Evaluation and Compliance with Facility Siting Regulations in the US
API RP 752 / 753 / 756
Overview

- Safety Moment
- Introduction to Facility Siting
- American Petroleum Institute Recommended Practices 752, 753 and 756 Overview
- Facility Siting Remedial Actions
- Questions
Safety Moment

- Window Hazards in Facility Siting
Safety Moment

- Window Hazards in Facility Siting
Introduction to Facility Siting
What is Facility Siting?

- Facility Siting refers to the evaluation of risk to people in buildings
  - The intent is that the building itself or its location doesn’t put people at greater risk than necessary
    - Building construction is significant in its ability to withstand an explosion
    - Building location is significant in the ability to safely evacuate during a fire or toxic release
  - OSHA PSM regulations address employees onsite
  - EPA RMP regulations address the public
Why Is Facility Siting an Issue?

Significant Vapor Cloud Explosions (VCEs) that led to Regulations

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Deaths</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>Flixborough, England</td>
<td>28</td>
<td>?</td>
</tr>
<tr>
<td>1987</td>
<td>Pampa, TX</td>
<td>3</td>
<td>30+</td>
</tr>
<tr>
<td>1988</td>
<td>Norco, LA</td>
<td>5</td>
<td>23</td>
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<tr>
<td>1989</td>
<td>Pasadena, TX</td>
<td>24</td>
<td>132</td>
</tr>
<tr>
<td>2005</td>
<td>Texas City, TX</td>
<td>15</td>
<td>170+</td>
</tr>
</tbody>
</table>

Significant for Europe

Several U.S. events in a short period
1974: Flixborough, UK - Cyclohexane VCE Explosion

28 deaths
The blast damaged 1,821 homes and 167 commercial buildings
2005: Texas City, Texas - BP Refinery Isomerization VCE

- Blow Down Stack
- Location of Trailers

15 deaths
170+ injuries
Other Types of Explosions and Hazards

- Other Explosions
  - Dust Explosion
  - Ammonium Nitrate (fertilizer) Explosion
  - Chemical Runaway Reaction
  - BLEVE (Boiling Liquid Expanding Vapor Explosion)
  - Pressure Vessel Burst

- Other Hazards
  - Jet Fires
  - Pool Fires
  - Toxic Vapor Clouds
1984: Bhopal, India - Union Carbide Toxic Gas Release

The 1984 Bhopal gas disaster

- Up to 10,000 deaths in first three days
- Additional 25,000 people died of related injuries by 1994

December 3, 1984
A cloud of methyl isocyanate gas leaks from the Union Carbide pesticide plant

Source: AFP/EPA/Al/ICMR

031209 AFP
2008: Savannah, Georgia - Sugar Mill Dust Explosion

14 deaths
38 injuries
2013: West, TX - Fertilizer Plant Explosion

15 deaths
160+ injuries
150 buildings damaged or destroyed
U.S. Regulations

- Occupational Safety and Health Administration (OSHA)
    - No real guidance on what “Facility Siting” means.
    - A review of OSHA inspection reports reveals they expect to see an evaluation of consequences or risk for every building at a site.

- Environmental Protection Agency (EPA)
  - Risk Management Program (RMP) lists “stationary source siting” as one of the elements in a PHA.
    - Some guidance provided, but very limited.
Without any regulatory guidance, the American Petroleum Institute (API) generated its own Recommended Practices (RPs):

- API RP 752: Permanent Building Siting
- API RP 753: Portable Building Siting
- API RP 756: Tent Siting

OSHA will issue citations and fines to companies not complying with these even though they are only “Recommended Practices”. Without any other guidance, they are typical industry practice.
API RP 752, 753 and 756 Overview
Occupied Buildings for Analysis

- Only buildings intended for occupancy are evaluated
  - If one person is assigned to a building, the building shall be evaluated regardless of how long he/she spends in the building.
    - Exception is enclosed process buildings where only essential personnel operating the process are located
      - Control Room in the process building would be occupied
    - Intermittently occupied buildings may be excluded (definition of intermittent is up to owner/operator).
      - There are no published definitions for intermittent occupancy so each company has to define. Just be ready to defend the definition selected.
      - Our recommendation would be < 20-40 man-hours/week and no < 25% of any one person's time is in the building.
Every building shall be designated either for evacuation or for use as an Emergency Shelter in a fire or toxic emergency and evaluated for such:

- Evacuation is not an option for explosion hazards
- This decision may change what is acceptable explosion damage and fire/toxic exposure in the study

Analysis shall be performed for both existing buildings and new construction.

All occupied buildings onsite shall be included.
Allowed Facility Siting Approaches

- TNT Equivalency is not allowed for VCE predictions
- All explosions predictions must calculate pressure and impulse

1. Spacing Tables
   - Tables of distances, allowed only for fire hazards

2. Consequence-Based Study
   - Maximum Credible Events (MCEs) postulated and evaluated

3. Risk-Based Studies:
   - Rigorous risk calculation to include numerical frequencies and consequences, typically called a Quantitative Risk Assessment (QRA)
Blast Wave Characteristics

- Positive Specific Impulse, $i_s$
- Negative Specific Impulse, $i_{s^-}$
- Pressure $P_{so}$
- Ambient Pressure $P_0$
- $P_{so^-}$
- Time After Explosion $t_A$
- $t_{o \rightarrow}$
- $t_{A \rightarrow t_0}$
- Duration $t_0$
- Duration $t_{o^-}$
- POSITIVE PHASE
- NEGATIVE PHASE

Diagram shows the pressure profile over time with positive and negative phases.
Pressure-Impulse Diagrams

- Lines of constant damage representing an infinite combination of pressure and impulse pairs that produce the same damage.

10 psi and 10 psi-ms produces the same damage as 0.6 psi and 30 psi-ms.
Each company must define its own level of tolerable risk. Most companies in the U.S. follow these criteria:

- Consequence-based studies for fire/toxic evacuation
  - Low fire/toxic exposures for evacuation
  - One exit outside the flammable cloud for evacuation
  - Explosion damage that does not produce structural failures
  - Prevent other injuries from non-structural component damage (windows, doors, debris)

- Risk-based studies
  - $1 \times 10^{-5}$ to $1 \times 10^{-4}$ fatalities/year for individual risk
  - FN curve for aggregate risk

- Emergency Shelters may have more stringent criteria.

Sample FN Criteria: [Graph showing FN criteria with Intolerable Risk Region, ALARP Region, and Tolerable Risk Region.]
Acceptable Trailer Damage Criteria

- 0.6 psi, no structural failures
  only window failures

- 0.9 psi, structural failures
  for walls facing explosion

Be consistent with the damage level used for permanent buildings.
I do not know of any company using 0.9 psi as acceptable damage.
Facility Siting
Remedial Actions
Remediation Plan

- A remediation plan is required
  - All buildings exceeding criteria shall be listed on a remediation plan
    - It is acceptable for the plan to include more detailed study of the hazards
  - Remediation plan shall have a schedule for implementation
  - Remediation plan shall be monitored and updated periodically
Typical Remedial Actions

- **Flammable Cloud Hazards**
  - Evaluate building as an Emergency Shelter

- **Explosion Hazards**
  - Relocate people to other acceptable buildings
  - Retrofit existing building to increase explosion resistance
  - Build new building

- **Fire Hazards**
  - Drainage and topography improvements (pool fires)
  - Shield walls at source or along evacuation route
  - Water spray along evacuation route
  - Evaluate building as an Emergency Shelter

- **Toxic Hazards**
  - Respirators
  - Evaluate building as an Emergency Shelter
Explosions could produce a toxic release or fire
  − An Emergency Shelter should consider explosions before the fire or toxic release

Below is an example of a building that might be fine for evacuation but not for shelter during a toxic release.

0.9 psi blast load damage
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Questions?

Victor Martinez Toriz
ABS Group Colombia
Av. El Dorado Calle 26 No. 68C-61
Oficina 224 – Edificio Torre Central
Office: +57 1 755-2134