1. They did not attack the fuel storage
Why is there Concern About Process Safety?

Are you Looking to be a TV Star?

Does Loss of Life Interest You?

Is Bankruptcy of Your Company Important?

Like to have a Movie Made about You?

“BP shares have lost approximately $90 billion in value, or 51%, since the Deepwater Horizon accident touched off the Macondo field blowout in late April. The common stock settled at $30.67 a share in trading Monday, near a 14-year low of $29 a share, which it touched last Wednesday.” (Moneywatch 6/15/2010)
What is Process Safety?

What is **NOT** Process Safety

- Car Crash
- Slips, Trips and Falls
- Back Injuries
- Pinched Fingers
- Dropped Objects
What is Process Safety?

```
What IS Process Safety

“Really, Really BAD Incidents are Usually Process Safety Incidents”  Jim Johnstone
```

Blowouts
Explosions
Fires
Toxic Gas Releases
Loss of Containment
Tanks Overflows
Line Leaks

“BOOM AFTER BOOM AFTER BOOM”
The Case for Risk Based Process Safety

Hazards are Not Uniform for ALL Operations

Different Activities Present Different Risks

Both TIME and CAPITAL are Precious!

Focus on GREATEST Risk Events
Road to Risk Based Safety

- Regulations
- Management Systems
- Risk-Based
There are Standards and RPs for **EVERYTHING**!

**Historical Publications**
- API – American Petroleum Institute
- NACE-National Association of Corrosion Engineers
- International Association of Oil and Gas Producers
- ASSE
- NFPA
- Pipe-in-Pipe
- GPSA
- **Center for Chemical Process Safety**

**EVEN Process Safety:**
- API RP 75 and 75L
Road to Risk Based Process Safety

- Industry Standards and Recommended Practices
- Management Systems
- Risk-Based
Regulations

United Kingdom Safety Case Law in 1991

US OSHA PSM and EPA RMP in 1992

US Bureau of Safety and Environmental Enforcement, Safety and Environmental Management Systems in 2010
• Industry Standards and Recommended Practices
• Regulations
• Risk-Based
Management Systems

1. Management Leadership, Commitment and Accountability
2. Risk Assessment and Management
3. Facilities Design and Construction
4. Information / Documentation
5. Personnel
6. Operations and Maintenance
7. Management of Change
8. Third Party Services
9. Incident Investigation and Analysis
10. Community Awareness and Emergency Preparedness
11. Operational Integrity Assessment and Improvement
Road to Risk Based Process Safety

- Industry Standards and Recommended Practices
- Regulations
- Management Systems
Life Shaping Process Safety Events

- **Tier 1**: Loss of primary containment events of greater consequence
- **Tier 2**: Loss of primary containment events of lesser consequence
- **Tier 3**: Near-misses and challenges to safety systems
- **Tier 4**: Operating discipline and leading performance measures
### Life Shaping Process Safety Events

<table>
<thead>
<tr>
<th>Incident</th>
<th>Impact</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969 Santa Barbara Oil Spill</td>
<td>80-100 MBO spilled to the ocean; impacts to marine mammals birds and beaches</td>
<td>Helped spur formation of US EPA; Formation of offshore spill cooperatives; Mandatory blowout training</td>
</tr>
</tbody>
</table>
The absorption of H₂S in the human body may produce the following symptoms:

- Olfactory Paralysis
- Excitement
- Eye Irritation
- Coughing
- Headaches
- Confusion
- Pulmonary Edema
- Brain Damage
- Respiratory Arrest
- Cardiac Arrest

**Incident**

1975 Denver City H₂S Release

**Impact**

9 deaths from H₂S exposure

**Results**

Regulations on H₂S; Material and engineering standards developed
<table>
<thead>
<tr>
<th>Incident</th>
<th>Impact</th>
<th>Results</th>
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<tr>
<td>1988 Piper Alpha</td>
<td>Fire and explosion killing 167 people</td>
<td>Offshore installations (Safety Case) Regulations 1992</td>
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<tr>
<td>Incident</td>
<td>Impact</td>
<td>Results</td>
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<td>--------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
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<tr>
<td>2010 Deepwater Horizon</td>
<td>4.9 MMBO discharged to the ocean; <strong>11 people</strong> killed</td>
<td>US Forms BSEE and requires SEMS; New BOP drilling and contingency requirements</td>
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<tr>
<td>Element</td>
<td>API RPI 75</td>
<td>OSHA PSM</td>
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<tr>
<td>----------------------------------------------</td>
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<td>----------</td>
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<td>Safe Work Practices</td>
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<tr>
<td>Training</td>
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<td>Pre-Start-Up Review</td>
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<tr>
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<th>BSEE SEMS</th>
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<td>Investigation of Incidents</td>
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<td>Records and Documentation</td>
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<td>Employee Participation</td>
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## Comparison of Process Safety Elements

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<tr>
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<th>API RPI 75</th>
<th>OSHA PSM</th>
<th>BSEE SEMS</th>
<th>CCPS</th>
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<tr>
<td>Ultimate Work Authority</td>
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<td>Reporting of Unsafe Conditions</td>
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<tr>
<td>Job Safety Analysis</td>
<td></td>
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<td>Independent Auditors</td>
<td></td>
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<td>✗ * embedded in an element</td>
</tr>
</tbody>
</table>
Barrier Management

- Hazard Analysis
- Training
- Management of Change
- Operating Procedures
- Mechanical Integrity
- Safety and Environmental Information
- Pre-Start up Review
- Emergency Response
Work Authority Delegation

Safe Work Practices

Ultimate Work Authority

Stop Work Authority
6 Steps to Apply Risk Based Process Safety in E&P

1 → 2 → 3 → 4 → 5 → 6
Step 1: Determine the Hazards

Typical Hazards

- Fire
- Explosion
- Toxic Release to Air
- Spills to Soil or Water

Questions to Ask

- How do I identify the hazards in my operation?
- When should I identify the hazards?
STEP 2: Determine Ways to Mitigate the Hazards

- Threat
- Threat
- Threat

Top Event

Preventative Barriers

Mitigating Barriers

Consequence

Consequence

Consequence

Hazard

1 → 2 → 3 → 4 → 5 → 6
## Example Bow Tie Analysis

<table>
<thead>
<tr>
<th>Threat</th>
<th>Preventative Barriers</th>
<th>Mitigating Barriers</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>- Coatings</td>
<td>- Low Pressure Shut Downs</td>
<td>- Fire</td>
</tr>
<tr>
<td>Over Pressure</td>
<td>- Metallurgy</td>
<td>- Gas Detection</td>
<td>- Spill to Land</td>
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<tr>
<td>Vehicle Impact</td>
<td>- Designed to Code</td>
<td>- Berms</td>
<td>- Spill to Water</td>
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<tr>
<td>Maintenance</td>
<td>- Corrosion Allowance</td>
<td>- Emergency Response Plan</td>
<td>- Air Pollution/ Odors</td>
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<tr>
<td></td>
<td>- Maintained to API 570</td>
<td>- Fire Extinguishers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Chemical Inhibition</td>
<td>- Spill Equipment</td>
<td></td>
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<tr>
<td></td>
<td>- Cathodic Protection</td>
<td>- Fire Detectors</td>
<td></td>
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<tr>
<td></td>
<td>- Relief Valve</td>
<td>- Cameras</td>
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<td>- High Pressure Shut Down</td>
<td>- Classified Electrical Equipment</td>
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<td></td>
<td>- Vehicle Barriers</td>
<td>- Hot Work Procedures</td>
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<td></td>
<td>- 100% X-Ray of Welds</td>
<td>- Site Drainage Design</td>
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<tr>
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<td>- Operating Procedures</td>
<td>- Stop Work Authority</td>
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<td></td>
<td>- Line Opening Procedures</td>
<td>- Isolation Valves</td>
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<td>- Automated Systems</td>
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</table>

### Top Event
- Oil and Gas Leak

### Hazard
- Fire
- Soil Contamination
- Water Contamination
- Air Contamination
Let’s Look at our BOW TIE after Considering Risk

<table>
<thead>
<tr>
<th>Threat</th>
<th>Preventative Barriers</th>
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<th>Consequence</th>
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<td>- Stop Work Authority</td>
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</table>

Top Event
Oil and Gas Leak

Hazard
- Fire
- Soil Contamination
- Water Contamination
- Air Contamination
### STEP 3: Determine Acceptable Risk

#### Markers to Consider

- **Death in an Industrial Incident**: $3.3 \times 10^{-5}$/Year
- **Death in an Automobile Crash**: $1.02 \times 10^{-4}$/Year

#### Likelihood Table

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Remote</th>
<th>Occasional</th>
<th>Probable</th>
<th>Frequent</th>
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<tbody>
<tr>
<td>Low</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Action</td>
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<td>Moderate</td>
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<td>Significant</td>
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<td>Catastrophic</td>
<td>Action</td>
<td>Stop</td>
<td>Stop</td>
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</table>
Ranking Risk for Different E&P Activities

Barrier Management
Safety and Environmental Information
Hazards Analysis
Management of Change
Operating Procedures
Safe Work Practices
Training
Mechanical Integrity
Pre-Startup Review
Emergency Response and Control
Reporting and Investigation of Incidents
Records and Documentation
Contractors
Work Authority Delegation
Stop Work Authority
Ultimate Work Authority
Program Administration
Policies and Procedures
Employee Participation
Measurement and Metrics
Audits of Process Safety Program
Continuous Improvement

Drilling
Completion
Production Operations
Surface Facilities
Workovers
Transportation
Others
# Ranking Risk for Different E&P Activities

<table>
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<tr>
<th>Barrier Management</th>
<th>Drilling</th>
<th>Completion</th>
<th>Production Operations</th>
<th>Surface Facilities</th>
<th>Workovers</th>
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STEP 4: Implement the Process Safety Measures

DO what it TAKES to Reduce Process Safety Incidents

Procedures
- Mechanical Integrity Program
- Change Out Equipment
- Install Safety Devices
- Many, Many more

1 → 2 → 3 → 4 → 5 → 6
STEP 5: Examine Effectiveness of Process Safety Measures
STEP 6: Update and Revise Process Safety Program

Plan
Do
Study
Act

1 → 2 → 3 → 4 → 5 → 6
Conclusions

Risk Based Process Safety Can:

PREVENT Fires, Explosions, Toxic Releases and Spills
TARGET Key Process Safety Elements for YOUR Operation
Keep YOU and YOUR COMPANY away from LITIGATION AND FINES
Help the IMPLEMENTATION of MANAGEMENT SYSTEMS
Improve UPTIME and reduce DOWNTIME
Increase CONFIDENCE by ALL in E&P Activities
Are you an Optimist or a Pessimist? Looking at the attack on Pearl Harbor

Three Mistakes

1. The Japanese attacked on Sunday morning

2. They did not attack the dry docks

3. They did not attack the fuel storage