CI-T 3 Cargo Tank/Local fine mesh FE Analysis Procedure in way of opening

(Mar. 2008)

Rule Section

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Description

Procedure and specific instructions for the panels with openings in modelling, stress assessment and buckling assessment of cargo tank FE and local fine mesh FE analyses.

Common Procedure

A. General

Depending on the actual opening and stiffening arrangement, or whether the openings are modelled or not in cargo tank FE or local fine mesh FE model, procedures of stress assessment and buckling assessments could be different. However, the current Rules do not specifically address these different procedures. This Common Interpretation is intended to outline these different procedures and to provide additional information, particularly on the following aspects:

1. Overall flow of stress and buckling assessments in cargo tank FE and local fine mesh FE analyses (Refer to Figure PR1)
2. Procedure of element shear stress correction for stress and buckling assessments (Refer to Table PR1)
3. Procedure of averaging element shear stress for buckling assessment (Refer to Table PR1)
   Note: Fine mesh analysis screening criteria for openings are not covered in by this Common Interpretation.

B. Notes for element shear stress correction:

1. Element shear stress correction as indicated in B/2.7.2.4, B/2.7.2.5 and Table PR1 are applicable to both stress and buckling assessments.
2. Where minor openings, such as cut-outs for local stiffeners, scallops, drain and air holes, are not included in the cargo tank FE model and local fine mesh FE model, unless exempted by B/2.7.2.5, the element shear stress correction as given in B/2.7.2.4 is to be carried out irrespective of whether the main openings are modelled or not.
3. For application of B/2.7.2.5, all the conditions indicated therein are to be satisfied concurrently.

C. Notes for buckling assessment of the panels with openings:

1. Element shear stress correction is to be carried out in accordance with B/2.7.2.4, B/2.7.2.5 and Table PR1. For axial compression, stress correction is in general not necessary.
2. In accordance with B/2.7.3.8, stresses obtained from either the cargo tank analysis or local fine mesh analysis may be used in the buckling assessment of panels. Buckling assessment is not necessarily required in local fine mesh FE analysis.
3. If openings are not modelled, buckling assessment is to be carried out in accordance with 10/3.4. Advanced buckling assessment cannot be used.
4. If openings are modelled and the opening edges are not stiffened, 10/3.4 should be used for the buckling assessment. Advanced buckling assessment cannot be used. For such case:
   (a) where da/αla ≤0.7 and db/la ≤0.7, Case 6 in Table 10.3.1 should be used for shear buckling.
   (b) where da/αla >0.7 or db/la >0.7, the reduction factor (r-factor) in Table 10.3.1 for shear buckling is not applicable in principle. In such case, other engineering principles should be used on a case -by-case basis (current CSR do not include specific guidance for such case).
   (c) For buckling assessment against axial compression, Cases 3 and 4 in Table 10.3.1 should be applied.
5. If openings are modelled and the opening edges are stiffened:
   (a) Small openings surrounded by stiffeners outside the opening are to be assessed for buckling using 10/3.4.
   (b) The inside panel with the opening needs not be assessed.
6. Also refer to be following excerpts from “Background document” related to buckling assessment of the panels with openings:

2.2.1.n The intention of introducing the thickness correction procedure in Appendix B/Table B.2.2 of the Rules for modelling web plating in way of an opening is to enable correct representation of the overall stiffness of the three cargo tanks FE model to allow correct load transfer within the structure without modelling of all openings. It is to be noted that the cargo tank analysis is only intended for assessing the overall strength of the structure. Local stresses in way of an opening is in addition assessed using fine mesh finite element analysis, as required by Appendix B/3.1 of the Rules, with accurate modelling of the opening geometry.

2.2.1.o For openings with height, h_o, greater or equal to length, l_o, the deflection across the opening is governed by shear deflection and the thickness correction is proportional to the loss of material in a given cross section.

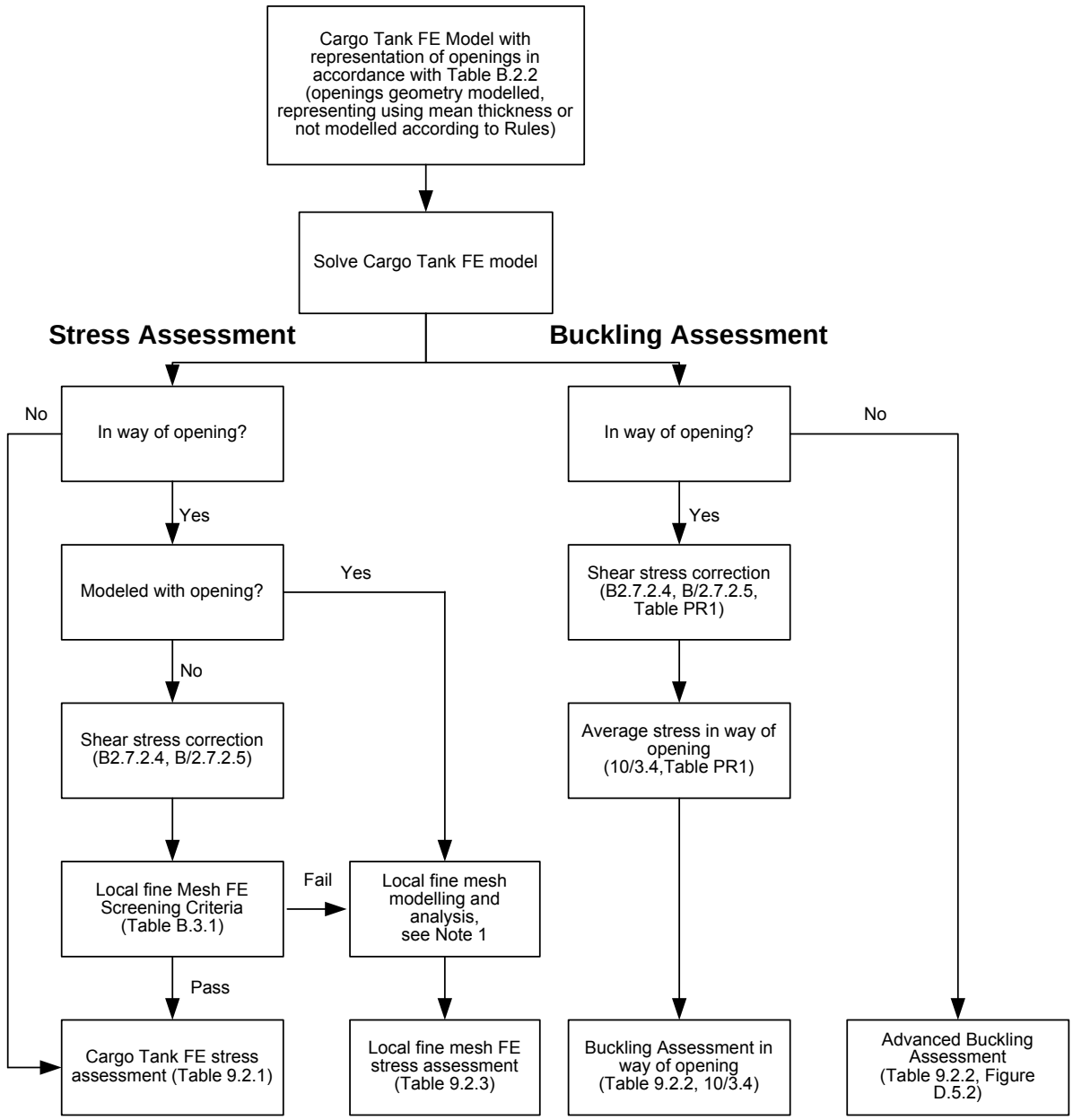
2.2.1.p For longer openings the deflection is a result of combined shear and bending deflection. This effect of bending deflection is taken into account by applying the correction factor, g_o, to the pure shear deflection thickness.

2.2.1.q For large openings, i.e. with $h_o/h \geq 0.5$ or $g_o \geq 2.0$, it is considered necessary to include the geometry of the opening in the cargo tank model in order to obtain an acceptable result, see Appendix B/Table B.2.2 of the Rules for definitions of l_o, h_o and g_o. In this case, fine mesh finite element analysis is mandatory in order to determine the local stress in way of the opening. See B/3.1.6.b.

2.2.1.r In all cases the geometry of an opening can be included in the cargo tank finite element model, even if its size is such that it is acceptable to represent its effect by means of reduced thickness in accordance with Appendix B/Table B.2.2 of the Rules. However, it should be noted that the screening formula, given in Appendix B/3.1.6 of the Rules for determining whether it is necessary to perform a fine mesh analysis of the opening, is only applicable for the cases where the geometry of an opening has not been included in the cargo tank model. If the geometry of an opening is included in the cargo tank model, fine mesh analysis is to be carried out to determine the local stress in way of the opening.

Figure PR1

Flow Chart of Cargo Tank and Local Fine Mesh FE Analyses in way of openings

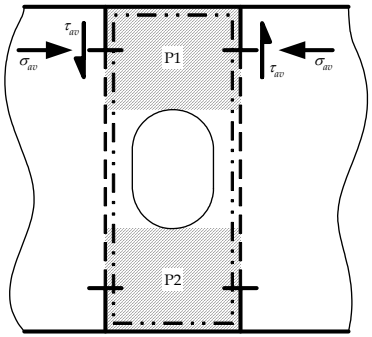
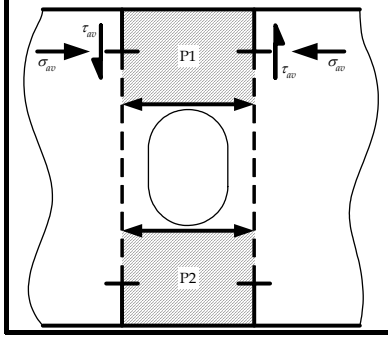


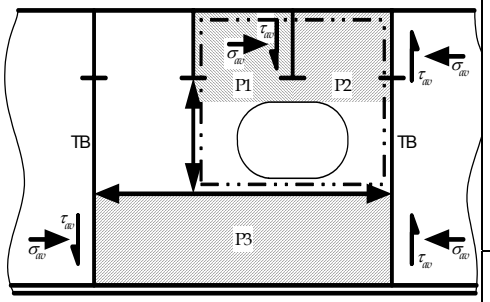
Note:

1. Small openings (e.g. slots for stiffeners, scallops, drain holes, air holes) shall also be included in local fine mesh model to avoid any additional shear correction.

Table PR1

Stress Correction in way of Opening for Buckling Assessment in accordance with Section 10/3.4

Opening Arrangement (These are the same arrangements as Table 10.3.3 for Reduction Factors)	**Major Opening Modelled?**	**Axial Compressive Stress**	**Shear Stress**	
			Shear Stress Correction (B/2.7.2.4, see Note 1)	**Averaging element shear stresses within panel** (calc of working shear stress)
(a) without edge reinforcements 	No	Calculate average stress for each P1 and P2 separately In general, correction of axial compressive stress to account for opening is not necessary.	Shear stress correction, where applicable, is to be done for P1, P2 and in way opening	Average element shear stresses within the area marked with (same area for the reduction factor C_T in Table 10.3.3.(a)): This includes the elements in way of opening.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 only. Opening part is excluded since there are no elements.	Average element shear stresses within the area marked with (same area for the reduction factor C_T in Table 10.3.3.(a)): Opening part is excluded since there are no elements.
(b) with edge reinforcements 	No	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 and in way opening	Average element shear stresses within P1 and P2 separately. Opening part needs not be assessed.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 only Opening part is excluded since there are no elements.	Average element shear stress within P1 and P2 separately Opening part needs not be assessed.

(c) example of hole in web  	No	Same as above	Shear stress correction, where applicable, is to be done for P1, P2, P3 and in way opening. For P3, correct only the shear stress of elements in way of cross section at the opening.	For the panel of P1 and P2 with opening, average element shear stress within the area marked with: This includes the elements in way of opening. For P3, average element shear stresses within P3.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2, P3 Opening part is excluded since there are no elements. For P3, correct only the shear stress of elements in way of cross section at the opening.	For the panel of P1 and P2 with opening, average element shear stress within the area marked with: Opening part is excluded since there are no elements. For P3, average element shear stresses within P3.

Note:

1. Where modelled shear area and actual shear area are different, including area loss due to minor openings, element shear stresses in way of the cross section of the opening are to be corrected in accordance with B/2.7.2.4.

Implementation date

This CI is effective from 1 April 2008.

Background

Depending on the actual opening and stiffening arrangement, or whether the openings are modelled or not in cargo tank FE or local fine mesh FE model, procedures of stress assessment and buckling assessments could be different. However, the current Rules do not specifically address these different procedures. This Common Interpretation has been prepared to provide an outline of these different procedures.