(x,y)} + F_{s\,(x,y)}$$

where

$F_{(x,y,z)}$	=	longitudinal, transverse and vertical forces
m	=	mass of the unit
$a_{(x,y,z)}$	=	longitudinal, transverse and vertical acceleration (see table 2)
$F_{w\,(x,y)}$	=	longitudinal and transverse force by wind pressure
$F_{s\,(x,y)}$	=	longitudinal and transverse force by sea sloshing

The basic acceleration data is presented in Table 2.

Table 2: Basic acceleration data.

Transverse acceleration a_y in m/s^2										Longitudinal acceleration a_x in m/s^2
on deck, high	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
on deck, low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
'tween-deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
lower hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0 … L	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
Vertical acceleration a_z in m/s^2	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Remarks:

The given transverse acceleration figures include components of gravity, pitch and heave parallel to the deck. The given vertical acceleration figures do not include the static weight component.

The basic acceleration data is to be considered as valid under the following operational conditions:

1. Operation in unrestricted area.
2. Operation during the whole year.
3. Duration of the voyage is 25 days.
4. Length of the ship is 100 m.
5. Service speed is 15 knots.
6. $B/GM \geq 13$. (B: breadth of ship, GM: metacentric height).

For operation in a restricted area, reduction of these figures may be considered, taking also into account the season of the year and the duration of the voyage.

For ships of a length other than 100 m and a service speed other than 15 knots, the acceleration figures should be corrected by a factor given in Table 3.

Table 3. Correction factors for length and speed.

	Length										
Speed	**50**	**60**	**70**	**80**	**90**	**100**	**120**	**140**	**160**	**180**	**200**
9 kn.	1,20	1,09	1,00	0,92	0,85	0,79	0,70	0,63	0,57	0,53	0,49
12 kn.	1,34	1,22	1,12	1,03	0,96	0,90	0,79	0,72	0,65	0,60	0,56
15 kn.	1,49	1,36	1,24	1,15	1,07	1,00	0,89	0,80	0,73	0,68	0,63
18 kn.	1,64	1,49	1,37	1,27	1,18	1,10	0,98	0,89	0,82	0,76	0,71
21 kn.	1,78	1,62	1,49	1,38	1,29	1,21	1,08	0,98	0,90	0,83	0,78
24 kn.	1,93	1,76	1,62	1,50	1,40	1,31	1,17	1,07	0,98	0,91	0,85

For length/speed combinations not directly tabulated, the following formula may be used to obtain the correction factor with v= speed in knots, and L = length between perpendiculars in meters:

$$\text{Correction factor} = (0.345\ v/\sqrt{L}) + (58.62\ L - 1034.5)/L^2$$

This formula shall not be used for ship lengths less than 50 m, or more than 300 m.

In addition for ships with B/GM less than 13, the transverse acceleration figures should be corrected by a factor given in Table 4.

Table 4: Correction factors for B/GM < 13

B/GM	**7**	**8**	**9**	**10**	**11**	**12**	**13 or above**
On deck high	1,56	1,40	1,27	1,19	1,11	1,05	1,00
On deck low	1,42	1,30	1,21	1,14	1,09	1,04	1,00
Tween deck	1,26	1,19	1,14	1,09	1,06	1,03	1,00
Lower deck	1,15	1,12	1,09	1,06	1,04	1,02	1,00

The following cautions should be observed:

In the case of marked roll resonance with amplitudes above ± 30°, the given figures of transverse acceleration may be exceeded. Effective measures should be taken to avoid this condition.

In case of heading the seas at high speed with marked slamming shocks, the given figures of longitudinal and vertical acceleration may be exceeded. An appropriate reduction of speed should be considered.

In the case of running before large stern or aft quartering seas with a stability, which does not amply exceed the accepted minimum requirements, large roll amplitudes must be expected with transverse accelerations greater than the figures given. An appropriate change of heading should be considered.

Forces by wind and sea to cargo units above the weather deck should be accounted for by a simple approach:

force by wind pressure = 1 kN per m^2

force by sea sloshing = 1 kN per m^2

Sloshing by sea can induce forces much greater than the figure given above. This figure should be considered as remaining unavoidable after adequate measures to prevent overcoming seas.

Sea sloshing forces need only be applied to a height of deck cargo up to 2 metres above the weather deck or hatch top.

For voyages in restricted area sea sloshing forces may be neglected.

7.2 Balance of forces and moments

The balance calculation should preferably be carried out for

- transverse sliding in port and starboard direction
- transverse tipping in port and starboard direction
- longitudinal sliding under conditions of reduced friction in forward and aft direction.

In case of symmetrical securing arrangements one appropriate calculation is sufficient.

Friction contributes towards prevention of sliding. The following friction coefficients (μ) should be applied.

Table 5 – Friction coefficients

Materials in contact	Friction coefficient (μ)
Timber – timber, wet or dry	0,4
Steel – timber or steel – rubber	0,3
Steel – steel, dry	0,1
Steel – steel, wet	0,0

7.2.1 *Transverse sliding*

The balance calculation should meet the following condition (see also Fig. 1):

$$F_y \leq \mu \cdot m \cdot g + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$$

where

n is the number of lashings being calculated

F_y is transverse force from load assumption (kN)

μ is friction coefficient

m is mass of cargo unit (t)

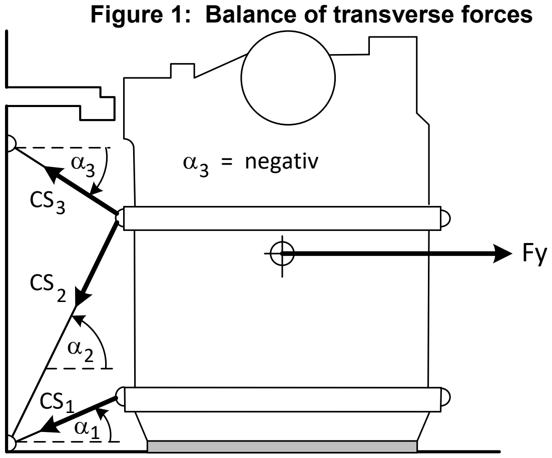
g is gravity acceleration of earth = 9.81 m/s^2

CS is calculated strength of transverse securing devices (kN)

$$\mathrm{CS} = \frac{\mathrm{MSL}}{1,5}$$

f is function of μ and vertical securing angle α (see Table 6)

Figure 1: Balance of transverse forces



A vertical securing angle α greater than 60° will reduce the effectiveness of this particular securing device in respect to sliding of the unit.

Disregarding of such devices from the balance of forces should be considered, unless the necessary load is gained by the imminent tendency to tipping or by a reliable pre-tensioning of the securing device which includes maintaining the pretension throughout the voyage.

Any horizontal securing angle, i.e. deviation from the transverse direction, should not exceed 30°, otherwise an exclusion of this securing device from the transverse sliding balance should be considered

Table 6: f – Values as a function of α and μ

	α												
μ	**-30°**	**-20°**	**-10°**	**0°**	**10°**	**20°**	**30°**	**40°**	**50°**	**60°**	**70°**	**80°**	**90°**
0,3	0,72	0,84	0,93	1,00	1,04	1,04	1,02	0,96	0,87	0,76	0,62	0,47	0,30
0,1	0,82	0,91	0,97	1,00	1,00	0,97	0,92	0,83	0,72	0,59	0,44	0,27	0,10
0,0	0,87	0,94	0,98	1,00	0,98	0,94	0,87	0,97	0,64	0,50	0,34	0,17	0,00

Remark: $f = \mu \sin \alpha + \cos \alpha$

As an alternative to using Table 6 to determine the forces in a securing arrangement, the method outlined in paragraph 7.3 can be used to take account of transverse and longitudinal components of lashing forces.

7.2.2 *Transverse tipping*

This balance calculation should meet the following condition (see also Fig.2);

$$F_y\, a \leq b \cdot m \cdot g + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots CS_n \cdot c_n$$

where

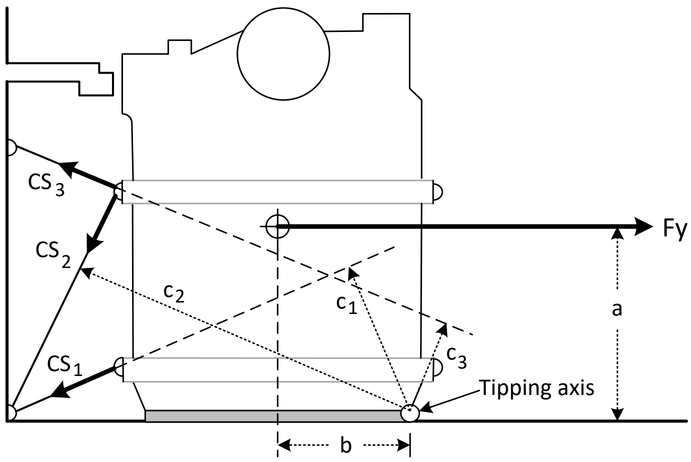
F_y, *m, g, CS, n* are explained under 7.2.1

a is lever-arm of tipping (m) (see Fig.2)

b is lever-arm of stableness (m) (see Fig.2)

c is lever-arm of securing force (m) (see Fig.2)

Figure 2: Balance of transverse moments



7.2.3 *Longitudinal sliding*

Under normal conditions the transverse securing devices provide sufficient longitudinal components to prevent longitudinal sliding. If in doubt, a balance calculation should meet the following condition:

$$F_x \leq \mu\,(m \cdot g - F_z) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$$

where

F_x	is longitudinal force from load assumption (kN)
μ, m, g, f, n	are as explained under 7.2.1
F_z	is vertical force from load assumption (kN)
CS	is calculated strength of longitudinal securing devices (kN)

$$\mathrm{CS} = \frac{\mathrm{MSL}}{1{,}5}$$

Remark: Longitudinal components of transverse securing devices should not be assumed greater than 0.5 CS.

7.2.4 *Calculated example*

A calculated example for this method is shown in Appendix 1 of annex 13.

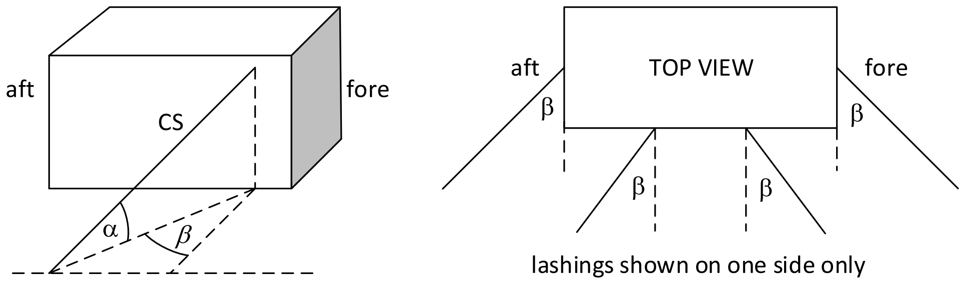
7.3 Balance of forces - alternative method

The balance of forces described in paragraph 7.2.1 and 7.2.3 will normally furnish a sufficiently accurate determination of the adequacy of the securing arrangement. However, this alternative method allows a more precise consideration of horizontal securing angles.

Securing devices usually do not have a pure longitudinal or transverse direction in practice but have an angle β in the horizontal plane.

This horizontal securing angle β is defined in this annex as the angle of deviation from the transverse direction. The angle β is to be scaled in the quadrantal mode, i.e. between 0 and 90°.

Figure 3 Definition of the vertical and horizontal securing angles α and β



A securing device with an angle β develops securing effects both in longitudinal and transverse direction, which can be expressed by multiplying the calculated strength CS with the appropriate values of f_x or f_y. The values of f_x and f_y can be obtained from Table 7.

Table 7 consists of five sets of figures, one each for the friction coefficients μ = 0.4, 0.3, 0.2, 0.1 and 0. Each set of figures is obtained by using the vertical angle α and horizontal angle β.

The value of f_x is obtained when entering the table with β from the right while f_y is obtained when entering with β from the left, using the nearest tabular value for α and β. Interpolation is not required but may be used

.

The balance calculations are made in accordance with the following formulae:

Transverse sliding : $\mathbf{Fy \le \mu \cdot m \cdot g + fy_1 \cdot CS_1 + ... + fy_n \cdot CS_n}$

Longitudinal sliding : $\mathbf{Fx \le \mu \cdot (m \cdot g - Fz) + fx_1 \cdot CS_1 + ... + fx_n \cdot CS_n}$

Transverse tipping : $\mathbf{Fy \cdot a \le b \cdot m \cdot g + 0,9 \cdot (CS_1 \cdot c_1 + CS_2 \cdot c_2 + ... + CS_n \cdot c_n)}$

Caution:

Securing devices, which have a vertical angle α of less than 45° in combination with horizontal angle β greater than 45°, should not be used in the balance of transverse tipping in the above formula.

All symbols used in these formulae have the same meaning as defined in paragraph 7.2 except f_y and f_x, obtained from Table 7, and CS is as follows:

$$CS = \frac{MSL}{1,35}$$

A calculated example for this method is shown in Appendix 1.

Table 7 – fx-values and fy-values as a function of, α, β and μ

Table 7.1 for μ = 0,4

β for fy	α														β for fx
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0,67	0,80	0,92	1,00	1,05	1,08	1,07	1,02	0,99	0,95	0,85	0,72	0,57	0,40	**90**
10	0,65	0,79	0,90	0,98	1,04	1,06	1,05	1,01	0,98	0,94	0,84	0,71	0,56	0,40	**80**
20	0,61	0,75	0,86	0,94	0,99	1,02	1,01	0,98	0,95	0,91	0,82	0,70	0,56	0,40	**70**
30	0,55	0,68	0,78	0,87	0,92	0,95	0,95	0,92	0,90	0,86	0,78	0,67	0,54	0,40	**60**
40	0,46	0,58	0,68	0,77	0,82	0,86	0,86	0,84	0,82	0,80	0,73	0,64	0,53	0,40	**50**
50	0,36	0,47	0,56	0,64	0,70	0,74	0,76	0,75	0,74	0,72	0,67	0,60	0,51	0,40	**40**
60	0,23	0,33	0,42	0,50	0,56	0,61	0,63	0,64	0,64	0,63	0,60	0,55	0,48	0,40	**30**
70	0,10	0,18	0,27	0,34	0,41	0,46	0,50	0,52	0,52	0,53	0,52	0,49	0,45	0,40	**20**
80	-0,05	0,03	0,10	0,17	0,24	0,30	0,35	0,39	0,41	0,42	0,43	0,44	0,42	0,40	**10**
90	-0,20	-0,14	-0,07	0,00	0,07	0,14	0,20	0,26	0,28	0,31	0,35	0,38	0,39	0,40	**0**

Table 7.2 for μ = 0,3

β for fy	α														β for fx
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0,72	0,84	0,93	1,00	1,04	1,04	1,02	0,96	0,92	0,87	0,76	0,62	0,47	0,30	**90**
10	0,70	0,82	0,92	0,98	1,02	1,03	1,00	0,95	0,91	0,86	0,75	0,62	0,47	0,30	**80**
20	0,66	0,78	0,87	0,94	0,98	0,99	0,96	0,91	0,88	0,83	0,73	0,60	0,46	0,30	**70**
30	0,60	0,71	0,80	0,87	0,90	0,92	0,90	0,86	0,82	0,79	0,69	0,58	0,45	0,30	**60**
40	0,51	0,62	0,70	0,77	0,81	0,82	0,81	0,78	0,75	0,72	0,64	0,54	0,43	0,30	**50**
50	0,41	0,50	0,58	0,64	0,69	0,71	0,71	0,69	0,67	0,64	0,58	0,50	0,41	0,30	**40**
60	0,28	0,37	0,44	0,50	0,54	0,57	0,58	0,58	0,57	0,55	0,51	0,45	0,38	0,30	**30**
70	0,15	0,22	0,28	0,34	0,39	0,42	0,45	0,45	0,45	0,45	0,43	0,40	0,35	0,30	**20**
80	0,00	0,06	0,12	0,17	0,22	0,27	0,30	0,33	0,33	0,34	0,35	0,34	0,33	0,30	**10**
90	-0,15	-0,10	-0,05	0,00	0,05	0,10	0,15	0,19	0,21	0,23	0,26	0,28	0,30	0,30	**0**

Table 7.3 for μ = 0,2

β for fy	α														β for fx
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0,77	0,87	0,95	1,00	1,02	1,01	0,97	0,89	0,85	0,80	0,67	0,53	0,37	0,20	**90**
10	0,75	0,86	0,94	0,98	1,00	0,99	0,95	0,88	0,84	0,79	0,67	0,52	0,37	0,20	**80**
20	0,71	0,81	0,89	0,94	0,96	0,95	0,91	0,85	0,81	0,76	0,64	0,51	0,36	0,20	**70**
30	0,65	0,75	0,82	0,87	0,89	0,88	0,85	0,79	0,75	0,71	0,61	0,48	0,35	0,20	**60**
40	0,56	0,65	0,72	0,77	0,79	0,79	0,76	0,72	0,68	0,65	0,56	0,45	0,33	0,20	**50**
50	0,46	0,54	0,60	0,64	0,67	0,67	0,66	0,62	0,60	0,57	0,49	0,41	0,31	0,20	**40**
60	0,33	0,40	0,46	0,50	0,53	0,54	0,53	0,51	0,49	0,47	0,42	0,36	0,28	0,20	**30**
70	0,20	0,25	0,30	0,34	0,37	0,39	0,40	0,39	0,38	0,37	0,34	0,30	0,26	0,20	**20**
80	0,05	0,09	0,14	0,17	0,21	0,23	0,25	0,26	0,26	0,26	0,26	0,25	0,23	0,20	**10**
90	-0,10	-0,07	-0,03	0,00	0,03	0,07	0,10	0,13	0,14	0,15	0,17	0,19	0,20	0,20	**0**

Table 7.4 for μ = 0,1

β for fy	α														β for fx
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0,82	0,91	0,97	1,00	1,00	0,97	0,92	0,83	0,78	0,72	0,59	0,44	0,27	0,10	**90**
10	0,80	0,89	0,95	0,98	0,99	0,96	0,90	0,82	0,77	0,71	0,58	0,43	0,27	0,10	**80**
20	0,76	0,85	0,91	0,94	0,94	0,92	0,86	0,78	0,74	0,68	0,56	0,42	0,26	0,10	**70**
30	0,70	0,78	0,84	0,87	0,87	0,85	0,80	0,73	0,68	0,63	0,52	0,39	0,25	0,10	**60**
40	0,61	0,69	0,74	0,77	0,77	0,75	0,71	0,65	0,61	0,57	0,47	0,36	0,23	0,10	**50**
50	0,51	0,57	0,62	0,64	0,65	0,64	0,61	0,56	0,53	0,49	0,41	0,31	0,21	0,10	**40**
60	0,38	0,44	048	0,50	0,51	0,50	0,48	0,45	0,42	0,40	0,34	0,26	0,19	0,10	**30**
70	0,25	029	0,32	0,34	0,35	0,36	0,35	0,33	0,31	0,30	0,26	0,21	0,16	0,10	**20**
80	0,10	0,13	0,15	0,17	0,19	0,20	0,20	0,20	0,19	0,19	0,17	0,15	0,13	0,10	**10**
90	-0,05	-0,03	-0,02	0,00	0,02	0,03	0,05	0,06	0,07	0,08	0,09	0,09	0,10	0,10	**0**

Table 7.5 for μ = 0,0

β for fy	α														β for fx
	-30	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0,87	0,94	0,98	1,00	0,98	0,94	0,87	0,77	0,71	0,64	0,50	0,34	0,17	0,00	**90**
10	0,85	0,93	0,97	0,98	0,97	0,93	0,85	0,75	0,70	0,63	0,49	0,34	0,17	0,00	**80**
20	0,81	0,88	0,93	0,94	0,93	0,88	0,81	0,72	0,66	0,60	0,47	0,32	0,16	0,00	**70**
30	0,75	0,81	0,85	0,87	0,85	0,81	0,75	0,66	0,61	0,56	0,43	0,30	0,15	0,00	**60**
40	0,66	0,72	0,75	0,77	0,75	0,72	0,66	0,59	0,54	0,49	0,38	0,26	0,13	0,00	**50**
50	0,56	0,60	0,63	0,64	0,63	0,60	0,56	0,49	0,45	0,41	0,32	0,22	0,11	0,00	**40**
60	0,43	0,47	0,49	0,50	0,49	0,47	0,43	0,38	0,35	0,32	0,25	0,17	0,09	0,00	**30**
70	0,30	0,32	0,34	0,34	0,34	0,32	0,30	0,26	0,24	0,22	0,17	0,12	0,06	0,00	**20**
80	0,15	0,16	0,17	0,17	0,17	0,16	0,15	0,13	0,12	0,11	0,09	0,06	0,03	0,00	**10**
90	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0**

Remark: $fy = \cos\alpha * \cos\beta + \mu * \sin\alpha$ $fx = \cos\alpha * \sin\beta + \mu * \sin\alpha$

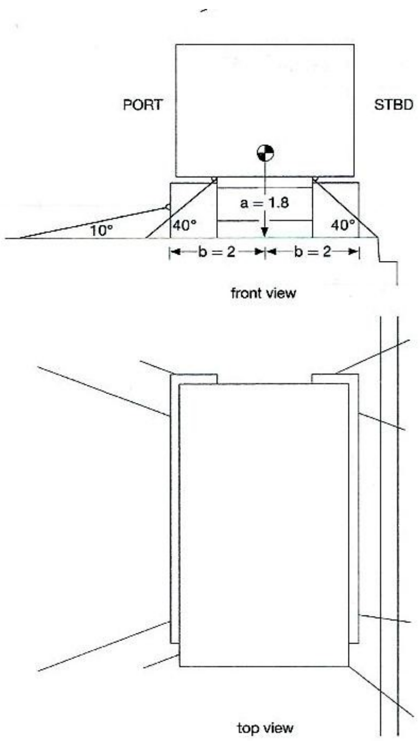
Appendix 1 and annex 13

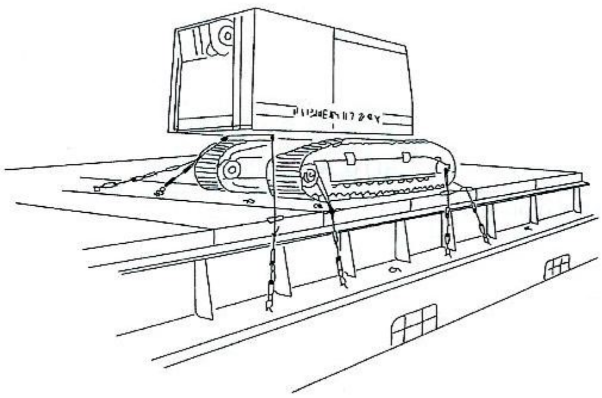
Calculated example 1

(refer to paragraph 7.2, Balance of forces and moments)

Ship : *L* = 120 m; *B* = 20 m; GM = 1,4 m; speed = 15 knots

Cargo : *m* = 62 t; dimensions = 6 x 4 x 4 m; stowage at 0.7 *L* on deck, low





Securing material:

wire rope:.. breaking strength = 125 kN
MSL = 100 kN

Shackles, turnbuckles, deck rings........................ breaking strength = 180 kN
MSL = 90 kN

Stowage on dunnage boards................................ μ = 0,3; CS = 90/1,5 = 60 kN

Securing arrangement:

Side	n	CS	α	f	c
STBD	4	60 kN	40°	0.96	-
PORT	2	60 kN	40°	0.96	-
PORT	2	60 kN	10°	1.04	-

External forces:

F_x = 2.9 x 0.89 x 62 + 16 + 8 = 184 kN

F_y = 6.3 x 0.89 x 62 + 24 + 12 = 384 kN

F_z = 6.2 x 0.89 x 62 = 342 kN

Balance of forces (STBD arrangement):

384 < 0.3 x 62 x 9.81 + 4 x 60 x 0.96

384 < 412 this is OK !

Balance of forces (PORT arrangement):

384 < 0.3 x 62 x 9.81 + 2 x 60 x 0.96 + 2 x 60 x 1.04

384 < 422 this is OK!

Balance of moments:

384 x 1.8 < 2 x 62 x 9.81

691 < 1216 no tipping, even without lashings!

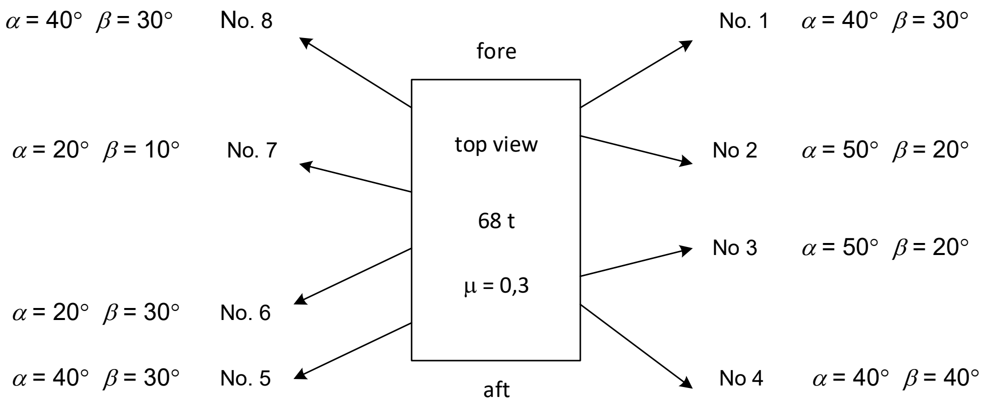
Calculated example 2

(refer to paragraph 7.3, Balance of forces - alternative method)

A cargo unit of 68 t mass is stowed on timber (μ = 0.3) in the ' tween deck at 0.7 L of a vessel. L = 160 m, B = 24 m,
v = 18 kn and GM = 1.5 m. Dimensions of the cargo unit are height = 2.4 m and width = 1.8 m.

The external forces are: F_x = 112 kN, F_y = 312 kN, F_z = 346 kN.

The top view shows the overall securing arrangement with eight lashings.



Calculation of balance of forces:

No.	MSL (KN)	CS (KN)	α	β	F_y	CS * f_y	F_x	CS * f_x
1	108	80	40° stbd	30° fwd	0,86	68,8 stdb	0,58	46,4 fwd
2	90	67	50° stbd	20° aft	0,83	55,6 stdb	0,45	30,2 aft
3	90	67	50° stbd	20° fwd	0,83	55,6stdb	0,45	30,2 fwd
4	108	80	40° stbd	40° aft	0,78	62,4 stdb	0,69	55,2 aft
5	108	80	40° port	30° aft	0,86	68,8 port	0,58	46,4 aft
6	90	67	20° port	30° aft	0,92	61,6 port	0,57	38,2 aft
7	90	67	20° port	10° fwd	1,03	69,0 port	0,27	18,1 fwd
8	108	80	40° port	30° fwd	0,86	68,8 port	0,58	46,4 fwd

Transverse balance of forces (STBD arrangement) Nos. 1, 2, 3 and 4:

$312 < 0.3 \times 68 \times 9.81 + 68.8 + 55.6 + 55.6 + 62.4$

$312 < 443$ this is OK!

Transverse balance of forces (PORT arrangement) Nos. 5, 6, 7 and 8:

$312 < 0.3 \times 68 \times 9.81 + 68.8 + 61.6 + 69.0 + 68.8$

$312 < 468$ this is OK!

Longitudinal balance of forces (FWD arrangement) Nos. 1, 3, 7, 8:

112 < 0.3 (68 × 9.81 - 346) + 46.4 + 30.2 + 18.1 + 46.4

112 < 237 this is OK!

Longitude balance of forces (AFT arrangement) Nos. 2, 4, 5, 6:

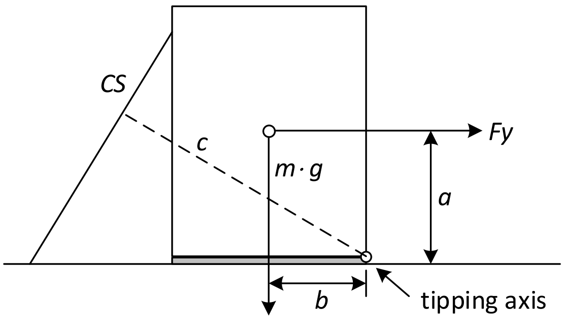
112 < 0.3 (68 × 9.81 - 346) + 30.2 + 55.2 + 46.4 + 38.2

112 < 266 this is OK!

Transverse Tipping

Unless specific information is provided, the vertical centre of gravity of the cargo unit can be assumed to be at one half the height and the transverse centre of gravity at one half the width.

Also, if the lashing is connected as shown in the sketch, instead of measuring c, the length of the lever from the tipping axis to the lashing CS, it is conservative to assume that it is equal to the width of the cargo unit.



312 · 2.4/2	≤ 1.8/2 · 68 · 9.81 + 0.9 · 1.8 ·(80 + 67 + 67 + 80)	
374	≤ 600 + 476	
374	≤ 1076	this is OK!

Appendix 2 of annex 13

Explanations and interpretation to the "Methods to assess the efficiency of securing arrangements for non-standardized cargo"

1 The exclusion from the scope of application of the methods of very heavy units as carried under the provisions of paragraph 1.8 of chapter 1 should be understood to accommodate the possibility of adapting the stowage and securing of such units to specifically determined weather- and sea-conditions during transport. The exclusion should not be understood as restriction of the methods to units up to a certain mass or dimension.

2 The acceleration figures given in Table 2 in combination with the correction factors represent peak values on a 25-day voyage. This does not imply that peak values in x-, y- and z- direction occur simultaneously with the same probability. It can be generally assumed that peak values in the transverse direction will appear in combination with less than 60% of the peak values in longitudinal and vertical direction.

Peak values in longitudinal and vertical direction may join more closely because they have the common source of pitching and heaving.

3 The advanced calculation method uses the "worst case approach". That is expressed clearly by the transverse acceleration figures which increase to forward and aft in the ship and thereby show the influence of transverse components of simultaneous vertical accelerations. Consequently there is no need to consider vertical accelerations separately in the transverse balance of forces and moments.

These simultaneously acting vertical accelerations create an apparent increase of weight of the unit and thus improve the friction in the balance of forces respectively the moment of stableness in the balance of moments. For this reason there is no reduction of the normal force (m·g) due to the present angle of heel.

The situation is different for the longitudinal sliding balance. The worst case would be a peak value of the longitudinal force Fx accompanied by an extreme reduction of weight through the vertical force Fz.

4 The friction coefficients shown in the methods are somewhat reduced against appropriate figures in other publications. The reason for this should be seen in various influences which may appear in practical shipping as: moisture, grease, oil, dust and other residues, vibration of the ship.

There are certain stowage materials available which are said to increase friction considerably. Extended experience with these materials may bring additional coefficients into practical use.

5 The principal way of calculating forces within the securing elements of a complex securing arrangement should necessarily include the consideration of:

- load-elongation behaviour (elasticity),
- geometrical arrangement (angles, length),
- pretension

of each individual securing element.

This approach would require a large volume of information and a complex, iterative calculation. Still the results would be doubtful due to uncertain parameters.

Therefore the simplified approach was chosen with the assumption that the elements take an even load of CS (calculation strength) which is reduced against the MSL (maximum securing load) by the safety factor 1.5.

6 When employing the advanced calculation method the way of collecting data should be followed as shown in the calculated example. It is acceptable to estimate securing angles, to take average angles for a set of lashings and similarly arrive at reasonable figures of the levers a, b and c for the balance of moments.

It should be born in mind that meeting or missing the balance calculation just by a tiny change of one or the other parameter indicates to be near the goal anyway. There is no clear-cut border line between safety and non-safety. If in doubt, the arrangement should be improved.

IMO-Vega Guide

See Res.A.581 (14) Guidelines for securing arrangements for the transport of road vehicles on ro-ro ships.

IMO-Vega Note

This Annex was amended by MSC/Circ. 1026 of 2002-05-27:

In paragraph 1, after the second sentence a new sentence is added.

In paragraph 4.2, the second sentence in the first sub-paragraph is replaced:

Previous text:

> Maximum securing load is to securing devices as safe working load is to lifting tackle.
>
> In 4.2, Table 1 (as amended by MSC/Cirs. 812), «70% of breaking strength» on the line regarding web lashing is replaced by «50% of breaking strength».
>
> Existing paragraph 5 is replaced and re-numbered as paragraph 6.

Previous text:

> Within the assessment of a securing arrangement by a calculated balance of forces and moments the calculation strengt of securing devices (CS) should be reduced against MSL using a safety factor of 1.5 as follows:
>
> $$CS = \frac{MSL}{1,5}$$

The reasons for this reduction are the possibility of uneven distribution of forces among the devices, strength reduction due to poor assembly and others.

Notwithstanding the introduction of such a safety factor, care should be taken to use securing elements of similar material and length in order to provide a uniform elastic behavior within the arrangement.

Existing paragraph 6 is re-numbered as paragraph 5. Existing sub-paragraph 6.1, 6.2 and 6.3 are re-numbered as 5.1, 5.2 and 5.3 accordingly.

Under the existing paragraph 7.2, the following text and a new table are added:

«Friction contributes……………. Table 5»

In paragraph 7.2.1, the text from (μ= 0.3 for steel-timber or steel-rubber) to (μ = 0.00 steel-steel, wet) is deleted; «table 5» in the definition of f is replaced by «table 6»; and a formula is added under the definition of CS.

After Table 3 text and formula are added.

Previous text in 7.2.1

The balance calculation should meet the following condition (see also Fig 1):

$F_y \leq \mu\ m\ g + CS_1\ f_1 + CS_2\ f_2 \ldots\ldots\ldots + CS_n\ f_n$

where

n is the number of lashings being calculated

F_y is transverse force from load assumption (kN)

μ is friction coefficient

(μ = 0.3 for steel-timber or steel-rubber)

(μ = 0.1 for steel-steel dry)

(μ = 0.00 for steel-steel wet)

m is mass of cargo unit (t)

g is gravity acceleration of earth = 9.81 m/sec^2

CS is calculated strength of transverse securing devices (kN)

f is function of my and vertical securing angle alpha (see Table 5)

Figure 1: Balance of transverse forces PCX

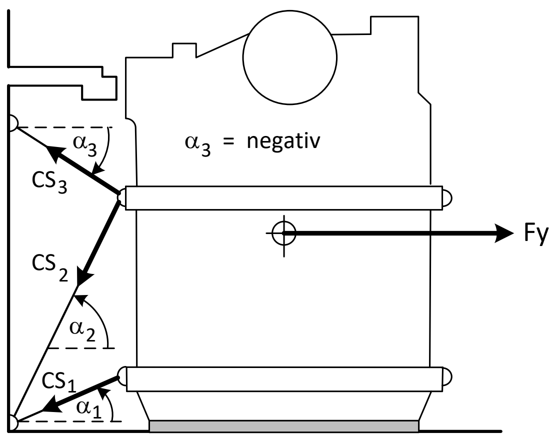


Figure 1: Balance of transverse forces

A vertical securing angle alpha greater than 60° will reduce the effectiveness of this particular securing device in respect to sliding of the unit. Disregarding of such devices from the balance of forces should be considered, unless the necessary load is gained by the imminent tendency to tipping or by a reliable pre-tensioning of the securing device which includes maintaining the pretension throughout the voyage.

Any horizontal securing angle, i. e. deviation from the transverse direction, should not exceed 30°, otherwise an exclusion of this securing device from the transverse sliding balance should be considered.

Table 5: f – Values as a function of α and μ

	α												
μ	**-30°**	**-20°**	**-10°**	**0°**	**10°**	**20°**	**30°**	**40°**	**50°**	**60°**	**70°**	**80°**	**90°**
0,3	0,72	0,84	0,93	1,00	1,04	1,04	1,02	0,96	0,87	0,76	0,62	0,47	0,30
0,1	0,82	0,91	0,97	1,00	1,00	0,97	0,92	0,83	0,72	0,59	0,44	0,27	0,10
0,0	0,87	0,94	0,98	1,00	0,98	0,94	0,87	0,97	0,64	0,50	0,34	0,17	0,00

Remark: $f = \mu \sin(\alpha) + \cos(\alpha)$

Existing Table 5 is re-numbered as Table 6.

Under the re-numbered Table 6, text is added.

In paragraph 7.2.3, under the definition of CS a formula is added

A new paragraph 7.2.4 is added as follows:

«7.2.4 Calculated example

A new paragraph 7.3 is added as follows:

«7.3 Balance of forces – alternative method

The existing text under the heading «Advanced calculation method: calculated example» with the heading are deleted from section 7 and added in as new Appendix 1 to the Annex with modifications as following paragraphs 15 and 16.

Previous text:

Explanations and interpretation to the «Methods to assess the efficiency of securing arrangements for non-standardized cargo»

1. The exclusion from the scope of application of the methods of very heavy units as carried under the provisions of Chapter 1.8 of the Code should be understood to accommodate the possibility of adapting the stowage and securing of such units to specifically determined weather- and sea- conditions during transport. The exclusion should not be understood as restriction of the methods to units up to a certain mass or dimension.
2. The acceleration figures given in Table 2 in combination with the correction factors represent peak values on a 25-day voyage. This does not imply that peak values in x-, y- and z- direction occur simultaneously with the same probability. It can be generally assumed that peak values in the transverse direction will appear in combination with less than 60% of the peak values in longitudinal and vertical direction.

   Peak values in longitudinal and vertical direction may join more closely because they have the common source of pitching and heaving.

3. The advanced calculation method use the «worst case approach». That is expressed clearly by the transverse acceleration figures which increase too forward and aft the ship and thereby show the influence of transverse components of simultaneous vertical accelerations. Consequently there is no need to consider vertical accelerations separately in the transverse balance of forces and moments. These simultaneously acting vertical accelerations create an apparent increase of weight of the unit and thus improve the friction in the balance of forces respectively the moment of stableness in the balance of moments. For this reason there is no reduction of the normal force (m g) due to the present angle of heel.

   The situation is different for the longitudinal sliding balance. The worst case would be a peak value of the longitudinal force Fx accompanied by an extreme reduction of weight through the vertical force Fz

4. The friction coefficients shown in the methods are somewhat reduced against appropriate figures in other publications. The reason for this should be seen in various influences which may appear in practical shipping as: moisture, grease, oil, dust and other residues, vibration of the ship.

   There are certain stowage materials available which are said to increase friction considerably. Extended experience with these materials may bring additional coefficients into practical use.

5. The principal way of calculating forces within the securing elements of a complex securing arrangement should necessarily include the consideration of:
   - Load-elongation behaviour (elasticity)
   - Geometrical arrangement (angles, length)
   - Pretension

   Of each individual securing element.

   This approach would require a large volume of information and a complex, iterative calculation. Still the results would be doubtful due to uncertain parameters.

   Therefore the simplified approach was chosen with the assumption that the elements take an even load of CS (calculation strength) which is reduced against the MSL (maximum securing load) by the safety factor 1,5.

6. When employing the advanced calculation method the way of collecting data should be followed as shown in the calculated example. Itis acceptable to estimate securing angles, to take average angles for a set of lashings and similarly arrive at reasonable figures of the levers a, b and c for the balance of moments.

   It should be born in mind that meeting or missing the balance calculation just by a tiny change of one or the other parameter indicates to be near the goal anyway.

There is no clear-cut borderline between safety and non-safety. If in doubt, the arrangement should be improved.

The existing text under the heading «Advanced calculation method: calculated example» with the heading are deleted from section 7 and added in as new Appendix 1 to the Annex with modifications as following paragraphs 15 and 16.

In new Appendix 1, the words «Advanced calculation method: calculated example» are replaced by the follows:

«Calculated example 1

(refer to paragraph 7.2, Balance of forces and moments)

In new Appendix 1, calculated example 2 is added after calculated example 1.

Table 1 was amended by MSC/Circ. 812 of 1997-06-16.

Previous text:

Table 1: Determination of MSL from breaking strength.

Material	**MSL**
Shackles, rings, deckeyes, turnbuckles of mild steel	50 % of breaking strength
Fibre rope	33 % of breaking strength
Web lashing	50% of breaking strength
Wire rope (single use)	80 % of breaking strength
Wire rope (re – usable)	30 % of breaking strength
Steel band (single use)	70 % of breaking strength
Chains	50 % of breaking strength

This Annex was added by MSC/Circ. 664 of 1994-12-22.

This Code was adopted by res. A. 714 (17) of 1991-11-06, applicable from 1998-07-01. Res. A. 714 (17) revoked res. A.288 (VIII), which is not included in IMO – Vega.