API 650 TANKS

INSTALLATION and COMMISSIONING

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Process Water Tanks
FMG Cloudbreak Mine-site

API 650 TANKS

- INSTALLATION
  - TANK BUNDS
  - FOUNDATIONS/RING BEAMS
  - WELDING PROCEDURES
  - FLOOR PLATE LAYOUT
  - STRAKE LAYOUT
  - ROOF CONSTRUCTION
  - ROOF LIFT
  - NOZZLE INSTALLATION
  - SURFACE PREPARATION
  - TOLERANCES
- COMMISSIONING
  - TANK STRAPPING
  - NDT
  - HYDROTESTING
  - PV VENTS
  - CONTROL PHILOSOPHY
  - INSTRUMENTS

Process Water Tanks, Diesel Storage Tanks, Cloudbreak

TANK BUNDS

- AS1940 mandates bunded storage for hydrocarbon storage facilities. Bund volume shall not be less than 110% of the volume of storage.
- For multiple tanks, multiple products the storage volume is 110% of the largest tank. Although each tank must be independent and fully isolatable from the other tanks.
- Bund Construction
  - Earthen bund fully lined with a composite Geo-Fabric, Welded HDPE liner, Geo Fabric Membrane installed on a select fill base
  - Bund walls with a 45 Degress angle of repose covered with a concrete filled revetment mattress.
  - Revetment mattress can either be painted or covered with a layer of concrete.
- Bund liner is pneumatically leaked tested on the overlapping welded seam.

TANK BUND CONSTRUCTION

1. Geo-Fabric HDPE Lined Bund.
2. Concrete filled revetment mattress prior to final coating.
3. Compacted select fill providing a metre of cover over the Geo-Fabric HDPE membrane.

Tank Bund Construction

Other forms of Bunding

- Self Bunded Tanks
  - Limits storage volume and results in multiple tanks.
- Concrete Bunds
  - Effective for a tank farm with an array of small tanks.
- Both methods cost prohibitive on large volume storage facilities.

Images courtesy of DRA Tank

Foundation Ring Beam Construction

- Tank foundations at typically of 3 types.
  - Concrete Ring Wall
  - Asphalt
  - Sand-pad
- FT&P almost exclusively build tanks on a concrete ring wall foundation.

Concrete Ring Beam Design

- Ring beams perform a variety of functions. A critical aspect of ring beam design is whether holding down bolts are required for wind overturning stability.
- Factors influencing the needs for holding down bolts include;
  - Cyclonic region and prevailing wind speeds. (AS/NZS 1170.2:2002)
  - Weight of Tank (excluding roof and contents)
  - Aspect ratio of the tank, tall versus squat to achieve the same storage
  - Client specifications.

Ring Wall Components

- Reinforcing Bars
  - Re-bar comprises ligatures placed on an angular pattern with a maintained spacing.
  - A total 8 to10 rolled circumferential lace bars located on the internal and external diameters of the ligatures.
  - Plywood board and rolled tubes make up the remainder of the form.

Ring Wall Components

- 30mm Ø PVC pipes are installed at 4 angular locations to provide weep holes leaking product.
- Tank earthing is facilitated by connecting the tank shell to the rebar.
- The ring wall is back filled with select fill and compacted to 95% mdd.
- Diesel is sprayed on the fill to prevent corrosion of the underside of the floor plate.
- Bitumen board installed on top of the ring wall providing a compressive membrane between it and the floor plate.

Construction of Ring Wall

- Ring beam foundation is excavated after the liner has been installed and the bund has been backfilled.
- A 50mm layer of blinding is installed to provide a stable base for the construction of the formworks.
- Establishing a stable level base/foundation is critical to achieving tight tolerances on the overall tank build.

Ring Wall Construction

Ring Wall Construction

Holding Down Bolts Analysis

Check for Over Turning

CHECK OF OVERTURNING MOMENT

TO: AS 1170.0-2002, API STANDARD 650-1198

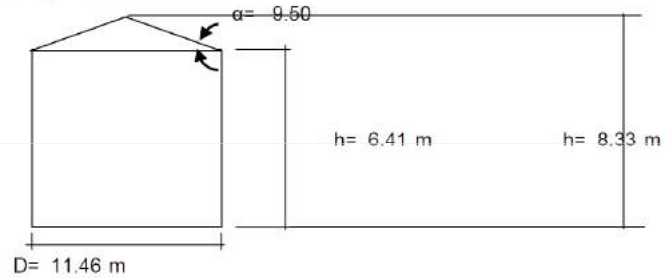
Author: Blake Thomson 28/04/08

(non-verified)

JN2332 - Diesel Storage Tank

(DO NOT ALTER. Only enter data highlighted blue)

Tank Details



Weight of Tank Shell	**CORRODED**		106.6 kN
Weight of Tank Roof	**CORRODED**		71.0 kN
Weight of Floor Plate	**CORRODED**		48.5 kN
Additional Mass			10.0 kN
Total weight			236.1 kN
Internal Pressure			0 kPa
Yield stress of floor plate F_{by}			280 MPa
Floor thickness t_b	**CORRODED**		6 mm
Yield stress of annular plate F_{ay}			280 MPa
Floor Annular Plate ta	**CORRODED**		6 mm
Width of Annular Plate			1 m
Contents Height		H	6.21 m
Contents Density		G	0.95 g
Roof Live Load			1 kPa

Wind Forces, Overturning Moments

Wind Forces As Per AS1170.2

Working Stress Wind Speed	76.4 m/s
Terrain Category	1
Region	D
$M_{z.cat\ roof}$	0.98
$M_{z.cat\ tank\ shell}$	0.93
M_t	1.00
M_s	1.00
M_d	0.95
$V_{des\ roof}$	71.4 m/s
$V_{des\ shell}$	67.6 m/s

Wind Forces, Overturning Moments

Overturning MomentsDue to wind

$M_{w.AS1170.2}$	1293.9	kNm	$M_{w.API\ 650}$	N/A	kNm
M_{pi}	0.0	kNm			
M_{DL}	1074.9	kNm			
M_F	3045.2	kNm			

Wind code check to AS1170.2

Requirements for Unanchored Tanks

$0.6\ M_w + M_{pi} < M_{DL}/1.5$

776.3 < 716.6

$M_w + 0.4\ M_{pi} < (M_{DL}+M_F) / 2$

1293.9 < 2060.1 **ANCHOR BOLTS ARE REQUIRED**

Design of Anchor Bolts

Design Presure	P	kPa	0
Test Presure	P_t	kPa	0
Failure Presure	P_f	kPa	0
Roof Plate Thickness	t_h	mm	10
Dead Load of Shell Coroded	W_1	kN	106.0
Dead load of Shell+Roof	W_2	kN	187.6
Dead Load of Shell WITHOUT Corrosion	W_3	kN	106.0
Wind Moment	M_w	kN-m	1293.9
Seismic Moment (Taken from M_{rw})	M_s	kN-m	1265.3
Bolt Size			M24
Bolt Grade			4.6
Yield Stress of Bolt	F_{Fy}	MPa	240
Ultimate Tensile Stress of Bolt	F_{uf}	MPa	400
Allowable Core Area of Bolt	A_c	mm^2	324
Allowable Tensile Stress Area of Bolt	A_s	mm^2	353
Actual Bolt Cross Section	A_A	mm^2	452

Uplift Load Cases	**(Table 5-21a)**		**UPLIFT**	**Acual Bolt Stress (Mpa)**	**Allow Bolt Stress (Mpa)**	**Status**
Design Pressure Case		N	0	0.0	105.0	**OK**
Test Pressure Case		N	0	0.0	140.0	**OK**
Failure Presure Case		N	0	0.0	240.0	**OK**
Wind Load Case		N	264027	46.7	192.0	**OK**
Seismic Load Case		N	254052	45.0	192.0	**OK**
Design Presure + Wind		N	345545	61.2	140.0	**OK**
Design Presure + Seismic		N	335569	59.4	192.0	**OK**
	MAXIMUM		**345545**			

Maxium Tensile Load Per Anchor					kN	21.6
Allowable Bolt Stress					MPa	140
Actual Bolt stress					MPa	61
	IF	**61**	**=**	**140**	**OK**	

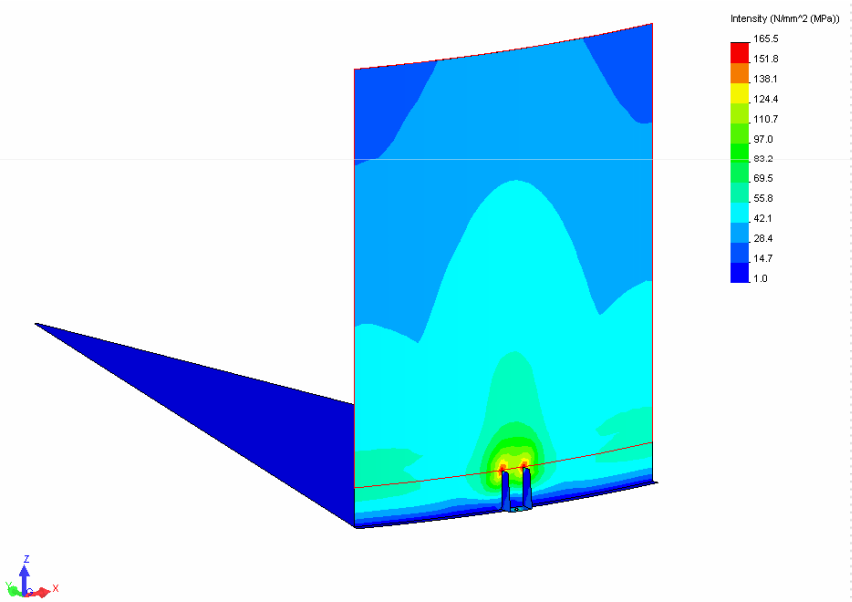
Holding Down bolt Arrangement

Ring Beam for HD Bolts

Inverted Tee Ring Beam

Holding Down Bolt Arrangement

FEA of HD Arrangement



Shell Bolting Arrangement

Weep Hole, Earthling Strap

Floor Plate Layout

- Typically floor plate ranges in thickness from 6-10mm without the addition of corrosion allowance.
- FT&P generally utilise an offset over lapping plate arrangement.
- Alternatively, an annular plate arrangement is often used which allows for thicker plate at the shell interface and simplifies floor replacement.

Floor Plate Layout

Floor Plate

AS1692 3.7 and Applicable Welding Code

- For Cylindrical Vertical Tanks greater than 4.5m in diameter AS1692 nominates a Category 6 tank.
- Category 6 Tank
  - AS1692 nominates either BS EN 14015 API620 or API650.
- Welding Standard
  - AS1692 allows an Australian Standard to be nominated in place if both purchaser and contractor are agreeable.

Welding Standard

- Which code FT&P use ?
  - AS3992 and Pre-qualified Procedures?
  - AS1554
  - AS1210
  - API650

Welding Standard

- API650 derives the welding code from
  - Section IX of the ASME code.
- FT&P almost exclusively use procedures qualified to API650.
- API650
  - Visual Examination permissible limits are commensurate with the build conditions.

Visual Examination

8.5.1 A weld shall be acceptable by visual inspection if the inspection shows the following:

a There are no crater cracks, other surface cracks or arc strikes in or adjacent to the welded joints

b Maximum permissible undercut is 0 4 mm ($^1/_{64}$ in) in depth for vertical butt joints, vertically oriented permanent attachments, attachment welds for nozzles, manholes, flush-type openings, and the inside shell-to-bottom welds. For horizontal butt joints, horizontally oriented permanent attachments, and annular-ring butt joints, the maximum permissible undercut is 0.8 mm ($^1/_{32}$ in.) in depth. 07

c The frequency of surface porosity in the weld does not exceed one cluster (one or more pores) in any 100 mm (4 in.) of length, and the diameter of each cluster does not exceed 2 5 mm ($^3/_{32}$ in.)

d. The reinforcement of the welds on all butt joints on each side of the plate shall not exceed the following thicknesses: 07

Plate Thickness mm (in)	Maximum Reinforcement Thickness mm (in)	
	Vertical Joints	Horizontal Joints
≤ 13 ($^1/_2$)	2 5 ($^3/_{32}$)	3 ($^1/_8$)
> 13 ($^1/_2$) to 25 (1)	3 ($^1/_8$)	5 ($^3/_{16}$)
> 25 (1)	5 ($^3/_{16}$)	6 ($^1/_4$)

The reinforcement need not be removed except to the extent that it exceeds the maximum acceptable thickness or unless its removal is required by 8 1 3 4 for radiographic examination.

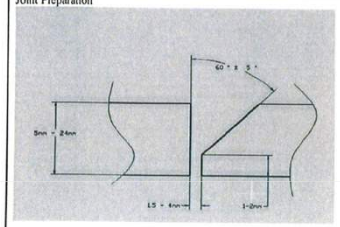
Vertical Down API650 Procedure

FUEL TANK AND PIPE PTY LTD

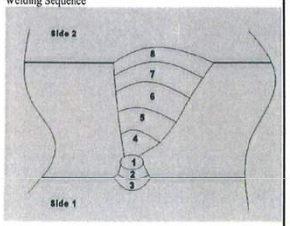
WELDING PROCEDURE SPECIFICATION

WPS No.	5	Rev No.	0	From WPQR	5	2nd WPQR	-
Client	Austrian Energy	Job No.	80089-041	Project	Distillate Storage Facility		
Applicable Code	API650-1998, ASME IX -2004			Material 1	Grade 250/300		
Specifications				Material 2	Grade 250/300		
Welding Process	MMAW			Thickness	5mm-24mm		
Joint Type	B-C4A,T-C4A,C-C4A			Diameter	N/A		
Position	3G						

Joint Preparation



Welding Sequence



Thermal Condition		Welding Technique / Preparation	
Min Preheat	N/A	Preparation Method	Flame/machine/cut & grind
Method		Gouge Method	Grind if reqd.
Temp. Check		Interpass Cleaning	Grind & or wire brush
Arc Energy	>2.0kJ/mm	Max Bead Width	N/A
Max Interpass	250 °C	Electrical Stickout	15mm
PWHT	Not Required	Shielding Gas Flow	N/A
		Purge Gas Flow	N/A

Ref	Consumable Brand	Consumable Classification	Consumable Treatment
A	Cigweld Ferrocraft 11	AS1553.1/E4111-2 A5.1 E6011	Do not bake or store in a hot box

Weld Details					Electrode/Filler		Flux	Welding Parameters				Travel Speed
Pass	Process	Side	Pos	Dir	Ref	Size	Or Gas	Pol	Amps (a)	Volts (v)	Heat Input kj/mm	(mm/min)
1	MMAW	1	3G	▼	A	3.25	N/A	DCEP	95-125	28-32	1.8 - 2.2	85-105
2	MMAW	1	3G	▼	A	3.25	N/A	DCEP	95-125	28-32	0.6 - 0.8	250-300
3	MMAW	1	3G	▼	A	3.25	N/A	DCEP	95-125	28-32	0.9 - 1.2	160-200
4	MMAW	2	3G	▼	A	4	N/A	DCEP	130 -160	23-29	1.4 - 1.7	115-145
5	MMAW	2	3G	▼	A	4	N/A	DCEP	130 -160	23-29	1.0 - 1.2	160-200
6	MMAW	2	3G	▼	A	4	N/A	DCEP	130 -160	23-29	1.4 - 1.7	115-140
7	MMAW	2	3G	▼	A	4	N/A	DCEP	130 -160	23-29	1.5 - 1.9	105-130
8	MMAW	2	3G	▼	A	4	N/A	DCEP	130 -160	23-29	1.8 - 2.2	90-110

Notes:
1. Number of passes may vary according to thickness
2. Grind back to sound metal before welding

Fuel Tank & Pipe

Approved Client

Release Stamp

NATAS - ITS APPROVED

Welding Procedures

- Weld Procedures
  - Defined under ASME IX
    - FCAW/Machine Welded Horizontals
    - Vertical Down MMAW Verticals
    - MMAW butt weld with backing plate for fillet to butt weld transition as the floor approaches the shell.
    - MMAW Iron Powder for fillet Welds on floor, roof, wind girder, compensating plates.

Shell Plate Thickness

Appendix A, Determination of Shell Thickness

A.4 Thickness of Shell Plates

A.4.1 The minimum thicknesses of shell plates shall be computed from the stress on the vertical joints, using the following formula:

In SI units:

$$t = \frac{4.9D(H-0.3)G}{(E)(145)} + CA$$

where

t = minimum thickness, in mm (see 5.6.1.1),

D = nominal diameter of the tank, in m (see 5.6.1.1, Note 1),

H = design liquid level, in m (see 5.6.3.2),

- G = specific gravity of the liquid to be stored, as specified by the Purchaser. The specific gravity shall not be less than 1.0,

E = joint efficiency, which is either 0.85 or 0.70 (see A.3.4),

- CA = corrosion allowance, in mm, as specified by the Purchaser (see 5.3.2).

Tank Aspect Ratio

- Tank Aspect Ratio is significant in the overall design of the tank.
  - In respect of tank holding down bolts, a squatter tank is favourable.
  - Increasing height increases static head which influences shell thickness.
  - Volume is proportional to Diameter Squared. Thus changes in diameter have a great influence on height.
  - Squatter tanks are more economical on material. (Calculus minima question in TEE)
  - Increasing diameter is often restricted by space.
  - Plate heights in either 3m or 3.2m thus preference for tanks over 6m high

Aspect Ratio for 600kL Tank

Tank Height m	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25	8.5
Tank Area m^2	125.7	120.0	114.8	110.0	105.6	101.5	97.8	94.3	91.0	88.0	85.2	82.5	80.0	77.6
Tank Diameter D m	12.7	12.4	12.1	11.8	11.6	11.4	11.2	11.0	10.8	10.6	10.4	10.2	10.1	9.9
Appendix A Shell Thickness														
100% Joint Efficiency mm	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8
70% Joint Efficiency mm	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.9	3.9
Corrosion Allowance mm	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	4.0
Minimum Thickness mm	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	6.9	7.9
Actual Thickness mm	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	7.0	8.0
Tank Weight														
Shell Weight kg	9765.7	9995.5	10220.1	10439.9	10655.2	10866.2	11073.2	11276.4	11476.0	11672.2	11865.2	12055.0	14282.2	16568.0
Floor Weight kg	5883.4	5616.0	5371.8	5148.0	4942.1	4752.0	4576.0	4412.6	4260.4	4118.4	3985.5	3861.0	3744.0	3633.9
Total Weight kg	15649.1	15611.5	15592.0	15587.9	15597.3	15618.2	15649.2	15689.0	15736.4	15790.6	15850.7	15916.0	18026.2	20201.9
Projetced Area m^2	66.4	68.0	69.5	71.0	72.5	73.9	75.3	76.7	78.1	79.4	80.7	82.0	83.3	84.5

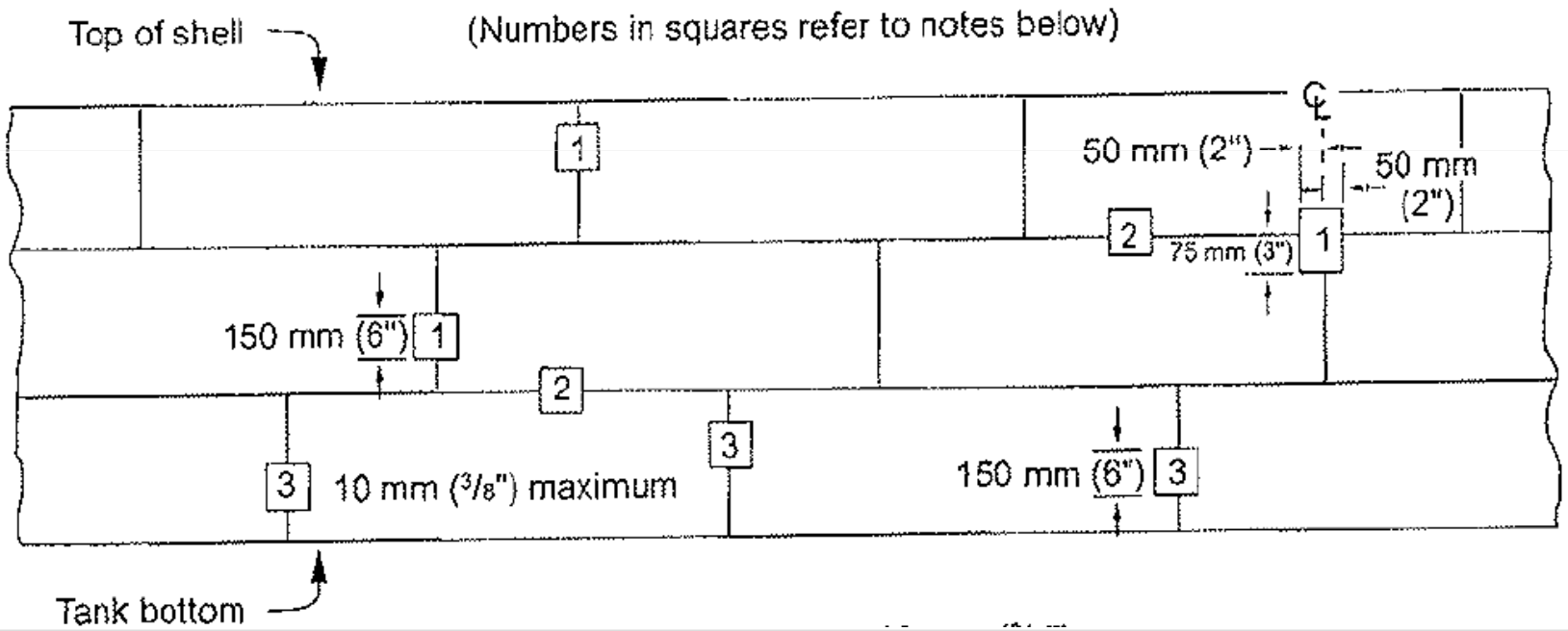
Shell Plate Thickness

Appendix A, Optional Design Basis for Small Tanks.

- Appendix A allows joint efficiencies of either 0.85 or 0.7
- If 0.7 is used 42% additional plate thickness is required.
- Joint efficiency of 0.7 provides a relaxation on NDT. Documented in Clause A3.4 of API650.
  - By agreement of contractor and purchaser.

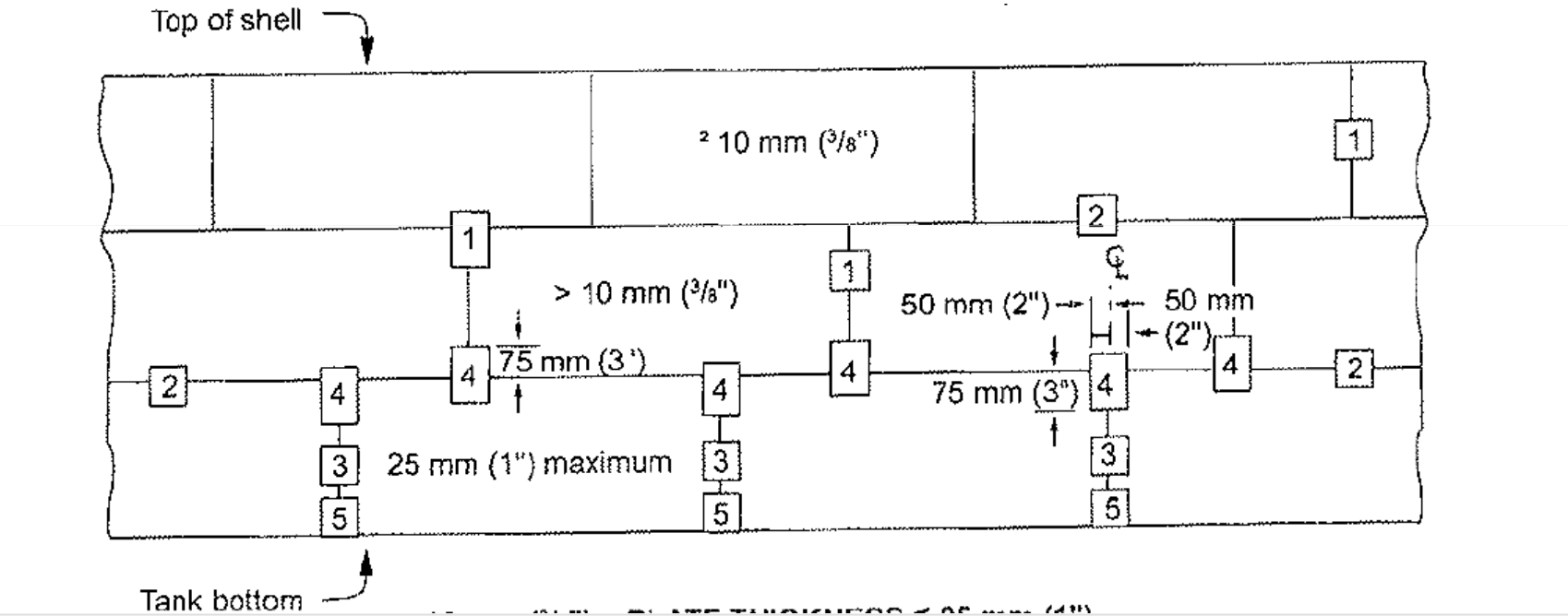
Radiography Requirement

Plate Thickness <=10mm



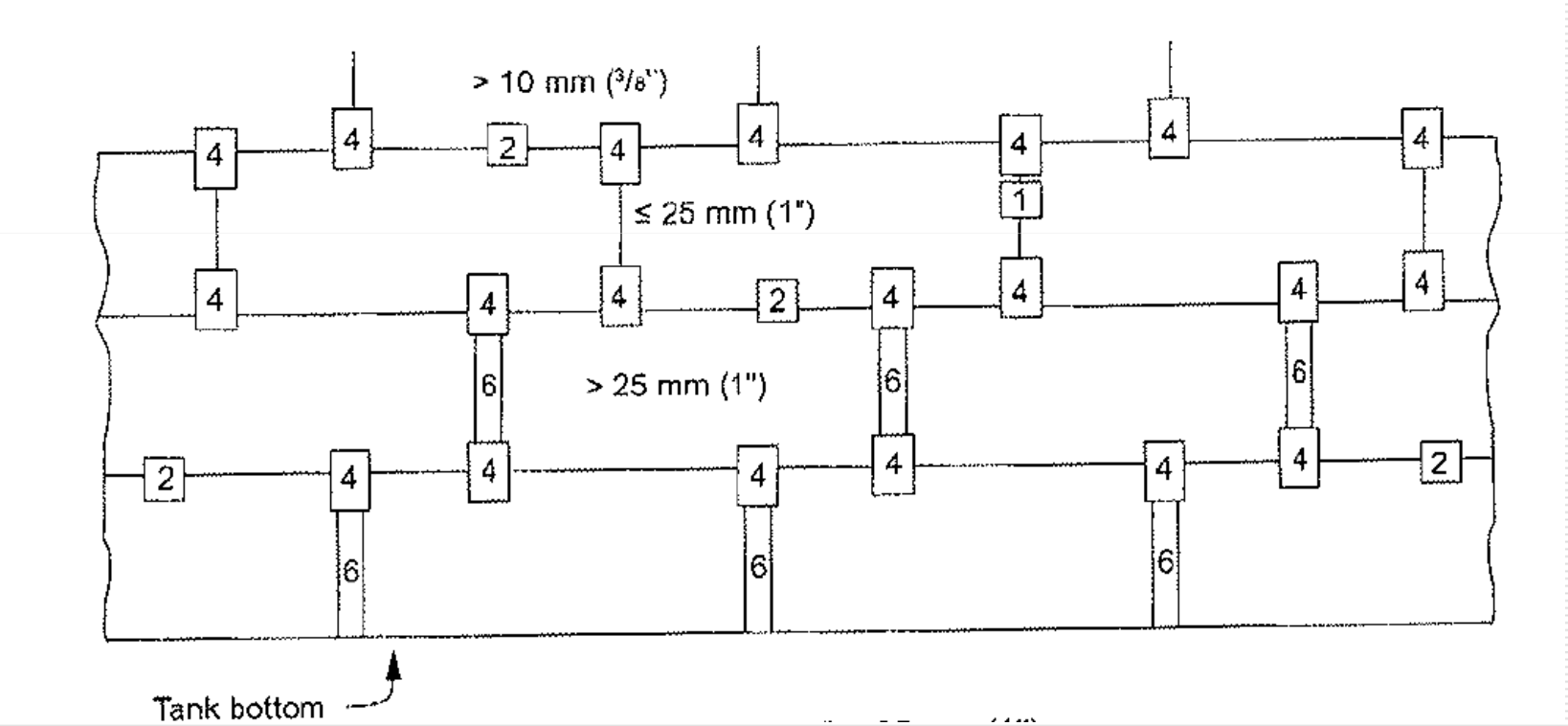
Radiography Requirement

Plate Thickness <=25mm



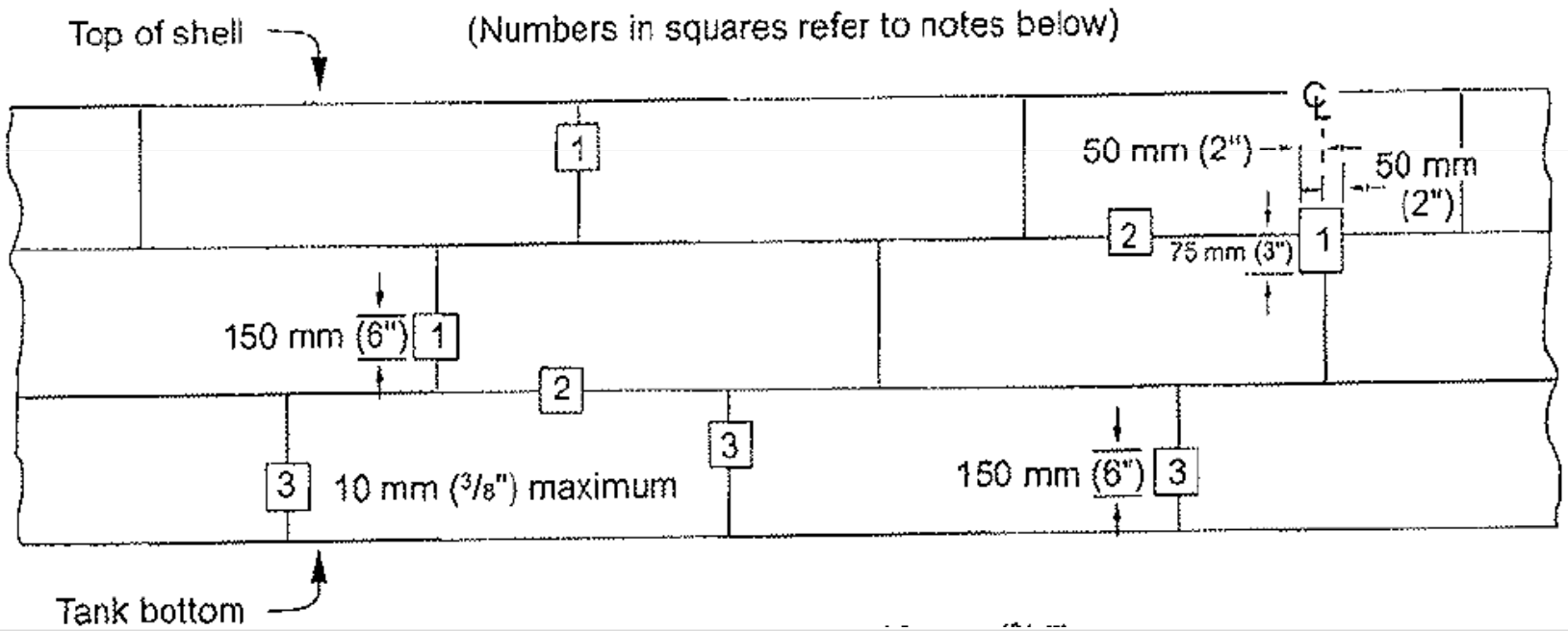
Radiography Requirement

Plate Thickness >25mm



Radiography Requirement

Plate Thickness <=10mm



Radiography Requirement

Radiography Notes:

Notes:

1. Vertical spot radiograph in accordance with 8 1.2.2, Item a: one in the first 3 m (10 ft) and one in each 30 m (100 ft) thereafter, 25% of which shall be at intersections
2. Horizontal spot radiograph in accordance with 8 1.2 3: one in the first 3 m (10 ft) and one in each 60 m (200 ft) thereafter
3. Vertical spot radiograph in each vertical seam in the lowest course (see 8 1.2.2, Item b). Spot radiographs that satisfy the requirements of Note 1 for the lowest course may be used to satisfy this requirement
4. Spot radiographs of all intersections over 10 mm ($^3/_8$ in) (see 8.1.2 2, Item b).
5. Spot radiograph of bottom of each vertical seam in lowest shell course over 10 mm ($^3/_8$ in) (see 8.1 2 2, Item b).
6. Complete radiograph of each vertical seam over 25 mm (1 in.). The complete radiograph may include the spot radiographs of the intersections if the film has a minimum width of 100 mm (4 in) (see 8.1.2 2 Item c).

Strake Layout

Key Plates

Location of Plates

- Shell plate horizontal and vertical plate clearances are maintained by key plates, shims and wedges.
- Key plates are secured to the shell.
- Driven wedges maintain the gaps for welding
- Shims maintain the clearance on the horizontal weld.

Automatic Welder

- This style of welder used for horizontal welds.
- The welding process is controlled by an oscillator.
- A range of patterns and welding parameters can be controlled.
- The welder runs along a magnetic flexible steel track.
- Viable on larger tanks.

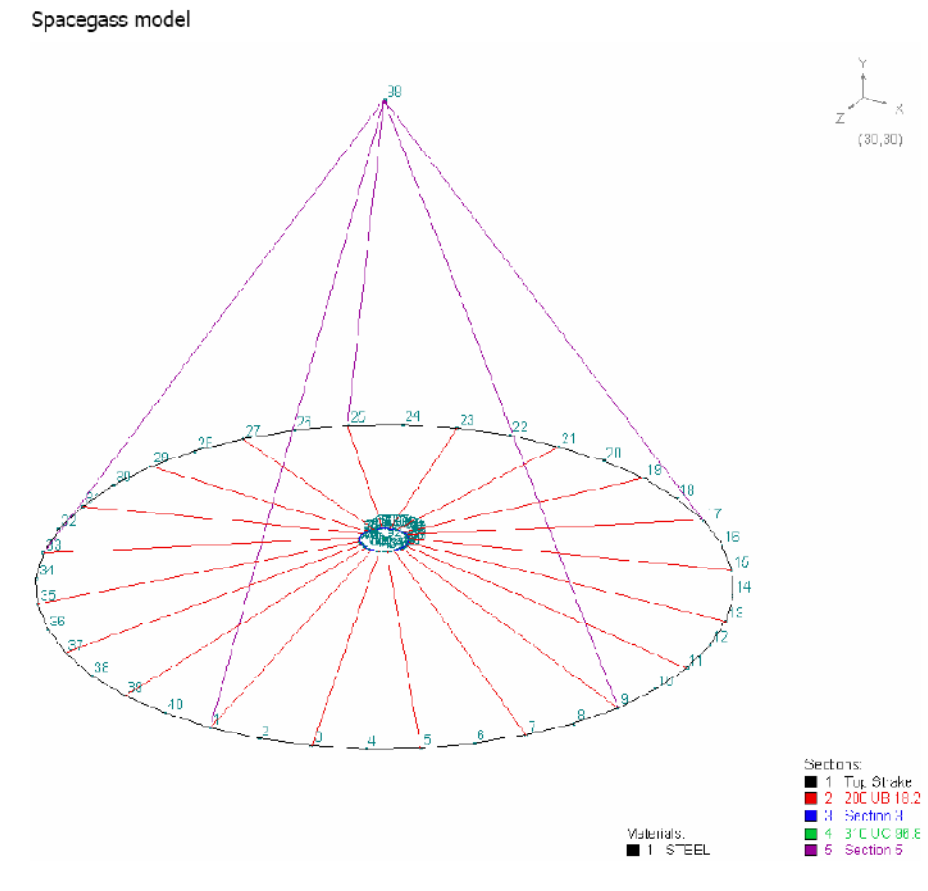
Final Strakes

Roof Construction

Roof Construction

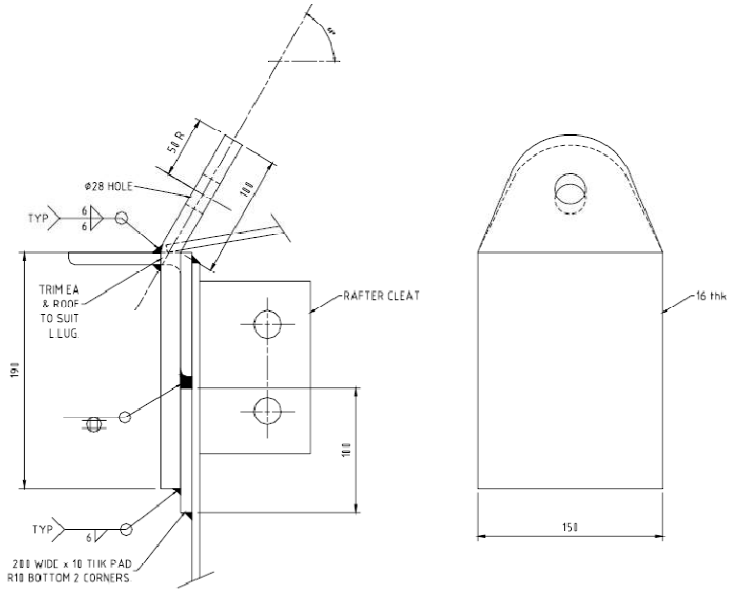
- Fuel Tank & Pipe often build the roof on the ground and lift this on to the completed strakes.
- Fully engineered lift studies are generated using Spacegass and other analytical methods.
- Lifting lug design

Spacegass FEA model.



Lifting Lug Design

Sketches



5 OFF LIFTING LUGS EQUISPACED
LOCATED IN LINE WITH RAFTER CLEATS

NOTES
1) ALL MATERIAL TO COMPLY WITH AS3678-250
2) ALL WELDING TO COMPLY WITH AS1554.1 CAT. SP.
3) USE 9.92tm LONG WIRE ROPE SLINGS.

Finished Roof Can

Roof Lift

Tolerances and Deviations

API 650 provides guidance.

Typical client requirements

- Circumference
  - ±1.5 x D/1000 +30mm
- Diameter
  - ±1.5 x D/1000 +20mm
- Height and Horizontality of Plate Edge
  - ± 40mm
- Local Deviations
  - Buckle height floor/roof plate

  D/1000 x (t+20)/t

Tolerances and Deviations

- Verticality of the Tank

Tank diameter	Deviation
D ≤ 10 m	$\frac{2.5xH}{1000}$
10 m < D ≤ 30 m	$\frac{2.8xH}{1000}$

Tank Survey

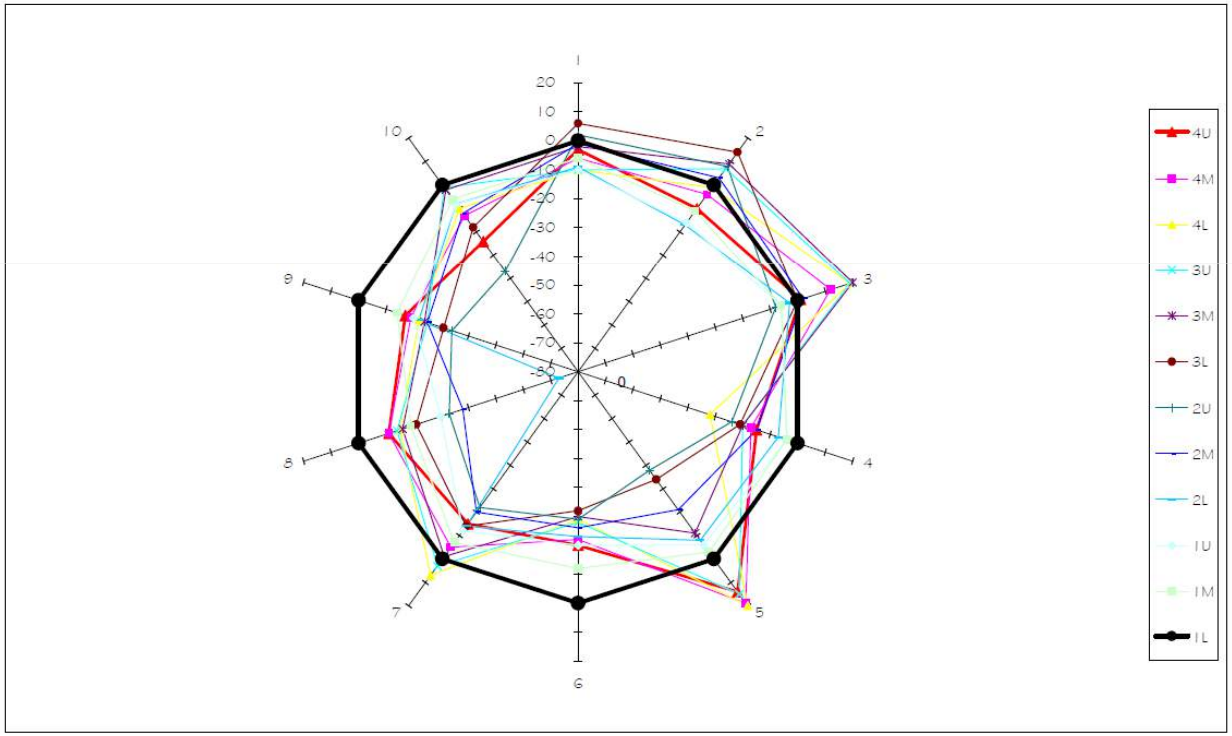
Tank 107 Verticality (Plumbness) Data Table

4U	-3	-10	1	-15	14	-20	-15	-11	-17	-24
4M	-6	-4	12	-17	19	-22	-5	-11	-19	-13
4L	-10	-1	19	-32	20	-29	7	-15	-22	-10
3U	-10	7	19	-20	15	-28	3	-14	-25	-1
3M	-2	9	20	-20	-11	-30	-1	-16	-24	-2
3L	6	14	0	-21	-34	-32	-14	-21	-31	-18
2U	2	8	-8	-24	-38	-29	-22	-33	-34	-37
2M	-1	3	2	-15	-21	-26	-20	-38	-25	-12
2L	-9	-17	-3	-7	-8	-23	-14	-73	-22	-8
1U	-10	-16	-6	-4	-6	-20	-12	-30	-20	-8
1M	-6	-11	-6	-4	-3	-12	-7	-19	-14	-6
1L	0	0	0	0	0	0	0	0	0	0
	1	2	3	4	5	6	7	8	9	10

TANK SHELL STATIONS AROUND BASE

Tank Survey

Tank 107 Verticality (Plumbness) Graph



SHELL STATION RADIAL DISPLACEMENT FROM FROM BASE
Fortescue Metal Group Tank 107 - Cloudbreak Mine PS073841/7

COMMISSIONING

- Tank Strapping
  - Tank Strapping is a method of measuring the deviation of the tank from its cylindrical form.
  - The method employs a laser and provides an accurate circumferential profile of the tank at different heights up the tank.
  - Strapping data is then entered into the tank gauging system providing an accurate means of interpolating the tank volume.

Strapping Data

CERTIFICATE OF CALIBRATION - N0. PS073841/6

This table gives volumes in litres for millimetres of product measured over the datum (tank floor).
The tank is a vertical tank with a fixed roof and a coned down floor.

The first red highlighted area on page 3 of the table is below the high point of the floor.
In this zone the average values from the bottom of the page should not be used.
Intermediate volumes in the zone should be interpolated from the nearest values in the table.

Tank dimensions:	Diameter (external at base):	14.013	metres
	Shell height:	12.024	metres
	Maximum Safe Fill height:	**11,650**	mm
	Capacity at M.S.F. height:	1,789,820	litres
Reference height:		**12,478**	mm
The tank has been calibrated for a temperature of:		**15**	deg C
Manual gauging datum below shell bottom edge (average height):		11	mm

Heights of tank fittings relative to the datum

Manhole	base exposed at:	630	mm
100NB Inlet (diffuser slot)	covered at:	250	mm
150NB Outlet	covered at:	330	mm

75NB and 25NB dewatering lines draw from a centrally located sump.

Volume below datum plate calibrated by physical survey.

Tank volumes have been calculated using the following factors:-

Young's Modulus:	2,040,000	kg/cm2
Coefficient of linear expansion of the tank shell metal:	0.000011	/Deg C
Calibration Tape Certification Temperature:	20	Deg C
Coefficient of linear expansion of the strapping tape metal:	0.000011	/Deg C
Tank shell expansion under liquid head calculated at density:	0.8400	kg/litre

No adjustment has been incorporated into this table for product meniscus effect on dip tape readings.

All measurements are traceable to Australian national standards.

Shell thickness data obtained from tank drawings.

Calibration Performed: 23/08/07
Certificate issued: 24/08/07
Calibration to: ISO Standard 7507

For and on behalf of
PETROSPECTION Pty Ltd

Non Destructive Engineering

- FT&P employ the following methods on tank welds.
  - Vacuum box testing.
  - Radiography
    - (Usually on Tee's i.e. intersections of vertical and horizontal welds)
    - RT is only required if the joint efficiency exceeds 70%. (API 650)
  - Magnetic Particle Inspection (100% of Joints)
  - Dye Penetrant (100% of Joints)
  - Air Testing of compensating plates.

MPI of Tank Welds

HYDROTESTING

- Hydro testing
  - Subject to availability of clean water.
  - For diesel tanks hydro-testing subjects the tank to a structural load higher than the service load due to difference in SG of water and Diesel.
  - Hydro Testing allows testing of tank settlement
  - Often the previous methods are used in lieu of Hydro-testing (Vacuum Box, MPI, Dye Penetrant on every joint)
  - On a 1.75Ml tank, the cost of clean water at a remote mine-site was $0.40 per litre.
  - Pragmatism prevailed, and Hydrotesting excluded.
  - FT&P tender exclusions include provision of clean water.
  - FT&P have experienced considerable algae growth on tank internal surfaces following hydro testing and resulting in significant additional costs arising out the cleaning the tank.

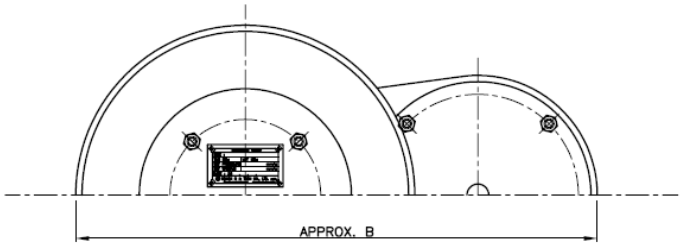
PV Vents/Safety Valves

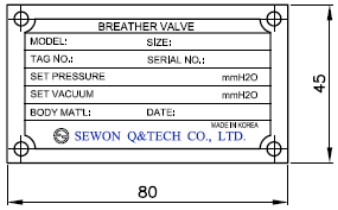
- On diesel tanks, FT&P install self desiccating filters
- Filters prevent ingress of moisture arising from the air humidity.
- Filters become clogged if they are not maintained.
- This can create either a vacuum or pressure condition in the tank

PV Vents/Safety Valves

- A vacuum condition can lead to catastrophic failure of a tank.
- Mitigated by the PV Valve.
- A plastic bag secured over a tank vent during routine maintenance led to tank failure in a UK refinery during a crash cooling event (rain storm).
- Pressure 0 KPa Gauge
- Vacuum 1.3 KPa Gauge
- Vent sizing in accordance with AS1940
- FT&P use Shands and Jur PV valves or equivalent.
- Sizing of vents will be undertaken by manufacturer

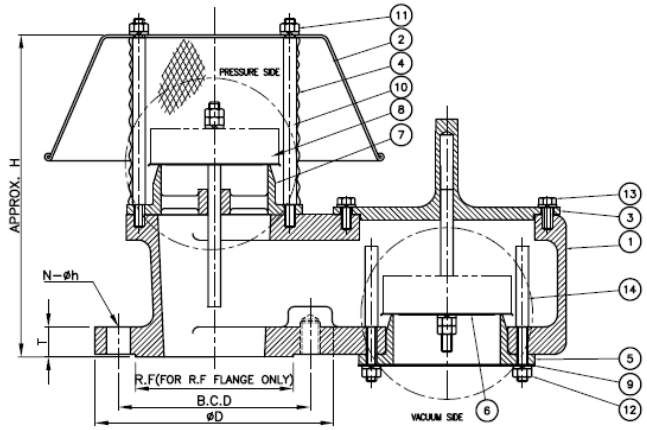
PV Vent





NAMEPLATE DETAIL

Tag No.	--	
SIZE	3"	
Q'TY	1	SET(S)



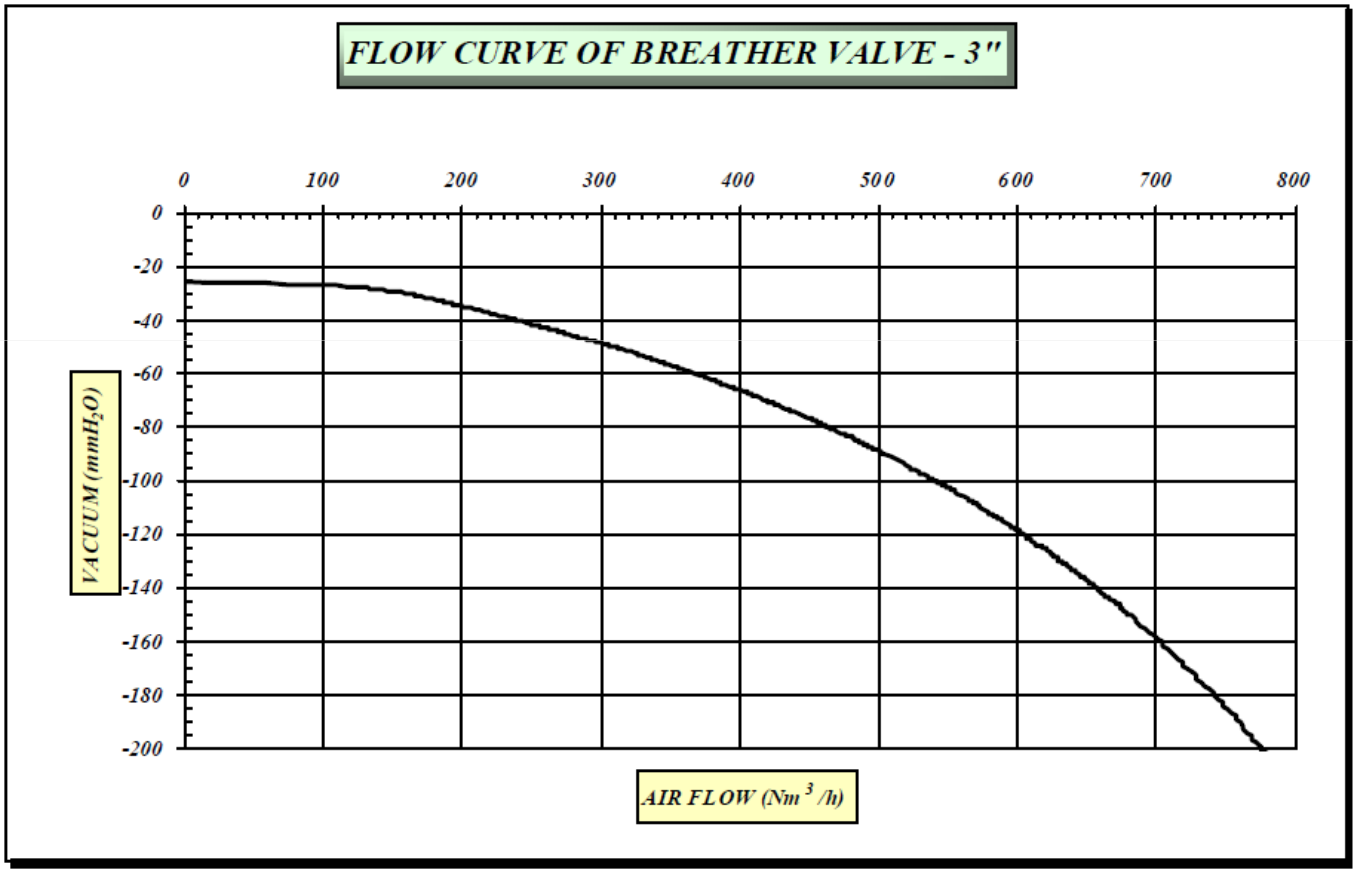
Venting Requirements

3. Venting Requirements			
3.1	CODE OR STANDARD		API 2000
3.2	MAXIMUM FILLING RATE	m3/h	108
3.3	MAXIMUM EMPTYING RATE	m3/h	24
3.4	OUT-BREATHING FOR		
	(A) LIQUID MOVEMENT IN [Table 1B]	Nm3/h	109
	(B) THERMAL EFFECT [Table 1B]	Nm3/h	61
	(C) HEATING DEVICE EFFECT [Equation B-5]	Nm3/h	
3.5	OUT-BREATHING CAPACITY REQUIREMENT	Nm3/h	**170**
3.6	IN-BREATHING FOR		
	(A) LIQUID MOVEMENT OUT [Table 1B]	Nm3/h	23
	(B) THERMAL EFFECT [Table 1B]	Nm3/h	101
3.7	IN-BREATHING CAPACITY REQUIREMENT	Nm3/h	**124**
3.8	WETTED AREA	m2	
3.9	ENVIRONMENTAL FACTOR [Table 4A or 4B]		
3.10	EMERGENCY VENTING REQUIREMENT [Equation 1B]	Nm3/h	

Venting Requirements

5. PRESSURE AND/OR VACUUM RELIEF VALVE			
5.1 SELECTED MODEL		SBF	
5.2 INLET SIZE (OR INLET SIZE & OUTLET SIZE)		3"	
5.3 CONNECTION TYPE AND CLASS		ANSI CLASS 150	
5.4 TYPE OF FLANGE FACING		RAISED FACE	
5.5 TYPE		WEIGHT LOADED	
5.6 SERVICE		PRESSURE & VACUUM RELIEF	
5.7 MATERIALS			
(A) BODY AND/OR COVER		A216-WCB	
(B) SEAT AND PALLET		A351-CF8 / 304 S.S	
(C) DIAPHRAGM		TEFLON	
(D) WEATHER HOOD		304 S.S	
(E) SPRING		-	
(F) SUPPORT / GUIDE		304 S.S	
(G) O-RING, FOR SPRING LOADED TYPE ONLY		-	
5.8 VENT GAS DISCHARGE		TO THE ATMOSPHERE	
5.9 SET PRESSURE AND SET VACUUM	mmH2O	100	-25
5.10 OUT-BREATHING CAPACITY *NOTE 1)	Nm3/h	596	AT OP 50%
5.11 IN-BREATHING CAPACITY *NOTE 1)	Nm3/h	224	AT OP 50%

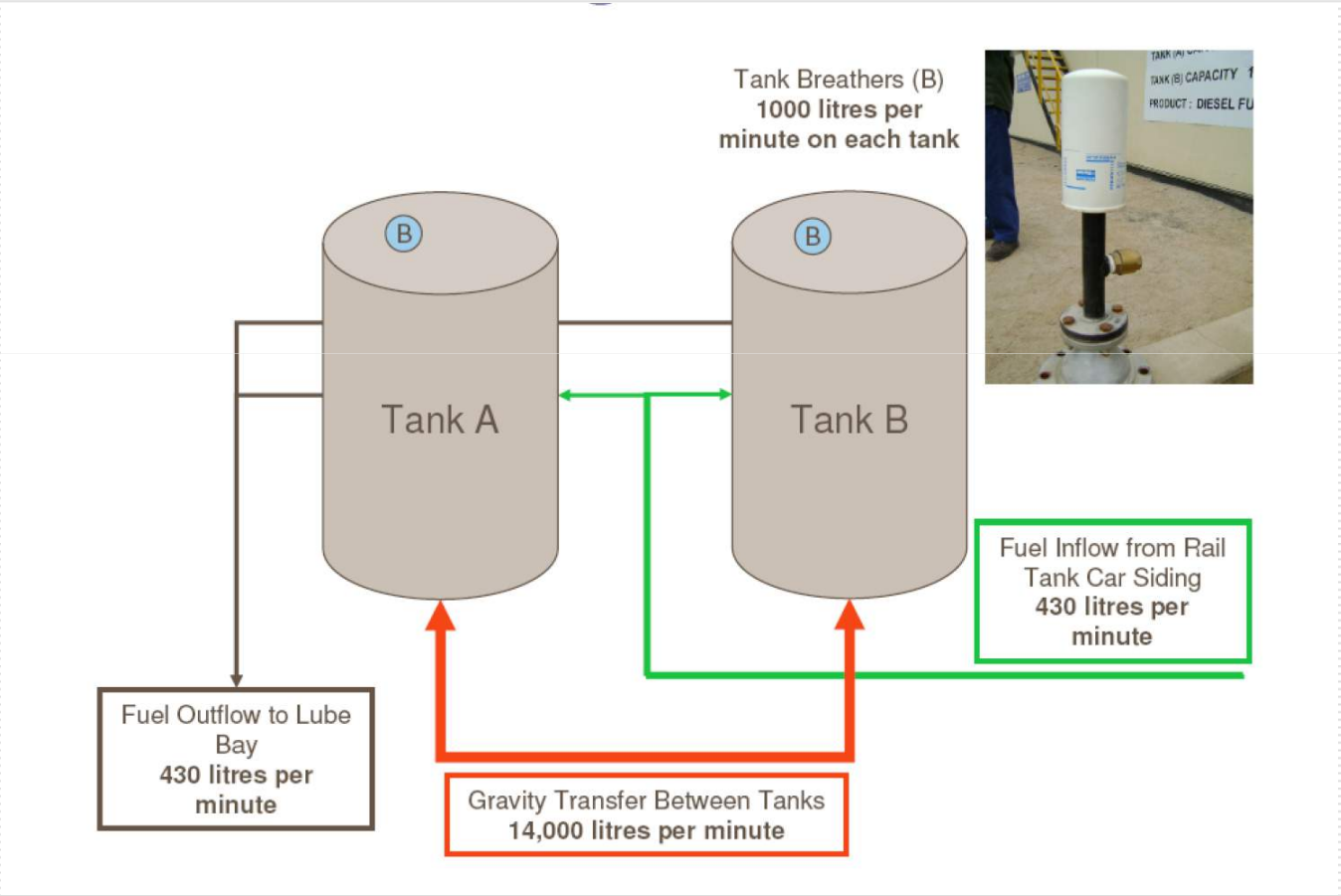
Flow Curve for a Vacuum Vent



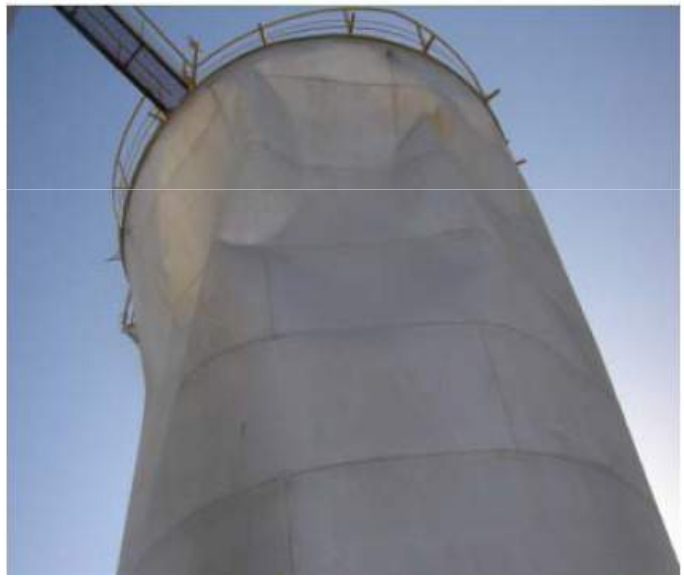
Rossing Fuel Tank Collapse

- 2 x 1.2m Litre fuel Tanks failed due to vacuum condition.
- DN150 Vents on each tank replaced by DN50 Silica Gel Breathers.
- Gravity equalisation between tanks resulted in vacuum condition.
- Tank collapsed due to inappropriate sizing of the breathers.

Tank Failure (Vacuum Condition)



Tank Failure (Vacuum)



Tank Failure (Vacuum)

Tank Failure

Root Causes:

- Engineering Design Standards within BP for this type of work were not followed
- The BP Contractor was not properly supervised by BP or Rio Tinto
- The Technical design was not correct – the full scope of the way the facility would be operated was not included
- Risk assessment on the change of breathers was ineffective
- The required BP permits were not issued (Rio Tinto permits were used) – this meant some standard BP items were not covered
- Communication between BP Engineering, RG Construction and the manufacturer of the Breathers was ineffective

Tank Failure

Root Causes:

- No risk assessment / change management was in place
- No operating procedure was in place for tank commissioning
- The operator opened the valve before the tank was commissioned
- The operating team were not trained in standard BP work procedures including commissioning of tanks – operating staff are Contractors and not part of standard BP communication and training
- BP Engineering did not have enough involvement in the project including commissioning – an untrained operator was supervising most of the work
- Communication between BP Engineering, RG Construction and the Operating team was not effective
- Lack of training meant that information provided was not understood by all parties

Article supplied by Laurie Parks, Rio Tinto

CONTROL PHILOSOPHY

- Checks
  - Tank Selection Control, duty.
  - Tank Selection Control, filling
  - High Level Alarm
  - HH Alarm
  - Double redundancy of above.
  - Low Level Arm

INSTRUMENTS

- Level Gauges
  - FT&P use the OPW iSite system
  - Accurate to 1 mm
  - Provides temperature compensation for bulk fluid temperature. (ATO Tax rebates)
  - Level gauge use strapping data to calculate volume.
  - The gauge supports many soft level alarms that can be used for a variety of purposes including backup HH, H, L, LL alarms and re-order level via the Ethernet link.
  - The system is approved by the EPA in California as a leak detection system.

INSTRUMENTS

- Level Switches
  - Reed switch used for High, High High
  - OPW iSite provides backup to the above.
- Typically no other additional instruments are required.

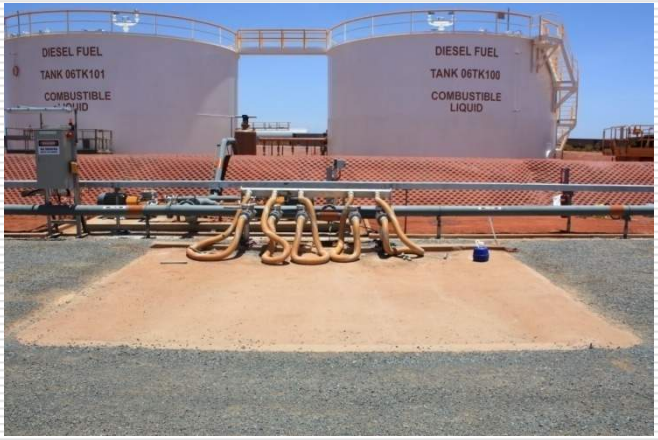
End of Presentation

- Thank you for your Attention!
- Acknowledgements
  - Michael King, EA WA Mech. Branch Chairman
  - Paula West, Alcoa
  - Ben Pisano Blake Thompson CDMS.
- Questions

About FT&P

- Current Turnover, $AUS 30m
- Clients Include
  - FMG, Rio Tinto, Sino Iron, Austrian Energy and Environment, Worley Parsons, AR Fuels, Shell, Woodside.
- Co-Operation Agreement with Bilfinger Berger Services, Leighton's for Tank Building Activities.
- Design Services agreement with BHP
- Considerable D&C interest from the Middle East
- Potential alliance with the US Military and partners to provide modular fuel infrastructure in Iraq and Afghanistan
- Accredited with PICA WA for fuel installations
- A member of ACEA (Australian Consulting Engineers)

FT&P Rail Loading



FT&P Rail Unloading

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