Process Safety
Facility Planning and Siting

23 March 2011
Facility Planning

• External
  – Location of Site / Effects on Community
  – Exterior Effects on Site

• Internal
  – Location/Arrangement within Site

• Incidents

• Risk Assessment Methodology
Facility Planning

• Why is location of site important?
• Why is proper planning important?
• Look at the present, learn from the past, and anticipate the future
• Include proper people in planning process
  – Engineers / Designers
  – Operations
  – Management
  – Emergency Services
External Siting

Types of Incidents

• Fires and Explosions
• Toxic Air Release
• Spill into Waterways
• Disruption of Public Wastewater Treatment Plant
• Groundwater Contamination
• Normal Air Emissions
External Siting

- Location of a site with respect to surrounding area and community.
- Evaluate the effects of an incident on areas outside the plant.
- Evaluate the effects of normal operation on areas outside the plant.
- NIMBY – Not In My Back Yard
External Siting

• Evaluate the effects of surroundings on the facility.
  – Adjacent Highways/Railways
    • Transport of Hazardous Chemicals
  – Environment
  – Weather
Incidents

Possible Effects of an Incident

• Loss of Life
• Loss of Jobs
• Business Interruption
• Increased Consumer Costs from Reduced Supply
• Increased Costs in Insurance Costs / Premiums
• Environmental Impacts
• Negative Impact on Company Reputation
Incident No. 1

Flixborough, UK

- 16:53 Saturday, June 01, 1974
- 28 People Killed, 36 Injured
- Fire on an 8 inch Pipe
- Bypass Pipe Containing Cyclohexane (150°C, 10 bar) ruptured.
- 40 Tonnes Cyclohexane leaked – 100 to 200 m Vapor Cloud.
Incident No. 1

Flixborough, UK

- 1,800 buildings within 1 mile radius damaged
- Fires in area lasted for 10 days
- Explosion equivalent to 15 Tonnes TNT
- All 18 people in control room killed
- 500+ would have been killed during a weekday
Incident No. 1

Flixborough, UK
Incident No. 1
Incident No. 2

Toulouse, France

- AZF – Fertilizer Manufacturing and Warehouse
- September 25, 2001 – Originally thought to be terrorism
- 300 Tonnes of Ammonium Nitrate Exploded
  - Mislabeled Chemical, Hot & Humid Conditions in Warehouse
- Crater – 100 ft deep, 650 ft diameter
- Steel structure found 3 km away
- Blast measured 3.4 on Richter scale, heard 80 km away
Incident No. 2

Toulouse, France

- Plant Built in 1924 – Rural Area
- 2005 Population – Over 400,000
- Residential area – 1 km away
- Schools, University and hospitals evacuated
- 29 deaths (28 plant, 1 nearby school)
- 2,500 serious injuries; 8,000 minor injuries
- City advised people to stay indoors and close windows
- Two-Thirds city’s windows shattered
- 40,000 people homeless
Incident No. 2
Incident No. 3

Buncefield Tank Farm

- Tank Farm in Hertfordshire, England
- Incident Occurred on December 11, 2005
- Overflow of Filling Gasoline Storage Tank and Resulting Explosion
- Flammable Cloud – 400m Across
- Explosion 2.4 on the Richter Scale
- 23 Storage Tanks on Fire
- 43 Injured, 0 Fatalities
- Fire Burned for Several Days
Incident No. 3
Incident No. 3

View From London
Incident No. 3
Incident No. 3
Incident No. 3
Incident No. 3
Incident No. 4
Chemie-Pack, Moerdijk, The Netherlands

- Chemical Packing Plant – 50 Employees
- Incident Occurred on January 5, 2011
- No Immediate Injuries
- 400,000 L Carcinogenic Chemicals in Storage
- Flames 40m (130 ft) high
- Fumes and Smoke reached 3.2km away
- Company fined in 2006 for fire and safety violations
Incident No. 4
Chemie-Pack, Moerdijk, The Netherlands

• Shipping on Hollands Diep River was halted for the area
• A16 and A17 Roads Closed
• Train Traffic Stopped
• Fire spread to the nearby Wärtsilä engine factory
• Government stopped sale of vegetables from nearby farms
• Children to stay indoors while environmental impact was assessed
Incident No. 4
Incident No. 4
Incident No. 4
Incident No. 4
Incident No. 5

Port Wentworth, Georgia

- February 7, 2008
- Imperial Sugar Plant Explosion
- 112 people at the plant - 14 Killed, 42 Injured
- CSB Investigation
  - Poor Equipment Design, Maintenance and Housekeeping
  - Sugar Conveyor was inadequately designed with dust buildup
  - No evacuation drills, Emergency Lighting disabled
Incident No. 5
Incident No. 5
Incident No. 5
Normal Operations

Evaluate

1. Air Emissions
2. Adjacent Waterways
3. Flood Plains
4. Noise Pollution
5. Light Pollution
6. Effects on Traffic
7. Maintenance
8. Infrastructure – Utility Needs
9. Site Security
Normal Operations

1920’s-1930’s Industry
Normal Operations
Normal Operations

Traffic Effects from Facility
Internal Siting

Location of Facilities within Plant

- Isolate Critical Buildings and Utilities from Hazards
- Redundancy on Utilities and Controls
- Proper Design of Utilities, Buildings and Structures for Overpressures and Fires
- Proper Level of Emergency Services
Internal Siting

Location of Facilities within Plant

- Control Buildings
- Firefighting Equipment
- Power Generation
- Water Utilities
- Shelter In Place
Internal Siting

How will Incident in a Plant Affect:

- Short Term Operations
- Long Term Operations
- Occupied Areas
- Emergency Services
- Ability to Evacuate the Site
- Escalation of Incident
Internal Siting

Location of Facilities within Plant

- Heat Flux Consequences

<table>
<thead>
<tr>
<th>Thermal flux (kW/m²)</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 1.5</td>
<td>Sunburn</td>
</tr>
<tr>
<td>5 – 6</td>
<td>Personnel injured (burns) if they are wearing normal clothing and do not escape quickly</td>
</tr>
<tr>
<td>8 – 12</td>
<td>Fire escalation if long exposure and no protection</td>
</tr>
<tr>
<td>32 – 37.5</td>
<td>Fire escalation if no protection (consider flame impingement)</td>
</tr>
<tr>
<td>Up to 350</td>
<td>In flame. Steel structures can fail within several minutes if unprotected or not cooled</td>
</tr>
</tbody>
</table>

Source: IP-19, Table 2.1
### Internal Siting

**Location of Facilities within Plant**

- **Overpressure Consequences**

<table>
<thead>
<tr>
<th>Static overpressure (barg)</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>10% window breakage</td>
</tr>
<tr>
<td>0.03</td>
<td>Injuries from flying glass. 50% window breakage</td>
</tr>
<tr>
<td>0.15</td>
<td>Partial collapse of brickwork, roofs lifted. 100% window breakage</td>
</tr>
<tr>
<td>0.3</td>
<td>Destruction of steel-framed buildings, ear-drum rupture. Severe roof damage, people killed by falling masonry</td>
</tr>
<tr>
<td>0.5</td>
<td>People in the open picked-up and thrown. Severe masonry damage, rail tank wagons overturned, trees snapped in half</td>
</tr>
<tr>
<td>0.7</td>
<td>Severe structural damage to heavy steel and reinforced concrete buildings. Rail tank wagons ruptured and reactors overturned</td>
</tr>
</tbody>
</table>

Source: IP-19, Table 2.2
Planning Process

Site Location and Layout

• Perform Risk Assessments on:
  – Process
  – Operations
  – Equipment
  – Site Layout
  – Emergency Operations
Planning Process

Steps to Risk Assessment

1. Identify the Hazards
2. Identify Who Might be Harmed and How
3. Evaluate the Risks and Methods of Mitigation
4. Record the Findings and Implementation
5. Review the Assessment and Update as Required
Planning Process

Types of Risk
1. Fire and Explosion
2. Materials and Equipment
   - Hazardous Materials, Maintenance, Proper Selection
3. Personnel and Practices
4. Environment
5. Business Interruption
6. Company Reputation
Planning Process

Risk Control
1. Eliminate the Hazard
   – Use Less Hazardous Chemicals or Process
2. Loss Prevention
   – Prevent Accidents From Occurring
3. Loss Reduction
   – Building Construction, Firefighting Systems
4. Segregation of Exposures
   – Location of Critical Buildings and Processes
5. Transfer of Risk
   – Contract Manufacturing for Materials
Planning Process

Determine Level of Acceptable Risk

• Based on Probability and Consequences of an Incident
• Industry Standards
• Corporate Standard
• Insurance Requirements
# Risk Matrix

## Incident Listing

<table>
<thead>
<tr>
<th>Incident</th>
<th>Consequence</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small incidents</td>
<td>Slight injury</td>
<td>Has occurred in-house</td>
</tr>
<tr>
<td>Pump seal</td>
<td>Slight effect</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Compressor incident</td>
<td>Minor injury</td>
<td>Happens several times per year at location</td>
</tr>
<tr>
<td>Turbine enclosure</td>
<td>Minor injury</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Vessel incident</td>
<td>Major injury</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Cone roof tank</td>
<td>Major injury</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Floating roof tank</td>
<td>Major injury</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Aircraft incident</td>
<td>Major injury</td>
<td>Happens several times per year</td>
</tr>
<tr>
<td>Buildings incident</td>
<td>Major injury</td>
<td>Happens several times per year</td>
</tr>
</tbody>
</table>

## Key

- **Incident number**
- **Strategy 1**: Minor incident intervention only
- **Strategy 2**: Dedicated fixed fire protection systems
- **Strategy 3**: Systems/equipment plus back-up
- **Strategy 4**: Systems/equipment plus fire brigade

Source: IP-19, Figure 3.2
Heat Radiation Contours

This fire map is provided for guidance only and should not be regarded as a definitive map of any fire that may occur. Radiation contours as at top of tank.

- 6 kW/m² Contour
- 12 kW/m² Contour
- Flame drag contour
- Tank full surface fire area

Source: IP-19, Figure G.1
Overpressure Contours
Wind Rose Plot
Planning Process

Determine Methods to Reduce Risk

- Change Process
- Safety Interlocks and Controls
- Automate Process
- Pressure Relief and Explosion Prevention Systems
- Fire Protection Systems
- Preventative Maintenance
- Training and Drills
- Management of Change
Reference Standards

- **API 752**: Management of Hazards Associated with Location of Process Plant Permanent Buildings
- **API 753**: Management of Hazards Associated with Location of Process Plant Portable Buildings
- **IP-19**: Fire Precautions at Petroleum Refineries and Bulk Storage Installations (UK)
- **FM LPDS 7-42**: Guidelines for Evaluating the Effect of Vapor Cloud Explosions Using a TNT Equivalency Method
- **FM LPDS 7-44**: Spacing of Facilities in Outdoor Chemical Processing Plants
- **Seveso II Directive**
- **COMAH** – Control of Major Accident Hazard Regulations (UK)
Open Discussion

Questions??

• Call Bob Moser (day or night) at 1.610.888.6920