Fire and Safety for Offshore drilling and production

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Fire and safety related applications

- Gas Dispersion and Ventilation
  - Formation of combustible gas clouds
  - Smoke and plume trajectories
  - Gas concentration levels
  - Ventilation times
  - Helicopter operations
- Explosion and Fire Propagation
  - Fire Suppression
  - Blast wave interaction with structure
Offshore Leg - Geometry

Release of heavy hydrocarbon gas and liquid inside the leg of an offshore platform

Asses the role of extract ventilation in mitigating against flammable gas concentrations

Internal Structure

Leak Location
Potential hazard

• Heavy gas fills the enclosure from the bottom up
• Flammable mixture forms a band which rises up over time. Potential ignition sources within the structure and from people working with machinery
• Gas is also toxic
Offshore Leg - Ventilation

Extract ventilation configuration
Offshore Leg – Liquid Flow

Particle transport calculation for liquid drops

Typical Particle Tracks (coefficient of restitution = 0)

Typical induced flow pattern
Offshore Leg - Results

Ventilation turned off

- 5 minutes
- 10 minutes
- 15 minutes

After 10 minutes the flammable volume covers most of the internal structures
Offshore Leg - Results

Ventilation turned on

The flammable volume stays below the internal structures
Platform Exhaust Plume

Original platform design

Exhausts circled
Platform Exhaust Plume

Temperature
554.8
419.6
284.5
149.4
14.2
[C]
Platform Exhaust Plume

Redesigned exhausts to extend higher
Platform Exhaust Plume
Optimization of a Funnel

Courtesy of Daewoo Shipbuilding and Marine Engineering, Co.
Optimization of a Funnel

Original design

After optimization

Courtesy of Daewoo Shipbuilding and Marine Engineering, Co.
Brown & Root Energy Services commissioned BMT Fluid Mechanics to assess the ventilation rates within the production and cellar decks for the Malampaya offshore platform in the Philippines.

BMT uses ANSYS CFD routinely to assess gas releases and smoke spread. “We chose ANSYS CFD because it is the most widely accepted CFD code within the oil and gas industry.”

Courtesy of BMT Fluid Mechanics Limited, UK on behalf of Brown & Root
Ventilation and Safety Study

Ventilation rates were computed by performing simulations of the airflow through the platform for a range of wind directions.

Poor local ventilation was predicted in the wake of large obstacles such as the blast wall and accommodation block.

Courtesy of BMT Fluid Mechanics Limited, UK
Ventilation and Safety Study

Time dependent gas-dispersion simulations were carried out for the wind angles that resulted in poor local ventilation rates.

Gas concentration contours from a 5 kg/s release after 60 seconds

This led to:

- Accurate estimation of the ventilation efficiencies based on the wind frequency (direction & speed) for the site
- Recommendations for gas detector positioning
Helideck Wind Environment

Over the helideck the following conditions are desired:

- Standard deviation of the mean vertical wind fluctuation $\sigma_w$ must not exceed 1.75 m/s as sudden downdrafts add workload to the pilot during TO/L.
- HC concentration must not exceed 10% LFL as excess HC may cause flame-out in the helicopter turbines.
- 3 second average temperature variation must not exceed 2°C as this causes variations in density, hence lift on the rotor blades.

Typical oil/gas platform helideck study

- Blockage presented by platform is significant - this is most important around the helideck and the detail of the helideck air gap is very significant.
- Crane arms and flare boom are typically included as porous bodies; the jacket is remote from the helideck and less significant.
- GT stacks & vents are included for thermal and HC plumes.

Courtesy of MMI Engineering
Helideck Wind Environment

• Bending of streamlines creates shear and generates turbulence – hence it is important for the wind profile to be as “clean” as possible over the helideck (*fig. bottom left - streamlines*)

• GT stacks, crane arms, etc have wakes, creating more shear layers and turbulence (*fig. bottom right – resultant in-plane velocity*)

• Usual to consider 8 or 16 wind directions and a number of critical wind speeds.
LNG Spill and Fire

Challenges

• Accident Scenario and safety concerns
• LNG leaks and the dispersion in the liquid
• LNG evaporation and tracking of the dispersed gas
• Vapor cloud formation and ignition as the vapor cloud reaches the water surface
• Spreading of the pool fire and the associated multi-body hydrodynamics

Pool fire caused by spread, evaporation and ignition of an LNG Leak

Animation Courtesy of CEI
Blast Prevention

Challenges
- Transport of combustible products and cargo
- Study accident scenarios
- Design integrity for offshore vessels and platform for both structural and safety concerns

ANSYS CAE Solutions
- Perform dynamic system response to accident scenarios
- Evaluate structural designs and reinforcement options for sustaining blast forces
- Understand the possible root cause of accidents
- Evaluate the extent of damage for blast impact scenarios

Simulated stress on a section of LPG tanker

CDC (Certain Dangerous Cargoes) barge explosion

Images courtesy of ABS
Blast Wave – Structure Interaction

AUTODYN-3D v5.0 from Century Dynamics

AUTODYN-3D

Blast Wall Response to Explosion Loading
Explosion Modeling on oil platforms

- Detailed Geometry Modeling Approach
  - More accurate as involves less approximations
  - Feasible as computing resources are getting cheaper
  - Useful for sensor, local baffles and deflector placement studies
  - Time consuming and complex

- Porosity Distributed Resistance Approach
  - Smaller geometric details are lumped through porous approximation
  - Quicker and easier to run
  - Less accurate
  - Work in progress at ANSYS on this approach.
Thank You! Questions??