# ACI Committee 376

## Concrete Structures for Refrigerated Liquefied Gas (RLG) Containment

## Agenda

Thursday, June 19, 2008

**11:00 AM – 5:00 PM**

**and**

Friday, June 20, 2008

**8:30 AM – 5:00 PM**

**14250 Greenspoint Drive**
**Houston, TX 77060**
(Contact numbers: 281 / 654 – 6067, 281 / 654 – 6853, *or 832 / 713 – 1343*)

1. **CALL TO ORDER and APPROVAL OF AGENDA**

2. **INTRODUCTIONS**

3. **APPROVAL OF MINUTES**
   Minutes of the Los Angeles meeting from Spring 2007.

4. **VOTING ON NEGATIVE VOTES**
   - R5.1.5 & R5.2.5
   - 7.7.2
   - APPENDIX A - GENERAL COMMENT
   - 10.2.x - Anchorage
   - 10.3.x – Pressure and Vacuum Relief Testing –
   - Negatives from the ballot on "*4th Ballot on Chapter VII - 5/19 to 6/18/2008*"
   - Negatives from the ballot on "*1st Ballot on INTRODUCTION, Chapter I & Appendix AA - 5/19 to 6/18/2008*"

## 5. REVIEW AND RESOLUTION OF *Approved-With-Comment* VOTES

- 5.1 – Load Factors for the ULS of the Primary Container
- R5.1.1 – Dead Loads
- R5.1.3 – Product Pressure
- R5.1.4 – Thermal and/or Moisture
- R5.1.6 – Shrinkage
- R5.1.7 – Creep
- R5.1.8 – General Live Loads
- R5.1.9 – Differential Settlement
- R5.1.10.1 – Wind
- R5.1.10.2 – Other
- R5.1.11 – Seismic Loads
- R5.1.12 – Explosion and Impact
- R5.2.1 – Dead Loads –
- R5.2.3 – Product Pressure
- R5.2.4 – Thermal and/or Moisture
- R5.2.6 – Shrinkage
- R5.2.7 – Creep
- R5.2.8 – General Live Loads
- R5.2.9 – Differential Settlement
- R5.2.10.1 – Wind
- R5.2.10.2 – Other
- R5.2.11 – Seismic Loads
- R7.2.2.2
- 7.8.5
- Appendix A – General Comment
- Approved-with-Comment from the ballot on "*4th Ballot on Chapter VII - 5/19 to 6/18/2008*"
- Approved-with-Comment from the ballot on "*1st Ballot on INTRODUCTION, Chapter I & Appendix AA - 5/19 to 6/18/2008*"

## 6. REVIEW AND RESOLUTION OF THE GAP ANALYSIS RESULTS

Review, ranking and resolution of attached Gap Analysis results.

Respectfully submitted,
*Neven Krstulovic-Opara*
*Chairman, ACI 376*

cc: D. W. Falconer (*TAC Secretary and Managing Director of Engineering*)
R. Janowiak (*TAC Contact Member*)

ACI 376 Gap Analysis Comments



| No. | Text | Committee Member | Comment | Response | Action Needed |
|---|---|---|---|---|---|
| 1 | **R1.0** | Hoptay | Full Containment definition should control vapor. | None | Yes |
| 2 | **1.1 Definitions** | Hoptay | Concrete compressive strength – Add based cylinder strength.<br>OBE, SSE definitions, need SSEaft<br>Thermal Corner Protection – add “wall to slab junction in definition.<br>Vapor Container – membrane tank not part of this standard. | None | Yes |
| 18 | **2.8.3.1** | Legatos | Cite the correct applicable ASTM Standards for wire (A821 or A227, A421 and A648). Also, specify tests and chemical-composition limits for the wire consistent with past cryogenic-storage applications. | Maybe | Yes |
| 23 | **R2.8.3.5** | Legatos | Current version is inconsistent with both: (a) standard practice related to wire- and strand-wrapping systems for circumferential tank prestressing (as reflected in ACI and AWWA Standards; and (b) actual irrefutably successful practice of using these same prestressing systems in operating cryogenic storage applications. | Maybe | Yes |
| 24 | **2.8.4** | Hoptay | Quantify “high degree of toughness”. | No | Yes |
| 26 | **2.10** | Hoptay | Design requirements for liner should be moved to chapt 6 or 7. | No | Yes |
| 27 | **R2.10.1 i)** | Hoptay | Ductility does not apply to sacrificial liners. | No | Yes |
| 28 | **2.14** | Hoptay | Discussing conflict between documents. R2.14 second paragraph – confusing. | | |
| 29 | **2.14.1** | Hoptay | Consider adding references: ASTM C31, C33, C39 and C94. | No | Yes |
| 30 | **2.14.10** | Hoptay | Has EN14620 been reviewed for conflicts with ACI376 (i.e. load factors). | No | Yes |
| 34 | **3.1.14** | Hoptay | What “internal loadings” shall be considered. | No | Yes |
| 35 | **Table 3.2** | Hoptay | Is table consistent with Tables 5.1 and 5.2. | No | Yes |
| 36 | **4.2.4** | Hoptay | Why a) 1) not apply to b). | No | Yes |
| 39 | **4.2.10.1** | Hoptay | Clarify which requirements apply for conditions. | No | Yes |
| 40 | **4.2.10.1.1** | Hoptay | Section 2.8.1 and 4.2.10.1.1 appear to cover the same material.<br>4.2.10 and 8.2.1 appear to cover similar items. | No | Yes |
| 41 | **4.2.10.1.6** | Hoptay | What is the acceptance criteria? | No | Yes |
| 43 | **4.3.11** | Hoptay | Consider defining limit similar to 4.3.10. | No | Yes |
| 44 | **4.3.12** | Hoptay | Add commentary to describe other methods. | No | Yes |
| 45 | **4.3.15** | Hoptay | Crack width units need to be consistent.<br>General comment – do crack widths apply to permanently exposed surfaces? | No | Yes |
| 47 | **Chapt 5 commentary** | Hoptay | Commentary to be consistent with final table. Change ACI318 reference to ACI350. | | |
| 48 | **Below Table 5-2** | Hoptay | Should reference to off-shore terminals be in this section? | | |
| 49 | **R6.1.1** | Hoptay | First sentence – add “2 dimensional model”. | | |
| 50 | **Chapt 6** | Hoptay | Add design requirements for TCP. Add design requirements for design of primary containment liner. | | |
| 51 | **R6.1.1.6** | Hoptay | Is there a more specific reference than “historical”? | | |
| 52 | **6.1.1.9** | Hoptay | Add definition of “Constituent Models” to definition list. | | |
| 53 | **6.2.2** | Hoptay | Add reference to table 5-1. | | |
| 54 | **R6.2.3** | Hoptay | Strength reduction factors not chapt 5. | | |
| 55 | **6.3.2 and 6.3.3** | Hoptay | Appear to be redundant – combine? | | |
| 60 | **8.2.2.3** | Brannan | Part of R8.2.3 is the second paragraph "Refer to NFPA 59A8.2 and Section 3.1.1.3 of this code for additional specific guidance." Suggest using the second paragraph from R8.2.3 as a new R8.2.2.2 and deleting it from R8.2.3.4 | Maybe | Yes |
| 63 | **R8.3.4** | Hoptay | Does the 0.4 already include the appropriate factor of safety. | No | Yes |
| 67 | **8.6.1.2** | Hoptay | Clarify which requirements are to be met. | No | Yes |
| 72 | **9.2.3** | Hoptay | Verify tolerance of “10% of wall radius”. | | |
| 73 | **9.2.3.1** | Hoptay | Verify “20% of base slab radius”. | | |
| 74 | **Chapt9** | Hoptay | Wall tolerances for wall built using the free standing liner. | | |

## CHAPTER 5 – LOAD FACTORS

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|---|---|
| (light blue) | Approved Sections |
| (light green) | Section Approved with Comments to be resolved |
| (purple) | Negative Vote |

| Latest Text Reviewed | Vote | Committee Members' COMMENTS | Author | RESPONSE | Notes |
|---|---|---|---|---|---|
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | Voted Negative based on the following 3 points:<br><br>1.) Definition of Footnote No.2 on table 5.1 and how the environmental durability factor is to be applied needs to be added to the code side of the document possibly in Section 5.1.3. Do the limits that ACI 350 place on direct and hoop stress include thermal stresses? How do these stress limits work with the low stress design limits for non-cryogenic reinforcing that are contained in Chapter II?<br><br>2.) How does Footnote No. 2 apply to secondary containment? | Hoptay | | |
| | | XX - General - First sentence : The strength reduction factors occur in both ACI 350 and ACI 318. Suggest that we indicate both locations | Hoff | | |
| | | Table "<br>Other than the strength reduction factor for "tension controlled sections" and "post-tensioned anchorage", all the other factors listed are different than those contained in ACI 350 and ACI 318. Those factors are:<br>1. Compression controlled sections<br>a. with spiral reinforcement 0.75<br>b. with other reinforcement 0.70<br>2. Shear and torsion 0.85<br>3. Bearing on concrete 0.70<br>4. Flexure without axial load etc. 0.85<br>5. Strut and tie models 0.85 | | | |
| | | Table 5.1: In "Dead Loads", change the first three categories from "1.2" to "1.4" to be consistent with the text and the referenced codes.<br><br>Table 5.2: In "Dead Loads", change the first three categories from "1.2" to "1.4" to be<br>consistent with the text and the referenced codes. | | | |
| | | ***Gap Analysis***<br>5.0 XX, since Strut and Tie Models are listed in the Table the second sentence should stating the value should be removed. | Hoptay | | |
| **5.1 – Load Factors for the ULS of the Primary Container**<br><br>The load factors used for the ULS of the primary container shall be as noted in Table 5.1. | | Change "as noted" to "in accordance with." | Pawski | **5.1 – Load Factors for the ULS of the Primary Container**<br>The load factors used for the ULS of the primary container shall be in accordance with ~~as noted in~~ Table 5.1. | |
| | | Second sentence: The strut and tie model strength reduction factor only occurs in ACI 318 | Hoff | | |
| **Comments related to issues that were** | **N.A.** | Section 5.1: Comment: What about SLS load factors? Will these | Hjorteset | | |

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| **not voted on in this ballot.** | | load factors be addressed? | | | |
| **R5.1.1 – Dead Loads –** The 1.4 load factor for dead load for the normal operating conditions during construction, installation, testing and commissioning is consistent with ACI 350[5.1], Eq. 9.1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.<br><br>The 1.4 load factor for operation loads is consistent with ACI 350[5.1], Eq. 9.1 since it is assumed that the dead load will be combined with other operating loads. The factor may be reduced to 1.2 when combined with loads such as settlement and piping live load. The 0.9 is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.<br><br>The 1.2 load factor for the OBE loading is consistent with ACI 350[5.1], Eq. 9.5 since it is assumed that the dead load will be combined with other operating loads such as settlement and live load. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.0 load factor for the SSE, explosion, impact and fire is should be reduced to 0.9 when the higher dead load reduces the effect of other loads. | | Combine Commentary R5.1 and R5.2 where there is duplication.<br><br>Renumber with a, b, c, …. Examples:<br>R5.1 and R5.2 0 (a) Dead Loads –<br>R5.1 and R5.2 0 (b) Prestrerssing Loads –<br>R5.1 and R5.2 0 (c) Product Pressure –<br>R5.1 and R5.2 0 (d) Thermal and Moisture –<br>R5.1 and R5.2 0 (e) Construction and commissioning Loads –<br>R5.1 and R5.2 0 (f) Shrinkage – | Pawski | | |
| | | Section R5.1.1: Comment: in last paragraph, replace "is should be reduced to 0.9" to "should be reduced to 0.9" | Hjorteset | **R5.1.1 – Dead Loads –** *Under normal operating conditions and per ACI 350[5.1]:*<br>• *the dead load factor of 1.4 should be used when dead loads are combined only with the product pressure,*<br>• *the dead load factor of 1.2 should be used for all other normal loading conditions, per ACI 350[5.1] equation 9.1,*<br>• *the dead load factor of 0.9 shall be used when the dead load reduces the effect of other loads, per ACI 350[5.1], Eq. 9.6 and Eq. 9.7.*<br><br>~~The 1.4 load factor for dead load for the normal operating conditions during construction, installation, testing and commissioning is consistent with ACI 350[5.1], Eq. 9.1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.~~<br><br>~~The 1.4 load factor for operation loads is consistent with ACI 350[5.1], Eq. 9.1 since it is assumed that the dead load will be combined with other operating loads. The factor may be reduced to 1.2 when combined with loads such as settlement and piping live load. The 0.9 is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.~~<br><br>The 1.2 load factor for the OBE loading is per ~~consistent with~~ ACI 350[5.1], Eq. 9.5 since it is assumed that the dead load will be combined with other operating loads such as settlement and live load. The 0.9 load factor is per ~~consistent with~~ Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.0 load factor for the SSE, explosion, impact and fire ~~is~~ should be reduced to 0.9 when the higher dead load reduces the effect of other loads. | |
| | | • The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350.<br><br>• Section R.5.1.1: In ACI 350 the 1.4 load factor is also reduced to 1.2 when combined with T, L, Lr, S, or R. It would eliminate questions if these were added to the commentary.<br><br>• Section R5.1.1 & R5.2.1: The first sentence indicates that a 1.4 load factor applies to construction, installation and testing and commissioning but Table 5.1 only lists a 1.2 factor. Add 1.4/1.2 to the Tables 5.1 and 5.2. | Hoptay | | |
| | | • Other than Equation 9.1, all the other equations referenced in this section are the equations in ACI 318, not ACI 350. Suggest that ACI 350 be changed to ACI 318 including Equation 9.1.<br><br>• Third paragraph, second sentence: Change "…consistent with Eq. 9-6 and Eq. 9.7…" to consistent with ACI Eq. 9-6 and Eq. 9.7…". | Hoff | | |
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | Section R5.1.2: Negative: There is no section R5.1.2 and hence prestressing loads have not been addressed. The load factors vary between 1.0, 1.15, and 1.2 in Table 5.2 with no guidance on how to use them. I believe that we agreed in Los Angeles that | Hjorteset | Section R5.1.2 has been balloted on during the LA meeting and has been added to the chapter. During the LA meeting the committee decide and voted unanimously that:<br>a) load factors for all the prestressing-induced loads outside the | |

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| | | load factors should all be 1.0 including a statement that time dependent effects (including changing static systems) should accounted for. | | anchorage region be changed to 1.0, and<br>b) a load factor of 1.2 be used for all the prestressing-induced loads within the anchorage region (i.e., loads used in design and detailing of the anchorage zone)<br>c) the following text on changing static systems be added: "*Time dependent effects (relaxation, creep, and shrinkage) on the structural system, as well as changing static systems caused by construction sequence shall be included in the design*."<br>These changes are reflected in paragraphs 5.1.2 and R5.1.2, as well as Tables 5.1 and 5.2. | |
| | | R5.1.2, does the first paragraph imply that the prestressing load to be used is the maximum tendon jacking force only? | Hoptay | | |
| | | ACI 350 Section 9.2.1 (e) states "Both the full value and the zero value of L and F shall be used in the above load combinations to determine the most severe conditions." This is not stated Section 5.1.3 or 5.1.8 of this chapter. Should 0.9 be applied to the fluid pressure similar to dead load given the variance between design product density and actual product density? | Hoptay | | |
| **R5.1.3 – Product Pressure**<br>The 1.2 load factor for product load under testing / commissioning and operating conditions is consistent with ACI 350 Eq. 9-2. The 1.4 load factor, applied when product pressure is combined only with the dead load, is consistent with ACI 350 Eq. 9-1.<br><br>During the testing and commissioning phase, the "product" denotes liquid used in hydrostatic testing.<br><br>The 1.2 load factor for the OBE loading condition is consistent with ACI 350[5.1] Eq. 9-2 and Eq. 9-5. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | **R5.1.3 – Product Pressure**<br>The 1.2 load factor for product load under testing / commissioning and operating conditions is per ~~consistent with~~ ACI 350 Eq. 9-2. The 1.4 load factor, applied when product pressure is combined only with the dead load, is per ~~consistent with~~ ACI 350 Eq. 9-1.<br><br>During the testing and commissioning phase, the "product" denotes liquid used in hydrostatic testing.<br><br>The 1.2 load factor for the OBE loading condition is per ~~consistent with~~ ACI 350[5.1] Eq. 9-2 and Eq. 9-5. | |
| **R5.1.4 – Thermal and/or Moisture**<br>The 1.2 load factor for all normal thermal effects is per ACI 350[5.1] Eq. 9-2. For the OBE, the 1.2 load factor is consistent with ACI 350 Eq. 9-2 and Eq. 9-5.<br><br>For the OBE. The 1.2 load factor for normal thermal effects is per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | **R5.1.4 – Thermal and/or Moisture**<br>The 1.2 load factor for all normal thermal effects is per ACI 350[5.1] Eq. 9-2. For the OBE, the 1.2 load factor is per ~~consistent with~~ ACI 350 Eq. 9-2 and Eq. 9-5.<br><br>For the OBE. The 1.2 load factor for normal thermal effects is per ACI 350[5.1] Eq. 9-2. | |
| **R5.1.5 – Construction and Commissioning Loads**<br>Construction loads are categorized as live loads. The load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.<br><br>Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1] Eq. 9-1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when higher installation loads reduce the effect of other loads.<br><br>Testing and commissioning loads are controlled and monitored and as such are treated as dead loads. The load | | Negative of the following text:<br>*"Construction loads are categorized as live loads. The load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.*<br><br>*Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1] Eq. 9-1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when higher installation loads reduce the effect of other loads."*<br><br>Revise – '*Construction loads are categorized as live loads. The load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.* | Thompson | | |

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| factor of 1.2 is per ACI 350[5.1] Eq. 9-2 since they are combined with thermal loads.<br><br>The abnormal loading conditions are not applicable to Construction and Commissioning. | | *Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1] Eq. 9-1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when higher installation loads reduce the effect of other loads.*<br><br>to read:<br><br>**Construction loads can be applied using standard design practices or they can be analyzed using ASCE_37 Design Loads on Structures during Construction which includes the application of live load, dead load, equipment loading, and environmental effects during the construction process.**<br><br>**Reason:** ASCE 37 provides a much more comprehensive look at construction loading rather than just applying a load factor of 1.6. It should be allowed to give contractors an alternate approach to evaluating construction loading. This may be more aptly placed in 5.1.5 rather than in the commentary. | | | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | Replace "*consistent with*" with "*per*". | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.1.6 – Shrinkage**<br>For the normal loading conditions, ACI 350[5.1] includes shrinkage under "T" type loading and, per Eq. 9-2, the load factor when combined with other loadings is 1.2.<br><br>For the OBE, the 1.2 load factor is used in combination with other loads per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.1.7 – Creep**<br>For the normal loading conditions, ACI 350[5.1] includes creep under "T" type loading and, per Eq. 9-2, the load factor when combined with other loadings is 1.2.<br><br>For the OBE, the 1.2 Load Factor is used in combination with other loads per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | ACI 350 Section 9.2.1 (e) states "Both the full value and the zero value of L and F shall be used in the above load combinations to determine the most severe conditions." This is not stated Section 5.1.3 or 5.1.8 of this chapter. Should 0.9 be applied to the fluid pressure similar to dead load given the variance between design product density and actual product density? | Hoptay | | |
| **R5.1.8 – General Live Loads**<br>For general live loads (e.g., piping loads) under normal loading conditions as well as for an OBE earthquake, a load factor of 1.6 is used, per ACI 350[5.1] Eq. 9-2. The load factor can be reduced to 0.5 where live loads are greater than 100 psf, per ACI 350 paragraph 9.2.1 (a). | | Section R5.1.8: Comment: How can load factors go from 1.6 when live load is estimated at 100 psf down to 0.5 when the live load is estimated at 101 psf? It does not make sense. | Hjorteset | | |
| | | ACI 350 uses a live load factor of 1.7 whereas ACI 318 uses a live load factor of 1.6 as is noted in our tables. Recommend that we use the 1.6 and reference ACI 318 each place it we currently | Hoff | | |

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| For the OBE, the 1.2 load factor is used in combination with other loads, per ACI 350[5.1] Eq. 9-2. | | have ACI 350. | | | |
| **R5.1.9 – Differential Settlement**<br>For the normal loading conditions as well as OBE, a load factor of 1.2 is used per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.1.10.1 – Wind**<br>Wind load can only have an effect on the primary container during construction. Once the secondary container has been completed, it protects the primary container form wind effects.<br><br>When directionality effects have been included in calculating wind loads, a load factor of 1.6 should be used, per ACI 350[5.1] Eq. 9-4. When directionality effects have not been considered, a load factor of 1.3 can be used, per ACI 350[5.1] section 9.2.1 (b). | | Revise first paragraph to read:<br>"Wind load effects may apply to either the primary or secondary container depending on which is constructed first or constructed in parallel. Shielding of the primary (inner) by the secondary (outer) container may be considered."<br><br>Justification: Whether or not protection is required depends on the construction sequence. | Brannan | **R5.1.10.1 – Wind**<br>Wind load effects may apply to either the primary or secondary container depending on which is constructed first or constructed in parallel. Shielding of the primary (inner) by the secondary (outer) container may be considered.<br>~~Wind load can only have an effect on the primary container during construction. Once the secondary container has been completed, it protects the primary container form wind effects.~~<br><br>When directionality effects have been included in calculating wind loads, a load factor of 1.6 should be used, per ACI 350[5.1] Eq. 9-4. When directionality effects have not been considered, a load factor of 1.3 can be used, per ACI 350[5.1] section 9.2.1 (b). | |
| | | R5.1.10.1 Change "form" to "from" | Hanskat | | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.1.10.2 – Other**<br>Other environmental loads can only have an effect on the primary container during construction. Once the secondary container has been completed, it protects the primary container form wind effects.<br><br>For other environmental loads, a load factor of 1.6 should be usedd, per ACI 350[5.1] Eq. 9-3 for normal loading conditions. When wind effects are considered together with other environmental loads, the load factor can be reduced to 0.5 per ACI 350 Eq. 9.4 . | | Revise first paragraph to read:<br>"Other environmental load effects may apply to either the primary or secondary container depending on which is constructed first or constructed in parallel. Shielding of the primary (inner) by the secondary (outer) container may be considered."<br><br>Justification: Whether or not protection is required depends on the construction sequence.<br><br>Correct spelling in second paragraph: "used" | Brannan | **R5.1.10.2 – Other**<br>Other environmental load effects may apply to either the primary or secondary container depending on which is constructed first or constructed in parallel. Shielding of the primary (inner) by the secondary (outer) container may be considered.<br>~~Other environmental loads can only have an effect on the primary container during construction. Once the secondary container has been completed, it protects the primary container form wind effects.~~<br><br>For other environmental loads, a load factor of 1.6 should be used, per ACI 350[5.1] Eq. 9-3 for normal loading conditions. When wind effects are considered together with other environmental loads, the load factor can be reduced to 0.5 per ACI 350 Eq. 9.4. | |
| | | R5.1.10.2 Change "form" to "from" and "usedd" to "used" | Hanskat | | |
| | | R5.1.10.2, second paragraph, misspelling, "usedd | Hoptay | | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.1.11 – Seismic Loads**<br>For the OBE condition, the load factor of 1.3 should be used, per ACI 349[5.3] Section 9.2.1, Eq.10.<br><br>For the SSE condition, the load factor of 1.0 should be used, per ACI 350[5.1] Eq. 9-5 and Eq.9-7 and ACI 349[5.3] Section 9.2.1. Eq. 4. | | First sentence: We refer to ACI 349, Section 9.2.1, Eq. 10 for the OBE condition. ACI 350, R9.2.3 notes that if earthquake effects must be considered that a different set of load factors than those we have referred to in ACI 349 are to be used. Which do we want to do? | Hoff | | |
| **R5.1.12 – Explosion and Impact**<br>Explosion and impact loads generally have little of no effect on the primary tank of a double wall tank. However if the | | The statement in R5.1.12 "However if the tank is on piles the response of the entire structure may induce forces in the primary | Allen | **R5.1.12 – Explosion and Impact**<br>Explosion and impact loads generally have little or ~~of~~ no effect on the primary tank of a double wall tank. However, depending on the | |

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| tank is on piles the response of the entire structure may induce forces in the primary container. | | foundation an explosion could still induce forces throughout the tank. | | foundation response ~~if the tank is on piles~~, the response of the entire structure may induce forces in the primary container. | |
| | | R5.1.12<br>"Explosion and Impacts" states that these events have no impact on the Primary Container | Douglas | | |
| | | Section R5.1.12<br>Comment: Replace "little of no" with "little or no" | Hjorteset | | |
| | | R5.1.12, First "of" should be replaced with "or". | Hoptay | | |
| **5.2 – Load Factors for the ULS of the Secondary Container**<br><br>The load factors used for the ULS of the secondary container shall be as noted in Table 5.2. | | Change "as noted" to "in accordance with." | Pawski | **5.2 – Load Factors for the ULS of the Secondary Container**<br><br>The load factors used for the ULS of the secondary container shall be in accordance with ~~as noted in~~ Table 5.2. | |
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | Section 5.2: Comment: What about SLS load factors? Will these load factors be addressed? | Hjorteset | | |
| **R5.2.1 – Dead Loads –** The 1.4 load factor for dead load for the normal operating conditions during construction, installation, testing and commissioning is consistent with ACI 350[5.1], Eq. 9.1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.<br><br>The 1.4 load factor for operation loads is consistent with ACI 350[5.1], Eq. 9.1 since it is assumed that the dead load will be combined with other operating loads. The factor may be reduced to 1.2 when combined with loads such as settlement and piping live load. The 0.9 is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.<br><br>The 1.0 load factor for the Spill and the Spil + $SSE_{aft}$ event should be reduced to 0.9 when the higher dead load reduces the effect of other loads. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.2 load factor for the OBE loading is consistent with ACI 350[5.1], Eq. 9.5 since it is assumed that the dead load will be combined with other operating loads such as settlement and live load. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.0 load factor for the SSE, explosion, impact and fire is should be reduced to 0.9 when the higher dead load reduces the effect of other loads. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads. | | Section R5.2.1: Comment: in last paragraph, replace "is should be reduced to 0.9" to "should be reduced to 0.9" | Hjorteset | **R5.2.1 – Dead Loads – –** *Under normal operating conditions and per ACI 350[5.1]:*<br>• *the dead load factor of 1.4 should be used when dead loads are combined only with the product pressure,*<br>• *the dead load factor of 1.2 should be used for all other normal loading conditions, per ACI 350[5.1] equation 9.1,*<br>• *the dead load factor of 0.9 shall be used when the dead load reduces the effect of other loads, per ACI 350[5.1], Eq. 9.6 and Eq. 9.7.*<br><br>~~The 1.4 load factor for dead load for the normal operating conditions during construction, installation, testing and commissioning is consistent with ACI 350[5.1], Eq. 9.1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.~~<br><br>~~The 1.4 load factor for operation loads is consistent with ACI 350[5.1], Eq. 9.1 since it is assumed that the dead load will be combined with other operating loads. The factor may be reduced to 1.2 when combined with loads such as settlement and piping live load. The 0.9 is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when the higher dead load reduces the effect of other loads.~~<br><br>The 1.0 load factor for the Spill and the Spil + $SSE_{aft}$ event should be reduced to 0.9 when the higher dead load reduces the effect of other loads. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.2 load factor for the OBE loading is consistent with ACI 350[5.1], Eq. 9.5 since it is assumed that the dead load will be combined with other operating loads such as settlement and live load. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads.<br><br>The 1.0 load factor for the SSE, explosion, impact and fire ~~is~~ should be reduced to 0.9 when the higher dead load reduces the effect of other loads. The 0.9 load factor is consistent with Eq. 9-6 and Eq.9-7 when the higher dead load reduces the effect of other loads. | |
| | | Section R5.1.1 & R5.2.1, The first sentence indicates that a 1.4 load factor applies to construction, installation and testing and commissioning but Table 5.1 only lists a 1.2 factor. Add 1.4/1.2 to the Tables 5.1 and 5.2.<br><br>R5.2.1 fifth paragraph, "...impact and fire is should be reduced…" delete "is<br><br>The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | | |
| | | Other than Equation 9.1, all the other equations referenced in this section are the equations in ACI 318, not ACI 350. Suggest | Hoff | | |

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| | | that ACI 350 be changed to ACI 318 including Equation 9.1.<br><br>Third paragraph: Change "…consistent with Eq. 9-6 and Eq. 9.7…" to consistent with ACI Eq. 9-6 and Eq. 9.7…". | | | |
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | Section R5.2.2<br>Negative: There is no section R5.1.2 and hence prestressing loads have not been addressed. The load factors vary between 1.0, 1.15, and 1.2 in Table 5.2 with no guidance on how to use them. I believe that we agreed in Los Angeles that load factors should all be 1.0 including a statement that time dependent effects (including changing static systems) should accounted for. | Hjorteset | The committee decide and voted unanimously that:<br>d) load factors for all the prestressing-induced loads outside the anchorage region be changed to 1.0, and<br>e) a load factor of 1.2 be used for all the prestressing-induced loads within the anchorage region (i.e., loads used in design and detailing of the anchorage zone)<br>Both Table 5.1 and 5.2 reflect this change. | |
| **R5.2.3 – Product Pressure**<br>The 1.2 load factor for product pressure under testing / commissioning and operating conditions is consistent with ACI 350 Eq. 9-2. The 1.4 load factor, applied when product pressure is combined only with the dead load, is consistent with ACI 350 Eq. 9-1.<br><br>In the case of pressure from vapor, gas or vacuum, the 1.0 load factor for the Spill and the Spil + $SSE_{aft}$ event should be reduced to 0.0 since due to the generation of vapor during a spill event vacuum loading is not a credible event.<br><br>The 1.2 load factor for the OBE loading condition is consistent with ACI 350[5.1] Eq. 9-2 and Eq. 9-5. | | Correct spelling in second paragraph: "Spill" | Brannan | **R5.2.3 – Product Pressure**<br>The 1.2 load factor for product pressure under testing / commissioning and operating conditions is per ~~consistent with~~ ACI 350 Eq. 9-2. The 1.4 load factor, applied when product pressure is combined only with the dead load, is per ~~consistent with~~ ACI 350 Eq. 9-1.<br><br>In the case of pressure from vapor, gas or vacuum, the 1.0 load factor for the Spill and the Spill + $SSE_{aft}$ event should be reduced to 0.0 since due to the generation of vapor during a spill event vacuum loading is not a credible event.<br><br>The 1.2 load factor for the OBE loading condition is per ~~consistent with~~ ACI 350[5.1] Eq. 9-2 and Eq. 9-5. | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | | |
| | | Section R5.2.3: Comment: It seems like there is a typo in Table 5.2. For fire, I believe that the load factor for product pressure vapor should be 1.0 and for liquid, it should be 0.0. Current Table 5.2 shows it the other way around. | Hjorteset | The assumption is that the roof has fallen and that product is on fire. Hence, there is no vapor pressure. Since the product is still in the tank, product pressure is still present. | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.4 – Thermal and/or Moisture**<br>The 1.2 load factor for all normal thermal effects is per ACI 350[5.1] Eq. 9-2. For the OBE, the 1.2 load factor is consistent with ACI 350 Eq. 9-2 and Eq. 9-5.<br><br>For the OBE. The 1.2 load factor for normal thermal effects is per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | **R5.2.4 – Thermal and/or Moisture**<br>The 1.2 load factor for all normal thermal effects is per ACI 350[5.1] Eq. 9-2. For the OBE, the 1.2 load factor is per ~~consistent with~~ ACI 350 Eq. 9-2 and Eq. 9-5.<br><br>For the OBE. The 1.2 load factor for normal thermal effects is per ACI 350[5.1] Eq. 9-2. | |
| **R5.2.5 – Construction and Commissioning Loads**<br>Construction loads are categorized as live loads. The load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.<br><br>Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1] Eq. 9-1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when higher installation loads reduce the effect of other loads.<br><br>Testing and commissioning loads are controlled and monitored and as such are treated as dead loads. The load | | Negative on the following text:<br>*"Construction loads are categorized as live loads. The load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.*<br><br>*Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1]* | Thompson | | |

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| factor of 1.2 is per ACI 350[5.1] Eq. 9-2 since they are combined with thermal loads.<br><br>The abnormal loading conditions are not applicable to Construction and Commissioning. | | *load factor of 1.6 is per ACI 350[5.1] Eq. 9-2.*<br><br>*Installation loads are better refined and less variable than construction loads and are treated as dead loads per ACI 350[5.1] Eq. 9-1. The 0.9 load factor is consistent with ACI 350[5.1], Eq. 9.6 and Eq. 9.7 when higher installation loads reduce the effect of other loads.*<br><br><u>to read</u>:<br><br>**Construction loads can be applied using standard design practices or they can be analyzed using ASCE_37 <u>Design Loads on Structures during Construction</u> which includes the application of live load, dead load, equipment loading, and environmental effects during the construction process.**<br><br>**<u>Reason:</u>** ASCE 37 provides a much more comprehensive look at construction loading rather than just applying a load factor of 1.6. It should be allowed to give contractors an alternate approach to evaluating construction loading. This may be more aptly placed in 5.2.5 rather than in the commentary. | | | |
| | | The commentary was taken from the explanation that was a part of the initial generation of the Tables. It is suggested that in the commentary where it states "…is consistent with ACI 350…" be removed and replace with just a reference to ACI 350. | Hoptay | Replace "*consistent with*" with "*per*". | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.6 – Shrinkage**<br>For the normal loading conditions, ACI 350[5.1] includes shrinkage under "T" type loading and, per Eq. 9-2, the load factor when combined with other loadings is 1.2.<br><br>For the OBE, the 1.2 load factor is used in combination with other loads per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.7 – Creep**<br>For the normal loading conditions, ACI 350[5.1] includes creep under "T" type loading and, per Eq. 9-2, the load factor when combined with other loadings is 1.2.<br><br>For the OBE, the 1.2 Load Factor is used in combination with other loads per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.8 – General Live Loads**<br>For general live loads (e.g., piping loads) under normal loading conditions, a load factor of 1.6 is used, per ACI 350[5.1] Eq. 9-2. The load factor can be reduced to 0.5 where live loads are greater than 100 psf, per ACI 350 paragraph 9.2.1 (a).<br><br>General live loads are not required to be combined with abnormal loadings. | | Section R5.2.8<br>Comment: How can load factors go from 1.6 when live load is estimated at 100 psf down to 0.5 when the live load is estimated at 101 psf? It does not make sense. | Hjorteset | | |
| | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. Also, as noted above, ACI 350 use a live load factor of 1.7 where as ACI 318 uses a live load factor of 1.6. | Hoff | | |

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| **R5.2.9 – Differential Settlement**<br>For the normal loading conditions as well as OBE, a load factor of 1.2 is used per ACI 350[5.1] Eq. 9-2. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.10.1 – Wind**<br>When directionality effects have been included in calculating wind loads, a load factor of 1.6 should be used, per ACI 350[5.1] Eq. 9-4. When directionality effects have not been considered, a load factor of 1.3 can be used, per ACI 350[5.1] section 9.2.1 (b).<br><br>Wind loads are not required to be combined with abnormal loadings. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.10.2 – Other**<br>For other environmental loads, a load factor of 1.6 is required, per ACI 350[5.1] Eq. 9-3 for normal loading conditions. When wind effects are considered together with other environmental loads, the load factor can be reduced to 0.5 per ACI 350 Eq. 9.4<br><br>Other environmental loads are not required to be combined with abnormal loadings. | | All the equations referenced in this section are the equations in ACI 318, not ACI 350. Recommend that ACI 350 be changed to ACI 318 in all locations. | Hoff | | |
| **R5.2.11 – Seismic Loads**<br>For the Spill + $SSE_{aft}$ condition a load factor of 1.0 should be used, per ACI 350 Eq. 9-5 and Eq.9-7, as well as ACI 349 Section 9.2.1.4.<br><br>For the OBE condition, the load factor of 1.3 should be used, per ACI 349[5.3] Section 9.2.1, Eq.10.<br><br>For the SSE condition, the load factor of 1.0 should be used, per ACI 350[5.1] Eq. 9-5 and Eq.9-7 and ACI 349[5.3] Section 9.2.1. Eq. 4. | | Change "ACI 350" to "ACI 318" throughout.<br><br>First paragraph: Change "…as ACI 349 Section 9.2.1.4." to " "…as ACI 349 Section 9.2.1, Eq 4." | Hoff | | |
| **Comments related to issues that were not voted on in this ballot.** | **N.A.** | Section R5.2.12: Comment: Replace “little of no” with “little or no” | Hjorteset | | |
| | | R5.2.12 There is no reference to explosion and impact for the outer tank.<br>Suggestion:- "Explosion, Impact, Fire: For explosion impact (and fire) conditions the load factor of 1.0 should be used." (or 1.05?) | Douglas | | |

# CHAPTER 7 – DETAILING

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| | Approved Sections |
| | Section Approved with Comments to be resolved |
| | Negative Vote |

| Balloted Text | Vote | Committee Members' COMMENTS | Author | RESPONSE | Notes |
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| **Section R7.2.2.2**<br>The ballot proposes that (a) the negative by Hoptay is found persuasive **in part** and (b) that while all four paragraphs be retained in Section R7.2.2.2, the current *first* paragraph be moved to the end of the section; and that it include a reference to Section 7.5.2 (and vice versa) as follows:.<br><br>**R7.2.2.2** ~~In order to control shrinkage cracks caused by restraint of free shrinkage, the reinforcement should be increased to 1.0 percent for about the first 4 ft (1200 mm) when floor or wall concrete is placed against and bonded to previously placed concrete, such as at construction joints (see Figure R7.1). For crack control, it is preferable to use several small diameter bars rather than an equal area of large bars.~~<br><br>Shrinkage and temperature reinforcement should not be spaced farther apart than 12 in. and the minimum bar size should be No 4.<br><br>Shrinkage and temperature reinforcement is normally divided equally between both concrete faces. Where special conditions exist that significantly change the rate of drying or cooling on one face of the member, shrinkage and temperature reinforcement may be adjusted accordingly. However, no less than 1/3 of the required area of shrinkage and temperature steel should be distributed at any one face.<br><br>The required amount of shrinkage and temperature reinforcement is a function of the distance between the movement joints, particular concrete mix and other properties, amount of aggregate, member thickness, existing reinforcement, and environmental conditions. These factors have been considered in applying the analysis method developed by Vetter[7.3] to environmental engineering concrete structures, and the recommendations contained in ACI 350[7.1] are based on that work[7.4].<br><br>In order to control shrinkage cracks caused by restraint of free shrinkage, the reinforcement should be increased to 1.0 percent for about the first 4 ft (1200 mm) when floor or wall concrete is placed against and bonded to previously placed concrete, such as | Approved = 20<br>App w com = 1<br>Neg = 0<br>Abs = 2 | As previously commented, the 1% reinforcing should be limited to a maximum based on a 24 inch thick section. This is the limit set in ACI 373 Section 3.2.1.4 | Hoptay, Joseph | | |

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| at construction joints (for construction joint provisions and details, see Section 7.5.2 and Figure R7.1). For crack control, it is preferable to use several small diameter bars rather than an equal area of large bars.<br><br>Reason: On one hand, it is true that the first paragraph in this section might be thought to belong to Section 7.5.2 because it relates to reinforcement in the vicinity of and parallel to construction joints. However, its main theme is *minimum reinforcement* as a means of preventing cracking. Consequently, it is in the same category as the next three paragraphs, which deal with the subject matter of this section, namely "minimum non-prestressed reinforcement". | | | | | |
| **Section 7.3.3**<br>The ballot proposes that (a) the negative by Hoptay is found persuasive, and (b) that Sections 7.3.3 and 7.3.4; and R7.3.3 and R7.3.4 be from this chapter be moved to Chapter 9 as follows:<br><br>**9.4.7 – Grout for bonded prestressing tendons**<br><br>9.4.7.1 – (Insert current 7.3.3)<br><br>9.4.7.2 – (Insert current 9.4.7) ("Grout trials shall be used to ensure the following")<br><br>9.4.7.3 – (Insert current 7.3.4)<br><br>R9.4.7.1 – (Insert current R7.3.3)<br><br>R9.4.7.2 – (Insert current R9.4.7) ("Full scale grout tests are performed...")<br><br>R9.4.7.3 – (Insert current R7.3.4)<br><br>Reason: The provisions of this Section 7.3.3 actually belong in Chapter 9, Construction. | Approved = 19<br>App w com = 1<br>Neg = 0<br>Abs = 3 | Chapter IX will need to be reviewed when these sections are added | Hoptay, Joseph | | Review Chapter IX after these sections are added |
| **Section 7.4.1**<br>The ballot proposes that the negative by Sward is not found persuasive and that Section 7.4.1 be retained as is.<br><br>Reason: The requirement for a minimum 1-inch cover over the last wire or strand is in accordance with ACI 350 (Section G.4.2.4), as well as the other principal standards governing the design and construction of wire- and strand-wrapped tanks (ACI 372 and AWWA D110). Moreover, this requirement was used in the design of existing wire-wrapped prestressed concrete LNG storage tanks; and is standard practice for the design and construction of thousands of wire- and strand-wrapped water storage tanks. | Approved = 19<br>App w com = 2<br>Neg = 0<br>Abs = 2 | Since the design of refrigerated liquid storage tanks is longer than typical storage tanks and many are placed in marine environments, the committee may want to discuss an increase in cover for the outer container only? | Hoptay, Joseph | The ballot was on whether Sward's negative is persuasive or not. Listed comments are therefore recorded as comments for the Editorial TG. | *Address issue of larger cover when needed:*<br><br>Since the design of refrigerated liquid storage tanks is longer than typical storage tanks and many are placed in marine environments, the committee may want to discuss an increase in cover for the outer container only? |
| | | Minimum 1" final shotcrete coating thickness is for corrosion protection. Other serviceability considerations such as aggressive environments or fire protection may require greater thickness | Pawski, Rolf | | |

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| **Section 7.7.1**<br>The ballot proposes that the negative by Hoptay is found persuasive, and that in the second paragraph in Section 7.7.1, the reference to ACI 318 be deleted and replaced with a reference to ACI 350, Appendix D as follows:<br><br>**7.7.1 General**<br>This section is applicable to design and detailing of metal components for anchoring to elements of concrete containments.<br>Unless otherwise specified, anchoring to concrete shall comply with ~~ACI 318~~ ACI 350 Appendix D.<br><br>Reason: ACI 350, Appendix D, is a more appropriate reference than ACI 318. | Approved = 21<br>App w com = 0<br>Neg = 0<br>Abs = 2 | | | | |
| **Section 7.7.2**<br>The ballot proposes that the negative by Hoptay is found persuasive **in part**, and that Part (c) of Section 7.7.2 be revised as follows:<br><br>c) Weld shrinkage associated with welding of attachments., when such shrinkage can cause cracking in the adjoining concrete.<br><br>Reason: It is true that in some cases (such as some cast-in-place concrete applications) weld shrinkage due to welding of attachments is not a problem. There are other cases, however, where weld shrinkage is in fact a problem (such as when welding an attachment to an already embedded plate). | Approved = 20<br>App w com = 0<br>Neg = 1<br>Abs = 2 | The wording should remain unchanged. The proposed change makes "cracking of concrete" the sole criterion for acceptable performance, and thereby dilutes the requirement to consider the effects (meaning all) of weld shrinkage on performance. For example the effect on ULS strength of cracking associated with weld shrinkage is minimal, but if this cracked concrete is required for corrosion protection or liquid tightness it would be an important consideration.<br><br>Welding out corner protection before casting concrete doesn't solve the weld shrinkage problem if other parts are connected by welding later. Reference here is to actual experience | Pawski, Rolf | | |
| **Section 7.8.5**<br>The ballot proposes that the negative by Hjorteset is found persuasive **in part**, and that Sections 7.8.5 and R7.8.5 be revised as follows:<br><br>**7.8.5 – Steel plate liners**<br>The minimum thickness of steel *plate* liners covered by this section shall be 0.12 in. (3 mm) and shall conform to the requirements of Section 2.10. For the purposes of this code, steel liners less than 0.12 in. (3 mm) in thickness shall be considered steel *sheet* liners, and shall be designed to satisfy the applicable performance criteria of Section 2.11. [Ed. Note: See resolution of Hoptay's comment on Section 7.8.6.2 below.]<br><br>**R7.8.5 - Steel plate liners**<br>Steel plate liners should be considered vapor and liquid tight as | Approved = 19<br>App w com = 2<br>Neg = 0<br>Abs = 2 | Chapter II will need to be reviewed when these sections are added | Hoptay, Joseph | | Review Chapter II after these sections are added. |
| | | There is a nomenclature issue associated with introducing the word "sheet" as being distinct from "plate." To resolve the issue we should eliminate using "plate" or "sheet" and use the term "steel liner" with thickness as a basis for distinguishing performance requirements.<br><br>The AISC Manual of Steel Construction Table 2-2 provides the AISI Standard Nomenclature for Flat-Rolled Carbon Steel. "Plate" over 48" wide is available only in thicknesses 0.18" (4.5mm) and greater, while "sheet" is available only in thickness less than that. these limits do not align with what we are using to distinguish the two words | Pawski, Rolf | | |

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| long as the material selection is appropriate. The material selection should be based on the design metal temperature to be determined by the contractor in conjunction with the specified allowable stress limits. The minimum thickness of a steel plate liner should be selected based on its ability to meet the project design requirements, availability and constructability, including welding, but should not be less than 0.12 in. (3 mm). Steel liners less than 0.12 in (3 mm) in thickness should be considered steel *sheet* liners, whose performance may be approximated by that of coatings. Any creep or long-term deformation of the concrete due to operational conditions applied to the structure should be taken into account for the design of the liner. The anchoring system should be designed for combined shear and tension.<br><br>Reason: To allow the use of thin-gauge steel sheet liners. | | | | | |
| **Section 7.8.6.2**<br>The ballot proposes that the negative by Hoptay and the negative by Hjorteset are found persuasive **in part,** and that:<br>(a) the provisions of Section 7.8.6.2 be moved to Chapter 2, under a **new Section 2.11**; and that the current Sections 2.11 through 2.14 be renumbered 2.12 through 2.15, and<br>(b) in new **Section 2.11** (see above), the second sentence in Part (f) be revised as follows:<br><br>f) A bridging capability value of 120% of the calculated design crack width at normal operating temperatures and at crack opening velocity equal to the maximum crack opening velocity to be expected during an OBE event shall be used.<br>[Ed. Note: It is suggested that explanatory notes be inserted in the new R2.11 addressing such details as: Coating materials affected by this test (epoxy?); method of testing; comparison of crack-opening velocities vis-à-vis ground velocities associated with an OBE; and test temperature conditions (ambient or cryogenic).]<br><br>Reason: While the provisions of Section 7.8.6.2 are not currently in Chapter 2, they do properly belong there in as much as they pertain to materials properties rather than to ensure the crack-bridging capabilities of coatings under high-velocity loading conditions. | Approved = 20<br>App w com = 1<br>Neg = 0<br>Abs = 2 | Chapter II will need to be reviewed when these sections are added | Hoptay, Joseph | | Review Chapter II after these sections are added. |
| **Figure R7.1**<br>The ballot proposes that the negative by Hoptay is found persuasive **in part,** and that the following note be added to the WALL/FLOOR JOINT part of Figure R7.1:<br><br>WALL-TO-BASE WATERSTOP REQUIRED FOR UNLINED WALLS (PRIMARY AND SECONDARY); OPTIONAL FOR LINED WALLS. | Approved = 21<br>App w com = 0<br>Neg = 0<br>Abs = 2 | | | | |

Reason: The proposed clarification is helpful, except that it should apply to both the primary and secondary containers (the latter in case of an accidental spill in the annular space).

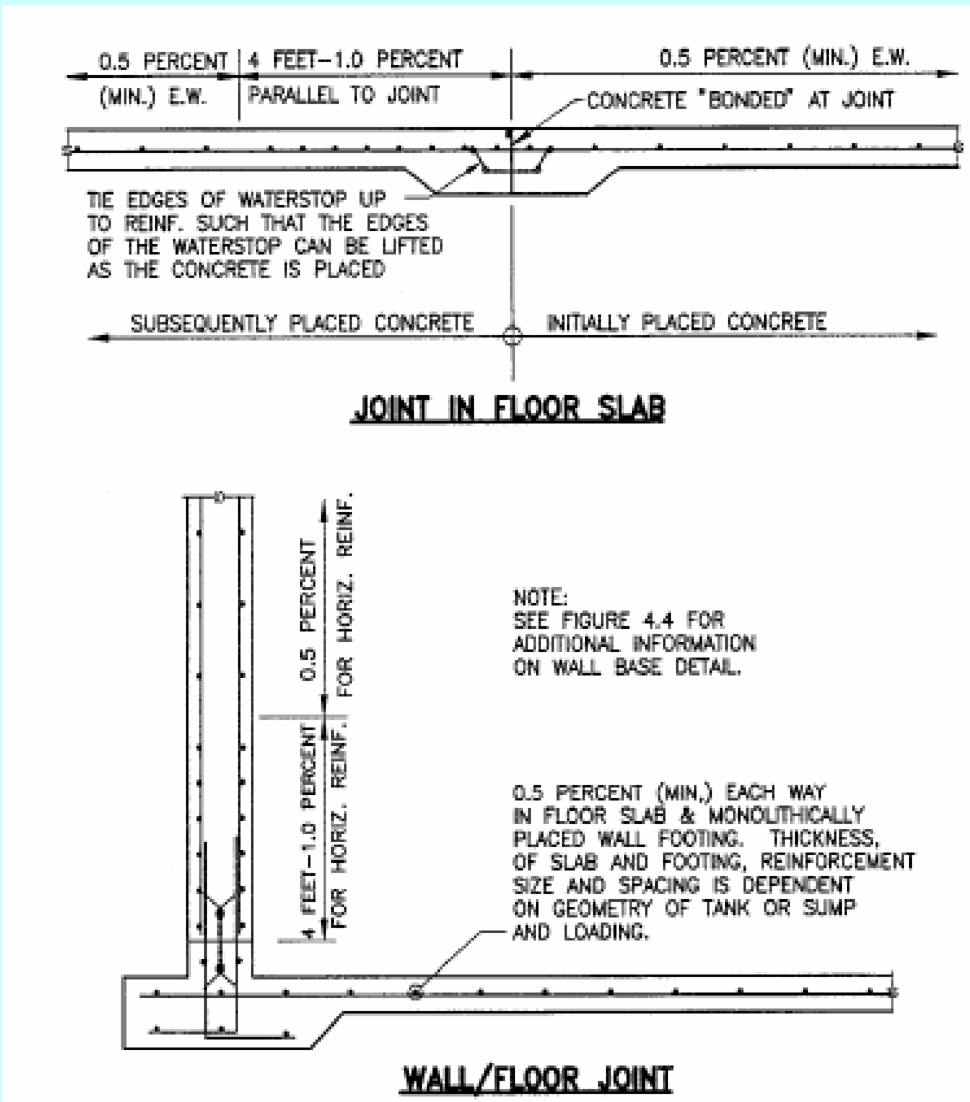
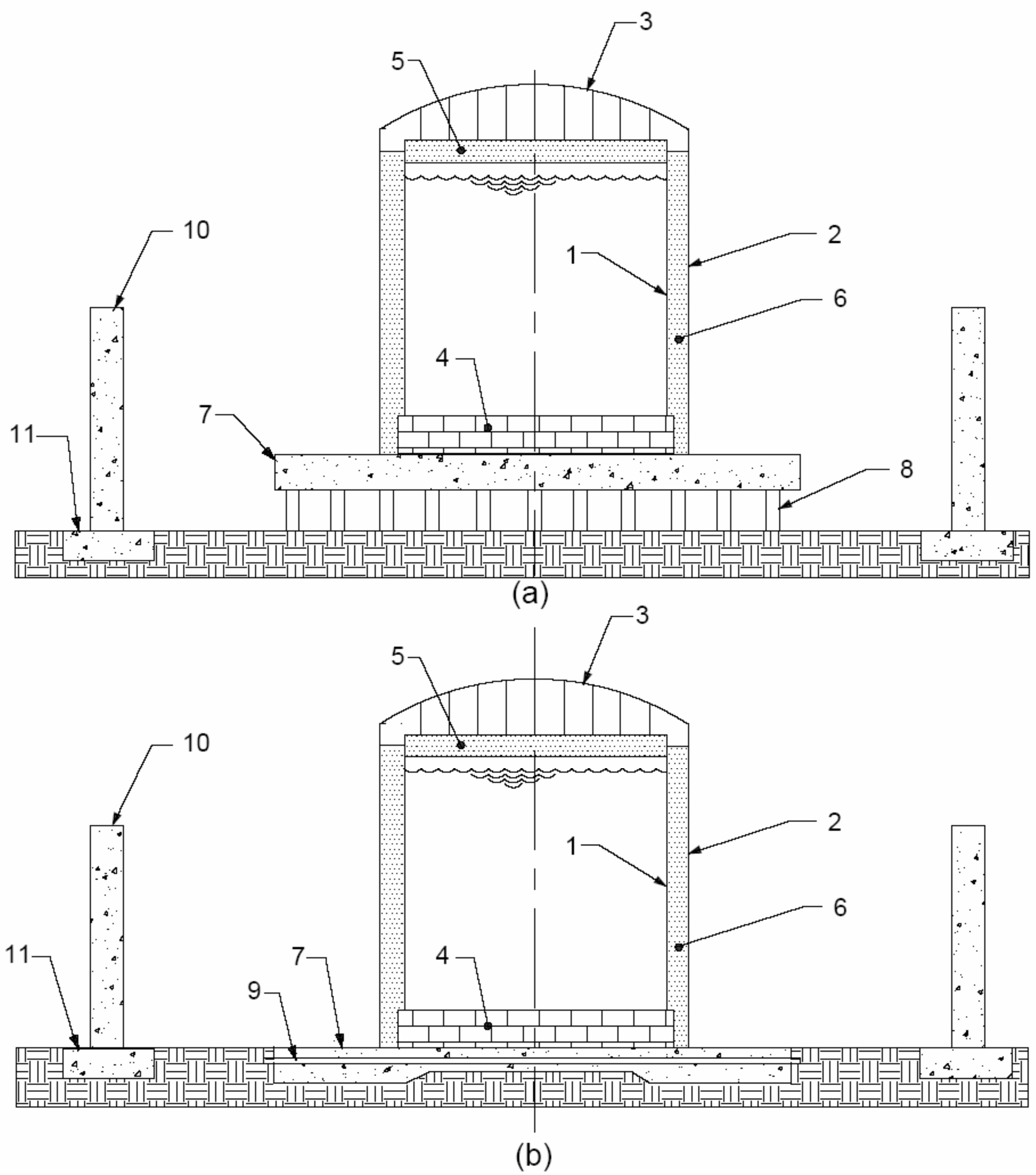



*Figure R7.1: Recommendations for increased reinforcing percentage parallel to bonded joints. Note that a wall-to-base waterstop is required for both the primary and the secondary unlined concrete walls. The waterstop is optional for lined walls.*

## Appendix A – Tank Details

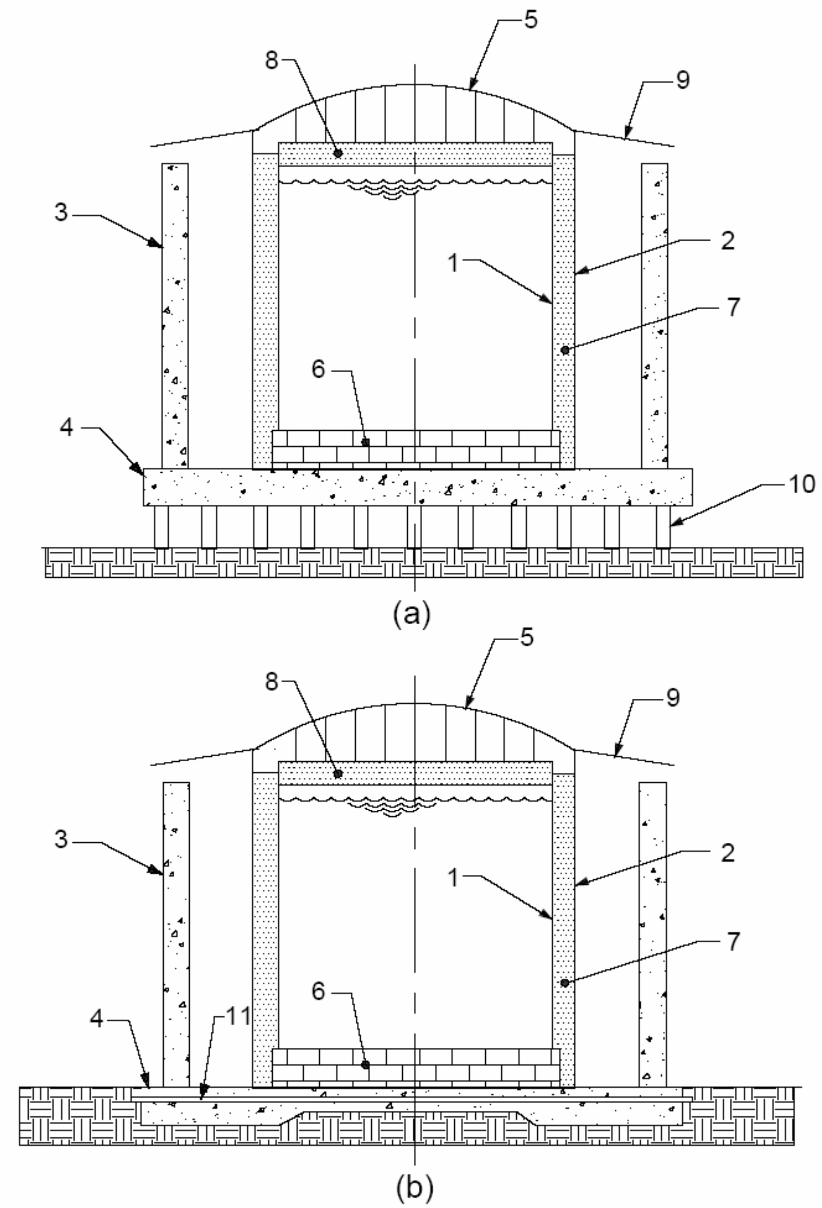
| | |
|---|---|
| | Approved Sections |
| | Section Approved with Comments to be resolved |
| | Negative Vote |

| Text Balloted | Vote | Committee Members' COMMENTS | Author | RESPONSE | Notes |
|---|---|---|---|---|---|
| **APPENDIX A**<br>**GENERAL COMMENT**<br>The ballot proposes that the first negative by Hoptay is found persuasive, and that the six figures illustrating the different containment types be reintroduced in Appendix A (see the attached file).<br><br>Reason: There is a need for a series of figures illustrating the different containment types (single, double and full containment). Such figures were in fact included in the earlier drafts of this code and are cited in the last paragraph of Section R1.0; and they should be reintroduced in Appendix A. | Approved = 18<br>App w com = 1<br>Neg = 1<br>Abs = 3 | Figure 6 can not be included in this standard since membrane tanks are not included in this standard. None of the chapters currently include any guidance from membrane tanks. | Hoptay, Joseph | Remove Fig 6 and update drawings | |
| | | Agree with proposed change for Hoptay - Part 1, but think we should have these undated and redrawn in a format consistent with other graphics in Appendix A. | Pawski, Rolf | | |
| **APPENDIX A**<br>**GENERAL COMMENT**<br>The ballot proposes that the second negative by Hoptay is found not persuasive and that no changes be made in response to Part 2 of Hoptay's negative.<br><br>Reason: The details suggested by this comment (combining primary and secondary containers with cast-in-place and panel construction) do not lend themselves to unique, exclusive solutions. Instead, the designer should be allowed some latitude in developing these details to suit the needs of a particular project – as long as they satisfy the prescribed performance criteria. | Approved = 19<br>App w com = 1<br>Neg = 0<br>Abs = 3 | While it is recognized that the designer should have latitude to develop details that meet a particular project need, the minimum performance criteria, design and analysis and details all need to recognize all possible design concepts that are currently envisioned and provide guidance for those concepts | Hoptay | | |



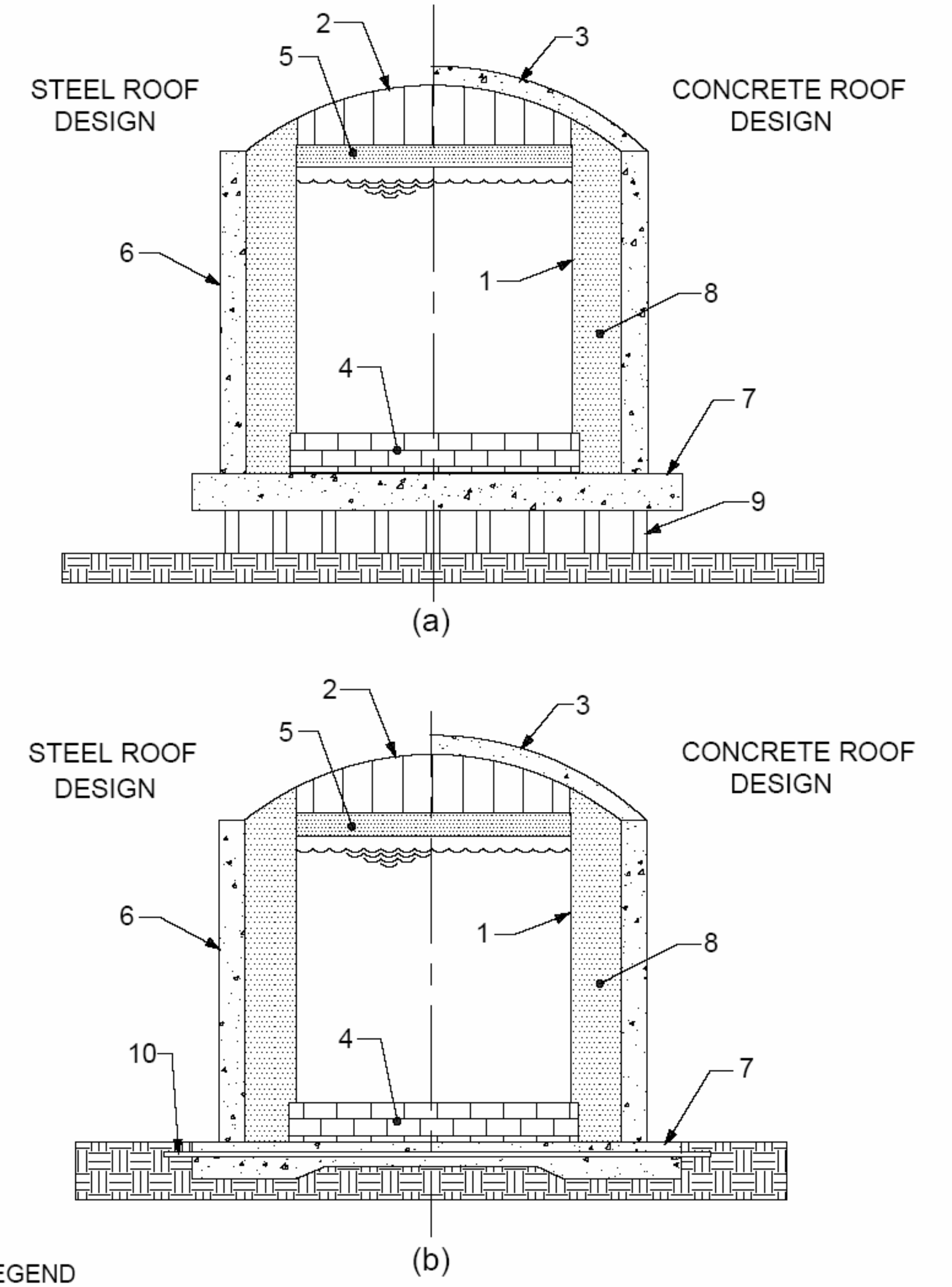

LEGEND
1 Primary container (steel)
2 Outer steel shell (vapor barrier)
3 Steel roof
4 Bottom rigid insulation
5 Suspended ceiling insulation
6 Loose fill insulation
7 Foundation slab
8 Piles
9. Foundation heating system
10 Bund wall (dike) (Pretressed concrete)
11 Bund wall footing

Fig. A.1 - Examples of concrete bund walls (dikes) for a single-containment tank system



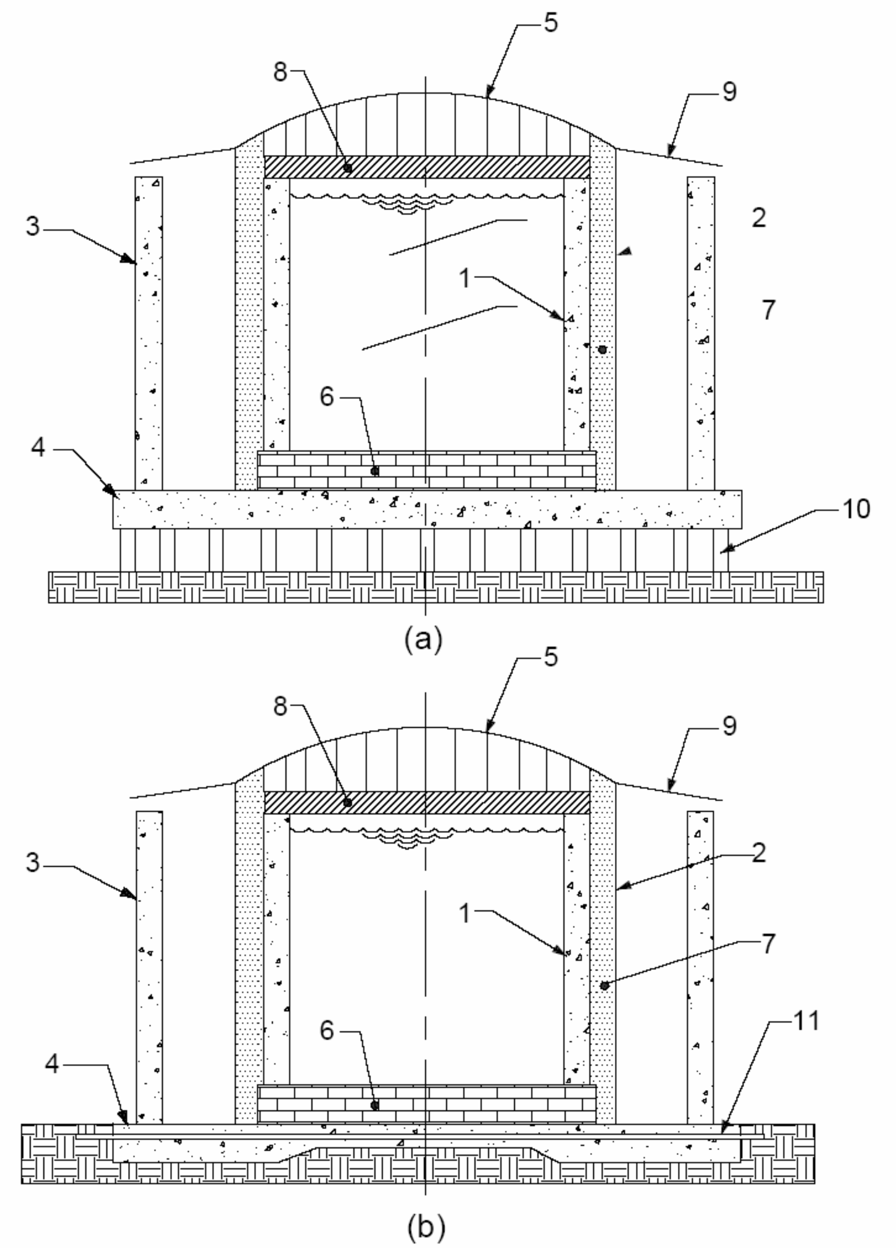

LEGEND
1 Primary container (steel)
2 Outer steel shell (vapor barrier)
3 Secondary container (prestressed concrete)
4 Foundation slab
5 Steel roof
6 Bottom rigid insulation
7 Loose fill insulation
8 Suspended ceiling insulation
9 Rain shield
10 Piles
11 Foundation heating cables

Fig.A.2 - Examples of concrete secondary container walls for a double-containment tank system (Adapted from EN 1473)



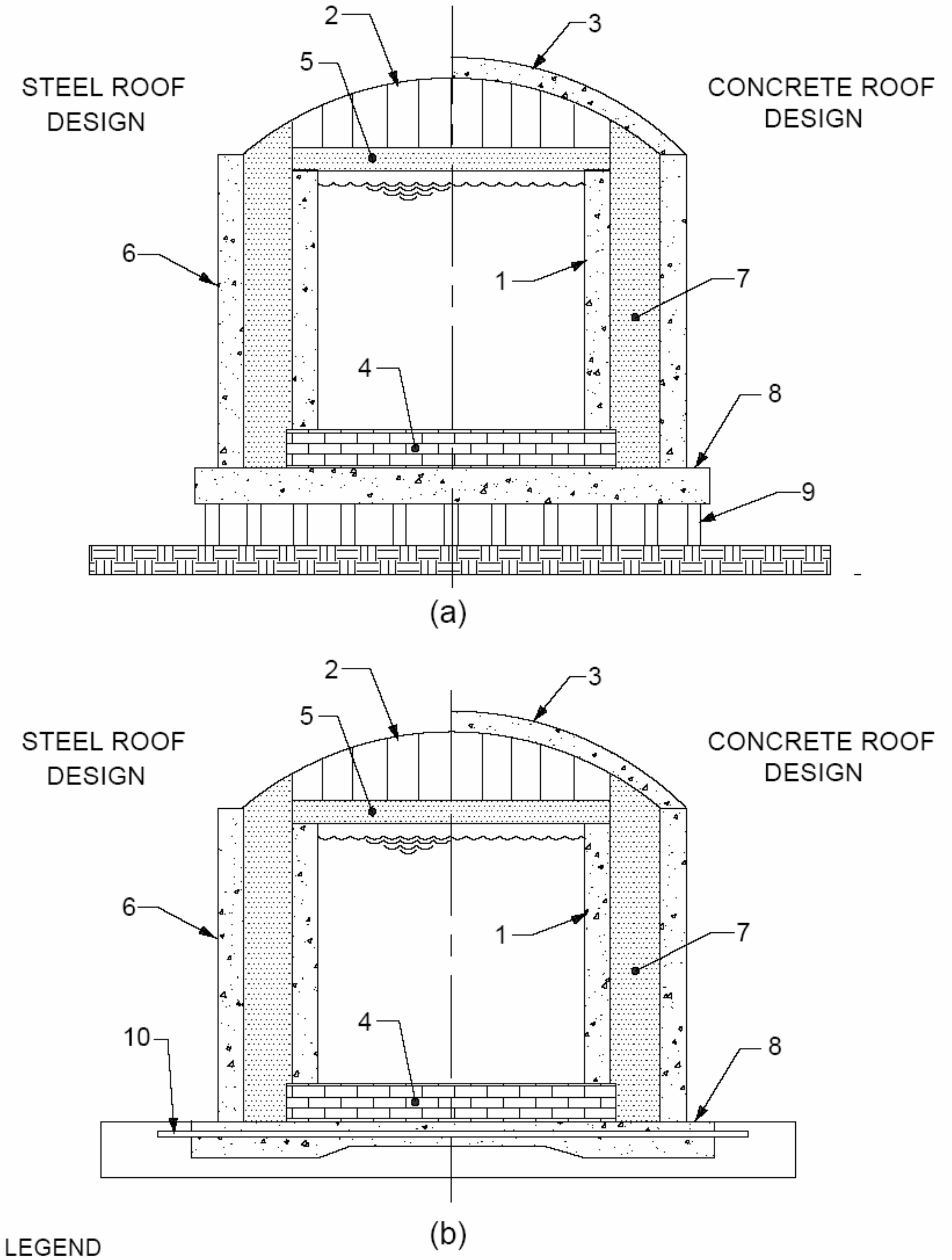

LEGEND
1 Primary container (steel)
2 Steel roof
3 Concrete roof
4 Bottom rigid insulation
5 Ceiling insulation
6 Secondary container (and vapor barrier) (Prestressed concrete)
7 Foundation slab
8. Loose fill insulation
9 Piles
10 Foundation heating system

Fig. A.3 - Examples of concrete secondary container walls for a full-containment tank system (Adapted from EN 1473)




LEGEND
1 Primary container (prestressed concrete)
2 Outer steel shell (vapor barrier)
3 Secondary container (prestressed concrete)
4 Foundation slab
5 Steel roof
6 Bottom rigid insulation
7 Loose fill insulation
8 Suspended ceiling insulation
9 Rain shield
10 Piles
11 Foundation heating cables

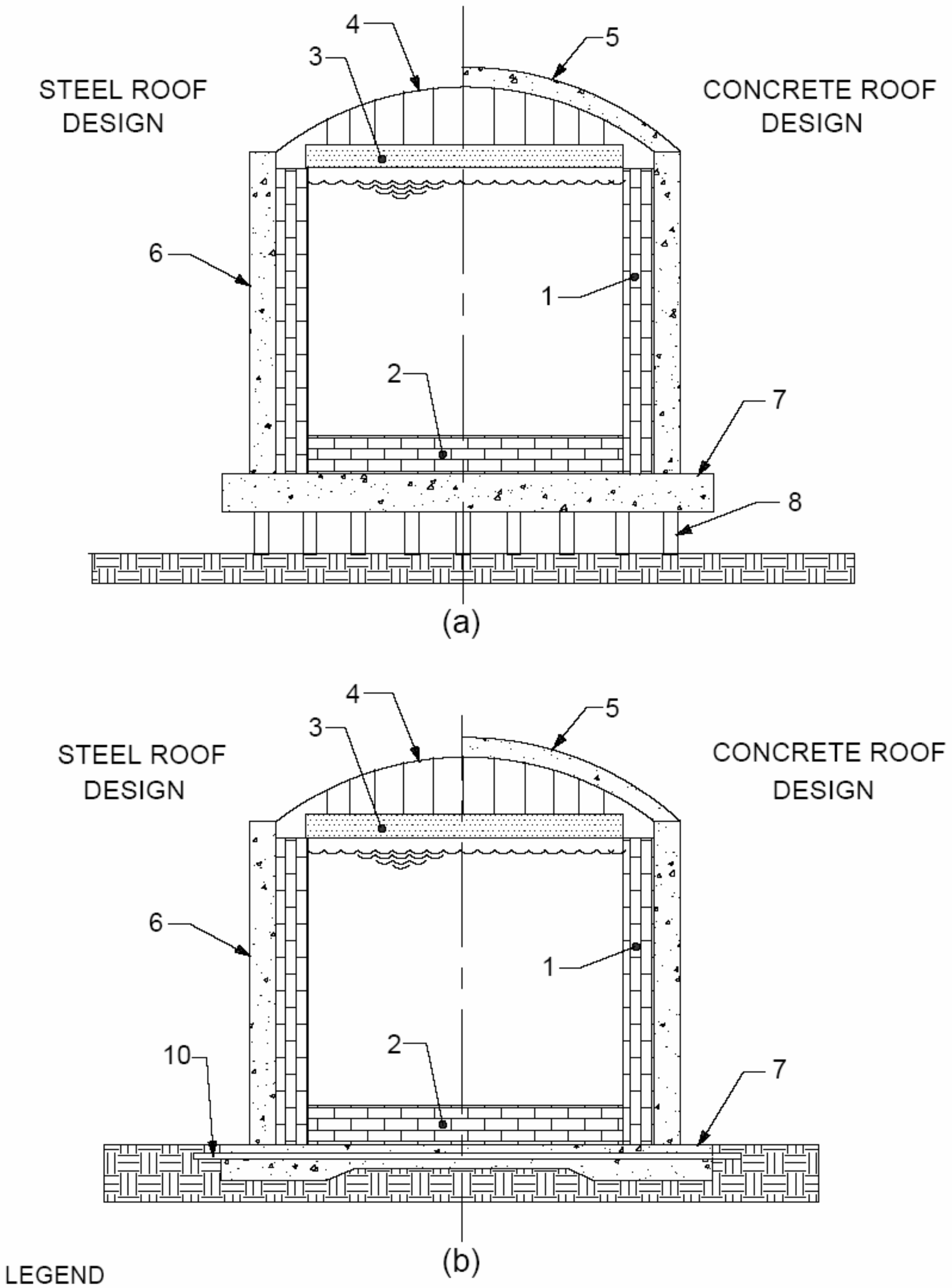
Fig.A.4 - Examples of concrete primary container walls in a double-containment tank system




LEGEND

1 Primary container (pretressed concrete)
2 Steel roof
3 Concrete roof
4 Bottom rigid insulation
5 Suspended ceiling insulation
6 Secondary container (Prestressed concrete)
7 Loose insulation
8. Foundation slab
9 Piles
10 Foundation heating system

Fig. 5 - Examples of concrete primary container walls in a full-containment tank system

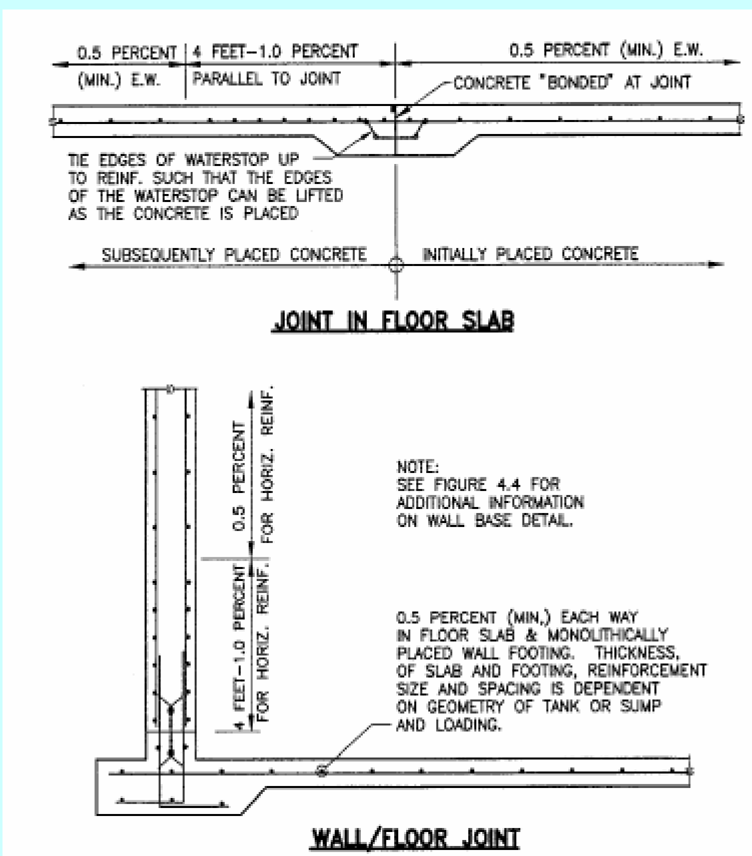



LEGEND

1 Primary container membrane
2 Bottom rigid insulation
3 Ceiling insulation
4 Steel roof
5 Concrete roof
6 Secondary container (Prestressed concrete)
7 Foundation slab
8 Piles
9 Foundation heating system

Fig. 6 - Examples of concrete primary container walls for a membrane tank

## Comments by Non-Voting Members

| Balloted Text | Vote | Committee Members' COMMENTS | Author | RESPONSE | Notes |
|---|---|---|---|---|---|
| **Figure R7.1**<br>The ballot proposes that the negative by Hoptay is found persuasive **in part,** and that the following note be added to the WALL/FLOOR JOINT part of Figure R7.1:<br><br>WALL-TO-BASE WATERSTOP REQUIRED FOR UNLINED WALLS (PRIMARY AND SECONDARY); OPTIONAL FOR LINED WALLS.<br><br>Reason: The proposed clarification is helpful, except that it should apply to both the primary and secondary containers (the latter in case of an accidental spill in the annular space).<br><br>*Figure R7.1: Recommendations for increased reinforcing percentage parallel to bonded joints. Note that a wall-to-base waterstop is required for both the primary and the secondary unlined concrete walls. The waterstop is optional for lined walls.* | Approved = 21<br>App w com = 0<br>Neg = 0<br>Abs = 2 | Water stops are not commonly used for the secondary container in full containment tanks as the base joint is behind the secondary bottom. Neither are water stops used in the secondary container above the secondary bottom when jump formed construction is used. Therefore there does not appear to be a case for introducing this requirement for the secondary container. For the primary container the performance of the joint should be specified and as appropriate that performance should be verified. In my opinion it is not necessary to use a water stop and Arup has many examples of successful water tight concrete construction which did not use water stops. Indeed the water stop has the potential to complicate the overall joint detail and fail to achieve the desired objective. Finally the hydrotest will provide a very good test of the tightness of this joint. | Powell | | |

## CHAPTER 10 – COMMISSIONING AND DECOMISSIONING CRITERIA

| | |
|---|---|
| (cyan) | Approved Sections and Approved Sections with resolved Editorial Comments |
| (green) | Section Approved with Comments to be resolved |
| (purple) | Negative Vote |

| CODE | Vote | Comments | Author | RESPONSE | Notes |
|---|---|---|---|---|---|
| The ballot proposes that the paragraph 10.2.x be replaced with the following text:<br><br>**10.2.x - Anchorage –** Where anchorage is provided that requires tightening of individual anchors, tightening shall be in accordance with procedures defined by the designer. Unless otherwise specified, the following shall be performed:<br>(a) prior to the pneumatic testing of the secondary container, and<br>(b) during the hydrotest, with the primary tank filled at the maximum water level.<br><br>Anchorages shall be visually inspected prior to and after testing. | ***Ballot Results 2/18 – 3/19/08***<br><br>Approved = 22<br>App. w. Com.= 1<br>Abst.= 4<br>Neg.= 2 | This doesn't tell you what should be performed, only when it should be performed. Seems like something was left out of this clause. | Hoff | **TG Houston Meeting – 3-18-08:** Brannan, Hjorteset, Ballard, NKO<br><br>• Hoff's and Hoptay's negative votes found persuasive. The negative is addressed by inserting "anchor tightening ~~the following~~", as shown below.<br>• Hanskat's editorial comments: TG believes that word "tightening" better reflects the intent which is to at least tighten the connection vs. prestressing or tensioning it. Ultimately, it is the Designers task to choose tightening or prestressing.<br><br>Find out whether Hoff and Hoptay agree with the change and whether this addresses their negative.<br><br>The change is only editorial. Unanimously agreed by all the TG members present: Brannan, Hjorteset, Ballard, NKO.<br><br>**10.2.x - Anchorage –** Where anchorage is provided that requires tightening of individual anchors, tightening shall be in accordance with procedures defined by the designer. Unless otherwise specified, anchor tightening ~~the following~~ shall be performed:<br>(a~~b~~) during the hydrotest, with the primary tank filled at the maximum water level, and<br>(b~~a~~) prior to the pneumatic testing of the secondary container~~, and~~.<br><br>Anchorages shall be visually inspected prior to and after testing. | Ballard: I think (b) and (a) should be reversed since the hydro test should be performed first to insure that the inner tank anchorages are tight before the pressure test. Someone might read this paragraph as a do (a) then do (b) direction. |
| | | The paragraph states that " *unless otherwise specified the following shall be performed*" but the following are not actions but points of time during construction. The paragraph needs to be reworded. | Hoptay | | |
| | | Is "tightening" the best word? In post-tensioning we typically say "tensioning" or "stressing". | Hanskat | | |
| The ballot proposes that the following text be added to paragraph R10.2.2<br><br>**R10.2.2 – (see current R10.2.2)**<br>• ASTM G16 and ASTM G46 may ~~could~~ be used as guidelines for determining which pitting and corrosion testing methodology is appropriate for the examination of pitting and corrosion of the surfaces in question after the hydrotest. The procedure to be used, areas to be tested and the acceptable corrosion and pitting limits should be agreed upon by the Engineer, Owner and Contractor before the hydrotest is performed, subject to the criteria of 10.2.1. | ***Ballot Results 2/18 – 3/19/08***<br><br>Approved = 23<br>App. w. Com.=1<br>Abst.= 4<br>Neg.= 0 | From the titles of each of the ASTM standards listed it is not obvious that guidance is provided in either standard as to which testing methodology is appropriate as indicated in R10.2.2. | Hoptay | **TG Houston Meeting – 3-18-08:** Brannan, Hjorteset, Ballard, NKO<br><br>ASTM G 46 lists a series of testing methodologies including:<br>• Visual inspection, including metallographic examination<br>• Non-destructive inspections including radiographic, electromagnetic, sonics, and penetrants,<br>• Mass loss, including pit depth measurement (including metallographic, machining, micrometer or depth gage, microscopical),<br>• etc.<br><br>Text was adjusted as shown below. Furthermore, the text is moved to **R10.2.2***<br>This is only an editorial change. Unanimously agreed by all the TG members present: Brannan, Hjorteset, Ballard, NKO.<br><br>**R10.2.2 – (see current R10.2.2)**<br>~~ASTM G16 and~~ ASTM G46 may ~~could~~ be used as guidelines for determining which pitting ~~and~~ | |

| CODE | Vote | Comments | Author | RESPONSE | Notes |
|---|---|---|---|---|---|
| | | | | corrosion testing methodology is appropriate for the examination of pitting and corrosion of the surfaces in question after the hydrotest. ASTM G 16 may be used for applying statistical analysis to corrosion data. The procedure to be used, areas to be tested and the acceptable corrosion and pitting limits should be agreed upon by the Engineer, Owner and Contractor before the hydrotest is performed, subject to the criteria of 10.2.1. | |
| The ballot proposes that Hatfield's negative vote is found convincing and that it be introduced as shown below:<br><br>**10.3.x – Pressure and Vacuum Relief Testing** – Proper functioning of all pressure and vacuum relief valves and devices shall be confirmed by:<br>• Check pressure relief by increasing pressure in the vapor space.<br>• Check vacuum relief by creating a vacuum with a vacuum pump, or alternatively, by partially withdrawing water from the tank.<br><br>Alternatively, in-situ component testing of relief & vacuum breaker valves with test gas applied to the pressure sensing line and set point of controls calibrated with a dead weight tester. | ***Ballot Results 2/18 – 3/19/08***<br><br>Approved = 20<br>App. w. Com.= 2<br>Abst.= 5<br>Neg.= 1 | Revise last sentence to read: " Alternatively, in-situ component testing of relief and vacuum breaker valves by applying test gas pressure or vacuum to the control valve pressure/vacuum sensing line is permitted. The set point of controls shall be calibrated with a dead weight tester."<br><br>Add the following sentence: "Monitor the pressure/vacuum in the tank at all times during testing using instruments with alarm settings to guard against pressure/vacuum conditions outside design limits." | Brannan | **TG Houston Meeting – 3-18-08:** Brannan, Hjorteset, Ballard, NKO<br><br>Changes are more than editorial and the paragraph should be reballoted.<br><br>Proposed changes unanimously agreed to by all the TG members present: Brannan, Hjorteset, Ballard, NKO.<br><br>**10.3.x – Pressure and Vacuum Relief Testing** – Proper functioning of all pressure and vacuum relief valves and devices shall be confirmed by:<br>• Increasing pressure in the vapor space to check pressure relief ~~by increasing pressure in the vapor space~~.<br>• Creating a vacuum to check vacuum relief by ~~creating a vacuum with~~ a vacuum pump, or alternatively, by partially withdrawing water from the tank.<br><br>~~Alternatively,~~ In-situ component testing of relief and vacuum breaker valves by applying ~~with~~ test gas ~~applied to the~~ pressure or vacuum to the control valve pressure/vacuum sensing line is permitted. The ~~and~~ set point of controls shall be calibrated with a dead weight tester.<br><br>Proper functioning of the relief valves and associated sensing systems shall be verified before the tank is placed into operation.<br><br>The pressure/vacuum in the tank shall be monitored at all times during testing using instruments with alarm settings to guard against pressure/vacuum conditions outside design limits.<br><br>Insert in the Commentary<br>**R10.3.x -** …. Verifying proper functioning of the relief valve system includes, but is not limited to ensuring that the pressure drop in the sensing line does not cause premature reseating of the valves. | |
| | | Editorial suggestion, change the bullet points to read:<br><br>- Increasing pressure to ... check pressure relief<br><br>- Creating a vacuum to ... check vacuum relief | Pawski | | |
| | | I agree that during normal plant operation that the pressure relief valves are tested as described in the alternate. However, prior to the tank being placed into operation the relief valve sensing system needs to be verified as working properly to insure, for example, that the pressure drop in the sensing line does not cause the valves to reseat prematurely. This is not a new requirement for the testing tank relief valves prior to the tank being placed into service and is a requirement of API 620 for single containment tanks. API 620 Q.9.2.5 states the following," Pressure relief and vacuum relief valves shall be checked by applying the design gas pressure to the outer tank, followed by evacuation of the outer space to the vacuum setting of the relief valve." | Hoptay | | |