

2016 API TANKS,
VALVES, AND PIPING
CONFERENCE & EXPO

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Importance of Door Sheet Stiffening

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Door Sheets

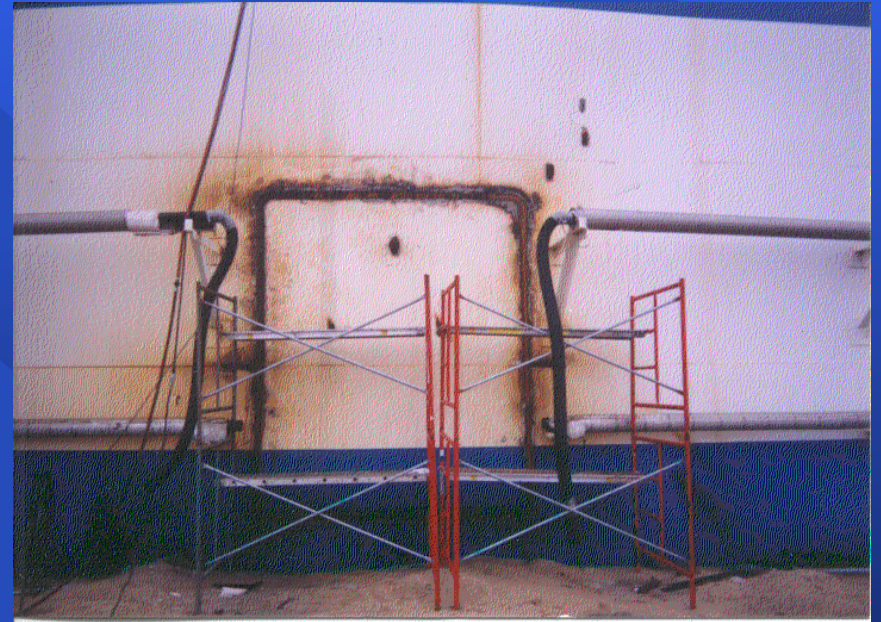
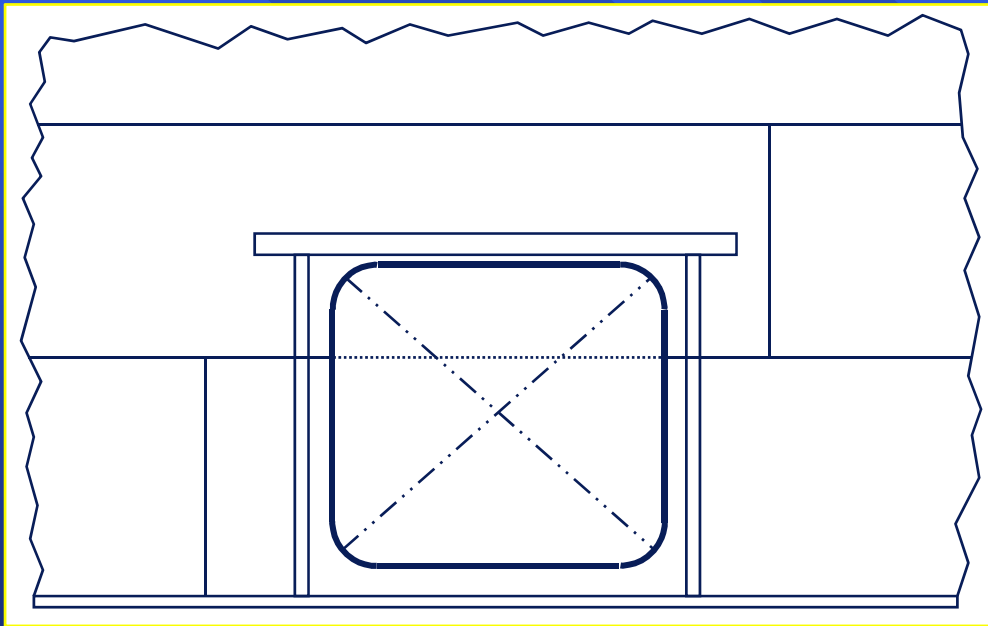
- What are they?
 - Temporary construction openings
 - Equipment and personnel access
 - Used for new tanks
 - Used for repaired and rehabilitated tanks
 - Full height shell plates, or
 - » Larger than full height of shell plate course
 - » Smaller than full height of shell plate course

Door Sheets

- What types are most commonly used?
 - Rounded corner type
 - Square corner type
 - Combination type
 - Bolted API Type (Obsolete)
 - » Very difficult to replace once removed
 - » Should not try to use for repair work

Types of Door Sheets

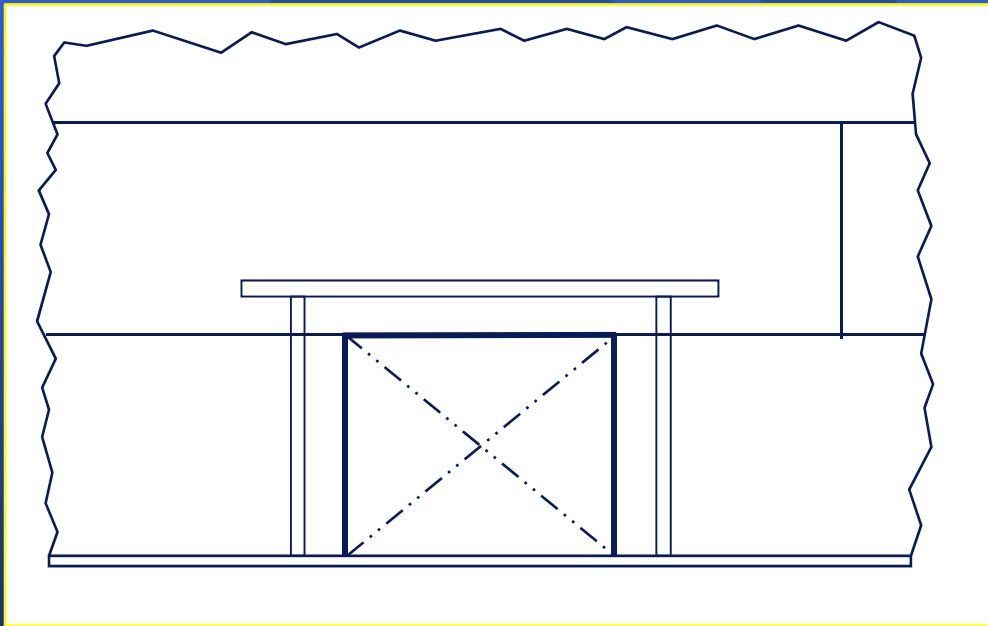
■ Rounded Corner Doorsheet



Source: TIC Project Files

Types of Door Sheets

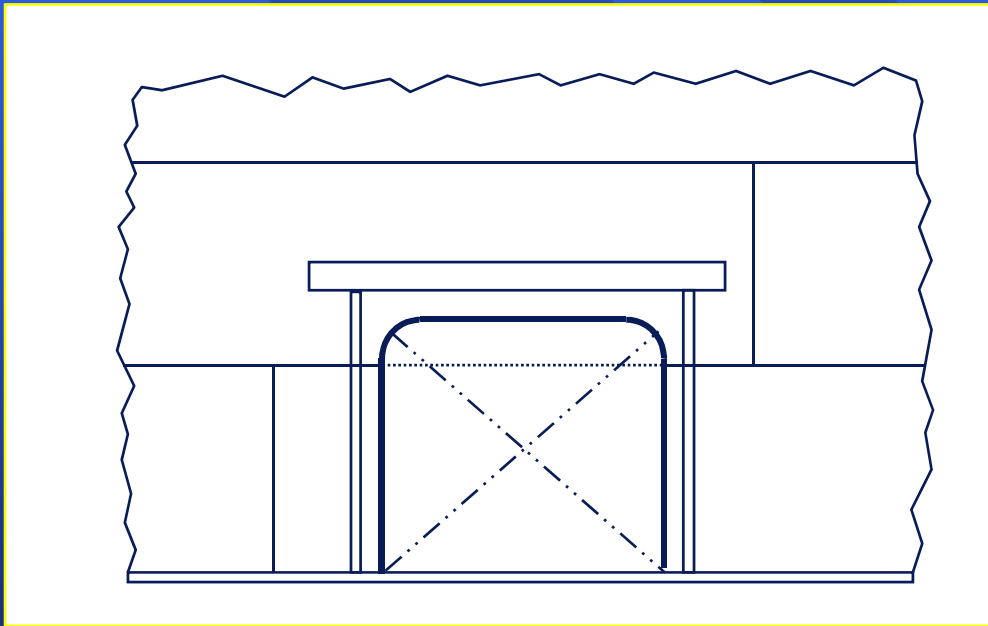
■ Square Corner Doorsheet



Source: *waterjet-cutting-doorsheet_0 internet*

Types of Door Sheets

■ Combination Doorsheet



Source: api-tank-single-course-door-sheet-internet

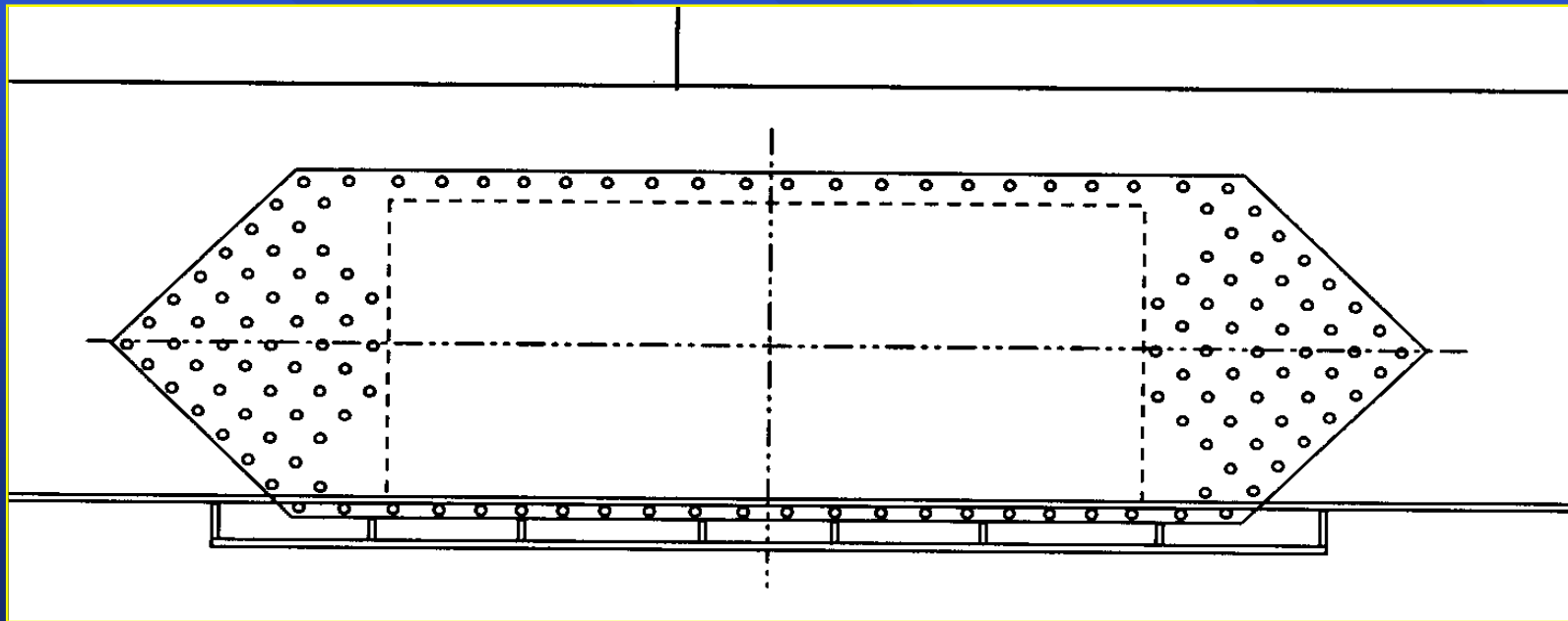


Source: DE19_002-539x354 internet

Types of Door Sheets

■ Obsolete Bolted Door Sheet

- Very difficult to re-install after removal due to misalignment of bolt holes resulting from shell distortions



API Standards – Door Sheet Requirements

- API 650 and API 620
 - No provisions for door sheets
- API 653 – 9.2.4 Door Sheet Installation
 - Addresses welded and riveted tanks
 - Specifies minimum weld spacing and weld cut-back
 - Specifies when to use rounded corners
 - Does not address weld sequencing to minimize distortion
 - Currently does not address door sheet stiffeners

Door Sheet Stiffening

- Why is Stiffening Necessary?
 - Prevent deflection of the shell at the opening during new tank construction.
 - Stabilize the shell against deflection during removal and re-installation of the door sheet for existing tank repairs, including:
 - » Sagging and flattening of shell at top of opening
 - » Shell deformations at the sides and upper corners

API Standards – Door Sheet Requirements

- Agenda Item in Committee Proposes to Add:
 - 9.2.4.3 Large door sheets of the type shown in Figures 9.2, 9.3, 9.4 and 9.5 shall have the top and sides of the opening stiffened to prevent a) sagging and flattening of the shell at the top of the opening, and b) shell deformations at the sides and upper corners resulting when the door sheet is first removed or when it is replaced and welded into the shell. Installation of the stiffening members shall be done prior to cutting the door sheet and the members shall remain in place until the door sheet is completely and satisfactorily re-installed. The requirements for door sheet stiffening may be waived if a tank engineer confirms by calculation and/or analysis that the stiffening is not required.

API Standards – Door Sheet Requirements

■ Summary of Agenda Item in Committee:

– If adopted, new agenda item will:

- » Specify general arrangement of door sheet stiffeners,
- » Specify timing of stiffener installation and removal,
- » Allow waiver of door sheet stiffeners with analysis

– If adopted, new agenda item will not:

- » Provide rules for design of stiffeners
- » Mandate the use of stiffening in all cases

Guidelines for Door Sheets & Stiffening

- Select Location of Door Sheet
 - Convenient to equipment and materials
 - Away from shell distortions, discontinuities
 - Observe API 653 weld spacing requirements
 - Flush with bottom vs. elevated above bottom?



Source: TIC Project Files, Everett, WA

Guidelines for Door Sheets & Stiffening

- Size of Door Sheet Opening
 - Width \leq 12 ft and \leq Tank Diameter / 5
 - Height $<$ Height of First Two Shell Courses
 - 10% to 15% $>$ Dimension of Largest Item of Equipment to Pass Through Door Sheet

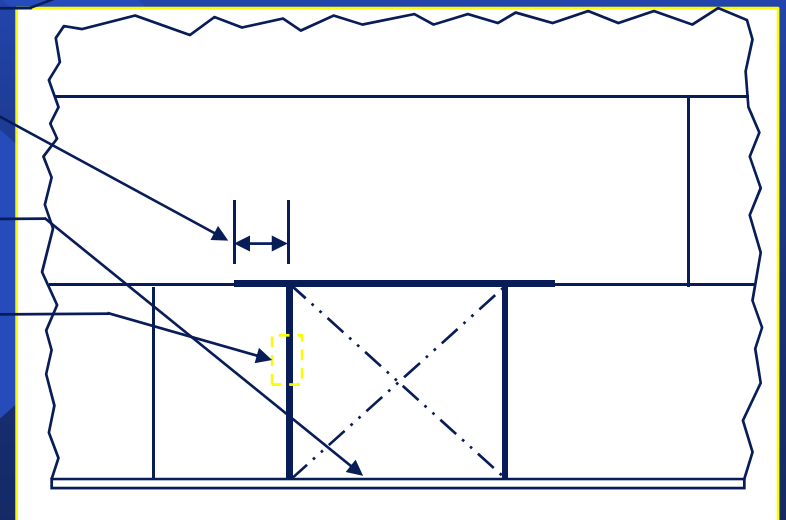
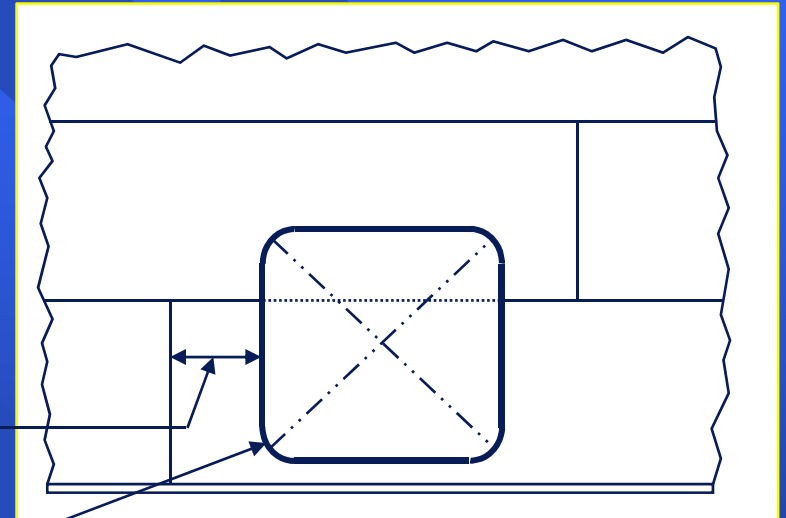


Source: commons.wikimedia.org

Guidelines for Door Sheets & Stiffeners

■ Details of Door Sheet per API 653, 9.2.4

- API 653, Figures 9.2 thru 9.5
- Weld Spacing and Offsets
- Rounded Corners
- Weld Cutbacks
- Welding Sequence
- Inspection and NDE



How Does Tank React to Large Openings?

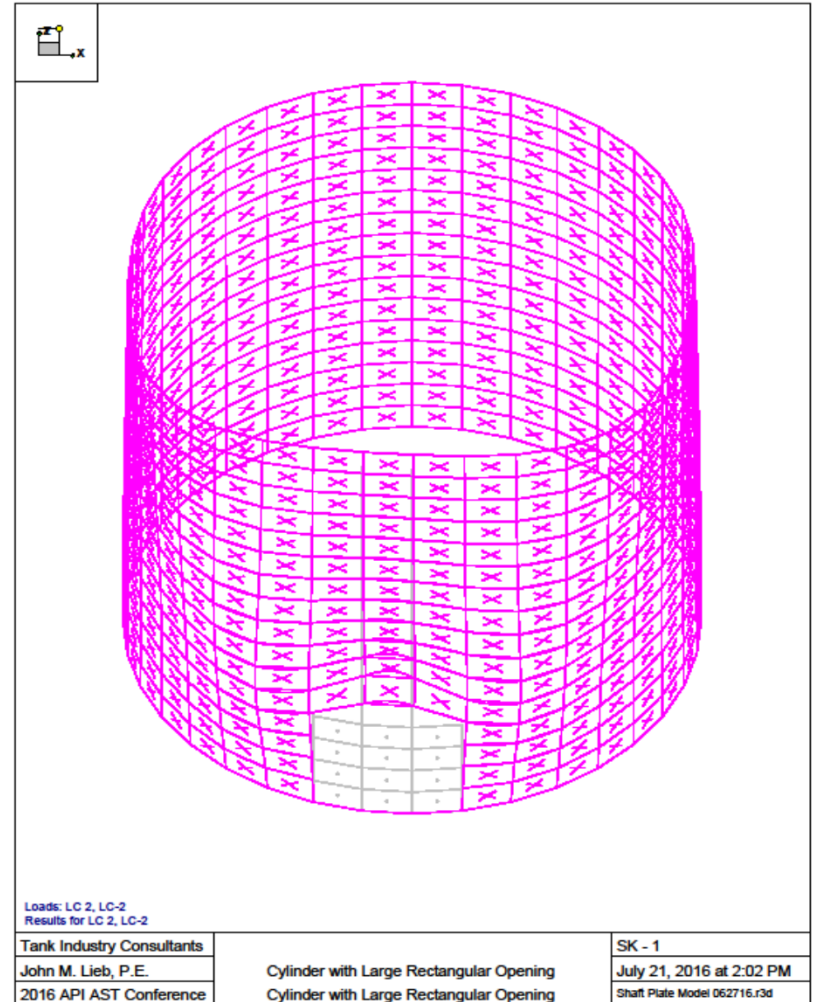
Behavior of Tank Shell
With Large Rectangular
Opening:

Displacements shown are
greatly magnified . . .

Flattening above door
sheet . . .

Bulging at corners . . .

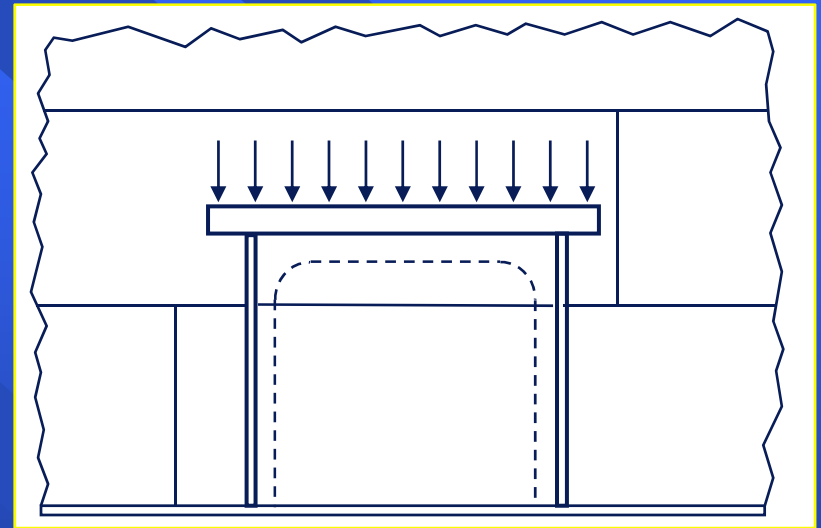
Ovalling of shell . . .



Guidelines for Door Sheets & Stiffening

■ Stiffeners

- Vertical side and horizontal top stiffeners
- Install before opening is cut and remain on shell until door sheet is replaced
- Locally stiffen area surrounding door sheet
- Must carry loads of shell and roof above opening



Source: TIC Project Files

Benefits of Door Sheet Opening Stiffeners

■ Horizontal Top Stiffener

- Resists tendency of shell above door sheet opening to flatten and shell to “twist” at corners of opening
- Transfers load of shell above opening to vertical side stiffeners

■ Vertical Side Stiffeners

- Resists tendency of shell on sides of opening to bow or “belly”
- Transfers load of shell above opening to tank foundation

Guidelines for Door Sheets & Stiffening

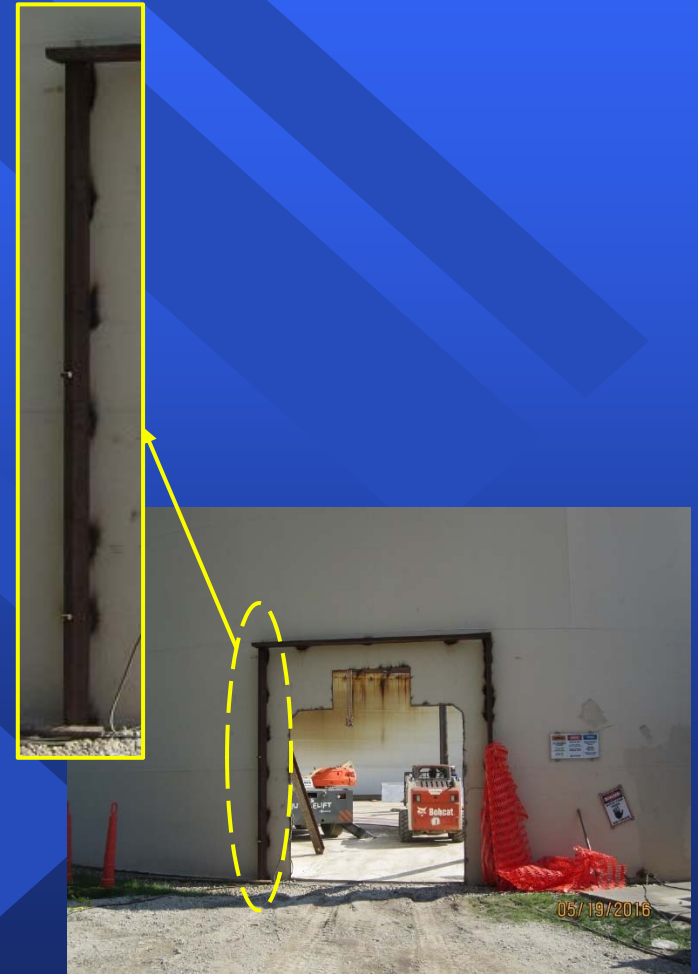
- Top Horizontal Stiffener:
 - Rolled to curvature of shell or straight as shown here
 - Usually not required for openings < 6 ft wide
 - Min. 6” from edge of opening
 - Attach with intermittent welds or brackets, except fully weld to vertical stiffeners



Source: Photo by J. M. Lieb

Guidelines for Door Sheets & Stiffening

- Vertical Side Stiffeners:
 - Extend from top stiffener to bottom of tank shell
 - Min. 6” from edge of opening
 - Attach with intermittent welds, except fully weld to horizontal stiffener
 - Normally same size as top horizontal stiffener



Source: Photo by J. M. Lieb

Guidelines for Door Sheets & Stiffening

■ Typical Stiffener Sections

- Angle (6 x 4 x 1/2 min.)
- Channel
- WT
- Wide Flange

■ Other Sections

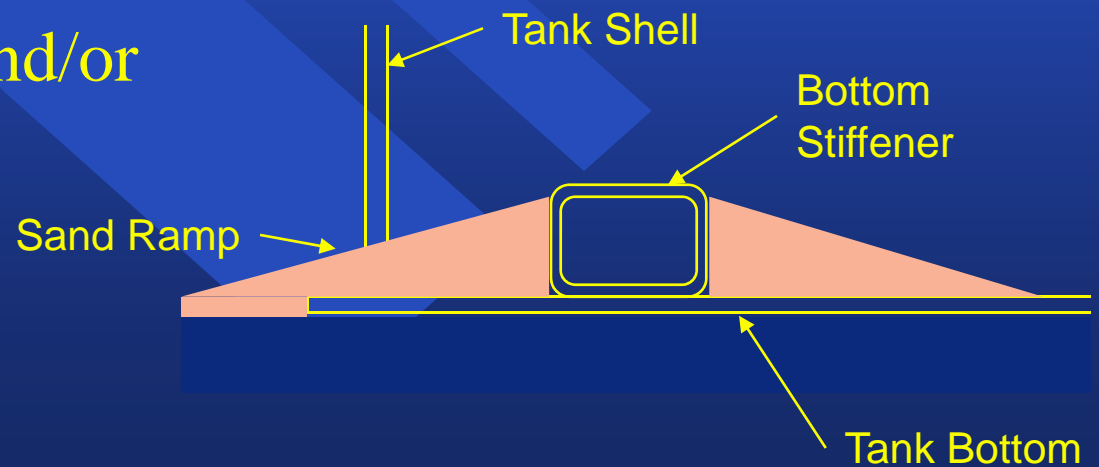
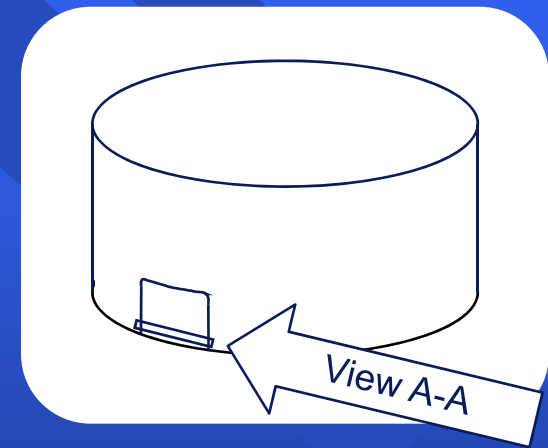
- Rectangular Tube



Source: DiscountSteel.com

Guidelines for Door Sheets & Stiffening

- Other Stiffeners:
- Bottom Stiffeners
 - When door sheet opening is flush with bottom of tank, and
 - Activity of heavy equipment through opening may cause distortion of bottom and/or shell

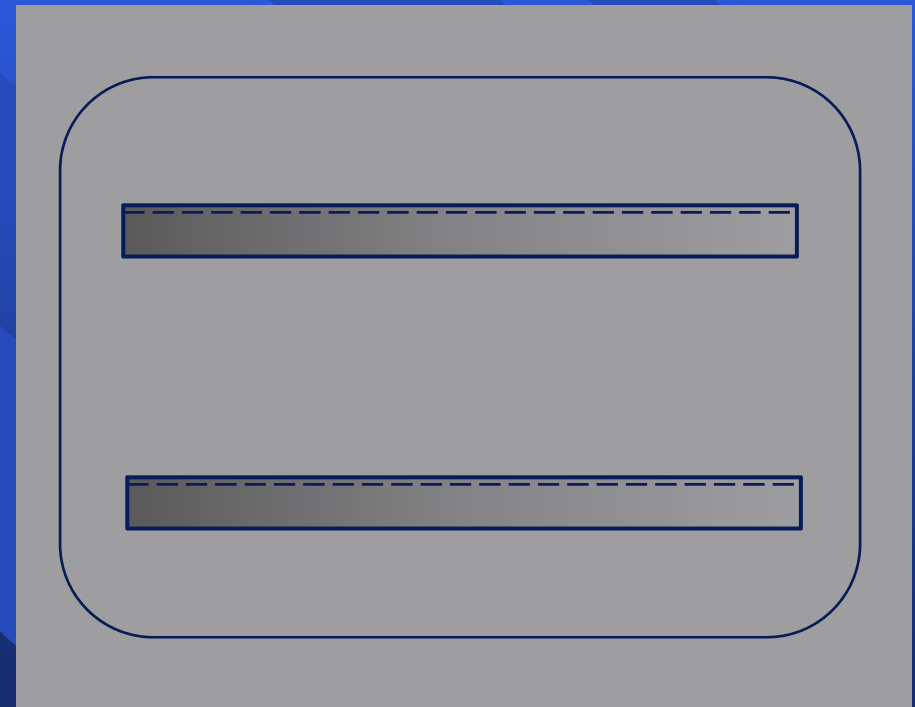


Guidelines for Door Sheets & Stiffening

- Other Stiffeners:
- Door Sheet Plate Stiffeners
 - Sometimes used to hold shape of door sheet plate
 - Rolled to shell curvature or straight as shown
 - Usually not required on most common size door sheets



Plan View

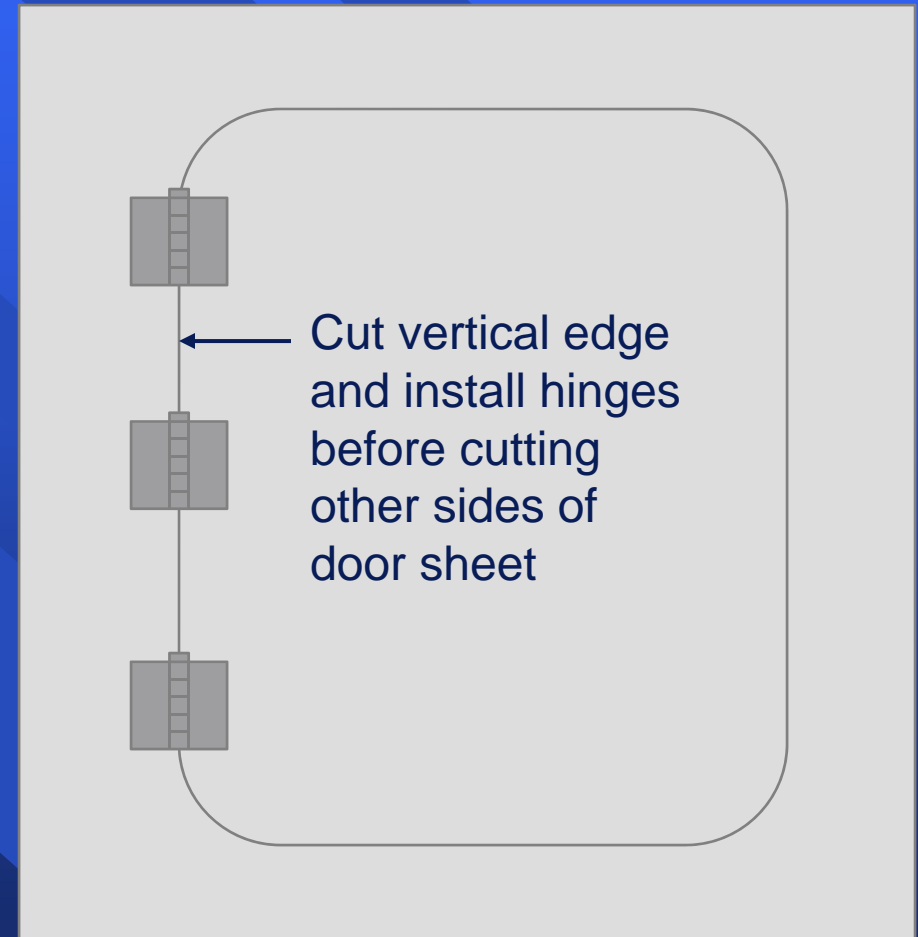


Elevation View

Guidelines for Door Sheets & Stiffening

■ Hinges

- Sometimes used to facilitate positioning of door sheet during replacement
- Install hinges after cutting vertical side but before cutting horizontal sides
- Can adversely affect re-installation of door sheet if not done properly



Guidelines for Door Sheets & Stiffening

■ Stiffener Removal & NDE

- Air-arc gouge or grind off stiffener attachment welds
- Grind smooth remnants of attachment welds but don't over-grind
- Visually examine ground areas for indications of cracks or other defects
- Magnetic particle or dye penetrant examine ground areas
- Repair defects per API 653 if and as necessary

Examples of Door Sheet Stiffening



Source all Photos: TIC Project Files, Everett, WA

Examples of Door Sheet Stiffening

Removing Solid Materials
Through Door Sheet



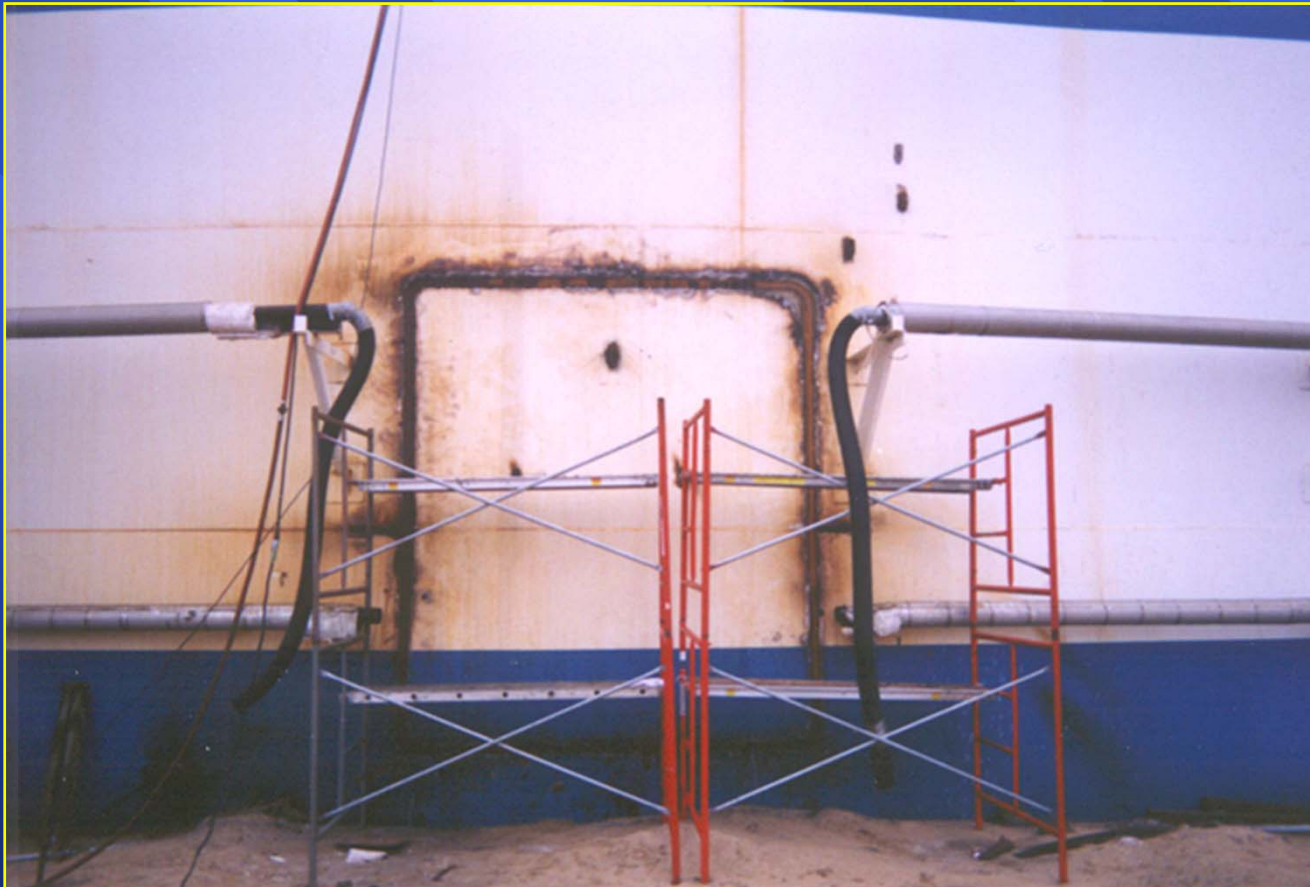
Source: Unknown – TIC Project Files

Water Jet Cutting a Door Sheet
(Note Flush Type Cleanout)



Source: waterjet-cutting-doorsheet_0 internet

What Can Happen Without Stiffening



Source: Photo by J. M. Lieb

What Can Happen Without Stiffening



Significant shell distortion above door sheet along diagonal line from corner of door sheet

Source: Photo by J. M. Lieb

What Can Happen Without Stiffening

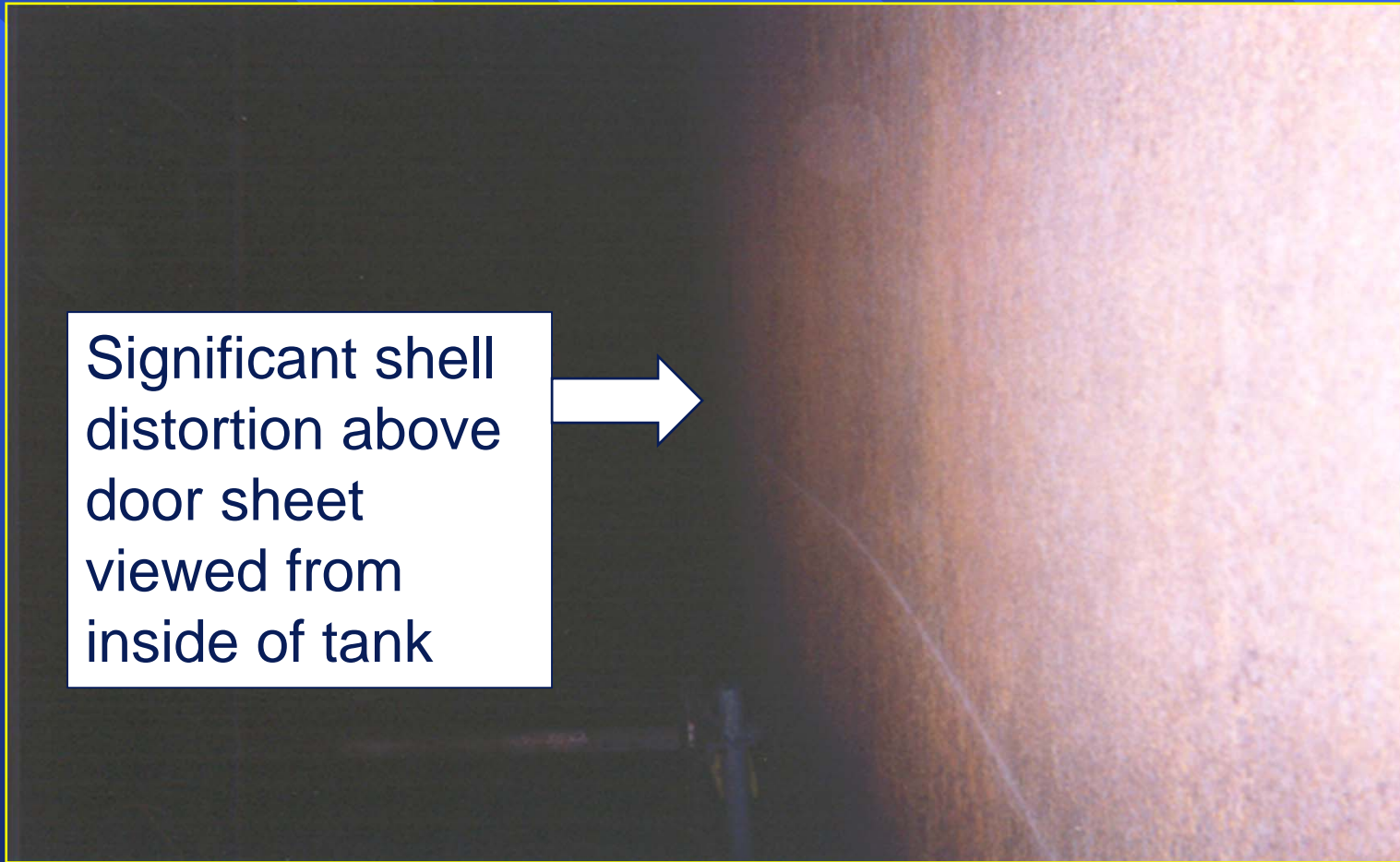


Significant shell distortion above door sheet along diagonal line from corner of door sheet

Source: Photo by J. M. Lieb

What Can Happen Without Stiffening

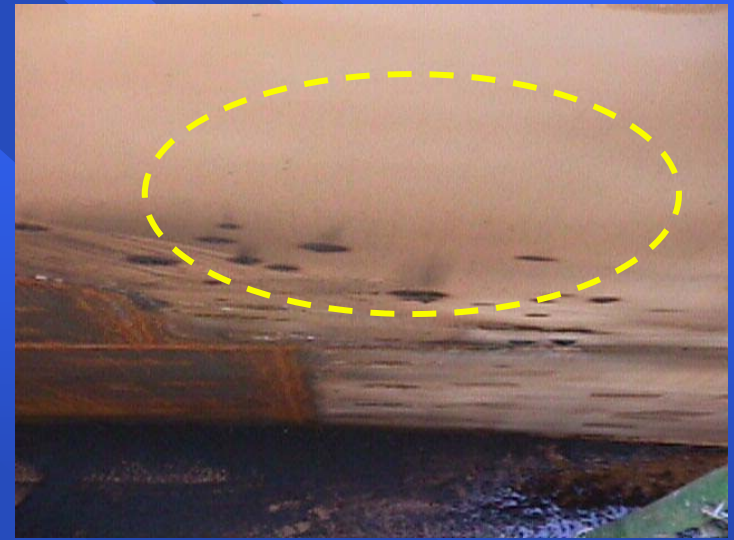
Significant shell
distortion above
door sheet
viewed from
inside of tank



Source: Photo by J. M. Lieb

What Can Happen Without Stiffening

Different Tank; Similar Distortions



Source All Photos: TIC Project Files

What Can Happen Without Stiffening

Same Tank as Previous Slide



Source All Photos: TIC Project Files

Other Contributing Causes to Door Sheet Problems



Poor workmanship:
Cutting
Fitting
Welding



Improper storage of
door sheet



Source: All Photos by J. M. Lieb

What are the Risks?

- Unsightly Tank
- Reduced Wind Stability (Flat Spots)
- Obstruction of Floating Roof Travel
 - Binding of seals
 - Damage to seals
- Potential Fatigue Cracking

A risk matrix with 'Impact' on the vertical axis and 'Likelihood' on the horizontal axis. The vertical axis has three levels: High, Medium, and Low. The horizontal axis has three levels: Low, Medium, and High. The cells are color-coded: High Impact/Low Likelihood is yellow; High Impact/Medium Likelihood is red; High Impact/High Likelihood is red; Medium Impact/Low Likelihood is green; Medium Impact/Medium Likelihood is yellow; Medium Impact/High Likelihood is red; Low Impact/Low Likelihood is green; Low Impact/Medium Likelihood is green; Low Impact/High Likelihood is yellow.

	Likelihood		
	Low	Medium	High
High	Yellow	Red	Red
Medium	Green	Yellow	Red
Low	Green	Green	Yellow

Door Sheet Recommendations

■ Engineering Specification

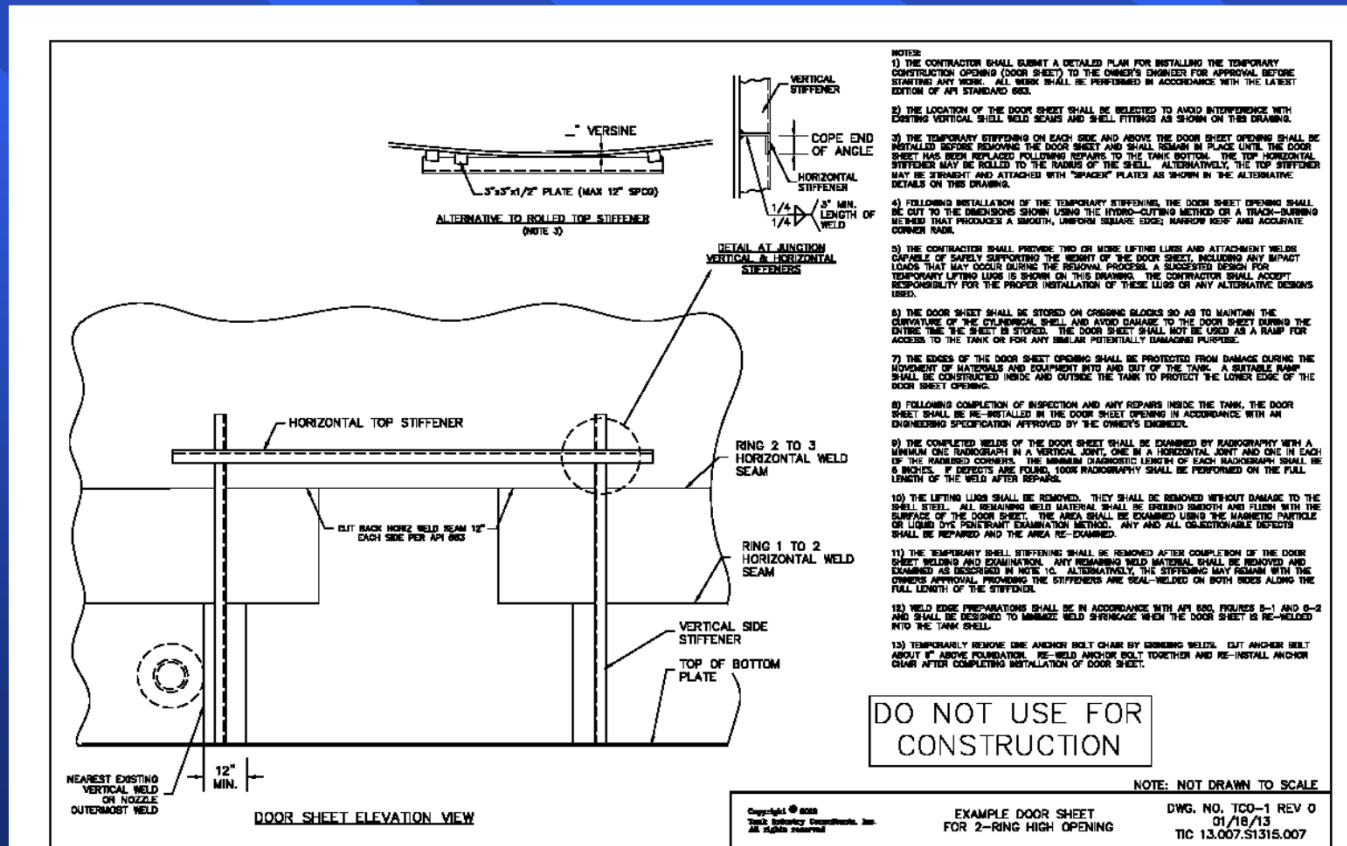
- Door sheet should not be treated as incidental to the work requiring the door sheet
- Why is a Specification important?
 - » Documents technical requirements
 - » Establishes responsibilities of various parties

■ Carefully Evaluate Stiffener Requirements

- When in doubt, use stiffeners
- Inexpensive method to mitigate risk of distortion

Door Sheet Plans

■ Require a Door Sheet Plan!



Source: Tank Industry Consultants (TIC)

Door Sheet Plans

- Without an Engineered Door Sheet Plan:
 - Must rely solely on Contractor for problem-free door sheet removal/re-installation.
 - Most major field-erected Tank Manufacturers have experience and will provide door sheet plans upon request, but ...
 - Inexperienced Contractors may not anticipate problems that can result from improper door sheet removal/re-installation or may not have suitable door sheet plans to submit.

Door Sheet and Opening Stiffening

■ Summary

- Door sheet should not be treated as incidental to the work requiring the door sheet
- Carefully evaluate door sheet requirements, minimize size when possible
- Stiffen the door sheet opening if and when necessary or when in doubt
- Perform door sheet removal and installation in accordance with specifications and per API 653

Door Sheet Stiffening



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