THE CARMAGEN Engineering, Inc. REPORT

Partnering in Engineering Excellence **May 2008**

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Changes in API 650, Welded Steel Tanks for Oil Storage

By Vincent A. Carucci / Stephen J. Gliebe

The following highlights several changes to API 650 that are contained in the Eleventh Edition dated June 2007. It should be noted that the addition of Reference Section 2 and Definition Section 3 resulted in changes to paragraph numbers for all the subsequent sections.

Section 1: Scope

- Appendix L is now a mandatory appendix (Para. 1.1.18). It provides the Data Sheet and the Data Sheet instructions for listing required information to be used by the Purchaser and the Manufacturer.
- A new Appendix W provides commercial and documentation recommendations that may be applied when specified by the purchaser on the tank data sheet.
- A new section (Para. 1.3) covers the responsibilities of both the tank manufacturer and purchaser. It clearly states that the manufacturer is responsible for complying with all the provisions of API 650, and the purchaser's inspection, review, and even acceptance of the tank does not relieve the manufacturer of his responsibility.

Section 2: References

References have been moved to Section 2, and several new reference standards have been added. Among them are three Process Industry Practices (i.e., PIP) and several from the US EPA and OSHA.

Section 3: Definitions

A new Section 3 with definitions has been added.

Section 4: Materials

- Materials limitations have been added. Rimmed or capped steels are not permitted (Para. 4.1.1.2). Use of cast iron for any pressure part or any part attached to the tank by welding is not permitted (Para. 4.1.1.3). Cadmium-plated components shall not be used without the expressed consent of the Purchaser (Para. 4.1.1.4).
- Flange bolting and gasket requirements are now specified (Paras. 4.7 and 4.9).

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Section 5: Design

- Weld pass restrictions have been specified (Para. 5.1.3.6).
- The top surfaces of bottom welds must be ground flush where they contact the bottoms of the shell, insert plates, or reinforcing plates (Para. 5.1.5.1).
- A new Figure 5-4 has been added to illustrate the basis for determining the net working capacity of the tank.
- Additional data has been added to clarify corrosion allowance requirements (Para. 5.3.2).
- A new Figure 5-5 has been added to illustrate a suggested detail for a foundation drip ring to prevent ingress of water between the tank bottom and foundation.
- The use of Table 5.1 for determining the thickness of the annular bottom-plate thickness is now restricted to tanks with an effective product height of H x G ≤ 23 m (75 ft).
- The minimum thickness of the first shell course of tanks with diameters less than 15 m (50 ft) but greater than 3.2 m (10.5 ft) has been increased from 5 mm (3/16 in.) to 6 mm (1/4 in.) (Para. 5.6.1.1).
- New requirements for shell nozzle flanges have been provided (Para. 5.7.6.1.a). Depending on the size, shell nozzle flanges shall meet the requirements of ASME B16.5, ASME B16.47 Series A or B, or ASME Section VIII, Division 1.
- Added requirement that shell manhole covers less than 34 kg (75 lb) have two handles (Para. 5.8.3.5). Covers weighing more than 34 kg (75 lb) shall be equipped with either a hinge or a davit.
- A requirement for protecting all free vents with corrosion-resistant coarse-mesh bird screens has been added (Para. 5.8.5.5).
- New requirements for flanged and threaded roof nozzles have been provided (Paras. 5.8.5.6 and 5.8.5.7).
- OSHA 29 CFR 1910, Subpart D, has been added to the list of required references for platforms, walkways, and stairways. Examples of acceptable details have been provided in three Process Industry Practices (Para. 5.8.10).
- Design requirements for floating suction lines have been added (Para. 5.8.11.1).
- A new Figure 5-23 has been added to show the details of a grounding lug (Para. 5.8.11.3).
- Additional design details have been provided for the drain holes in stiffening rings (Para. 5.9.3.3).
- The minimum width of a tank walkway must be adjusted to consider all projections (Table 5-17.2).
- The minimum width of stairs has been increased from 610 mm (24 in.) to 710 mm (28 in.) (Table 5-18.2).
- A requirement that circumferential stairways extend from the bottom of the tank up to a roof edge landing or gauger's platform has been added (Table 5-18.10).
- The requirements for openings for stairways in an intermediate stiffener have changed (Para. 5.9.9.7).
- A new Figure 5-26 has been added to show some acceptable column base details for a supported cone roof. The details are intended to provide for load distribution, corrosion and abrasion protection, free vertical movement, and prevention of lateral movement (Para. 5.10.4.7).
- When tank anchorage is required, a minimum of 4 anchors shall be installed (Para. 5.12.2).

Section 6: Fabrication

- A new paragraph covers the use of materials used to aid fabrication. It states that materials (e.g., lubricants, crayons) shall not have a detrimental effect on the structural integrity of the tank. Attachments that contain zinc or cadmium may not be welded to the tank within 12 mm (1/2 in.) of a weld (Para. 6.1.1.3).
- Prior to installing shell and roof plates, and before inserting a nozzle into a plate, the manufacturer shall visually inspect all edges of the plate to determine if laminations are present. Guidance on evaluating and repairing laminations is provided (Para. 6.2.4).

Section 7: Erection

- Requirements for foundation and grade work, and for removal of internal and external temporary attachments have been expanded and clarified (Para. 7.1).
- A new paragraph (Para. 7.3.6) covering hydrostatic testing requirements has been added. It provides details on items such as manufacturer responsibilities, purchaser responsibilities, tank metal temperature, fill and discharge rates, and settlement measurements.

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- Installation tolerances have been provided for nozzles and manholes (Paras. 7.5.6 and 7.5.7).

Section 8: Inspection

The criteria for determining the number of spot radiographs required on a tank have been changed. The new criteria are based on a per tank basis, rather than the prior practice which allowed selection based on a group of tanks (Para. 8.1.2.4).

Appendix A: Optional Design Basis for Small Tanks

Conformance to toughness requirements has been expanded to include bottom reinforcing plates in flush-type connections and flush-type shell connections, and flush-type fitting necks attached to the shell (Para. A.2.4).

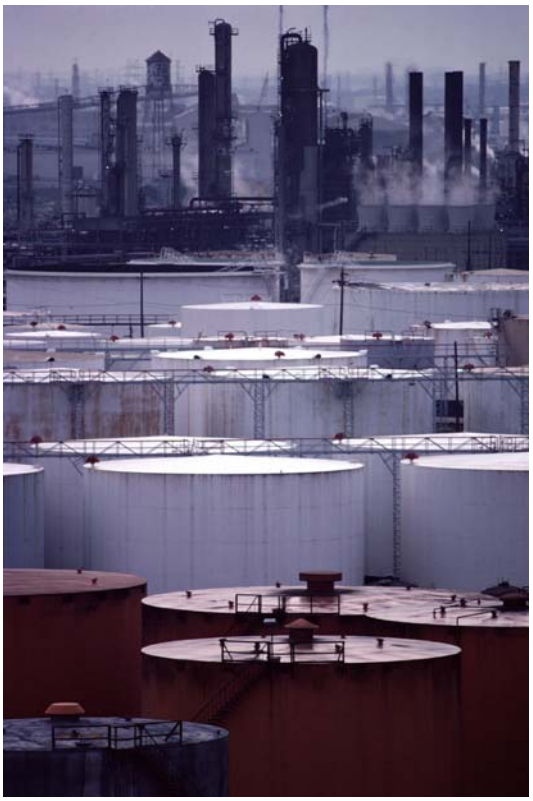
Appendix C: External Floating Roofs

There are changes to most of the paragraphs in Appendix C for external floating roofs. A complete review is recommended. Some of the changes to the design section are highlighted below.

- General – Para. C.3.1
  - Requirements detailing overflow protection and alarms have been added. Overflow slots shall not be used as the primary means of detecting an overflow incident (Para. C.3.1.1).
  - Minimum wall thickness requirements for sleeves and fittings that penetrate the roof deck have been specified (Para. C.3.1.2).
  - Detailed electrical bonding requirements are provided (Para. C.3.1.6).
- Decks – Para. C.3.3.6 – All covers for roof openings, except roof drains and vents, shall have gaskets or other sealing surfaces and shall be provided with an air tight cover.
- Ladders – Para. C.3.7 – New requirements covering step assemblies, ladder slope, wheels, and ladder grounding have been added.
- Roof Drains – Para. C.3.8 – New requirements covering drain hoses, sump design, roof drain trash stops, and freeze prevention have been added.
- Supporting legs – Para. C.3.9 – Minimum leg thickness and reinforcement requirements for leg sleeves have been specified.
- Roof Manholes – Para. C.3.11 – The minimum number of manholes has been specified based on the tank diameter.
- Anti-rotation devices – Para. C.3.12 – Guide poles must be used as an anti rotation device.
- Peripheral seals (rim seals) – Para. C.3.13 – Details specific to the types of primary, secondary, and mechanical shoe seals have been provided.
- Other Roof Accessories – Para. C.3.15 – A new section covering wax scrapers, foam dams, sample hatches, and automatic level gauges has been added.

Vincent Carucci, President of Carmagen Engineering, Inc., also provides mechanical engineering expertise in the areas of pressure vessels, heat exchangers, piping systems, and storage tanks to the process and power industries, insurance companies, and attorneys.

Steve Gliebe is a Professional Engineer with 30 years experience in the refining and chemical industries. He is well-versed in both engineering and supervision including hands-on experience managing maintenance and capital projects, training union and management colleagues, supervising maintenance/inspection organizations, developing programs for preventative maintenance of fixed equipment and piping per industry standards, and performing root-cause analyses to improve equipment reliability. Please contact Vince Carucci if you'd like more information on Carmagen's expertise in these areas.



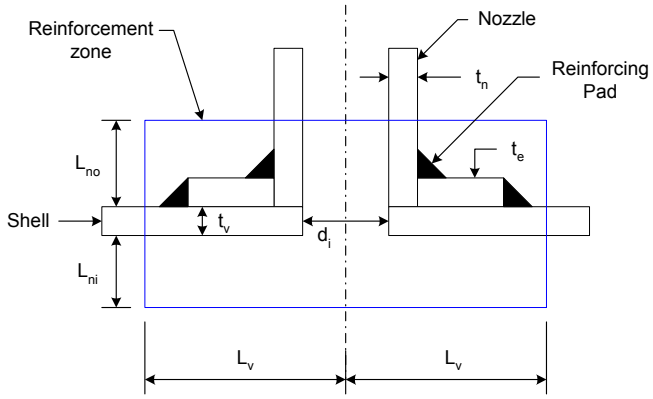
Article 3, API 579-1
Fitness-For-Service (FFS) - Nozzle Assessment

By Stephen J. Gliebe, P.E.

The first and second installments of this series of newsletters focused on Level 1 and Level 2 general metal loss in what API 579-1 / ASME FFS-1 2007 defines as Type A Components. These are components that have a design equation that specifically relate pressure or liquid fill height, and other loads, to a required wall thickness (e.g., pressure vessel cylindrical and conical shell sections).

In this (third) installment, we will take a look at general metal loss (GML) in nozzles. In API 579-1, nozzles are considered Type B Components. These are components that do not have a design equation that specifically relate pressure or liquid fill height, and other loads, to a required wall thickness. These components have a code design procedure to determine an acceptable configuration. These rules typically result in one component with a thickness that is dependent upon another component. Other examples of Type B Components include the reinforcement zone of conical transitions, branch connections, and flanges.

Assessment of GML in Type B Components must start at Level 2. Below are some guidelines for performing a Level 2 assessment for a reinforced nozzle connection in a shell such as that shown below. Nomenclature can be found in API 579-1 Part 4 and Annex A.



GML Level 2 Limitations

GML Level 2 assessments are permitted only if certain conditions are satisfied. The complete list of limitations in Parts 2 and 4 of API 579-1 should be reviewed before proceeding with a GML Level 2 FFS assessment. Some of the limitations for nozzle assessments are:

- For openings in a cylindrical shell, the opening does not exceed the following:
  - For vessels 1524 mm (60 inches) and less, min [D/2, 508 mm (20 in)]
  - For vessels over 1524 mm (60 inches), min [D/3, 1016 mm (40 in)]
- If nozzle loads are significant, a stress analysis must be performed

GML Level 2 Methodology

Guidance on performing a nozzle GML assessment is provided in API 579-1 Part 4, and Annex A Para. A.3.11. The procedure is based on the one used for the design of nozzles in the ASME Code Section VIII, Division 1. It may be used on nozzles with or without a reinforcing pad.

Assessment Summary:

- Determine the average thickness within the nozzle reinforcement zone
- Calculate the required reinforcement area
- Specify the Future Corrosion Allowance (FCA)
- Calculate the available reinforcement area due to the:
  - Excess thickness in the shell and nozzles
  - Reinforcement pad
  - Nozzle and reinforcement pad attachment welds
- Perform a weld strength analysis
- Compute the MAWP of the nozzle component
- If the flaw is unacceptable:
  - Repair, rerate or replace
  - Lower the FCA
  - Conduct a Level 3 assessment

Article 4

Article 4 in this series will cover API 579-1 Level 1 pitting assessments.

Steve Gliebe is a Professional Engineer with 30 years experience in the refining and chemical industries. He is well-versed in both engineering and supervision including hands-on experience managing maintenance and capital projects, training union and management colleagues, supervising maintenance/inspection organizations, developing programs for preventative maintenance of fixed equipment and piping per industry standards, and performing root-cause analyses to improve equipment reliability. Please contact Vince Carucci if you'd like more information on Carmagen's expertise in these areas.

Changes in API 653, Tank Inspection, Repair, Alteration, and Reconstruction

By Stephen J. Gliebe, P.E.

The following highlights several changes to API 653 that are contained in the Third Edition, Addendum 3, dated February 2008. Note that there is a new, non-mandatory, Appendix H that provides guidance on performing a similar service assessment. Highlights of the similar service assessment methodology are also provided below.

Section 3: Definitions

New definitions have been added for candidate tank, control tank, hydrotest, product-side, similar service assessment, and soil-side.

Section 4: Suitability For Service

- Roof: When a frangible roof-to-shell joint is required, a review of items impacting compliance with API 650, Section 5.10.2, is required (Para. 4.2.2.2).
- Vents: Vents shall be inspected for proper operation and screens shall be verified to be free of obstruction (Para. 4.2.4.5.2).
- Bottom: Para. 4.4.3 has been renamed Tank Bottom Release Prevention Systems. The sections covering cathodic protection and internal linings have been expanded, and new sections covering internal inspection and release prevention barriers were added.

Section 6: Inspection

Reporting requirements have been greatly expanded (Para. 6.9). Refer to the sections covering report contents and recommendations for additional details.

Section 8: Reconstructed Tanks

All tanks that are reconstructed shall be checked for seismic stability based on the rules of the current applicable standard (Para. 8.8).

Section 9: Tank Alteration and Repair

- Guidance is provided for installing a new bottom through an existing tombstone reinforcing plate (Para. 9.9.4).
- Fixed roof repairs involving tank venting shall be made such that normal and emergency venting meet the requirements of API Std. 650 (Para. 9.11.1.1).
- Fixed roof repairs involving modification to the roof structure and the frangible joint shall be in compliance with the requirements of API Std. 650 (Para. 9.11.1.2).
- Hot taps: Equations for calculating the hydrotest pressure of the hot tap nozzle have been provided (Para. 9.14.5.3).

Section 11: Welding

A new section covering preheat or controlled deposition welding methods as alternatives to post weld heat treatment has been added (Para. 11.3).

Section 12: Examination and Testing

Hydrotesting: A new section provides requirements for cases where a hydrostatic test is not required, such as repairs or alterations to a floating roof, and bottom repair or replacement outside the critical zone.

Appendix H: Similar Service Assessment

Appendix H, Similar Service Assessment, is new. The appendix provides a detailed approach for establishing internal inspection intervals for tanks for which corrosion rates have not been directly measured. Highlights of the methodology and a partial data sheet are noted below. Refer to Appendix H for complete details.

Methodology:

- Select a “control tank.” This is the tank for which service conditions and corrosion rates are well known.
- Select the “candidate tank.” This is the tank to be compared to the control tank to determine if similar service concepts apply.
- Complete the four assessments noted on the datasheets, including:
  - Tank bottom product-side
  - Tank bottom soil-side
  - Shell product-side
  - Shell external-side
- Determine the internal inspection interval
- Approve and file the completed data sheet

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Partial Similar Service Assessment Data Sheet

CONTROL TANK ID: _____ LOCATION: _____
DIAMETER (FT): _____ HEIGHT (FT): _____ CAPACITY: _____ BBLS

CANDIDATE TANK ID: _____ LOCATION: _____
DIAMETER (FT): _____ HEIGHT (FT): _____ CAPACITY: _____ BBLS

SECTION 2.0 - TANK BOTTOM (SOIL-SIDE) ASSESSMENT

H.2.1 **TANK CHARACTERISTICS**

	Control Tank[1]	Candidate Tank[2]	MATCH[3] Yes	MATCH[3] No	IF NO, SEE SEC.[4]
a. YEAR TANK ERECTED			☐	☐	H.2.1.1
b. BOTTOM MATERIAL			☐	☐	H.2.1.2
c. CORROSION ALLOWANCE			☐	☐	H.2.1.4
d. DOUBLE BOTTOM			☐	☐	H.2.1.7

H.2.2 **SOIL/MATERIAL IN CONTACT WITH OR AROUND BOTTOM PLATE[5]**

	Control Tank[1]	Candidate Tank[2]	MATCH[3] Yes	MATCH[3] No	IF NO, SEE SEC.[4]
a. SOIL TYPE			☐	☐	H.2.1.8
b. SOIL pH			☐	☐	H.2.1.8
c. SOIL ALKALINITY			☐	☐	H.2.1.8

(Partial extract from API 653)

Steve Gliebe is a Professional Engineer with 30 years experience in the refining and chemical industries. He is well-versed in both engineering and supervision including hands-on experience managing maintenance and capital projects, training union and management colleagues, supervising maintenance/inspection organizations, developing programs for preventative maintenance of fixed equipment and piping per industry standards, and performing root-cause analyses to improve equipment reliability. Please contact Vince Carucci if you'd like more information on Carmagen's expertise in these areas.

HIGHLIGHTS

Training

- Presented one-day, introductory level training courses covering piping design and maintenance, and heat exchanger design. These courses are part of an ongoing program in which our refining client has engaged Carmagen to present courses that the client has already developed themselves.
- Presented our Fitness-for-Service course for a training company located in the Caribbean. The course was attended by engineers from several companies who found it practical and immediately applicable to their needs.
- Presented our Aboveground Storage Tank Design and Maintenance course in Canada. This was the second "public" presentation of this popular course in the same region in less than six months, and was well received.
- Providing global manufacturing training course development support for a major refiner. This includes both assistance in the overall program and in developing specific training modules.

Heat Transfer Equipment

- Evaluated the design and operation of fired heaters on atmospheric and vacuum units to develop recommendations that will improve performance and/or run lengths. Recommendations were made that, if followed, will improve heater performance and reduce coking in the tubes.
- Made an initial site visit to review the performance and obtain operating data of multiple fired heaters installed at a Canadian tar sands upgrading unit. This one week visit was the starting point for a more extensive, energy audit of the fired equipment being carried out.

Process, Operations, and Safety

- Provided the mechanical and process design members of a Hazop Resolution Team (HRT) at a domestic refinery. The purpose of the HRT is to follow-up on items that were identified during prior refinery Hazops, and determine what follow-up action is needed (e.g., equipment rerates, operating changes, etc.).
- Performing ENCON scoping study of overseas refinery to identify areas for further plant energy optimization and heat recovery.
- Completed work for a Northeast refiner's expansion program to investigate broad process opportunities, including fuel gas balance improvement, H_2 management and reformer octane optimization, review of tower internal modifications, and other miscellaneous support.
- Conducting revamp studies for Northeast refiner's multiple trains of crude and vacuum unit fractionation, with the objective of identifying profit improvement opportunities.
- Conducting scoping review of overseas client's wastewater treatment facilities.
- Providing on-going, multi-unit HAZOP support to a domestic refiner's overall safety program.
- Completed review of a domestic refiner's FCC main fractionator internals to improve performance and reliability.
- Providing long-term, onsite process support to a refinery in the MidWest to augment client's resources to address miscellaneous small projects, troubleshooting, and staff mentoring.
- Performing hydrogen plant/management scoping support to a refinery in the MidWest.
- Supporting a Middle East refiner's long range safety/HAZOP program.
- Providing process and mechanical engineering support for a licensor's process development/design effort for commercialization of an overseas demonstration plant for new LPG Dehydrogenation technology.
- Completed process support associated with Fluid Coker coke handling system, baghouse fire incident assessment, and mechanical support issues in the reactor.
- Completed onsite Sulfur Recovery Unit scoping/ troubleshooting support for a client in the MidWest.
- Completed Cold Eyes Review of an international pharmaceutical company's global pressure relief and venting engineering standard.
- Performing onsite process support for an overseas refiner changing FCC operations from full combustion to partial burn regeneration mode.
- Preparing process specification/estimate for a Central American refiner implementing an upgrade in diesel dehazing provisions.

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Materials, Refractory, and Corrosion

- Providing ongoing materials engineering support to a major, integrated oil company. Current activities primarily involve helping to develop appropriate inspection plans for identified process units at a domestic refinery. Have also provided comments to update their pipeline coating practices.
- Providing ongoing materials engineering support to companies that are engaged in developing biofuels processes.
- Prepared a revision to a major refining company's refractory standard so that it meets the refiner's ongoing needs.
- Continued to provide ongoing, refractory engineering support to a major domestic refiner through multiple onsite visits before and during turnarounds, and by "remote" review of refractory design specifications, repair procedures, and testing procedures.

Project Management

- Providing onsite Project Construction Director for an Electrostatic Precipitator Project currently under construction at a domestic refinery.
- Continuing to provide both full-time and part-time project management and cost engineering support to multiple projects and clients in the US and overseas.

Mechanical Equipment

- Performed risk-based assessment of a reformer unit feed effluent exchanger to determine if its inspection interval could be increased. Based on mechanical, materials, and safety engineering evaluations, concluded that the exchanger's inspection interval may be increased such that it did not need to be opened during an upcoming turnaround, thus saving both time and expense.
- Completed Fitness-for-Service assessments of two towers at a European refinery. Also provided recommendations for inspection plans and inspection intervals. Determined that these 40 year old towers were good for continued, reliable service well into the future.
- Started mechanical engineering design audit activity of critical piping systems for a grass roots FCCU and Hydrocracker project for a client in the Far East. The work is focused primarily on the main, refractory-lined systems in the FCCU, and the critical high pressure/temperature lines in the Hydrocracker. An engineer from the prime contractor is resident in Carmagen's office for an extended period during this work.
- Evaluated the cause of a Fluid Coker Reactor dipleg brace failure, and whether it was appropriate to prematurely shut the unit down for repair. It was concluded that the failure was probably caused by a short-term temperature excursion, the probability of incurring an emergency shut down of the unit before the next scheduled turnaround was low, and that taking an unplanned shutdown to repair the brace was not economically justified. It was also recommended that an improved dipleg bracing arrangement be designed and fabricated so that it is ready to install at the next opportunity.
- Developed a bracing system design for a Fluid Coker Elutriator piping system in order to reduce its vibration. Excessive vibration was identified by the refiner as being the cause of a branch connection failure that occurred.

Miscellaneous

- Continued to provide welding, materials, and process engineering litigation consulting support for multiple major cases.
- Providing ongoing technical litigation support in analytical chemistry, process, and metallurgical areas to defend major refiner in class action suit.
- Completed noise analysis and study of refiner's machine shop to reduce noise levels.