MARSH

SOLUTIONS...DEFINED, DESIGNED, AND DELIVERED.

PERFORMANCE BASED INDUSTRIAL FIRE SAFETY

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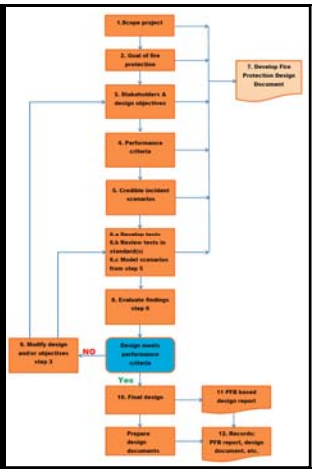
MARSH & McLENNAN COMPANIES

PROCESS FLOW DIAGRAM

- 12 steps
- PFB evolves around credible scenarios



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DESIGN SCENARIO ↔ CREDIBLE SCENARIOS

- More than one credible scenario can occur
- Response should be able to tackle the largest scenario
- Largest scenario is design scenario

http://www.a-risc.com/bowtiemethod.html

- Bund fires two consecutive bowties
  1. for Loss of Containment
  2. for fire

PERFORMANCE BASED - PRESCRIPTIVE

PFB

Advantages

- Cheaper & custom made solutions that fit you
- All stakeholders involved
- Weight decisions between prevention and repression
- Allow use of new 'solutions'
- Future changes informed based

Disadvantages

- Requires specific knowledge

PRESCRIPTIVE

Advantages

- Follow code/standard
- Tick boxes

Disadvantages

- Without profound knowledge the risks may not be covered
- May cost more
- Difficult to use new ' solutions'

EXAMPLE CREDIBLE SCENARIO TANK

Full contact GRE honey comb floating roof tank with Aluminium geodesic dome roof

Two credible scenarios:

- Rim seal fire
- Full surface fire

Design scenario: Full surface fire

http://www.petrexinc.com/wp-content/uploads/2012/07/HC-Slide-Intro.pdf[4]

DETECTION + ACTIVATION

Cooling systems

- Polyflow
- Deluge installation + detection

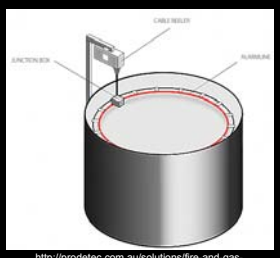
http://www.saval.nl/wp-content/blogs.dir/5/files/2012/07/Polyflo.pdf

http://www.vfpfire.com/systems-deluge.php

FIRE DETECTION (1)

Floating roofs

- Polyflow
- Linear detection



http://prodetec.com.au/solutions/fire-and-gas-solutions/fire-detection/flame-detection/linear-heat-detection-floating-roof-tanks

FIRE DETECTION (2)

Cone roof tanks without innerfloater

- Linear detection
- Flame detectors
- Heat detectors
- Delayed detection based on ΔT measurement of liquid in tank

BUND - LOSS OF CONTAINMENT

Detailed Performance Based analysis to find cause(s) of Loss of Containment (LoC), reliability and availability of Lines of Defense (LoD) for LoC

- LEL detection – before the fire starts
  - Options to prevent fire
  - Or spill fire and not fully developed
  - LEL detection is robust and reliable

INCREASE SENSITIVITY LEL DETECTOR

Relative Response of a Flammable/Combustible Sensor

Combustible gas / vapor	Relative response when sensor is calibrated on pentane	Relative response when sensor is calibrated on propane	Relative response when sensor is calibrated on methane
Hydrogen	2.2	1.7	1.1
Methane	2.0	1.5	1.0
Propane	1.3	1.0	0.65
n-Butane	1.2	0.9	0.6
n-Pentane	1.0	0.75	0.5
n-Hexane	0.9	0.7	0.45
n-Octane	0.8	0.6	0.4
Methanol	2.3	1.75	1.15
Ethanol	1.6	1.2	0.8
Isopropyl Alcohol	1.4	1.05	0.7
Acetone	1.4	1.05	0.7
Ammonia	2.6	2.0	1.3
Toluene	0.7	0.5	0.35
Gasoline (Unleaded)	1.2	0.9	0.6

http://site.jjstech.com/pdf/GFG/GfG_LEL_PID_NDIR_sensors_and_applications.pdf

STAFF

Emergency Response plan describes role of

- Control room staff
  - Secure safe operations and ESD
  - Monitor fire water
  - Guidance
- Manager
- Process engineers
- HSE representative
- HR

STAFF: PREPLANNING & LOGISTIC RESPONSE PLAN

- Emergency Response Team
  - Staff in standard safety gear – exposure ≤1 kW/m^2
    No exposure to toxic substance unless equipped with proper safety gear and trained
  - Responders – full safety gear
    - Exposure ≤3 kW/m^2
    - Toxic substances
- Not in scope of preplanning
  Commander's decision for short term higher kW/m^2 exposure in practice

MUTUAL AID

- Affected site can have sufficient staff, water, foam equipment for 'small' incidents
- Consider mutual aid for larger incidents
- Scenario development based on response time
- Describe course of scenario development in time
- Control mode with fixed systems (usually cooling) before response starts
- Fixed water supply and/or mobile water supply

FOAM (1)

Foam management

- Design fixed system without bladder or pressure foam concentrate tank – allows stock up
- Does the scenario development allow for split between onsite and/or offsite foam concentrate storage (including compatibility)
- How much foam is needed and how long does it last
- How fast can additional foam supplies be brought onsite

FOAM (2)

Mobile semi fixed and fixed application

- Mobile application requires 50 – 60% more water/foam than (semi) fixed application
- Semi fixed application
  Fire truck supplies premix (water/foam) to fixed system via manifold from a safe location
- Fixed application manual or automatic activation

MOBILE RESPONSE VERSUS (SEMI) FIXED FOAM SYSTEM (1)

Mobile	(Semi) fixed
• Cone roof tanks Ø 3-18 m Weak seam and no ERV or Nitrogen  • Floating roof tanks Full surface fire up to Ø 60-80 m depending on height of tank	• Cone roof tanks Irrespective of tank diameter • Floating roof tanks Semi fixed up to 35 meter cylinder height Fixed up to 44 meter cylinder height

MOBILE RESPONSE VERSUS (SEMI) FIXED FOAM SYSTEM (2)

Mobile	(Semi) fixed
• Tank with inner floater Roof prohibits mobile response • Tank with floating roof and Aluminum geodesic dome roof Roof hinders mobile response	• Tank with innerfloater and tank with Aluminum geodesic dome roof Semi fixed up to 35 meter cylinder height Fixed up to 44 meter cylinder height Tank diameter up to Ø 60-80 m

BUNDFIRES

ON DAY 3 BUNDFIRES ARE DISCUSSED IN DETAIL

WATER

- Water source
  - Limited supply (basin, tank, ..)
  - Open water, pond, river, .reservoir..
  - Well
- Water quality
  - NFPA → determine water quality
  - Water quality affects foam. This is especially relevant for water soluble solvents

CONTROLLED BURN

PFB approach does allow controlled burn for tank fires and bund fires when the scenario description shows it to be a good option and no spread and/or escalation initial incident can occur:

- If tank is designed for burn down scenario
- For toxic substances where the combustion products pose lower risks
- For (short term) pool fires & low level tank fires
- For specific locations

MOBILE AND/OR FIXED COOLING

Radiant heat & flame impingement ≥ 10 kW/m^2

- Tank fire
  Depending on provisions on tank, direct affected tanks, objects → fixed & mobile shielding (monitors & hydroshields)
- Bund fire
  Tanks in affected bund → fixed cooling
  Avoid dry spots
  2 or 10 l/min/m^2 depending on response time
- Tanks, constructions & objects outside affected bund → mobile cooling (monitors & hydroshields)

HEAT FLUX 32 - 37.5 kW/m^2

No delayed cooling for constructions and objects exposed to heat fluxes of 32 – 37.5 kW/m^2 and higher and for direct flame impingement.

Risk of:

- Spread of fire
- Failing structures
- Escalations of incident

QUESTIONS

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