LL61 Method of correction for the effect of free surface of liquids in tanks (Regulation 10(2), UR L3 and UI LL45)

(1997)
(Rev.1
July 2008)

1 For all loading conditions, the initial metacentric height and the righting lever curve should be corrected for the effect of free surfaces of liquids in tanks.

2 Free surface effects will exist whenever the filling level in a tank is less than 100% and greater than 0%. Where the total free surface effects of nominally full (i.e. 98% or above) tanks is small in relation to the metacentric height of the vessel, with the agreement of the administration the effects for such tanks may be ignored. Free surface effects should be considered whenever the filling level in a tank is less than 98%.

3 Tanks which are taken into consideration when determining the free surface correction may be in one of two categories:

3.1 Tanks with filling levels fixed (e.g. liquid cargo, water ballast). The free surface correction should be determined for the actual filling level to be used in each tank.

3.2 Tanks with filling levels variable (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquid cargo and water ballast during liquid transfer operations). Except as permitted in 5 and 6, the free surface correction should be the maximum value attainable between the filling limits envisaged for each tank, consistent with any operating instructions.

4 In calculating the free surface effects in tanks containing consumable liquids, it should be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account should be those where the effect of free surfaces is the greatest.

5 Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surface effects should be calculated to take account of the most onerous transitory stage relating to such operations.

6 For vessels engaged in liquid transfer operations, the free surface corrections at any stage of the liquid transfer operations may be determined in accordance with the filling level in each tank at that stage of the transfer operation.

7 The corrections to the initial metacentric height and to the righting lever curve should be addressed separately as follows:

7.1 In determining the correction to initial metacentric height, the transverse moments of inertia of the tanks should be calculated at 0 degrees angle of heel according to the categories indicated in 3.

Footnote: This UI is also applicable to Regulation 10(2) of the 1988 Protocol and the revised 1988 Protocol.

LL61
(cont)

7.2 The righting lever curve may be corrected by any of the following methods subject to the agreement of the Administration:

.1 Correction based on the actual moment of fluid transfer for each angle of heel calculated.

.2 Correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of heel calculated, (i.e.: $GG_1 \sin\theta$).

.3 Correction based on the summation of M_{fs} values for all tanks taken into consideration, see 8.

With the exception of item 7.2.3 above, corrections may be calculated according to the categories indicated in 3.

Whichever method is selected for correcting the righting lever curve, only that method should be presented in the vessel's stability booklet. However, where an alternative method is described for use in manually calculating loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, should be included.

8 The values of M_{fs} for each tank may be derived from the formula:

$$M_{fs} = vb\rho k\sqrt{\delta}$$

where:

M_{fs} is the free surface moment at any inclination in metre-tonnes
v is the tank total capacity in cubic metres
b is the tank maximum breadth in metres
ρ is the mass density of liquid in the tank in tonnes/cubic metre
δ is equal to v/blh (the tank block coefficient)
h is the tank maximum height in metres
l is the tank maximum length in metres
k is the dimensionless coefficient to be determined from the following table according to the ratio b/h. The intermediate values are determined by interpolation.

LL61
(cont)

Table of Values for Coefficient "k" for Calculating Free Surface Corrections

$$k = \frac{\sin\theta}{12}\left(1 + \frac{\tan^2\theta}{2}\right) * \frac{b}{h}$$ where $\cot\theta \geq b/h$

$$k = \frac{\cos\theta}{8}\left(1 + \frac{\tan\theta}{b/h}\right) - \frac{\cos\theta}{12(b/h)^2}\left(1 + \frac{\cot^2\theta}{2}\right)$$ where $\cot\theta \leq b/h$

θ b/h	5°	10°	15°	20°	30°	40°	45°	50°	60°	70°	75°	80°	85°	θ b/h
20	0.11	0.12	0.12	0.12	0.11	0.10	0.09	0.09	0.07	0.05	0.04	0.03	0.02	20
10	0.07	0.11	0.12	0.12	0.11	0.10	0.10	0.09	0.07	0.05	0.04	0.03	0.02	10
5	0.04	0.07	0.10	0.11	0.11	0.11	0.10	0.10	0.08	0.07	0.06	0.05	0.04	5
3	0.02	0.04	0.07	0.09	0.11	0.11	0.11	0.10	0.09	0.08	0.07	0.06	0.05	3
2	0.01	0.03	0.04	0.06	0.09	0.11	0.11	0.11	0.10	0.09	0.09	0.08	0.07	2
1.5	0.01	0.02	0.03	0.05	0.07	0.10	0.11	0.11	0.11	0.11	0.10	0.10	0.09	1.5
1	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.10	0.12	0.13	0.13	0.13	0.13	1
0.75	0.01	0.01	0.02	0.02	0.04	0.05	0.07	0.08	0.12	0.15	0.15	0.16	0.16	0.75
0.5	0.00	0.01	0.01	0.02	0.02	0.04	0.04	0.05	0.09	0.16	0.18	0.21	0.23	0.5
0.3	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.05	0.11	0.19	0.27	0.34	0.3
0.2	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.07	0.13	0.27	0.45	0.2
0.1	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.04	0.06	0.14	0.53	0.1

9 Small tanks which satisfy the following condition using the values of "k" corresponding to an angle of inclination of 30 degrees, need not be included in the correction:

$$vb\rho k\sqrt{\delta} \;/\; \Delta_{min} < 0.01 \text{ m}$$

where Δ_{min} = the minimum ship displacement in tonnes.

10 The usual remainder of liquids in empty tanks need not be taken into account in calculating the corrections providing the total of such residual liquids does not constitute a significant free surface effect.

End of Document