NISTM June 27, 2013 Tank Conference
Anaheim, California

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Fixed Roof Tank Over Pressure Incident

- An unexpected high flow rate of nitrogen surged into the tank at the arrival of the first pipeline displacement pig, causing the frangible roof seam on the Tank to part. Damage occurred on the tank roof, sidewall and tank stairway landing.

Lightning Strike Tank Seal Fire

- A tank rim-seal fire was started when a 160,000 barrel open floating roof tank in gasoline service was struck by lightning. At the time of the incident, the tank was approximately ¾ full and had been undisturbed for approximately 3 weeks. The tank roof seals consist of a primary mechanical shoe seal and a secondary metallic wiper seal, which were installed in late 2000 when the tank was in diesel service. In 2004 the tank was converted to gasoline service. The seals were originally installed to minimize the amount of rainwater getting into the tank.

Seal Damage from Lightning-Related Fire

What went wrong

- The urethane that was used for the primary shoe seal fabric is compatible with diesel, but is not compatible with the oxygenate blended into gasoline. The fabric deteriorated after the tank was converted to gasoline service, which resulted in holes and tears in the fabric.
- No Management of Change was performed when the tank was switched to gasoline service, because the MOC process had not yet been implemented at this terminal location.
- The lightning shunts were not being inspected as part of preventative maintenance at this terminal, and some of them were discovered afterwards to not be in contact with the tank shell.

Lightning Strike Tank Seal Fire

- **Lessons Learned**
- Compatibility of primary shoe seal fabrics with stored products is not widely recognized among the terminal workforce. To maintain this learning, an item related to this incident, including Lessons Learned, has been added to the Terminal and Operations Engineering SharePoint site.
- This incident helps to reinforce the importance of the MOC process, which is now in place at this location.
- Visual inspection of lightning shunts has been added to the monthly tank inspection checklist.

Example of lightning shunt not contacting shell of tank

Floating Roof Collapse and LOC

What went wrong

- The tank was isolated three months prior to the spill incident, which included closing and locking the roof drain valve.
- Almost no inspection of the roof was being performed by terminal workers, despite frequent rainfall in the area. Excessive water accumulation on the roof caused the landing legs to collapse.
- The contract Entry Supervisor reported an excessive amount of water on the tank roof shortly after he ordered his worker out of the tank; however, no corrective actions were taken.

Floating Roof Collapse and LOC

Lessons Learned

- Always perform frequent inspections of EFR tanks, whether in-service or out-of-service, in order to determine, among other things, liquid accumulation on the roof and to drain the roof when necessary.
- Always conduct inspection of EFR tanks following rain storms to help ensure that the roof is drained of accumulated water arising from the rain fall.
- Always conduct pre-job planning and risk assessment as the first step in the equipment isolation process and in the preparation of the Isolation Checklist, and always ensure that Terminal Management approves the isolation plan before implementing.
- Senior and more experienced facility personnel must always take ownership for ensuring that critical reviews are conducted on all plans that can affect the safety of the facility in which they work, and always exercise Stop Work Authority where there is doubt regarding the adequacy of such plans, irrespective of the perceived level of final authorization.
- Always address abnormal conditions and take deliberate steps to respond to safety concerns in order to ensure that risks created by the presence of a potential hazard are assessed to help prevent possible losses.

How Do You Assess Risks?

- Guesses, hunches,arm-waiving, or just keeping the blinders on are not uncommon, but there are better ways…

What is Risk?

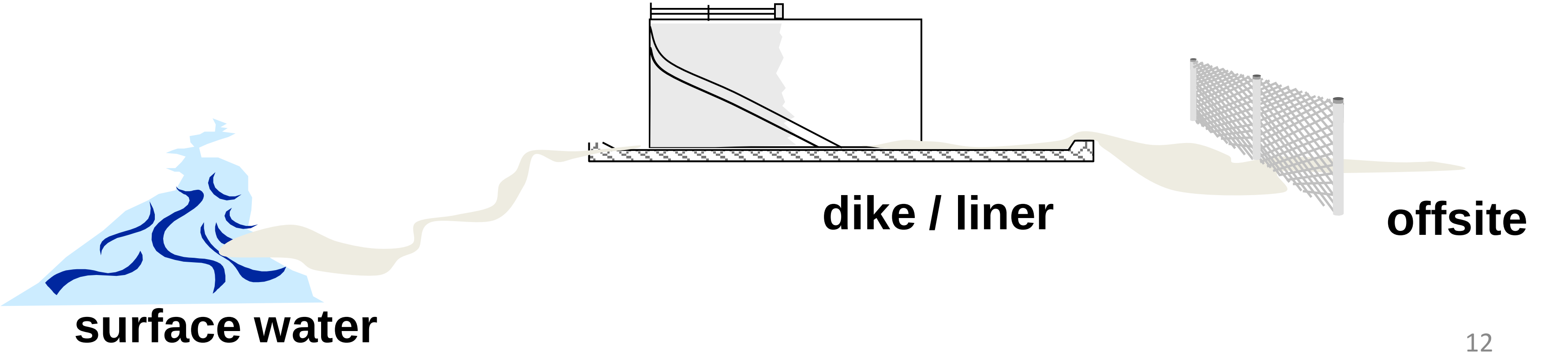
- Risk is the combination of:
  - the likelihood of a failure (LOF) that causes a loss, and
  - the consequence of that failure (COF)
- Risk = LOF x COF

Risk Assessment and Management

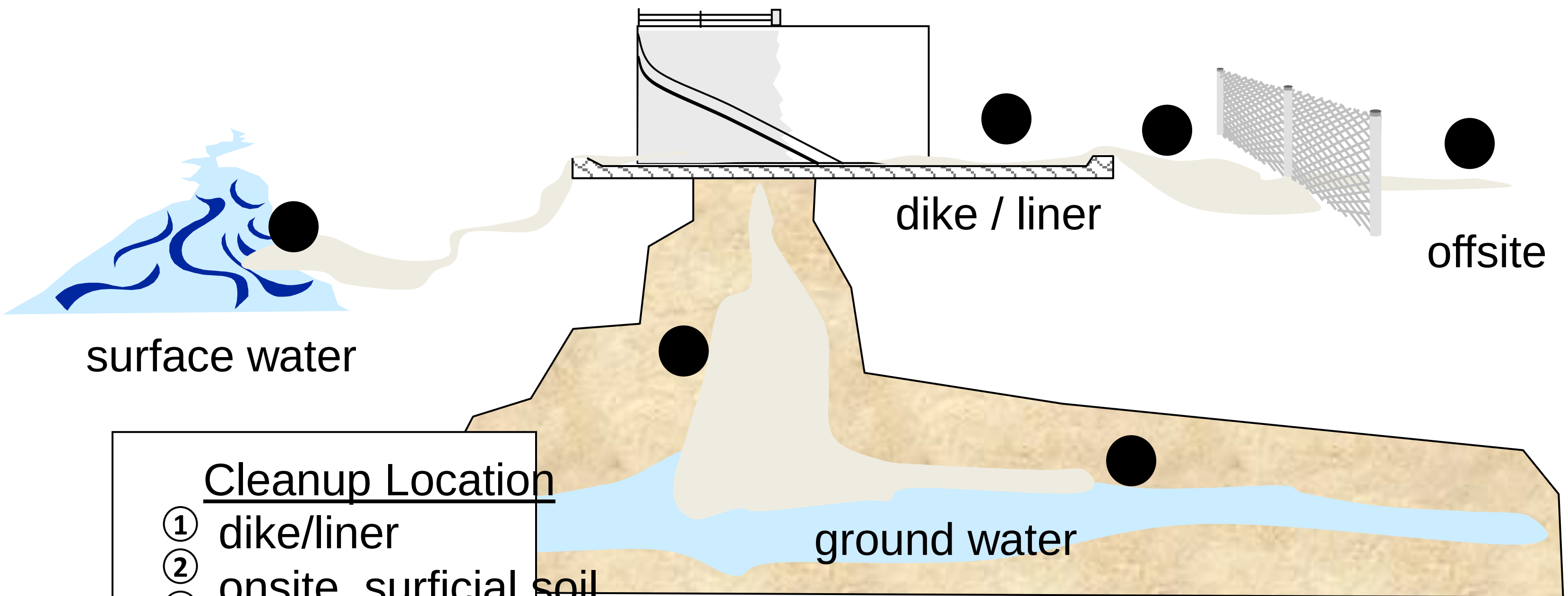
- Risk can be assessed by determining:
  - What can go wrong
  - How likely is it to happen, and
  - What would be the consequences
- Risk can then be managed by instituting strategies to reduce the risk

Details of Consequence Analysis

- Above ground release scenario:
  - Release volume: flow rate and duration.
  - Flow rate: overfill rate or hole size.
  - Also account for dike containment and distance to offsite receptors.



AST Consequence Analysis
Overview of Leak Scenarios

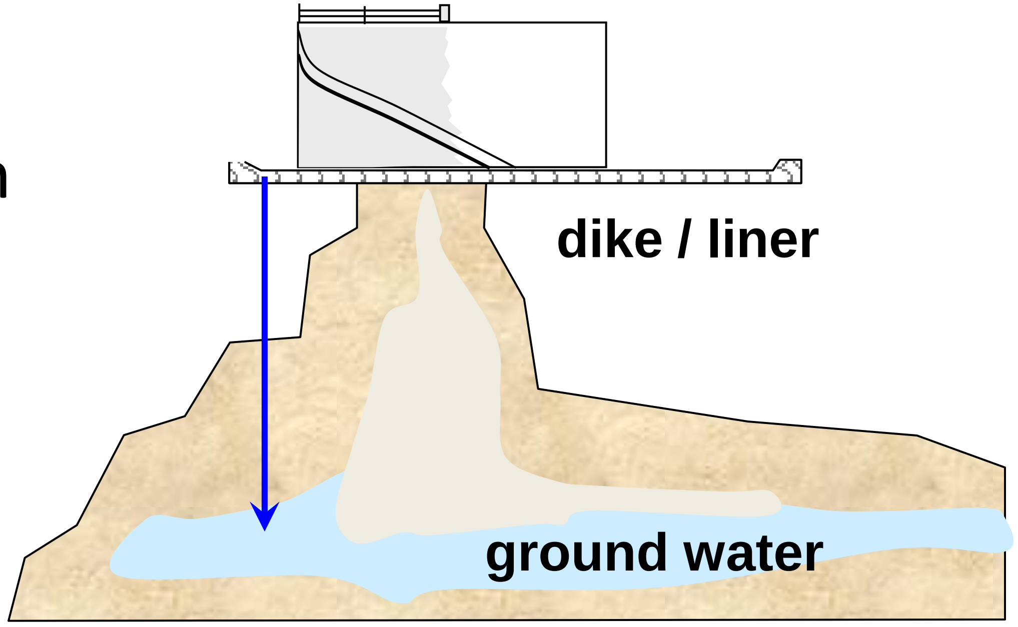


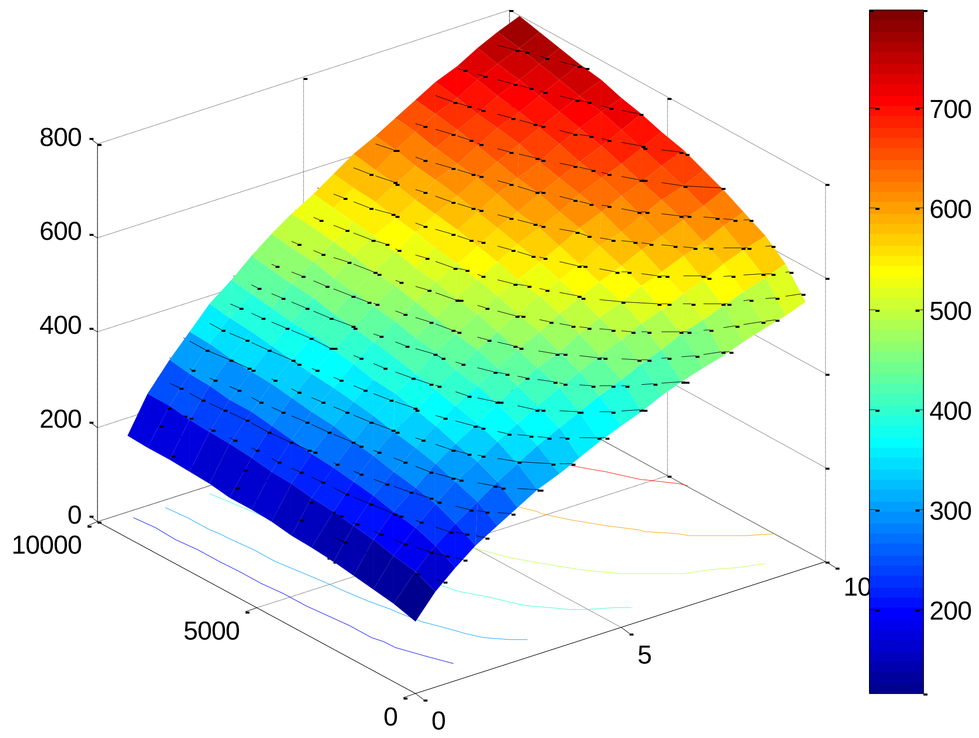
<u>Cleanup Location</u>

① dike/liner
② onsite, surficial soil
③ offsite, surficial soil
④ subsurface soil
⑤ groundwater
⑥ surface water

Details of Consequence Analysis

- Below Ground Releases
  - first, estimate time required to reach groundwater depth
  - then, if release duration results in contact, estimate portion in water





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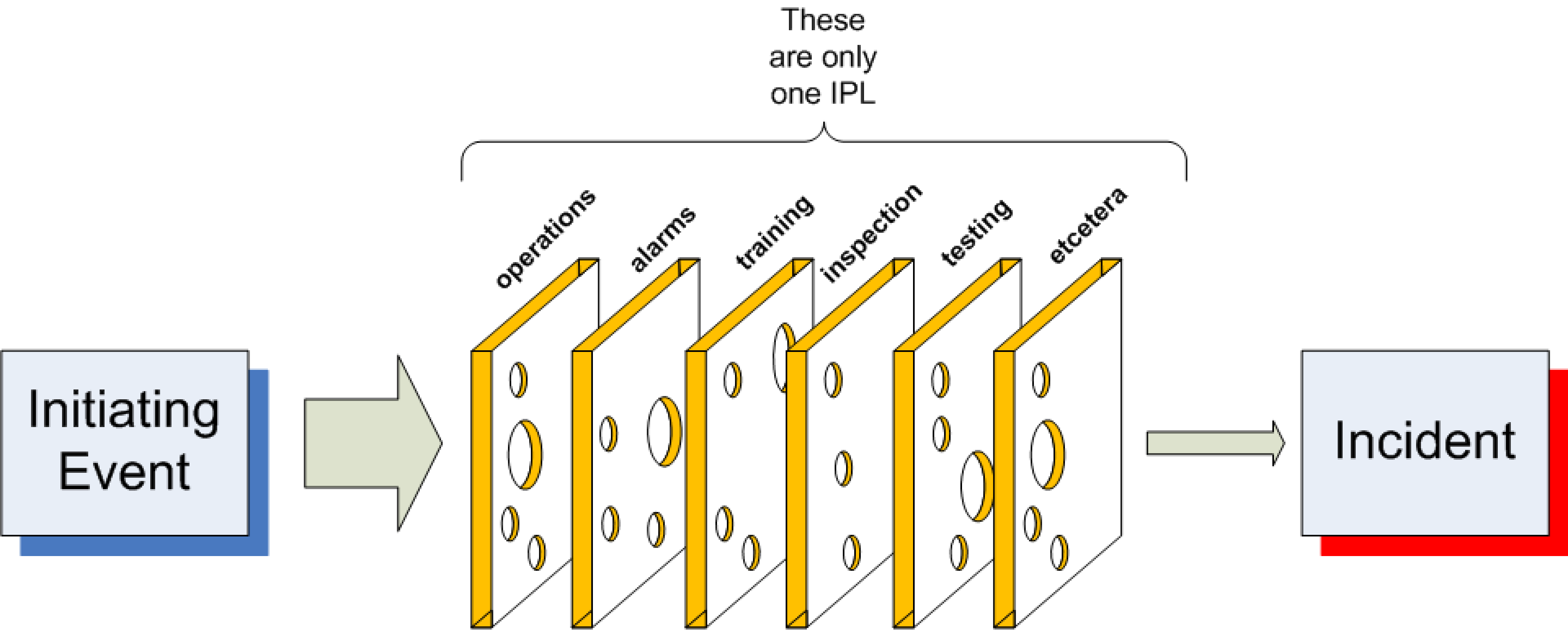

To make additional IPLs requires a significant “price”.
The layers must be independent of the initiating cause, a failure of one layer cannot cause another layer to fail, the layers must be independent, must be effective, must be capable of detecting the process anomoly, must act to bring the process to a safe state.

Decreasing Consequence Indices

Decreasing Likelihood Indices

6	5	4	3	2	1
7	6	5	4	3	2
8	7	6	5	4	3
9	8	7	6	5	4
10	9	8	7	6	5
10	10	9	8	7	6

Risks addressed by various components of the standard		Components of basic standard									Options for some categories of tanks				
		RPB or double bottom	Bottom coating	Dome roof	Steel annular pontoon floating roof	Floating suction	Diffuser	Deep sump	Tank safety valves	ATG plus IPL2 overfill protection	Filter outbound (clean tanks or proprietary line)	Precision leak test every 2 yrs (int. term tanks)	Update, review & audit modes and procedures for overfill protection	Monthly visual inspection+weekly vapor sniffing of aluminum floating roof	Full standard
Undetected leaks	A	**X**										X			
Requirement for dike field liner	B	X								**X**					
Bottom corrosion; decreased tank life	C		**X**												
Static charge during filling	D						**X**		X						
Water in product	E		X	X		X	X	**X**							
Particulate in product	F		X	X		**X**	X	X			X				
Tanks out of service for product mix	G					**X**	X								
Explosion/fire in vapor space	I			X	**X**				X	X				X	
Roof drain failure	J			**X**											
Creation of confined space (new risk)	K			X											
Vapor emissions	L			**X**	X										
Overfill	N									**X**			X		
Undesired draining of tank	O								**X**						
Increase inspection and maintenance cycle to 20 years	P														X
Landing of Roof	R									**X**					
Tank contamination/product mix	S														

For each risk, the primary component that mitigates the risk is highlighted

The Decision Problem

- Which control technique should be selected for this AST:
  - Prevention?
  - Detection?
  - Protection?

Note: Remediation is not an acceptable control measure

The Big Picture = Management Systems

- Local, State, and Federal Regulations and Rules
- Corporate Management Systems
- Industry and API standards
- Experts and Consultants
- State of the Art Ideas: risk assessment, fitness for service, risk based inspection, etc

Operational Excellence Management System

An Overview of the OEMS

Contents

Chairman's Message

John Watson
Chairman and CEO
of Chevron Corporation

Our Chevron Way values place the highest priority on the health and safety of our workforce and protection of our assets and the environment. The Operational Excellence Management System (OEMS) translates this priority into world-class performance, providing Chevron with a competitive advantage and driving business results.

The OEMS is a comprehensive, proven means for systematic management of process safety, personal safety & health, the environment, reliability and efficiency. Through disciplined application of the OEMS, we integrate OE processes, standards, procedures and behaviors into our daily operations.

The OEMS helps us identify and manage the risks we encounter in our global business operations. The system is effective because it requires leader-driven assessment of strengths and gaps, completion of risk-reducing actions, regular review of progress and continual improvement.

While leaders are responsible for managing the OEMS and enabling OE performance, every individual in Chevron's workforce is accountable for complying with the principles of "Do it safely or not at all" and "There is always time to do it right." Success depends on operational discipline from each of us in applying the Tenets of Operation to our daily decisions. We must recognize hazards, follow required practices and procedures and appropriately manage workplace changes. If necessary, every member of our workforce is authorized to exercise Stop-Work Authority.

I encourage you to study this manual. Keep it nearby. Refer to it often. It will guide us to perform every task, the right way, every time.

I am committed to meeting our OE Objectives. I ask you to join me. Together, we'll work safely, protect the environment, and operate reliably and efficiently as we provide energy the world requires for economic growth and human progress.

John

Operational Excellence Management System (OEMS)

The Operational Excellence Management System consists of three parts:

Leadership Accountability
Management System Process
OE Expectations

Tenets of Operation

To achieve and sustain our objectives, we must develop a culture where everyone believes all incidents and operating disruptions are preventable and that "zero incidents" is possible.

Tenets are a code of conduct used by the workforce as a tool to guide daily decisions. Leaders play an important role in setting expectations and reinforcing behaviors consistent with the tenets. The Tenets of Operation are based on two key principles:

1. Do it safely or not at all.

2. There is always time to do it right.

Each organization will deploy the Tenets of Operation to provide a foundation for establishing a culture of operational excellence at Chevron.

Always:

1. Operate within design and environmental limits.
2. Operate in a safe and controlled condition.
3. Ensure safety devices are in place and functioning.
4. Follow safe work practices and procedures.
5. Meet or exceed customer's requirements.
6. Maintain integrity of dedicated systems.
7. Comply with all applicable rules and regulations.
8. Address abnormal conditions.
9. Follow written procedures for high-risk or unusual situations.
10. Involve the right people in decisions that affect procedures and equipment.

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ExxonMobil

Taking on the world's toughest energy challenges.™

Operations Integrity Management System

The OIMS Framework includes 11 Elements. Each Element contains an underlying principle and a set of Expectations. The OIMS Framework also includes the characteristics of, and processes for, evaluating and implementing OI Management Systems.

Application of the OIMS Framework is required across all of ExxonMobil, with particular emphasis on design, construction and operations. Management is responsible for ensuring that management systems satisfying the Framework are in place. The scope, priority and pace of management system implementation should be consistent with the risks associated with the business.

OIMS 11 Elements

Features of a Management System

- MS is a business function of the overall organization.
- MS is a systematic and organized approach to solving safety and environmental problems.
- The purpose of a MS is to achieve and maintain the necessary level of safety and environmental in an organization.
- Implementation of a MS involves management organization, responsibility, and competence (‘human issues’).

SMS Key Elements

- **Key Element 1: Safety and Environmental Advocacy**
- **Key Element 2: Safety and Environmental Information**
- **Key Element 3: Hazard and Risk Assessment and Analysis**
- **Key Element 4: Management of Change**
- **Key Element 5: Procedures and Safe Work Practices**
- **Key Element 6: Training**
- **Key Element 7: Equipment Integrity and Industry Standards**
- **Key Element 8: A Permit System**
- **Key Element 9: Pre start up safety review**
- **Key Element 10: Emergency response and control**
- **Key Element 11: Near Miss and Incident investigation**
- **Key Element 12: Auditing**
- **Key Element 13: Documents and Data Information Management Systems**

More Information on Management Systems

- PEMY Consulting (phil@pemyconsulting.com)
- API RP 75 Development of a Safety and Environmental Management Program for Offshore Operations and Facilities
- API RP 75L Guidance document for the Development of a Safety and Environmental Management System for Onshore Oil and Natural Gas Production Operation and Associated Activities
- API 770 A Manager's Guide to Reducing Human Errors – Improving Performance in the Process Industries
- API 754 Process Safety Performance Indicators for the Refining and Petrochemical industries
- UK Health Safety Executive Web Site

API Tools

- API 2610 – petroleum terminals
- API 340-PUB 340 summarizes 99 causes of liquid releases at AST facilities and presents 176 measures to prevent or control them.
- API 653 – tank inspection
- API 2611 – piping inspection for terminals
- etcera

API 2610

CONTENTS

RP 12R1	*Setting, Maintenance, Inspection, Operation, and Repair of Tanks in Production Service*
Publ 306	*An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks*
Publ 307	*An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks*
Publ 315	*Assessment of Tankfield Dike Lining Materials and Methods*
Publ 334	*A Guide to Leak Detection for Aboveground Storage Tanks*
Publ 340	*Liquid Release Prevention and Detection Measures for Aboveground Storage Facilities*
Publ 341	*A Survey of Diked-area Liner Use at Aboveground Storage Tank Facilities*
Publ 351	*Overview of Soil Permeability Test Methods*
RP 500	*Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division I and Division 2*
RP 520	*Design of Pressure Relieving Systems*
RP 540	*Electrical Installations in Petroleum Processing Plants*
API 570	*Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems*
RP 575	*Inspection of Atmospheric & Low Pressure Storage Tanks*
Std 607	*Fire Test for Soft-seated Quarter Turn Valves*
RP 1110	*Pressure Testing of Liquid Petroleum Pipelines*
RP 1124	*Ship, Barge, and Terminal Hydrocarbon Vapor Collection Manifolds*
RP 1125	*Overfill Control Systems for Tank Barges*
Std 1529	*Aviation Fueling Hose*
API 1581	*Specifications and Qualification Procedures for Aviation Jet Fuel Filter/ Separators*
RP 1604	*Closure of Underground Petroleum Storage Tanks*
RP 1615	*Installation of Underground Petroleum Storage Systems*
RP 1621	*Bulk Liquid Stock Control at Retail Outlets*
RP 1626	*Storing and Handling Ethanol and Gasoline-Ethanol Blends at Distribution Terminals and Service Stations*
RP 1627	*Storage and Handling of Gasoline-Methanol/Cosolvent Blends at Distribution Terminals and Service Stations*
Publ 1628	*A Guide to the Assessment and Remediation of Underground Petroleum Releases*
Publ 1629	*Guide for Assessing and Remediating Petroleum Hydrocarbons in Soil*
RP 1631	*Interior Lining and Periodic Inspection of Underground Storage Tanks*
RP 1632	*Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems*
RP 1637	*Using the API Color-Symbol System to Mark Equipment and Vehicles for Product Identification at Service Stations and Distribution Terminals*
Publ 1638	*Waste Management Practices for Petro-*

8.1.3.2 Leak Detection

Many different types of leak detection systems currently exist. Some systems are designed to take continuous readings, and other systems use periodic readings (including visual monitoring) to determine tank integrity. Current API references on leak detection include API Publ 306, API Publ 307, API Publ 334, API RP 575, and API Std 650. Additionally, there are a number of different technologies being used, as well as new technologies being developed, for use in aboveground storage tanks to check integrity. Examples of systems include acoustic emissions, tracer methods, volumetric (including mass deviation) monitoring, and vapor sensing. Each system requires trained and skilled personnel to interpret the results. The most common means of AST leak detection include, but are not limited to the following:

a. Use of monitoring wells in the tank farm area.
b. Use of a leak detection system (see API Std 650, Appendix I).
c. Placement of smaller tanks on a steel reinforced concrete slab underlying the entire tank bottom (an RPB).
d. Tightness testing.

In addition, if a facility meets the CAA definition of a "Major Source," other emission requirements will apply (see EPA regulations) (see 5.3.1).

8.1.4 Tank Calibration

Refer to API *MPMS* Ch. 2 for calibration of new or recalibration of existing tanks.

8.1.5 Coating and Protection from Corrosion

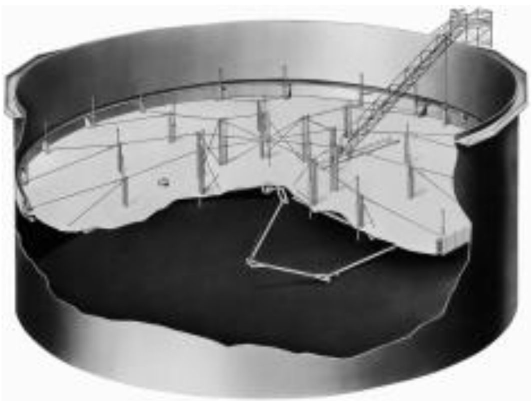
See Section 10 for information coatings and corrosion protection.

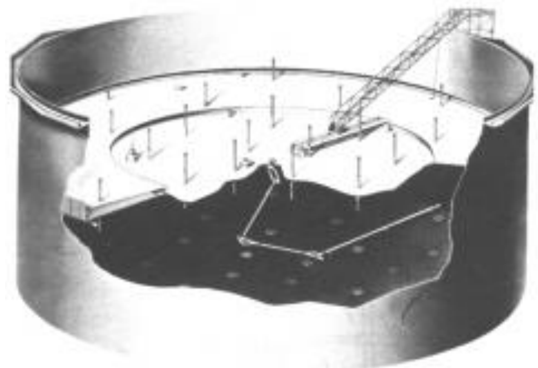
8.1.6 Tank Appurtenances

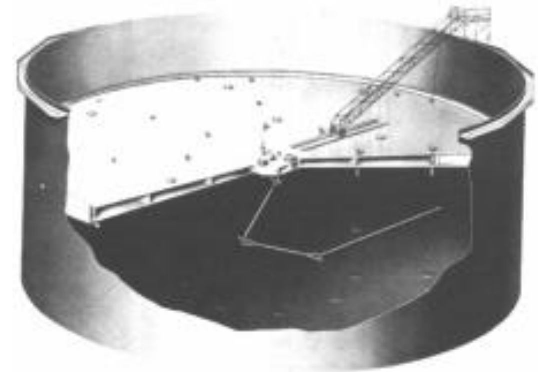
8.1.6.1 Vents

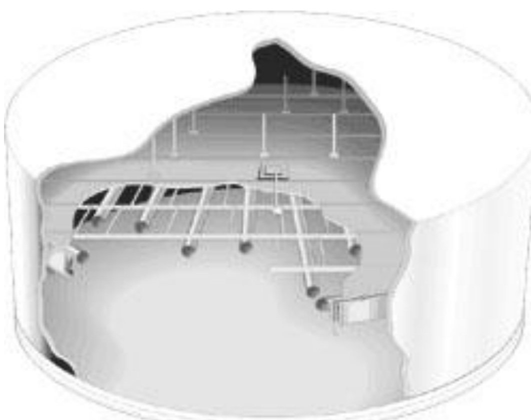
Normal tank venting should be provided in conformance with NFPA 30, API Std 650 and API Std 2000. Emergency venting shall be provided for all tanks. Emergency venting may include a weak or frangible roof to shell connection (typically, tanks greater than 50 ft [15.24 m] in diameter). Additional emergency venting may be required by local code or

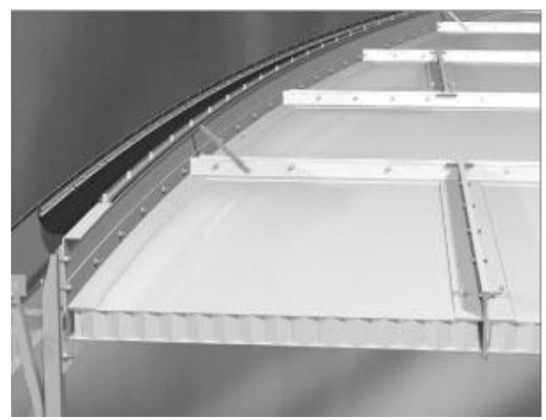
Types of Storage Tank Floating Roofs



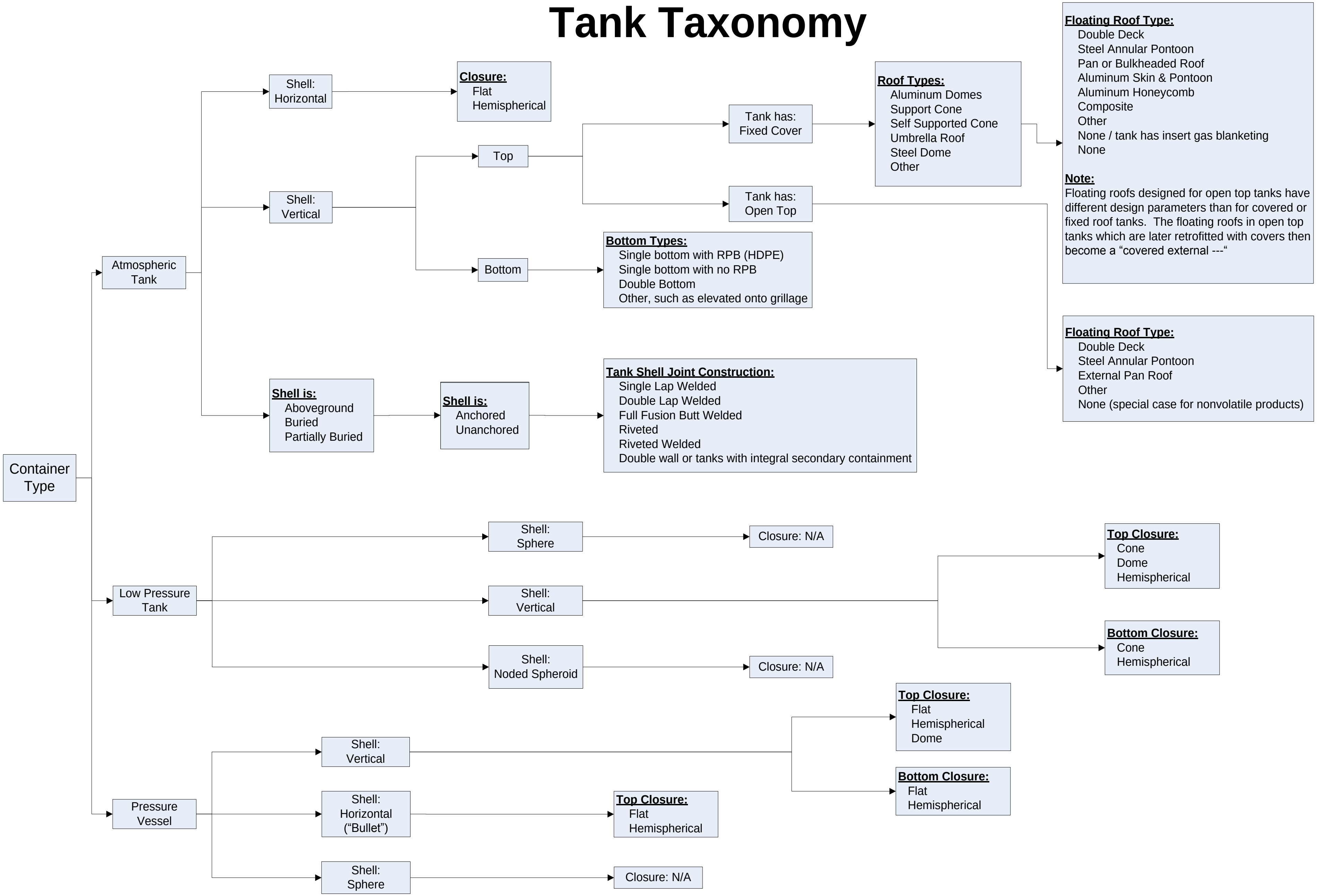




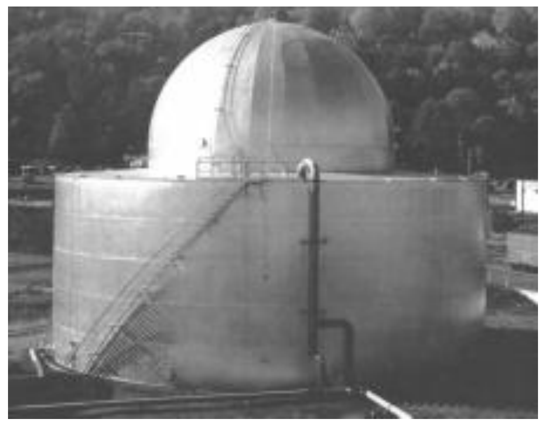


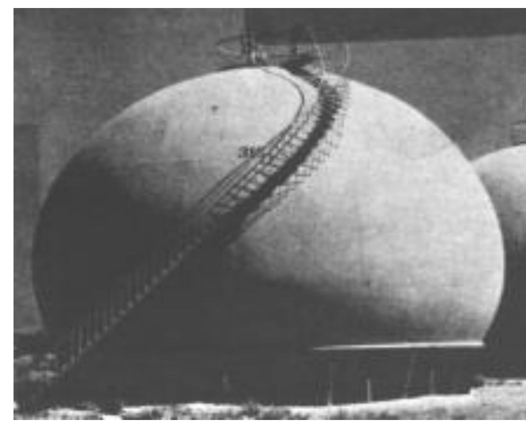


Tank Taxonomy



Types of Storage Tank Fixed Roofs

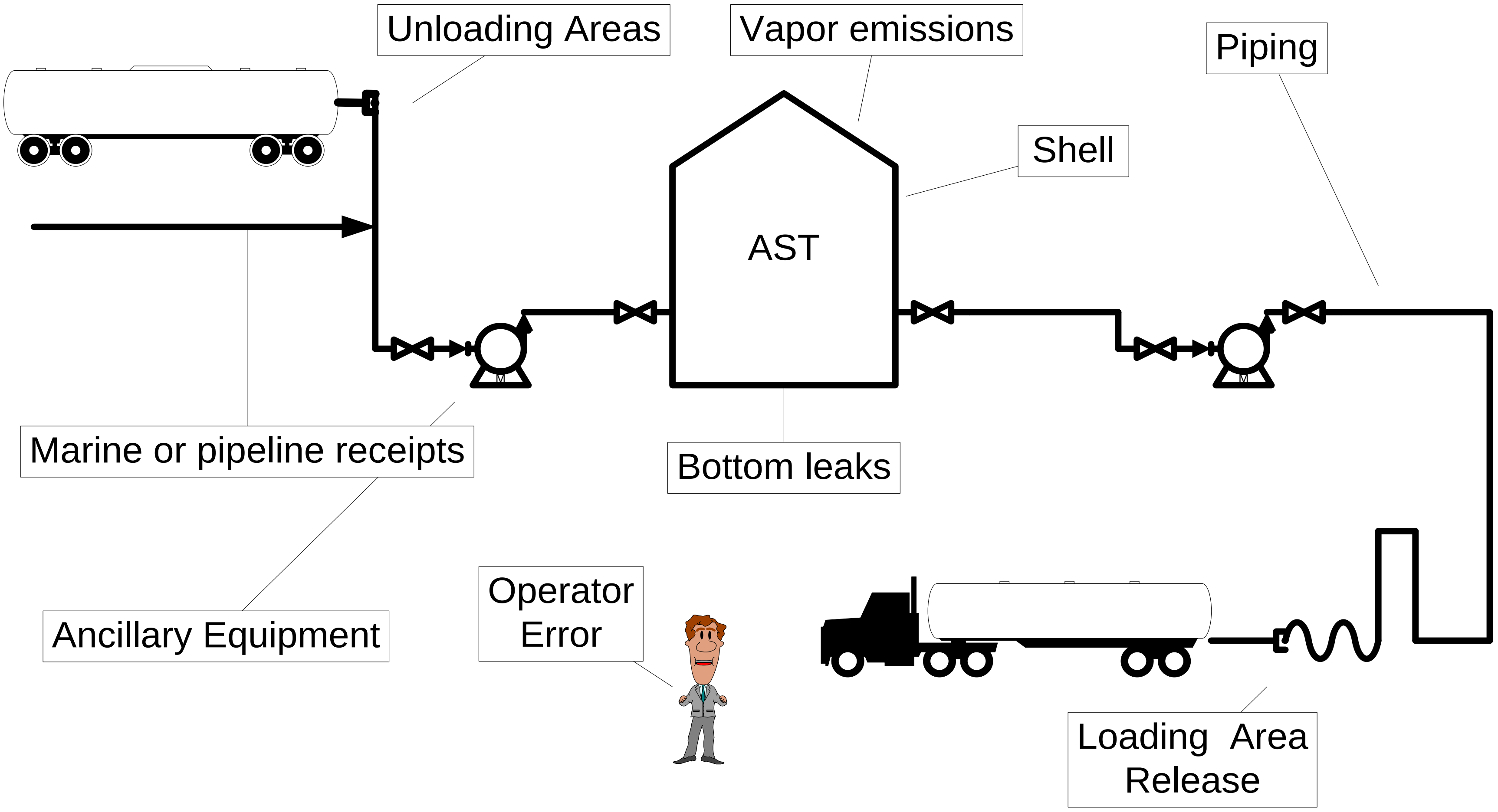




Sources of Potential Releases at AST Facilities

- Aboveground storage tanks
- Piping systems
- Loading areas
- Ancillary equipment
- Operating systems
- overfills

Sources of Potential Releases at AST Facilities



Protection Control Measures

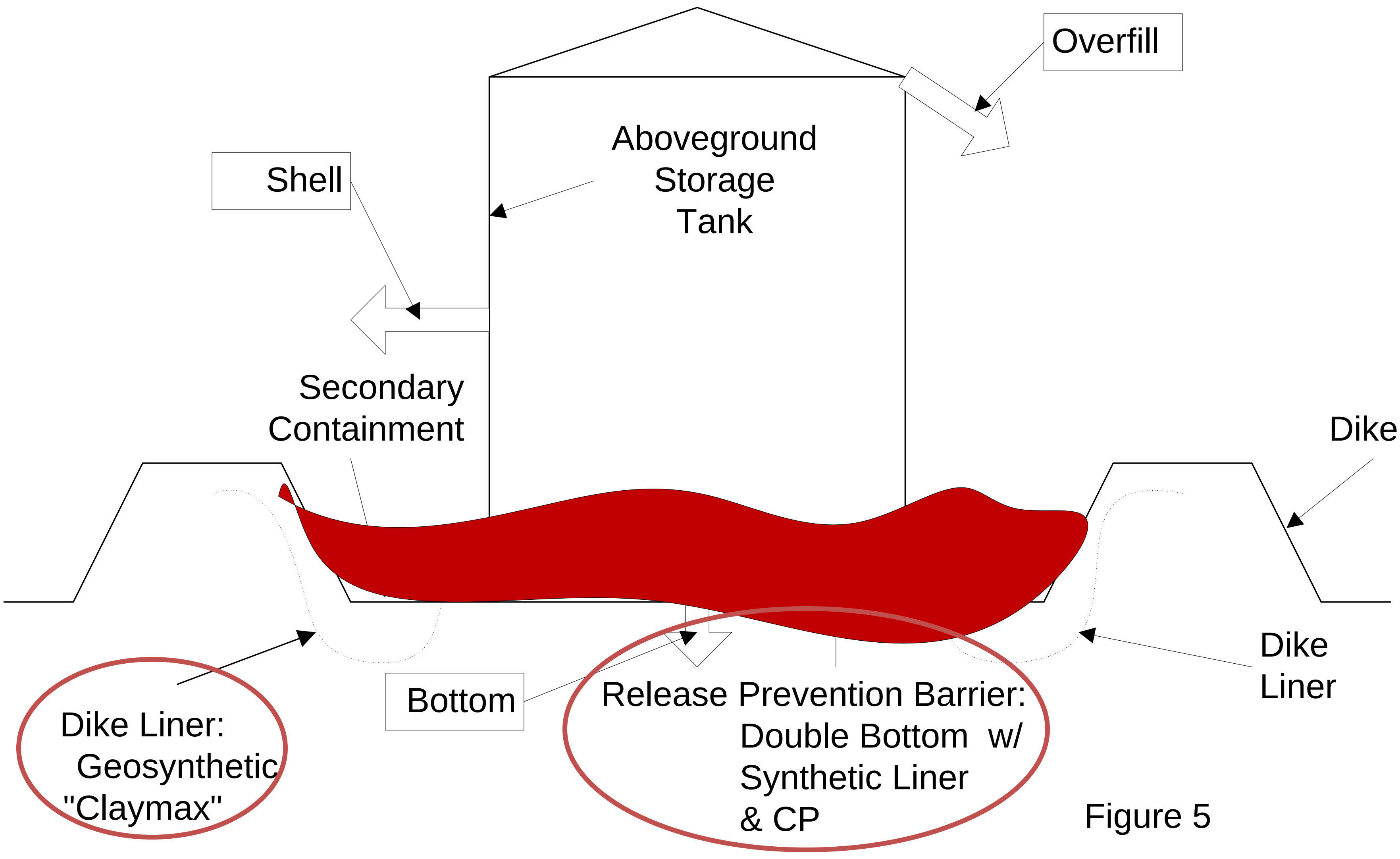


Figure 5

Example Focus Area - Secondary Containment

- The ultimate insurance policy
- Historical
- Regulatory
- Most are never used
- Lack of standardization
- Proof testing
- Leaks

Marsh Risk Engienering Position Paper 01

LOCATION	DATE	FUEL RELEASED	CONSEQUENCE
Jacksonville, Florida, USA	1993	Unleaded petrol/ gasoline	190 m^3 released. The spill ignited, leading to a major explosion and fire.
Coryton, UK	1997	Unleaded petrol/ gasoline	81 m^3 released. Spill contained within bund – no ignition.
Belgium	2001	Hexene	Approximately 90m^3 released. Spill contained within bund – no ignition.
Sour Lake, Texas, USA	2003	Crude oil	80 m^3 released. Spill contained within bund – no ignition.
Torrance, California, USA	2004	Jet fuel	Approximately 10m^3 released. Spill contained within bund – no fire or explosion.
Bayonne, New Jersey, USA	2004	Fuel oil	825 m^3 released. Oil contained on tank farm. – no fire or explosion.
Casper, Wyoming, USA	2004	Unleaded petrol/ gasoline	Up to 1270 m^3 released. Spill contained within bund – no ignition.
Rensselaer, NY, USA	2005	Unleaded petrol/ gasoline	0.4-4 m^3 released. Spill contained within bund – no ignition.

LOCATION	DATE	FUEL RELEASED	CAUSE	CONSEQUENCE
Fawley, UK	1999	Crude oil (400 tonnes)	Corrosion of tank base	No injuries or off-site effects. All of the oil was recovered from primary containment.
Milford Haven, UK	2005	Kerosene (653 tonnes)	Leak from damaged sump escaped through permeable floor of bund	No injuries, but nearby gardens, farmland, and stream contaminated. All wildlife killed in stream.
Antwerp, Belgium	2005	Crude oil (26,000 tonnes)	Catastrophic failure of storage tank as a result of corrosion	Overtopping of the bund wall occurred due to sudden release.
Plymouth Harbour, UK	2005	Kerosene (tonnage uncertain)	Corrosion of the tank base and a permeable bund base	No injuries. Kerosene entered into the ground.
Coryton, UK	2006	Gas oil (121 tonnes)	Tank overfilled, oil escaped from bund by defective drain valve	No injuries or harm to the environment.
Poole Harbour, UK	2006	Diesel oil (19 tonnes)	Diesel escaped through damaged base plate and through cracks in concrete bund floor	No injuries. Pollution of ground but not of the harbour.

SW Florida power plant- 80,000 gallon overfill

Buncefield fuel depot

Before Dec 11 2005

Buncefield fuel depot

Dec 11 2005 (a Sunday)

Many tanks connected by manifold.

Historical legacy - Newport

Numerous Unstandardized Methods of Design and Construction

- A dirt pond
- A flat earthen area with a concrete dike surrounding it
- Fully concreted basis or resevoir
- A tank within a tank
- A large pan

Secondary Containment

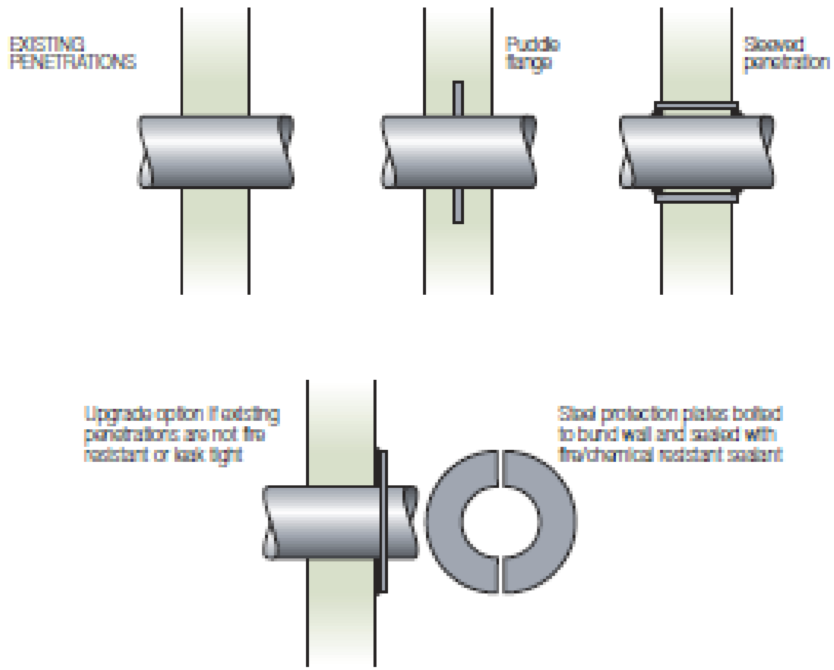
- No proof testing normally done; cannot be easily tested so we don’t know if it will really work
- But its not rocket science so qualified principles using qualified designs can reduce the risk
- Some principles:
  - Hydraulic pressure and tightness
  - Radian heat loads on joints and penetrations
  - Nature of underlying soil
  - Speed with which contents could permeate soil
  - Pros and cons of liners (lines can make things worse or distort the overall risk picture)
  - Bouyancy effects for either spills or major storms/floods
- API 653 does not address secondary containment inspection

Lessons from Buncefield

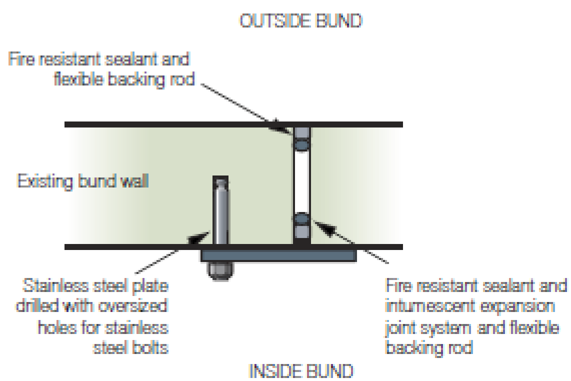
- **Any concrete structure for retention of liquids should be designed to minimise the risk of cracks forming. If cracks do form they should be adequately repaired.**

Leak Through Rebar Holes

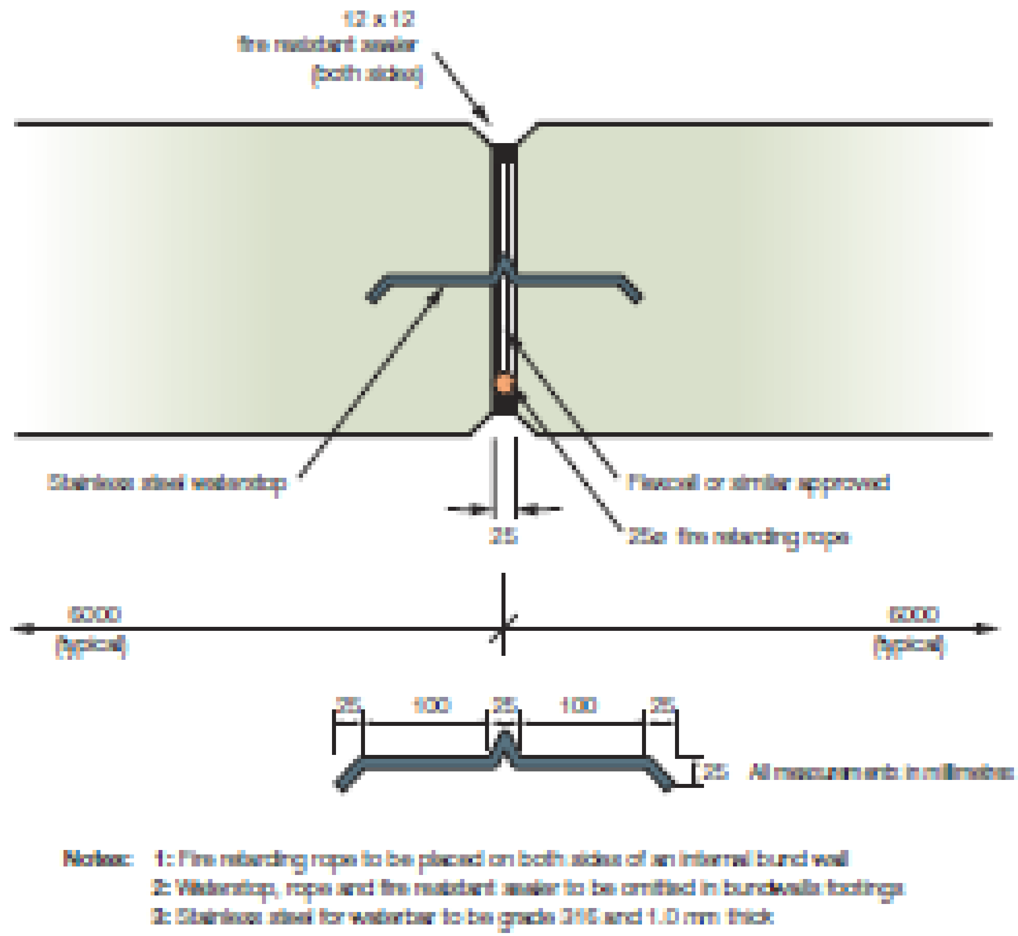
Good Practices for Penetrations



Good Practices for Joints



Good Practices for New Joints



Lining Secondary Containment

- Not normally used but regulatory pressure being applied
- Pros and Cons Not Clear⇒controversial topic
- API 341 covers this in detail

A Survey of Diked-Area Liner Use at Aboveground Storage Tank Facilities

Health and Environmental Affairs Department

API PUBLICATION NUMBER 341

API 341 Results

- Vehicular traffic and daily operations cause damage
- Material failures from uv radiation where exposed, chemical reactions with soil, freeze cycles, loss of plasticizers, embrittlement with time
- Failures at penetrations and around structures
- Subgrade failures due to settlement, liner movement stress failures
- API conclusion is that liner effectiveness is limited.
- *From a risk mitigation perspective, in most but not all cases, the resources used for liners would be far better allocated to things like API inspections, better design and construction, management systems, overfill protection, etc (PEMY opinion)*


1993
FLAMMABLE
DIESEL

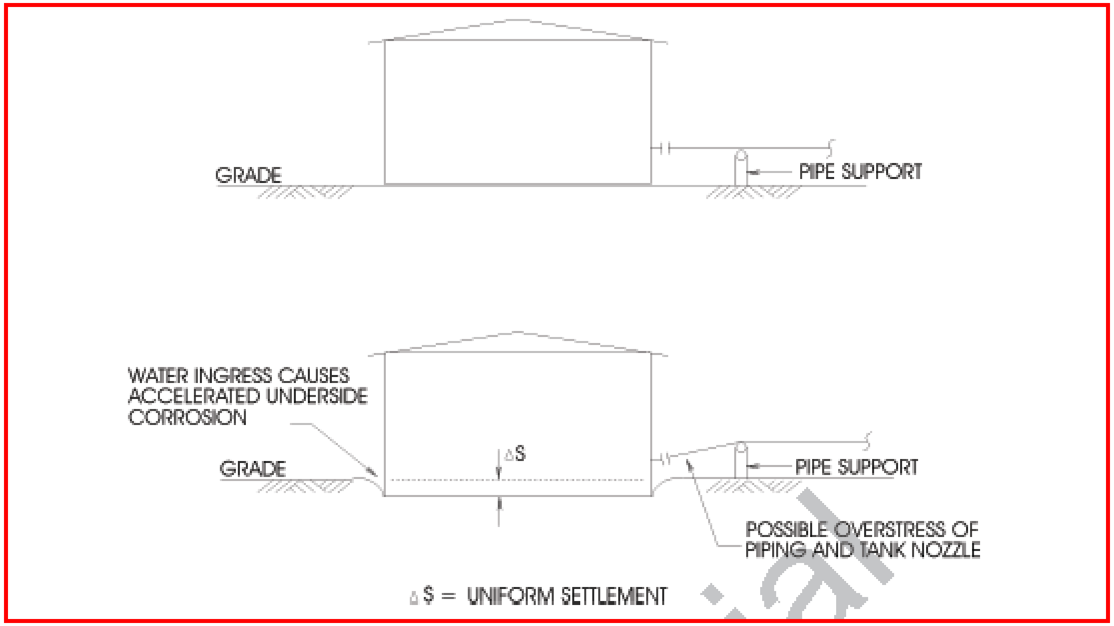

DIESEL


Option 1
Geomembrane

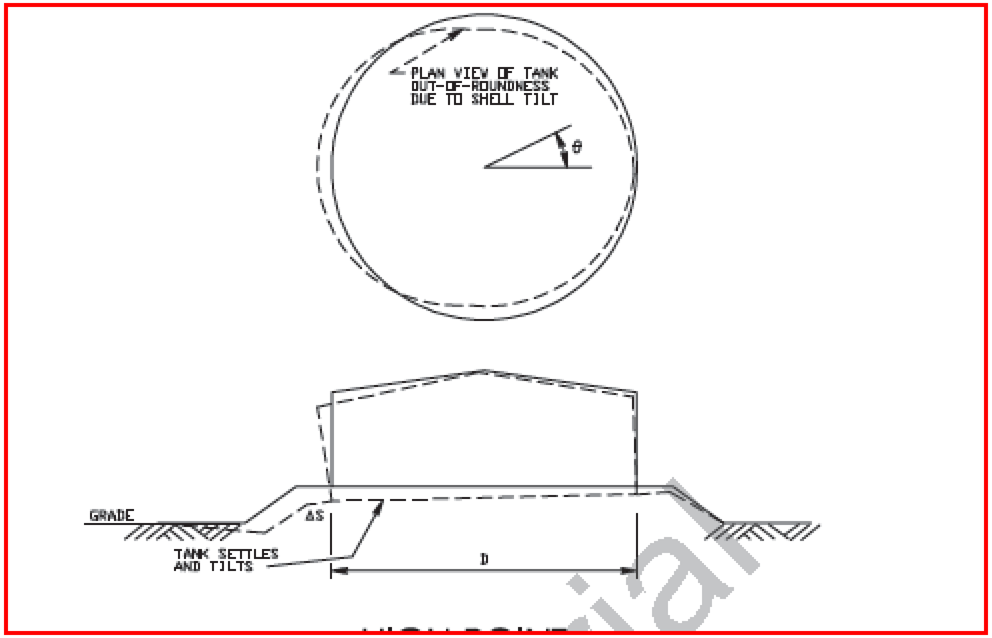
Option 2
Geosynthetic Clay Liner

Some Other Ways To Use Secondary Containment

- Severe settlement (+)
- Overfills (-)
- Seismic (-)
- Corrosion (+)
- Operational (-)
- Vandalism or Terrorism (-)
- And more (?)



GRADE
PIPE SUPPORT
WATER INGRESS CAUSES ACCELERATED UNDERSIDE CORROSION
ΔS
GRADE
PIPE SUPPORT
POSSIBLE OVERSTRESS OF PIPING AND TANK NOZZLE
ΔS = UNIFORM SETTLEMENT


PLAN VIEW OF TANK
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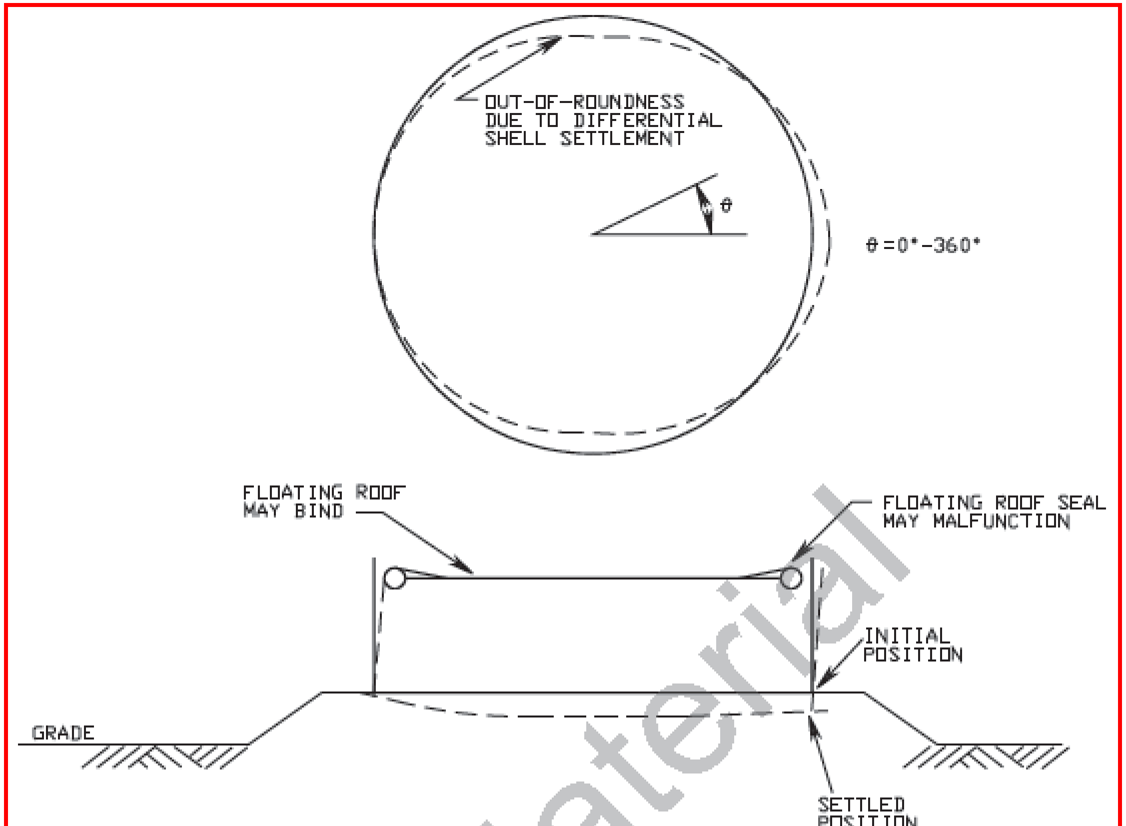
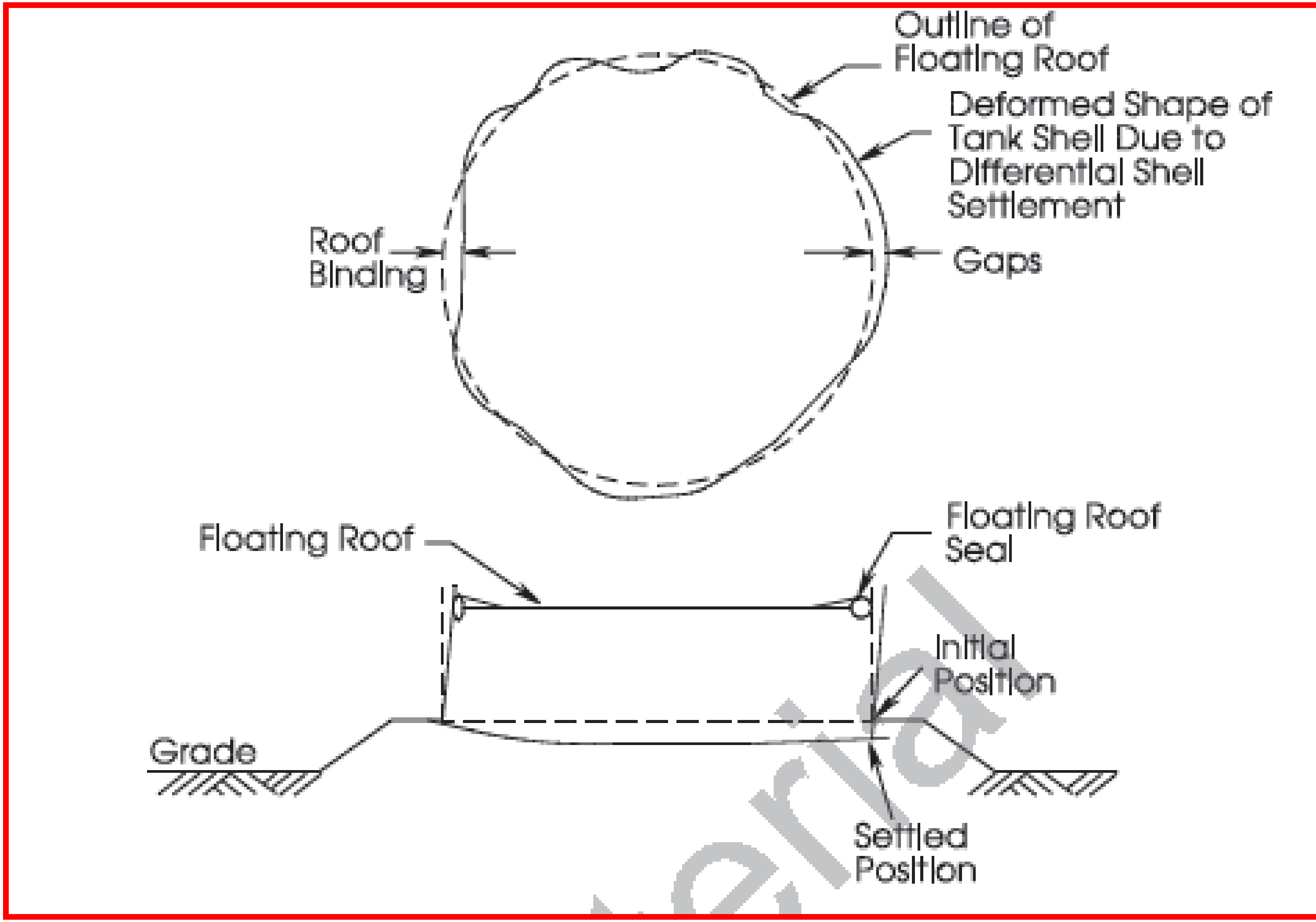
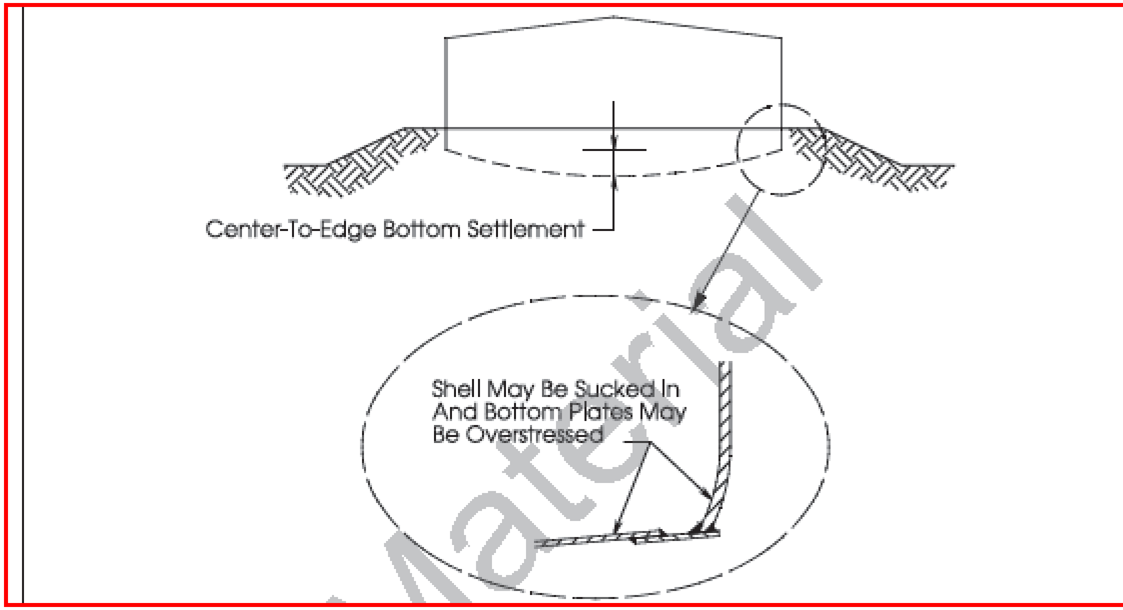
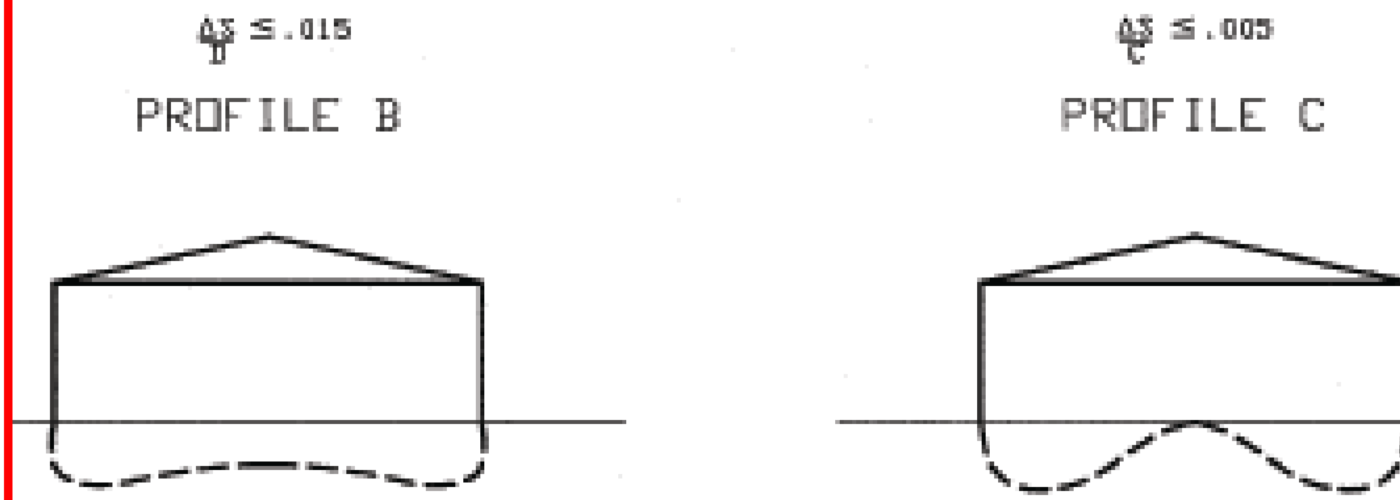
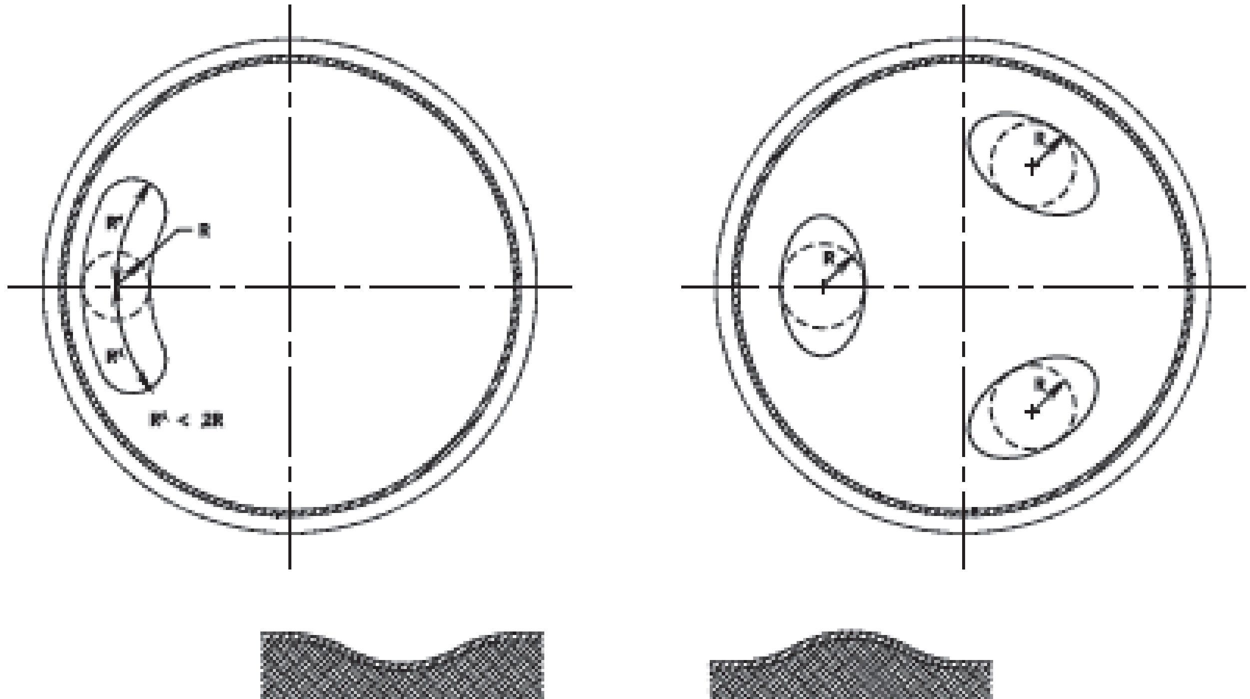


OUT-OF-ROUNDNESS
DUE TO DIFFERENTIAL
SHELL SETTLEMENT
θ
θ=0°-360°
FLOATING ROOF
MAY BIND
FLOATING ROOF SEAL
MAY MALFUNCTION
INITIAL
POSITION
GRADE
SETTLED
POSITION

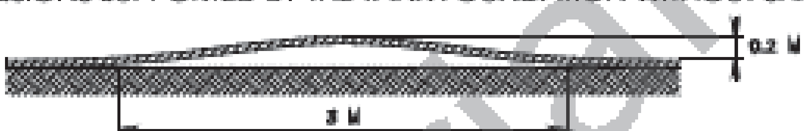

Outline of
Floating Roof
Deformed Shape of
Tank Shell Due to
Differential Shell
Settlement
Roof
Binding
Gaps
Floating Roof
Floating Roof
Seal
Initial
Position
Grade
Settled
Position


Center-To-Edge Bottom Settlement
Shell May Be Sucked In
And Bottom Plates May
Be Overstressed

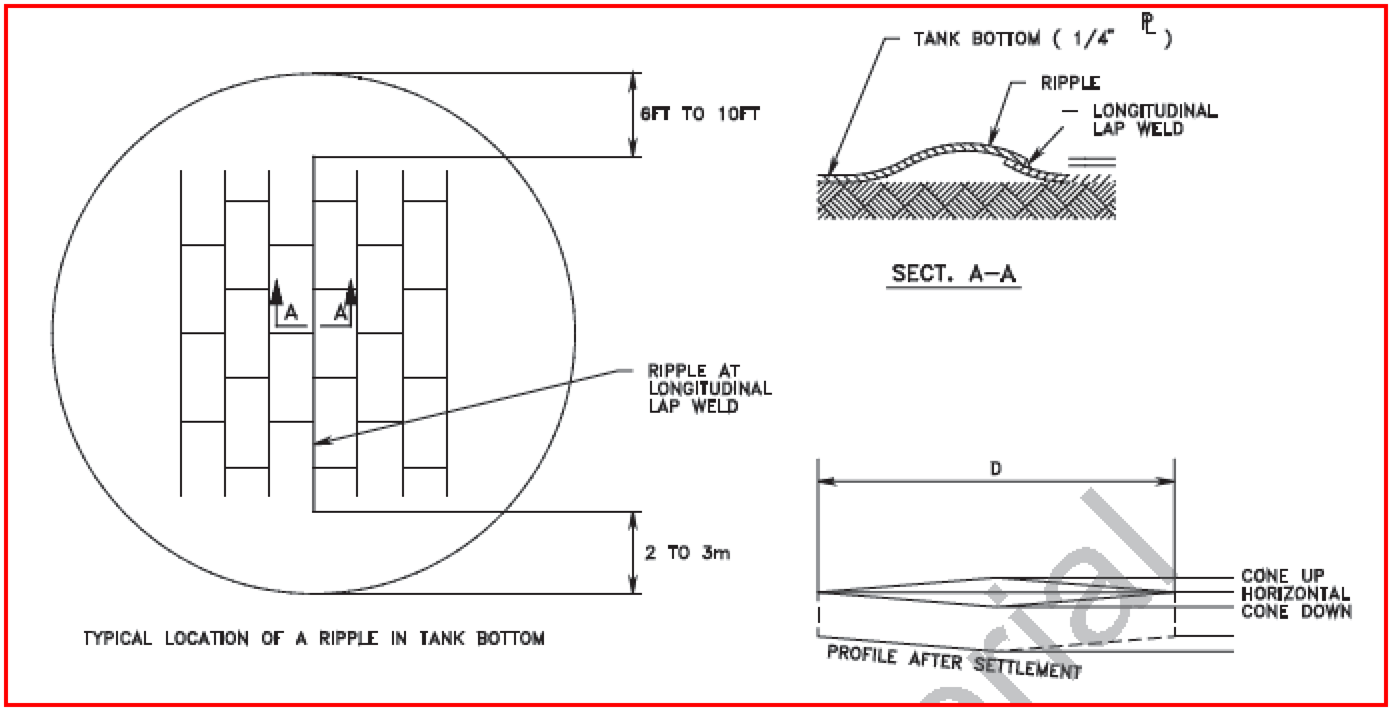

ΔS/D ≤ .015
PROFILE B
ΔS/C ≤ .005
PROFILE C

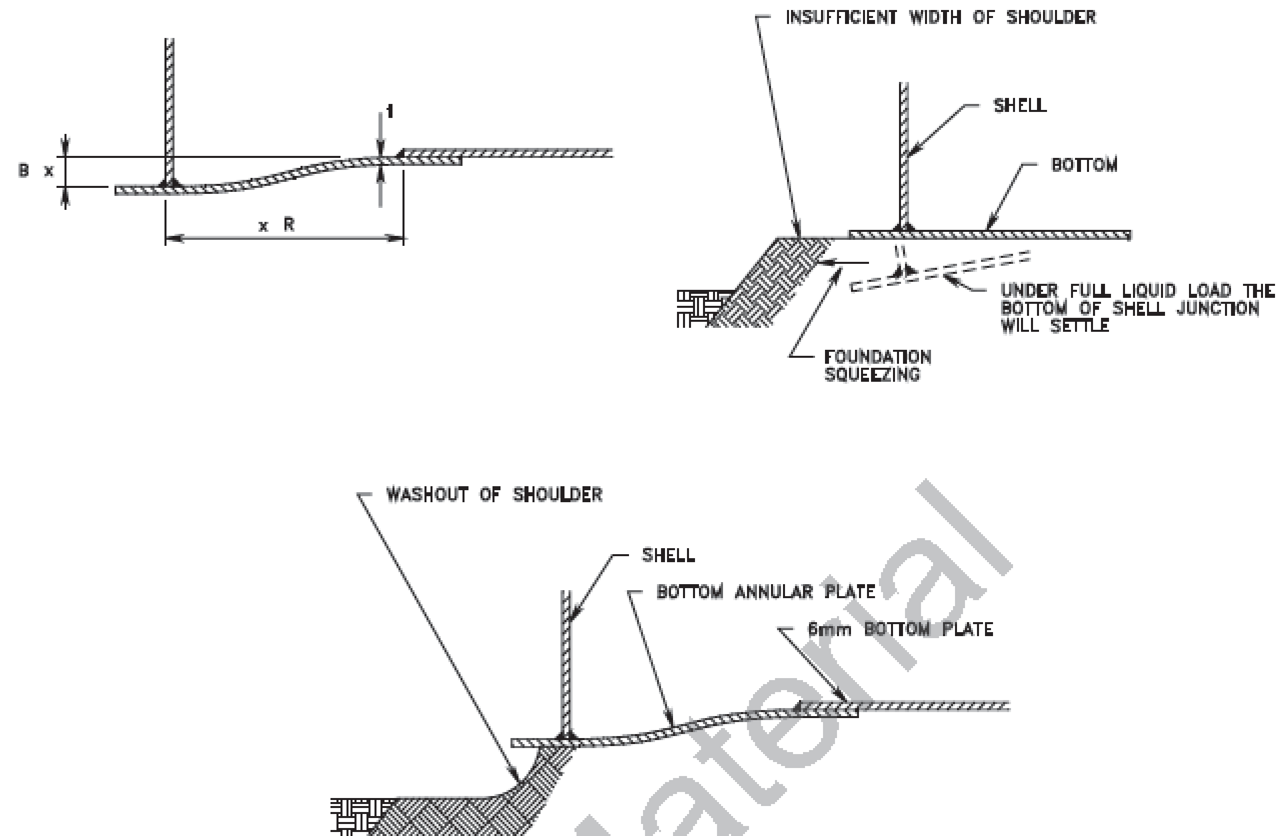


BULGES AND DEPRESSIONS SUPPORTED BY THE TANK FOUNDATION WITHOUT SHARP EDGES



BULGE NOT FILLED WITH FOUNDATION MATERIAL


6FT TO 10FT
A
A
RIPPLE AT LONGITUDINAL LAP WELD
2 TO 3m
TYPICAL LOCATION OF A RIPPLE IN TANK BOTTOM
TANK BOTTOM (1/4" PL)
RIPPLE
LONGITUDINAL LAP WELD
SECT. A–A
D
CONE UP
HORIZONTAL
CONE DOWN
PROFILE AFTER SETTLEMENT



t
B x
x R
INSUFFICIENT WIDTH OF SHOULDER
SHELL
BOTTOM
UNDER FULL LIQUID LOAD THE BOTTOM OF SHELL JUNCTION WILL SETTLE
FOUNDATION SQUEEZING
WASHOUT OF SHOULDER
SHELL
BOTTOM ANNULAR PLATE
6mm BOTTOM PLATE

Purpose of Foundations

- Support tank (obviously)
- Minimize corrosion
- Allow internal (and external drainage)
- Prevent many different modes of settlement (differential, out of plane, edge, etc)
- Allowance for future settlement
- Provide anchorage for pressure tanks or for seismic

Common Foundation Types

- Earthen
- Slab
- Crushed Stone Ringwall
- Concrete Ringwall
- Piled
- Others

Tank Size

- Large Tanks (50 feet in diameter or greater) – use concrete ringwall (preferred)
- Small Tanks (20 feet in diameter or less) – use concrete slab foundation (preferred).
- Medium Tanks (20 to 50 feet in diameter) can be classified as either large or small at the discretion of the foundation designer and tank design engineer, for the purpose of choosing the type of foundations only.

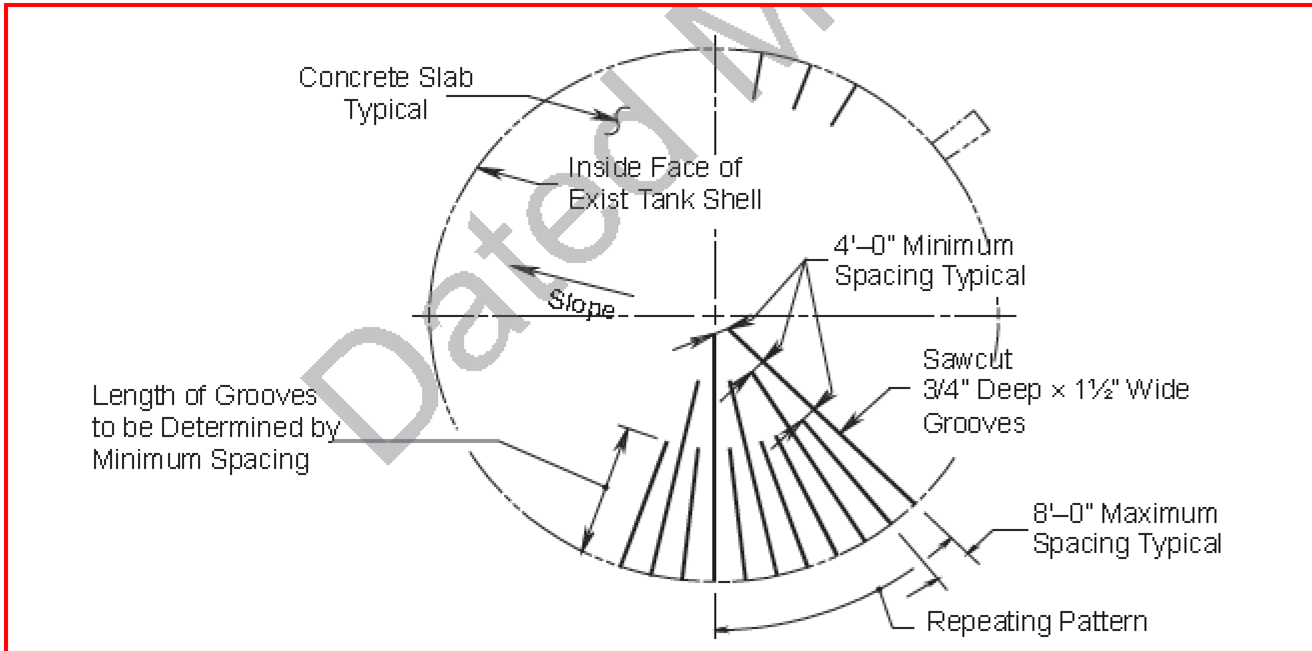
Caveat

- Do not just put a tank on a foundation (this is done all too often)
- Get a geotechnical engineering firm to assess and determine the soil and subsurface conditions
- Get a recommendation from them on the foundation type (but you will have to provide the criteria for acceptance)
- Make sure you consider RPBs

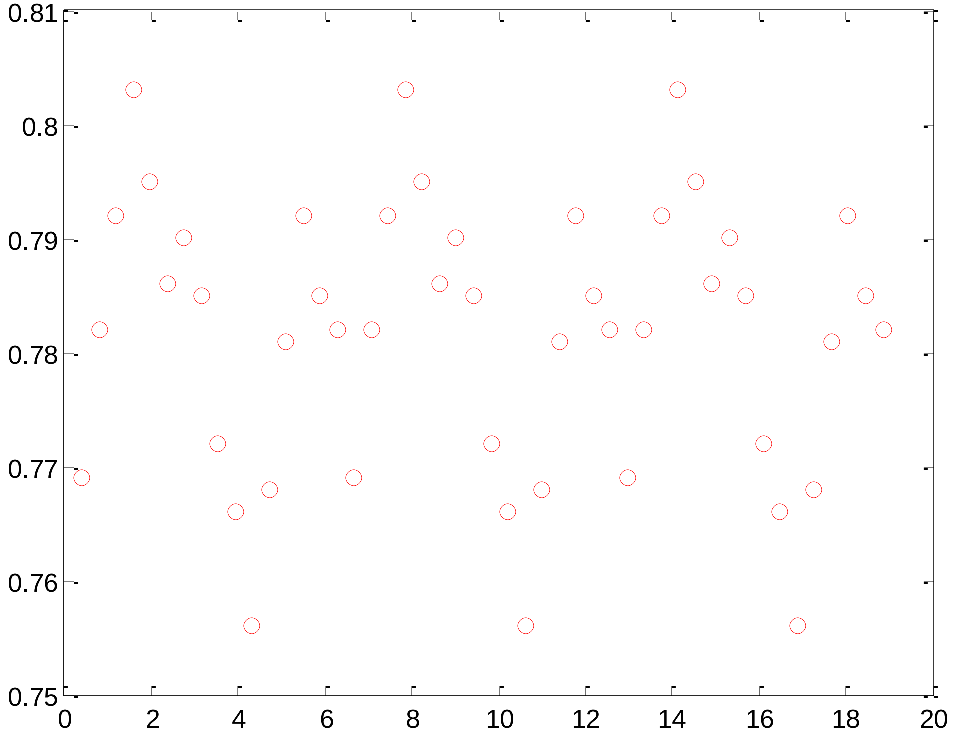
Soil Type

- **In some instances, large fixed roof tanks can be supported directly on properly prepared good native material. Choose this method only if recommended by the soils consultant. Pile supported concrete slab foundations are used for tanks on poor soils, regardless of the tank size**

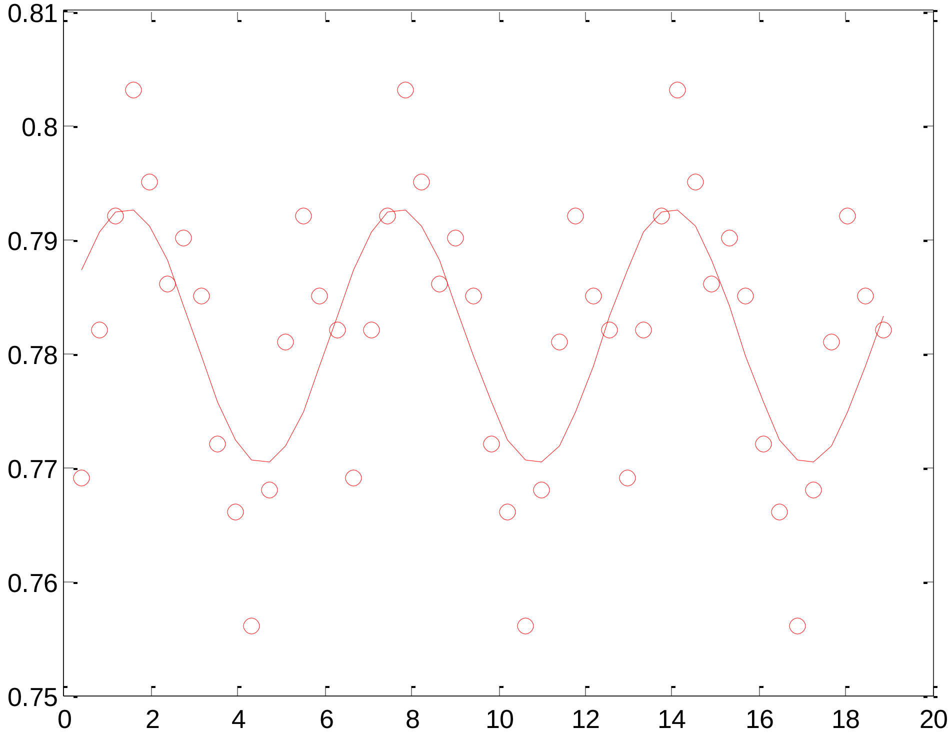
Leak Detection Groove Patterns



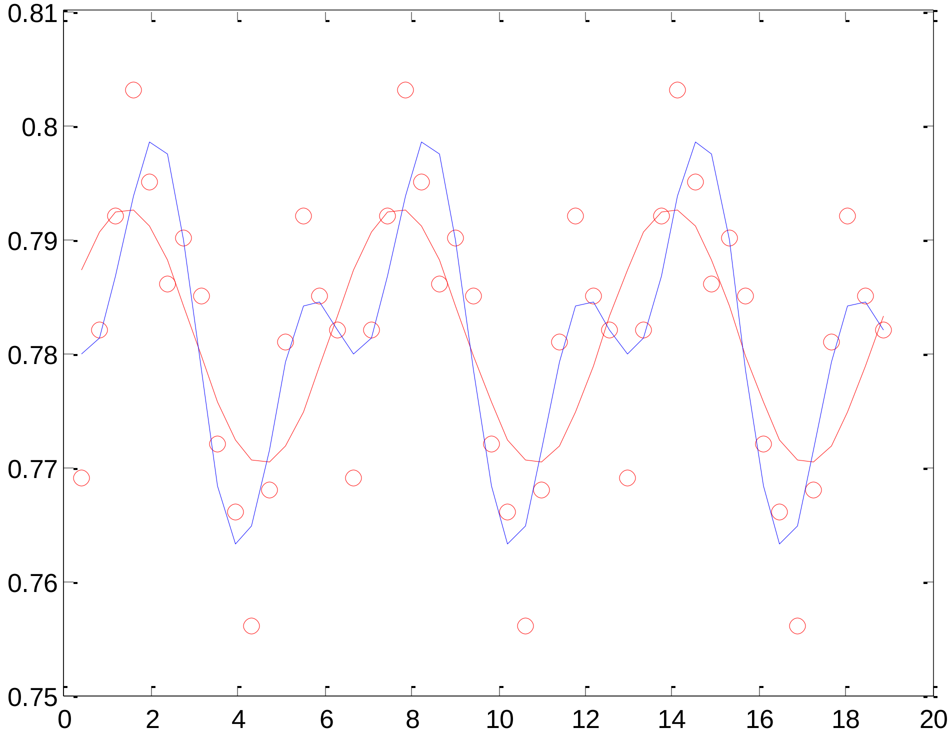
Settlement Data Real Tank



Best Fit Cosine Curve

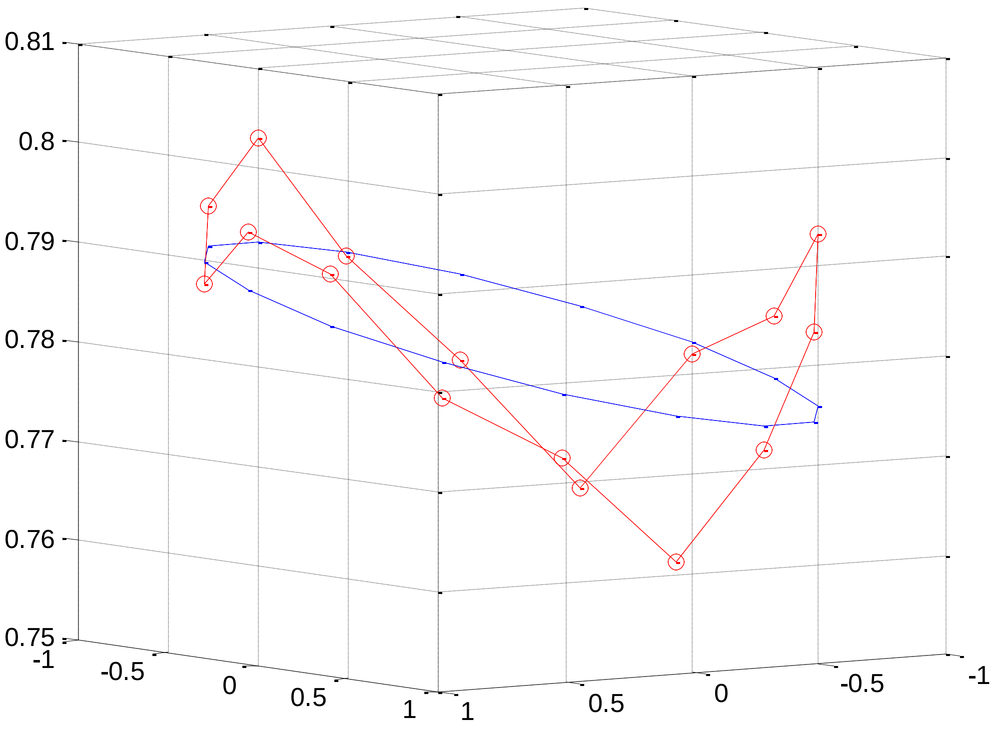


mse1 = 8.5875e-05

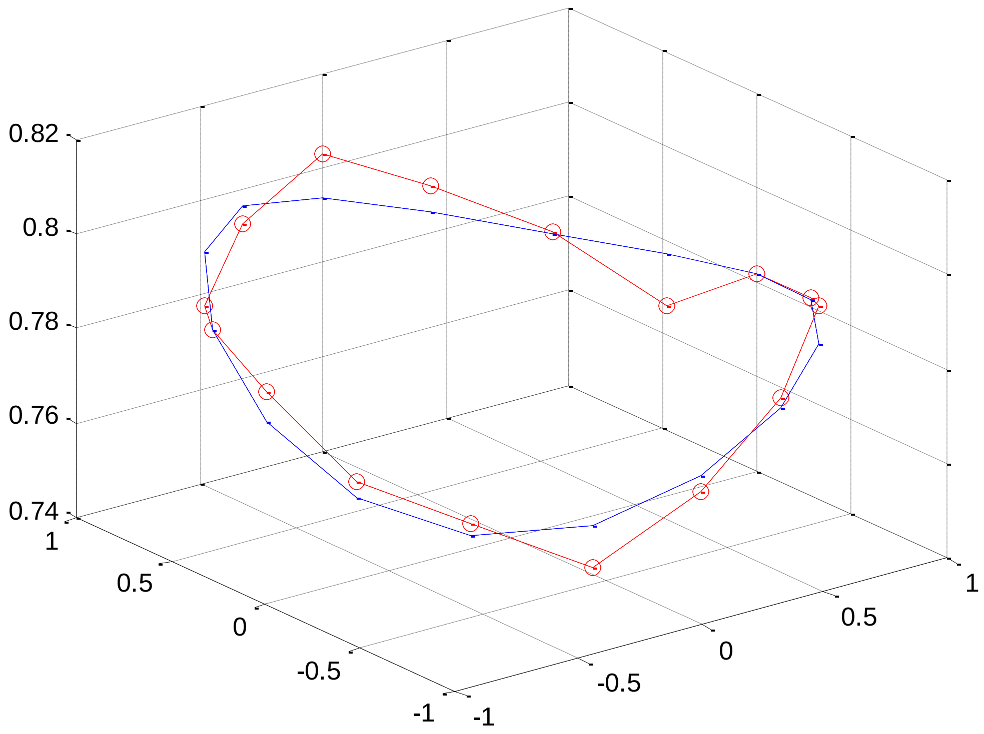


mse2 = 4.1506e-05

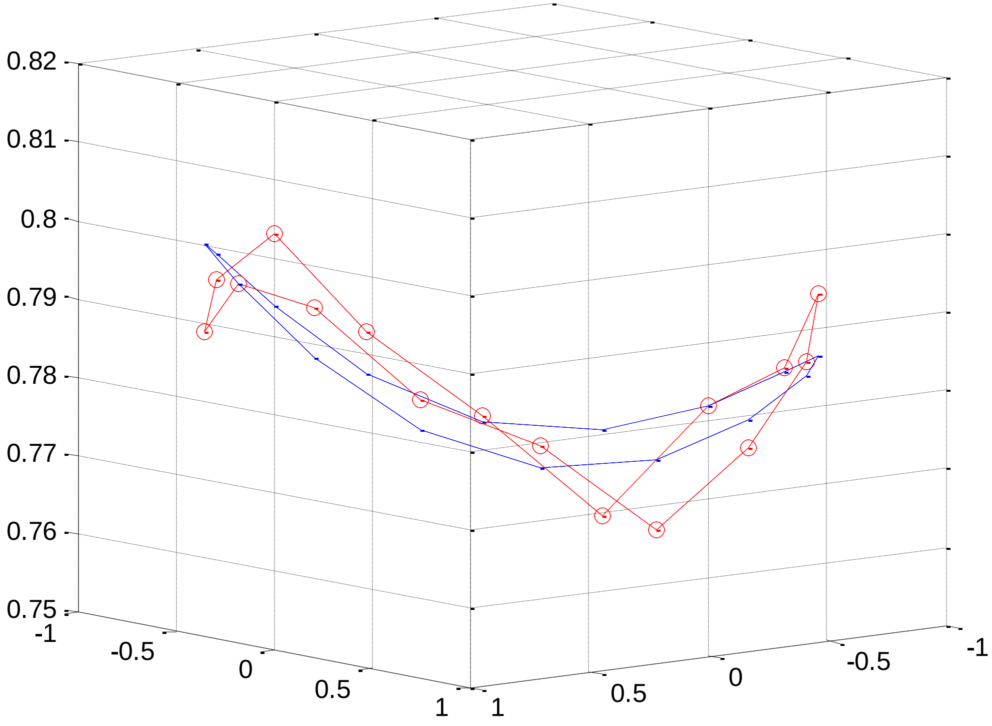
Best Fit Cosine Curve



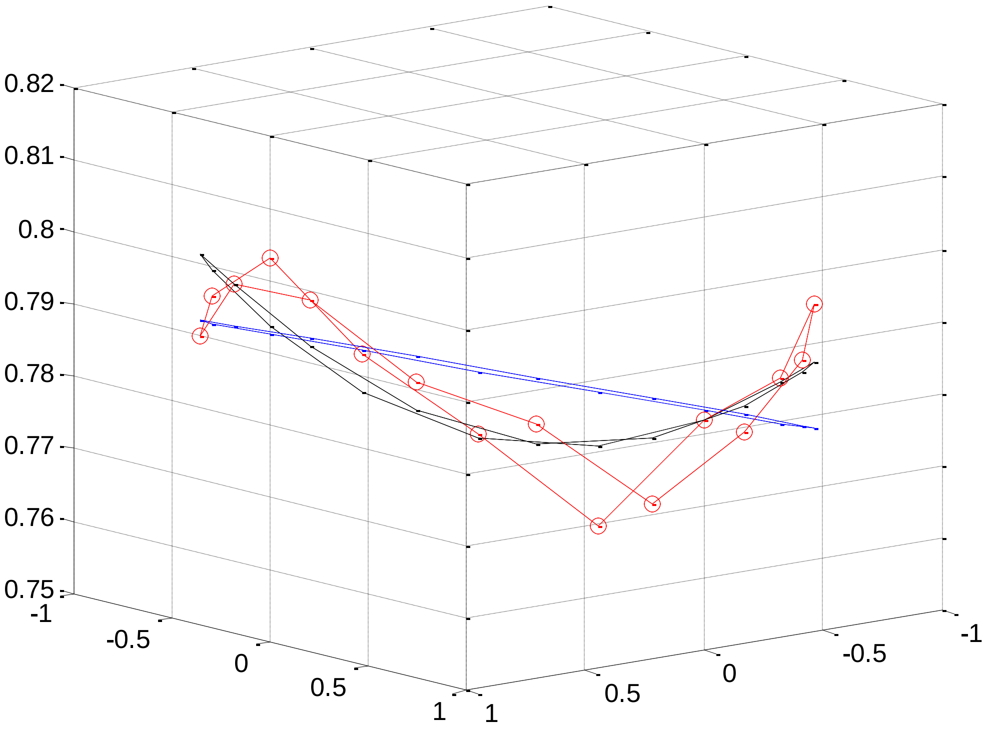
Second Mode Fit



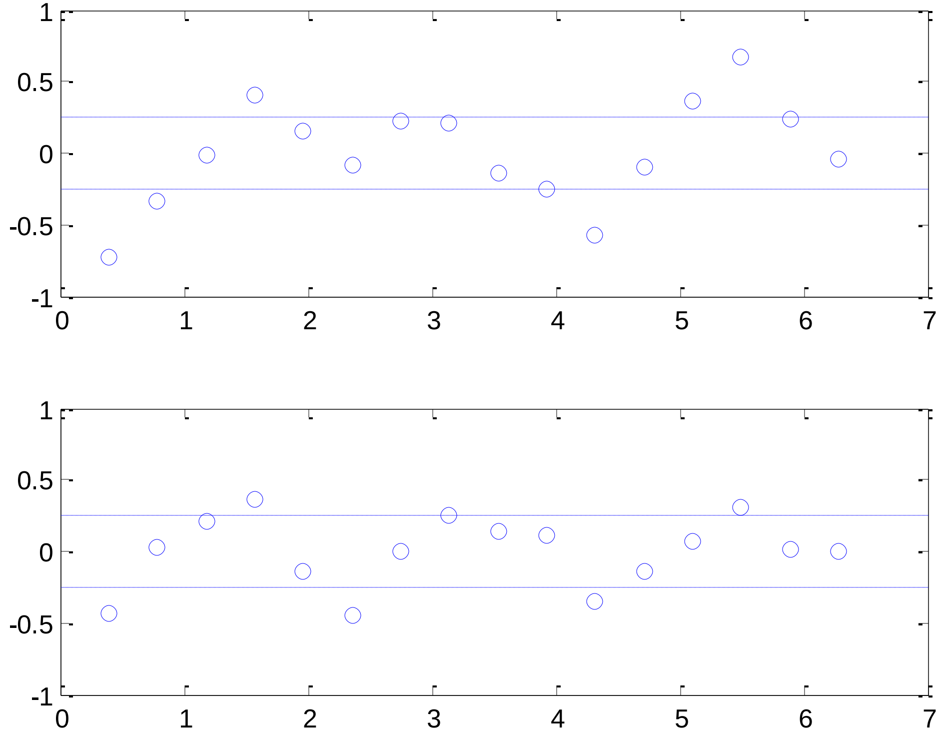
Better “view”

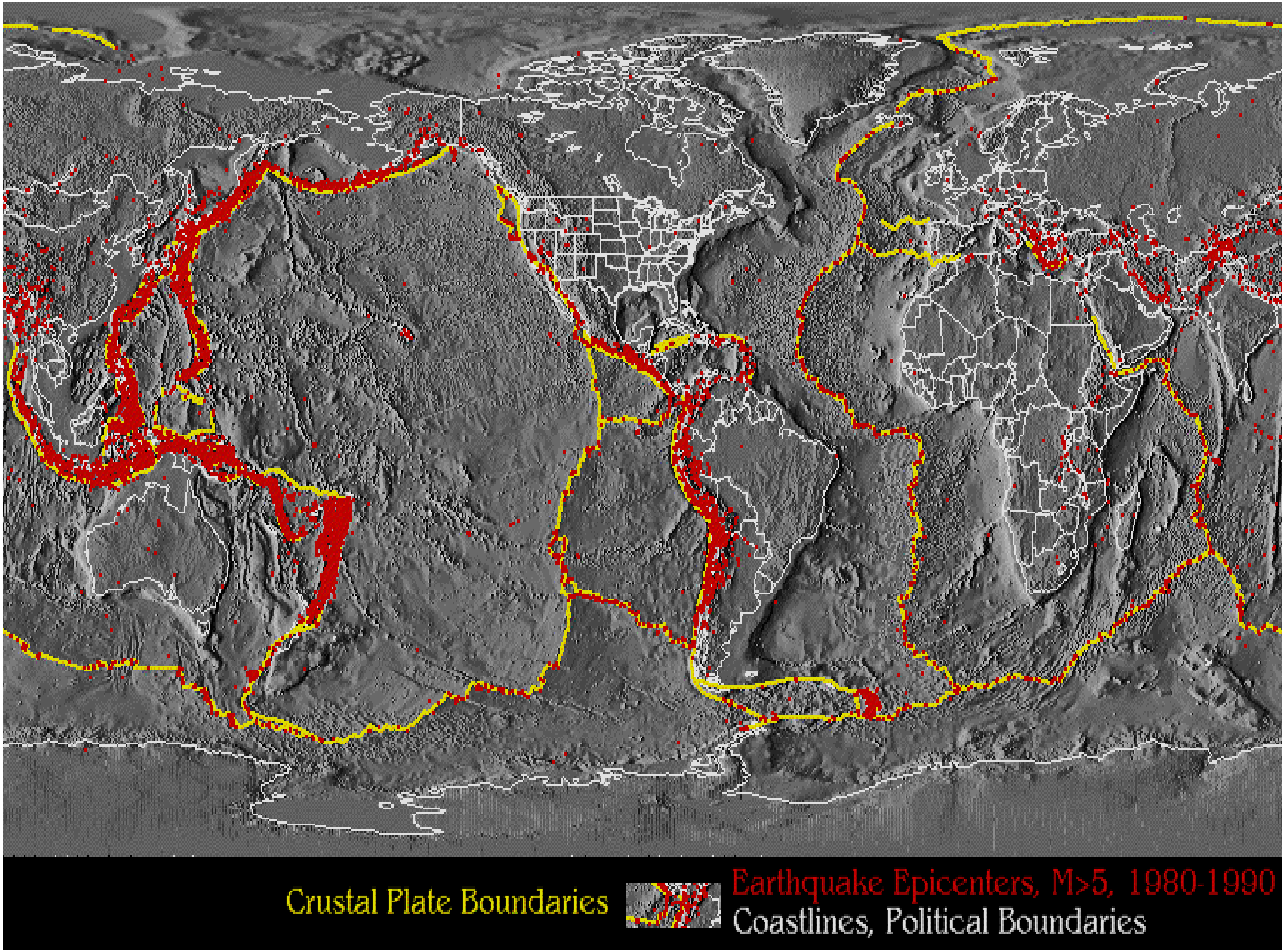


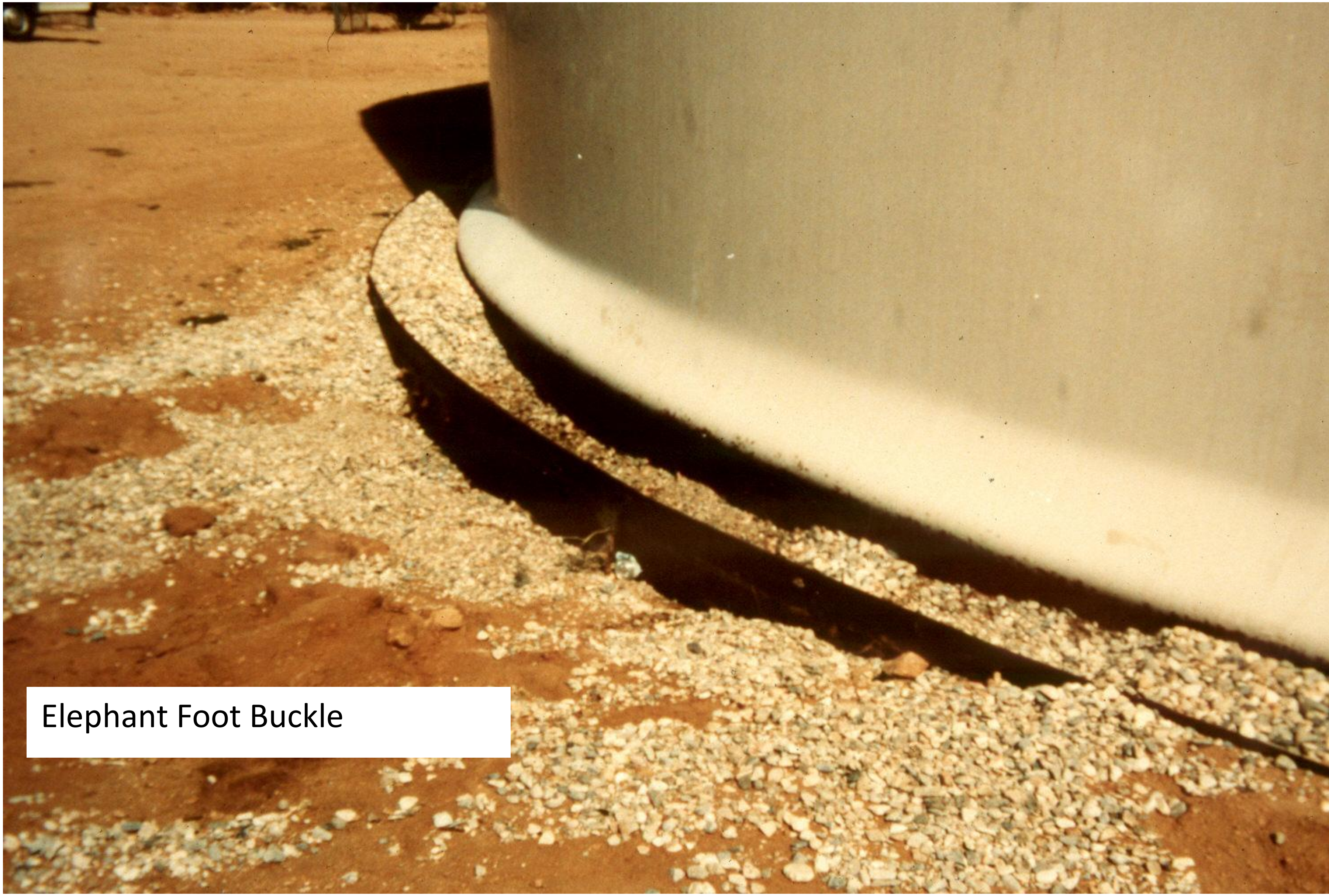
Better View Both Modes Shown



Residuals




Crustal Plate Boundaries
Earthquake Epicenters, M>5, 1980-1990
Coastlines, Political Boundaries



Elephant Foot Buckle

Tanques de Gasolinas (41, 40, 32) (MOGAS TKS)

Tanque de almacenamiento (Diesel-22)

BULLETS LPG (FUERA DE SERVICIO)(MOTHBALLED LPG BULLETS SANK AT ONE SIDE)

TANQUE 10 DAÑADO (FUEL OIL)

Thank You

For more information contact

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phil@pemyconsulting.com