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Sample Report for Storage Tank
Shell Structural Profile & Bottom Profile Survey

DOCUMENT REFERENCE	Report No : IET-16--17/000 Rev 00
PREPARED	MOHAMED RAUB
APPROVED	SANJAY BOSE
CONTROLLED COPY?	YES
CIRCULATION	· IET ADMINISTRATION & CLIENT

CONTENTS

1. Execution Summary

Survey had to be carried out on (Tank no); vertical Butt welded mild steel cylindrical tank, with a floating roof.

On behalf of our end client, (Company Name) we have performed a survey of the tank to provide data to assist in determining the compliance of tank with API Standard 653, Appendix B Shell Settlement specifications and Roundness.

The engineers who performed the onsite survey on (Date) were Mr. Sanjay Bose & Mr. Mohamed Raub.

This report should be read in conjunction with API 653 Appendix B.

The API 653, Appendix B standard allows the operator to interpret settlement data, particularly the determination of floor edge settlement break-over points and the nomination of statistical outlying data for shell settlement in determination of the plane of rigid tilt and the tank shell deflection.

We have exercised such judgment in good faith and provide illustrations of our working in this report; and we have processed the data for the convenience of engineering personnel assessing the tank against the API 653B standard. The ultimate responsibility therefore lies with the engineers in accepting the information in this report and its suitability for deciding upon the condition of the tank consequently, we are receptive to any requests from our client to re-process the tank data in accordance with their differing interpretation of the API 653B standard.

The Standard acknowledges that the tank's previous service history may be considered in evaluating many of the aspects of settlement.

We cannot comment whether the apparent settlement of the tank represents the as-built condition or is settlement since construction. The API 653 settlement specifications assume the current condition to have developed from a purely symmetrical tank, and as such should be viewed as a worst-case evaluation.

Other than by the methods described in API Standard 653 Appendix B, we do not attempt to calculate the tank shell stresses that may be generated by tank settlement.

2. Person To Contact

CLIENT:

❖ CONTRACTOR:

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3. Applicable Codes, Standards, Specification

1. API – 653 Tank Inspection, Repair, Alteration and Reconstruction – 5th Edition 2014
2. API 653, Annex B – Evaluation of Tank Bottom Settlement – 5th Edition 2014
3. ISO 7507 / API MPMS – Manual of Petroleum Measurement Standards.
4. MECHANICAL DATA Sheets' (As Built)

4. Abbreviation

- API – American Petroleum Institute
- ISO – International Standard Organization
- Smax - Permissible out-of-plane settlement
- L - Arc length between measurement points
- Y - Yield strength of the shell material
- E - Young's Modulus
- H - Tank height
- M - Meters
- mm – Millimeters

5. Tank Description

Client	:
Location	:
Tank Number	:
Material of Construction	:Mild Steel
Number of Shell Courses	:Eight (08)
Method of Construction	:Welding
Product Storage	:Crude Oil
Service	:Off-Stream
Type of Roof	:Floating Roof
Evaluation Code	:API 653 Edition-2014
Evaluation Carried out by	:Mr. Sanjay Bose – Surveyor
Date of Survey	:
Inspection/Survey Carried out	:Tank Shell Settlement Tank out-of roundness survey. Tank Verticality.
Values Considered for evaluation	:Height: 21.921 M Diameter: 92.000 M Arc Length (L): 9.639 M Yield Strength (Y): 30000 Young's Modulus (E): 29000000

6. Shell Roundness Survey Evaluation

A survey of tank shell was performed in accordance with API, to obtain verticality data at two heights of each strake (measured with optical equipment along 30 vertical stations around the tank exterior) and a tank reference circumference corresponding with the strake 1 upper section verticality reading.

To provide a report on the roundness of the tank shell, we have also determined the internal radii at each measurement station at 500 millimeters above the base of the tank shell.

The internal radii are derived from laser ranging (offset) measurements taken outside from the tank from a fixed point to each station around the lower section of 1st Course. These readings are adjusted using the tank shell verticality measurements to give an equivalent reading at 500 millimeters above the tank base. The tank centroid is computed from the adjusted offsets and the radius between the centroid and each measurement station calculated, as reported in the table below.

Radii at 500 mm above tank base

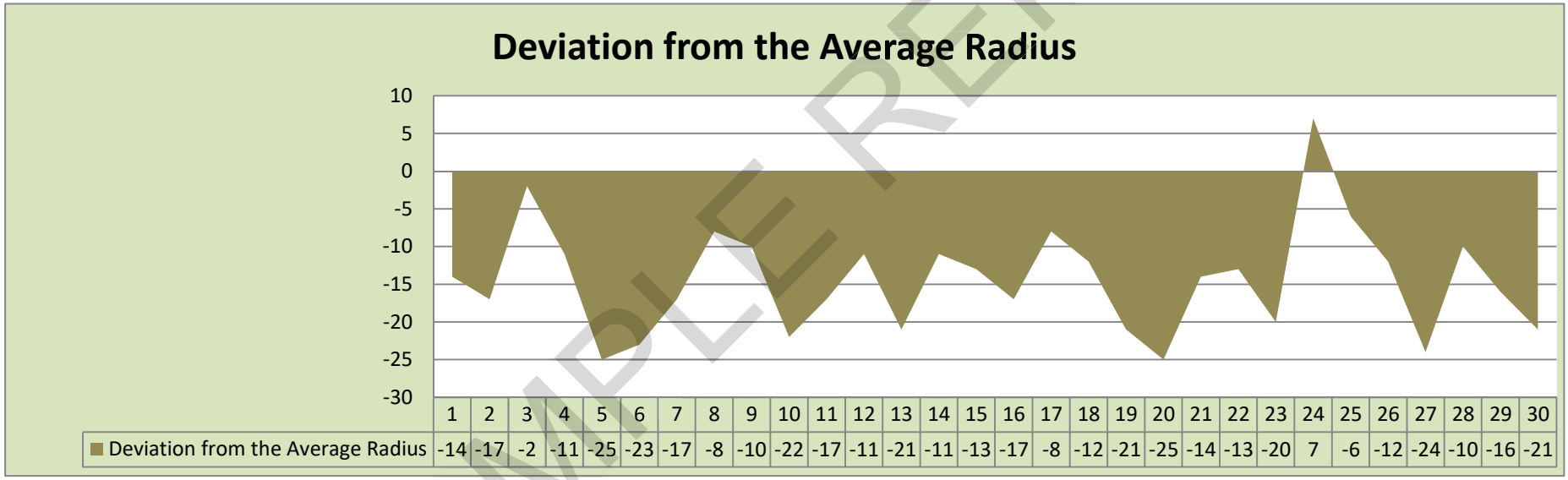
The maximum radius variation at 500 millimeters above the base of the tank shell is -25 millimeters

Station	Radius to Tank Centroid	Station	Radius to Tank Centroid	Station	Radius to Tank Centroid	Station	Radius to Tank Centroid
1	45.966	9	45.97	17	45.972	25	45.974
2	45.963	10	45.958	18	45.968	26	45.968
3	45.978	11	45.963	19	45.959	27	45.956
4	45.969	12	45.969	20	45.955	28	45.97
5	45.955	13	45.959	21	45.966	29	45.964
6	45.957	14	45.969	22	45.967	30	45.959
7	45.963	15	45.967	23	45.96		
8	45.972	16	45.963	24	45.987		

Following are the deviations between the reference radius and the radius at each individual station:

The tolerances given in API 653 Table 10.2 the max Permissible value for Radii measured at 1 ft. above the shell-to-bottom weld shall not exceed +31.75 mm (Tank Diameter (Feet) >250).

Radius tolerances measured higher than one foot above the shell-to-bottom weld the max Permissible Radius tolerances value will be three times the tolerances given in API 653 Table 10.2 which we mentioned before.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Deviation from the Average Radius	-14	-17	-2	-11	-25	-23	-17	-8	-10	-22	-17	-11	-21	-11	-13	-17	-8	-12	-21	-25	-14	-13	-20	7	-6	-12	-24	-10	-16	-21

Internal Offsets corrected for plate thickness - millimetres

Negative value = Tank Set IN

* Top = 80%, Bott = 20%

Station		1	2	3	4	5	6	7	8
Course	Thk (m)								
1 - top **	0.0430	0	0	0	0	0	0	0	0
1 - bott	0.0430	-14	-17	-2	-11	-25	-23	-17	-8
2 - top	0.0400	-5	-6	-12	0	-13	-10	-20	-3
2 - bott	0.0400	2	1	-3	3	-1	1	-4	0
3 - top	0.0318	-2	16	1	-12	-25	9	4	14
3 - bott	0.0318	-5	-1	-11	-2	-18	-5	-14	1
4 - top	0.0263	9	31	-5	-22	-2	18	9	12
4 - bott	0.0263	3	30	6	-12	-18	8	9	21
5 - top	0.0210	12	30	-10	-20	-7	12	6	9
5 - bott	0.0210	12	30	-9	-20	0	21	13	-51
6 - top	0.0157	5	39	-16	-45	-11	17	12	14
6 - bott	0.0157	8	32	-14	-28	-8	14	4	10
7 - top	0.0131	23	47	-25	-51	3	24	7	1
7 - bott	0.0131	8	33	-29	-52	-16	10	-2	3
8 - top	0.0124	16	43	-38	-58	2	22	-10	-8
8 - bott	0.0124	22	46	-30	-56	6	30	-3	-17

Station		9	10	11	12	13	14	15	16
Course	Thk (m)								
1 - top **	0.0430	0	0	0	0	0	0	0	0
1 - bott	0.0430	-10	-22	-17	-11	-21	-11	-13	-17
2 - top	0.0400	2	-5	-6	-22	-5	-1	3	-2
2 - bott	0.0400	4	1	-1	-7	1	-1	4	8
3 - top	0.0318	5	-12	5	-16	2	-3	-6	3
3 - bott	0.0318	10	2	0	-23	-2	1	3	2
4 - top	0.0263	6	4	14	-26	-6	-13	-11	6
4 - bott	0.0263	9	-5	11	-21	2	-5	-10	3
5 - top	0.0210	7	12	10	-26	-10	-20	-25	-3
5 - bott	0.0210	4	7	16	-27	-13	-21	-14	7
6 - top	0.0157	19	11	7	-4	-1	-4	-21	-6
6 - bott	0.0157	19	17	5	-17	-4	-9	-20	3
7 - top	0.0131	17	17	7	11	-4	-17	-27	-15
7 - bott	0.0131	13	-6	-4	-1	-14	-11	-32	-17
8 - top	0.0124	19	3	-8	60	-22	-24	-35	-18
8 - bott	0.0124	19	17	-3	8	-19	-17	-29	-16

Internal Offsets corrected for plate thickness - millimetres

Negative value = Tank Set IN

* Top = 80%, Bott = 20%

Station		17	18	19	20	21	22	23	24
Course	Thk (m)								
1 - top **	0.0000	0	0	0	0	0	0	0	0
1 - bott	0.0000	-8	-12	-21	-25	-14	-13	-20	7
2 - top	0.0000	-11	8	18	6	10	-14	-3	-22
2 - bott	0.0000	0	6	8	6	2	-3	3	-11
3 - top	0.0000	18	23	38	4	3	7	11	-15
3 - bott	0.0000	5	13	28	7	-1	-13	-1	-10
4 - top	0.0000	20	28	41	24	29	2	-7	-18
4 - bott	0.0000	24	29	44	10	12	13	14	-14
5 - top	0.0000	14	35	57	20	24	-3	-14	-14
5 - bott	0.0000	17	28	43	25	29	0	-10	-19
6 - top	0.0000	34	53	59	14	20	6	-20	-22
6 - bott	0.0000	23	46	63	21	24	-5	-19	-13
7 - top	0.0000	23	54	56	31	13	3	-38	-31
7 - bott	0.0000	28	50	51	6	6	-1	-36	-34
8 - top	0.0000	17	58	49	14	10	-14	-59	-40
8 - bott	0.0000	20	57	56	32	15	-5	-48	-38

Station		25	26	27	28	29	30
Course	Thk (m)						
1 - top **	0.0000	0	0	0	0	0	0
1 - bott	0.0000	-6	-12	-24	-10	-16	-21
2 - top	0.0000	2	-3	12	-4	11	12
2 - bott	0.0000	-1	2	3	3	3	8
3 - top	0.0000	13	20	42	34	12	2
3 - bott	0.0000	11	6	8	33	15	12
4 - top	0.0000	10	22	43	35	16	8
4 - bott	0.0000	14	25	49	39	14	6
5 - top	0.0000	-1	14	32	36	27	4
5 - bott	0.0000	8	19	42	34	18	6
6 - top	0.0000	-19	19	32	42	20	-7
6 - bott	0.0000	-10	14	30	39	29	6
7 - top	0.0000	-23	18	15	28	20	7
7 - bott	0.0000	-30	10	20	31	15	-20
8 - top	0.0000	-30	11	-1	10	17	-5
8 - bott	0.0000	-28	15	7	19	20	0

MAXIMUM OFFSET SET **IN** = **-59 MM**

MINIMUM OFFSET SET **OUT** = **63 MM**

CORRECTED EXTERNAL CIRCUMFERENCE AT REFERENCE COURSE 1 = 289.172 M

CORRECTED INTERNAL DIAMETER AT REFERENCE COURSE 1 = 91.9603 M

INTERNAL RADIUS = 45.98 M

Opposing station internal offsets - Calculated internal diameter - metres

Opposing Station / Course	1 & 16	2 & 17	3 & 18	4 & 19	5 & 20	6 & 21	7 & 22	8 & 23
1 - top **	91.960	91.960	91.960	91.960	91.960	91.960	91.960	91.960
1 - bott	91.929	91.935	91.946	91.928	91.910	91.923	91.930	91.932
2 - top	91.953	91.943	91.956	91.978	91.953	91.960	91.926	91.954
2 - bott	91.970	91.961	91.963	91.971	91.965	91.963	91.953	91.963
3 - top	91.962	91.995	91.985	91.987	91.940	91.973	91.972	91.986
3 - bott	91.958	91.965	91.963	91.987	91.950	91.955	91.934	91.961
4 - top	91.975	92.011	91.983	91.979	91.982	92.007	91.971	91.965
4 - bott	91.966	92.014	91.995	91.992	91.952	91.980	91.982	91.995
5 - top	91.969	92.004	91.985	91.997	91.973	91.996	91.963	91.955
5 - bott	91.979	92.007	91.979	91.983	91.985	92.010	91.973	91.899
6 - top	91.960	92.034	91.998	91.975	91.964	91.998	91.979	91.955
6 - bott	91.972	92.016	91.993	91.996	91.974	91.999	91.960	91.952
7 - top	91.968	92.030	91.989	91.965	91.994	91.997	91.970	91.923
7 - bott	91.951	92.021	91.981	91.959	91.950	91.976	91.957	91.927
8 - top	91.958	92.020	91.980	91.951	91.976	91.992	91.936	91.893
8 - bott	91.966	92.026	91.987	91.960	91.998	92.005	91.952	91.895

Opposing station internal offsets - Calculated internal diameter - metres

Opposing Station / Course	9 & 24	10 & 25	11 & 26	12 & 27	13 & 28	14 & 29	15 & 30
1 - top **	91.960	91.960	91.960	91.960	91.960	91.960	91.960
1 - bott	91.957	91.932	91.931	91.925	91.929	91.933	91.926
2 - top	91.940	91.957	91.951	91.950	91.951	91.970	91.975
2 - bott	91.953	91.960	91.961	91.956	91.964	91.962	91.972
3 - top	91.951	91.962	91.986	91.987	91.997	91.970	91.957
3 - bott	91.961	91.974	91.967	91.946	91.992	91.977	91.976
4 - top	91.948	91.974	91.996	91.977	91.989	91.963	91.957
4 - bott	91.955	91.969	91.996	91.988	92.001	91.969	91.956
5 - top	91.953	91.971	91.984	91.966	91.986	91.967	91.939
5 - bott	91.945	91.975	91.995	91.975	91.981	91.957	91.952
6 - top	91.958	91.953	91.987	91.989	92.002	91.977	91.933
6 - bott	91.967	91.968	91.980	91.974	91.996	91.981	91.947
7 - top	91.946	91.954	91.985	91.986	91.984	91.963	91.940
7 - bott	91.939	91.924	91.966	91.979	91.977	91.964	91.908
8 - top	91.939	91.933	91.963	92.019	91.948	91.953	91.920
8 - bott	91.941	91.949	91.972	91.975	91.960	91.963	91.931

MAXIMUM DIAMETER =	**92.034 M**	MINIMUM DIAMETER =	**91.893 M**
MAXIMUM TANK SET OUT	**74 MM**	MAXIMUM TANK SET IN =	**-67 MM**

Opposing station internal offsets - metres

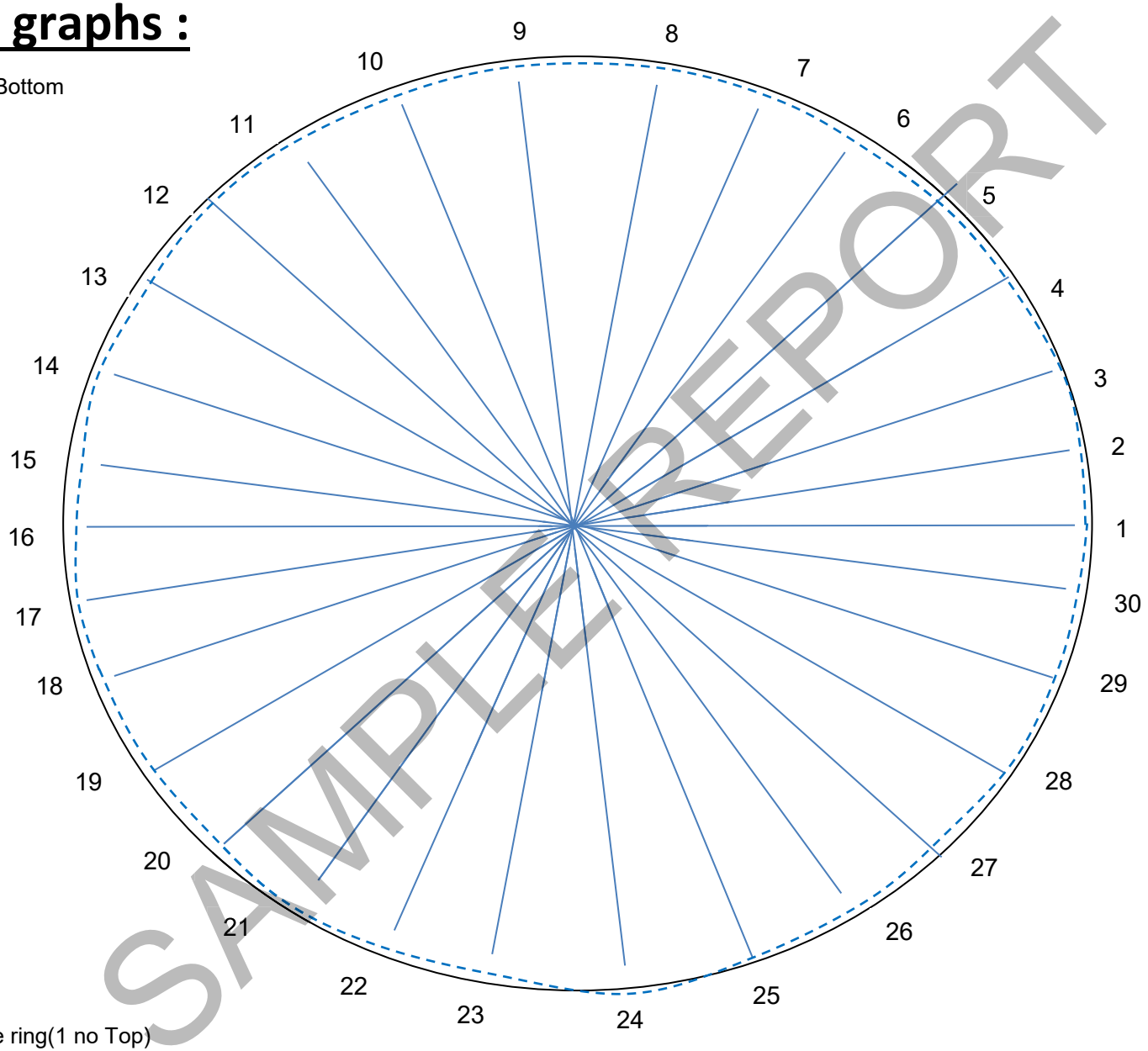
Opposing Station / Course	1 & 16	2 & 17	3 & 18	4 & 19	5 & 20	6 & 21	7 & 22	8 & 23
1 - top **	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 - bott	-0.031	-0.025	-0.014	-0.032	-0.050	-0.037	-0.030	-0.028
2 - top	-0.007	-0.017	-0.004	0.018	-0.007	0.000	-0.034	-0.006
2 - bott	0.010	0.001	0.003	0.011	0.005	0.003	-0.007	0.003
3 - top	0.001	0.034	0.024	0.026	-0.021	0.012	0.011	0.025
3 - bott	-0.003	0.004	0.002	0.026	-0.011	-0.006	-0.027	0.000
4 - top	0.014	0.050	0.022	0.018	0.021	0.046	0.010	0.004
4 - bott	0.005	0.053	0.034	0.031	-0.009	0.019	0.021	0.034
5 - top	0.009	0.044	0.025	0.037	0.013	0.036	0.003	-0.005
5 - bott	0.019	0.047	0.019	0.023	0.025	0.050	0.013	-0.061
6 - top	0.000	0.074	0.038	0.015	0.004	0.038	0.019	-0.005
6 - bott	0.012	0.056	0.033	0.036	0.014	0.039	0.000	-0.008
7 - top	0.008	0.070	0.029	0.005	0.034	0.037	0.010	-0.037
7 - bott	-0.009	0.061	0.021	-0.001	-0.010	0.016	-0.003	-0.033
8 - top	-0.003	0.059	0.019	-0.010	0.015	0.031	-0.025	-0.068
8 - bott	0.005	0.065	0.026	-0.001	0.037	0.044	-0.009	-0.066

Opposing station internal offsets - metres

Opposing Station / Course	9 & 24	10 & 25	11 & 26	12 & 27	13 & 28	14 & 29	15 & 30
1 - top **	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 - bott	-0.003	-0.028	-0.029	-0.035	-0.031	-0.027	-0.034
2 - top	-0.020	-0.003	-0.009	-0.010	-0.009	0.010	0.015
2 - bott	-0.007	0.000	0.001	-0.004	0.004	0.002	0.012
3 - top	-0.010	0.001	0.025	0.026	0.036	0.009	-0.004
3 - bott	0.000	0.013	0.006	-0.015	0.031	0.016	0.015
4 - top	-0.013	0.013	0.035	0.016	0.028	0.002	-0.004
4 - bott	-0.006	0.008	0.035	0.027	0.040	0.008	-0.005
5 - top	-0.007	0.011	0.024	0.006	0.026	0.007	-0.021
5 - bott	-0.015	0.015	0.035	0.015	0.021	-0.003	-0.008
6 - top	-0.002	-0.007	0.027	0.029	0.042	0.017	-0.027
6 - bott	0.007	0.008	0.020	0.014	0.036	0.021	-0.013
7 - top	-0.014	-0.006	0.025	0.026	0.024	0.003	-0.020
7 - bott	-0.021	-0.036	0.006	0.019	0.017	0.004	-0.052
8 - top	-0.022	-0.028	0.002	0.058	-0.013	-0.008	-0.041
8 - bott	-0.020	-0.012	0.011	0.014	-0.001	0.002	-0.030

Ring offset graphs :

Ring # : 1 no Top & Bottom

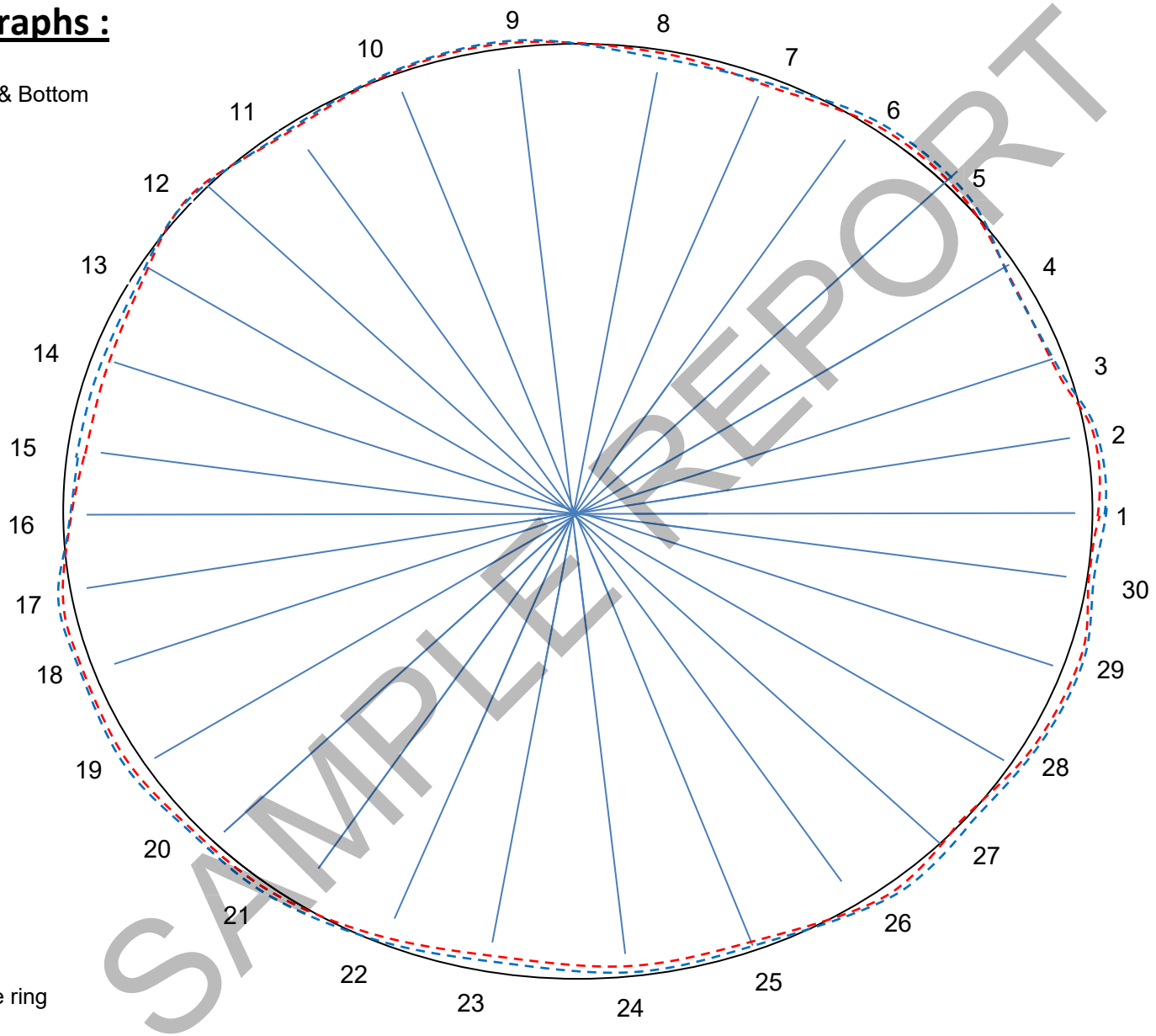


Reference ring(1 no Top)
1 no Bottom

*Not to scale, magnified for clarity

Ring offset graphs :

Ring # : 8 no Top & Bottom

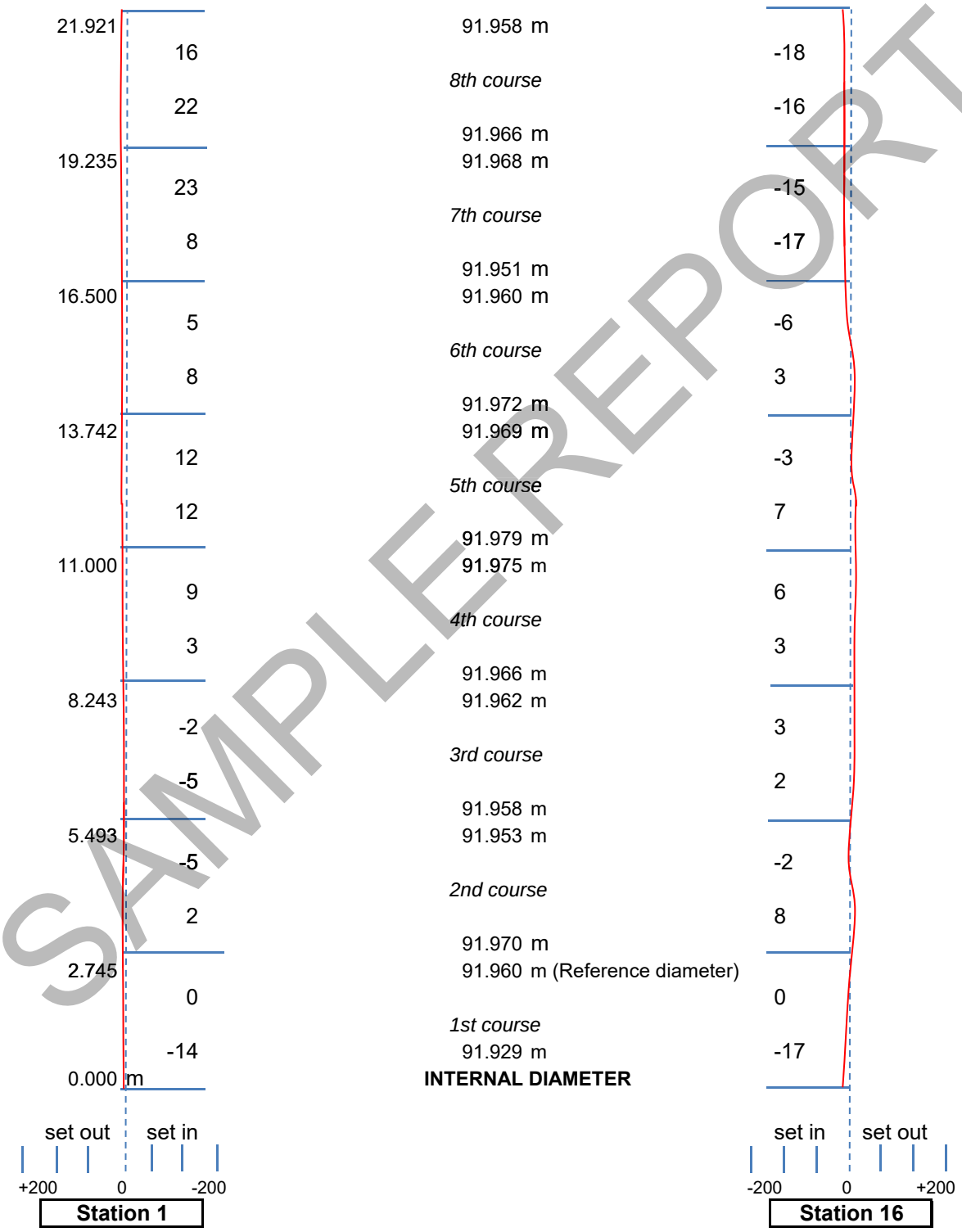


Reference ring
8 no Top
8 no Bottom

*Not to scale, magnified for clarity

Offset graphs-opposite stations :

INTERNAL OFFSETS (OPPOSING STATIONS) IN MM



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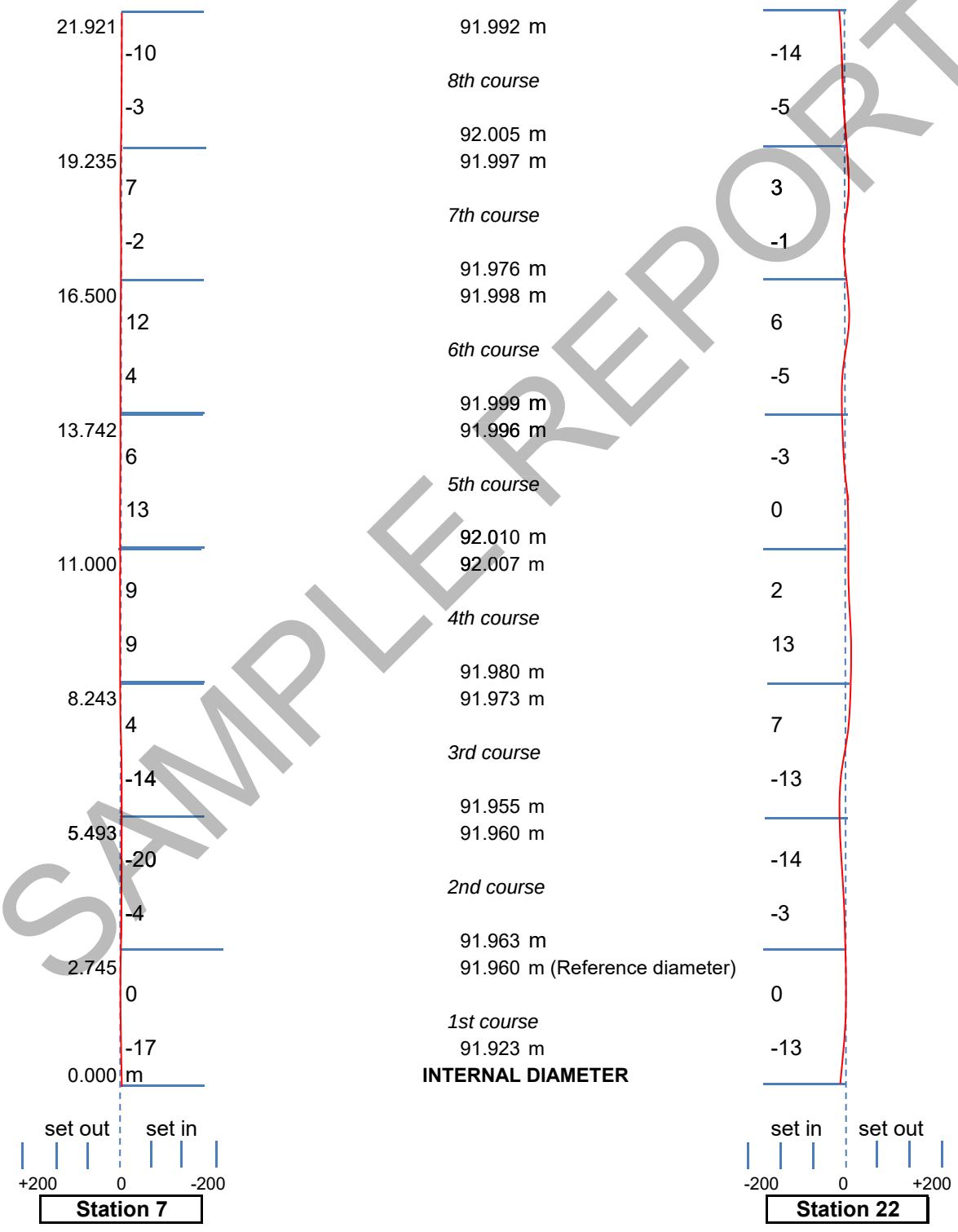
Offset graphs-opposite stations :

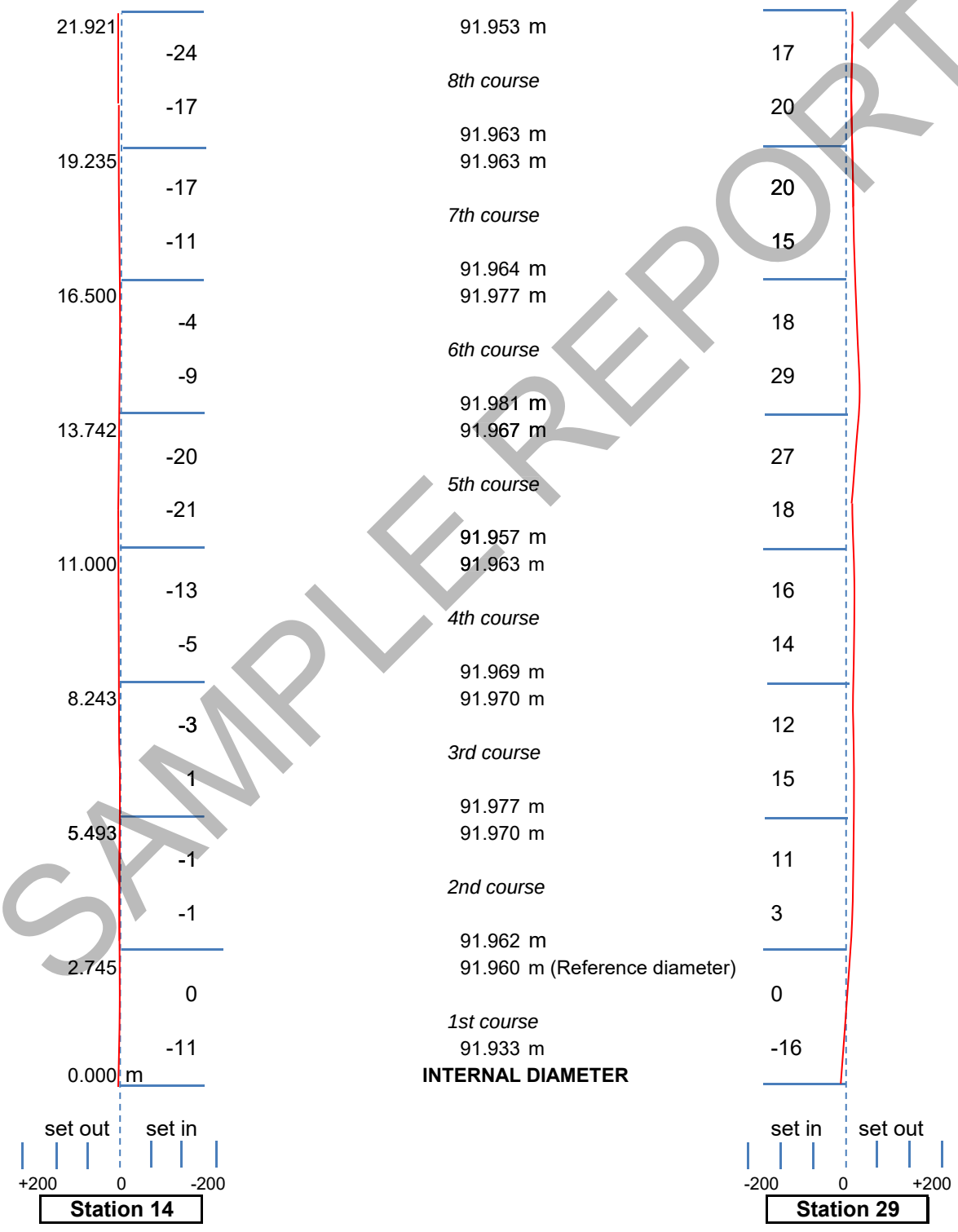
INTERNAL OFFSETS (OPPOSING STATIONS) IN MM



*Not to scale, magnified for clarity

Offset graphs-opposite stations :

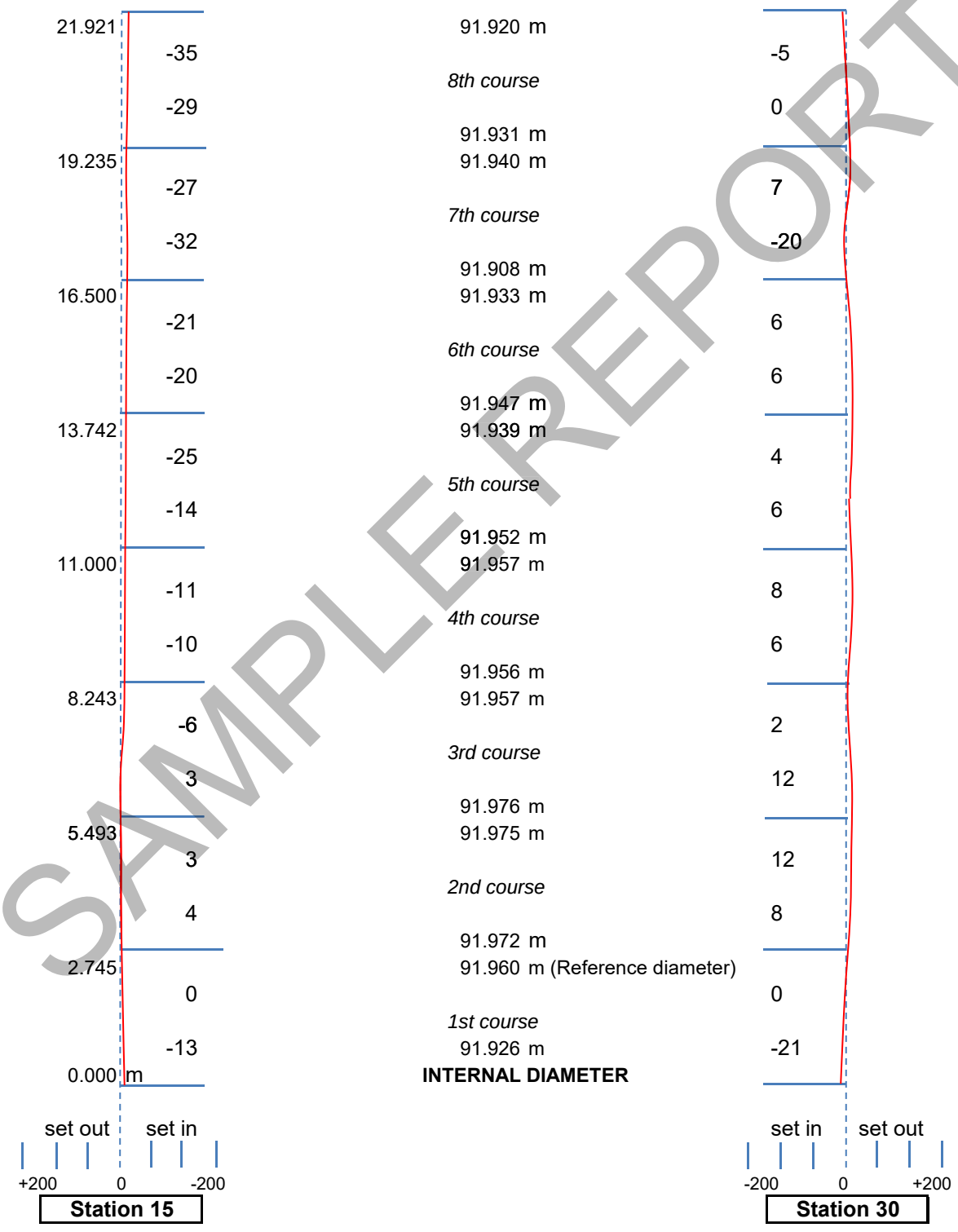
INTERNAL OFFSETS (OPPOSING STATIONS) IN MM



***Not to scale, magnified for clarity**

Offset graphs-opposite stations :

INTERNAL OFFSETS (OPPOSING STATIONS) IN MM



***Not to scale, magnified for clarity**

7.Tank Verticality Evaluation

Tank verticality survey was performed in accordance with API, to obtain verticality data at two heights of each tank of the top of the shell with respect to bottom of the shell (measured with optical equipment along 30 vertical stations around the tank exterior).

The verticality evaluation was made in two different formats. One format represents the verticality value in each shell two position with respect to the bottom of the first shell & other represents the value of the top of the tank with respect to the bottom of the tank.

Verticality value in each shell two position with respect to the bottom of the first shell

Station / Course	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 - top *	14	17	2	11	25	23	17	8	10	22	17	11	21	11	13	17	8	12	21	25
1 - bott	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 - top	6	8	-13	8	9	10	-6	2	9	14	8	-14	13	7	13	12	-6	17	36	28
2 - bott	13	15	-4	11	21	21	10	5	11	20	13	1	19	7	14	22	5	15	26	28
3 - top	1	22	-8	-12	-11	21	10	11	4	-1	11	-16	12	-3	-4	9	15	24	48	18
3 - bott	-2	5	-20	-2	-4	7	-8	-2	9	13	6	-23	8	1	5	8	2	14	38	21
4 - top	6	31	-20	-28	6	24	9	3	-1	9	14	-32	-2	-19	-15	6	11	23	45	32
4 - bott	0	30	-9	-18	-10	14	9	12	2	0	11	-27	6	-11	-14	3	15	24	48	18
5 - top	4	25	-30	-31	-4	13	1	-5	-5	12	5	-37	-11	-31	-34	-8	0	25	56	23
5 - bott	4	25	-29	-31	3	22	8	-65	-8	7	11	-38	-14	-32	-23	2	3	18	42	28
6 - top	-8	29	-41	-61	-13	13	2	-5	2	6	-3	-20	-7	-20	-35	-16	15	38	53	12
6 - bott	-5	22	-39	-44	-10	10	-6	-9	2	12	-5	-33	-10	-25	-34	-7	4	31	57	19
7 - top	7	34	-53	-70	-2	17	-6	-21	-3	9	-6	-8	-13	-36	-44	-28	1	36	47	26
7 - bott	-8	20	-57	-71	-21	3	-15	-19	-7	-14	-17	-20	-23	-30	-49	-30	6	32	42	1
8 - top	-1	29	-67	-78	-4	14	-24	-31	-2	-6	-22	40	-32	-44	-53	-32	-6	39	39	8
8 - bott	5	32	-59	-76	0	22	-17	-40	-2	8	-17	-12	-29	-37	-47	-30	-3	38	46	26

Verticality value in each shell two position with respect to the bottom of the first shell										
Station / Course	21	22	23	24	25	26	27	28	29	30
1 - top *	14	13	20	-7	6	12	24	10	16	21
1 - bott	0	0	0	0	0	0	0	0	0	0
2 - top	21	-4	14	-32	5	6	33	3	24	30
2 - bott	13	7	20	-21	2	11	24	10	16	26
3 - top	6	9	20	-33	8	21	55	33	17	12
3 - bott	2	-11	8	-28	6	7	21	32	20	22
4 - top	26	-2	-4	-42	-1	17	50	28	15	12
4 - bott	9	9	17	-38	3	20	56	32	13	10
5 - top	16	-12	-16	-43	-17	4	34	24	21	**3**
5 - bott	21	-9	-12	-48	-8	9	44	22	12	**5**
6 - top	7	-8	-27	-56	-40	4	29	25	9	-13
6 - bott	11	-19	-26	-47	-31	-1	27	22	**18**	0
7 - top	-3	-14	-48	-68	-47	0	9	8	6	-2
7 - bott	-10	-18	-46	-71	-54	-8	14	**11**	**1**	-29
8 - top	-7	-32	-70	-78	-55	-8	-8	**-11**	**2**	-15
8 - bott	-2	-23	-59	-76	-53	-4	0	**-2**	5	-10

MAXIMUM VERTICALITY SET **IN** =	**57 mm**
MINIMUM VERTICALITY SET **OUT** =	**-78 mm**

Verticality value of the top of the tank with respect to the bottom of the tank.																				
Station / Course	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 no bo	13.271	13.462	13.141	8.845	8.439	11.311	12.358	12.334	13.157	13.446	13.023	13.870	13.174	13.157	13.215	13.054	12.872	12.824	13.143	13.309
9 no top	13.272	13.433	13.208	8.923	8.443	11.297	12.382	12.365	13.159	13.452	13.045	13.830	13.206	13.201	13.268	13.086	12.878	12.785	13.104	13.301
Verticality Value	-1	29	-67	-78	-4	14	-24	-31	-2	-6	-22	40	-32	-44	-53	-32	-6	39	39	8

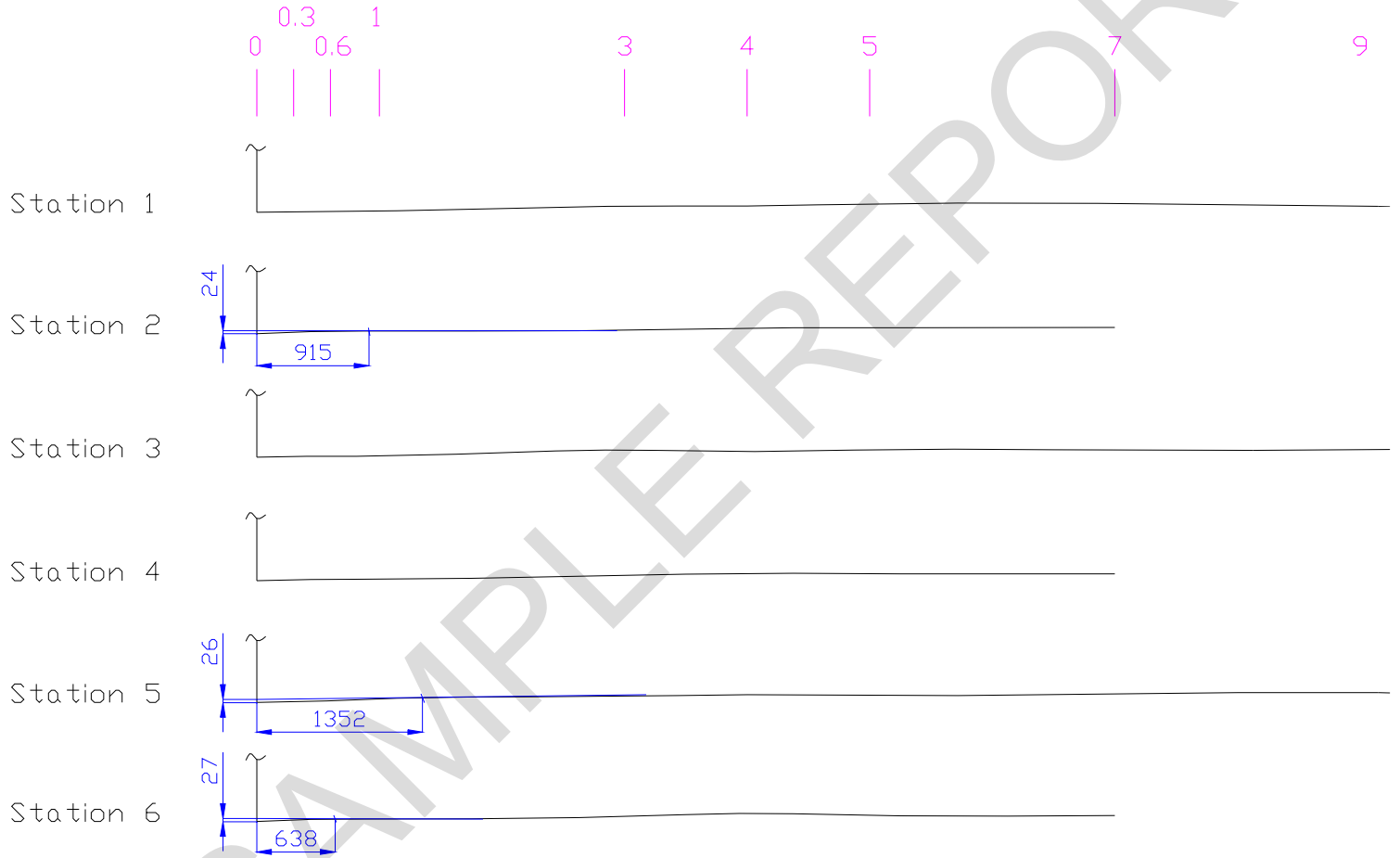
Verticality value of the top of the tank with respect to the bottom of the tank.										
Station / Course	21	22	23	24	25	26	27	28	29	30
1 no bo	13.411	11.733	11.851	11.172	10.144	8.584	7.127	9.772	12.943	11.924
9 no top	13.418	11.765	11.921	11.250	10.199	8.592	7.135	9.783	12.941	11.939
Verticality Value	-7	-32	-70	-78	-55	-8	-8	-11	2	-15

MAXIMUM VERTICALITY SET **IN** =	**40 mm**
MINIMUM VERTICALITY SET **OUT**	**-78 mm**

The maximum out-of-plumbness / verticality of the top of the shell with respect to bottom of the shell is ± 127mm.

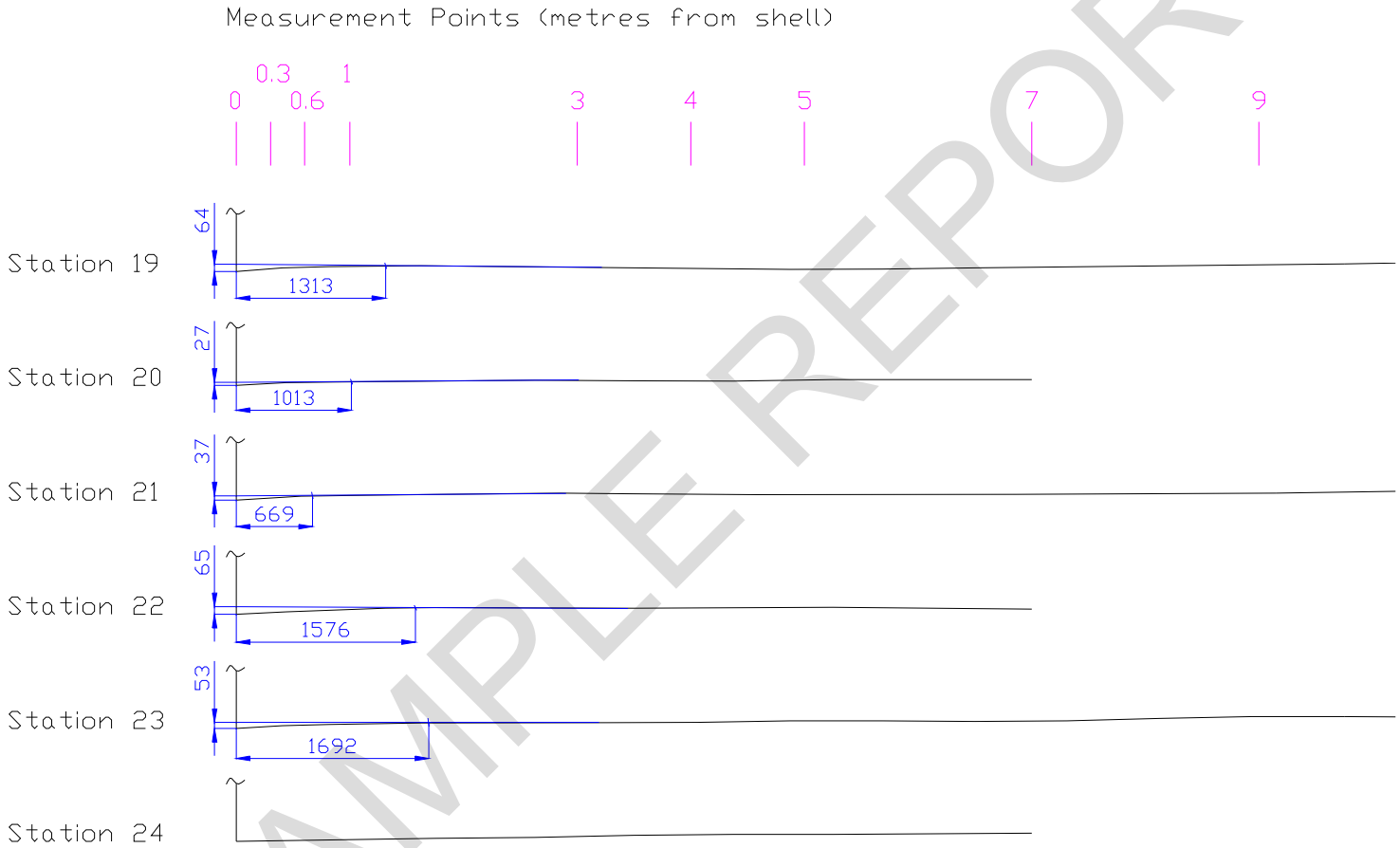
This evaluation is done in accordance with the section 10.5.2.1 of API Standard 653

8. Edge Settlement (API653B method)



The measurement points are connected with spline curves to produce each floor profile
Dimensions in millimetres

Edge Settlement (API653B method)



The measurement points are connected with spline curves to produce each floor profile
Dimensions in millimetres

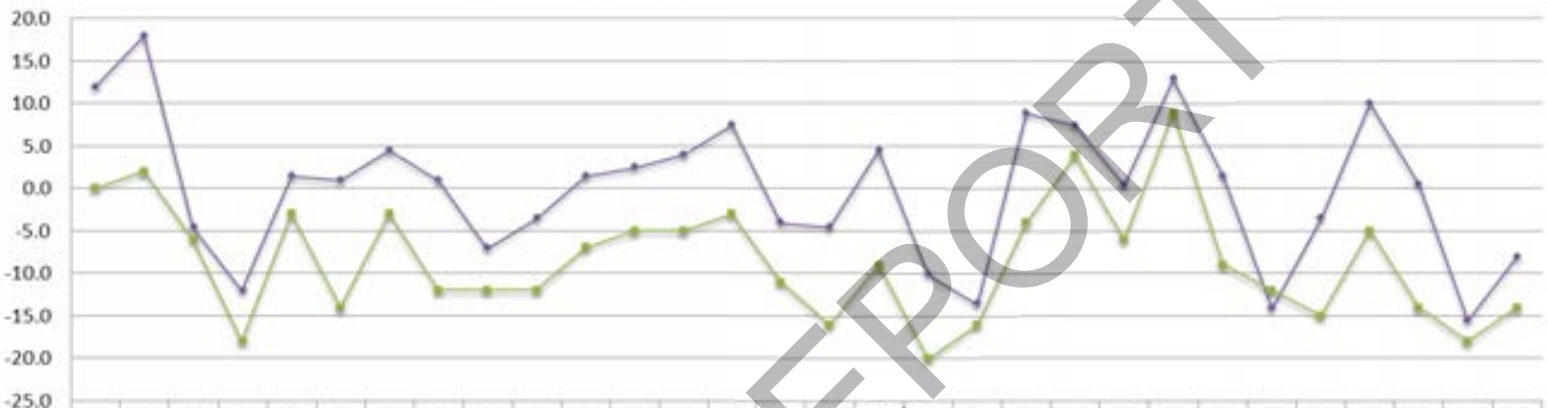
Edge Settlement Evaluation – API653B

API 653 Appendix B Floor Edge Settlement Evaluation Criteria

1. Tanks with larger edg settlem nts than Bew/Be/Bα are to be repaired, or have detailed analysis of the floor, and floor to shell junction.
2. Welds in tanks with settlement gr at r than or equal to 75% of Bew/Be/Bα and larg r than 2", are to be inspected with magnetic particle or liquid penetrant examination.
3. Tanks with settlement less than 75% of Bew/Be/Bα may be returned to servic .
4. An asterix preceeding an evaluation comment denotes a settlement radius that exceeds the range of the graph provided by the Standard (6 feet). he Bew/Be/Bα valu r port d in th table is extrapolated from th graph/s.

Station	Floor Weld Angle within Settled Area	API 653B Evaluation Method Reference	Actual Settled Area Radius R (mm)	Actual Settled Area Radius R (feet)	Max Allowable Settlement Bew/Be/Bα (inch)	Max Allowable Settlement Bew/Be/Bα (mm)	Actual Edge Settlement (mm)	Variation (mm)	Evaluation of settlement in accordance with API 653B Figures B-10, B-11 or Section B.3.4.3
1	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
2	none	B-11	915	3.00	4.67	119	24	-95	less than 75% of Be
3	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
4	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
5	none	B-11	1352	4.44	6.04	153	26	-127	less than 75% of Be
6	45°	B.3.4.3	638	2.09	3.03	77	27	-50	less than 75% of Bα
7	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
8	none	B-11	282	0.93	2.00	51	14	-37	less than 75% of Be
9	none	B-11	1218	4.00	5.65	144	58	-86	less than 75% of Be
10	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
11	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A
12	none	B-11	404	1.33	2.00	51	20	-31	less than 75% of Be
13	65°	B.3.4.3	455	1.49	2.00	51	19	-32	less than 75% of Bα
14	15°	B.3.4.3	706	2.32	3.49	89	31	-58	less than 75% of Bα
15	perpendicular	B-11	1487	4.88	6.43	163	58	-105	less than 75% of Be
16	perpendicular	B-11	1435	4.71	6.28	160	46	-114	less than 75% of Be
17	none	B-11	1407	4.62	6.20	157	43	-114	less than 75% of Be
18	45°	B.3.4.3	1288	4.23	5.02	128	50	-78	less than 75% of Bα
19	30°	B.3.4.3	1313	4.31	5.33	135	64	-71	less than 75% of Bα
20	none	B-11	1013	3.32	4.99	127	27	-100	less than 75% of Be
21	none	B-11	669	2.19	3.36	85	37	-48	less than 75% of Be
22	20°	B.3.4.3	1576	5.17	6.21	158	65	-93	less than 75% of Bα
23	35°	B.3.4.3	1692	5.55	6.18	157	53	-104	less than 75% of Bα
24	none	B-11	0	0.00	#N/A	#N/A	0	#N/A	#N/A

9. Tank Shell Settlement Evaluation



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Out-Of-Plane Deflection (mm)	12.0	18.0	-4.5	-12.0	1.5	1.0	4.5	1.0	-7.0	-3.5	1.5	2.5	4.0	7.5	-4.0	-4.5	4.5	-10.0	-13.5	9.0	7.5	0.5	13.0	1.5	-14.0	-3.5	10.0	0.5	-15.5	-8.0
Actual Edge Settlement (mm)	0.0	2.0	-6.0	-18.0	-3.0	-14.0	-3.0	-12.0	-12.0	-12.0	-7.0	-5.0	-5.0	-3.0	-11.0	-16.0	-9.0	-20.0	-16.0	-4.0	4.0	-6.0	9.0	-9.0	-12.0	-15.0	-5.0	-14.0	-18.0	-14.0

Location 1 to 30 as indicated above is moving in anti-clockwise direction

API Standard 653 (B.3.2) approximation for maximum out-of-plane deflection is 18.00 mm.

The Standard suggests further assessment or repair if the deflection exceeds the permissible value.

This evaluation is done in accordance with the section B.2.2.4f of API Standard 653

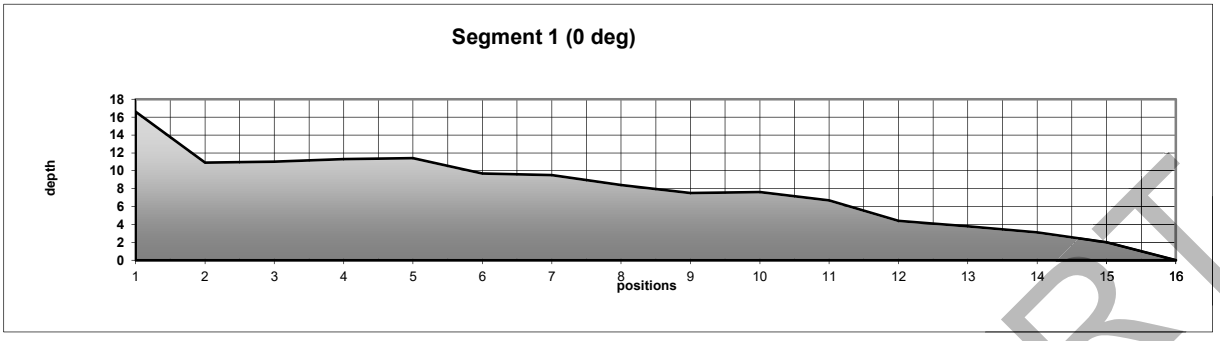
The max Permissible value As per API Standard 653 Edition 2014 (section B.3.2.1) is $\pm$ 24.10 mm by the following equation

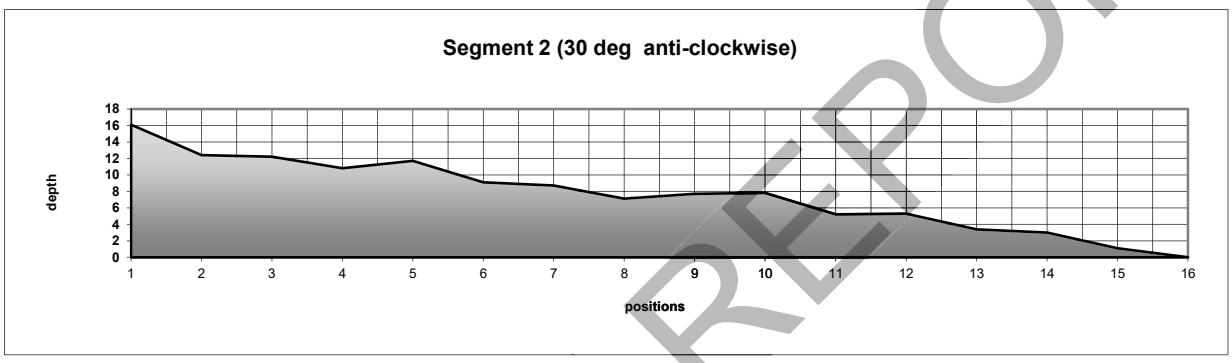
$$S_{maxft} = \frac{(L2 \times Y \times 11)}{2[(E \times H)]}$$

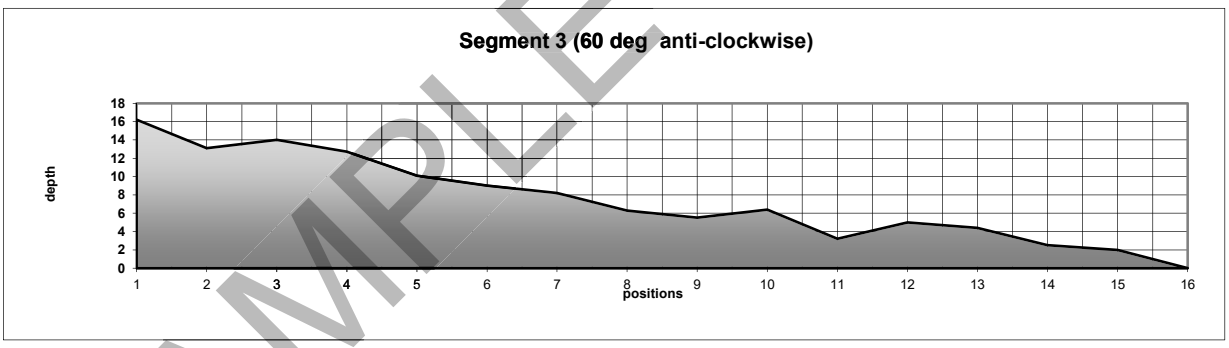
So, the tank can be used as per above mentioned value from API standard, but needs to checked for settlement at periodic interval.

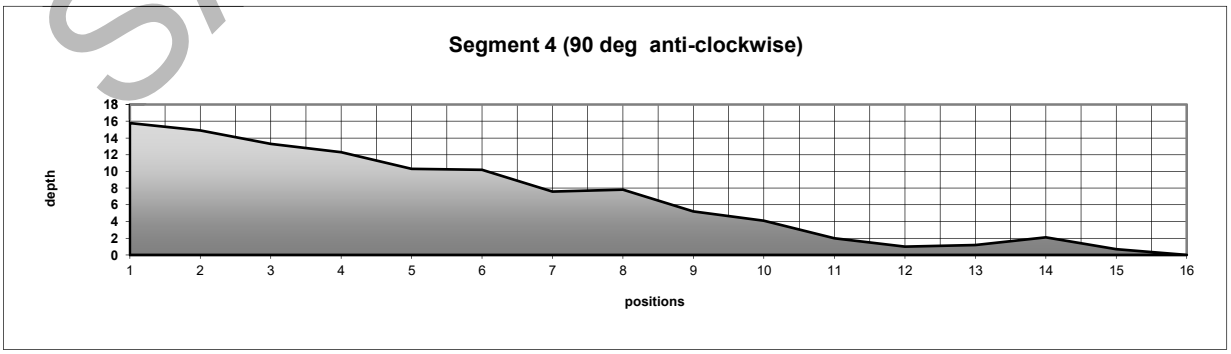
10. TANK BOTTOM FLOOR PROFILE FROM CENTRE (CONE UP)

CENTRELINE TANK SHELL SIDE





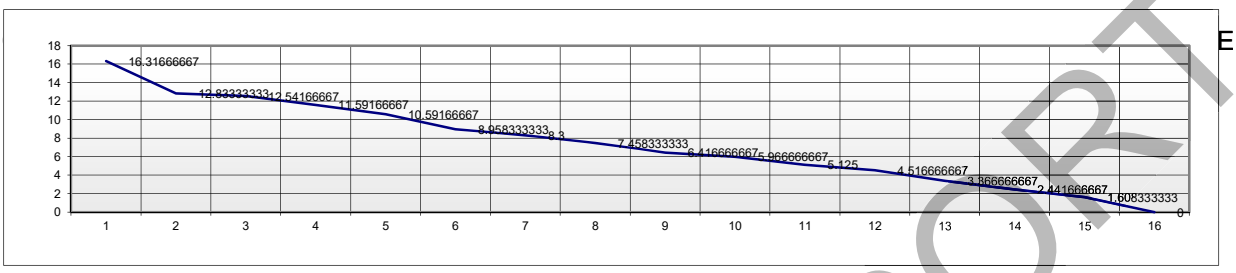


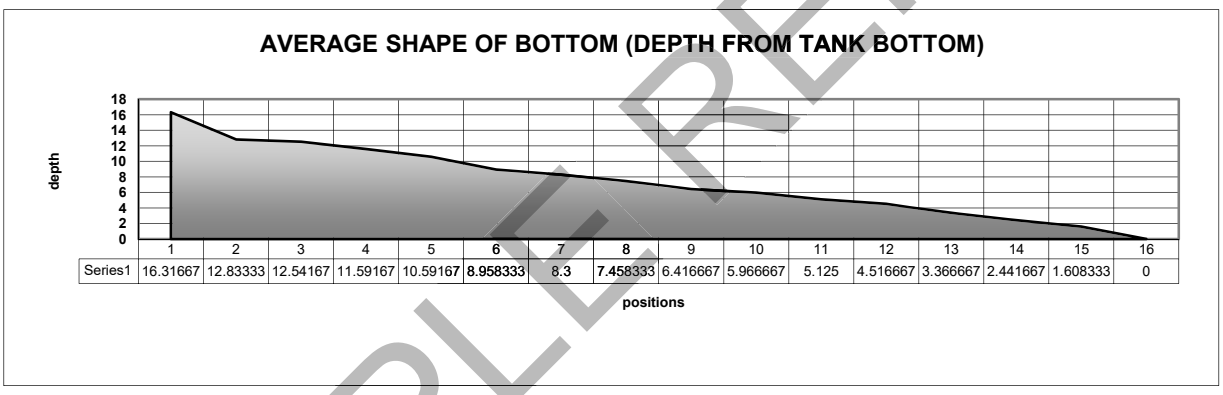


TANK BOTTOM FLOOR PROFILE FROM CENTRE (CONE UP)

AVERAGE SHAPE OF TANK BOTTOM

CONE-UP PROFILE
(ALL DEPTH IN CM)





CENTRELINE TANK SHELL SIDE

11. Evaluation Summary

❖ **Tank Shell Settlement :** The maximum out-of-plane deflection is 18.0 mm.

The max Permissible value As per API Standard 653 Edition 2014 (section B.3.2.1) is

± 24.10 mm by the following equation

$$S_{max\ ft} = \frac{(L^2 \times Y \times 11)}{2[(E \times H)]}$$

Where: Smax, ft is permissible out-of-plane settlement, in feet (ft);

L is arc length between measurement points, in feet (ft);

Y is yield strength of the shell material, in pound force per square inch (lbf/in^2);

E is Young's Modulus, in pound force per square inch (lbf/in^2);

H is tank height, in feet (ft).

❖ **Tank Out-of-Roundness / Ovality :** The maximum radius variation at 300mm above the base of the tank shell is -25.0 mm.

The tolerances given in API 653 Table 10.2 the max Permissible value for Radii measured at 1 ft. above the shell-to-bottom weld shall not exceed +31.75mm (Tank Diameter (Feet) >250).

❖ **Tank Out-of-Plumbness / Verticality :** The maximum Verticality value of the top of the tank with respect to the bottom of the tank is -78.0 mm & The maximum the verticality value in each shell two position with respect to the bottom of the first shell is -78.0 mm

The maximum out-of-plumbness / verticality of the top of the shell with respect to bottom of the shell is ± 127.0 mm.

This evaluation is done in accordance with the section 10.5.2.1 of API Standard 653

Reviewed & Approved By:

globalREMOTE

Inside Exploration Technologies
a group company of globalREMOTE

REPORT: C-XX STORAGE TANK-XXXX EDGE SETTLEMENT SURVEY DURING HYDROTEST

QATAR CHEMICAL COMPANY LTD.
MESAIEED, QATAR.

August 2016

DOCUMENT REFERENCE	IETQ-16-000 rev 00
PREPARED	MOHAMED RAUB
APPROVED	SANJAY BOSE
CONTROLLED COPY?	YES
CIRCULATION	• IET ADMINISTRATION & CLIENT

CONTENTS

1. Execution Summary

Edge settlement Survey on different water level (0, 20, 40, 60 & 80 percentage) during water filling and (40 & 0 percentage) during dewatering of hydro test had to be carried out on C-xxStorage Tank-xx-xxxx; vertical Butt welded mild steel cylindrical tank, with a fixed roof.

On behalf of our end client, Qatar Chemical Company Ltd.(QCHEM) we have performed a survey of the tank to provide data to assist in determining the compliance of tank with API Standard 653, Appendix B Shell Edge Settlement.

The engineers who performed the onsite survey were Mr. Sanjay Bose & Mr. Sobin Sibichen.

This report should be read in conjunction with API 653 Appendix B.

The API 653, Appendix B standard allows the operator to interpret settlement data, particularly the determination of floor edge settlement break-over points and the nomination of statistical outlying data for shell settlement in determination of the plane of rigid tilt and the tank shell deflection.

We have exercised such judgment in good faith and provide illustrations of our working in this report; and we have processed the data for the convenience of engineering personnel assessing the tank against the API 653 B standard. The ultimate responsibility therefore lies with the engineers in accepting the information in this report and its suitability for deciding upon the condition of the tank consequently, we are receptive to any requests from our client to re-process the tank data in accordance with their differing interpretation of the API 653B standard.

The Standard acknowledges that the tank's previous service history may be considered in evaluating many of the aspects of settlement.

We cannot comment whether the apparent settlement of the tank represents the as-built condition or is settlement since construction. The API 653 settlement specifications assume the current condition to have developed from a purely symmetrical tank, and as such should be viewed as a worst-case evaluation.

Other than by the methods described in API Standard 653 Appendix B, we do not attempt to calculate the tank shell stresses that may be generated by tank settlement.

2. Person To Contact

❖ **CLIENT:**

Qatar Chemical Company Ltd.,
Mesaieed Industrial City,
State of Qatar.

❖ **CONTRACTOR:**

Person to Contact:

❖ **Sub-Contractor:**

Inside Exploration Technologies WLL,
P.O. Box: 201763 Doha, State of Qatar.

Person to Contact: **Mr. Sanjay Bose**
Technical In-charge | Tank Survey & Calibration Division
T: +974 3347 1069
E: sanjay.b@global-remote.net

Mr. Ginosh Abraham
Director-Middle East.

3. Applicable Codes, Standards, Specification

1. API – 653 Tank Inspection, Repair, Alteration and Reconstruction – 5th Edition 2014
2. API 653, Annex B – Evaluation of Tank Bottom Settlement – 5th Edition 2014
3. ISO 7507 / API MPMS – Manual of Petroleum Measurement Standards.
4. MECHANICAL DATA Sheets' (As Built)

4. Abbreviation

- API – American Petroleum Institute
- ISO – International Standard Organization
- Smax - Permissible out-of-plane settlement
- L - Arc length between measurement points
- Y - Yield strength of the shell material
- E - Young's Modulus
- H - Tank height
- M - Meters
- mm – Millimeters

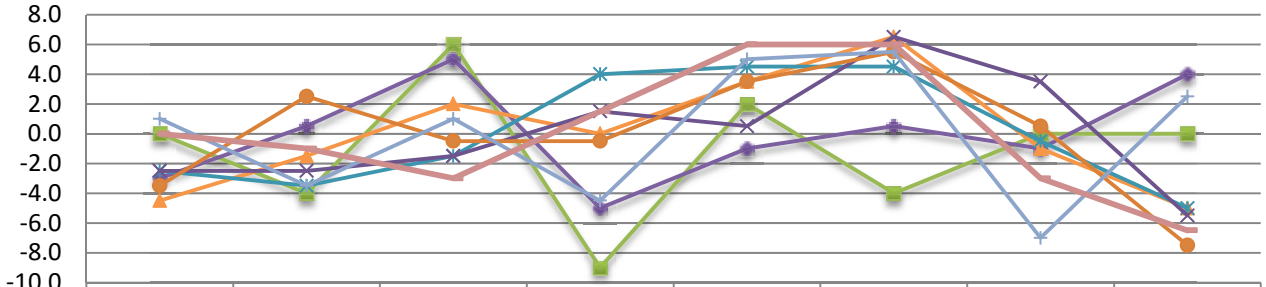
5. Tank Description

Client	Qatar Chemical Company Ltd.,
Location	Mesaieed, Qatar.
Tank Number	C-xx STORAGE TANK-xxxxxx
Material of Construction	Carbon Steel
Number of Shell Courses	Six (06)
Method of Construction	Welding
Product Storage	C-xx Product
Service	0, 20, 40, 60 & 80% water level during Hydro test
Type of Roof	Fixed Dome
Evaluation Code	API 653 Edition-2014
Evaluation Carried out by	Mr. Sanjay Bose – Surveyor
Date of Survey	
Inspection/Survey Carried out	• Tank Edge Settlement

Values Considered for evaluation:

Height: 10.800 M	**Arc Length (L):** 8.245 M	**Yield Strength (Y):** 30000	**Young's Modulus (E):** 29000000

6. Tank Edge Settlement Evaluation - During Hydrotest (Water filling)



	1	2	3	4	5	6	7	8
Actual Edge Settlement (mm)	0.0	-4.0	6.0	-9.0	2.0	-4.0	0.0	0.0
Settlement Value - 0% Water Level	-3.0	0.5	5.0	-5.0	-1.0	0.5	-1.0	4.0
Settlement Value - 20% Water Level	-4.5	-1.5	2.0	0.0	3.5	6.5	-1.0	-5.0
Settlement Value - 40% Water Level	-2.5	-3.5	-1.5	4.0	4.5	4.5	-0.5	-5.0
Settlement Value - 60% Water Level	-2.5	-2.5	-1.5	1.5	0.5	6.5	3.5	-5.5
Settlement Value - 80% Water Level	-3.5	2.5	-0.5	-0.5	3.5	5.5	0.5	-7.5
Settlement Value - 40% Water Level (Dewatering)	1.0	-3.5	1.0	-4.5	5.0	5.5	-7.0	2.5
Settlement Value - 0% Water Level (Dewatering)	0.0	-1.0	-3.0	1.5	6.0	6.0	-3.0	-6.5

Location 1 to 8 as indicated above is moving in anti-clockwise direction

API Standard 653 (B.3.2) approximation for maximum out-of-plane deflection is -7.5 mm.

The Standard suggests further assessment or repair if the deflection exceeds the permissible value.

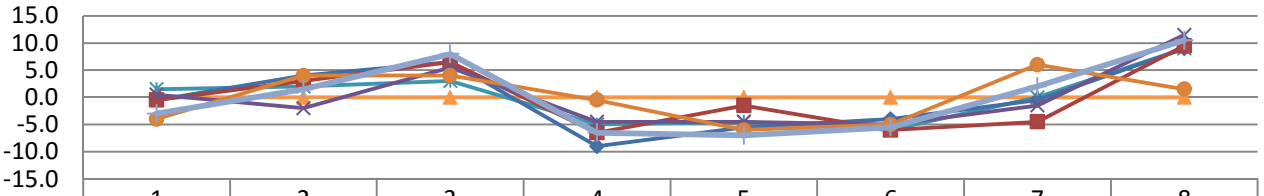
This evaluation is done in accordance with the section B.2.2.4f of API Standard 653.

The max Permissible value As per API Standard 653 Edition 2014 (section B.3.2.1) is ± 35.81 mm by the following equation

$$S_{maxft} = \frac{(L^2 \times Y \times 11)}{2[(E \times H)]}$$

7. Tank Edge Settlement Evaluation

With respect to 0% water level



	1	2	3	4	5	6	7	8
Settlement Value - 0% Water Level	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlement Value - 20% Water Level	1.5	2.0	3.0	-5.0	-4.5	-6.0	0.0	9.0
Settlement Value - 40% Water Level	-0.5	4.0	6.5	-9.0	-5.5	-4.0	-0.5	9.0
Settlement Value - 60% Water Level	-0.5	3.0	6.5	-6.5	-1.5	-6.0	-4.5	9.5
Settlement Value - 80% Water Level	0.5	-2.0	5.5	-4.5	-4.5	-5.0	-1.5	11.5
Settlement Value - 40% Water Level (Dewatering)	-4.0	4.0	4.0	-0.5	-6.0	-5.0	6.0	1.5
Settlement Value - 0% Water Level (Dewatering)	-3.0	1.5	8.0	-6.5	-7.0	-5.5	2.0	10.5

In the above graph Evaluation for Settlement Survey Value in different water level is calculated with respect to 0% water level as reference.

8. Evaluation Summary

The maximum out-of-plane deflection is -7.5 mm.

The max Permissible value As per API Standard 653 Edition 2014 (section B.3.2.1) is $\pm$ 35.81 mm by the following equation

$$S_{max\ ft} = \frac{(L^2 \times Y \times 11)}{2[(E \times H)]}$$

Where: Smax, ft is permissible out-of-plane settlement, in feet (ft);
L is arc length between measurement points, in feet (ft);
Y is yield strength of the shell material, in pound force per square inch (lbf/in^2);
E is Young's Modulus, in pound force per square inch (lbf/in^2);
H is tank height, in feet (ft).