OBJECTIVE

Safeguarding life, property and the environment
International Network and Staff

- Americas: 550
- Europe: 2800
- Africa & Arabia: 75
- Asia: 400
- Australasia: 75
Risk Assessment Software

DNV Risk Management Software
Commonly Used Definition of RISK

The likelihood of a specified undesired event occurring within a specified period or under specified circumstances
1. Identify Hazards
2. Postulate Accidents
3. Evaluate Consequences
4. Estimate Frequencies
5. Risk Summation

Options to Mitigate Consequences
Options to Decrease Frequencies

Risks Controlled? Yes
Optimise Options to Manage Risks
Perform technique for identifying Hazards - “Process Hazard Analysis”

- Hazard and Operability Studies (HAZOPS)
- Checklists
- “What-If” Analysis
- Failure Mode and Effect Analysis (FMEA)
- Safety Audits
- Historical Record

All recorded with DNV-Pro for ease of producing actions and recommendations
Identification of Hazards - II

DNV-Pro provides:

- Templates for HAZOP and other PHA recording
- Suggested Guidewords and Deviations
- Fully User Customised
- Can import many different types of study formats
- Numbering and Assignation of Recommendations

DNV-Pro is a consistent and reliable aid to saving time and improving the quality of Hazard Identification
We need to assess any possible Flammable, Explosive or Toxic Effects from releases of Liquids and/or Vapours.

DISCHARGE TERMS

GAS DISPERSION / POOLS

FLAMMABLE & TOXIC EFFECTS
PHAST gives us the ability to look at the following aspects of various types of accidental releases of a hazardous material:

- Mass release rate of material
- Liquid pools that are formed and evaporate
- Gas dispersion under four different air entrainment regimes
- Fire effects (Jet fires, pool fires, flash fires, BLEVEs)
Evaluation of Consequences - III

- Explosion Effects (Confined and Unconfined)
- Toxic Effects (Probits, ERPG Levels, IDLH Levels)
- Modelling for different weather conditions
- Graphical display of results on maps
Estimation of Frequencies

Can use historical failure rate data and modify if necessary to account for a specific plant.

Failure Frequency Data Sources:

- Published Works (Lees, CCPS)
- OREDA
- WOAD
- Electrical/Nuclear
- DNV
- Your Organisation!
Modification of Generic failure rate data can involve:

- Factoring individual failure causes e.g. corrosion, external impact
- Allowing for socio-economic effects
- Fault Tree Analysis
- Management Systems Audit
SAFETI - Risk Summation

Software for the Assessment of Flammable, Explosive and Toxic Impact

SAFETI combines the Consequences (How Big?) and Frequencies (How Often?) of the Hazards to determine the Risk.

SAFETI also takes into account:

- Distribution and vulnerability of local population
- Meteorological data (wind speed/direction/stability)
- Location of any ignition sources
Impact Calculations

CONTAINMENT VESSEL
Impact Calculations - II
Impact Calculations - III
Impact Calculations - IV

NIGHT TIME
Impact Calculations - V

IGNITION
Impact Calculations - VI

- Wind Direction
- Speed / Stability Categories
- Day / Night
- Time dependent ignition
- Various risk indices
- Every case modelled
Output from SAFETI is in the form of

- Contours of Individual Risk
- Societal Risk Curves
- Ranking of Risk from each Failure Scenario
The use of a measure of loss (life, production, asset loss or environmental damage) to measure the benefit of various available options.

Helps to use investment effectively and efficiently. It can also save money by stopping over-protection of some items.
Risk Reduction and Cost Benefit

Average Individual Risk vs. Cost (US$000,000)
Risk Analysis Tools

• Complex risk analyses require undertaking a large number of calculations and the efficient handling of large amounts of information
• Can not be done manually
• Assistance of suitable software packages is essential
The Project

QRA SCOPE

HAZARD IDENTIFICATION

PROBABILITY ASSESSMENT

CONSEQUENCE ASSESSMENT

RISK PROFILE

RISK COMMUNICATION

DECISION MAKING

CALCULATION EFFORT REQUIRED
Software allows more time for decision making and defining the scope
• Robust Commercial Software

• Support and Training

• Modelling that is well validated and uses leading technology

• Global user community driving product development and direction
Consequence Analysis
What is Consequence Analysis?

Estimate of effects for chemical release:
Accidental
Designed
Consequence Analysis

Emphasis is placed on the following aspects of various types of releases of a hazardous material

- Mass release rate of material
- Gas dispersion
- Liquid pools that are formed and evaporate
- Fire and Toxic effects
Possible Flammable, Explosive and Toxic Effects from releases of Liquids and/or Vapors are explored following the scheme:

- Discharge Calculations
- Dispersion Calculations
- Flammable/Toxic Effects Calculations
Discharge Determines

- Release Rate
- Phase of the Release
- Liquid Fraction
- Temperature
- Duration
Source Term Models used by PHAST

Instantaneous or catastrophic release

- Vessel
- Released material

Orifice leak

- Vessel
- Orifice
- Released material

Line release

- Vessel
- Pipe
- Rupture point
- Released material
Possible Flammable, Explosive and Toxic Effects from releases of Liquids and/or Vapors are explored following the scheme:

Discharge Calculations

\[\text{Dispersion Calculations} \rightarrow\]

\[\text{Flammable/Toxic Effects Calculations}\]
Pipe and Orifice Model: Atmospheric Expansion & Rain-out

- Flash
- Vapour
- Liquid
- Small droplets remain suspended
- Large droplets rain out
- Liquid pool
Dispersion

Needs:
- Discharge Results
- Weather Data

Types of Clouds:
- Instantaneous
- Continuous
- Short Duration
Cloud Formation

- Initial Turbulent Expanding Jet
- Dense Spreading and Turbulent Mixing
- Slumping Dense Cloud
- Passive/Gaussian
Initial Turbulent Expanding Jet

- Continuous releases have a direction
- Instantaneous releases occur in all directions
- Rapid expansion
- Rapid decrease of concentration
Dense Spreading and Turbulent Mixing

- Energy left
- Cloud expanding
- Cloud touches down
- High degree of mixing
- Cloud moving faster than the wind
Slumping Dense Cloud

- Lost energy
- Slumping and spreading
- Lower mixing rate
Passive / Gaussian

- Lost ALL initial energy
- Mixing due to turbulence
- Wind speed
UDM Dispersion Phases

- elevation phases: elevated, touching down, ground-level, lift-off, elevated, mixing layer
- dispersion phases: jet, heavy, passive
Short Duration Continuous Releases

(a) Release just begun

(b) Release ends

(c) Cloud moves away from the release point

(d) At this point the release is quasi-instantaneous

(e) Replaced with equivalent circular instantaneous cloud

(f) The circular cloud moves away
Possible Flammable, Explosive and Toxic Effects from releases of Liquids and/or Vapors are explored following the scheme:

Discharge Calculations

\[\rightarrow\] Dispersion Calculations

\[\rightarrow\] Flammable/Toxic Effects Calculations
Flammable and Toxic Effects

- Flash Fires
- Vapor Cloud Explosion
- BLEVE
- Pool Fire
- Jet Fire
- Probits
Testing and Verification

- Test models prior to integration
- Model verification:
  - sensitivity studies
- Model validation against experiments:
  - New, systematic re-validation for models which have substantially changed
Validation Against Large Scale Experiments

- passive dispersion (Prairie Grass)
- elevated two-phase jet (EC - propane, Desert Tortoise - ammonia)
- elevated HF jet (Goldfish)
- instantaneous (Thorney Island)
- pool evaporation - LNG (Maplin Sands, Burro)
  ‒ to further improve link pool/dispersion model
Validation against Prairie Grass 8 - concentration

Prairie Grass 8 - Elevated release of Sulfur Dioxide

- Concentration (mol %)
- Downwind distance (m)

Graph showing concentration versus downwind distance for Prairie Grass 8 Elevated release of Sulfur Dioxide.

- Centre-line
- At z = 0
- Experimental data
Validation against Thorney Island 8 - concentration

Thorney Island 8 - Instantaneous release of Nitrogen and Freon

- Concentration (mol %)
- Downwind distance (m)

Graph showing concentration versus downwind distance for Thorney Island 8, with experimental data points.
Benefits of Consequence Analysis

- Lower Liability
- Preventing/Minimizing Damage
- Regulatory Compliance
More Benefits of Consequence Analysis

- Environmental Awareness
- Quantitative Risk Analysis
- Added Benefit of Decrease in Downtime
PHAST

- Process
- Hazard
- Analysis
- Software
- Tools
Past - 10 Years Ago

- PHAST started as a development project by Technica for Rohm and Haas
- It was based on the models and code from SAFETI but developed for the PC
- The commercial launch was version 2 in June 1989 in Oslo.
Present - 10 years of Progress

- 600 Users
- 250,000 lines of code
- 200 C++ classes
- 50 Modelling modules
- New capabilities……..
  - Graphics, maps
  - Standalone models
  - Time dependency
  - Unified Dispersion Model...
The Future

- Continuous Improvement in Consequence Modelling
- Integration of PHAST models in other business applications
- Enhanced Functionality through DNV Software group
- Links to GIS
- Links to CAD Systems
- Web Integration
- Links to ERP systems
- ??? You tell us
11 Releases Of PHAST
Conclusion

• First 10 years has seen many developments
• PHAST continues to be the leading commercial tool
• We are preparing the release of the 11th version of PHAST
• This version uses state-of-the-art software technology
• DNV’s strategy allows more cost effective maintenance and development of software
• There are many improvements we can make
• Users are key in keeping PHAST a success
Process Hazard Analysis Software Tool

- Complete software package for consequence analysis
- Capability of modeling catastrophic releases, leaks, line ruptures, relief valves, disk ruptures and vents from vapor space
Program Structure

- 32 Bit Version
- Only PSU file is created
- Windows naming convention
- Can be run on NT by non-Administrators
- Software & hardware security
Installation

- Three types of installations:
  - Stand alone installation
  - Network installation sharing Administrative files only
  - Network installation sharing all common files
Modularization

- Test models prior to integration
- Model verification
  - Sensitivity studies
- Model validation against experiments
  - New, systematic re-validation for models which have substantially changed
More about PHAST...

- User friendly Interface
- Graphical & animated results
- Tabular results
New Structure

- Study Tree
  - Study Folder
  - Study
  - Folders
  - Models
Case Lists

- Allows for sensitivity studies
- Can modify one or more variables at a time
- Can visualize all variations on the same graph
- Reports display all variations
Case Definition

- Saturated Ethylene
- 10 000 Kg
- 2.068 bar
- 40 mm orifice
- 5 m below liquid level
- Outdoors vessel

DNV RISK MANAGEMENT SOFTWARE
Weather Data

- 1.5 m/s - D stability
- 5 m/s - D stability
- 1.5 m/s - F stability
Explosion Models

Example - PHAST Professional 6.0

Vessel/Pipe: BD VAPOR LEAK

Location | Indoor/Outdoor | Flammable | TNT | Multi Energy | Etc.
--- | --- | --- | --- | --- | ---
Explosion Method
- TNT
- TNO Multi-Energy
- Baker-Strehlow
Jet Fire Method
- API
- Shell
Early Explosion Mass Modification Factor 3
Use Late Ignition Location

Model
- Vessel or Pipe Source
- User Defined Source
- Pool Fire
- Jet Fire
- Bleve
- Pool Vaporization
- TNT Explosion
- Multi Energy Explosion
- Baker Strehlow Explosion

OK | Cancel | Help
Calculations can be performed after all appropriate data has been provided
Reports

- Selection of reports to be displayed
- Selection of Dispersion Report fields
- Reports can be exported directly into MS Word
- Reports can be generated for materials as well as parameters
Graphics

- All applicable graphs are displayed
- Dynamic view of some graphs is available
- Footprint height can be modified
- Multiple cases or weathers can be viewed at once for all plots
Graphics #2
Conclusion

- Substantial modularization and restructuring work for all models in PHAST 6.0

- New structure and characteristics allows more flexibility

- Component architecture opens new possibilities
  - Better model quality control
  - Easier and more efficient updates
  - Model version control
  - Better support of individual models