REACTIVE HAZARDS ASSESSMENT (RHA) PRACTICES
An Industry Benchmarking Survey

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- Scott Tipler - The Dow Chemical Company
- Ron Chittim - American Petroleum Institute
- Lara Swett - American Fuel & Petrochemical Manufacturers
Reactive Hazards Assessment Practices - Background

- Benchmarking study to understand details of Reactive Hazard Assessment (RHA) practices followed in industry
- Survey prepared by a steering team consisting of members from industry, API, and AFPM
- Survey conducted by AFPM
- Results compiled by the steering team
- Recommend to review the responses in order to identify opportunities for your organization
24 Respondents

- 17 chemical companies and 7 oil companies
- 15 companies have >1000 employees

Company site distribution

- 10 companies have >15 sites,
- 7 have 6-15 sites,
- 3 have 2-5 sites,
- 4 have 1 site
Reactive Hazards Assessment Practices - Summary

- Most companies have a formal RHA process that is included in their PHA
- Most companies include laboratories and pilot plant testing in their RHA methodology
- Hazards are considered for entire operation including storage areas, waste tanks, & utilities
- Many companies use the results of screening tests to determine the need for further testing
- Most companies use a mix of testing and modeling to understand the reactive hazards
  - The sequence of testing and the criteria for modeling varies
Reactive Hazards Assessment Practices - Summary, cont.

- Companies are conscious of subtle changes in the chemistry as they change sources of chemicals or catalysts.
- Most companies conduct screening or testing for incompatibility, many utilize NOAA CRW.
- Risk mitigation measures are in place to address risk of reactive hazards:
  - Instrumented interlocks and emergency relief are the most common mitigations.
  - Insulation and deluge systems are widely used to mitigate external fire scenario.
  - Checklists/procedures, dedicated equipment, and certificate or analysis & positive identification are commonly used to mitigate contamination.
  - Depressurizing is used for “hot spot” scenarios.
White paper is posted on the DIERS website

Recommended to review to identify opportunities for your organization - Especially the detailed comments
Reactive Hazards Assessment Practices - Profile and Program

- **RHA Program**
  - 18 have formal RHA program
  - 22 include RHA in PHA

- **RHA Trigger Criteria**
  - 3 for new batch
  - 7 for new lot
  - 12 for new supplier
  - 18 include pilot plant and/or laboratories

- **Potential for Missed Reactivity**
  - 7 use intensive testing
  - 5 use incident history
  - 4 use MSDS
Reactive Hazards Assessment Practices - Testing

- **Modeling**
  - 7 only use testing
  - 13 use both testing and modeling - modeling may be limited to relief design
  - Various commercial and home-grown software
  - 18 use transient simulations
    - None appear to simulate hotspots

- **Testing Hierarchy**
  - Screening followed by adiabatic testing
Testing Regime/Extent Decision

<table>
<thead>
<tr>
<th>Expert Decision</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>Experts Decide</td>
<td>3</td>
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<tr>
<td>PHA</td>
<td>2</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Scale &amp;/or energy</td>
<td>7</td>
</tr>
<tr>
<td>Protocol/Standard list of test</td>
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<tr>
<td>Screening to adiabatic</td>
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</tr>
<tr>
<td>Duration of storage</td>
<td>1</td>
</tr>
<tr>
<td>Gas generation</td>
<td>1</td>
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<tr>
<td>ΔH and ΔG calculations</td>
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Reactive Hazards Assessment Practices - Testing, cont.

Available Test Methods

<table>
<thead>
<tr>
<th>Test Method</th>
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<tbody>
<tr>
<td>DSC</td>
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<tr>
<td>Isothermal DSC</td>
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<tr>
<td>DTA</td>
<td>2</td>
</tr>
<tr>
<td>Isothermal DTA</td>
<td>2</td>
</tr>
<tr>
<td>Scanning - Other</td>
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</tr>
<tr>
<td>Micro-calorimetry</td>
<td>2</td>
</tr>
<tr>
<td>Adiabatic - High PHI</td>
<td>10</td>
</tr>
<tr>
<td>Adiabatic - Low PHI</td>
<td>12</td>
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<tr>
<td>Pilot Plant</td>
<td>2</td>
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<tr>
<td>Heat flow calorimetry</td>
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<tr>
<td>Dust</td>
<td>2</td>
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<tr>
<td>Minimum Ignition Energy</td>
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<tr>
<td>Flammable range</td>
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</tr>
<tr>
<td>Scaled Venting</td>
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<tr>
<td>UN-10 liter</td>
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</tr>
<tr>
<td>TGA</td>
<td>2</td>
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<tr>
<td>Shock Sensitivity</td>
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</tr>
<tr>
<td>Auto Ignition Temperature</td>
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</table>
Procedure for Peer Review

- Typically one or two level review

Training for Data Interpretation

- 3 - no program
- 4 - on the job training
- 2 - external training
Reactive Hazards Assessment Practices - Testing, cont.

- **Energy or Rate Based Criteria**
  - 100, 200 and 300 J/g by 4
  - Yes by 3
  - No by 4

- **Temperature Range**
  - Fixed upper limit - 300, 400, 450, 500 °C
  - Operating +50 or 100 °C
    - Archival
  - 17 mentioned various forms of archiving
    - Mostly electronic or share point
Reactive Hazards Assessment Practices - Incompatibility

- Testing for Incompatibility
  - 17 complete literature search
  - 17 consult with chemists

- 12 use NOAA CRW

- Additional Material for Incompatibility
  - Some consider “non-process” chemicals

<table>
<thead>
<tr>
<th>Material</th>
<th>Count</th>
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<tbody>
<tr>
<td>Materials of Construction</td>
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<tr>
<td>Gasket Materials</td>
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<tr>
<td>Lubricants</td>
<td>5</td>
</tr>
<tr>
<td>Air and Nitrogen Atmospheres</td>
<td>6</td>
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<tr>
<td>Water</td>
<td>7</td>
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<tr>
<td>Utilities</td>
<td>7</td>
</tr>
<tr>
<td>Absorbents</td>
<td>5</td>
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</tbody>
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Reactive Hazards Assessment Practices - Incompatibility

➢ Temperature Range for Incompatibility
  ▪ Question may have been misunderstood
    ▪ Same answers as temperature range for testing

➢ Screening for Atomic Grouping
  ▪ 13 Yes, 4 No

➢ Most (13) Incompatibility Charts are for Units, 3 for Site
Reactive Hazards Assessment Practices - Incompatibility, cont.

- **Types of Test for Incompatibility**
  - Screening or mixing

- **Number of Tests for 10 x 10 matrix**
  - 5, 5, 25

- **Number of Tests for Kinetics**
  - 7 responses
    - 1 for simple, 3-5 for complex
    - Most use the “worst” test data
Pooling of Reactants

- Relief
- SIS
- Monitor agitation
- Interlock for low temperature
- Inherent safety
- Some appear to have answered for “Pool Fire”
  - Deluge
  - Evacuation
  - Drainage
Heat Imbalance

- Relief
- SIS
- BPCS
- Robust temperature monitoring
- Flow limiting, including restrictive orifices
- Trips, Alarms
Fire

- Deluge
- Evacuation
- Drainage
- Fire brigade
- Relief
- Insulation
- Few appear to have answered for internal fire (deflagration)
  - Nitrogen blanketing
  - Oxygen monitoring
  - Relief
Mechanical Overheating
- Relief
- SIS
- Motor surface temperature
- Interlocks
- Trips - high temperature or high pressure

Contamination
- Unloading checklists and procedures
- Dedicated unloading equipment
- Certificate of Analysis, Positive identification
- Relief
Hot Spots in Catalyst Bed

- Question may have been misunderstood
  - Many answers were similar to mechanical overheating
  - Depressurization
  - Multiple thermocouple and SIS
  - Increase cooling, remove heat sources, stop hydrocarbon feed