REACTIVE HAZARDS ASSESSMENT (RHA) PRACTICES

An Industry Benchmarking Survey

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- Clark Shepard – ExxonMobil Research and Engineering
- 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

Reactive Hazards Assessment Practices – Respondents

- 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

Reactive Hazards Assessment Practices – Summary, cont.

- White paper is posted on the DIERS website

http://www.iomosaic.com/diersweb/communications.aspx

- Recommend to review to identify opportunities for your organization – Especially the detailed comments

Supporting Slides

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

Reactive Hazards Assessment Practices – Testing, cont.

- Testing Regime/Extent Decision

Experts Decide	3
PHA	2
Literature	1
scale &/or energy	7
Protocol/Standard list of test	3
Screening to adiabatic	5
Duration of storage	1
Gas generation	1
ΔH and ΔG calculations	1

Reactive Hazards Assessment Practices – Testing , cont.

- Available Test Methods

DSC	9
Isothermal DSC	1
DTA	2
Isothermal DTA	2
Scanning - Other	9
Micro-calorimetry	2
Adiabatic - High PHI	10
Adiabatic - Low PHI	12
Pilot Plant	2
Heat flow calorimetry	11
Dust	2
Minimum Ignition Energy	2
Flammable range	4
Scaled Venting	1
UN-10 liter	1
TGA	2
Shock Sensitivity	3
Auto Ignition Temperature	1

Reactive Hazards Assessment Practices – Testing , cont.

- 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

Materials of Construction	6
Gasket Materials	5
Lubricants	5
Air and Nitrogen Atmospheres	6
Water	7
Utilities	7
Absorbents	5

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

Reactive Hazards Assessment Practices – Risk Mitigation

- Pooling of Reactants
  - Relief
  - SIS
  - Monitor agitation
  - Interlock for low temperature
  - Inherent safety
  - Some appear to have answered for "Pool Fire"
    - Deluge
    - Evacuation
    - Drainage

Reactive Hazards Assessment Practices – Risk Mitigation, cont.

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

Reactive Hazards Assessment Practices – Risk Mitigation, cont.

- Fire
  - Deluge
  - Evacuation
  - Drainage
  - Fire brigade
  - Relief
  - Insulation
  - Few appear to have answered for internal fire (deflagration)
    - Nitrogen blanketing
    - Oxygen monitoring
    - Relief

Reactive Hazards Assessment Practices – Risk Mitigation, cont.

- 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

Reactive Hazards Assessment Practices – Risk mitigation

- 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