Challenges in implementing smart field tank's level Free Space Radar online & how it helps eliminate Process Safety Incidence: PETRONAS's Experience

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Malaysia and PETRONAS at a Glance

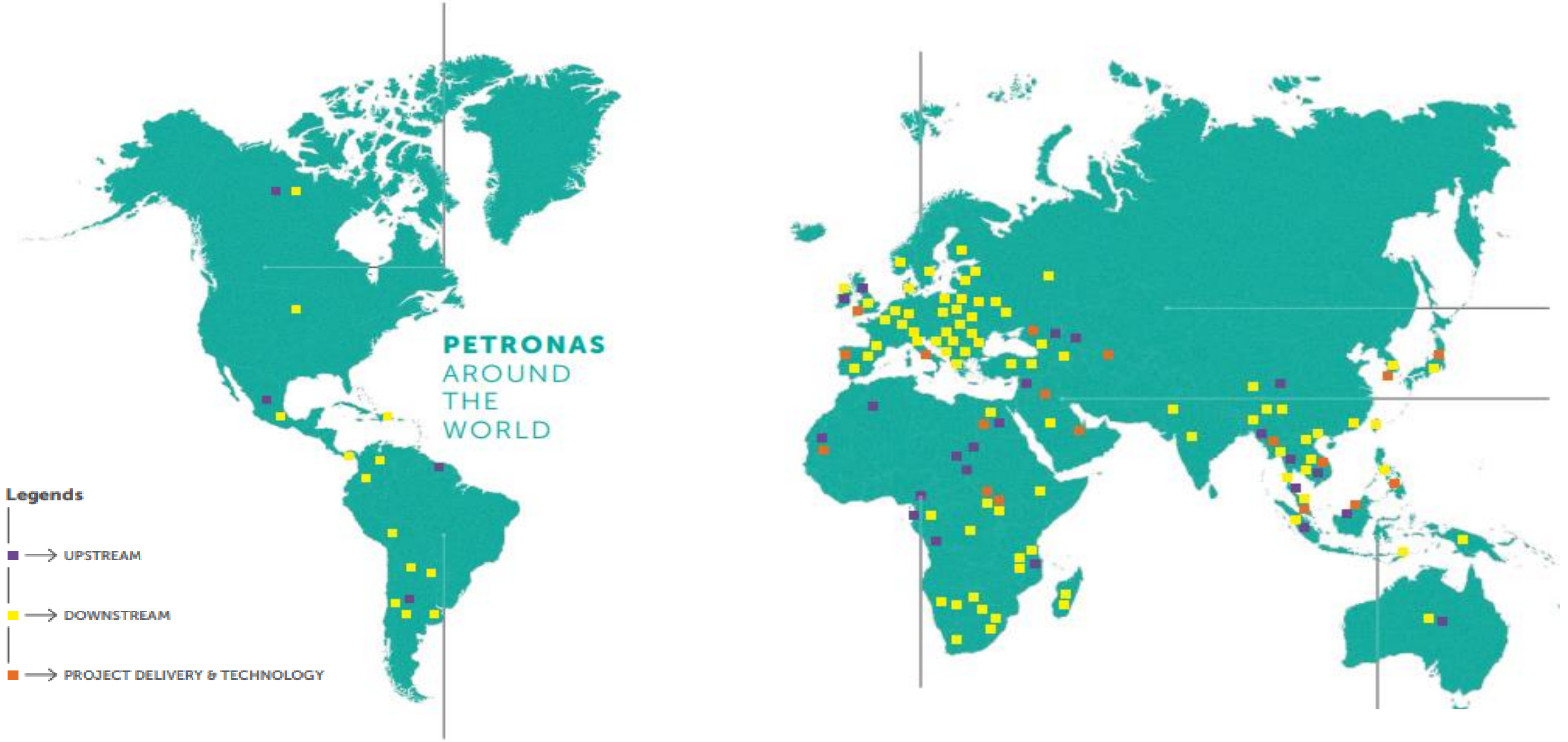
SPONSOR MERCEDES
F1 World Champions of 2014, 2015, 2016 & 2017

Changing the landscape
of the LNG industry with the world 1st PETRONAS Floating Liquefied Natural Gas

PETRONAS Global Presence

Our fully integrated value chain spans from exploration to marketing, logistics to technological infrastructures, with operations in over 50 countries around the world

North America



Latin America

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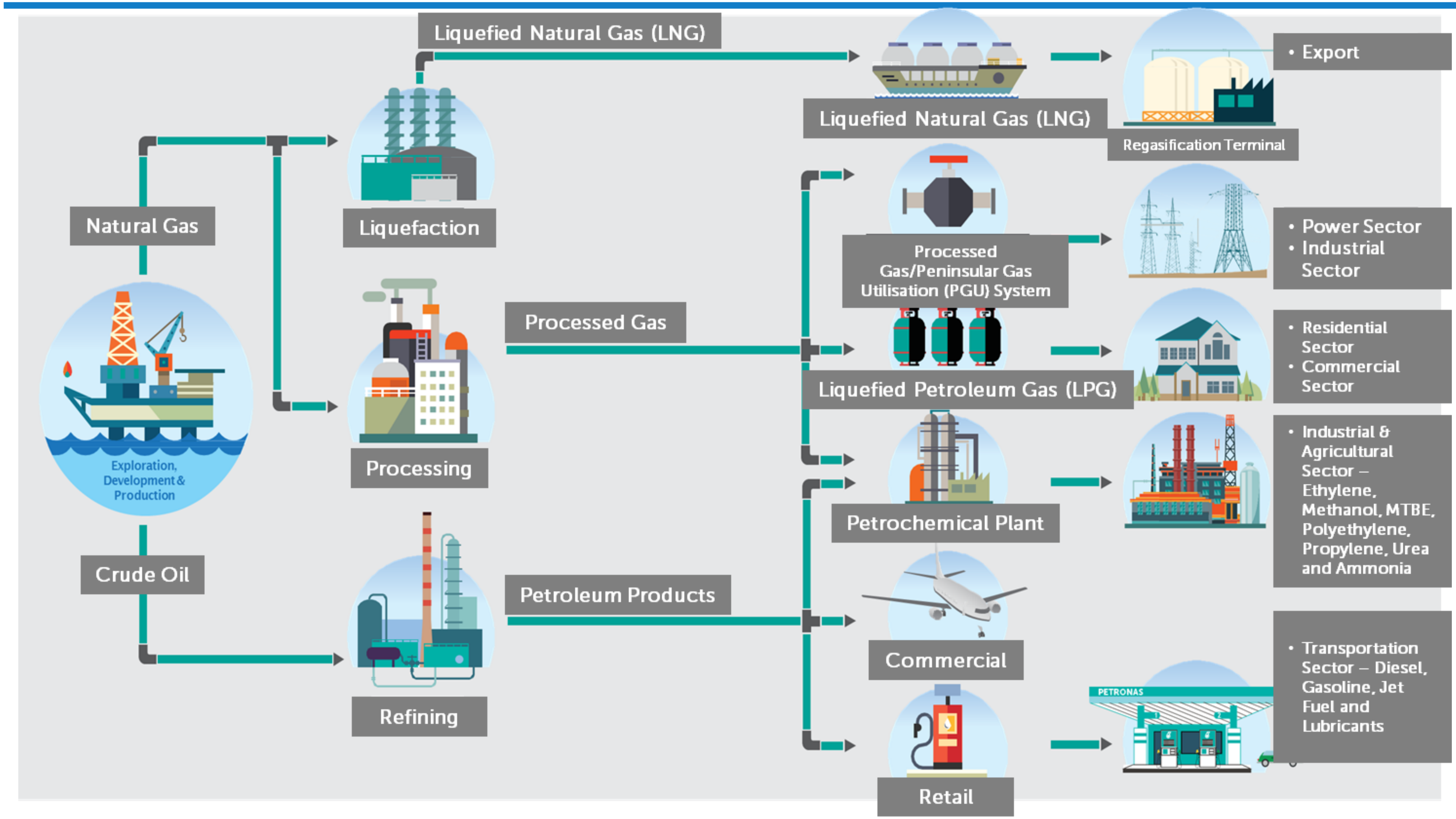
Fully Integrated Business

Maximise and add value to oil and gas assets



Source: PETRONAS Annual Report 2015

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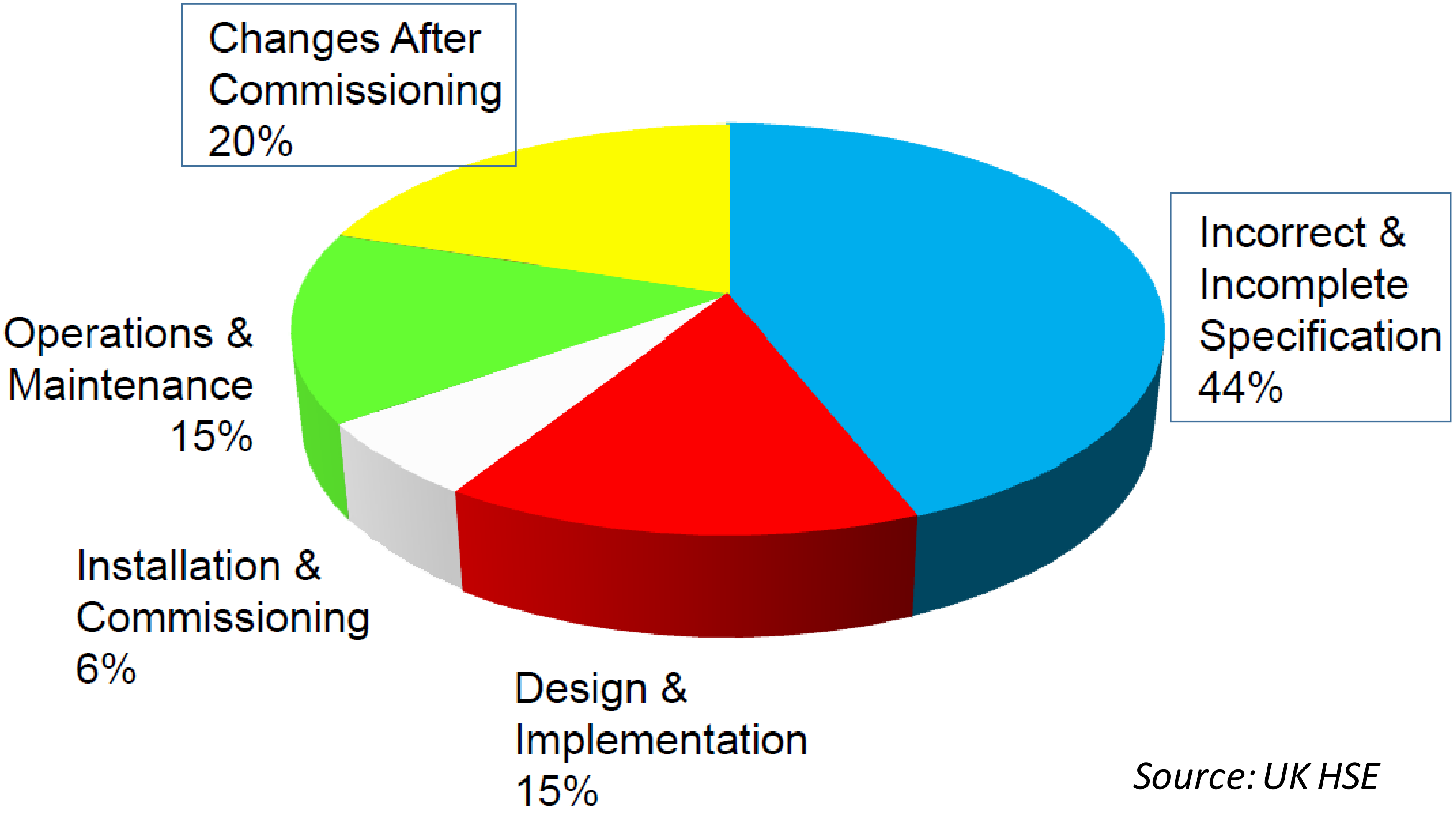
Instrumentation/ Control system failures in Process Industries



Source: UK HSE

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28 nos of Process Safety Incidence from 1971 ~ 1996

Year	Location	Chemical	Event	Deaths	Financial Loss‡
1971	Houston TX	Vinyl chloride monomer	BLEVE*	1	$145 million
1972	Brazil	Butane	UVCE**	37	$90 million
1972	West Virginia	Gas	CVCE***	21	$110 million
1973	Potschefstroom, South Africa	Ammonia	Toxic Release	18	$95 million
1973	Staten Island	LNG	Fire in empty storage tank	40	$350 million
1974	Flixborough, UK	Cyclohexane	UVCE**	28	$450 million
1976	Seveso, Italy	Tetrachloradibenzoparadioxin	Toxic Release	-	$35 million
1977	Columbia	Ammonia	Toxic Release	30	$35 million
1978	Waverly, USA	Propane	BLEVE*	12	$47 million
1981	Montanas, Mexico	Chlorine	BLEVE*	29	$103 million
1982	Spencer, USA	Water	BLEVE*	7	$8 million
1983	Houston TX, USA	Methyl Bromide	BLEVE*	2	$10 million
1984	Mexico City, Mexico	Propane	BLEVE*	650	$50 million
1984	Bhopal, India	Methylisocyanate	Toxic Release	2500	$350 million
1986	Kennedy Space Flight Center	Hydrogen	BLEVE*	7	$250 million
1987	Piper Alpha, UK	Hydrogen	Explosion & Fire	167	$300 million
1988	IL, USA	Propane	BLEVE*	15	$835 million
1989	Pasadena TX	Isobutane	BLEVE*	23	$255 million
1989	Antwerp, Belgium	Ethylene Oxide	UVCE**	20	$700 million
1989	Ufa, USSR	Ammonia	Explosion & Toxic Release	7	$570 million
1990	Bombay, India	Hydrocarbon	Fire & Explosion	35	$30 million
1990	Porto de Leixoes, Portugal	Propane	Fire & Explosion	14	$65 million
1990	Bankok, Thailand	Hydrocarbon	Fire & Explosion	17	$55 million
1993	Panipat, India	Ammonia	Explosion & Toxic Release	3	$75 million
1994	Dronka, Egypt	Chlorinated Gas	Toxic Release	4	$25 million
1995	Madras, India	Benzene	Explosion & Fire	150	$45 million
1995	Gujrat, India	Natural Gas	Fire	2	$10 million
1996	Mumbai, India	Hydrocarbon	Fire	2	$15 million

* Boiling Liquid Expanding Vapor Explosion
** Unconfined Vapor Cloud Explosion
*** Confined Vapor Cloud Explosion
‡ Approximate US Dollars

from Kahn, F. I., S. A. Abbasi, "Risk Analysis of a Chloralkali Industry Situated in a Populated Area Using the Software Package MAXCRED-II", Process Safety Progress, **16**(3), pp 172-184 (1997)

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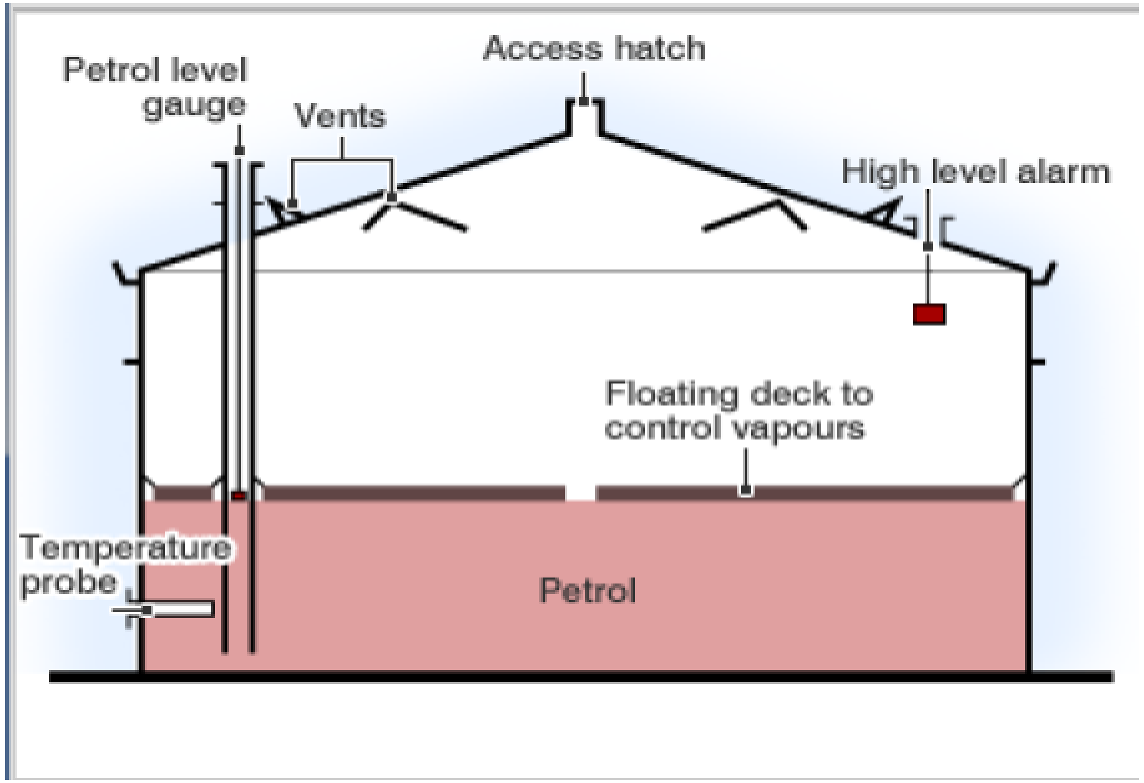
History repeating 1998 onward….
Process Safety Incidence continues to occur

Sample of Incidences

Incidence Location	Date	Highlight Issues on Process Safety / Instrumentation
Longford Australia	1998` (Sept)	Confirming Hazard and Risk Analysis underlying principle
Pascagoula, Mississippi	2002 (Oct)	Instrumentation Overall program management
Illiopolis, Illinois	2004 (Apr)	Bypass Management
Ontario, California	2004 (Aug)	Training on instrumentation
The Buncefield Incident	**2005 (Dec)**	**Unreliable level control/monitoring. Overfill Protection Safeguarding failed.**
Petrolia, Pennsylvania	**2008 (Oct)**	**Management of Change (MOC)**
Institute, West Virginia	**2008 (Aug)**	**Verifying/Validating instrumentation changes**
CAPECO, Puerto Rico	**2009 (Oct)**	**Unreliable level control/monitoring. No Overfill Protection System & interlock**

Source: ISA2015 Forum

Buncefield Incident, Hertfordshire, England Dec 2005, followed 4 years later CAPECO explosion Both by common issues – Overfill protection system failure



Source: ISA2015 Forum

Key issues:

- Tank level analog sensors had 14 times stuck 3.5 month before the incidence
- High level switch interlock failed due undermanaged technology change 18 month before the incidence

Burned 5 days
43 injuries, USD1.2Mil
2000 evacuated

Installation of Overfill Protection System complete with Smart Field Free Space radars helps eliminate process safety incidence

Before

All tanks' level safeguarding transmitters functions were sharing with the control/ monitoring ATG (Automatic Tank Gauging) as the Logic Solver.

THIS IS A NON-COMPLIANCE

TO IEC61151 FUNCTIONAL SAFETY STANDARDS

After

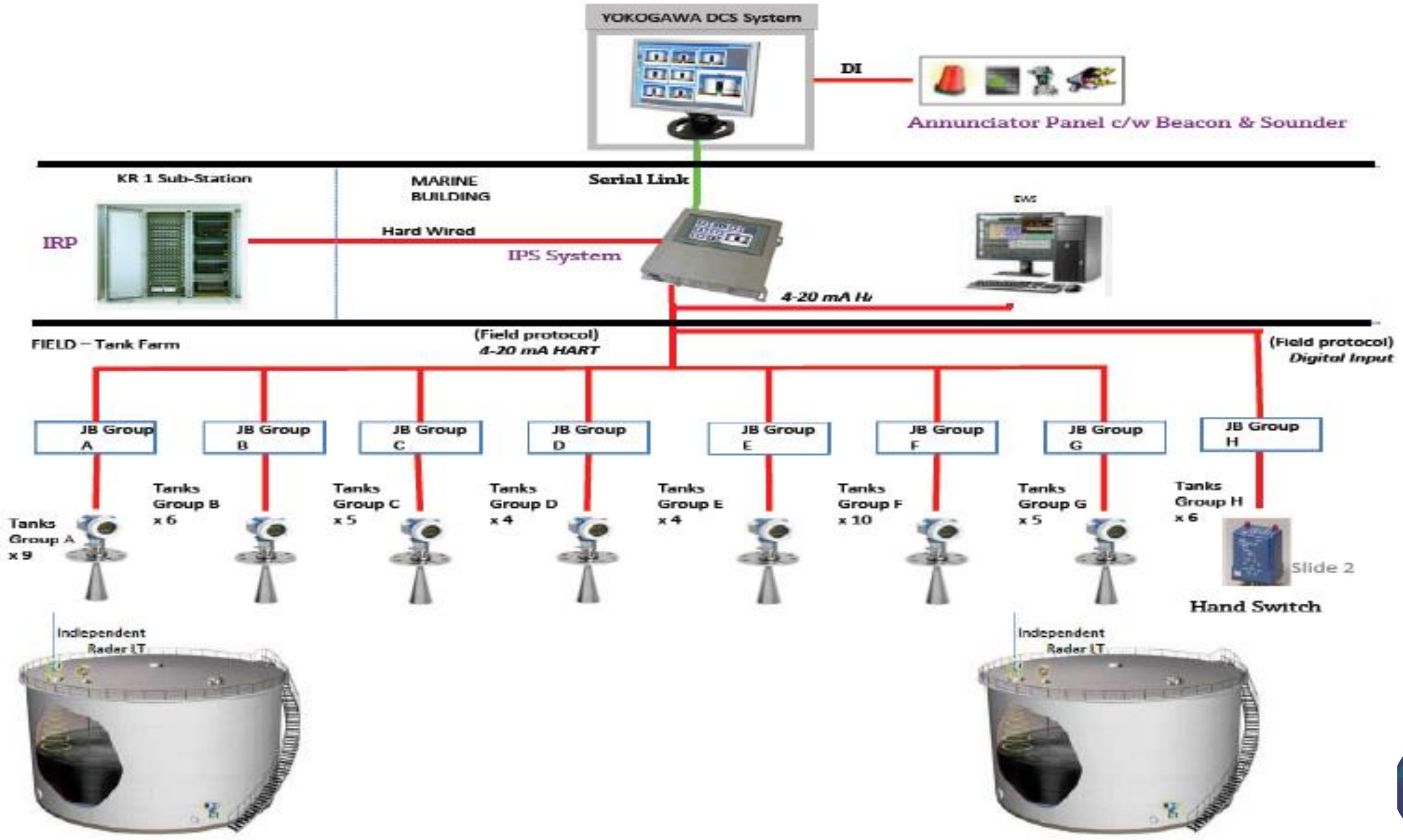
Dedicated SIL3 IPS PLC complete with newly installed and dedicated safeguarding free space radar transmitters for level measurement

Help Eliminate Tank Overfill Incidence at PETRONAS Tank-Farms.

A FULL COMPLIANCE to the IEC61511 Functional Safety Standards requirement.

Implementation of IPF (Instrumented Protective Function) Study Recommendation PETRONAS Refinery

Installed & commissioned dedicated Tank Overfill Protection (TOP) System comprised SIL3 IPS PLC completed with free space radar level transmitters



Free Space Radar Level Measurement
How Does It Work ?

- The time elapsed between the initial pulse and the reflected ‘return’ indicates the distance from the RADAR system to the object (t)
- Distance is calculated by the formula:

$$d=0.5ctF_d$$

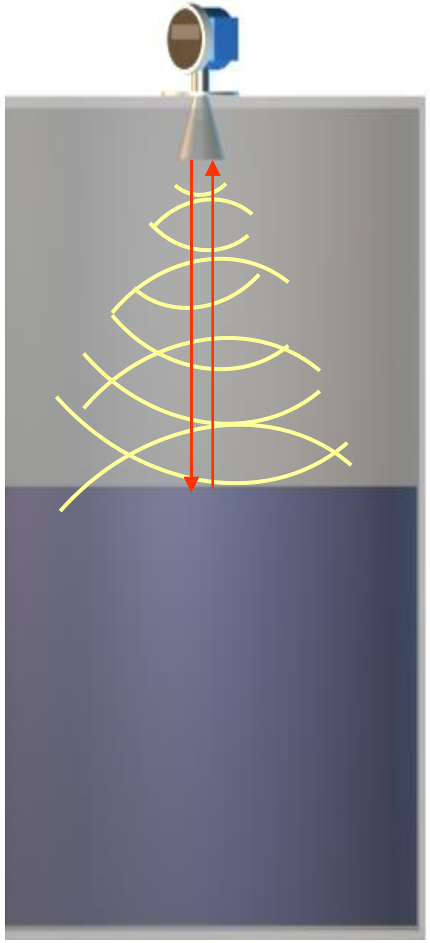
where;

d is distance

c is the Speed of Light

t is the time between the initial pulse and the return pulse

F_d is the constant for atmospheric dielectric



Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)

- PETRONAS Refinery TOP (Tank Overfill Protection) using Radar level transmitters had been installed for ALL 42 Tanks in Year 2014.

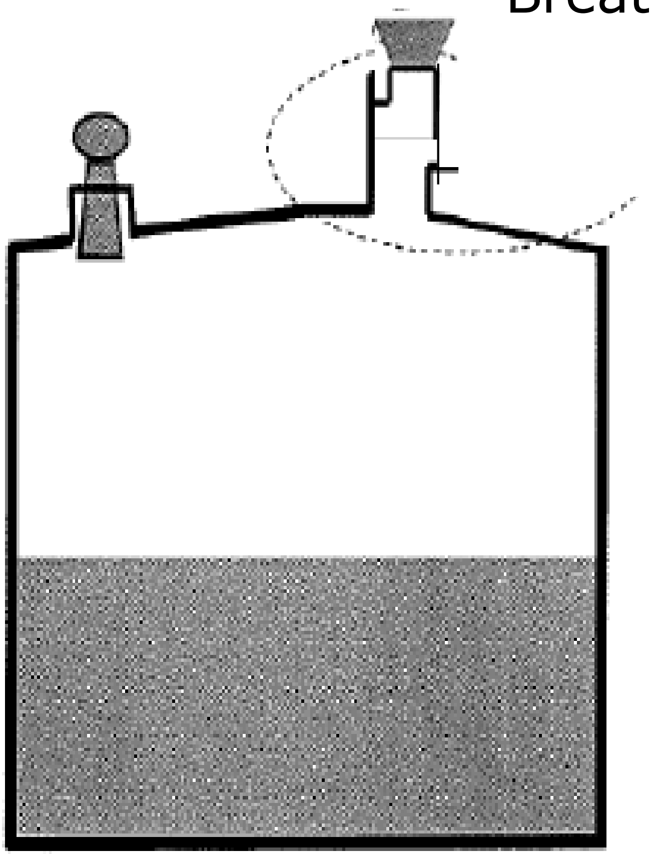
- There are three (3) CASES based on type of tankfarms roof design:

  - ✓ CASE A: 20 nos of Fixed Roof (Target at Actual Liquid Level Surface)
  - ✓ CASE B: 20 nos of Floating Roof (Target at Floating Roof)
  - ✓ CASE C: 2 nos of Internal Floating Roof (Target at Internal Floating Roof)

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued) CASE A: AS FOUND (for Fixed Roof tanks)

Existing Control/ Monitoring transmitter

Breather



20 tanks @ Fixed Roof (Target at Actual Liquid Level Surface)

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE A: The Challenge for Fixed Roof tank

No manhole/stilling well available for safeguarding level transmitter.

Note:

Existing manhole/stilling well already used for operator manual gauging activity

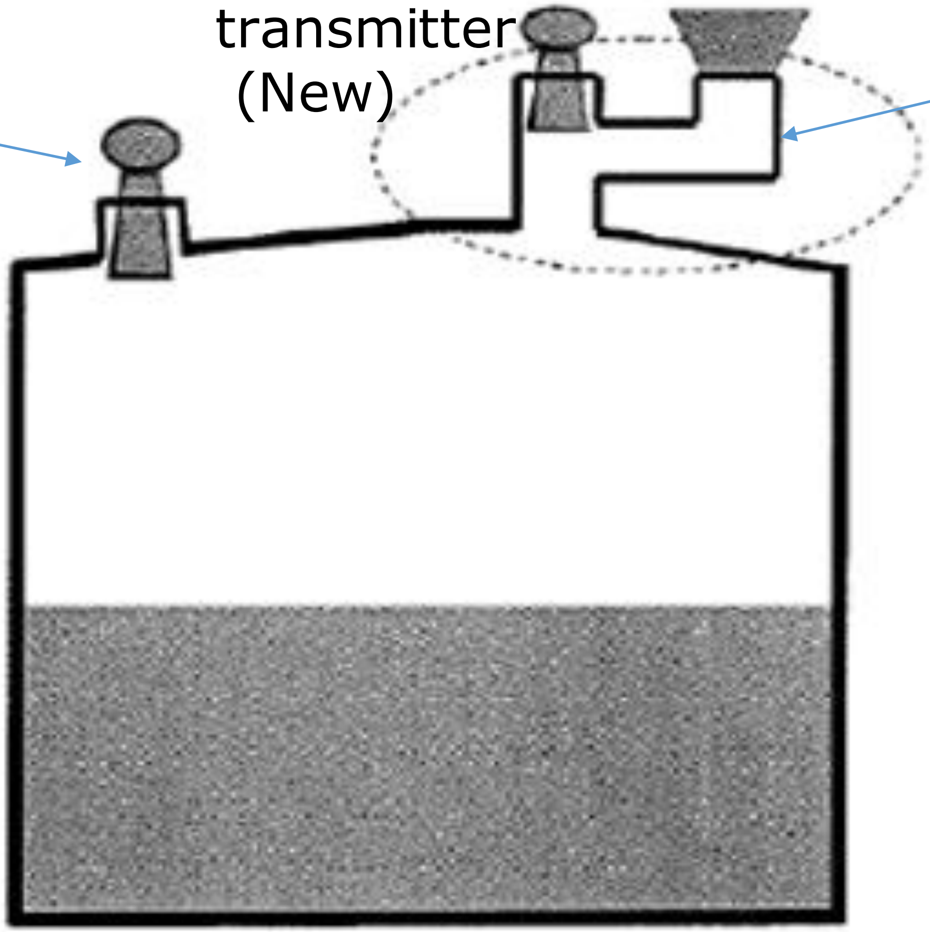
20 out of 42 tanks

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued) CASE A: The Solution for Fixed Roof tank

Make use of the breather access point, use tee bracket to install safeguarding level transmitter

20 out of 42 tanks

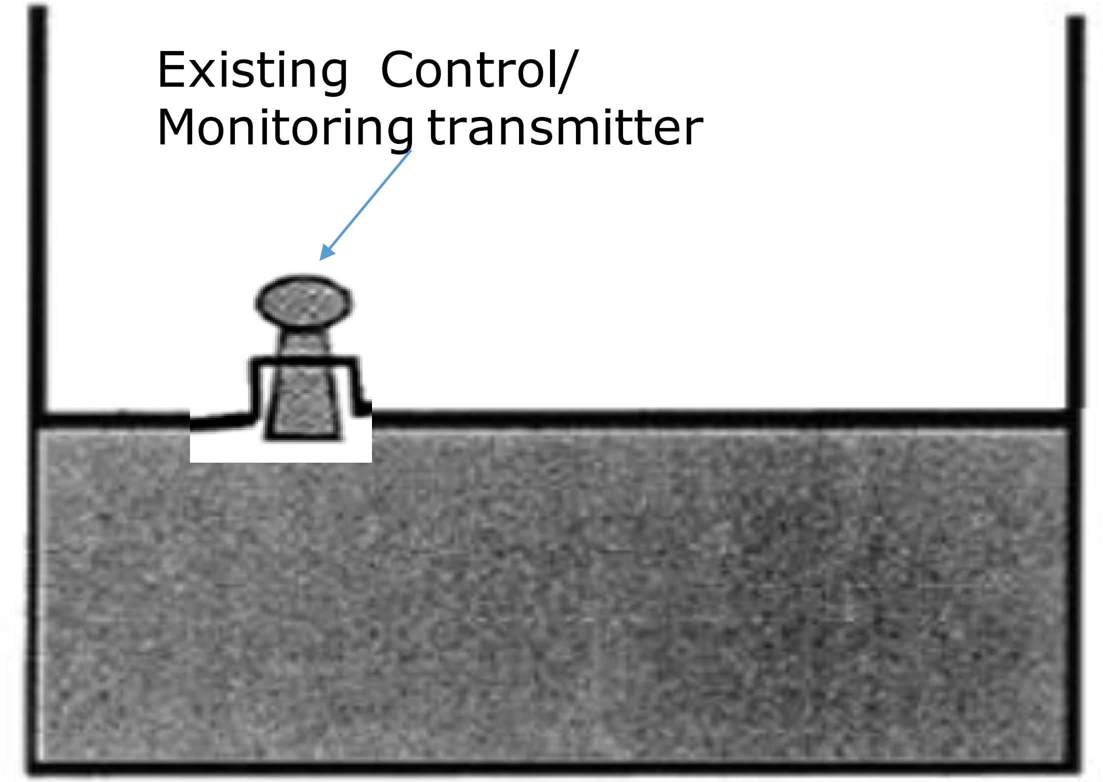
Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE A: AS LEFT for Fixed Roof tanks



20 nos of Fixed Roof Tanks (Target at Actual Liquid Level Surface)

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE B: AS FOUND (for Floating Roof tanks)

20 nos of Floating Roof
(Target at Floating Roof)



Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE B: The 1st Challenge for Floating Roof Tank

No access/manhole available for safeguarding level transmitter installation.

Note:

Existing manhole is already used by operator for manual gauging

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE B: Proposed Solutions for Floating Roof Tank

Solution 1:

Drill access/manhole during tank shutdown which we will have to wait next 15-20 years with high cost incurred

(Cost: RM6Mil for 20 tanks)

Solution 2:

Install safeguarding level transmitter using support at the edge of the tank rim and use floating roof surface as the target level without having to shutdown the tank

(cost savings more than RM6mil)

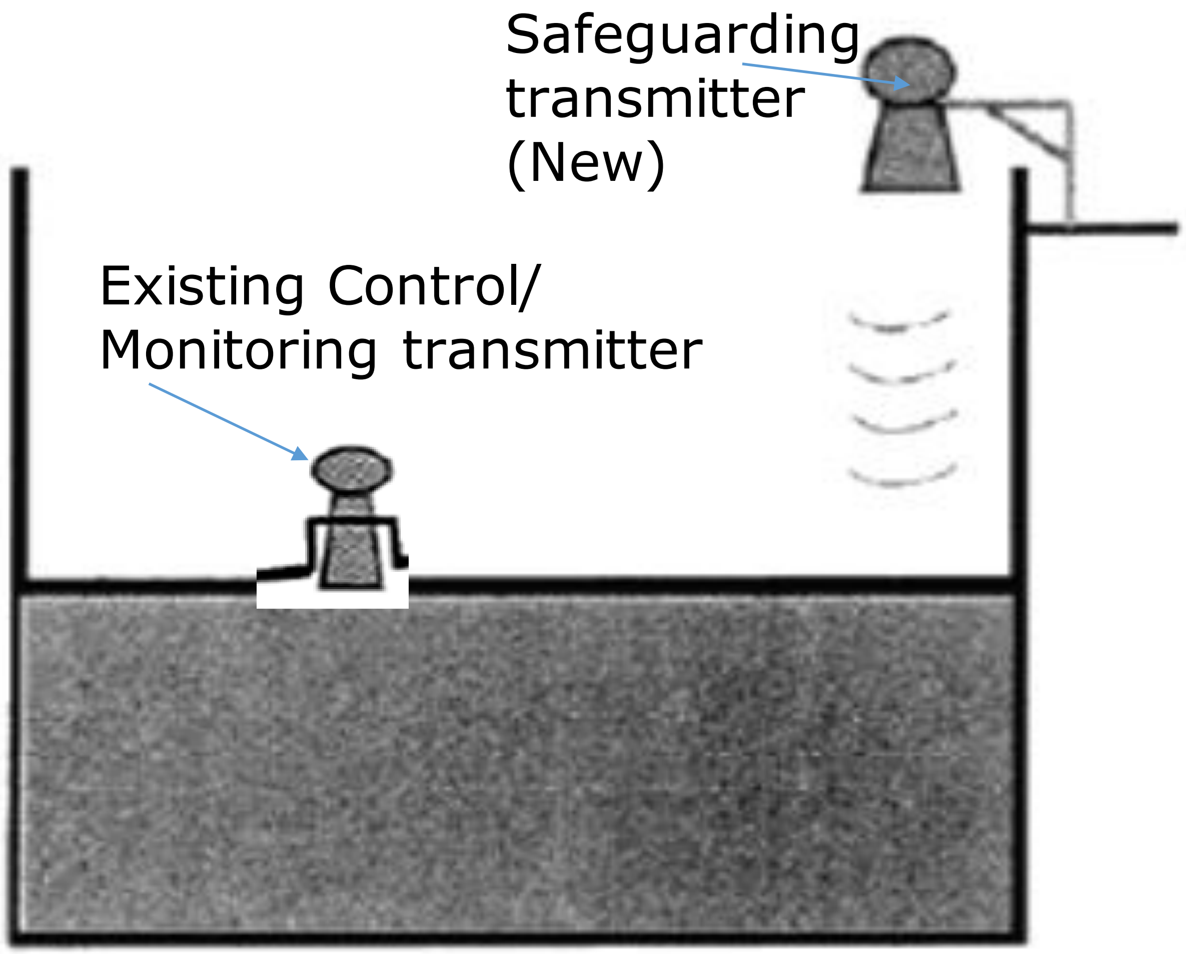
Implementation of IPF Study Recommendation PETRONAS Refinery (Continued) CASE B: The Selected Solution for Floating Roof Tank

Solution 2: Cost savings more than **RM6mil** by

Installing safeguarding level transmitter using support at the edge of the tank rim and use floating roof surface as the target level without having to shutdown the tank

Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE B: AS LEFT for Floating Roof Tanks

20 nos of Floating Roof (Target at Floating Roof)



Implementation of IPF Study Recommendation PETRONAS Refinery (Continued)
CASE B: The 2nd Challenge & the Root Cause

2nd Challenge

Frequent Deviation Alarms Triggered at TOP (Tank Overfill Protection) Floating Roof Safeguarding transmitters

<u>Root Cause Analysis</u>

a) Disturbance on Reflected Echoes Due to multiple *Dynamic Obstruction* on Target Surface on top of the roof

b) Not fully secured free Space Radar support/stanchion that can create minimum rotary movement

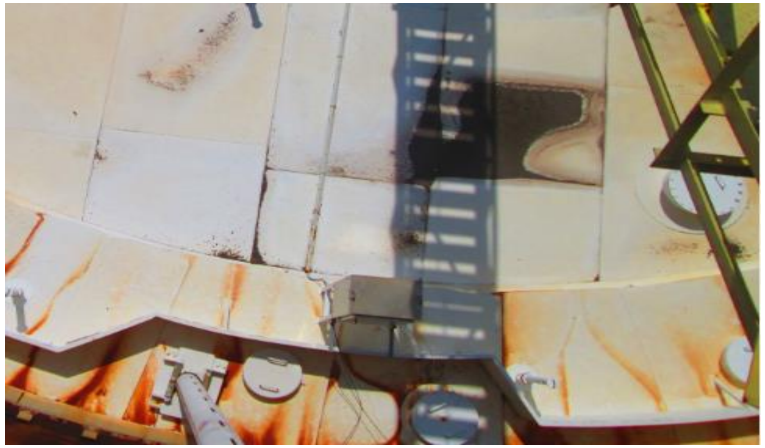
Implementation of IPF Study Recommendation PETRONAS Refinery (Continued) CASE B: The Solutions

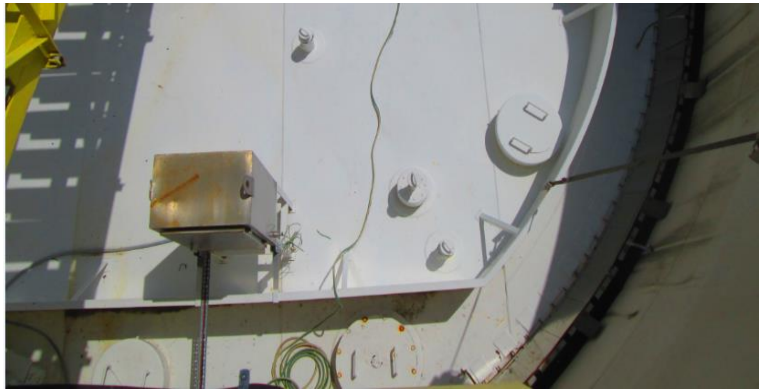
a) Install Reflector to guarantee a good target & stronger Reflected Echo (RE) as compared to RE from obstruction which cannot be mapped as it moves together with the roof (Dynamic Obstruction)

b) Secure with support/stanchion (by Threaded, Tapered, and with Lock Nut Type) of the Floating Roof Radar Level Transmitter

Root Cause Analysis for floating Roof issues

Sample of actual TARGET on Floating Roofs with Free Space Radar Transmitter installed @ 3m from the Tank Wall:





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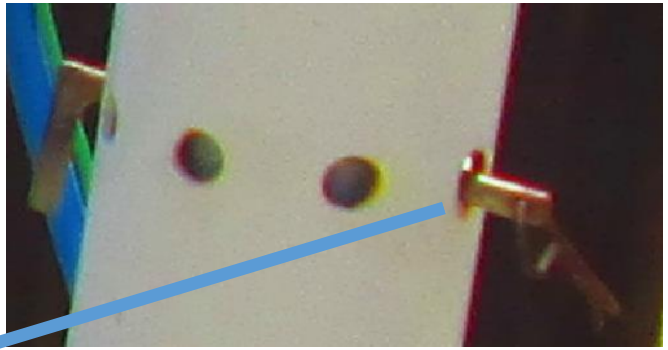
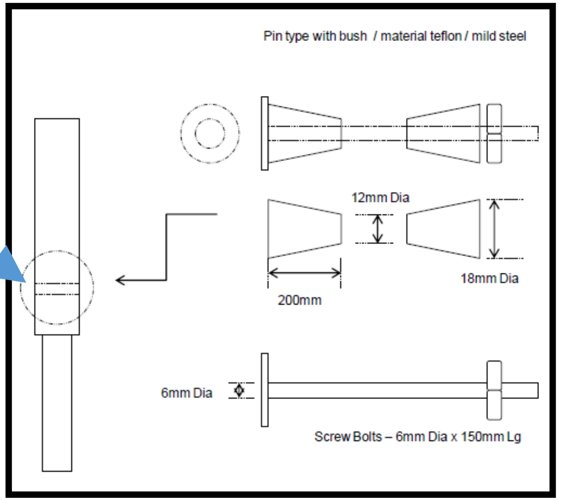
Root Cause Analysis for floating Roof issues (Continued)



Bigger Hole than the Pin can cause Minimum rotary Movement and thus potential in creating changes/deviation in reading

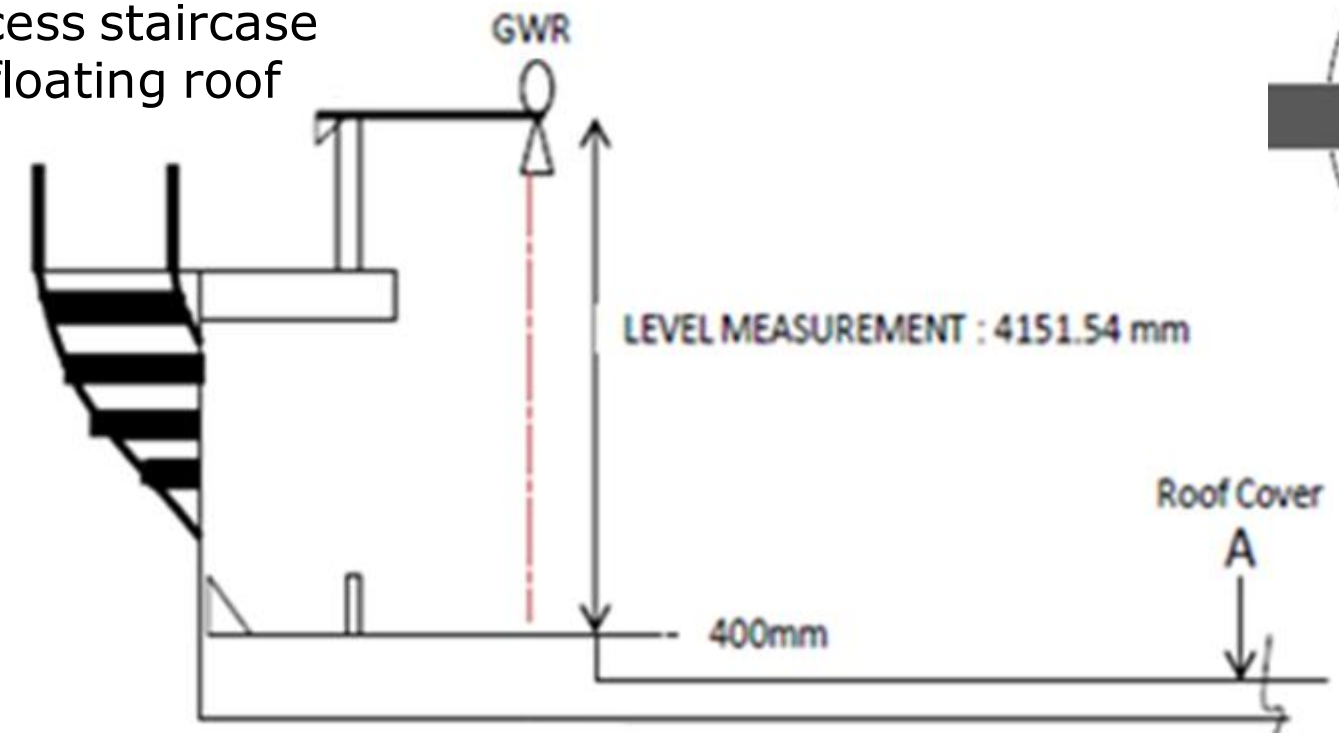


Recommended PIN Type/Design to avoid Rotary Movement of the Stanchion/Support

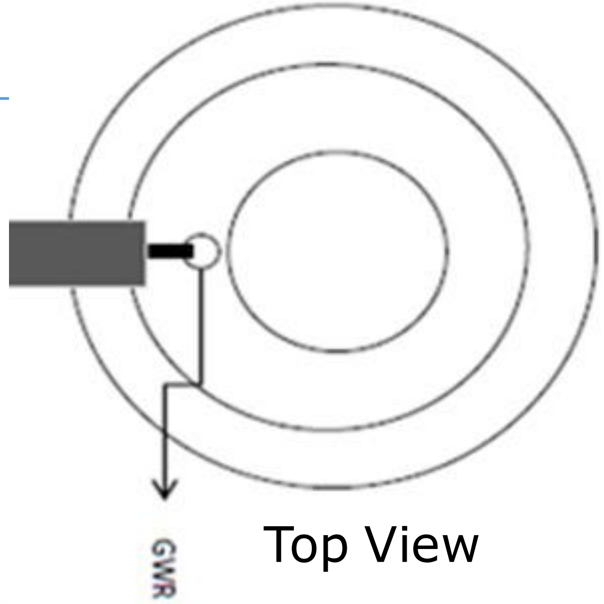
Installation Design of reflector on floating roof top

RECOMMENDATION:
To Install REFLECTOR to guarantee a good target & stronger RE (Reflected Echo) compared RE Quality/Multiple RE's from Floating Roof obstructions.

Access staircase to floating roof



Side View

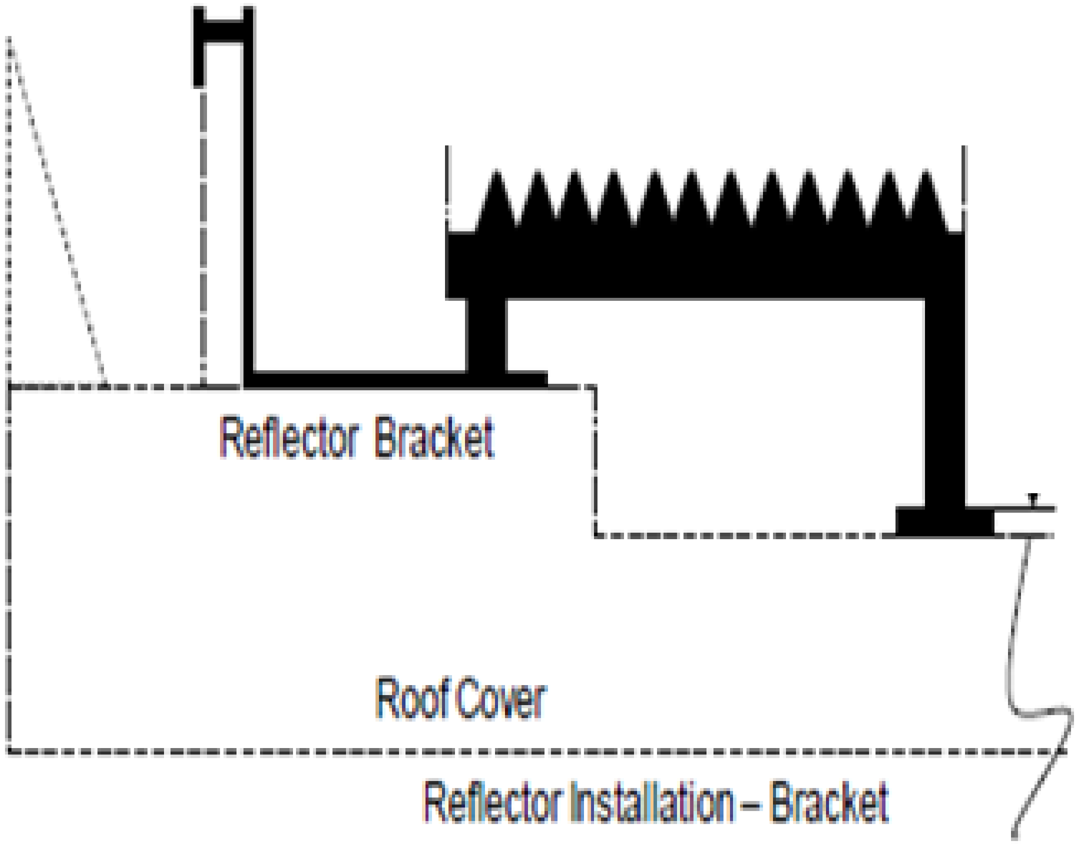


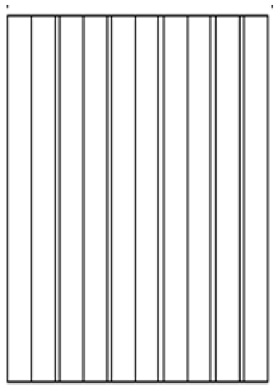
Top View

Installation Design of reflector on floating roof top (Continued)

RECOMMENDATION:
To Install REFLECTOR to guarantee a good target & stronger RE (Reflected Echo) compared RE Quality/Multiple RE's from Floating Roof obstructions. See sample drawing below.

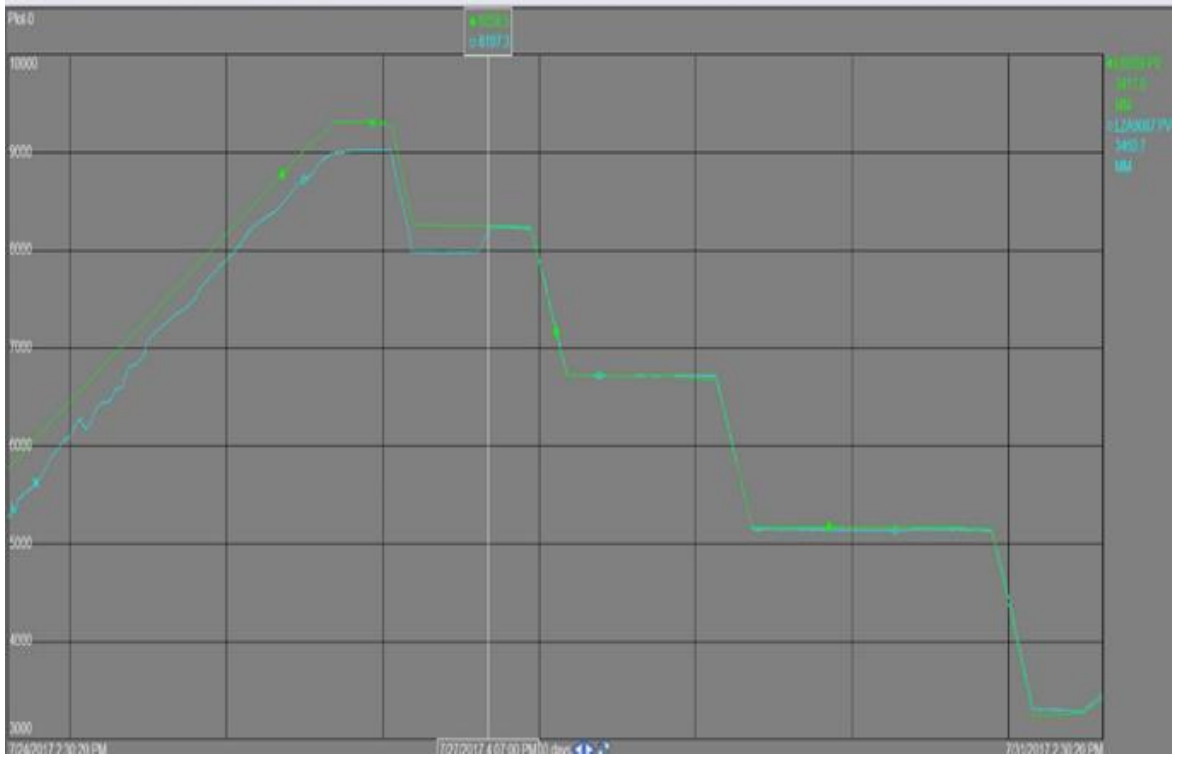
NOTE: Floating Roof Obstructions cannot be mapped as it move together with the Roof (Dynamic Obstruction).





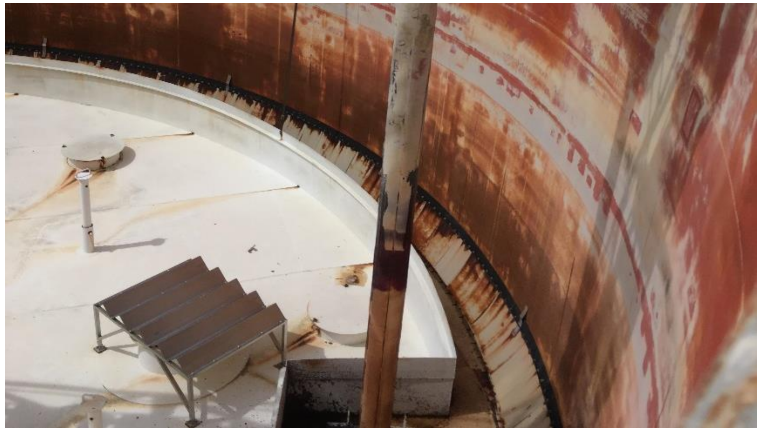
Top View

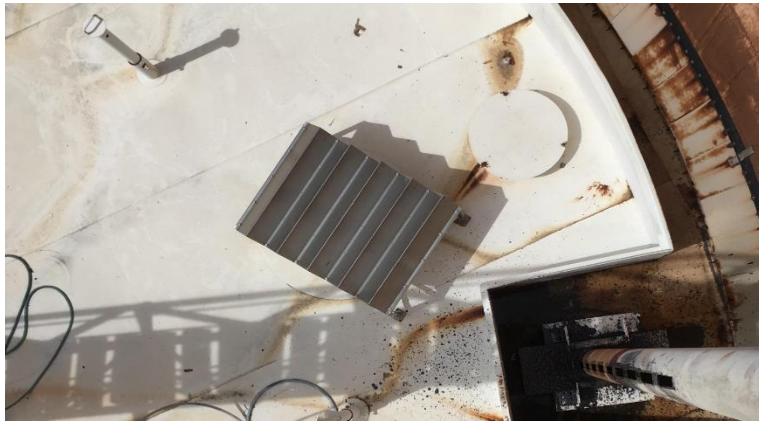
After Installation of Reflector on floating roof top for 20 nos of tanks



BEFORE & AFTER

Shown
1 tank





Legend: Green – Control/Monitoring Sensor/Transmitter
Blue – Safeguarding Sensor/Transmitter

Conclusion

Installation of free space radar level transmitters for tanks online without having to shutdown the tank, has helped in eliminating Process Safety Incidence with full compliance to the IEC61511 Functional Safety Standard for Process Industry