Inspection of Above Ground Storage Tanks

- Presented by: Alex Romanow Jr.

22nd Annual California CUPA Training Conference

THEME: "2020: PERFECTING OUR VISION"

DATES: February 3 – 6 / 2020

- **API Standard 653**, Tank Inspection, Repair, Alteration, and Reconstruction, Fifth Edition, November 2014, with Addendum 1 (April 2018).
- **API Standard 650**, Welded Steel Tanks for Oil Storage, Twelfth Edition, March 2013 with Addendum 1 (2014), Addendum 2 (2016), and Erratas 1 and 2 (2014), and Addendum 3 (August 2018).
- **API Recommended Practice 571**, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry, 2nd Edition, April 2011
- **API Recommended Practice 575**, Inspection of Atmospheric and Low-Pressure Storage Tanks, Third Edition, April 2014.
- **API Recommended Practice 577**, Welding Inspection and Metallurgy, Second Edition, December 2013.
- **API Recommended Practice 651**, Cathodic Protection of Aboveground Petroleum Storage Tanks, Fourth Edition, September 2014.
- **API Recommended Practice 652**, Lining of Aboveground Petroleum Storage Tank Bottoms, Fourth Edition, September 2014, with Errata 1 (August 2016)..

Bay #13, 3716 - 56th Avenue S.E., Calgary, AB. T2C 2B5. Phone: (403) 252-4487

Large Tank Inspection Program

- 50,000 BBL+

Small Tank Inspection Program

- 50 BBL to 50,000 BBL

Safety

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- Safety is an integral part of tank inspection.
- Proper ventilation is required.

Scheduling / Inspection Intervals

INSPECTION INTERVAL

- The following inspection intervals are based on completion of required repairs as outlined in this report, and in accordance to applicable standards.

ROUTINE IN-SERVICE INSPECTIONS

- The external condition of tank # 123 shall be monitored by close visual inspection from the ground on a routine basis and shall be performed by personnel knowledgeable of the storage facility operations, the tank, and the characteristics of the product stored. This inspection interval shall not exceed one month (Refer to Inspection Frequency Considerations below).

EXTERNAL INSPECTION

- A visual external inspection shall be performed on tank # 123 by an Authorized Inspector at an interval not to exceed 5 years (2025) (Refer to Inspection Frequency Considerations below). In-service Ultrasonic evaluation of the shell may be scheduled to correspond with the external inspection interval. In-service evaluation of the tank settlement shall be performed to monitor the existing tank settlement and any changes due to continued tank settlement. In-service inspection requirements and maintenance shall be performed on tank # 123 at periods not exceeding the recommended practices as per API Standard 653 to assure continued tank integrity. Tanks may be in operation during this period.

INTERNAL INSPECTION

- The recommended period until next formal internal inspection on tank # 123 is 20 years (2040) based on the observations and data of this inspection as outlined in this report. The tank owner / operator shall conduct a formal internal inspection and complete API Standard 653 inspection performed by an Authorized Inspector at this period of inspection.

INSPECTION FREQUENCY CONSIDERATIONS

- Factors and consideration determining inspection frequency on tank # 123 include, but are not limited to: change in operating mode, service, jurisdictional requireme (Ctrl) in-service inspection results, owner / operator requirements. Refer to API S "Inspection Frequency Considerations".

Table 6.1—Tank Safeguard

Tank Safeguard	Add to Initial Interval
i. Fiberglass-reinforced lining of the product-side of the tank bottom installed per API RP 652.	5 yrs
i Installation of an internal thin-film coating as installed per API RP 652.	2 yrs
iii. Cathodic protection of the soil-side of the tank bottom installed, maintained, and inspected per API RP 651.	5 yrs
18 iv. Release prevention barrier installed per API 650, Annex I.	10 yrs
v. Bottom corrosion allowance greater than 0.150 in.	(Actual corrosion allowance -150 mils)/corrosion rate*
vi. Bottom constructed from stainless steel material that meets requirements of API 650, Annex SC, and either Annex S or Annex X; and internal and external environments have been determined by a qualified corrosion specialist to present very low risk of cracking or corrosion failure.	10 yrs

18 * Corrosion rate to be 15 mpy, or as determined from Annex H, Similar Service.

MRT Calculations

SUMMARY CALCULATIONS – BOTTOM PLATE

$$MRT = (Minimum\ of\ RT_{BC}\ or\ RT_{ip}) - O_r(StP_r + UP_r)$$

Where:

- MRT = minimum remaining thickness at the end of interval O_r.
- O_r = in service interval of operation (as specified by owner or governed by inspection results).
- RT_{BC} = minimum remaining thickness from bottom side corrosion.
- RT_{ip} = minimum remaining thickness from internal corrosion.
- StP_r = maximum rate of corrosion not repaired on the top side. StP_r = 0 for coated areas of the bottom.
- UP_r = maximum rate of corrosion on the bottom side.
- StP_r = (*nominal thickness* - RT_{ip}) / (Age of tank)
- UP_r = (*nominal thickness* - RT_{BC}) / (Age of tank)

The bottom plate of Tank # 103 is 49 years old.

Bottom plate calculations (0.250 inch nominal)

	RESULTS WITHOUT REPAIRS		RESULTS AFTER REPAIRS	
RT_{BC}	0.139	inch	0.160	inch
RT_{ip}	0.150	inch	0.160	inch
O_r	15	years	15	years
StP_r	0.00204	inch/yr	0.00184	inch/yr
UP_r	0.00227	inch/yr	0.00184	inch/yr
MRT	0.0744	inch	0.105	inch
Required Thickness at O_r	0.100	inch	0.100	inch

A repair threshold of 0.090 inch was established using the above calculations. All areas of material loss resulting in a minimum thickness below the threshold were identified for repair in the repair recommendations on the previous page.

For a pit by pit analysis please refer to Bottom Plate Reduction Readings Tables, as formulated using the above equations as per API 653 4.4.5.1.

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1) A Magnetic Flux Leakage (MFL) scan was performed on accessible areas of the tank bottom plate. __________ (__) indications of underside material loss were identified. The MFL threshold for the scan was approximately ____ inch.

2) Resulting MFL indications were additionally evaluated with Ultrasonics (UT). The minimum thickness found was _____ inch including coating. The nominal thickness is ____ inch. Refer to Table A – Bottom Plate Reduction Readings for additional data.

3) The bottom plate was visually examined for topside pitting.

MRT Calculations

SUMMARY CALCULATIONS

$$MRT = (Minimum\ of\ RT_{BC}\ or\ RT_{ip}) - O_r(StP_r + UP_r)$$

Where:

- MRT = minimum remaining thickness at the end of interval O_r.
- O_r = in service interval of operation (as specified by owner or governed by inspection results).
- RT_{BC} = minimum remaining thickness from bottom side corrosion.
- RT_{ip} = minimum remaining thickness from internal corrosion.
- StP_r = maximum rate of corrosion not repaired on the top side. StP_r = 0 for coated areas of the bottom.
- UP_r = maximum rate of corrosion on the bottom side.
- StP_r = (*nominal thickness* - RT_{ip}) / (Age of tank)
- UP_r = (*nominal thickness* - RT_{BC}) / (Age of tank)

The bottom plate of Tank # 803 is 33 years old.

	RESULTS WITHOUT REPAIRS		RESULTS AFTER RECOMMENDED REPAIRS	
RT_{BC}	0.282 (MFL Threshold)	inch	N/A	inch
RT_{ip}	0.312	inch	N/A	inch
O_r	20	years	N/A	years
StP_r	0.000	inch/yr	N/A	inch/yr
UP_r	0.00121	inch/yr	N/A	inch/yr
MRT	0.258	inch	N/A	inch
Required Thickness at O_r	0.100	inch	N/A	inch

As per the above calculated data no bottom plate repairs were identified in the repair recommendations on the previous page.

The approximate threshold for 0.312-inch plate with a coating 10 to 30 mils thick is 0.040"inch. Therefore, as per API 653 4.4.5.1 NOTE 1, assumed corrosion of 0.040"inch was used as the basis for the calculations above.

Note: *StP_r = 0 for coated areas of the bottom. The expected life of the coating must equal or exceed O_r to use StP_r = 0.*

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NOTE 1 For areas of a bottom that have been scanned by the magnetic flux leakage (or exclusion) process, and do not have effective cathodic protection, the thickness used for calculating UP_r must be the lesser of the MFL threshold or the minimum thickness of corrosion areas that are not repaired. The MFL threshold is defined as the minimum remaining thickness to be detected in the areas examined. This value should be predetermined by the tank owner based on the desired inspection interval.

Areas of bottom side corrosion that are repaired should be evaluated with the corrosion rate for the repaired area unless the cause of corrosion has been removed. The evaluation is done by using the corrosion rate of the repaired area for UP_r, and adding the patch plate (if used) thickness to the term "minimum of RT_{bc} or RT_{ip}."


25FEET


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Foundation Settlement

INPUTS

Tank ID ↓	Tank radius (Feet) ↓	Shell Height (Feet) ↓	Bottom Course Material Specification ↓	Landmark at 0° ↓
1009	60.00	49.75	A131-A,B,CS	Manway A

Station #	Angle°	Elevation
i	CCW	Feet
0	0	6.824147
1	30	6.824147
2	60	6.811024
3	90	6.801181
4	120	6.781496
5	150	6.794619
6	180	6.771654
7	210	6.768373
8	240	6.788058
9	270	6.791339
10	300	6.801181
11	330	6.817585

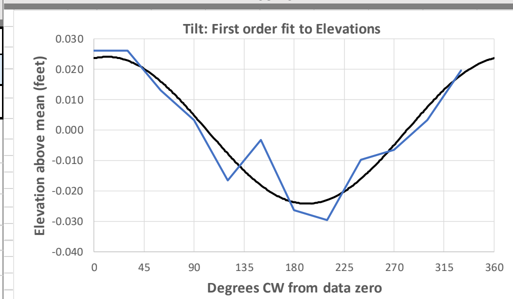
Color Scheme:
Primary User Input
Calculation or Void
Station Within Compliance
Review
Title
Description

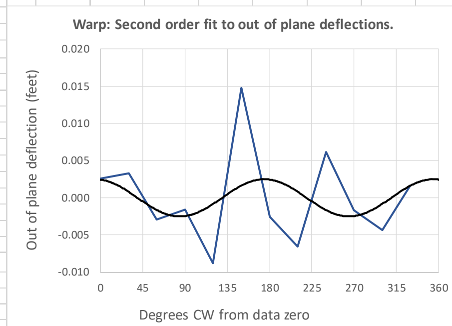
OUTPUTS

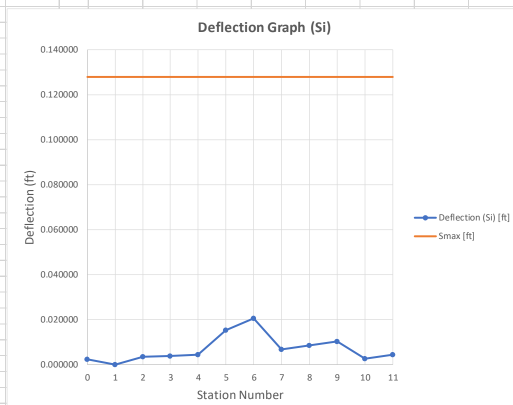
L (ft)	Y (psi)	E (psi)	Smax (ft)
31.41592654	34000	29000000	0.12792
L < 32 ft? Y			

Station #	Out-of-Plane Settlement	Deflection	Permissible by B.3.2.1?
i	Ui	Si	["Yes","No"]
0	0.001612	0.002500	Yes
1	0.002578	0.000110	Yes
2	0.003325	0.003491	Yes
3	-0.002909	0.003788	Yes
4	-0.001567	0.004272	Yes
5	-0.008769	0.015381	Yes
6	0.014793	0.020466	Yes
7	-0.002578	0.006672	Yes
8	-0.006606	0.008412	Yes
9	0.006190	0.010350	Yes
10	-0.001714	0.002631	Yes
11	-0.004355	0.004304	Yes

RESULTS







In-Service Inspection

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- Meets/Exceeds Standards in API Std. 653 Section 4 – Inspection
- Visual Inspection (VT)
- Ultrasonic Thickness Measurement (UT)
- Automated Ultrasonic Testing (AUT)
- Magnetic Particle Examination (MT)
- External Tank Settlement Evaluation
- Tank Plumbness Evaluation
- Out-of-Round Evaluation
- Berm Survey and Evaluation

External Tank Details

External Tank Defects


TK306


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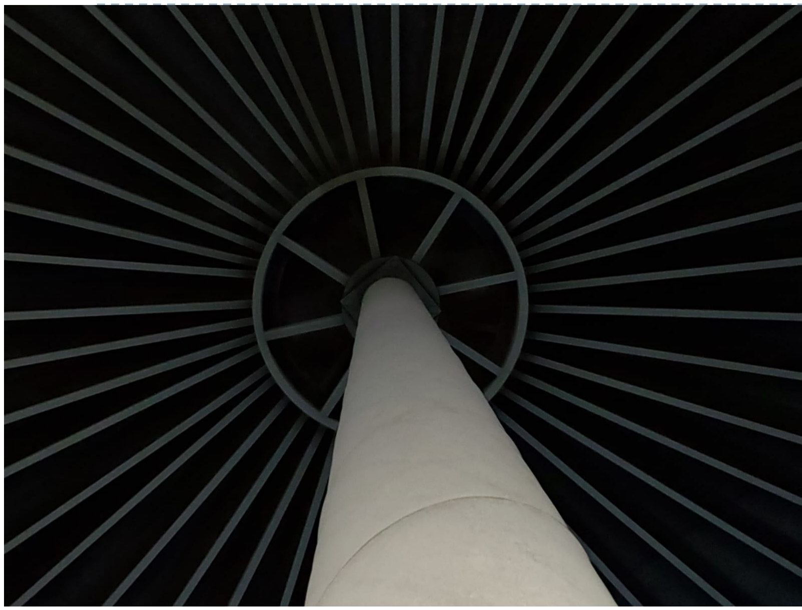
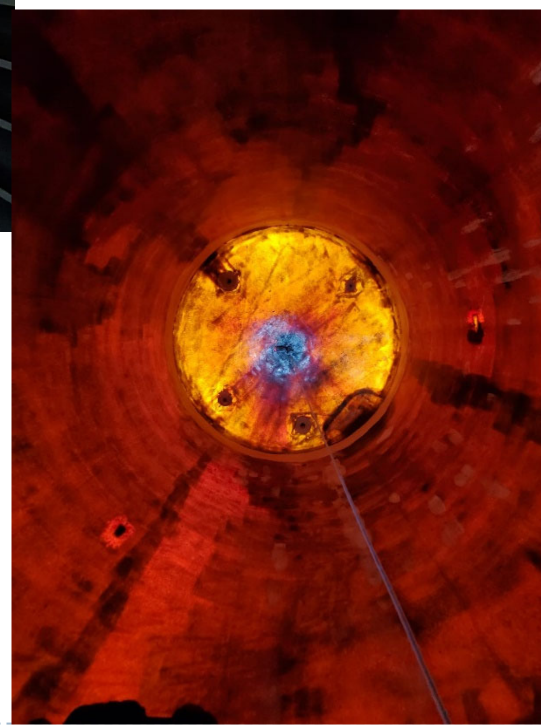
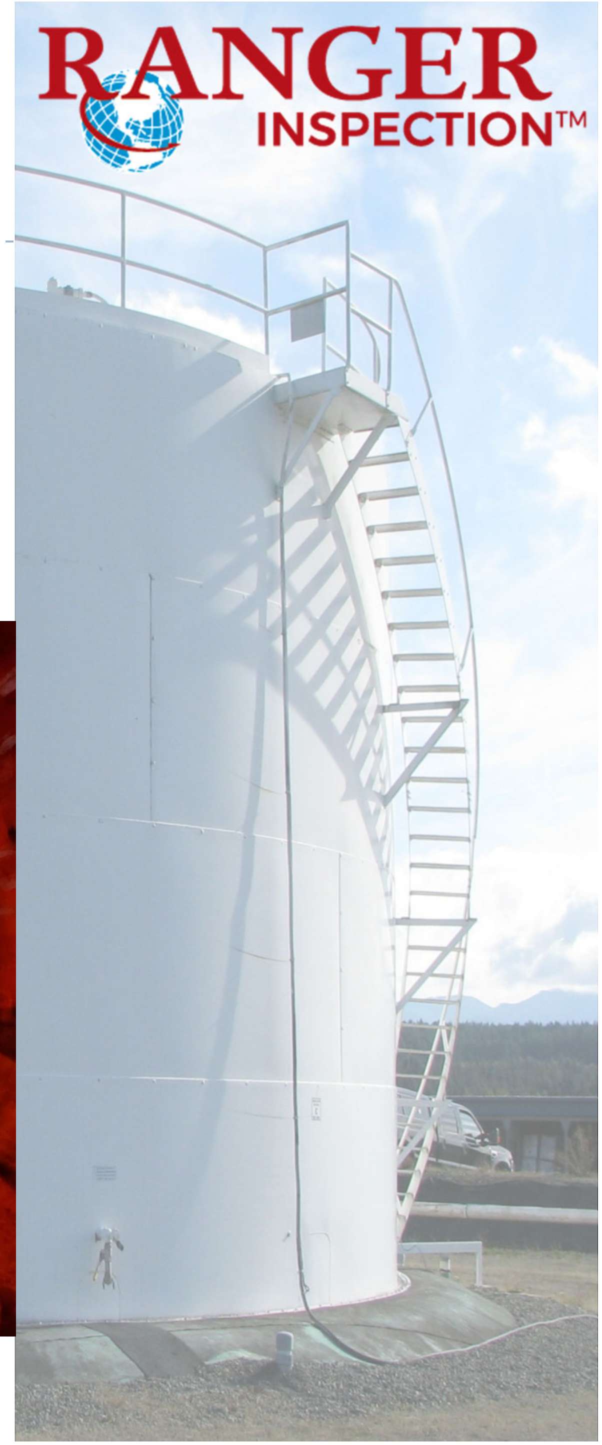
Out-of-Service Inspection

- Includes all aspects of In-Service Inspection as well as the following:
  - Completion of API Std. 653 Checklist (Appendix C)
  - MFL Floor Scan (MFE)
  - Ultrasonic (UT) Prove-Up
  - UT and VT Inspection of Fixed and/or Floating Roof
  - Internal Foundation Settlement Survey
  - Comprehensive Final Inspection Report
  - Bottom Plate CAD Drawing
  - Shell CAD Drawing
  - Fixed/Floating Roof CAD Drawing

Internal Tank Details



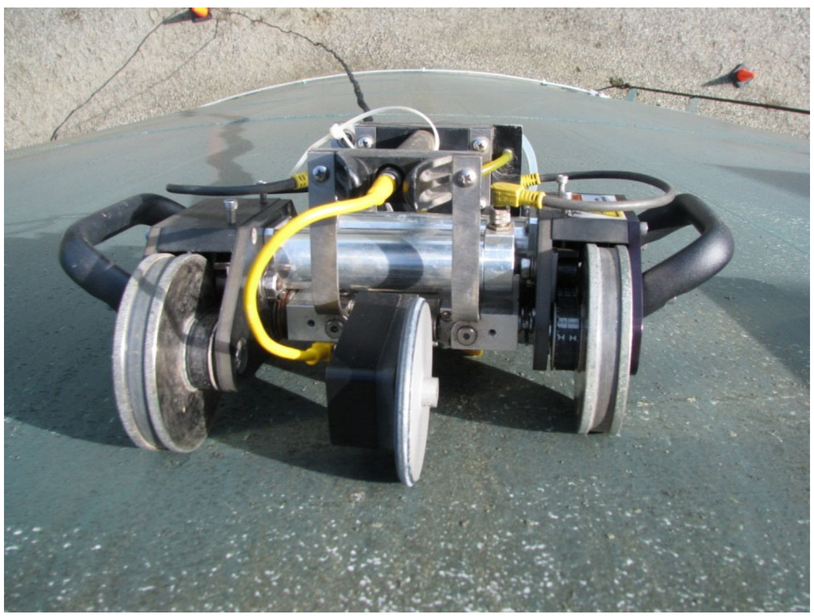




Internal Tank Defects

Equipment and Training

- As per API Standard 653 – Appendix G
- Highly trained and qualified examiners
- High qualification test acceptance scores



- UT Crawler

- Olympus Epoch650 Flaw Detector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Magnetic Flux Leakage Equipment - Evolution

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MFE 2412 Mark II

- Manually operated
- Weight = 110lbs
- Long battery life
- Easy to read/use display
- Rugged Design
- Folds down for easy transport
- 28” x 19” x 18” container in line with IATA (International Air Transport Association) requirements
- Manageable with one crew member

Magnetic Flux Leakage Equipment - Evolution

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MFE Mark III

- Manually operated
- Weight = 100lbs
- Long battery life
- Rugged tough screen Panasonic Toughbook display
- Improved magnetic bridge for higher sensitivity through coated floors
- Manageable with one crew member

Magnetic Flux Leakage Equipment - Evolution

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MFE Mark IV

- The Mark IV takes the precision, reliability, and durability of its predecessors to another level with upgraded, user-friendly software and a lightweight build. Its slim design boasts an unprecedented weight of only 65 lb.
- The real-time "A-Scan" display features an LED signal response that runs concurrently with a "C-Scan" mapping preview that clearly illustrates where the defect is relative to the magnetic bridge. This allows defects to be located even faster and drastically eliminates the needs of the scanner to be constantly moving while locating defects.
- The new speed tracking feature provides the operator immediate feedback so they are confident they are scanning within an optimal speed range, ensuring consistent, reliable, and accurate results.

Laser Level / Total Station

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What We Use:

- Leica Geosystems Total Station TCR403 Ultra R300
- Leica Geosystems Rugby 100

Tank Calibration Services

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Safe fill height = 10.820 m

725.0 kg/m3

Reference Gauge Height: 12.665 Radar hatch

8 Meters				9 Meters				10 Meters				11 Meters			
0.25	8,694.383	0.75	9,218.534	0.25	9,742.684	0.75	10,267.270	0.25	10,792.388	0.75	11,317.506	0.25	11,842.623	0.75	
0.26	8,704.866	0.76	9,229.017	0.26	9,753.167	0.76	10,277.772	0.26	10,802.890	0.76	11,328.008	0.26	11,853.126	0.76	
0.27	8,715.349	0.77	9,239.500	0.27	9,763.650	0.77	10,288.275	0.27	10,813.392	0.77	11,338.510	0.27	11,863.628	0.77	
0.28	8,725.832	0.78	9,249.983	0.28	9,774.133	0.78	10,298.777	0.28	10,823.895	0.78	11,349.013	0.28	11,874.131	0.78	
0.29	8,736.315	0.79	9,260.466	0.29	9,784.616	0.79	10,309.279	0.29	10,834.397	0.79	11,359.515	0.29	11,884.633	0.79	
0.30	8,746.798	0.80	9,270.949	0.30	9,795.099	0.80	10,319.782	0.30	10,844.900	0.80	11,370.017	0.30	11,895.135	0.80	
0.31	8,757.281	0.81	9,281.432	0.31	9,805.582	0.81	10,330.284	0.31	10,855.402	0.81	11,380.520	0.31	11,905.638	0.81	
0.32	8,767.764	0.82	9,291.915	0.32	9,816.065	0.82	10,340.786	0.32	10,865.904	0.82	11,391.022	0.32	11,916.140	0.82	

Capacity in Cubic Meters

mm	Cubic Meters	mm	Cubic Meters	mm	Cubic Meters
1	1.049	4	4.197	7	7.344
2	2.098	5	5.246	8	8.393
3	3.147	6	6.295	9	9.442

Liquid Head stress calculated at 0.725 density
Volume reflects a steel Temperature of 15.0 C

Nominal size = 36.587 m Diameter x 12.192 m Height

Overflow @ 11.320 meters

Calculated per API MPMS Ch. 2.2A and 2.2B

The quantities listed on this capacity table do not include adjustments to compensate for floating-roof displacement

RANGER CALIBRATION

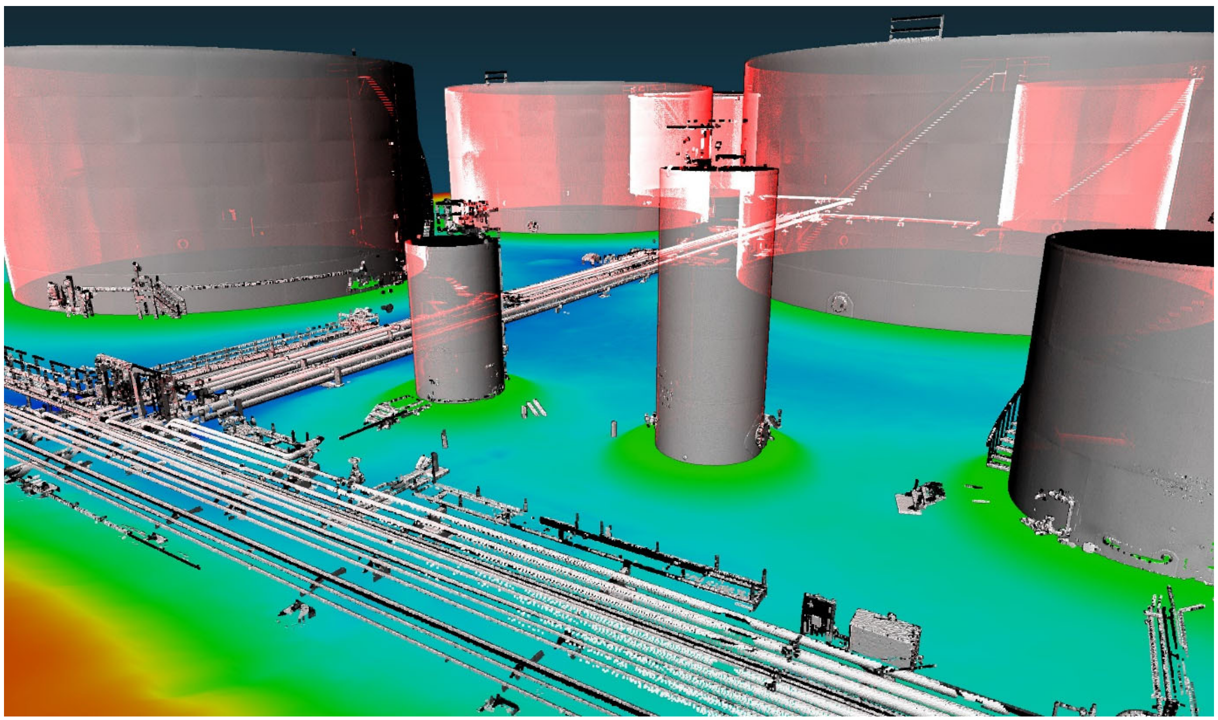
- Volumetric Strapping Tables
- Run Tables (Increment Table)
- Deduction Calculations & Corrections Summary
- Deadwood Measurement & Capacity Chart
- Field Strapping Information Summary

STC Measurement Procedures

- All STC Data Collection Procedures Comply with the Manual of Petroleum Management Standard – Chapter 2
- Based on Customer Requirements and/or Tank Construction we are Able to Select Which Method to Use for Storage Tank Calibration
  - MPMS Section 2A – Manual Tank Strapping Method
  - MPMS Section 2B – Optical Reference Line Method
  - MPMS Section 2C – Optical Triangulation Method
  - MPMS Section 2D – Internal Electro-optical Distance Ranging Method

RANGER 3D IMAGING

Additional Services Offered



- Shell Deflection and Deformation Survey & Evaluation
- Drone Inspections
- Advanced 3D Imaging
- Field Strapping Information Summary

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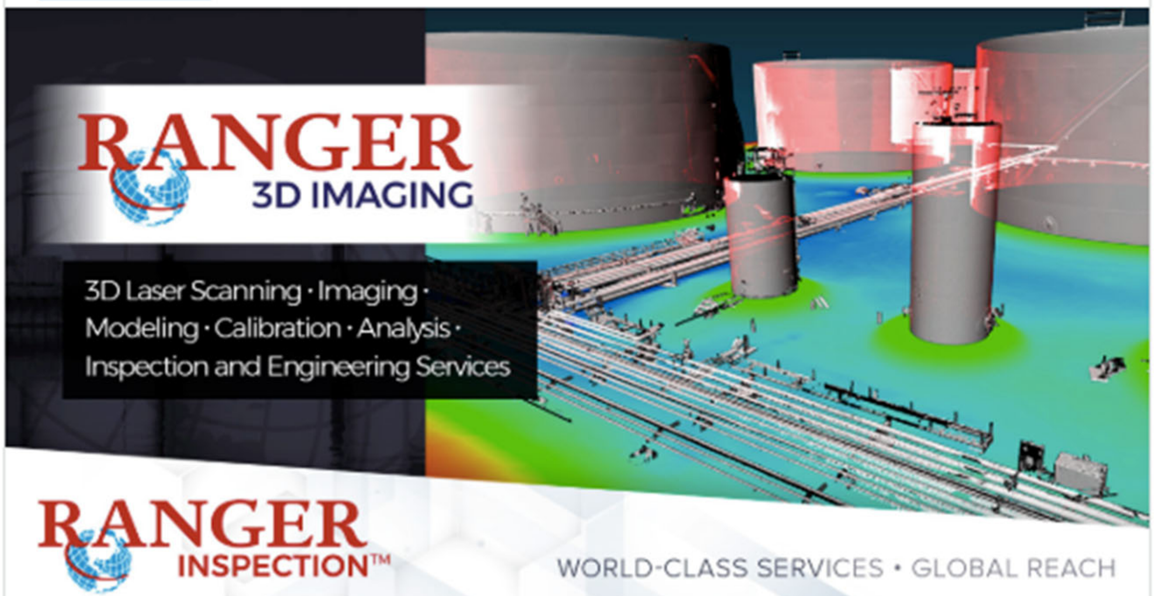

Ranger Drone

RANGER DRONE

Applications:

- Inspection of Tanks, Pressure Vessels, Piping, Towers, Stacks
- Refineries, Tank Farms, Oil & Gas Facilities
- Marine, Mining, Agriculture, Construction, Exploration
- Inspection of Bridges, Beams, Girders
- Confined Spaces, Sumps, Corridors
- Inspection of Welds, Corrosion, Coatings, Surfaces
- Buildings, Rooms, Attics, Crawl Space, Tunnels
- Search & Rescue, Reconnaissance
- Military / Police / Security

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Feb 12

Ranger Drone uses only the most reliable and capable Flyability and DJI equipment when performing Drone inspections. Inspect and explore indoor and confined spaces with our collision-tolerant Drones, improving safety and providing a less costly alternative to ropes, scaffolds, lifts, cranes, and excessive manpower. Our advanced Drones carry payloads including full HD cameras, thermal cameras, flexible vision above and below, ultrasonic probes, onboard lighting systems to illuminate dark areas. Providing safe operation of Drones and UAVs for inaccessible and difficult-to-reach places over a wide range of industries. A division of Ranger Inspection™. ISO 9001:2015 Certified. Please call: 403-252-4487.

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Concluding Remarks

- Questions?

- Alex Romanow Jr.
- Phone: 403-519-6690
- Email: alex@rangerinspectin.com