Dow Fire and Explosion Index (FEI)

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Presented to ES317Y in 2001 at UWO
Introduction

- V1.0 was first issued in 1964 by Bill Braise (RIP).
- V7.0 was last issued in 1994 and is now marketed by the AIChE ($50/copy).
- FEI is widely used outside of Dow.
- FEI is the leading hazard index methodology recognized by the chemical industry.
What is the Dow FEI?

The Dow FEI is a ranking system that gives a relative index to the risk of individual process units due to potential fires and explosions.
What is the Primary Purpose of the Dow FEI?

- It serves as a guide for the selection of fire and explosion protection methods.
- It assists in determining the spacing between adjacent process units within the ISBL.
- It is a guide for insurance agencies to set insurance rates.
- It ranks individual process units where special safety attention can be focused.
When should one perform an FEI?

- Late in Phase III Engineering after:
  - P&IDs have been completed,
  - Equipment has been sized,
  - A trial equipment layout has been done,
  - A DFC estimate has been completed.
Who Usually Performs the FEI?

- Generally a senior process engineer, who is acquainted with the details of the project, is assigned the task.
- Occasionally, different groups tackle the assignment and results are compared for consensus building.
What Does the FEI Consider?

- Six general process hazards.
- Twelve special process hazards.
- Nine process control credit factors.
- Four material isolation credit factors.
- Nine fire protection credit factors.
General Process Hazards

- Exothermic reactions.
- Endothermic processes.
- Material handling and transfer
- Enclosed or indoor process units.
- Access.
- Drainage and spill control.
Special Process Hazards

- Toxic materials.
- Sub-atmospheric pressure (<500 mmHg).
- Operating in or near flammable range.
  - Tank farm storage flammable liquids.
  - Process upset or purge failure.
  - Always in flammable range.
- Dust explosion.
- Pressure.
Special Hazards Cont’d

- Low temperature.
- Quantity of flammable/unstable material.
  - Liquids or gases in process.
  - Liquids or gases in storage.
  - Combustible solids in storage.
- Corrosion and erosion.
Special Hazards Cont’d

- Leakage – joints and packing.
- Use of fired equipment.
- Hot oil heat exchanger system.
- Rotating equipment.
Process Control Credit Factors

- Emergency power.
- Cooling.
- Explosion control.
- Emergency shutdown.
- Computer control.
Process Control Factors Cont’d

- Inert gas.
- Operating instruction procedures.
- Reactive chemical review.
- Process hazard analysis.
Material isolation Credit Factors

- Remote control valves.
- Dump or blow down control.
- Drainage.
- Interlocks.
Fire Protection Credit Factors

- Leak detection.
- Structural steel.
- Fire water supply.
- Special systems.
- Sprinkler systems.
- Water curtains.
- Foam.
- Hand extinguishers.
- Cable protection.
### FEI Example

**DOW FIRE AND EXPLOSION INDEX**

<table>
<thead>
<tr>
<th>Area /Country</th>
<th>Division:</th>
<th>WC</th>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Mnfg Unit:</td>
<td>LHC#1</td>
<td>Process Unit</td>
<td>C2 Splitter</td>
</tr>
<tr>
<td>Prepared By</td>
<td>Appr'd By</td>
<td>Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed By Mgt</td>
<td>Review By:</td>
<td>TC</td>
<td>Review By:</td>
<td>S&amp;LP</td>
</tr>
<tr>
<td>Materials In Process</td>
<td>Ethylene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Of Operation</td>
<td>Design</td>
<td>Startup</td>
<td>Norm Opn</td>
<td>Shutdown</td>
</tr>
<tr>
<td>Basic Materials For Material Factor</td>
<td>Ethylene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material Factor</strong> (See Table 1 or Appendix A or B) Note temperature requirements when unit temperatures over 140 °F =</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# General Process Hazards

<table>
<thead>
<tr>
<th>Base Factor</th>
<th>Penalty Factor Range</th>
<th>Penalty Factor Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-16 A</td>
<td>0.3 - 1.25</td>
<td>0.00</td>
</tr>
<tr>
<td>p-17 B</td>
<td>0.2 - 0.4</td>
<td>0.00</td>
</tr>
<tr>
<td>p-17 C</td>
<td>0.25 - 1.05</td>
<td>0.00</td>
</tr>
<tr>
<td>p-17 D</td>
<td>0.25 - 0.9</td>
<td>0.00</td>
</tr>
<tr>
<td>p-18 E</td>
<td>0.2 - 0.35</td>
<td>0.00</td>
</tr>
<tr>
<td>p-18 F</td>
<td>0.25 - 0.5</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**General Process Hazards Factor (F1) =**

1.50
## Special Process Hazards

### Base Factor =

<table>
<thead>
<tr>
<th>Base Factor</th>
<th>1.00</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-20 A Toxic Material(s), Use (0.2)(Nh)</td>
<td>Nh = 1.00</td>
<td>Note</td>
</tr>
<tr>
<td>p-20 B Sub-Atmospheric Pressure (&lt; 500 mm Hg)</td>
<td>Possible vacuum?</td>
<td>No</td>
</tr>
<tr>
<td>p-21 C Operation Near In or Near Flammable Range</td>
<td>Padding?</td>
<td>None</td>
</tr>
<tr>
<td>p-21 D Dust Explosion (See Table 3) Type =</td>
<td>None</td>
<td>Micron Sz = 0</td>
</tr>
<tr>
<td>p-21 E Pressure (See Fig. 2) Operating Psig =</td>
<td>58.4</td>
<td>Relief Set psig = 125</td>
</tr>
<tr>
<td>p-21 F Lowest Temperature =</td>
<td>-155 °F</td>
<td>Material Suitable? = Yes</td>
</tr>
<tr>
<td>p-21 G Quantity of Flammables /Unstable Material lb =</td>
<td>217,000</td>
<td>Heat Comb BTU/lb = 20,800</td>
</tr>
<tr>
<td>p-21 H Corrosion and Erosion Rates =</td>
<td>0.00</td>
<td>mil / Yr.</td>
</tr>
<tr>
<td>p-21 I Leakage - Joints and Packing Type =</td>
<td>Minor</td>
<td>Penalty = 0.00</td>
</tr>
<tr>
<td>p-21 J Use of Fired Equipment (See Fig. 6) Dist =</td>
<td>600 ft</td>
<td>Penalty Curve A-2</td>
</tr>
<tr>
<td>p-21 K Hot Oil Heat Exchange System (See Table 5) Volume =</td>
<td>0.00</td>
<td>Penalty 0.15 - 1.15</td>
</tr>
<tr>
<td>p-21 L Rotating Equipment Type =</td>
<td>Comp</td>
<td>Penalty 0.50</td>
</tr>
</tbody>
</table>

**Special Process Hazards Factor (F2)**

4.32

**Process Unit Hazards Factor (F1 x F2) = F3 =**

6.47

**Fire and Explosion Index (F3 x MF = FEI) =**

155.36

**Fire and Explosion Class (See Table 6) =**

**FEI Range =** 128 - 158 **Heavy**
Fig 8: Damage Factor

Figure 8 - Damage Factor

Material Factor (MF)

Damage Factor

- F3 = 1
- F3 = 2
- F3 = 3
- F3 = 4
- F3 = 5
- F3 = 6
- F3 = 7
- F3 = 8
- Case Pt.
## Process Control Credit Factors

1. **Process Control** (C1)
   - a) Emergency Power 0.98
   - b) Cooling 0.97 - 0.99
   - c) Explosion Control 0.84 - 0.98
   - d) Emergency Shutdown 0.96 - 0.99
   - e) Computer Control 0.93 - 0.99
   - f) Inert Gas 0.94 - 0.96
   - g) Operating Instruction/Proc 0.91 - 0.99
   - h) Reactive Chemical Review 0.91 - 0.98

\[
C1 = 0.75
\]
Material Isolation Factors

2. Material Isolation (C2)
   a) Remote Control Valves   .96 - .98   .96
   b) Dump / Blowdown        .96 - .98   .96
   c) Drainage              .91 - .97   .95
   d) Interlock            0.98

\[ C2 = 0.88 \]
### 3. Fire Protection (C3)

<table>
<thead>
<tr>
<th>Category</th>
<th>Factor Range</th>
<th>C3 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Leak Detection</td>
<td>.94 - .98</td>
<td>.98</td>
</tr>
<tr>
<td>b) Structural Steel</td>
<td>.95 - .98</td>
<td>.97</td>
</tr>
<tr>
<td>c) Buried Tanks</td>
<td>.84 - .91</td>
<td></td>
</tr>
<tr>
<td>d) Water Supply</td>
<td>.94 - .97</td>
<td>.94</td>
</tr>
<tr>
<td>e) Special Systems</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>f) Sprinkler Systems</td>
<td>.74 - .97</td>
<td>.97</td>
</tr>
<tr>
<td>g) Water Curtains</td>
<td>.97 - .98</td>
<td></td>
</tr>
<tr>
<td>h) Foam</td>
<td>.92 - .97</td>
<td></td>
</tr>
<tr>
<td>i) Hand Extngshrs / Mntrs</td>
<td>.95 - .98</td>
<td>.97</td>
</tr>
<tr>
<td>j) Cable Protection</td>
<td>.94 - .98</td>
<td>.94</td>
</tr>
</tbody>
</table>

C3 = \( \text{.79} \)
Credit Factor Summary

- Process Control, $C_1 = 0.75$
- Material isolation, $C_2 = 0.88$
- Fire Protection, $C_3 = 0.79$
- $C_1 \times C_2 \times C_3 = (0.75)(0.88)(0.79) = 0.52$
# Process Unit Risk Analysis Summary

## UNIT ANALYSIS SUMMARY

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit Factor = ( C_1 \times C_2 \times C_3 ) =</td>
<td>0.52</td>
</tr>
<tr>
<td>A-1. F &amp; E I</td>
<td>152.05</td>
</tr>
<tr>
<td>A-2. Radius of Exposure</td>
<td>127.7 ft</td>
</tr>
<tr>
<td>A-3. Value of Area of Exposure</td>
<td>19.16 $\text{MM}$</td>
</tr>
<tr>
<td>B. Damage Factor (Fig 8)</td>
<td>0.85</td>
</tr>
<tr>
<td>C. Base MPPD (A-3 \times B)</td>
<td>16.19 $\text{MM}$</td>
</tr>
<tr>
<td>D. Credit Factor</td>
<td>0.52</td>
</tr>
<tr>
<td>E. Actual MPPD (C \times D)</td>
<td>8.46 $\text{MM}$</td>
</tr>
<tr>
<td>F. Days Outage (MPDO)</td>
<td>74</td>
</tr>
<tr>
<td>G. Bus. Interruptn Loss (BI)</td>
<td>$\text{MM}$</td>
</tr>
</tbody>
</table>

- Radius of Exposure = 0.84 \* FEI
- Fr Special Fig 8 Interp’n Routine
- Days Outage = \( \text{EXP}(3.0489 + 0.58925 \times \text{LN}(H30)) \)
Features Not Used In V7.0

Dow Separation Distance vs FE Index - 4th Edition (1979)

Separation Distance, Ft. vs F&E Index

- VCM
- EO
- Best Fit
Limitations of Dow FEI

- No scientific basis for many of the features can be found in Dow records. Fig 8 is an example. (RAH study – 1993).
- Does not correlate well with known plant disasters (Flixborough, Phillips, Norco).
- While explosion damage is fairly advanced (Flixborough – 1974), fire damage alone is more difficult to predict.
- Not scenario driven as in recent QRA work in Holland and the U.K.
Recent Trends

- Insurance companies are looking at Maximum Foreseeable Loss, (MFL), based on Baker’s- 1994 blast technology for Detonations and Deflagrations as applied to plant equipment layout.
- There is a trend toward higher insurance premiums as insurance companies adjust their actuarial data.
- Many chemical companies may follow Exxon’s trend to insure themselves.