Building Blast Integrity (BBI) Assessment Suggested Process
Acknowledgements

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  – Corporate Explosion Specialist

• Mr. Jim Waque
  – Project Manager
Clarification

This information reflects current status of a process that is still under development
Purpose of Presentation

• Provide example of a suggested process
• Explain past experience required use of Computational Fluid Dynamics to rationalize anomalies that could not be explained using simpler methods
• Discussion
Purpose of This BBI Assessment Process

• To analyze explosions at petrochemical/plastics manufacturing facilities
• To understand effects of these explosions on occupied buildings
• To identify protection options, where required
• To explain possible additional analyses to help make final decisions.
Get the Right People Involved to Manage the Issue & Do the Analyses

• Lack of training/ experience leads to:
  – misunderstandings/ misconceptions about specific conditions required for explosions to occur
  – not being aware of all inputs required to properly analyze/ assess effects on buildings

• Recognize explosion/ building response analysis requires
  – Internal resources possessing specialized knowledge – if available
  – External resources possessing knowledge of detail work required (Special Consultants)

• Message: Don’t do it alone
Explosion Analysis Methods Used in NOVA

After initial dispersion modeling…..

(1) Baker-Strehlow Approach
   • Uses Results from Field Research Studies

(2) Computational Fluid Dynamic (CFD) Finite Element Analysis Approach
   • Uses fundamental laws of physics
Initial Approach Selection Guide

• **Baker-Strehlow**
  – Used in NOVA Polystyrene Plants
  – Flammable Chemicals On-Site
    • Low Combustion Reactivity
      – Methane and Carbon Monoxide only
      – No other chemicals
    • Medium Combustion Reactivity
      – *ie, all not included in Low/High Reactivity Groups*
      – Reference: High Reactivity Chemicals
        » Hydrogen, Acetylene, Ethylene, Ethylene Oxide, Propylene Oxide
  – Less physically complex installations
    • Low congestion; more spread out
    • Few areas of semi-confinement
    • Smaller facilities (less domino escalation concern)
    • Example, plastics manufacturing facilities
Initial Approach Selection Guide (Cont’d)

• CFD
  – More accurate in near field
  – Has been used in new projects (for dispersion and explosion modeling)
  – Can provide indication that deflagration to detonation transition is real or not

• Flammable Chemicals On-Site
  • High Combustion Reactivity
    » Hydrogen, Acetylene, Ethylene, Ethylene Oxide, Propylene Oxide

  – More physically complex installations
    • More congestion; high equipment density throughout layout
    • Many areas of semi-confinement
    • Larger facilities (appreciable domino escalation concern)
    • Example, ethylene manufacturing facilities

• Other Points
  – CFD not validated over 4 bar
  – Can be leveraged for other needs (eg, adding new process equipment and concerns over domino effect)
Baker-Strehlow Snap Shots

Identification of Potential Explosion Sites
Baker-Strehlow Snap Shots (Cont’d)

PES Explosion – Impulse Analysis
(Ref: V-Cloud Software By Baker Risk Consultants)
CFD Snap Shots

Realistic Dispersion (Ref: GexCon)
CFD Snap Shots (Cont’d)

More Precise Explosion Modeling (Ref: GexCon)
FEA Snap Shot
Dynamic Object Response (Ref: GexCon)
Integrated Analytical Process

• Step 1- Decide on **Initial** Explosion Approach
  Baker-Strehlow
  – Input
    • Define Potential Explosion Sites
      – Identify chemical of interest and size of flammable cloud in PES (determines quantity of flammable material)
      – Degree of Confinement (3D, 2.5 D, 2D, 1D)
      – Degree of Obstacle Density (congestion) (High, Med, Low)
  – Analytical work
    • Baker-Strehlow Explosion Analysis for each PES (V-Cloud Software)
  – Output
    • Pressure, Impulse vs. Distance Graph for each PES
Integrated Analytical Process (Cont’d)

• Step 1 - Decide on Initial Explosion Approach (Cont’d)

  CFD
  – Inputs
    • 3D CADD for facility (from drawings or laser scanning)
    • Process information (chemical, inventory, conditions, location)
    • Meteorological information
    • Size of finite element
    • Identification of specific scenarios (leak sources, wind effects, ignition sources, etc)
  – Analytical Work
    • Computer calculations solving differential equations for each finite element; integrating results from each finite element.
  – Output
    • Time-based (hence dynamic) simulation of chemical concentration & explosion pressure wave over plant layout
Integrated Analytical Process (Cont’d)

• Step 2 – Identify Objects of Interest (eg, Occupied Critical Buildings)
Integrated Analytical Process (Cont’d)

• Step 3 – Building Response Analysis
  – **Inputs**
    • Pressure level at building
    • Pressure wave impact angle
    • Impulse magnitude at building
    • Building construction & member connection features/ details
  – **Analytical Work**
    • Dynamic analysis (not static analysis) and expert assessment
    • For Baker-Strehlow Approach can use Baker Risk’s Safe Site 3rd Generation (SS3G) Software
  – **Outputs**
    • Description of nature and degree of damage
    • Fatality vulnerability (ie, % probability)
    • Identification of additional work required to reach conclusions (next slide)
    • Identification of feasible building protection options (eg, hardening, relocation, explosion risk mitigation)
Integrated Analytical Process (Cont’d)

• Possible additional work
  – Potential if use Baker-Strehlow approach
    • Depending on degree of confinement/obstacle density, high reactivity chemicals may need to be further analysed for the deflagration to detonation transition (ie, >> 8 x atm pressure)
      – ie, CFD analysis
Making Decisions

• Before Analysis
  – First Level
    • Management decision to proceed weighing:
      – Level of forecasted expenditure and level of coverage and basis
        (ie, qualitative acceptance of risk)

• After Analysis
  – Second Level
    • Based solely on analytical outputs; ie, extent of potential damage
      and injuries
    • Likely, if retrofit costs are not too high
  – Third Level
    • If required beyond 2nd level due to magnitude of expense involved
    • Quantitative Risk Assessment
      – Based on risk of fatalities
      – Is it acceptable or unacceptable risk (accounts for sensitivity to
        potential multiple fatalities)
  – Fourth Level (ultimate, if proceeds beyond 3rd level)
    • Independent management decision and basis
Other practical considerations

• Do it as a project with a Project Manager
• Use one consultant for all work
• Leverage learned efficiencies from pilot study at one site before doing other sites
• Use corporate explosion knowledgeable person – if available
• Use site technical resource familiar with technical concepts