

Southampton

Assessment of Hydrocarbon Explosion and Fire Risks

by

Professor Jeom Paik

The LRET Research Collegium Southampton, 11 July – 2 September 2011 Assessment of Hydrocarbon Explosion and Fire Risks in Offshore Installations: Recent Advances and Future Trends

> Prof. Jeom Kee Paik, Director The LRET Research Center of Excellence at Pusan National University, Korea

New Paradigm for Robust Design of Ships and Offshore ...



Trend in Offshore Oil & Gas Production Systems

- Fixed type in shallow waters \rightarrow Floating type in deep waters
- Ship-shaped offshore unit, Semi-sub, Spar, TLP
- Pipeline infrastructure → Multiple functions such as production, storage and offloading



FPSO for Oil and Gas Production





Vessel (hull), topsides (process facility), mooring, risers/flow lines, subsea, and export system

Oil/Gas Leak Resulting in Explosion and Fire





Source: HSE





Pipe Alpha Accident

- 6th July 1988, UK
- 167 people killed
- Property damage of 1.4billion US\$
- Risk based engineering became mandatory since the Pipe Alpha accident



Deepwater Horizon Accident

- 20th April 2010, Gulf of Mexico
- 11 people killed, 17 people wounded
- Environmental damage of approx. 30 billion US\$





Oil spill

Hydrocarbon Explosions and Fires

• Hydrocarbons can explode through ignition when combined with an oxidiser (usually air). Thus, when the temperature rises to the point at which hydrocarbon molecules react spontaneously to an oxidiser, combustion takes place. This hydrocarbon explosion causes a blast and a rapid increase in overpressure.

• Fire is a combustible vapour or gas that combines with an oxidiser in a combustion process that is manifested by the evolution of light, heat, and flame.

• The impact of overpressure from explosions and that of elevated temperature from fire are the primary concern in terms of the actions that result from hazards within the risk assessment and management framework.

Mechanism of Gas Explosion – Depending on Topology and Geometry



Factors Affecting Explosions and Fires





- \cdot Wind direction
- \cdot Wind speed
- · Leak rate
- \cdot Leak direction
- · Leak duration
- · Leak position (x)
- · Leak position (y)
- · Leak position (z)
- · Type of oil or gas (molecules)
- · Concentration ratio
- Temperature of oil or gas (LNG Cryogenic -163 degree C)

Risk Based Design Process



What is Risk? How to Manage Risk?

$$R = \sum_{i} F_i \times C_i$$

- Asset risk
 - Damage to structures and equipment
 - Duration of production delay (downtime)
- Environmental risk
 - Amount of oil that spills out of the offshore installation
- Personnel risk
 - Loss of life

Trends in Risk Assessment



API Procedure for Risk-based Design



Simulation-based Procedure for Risk-based Design



Joint Industry Projects





2011

FABIG Explosion Fire Technical 15 Notes SOLVEX 1990 Blast and Fire Engineering Project: Phase 1 Realistic Ges Explosion Tests 1 24 21 TN1 1991 Fire Resistant Design Kowat Scientific Mission MENGE 14 Influence of Chiplet size on Officitives of Water Spray Explosion Nitigation TN2 1992 Explosion Hitigation Systems 22 Release of Distance Guatarce Notes (DWs) and Supporting Courses Set Fires. Dropacting un Flat Surfaces 1993 Shell Jet and Pool Compartment Fire Tests 17 п TN3 1994 Ges Explosion Safety Programme 23 Ultimate Strength Techniques EMERGE Coetter# Stolly 1.1 Bast and Fire Engineering Project Phase 2 1914 38 1995 Explosion Resistant Design MEGGE Firms on the Sea Surface 12 24 GEERP 1996 Large Scale Experiments to Study Jat Free of Crude Ol/Gas/Water Mictures 1115 1997 Design Guide for SS Blast Walls 13 EME 12 Structural Model Evaluation Blast Engineering Project Phase 34 5 4 TN6 Large Scale Experiments to Study the Effectivatiess of Water Celuge in Magating Potential Offshore Jet and Pool Fires 1998 Material Data for Fire and Blast Elevated Temperature and High Strain Properties of Offshore Streets 1999 Gao Buiktup from High Pressure Natural Gao Releases in Naturally Verbland Offshore Hobulus 14 2000 Esphanns in Offshare Hodules Policieng Raslittic Rafesses Integrity and ethycharal Response of Paying Systems Subject to Fire and Base 2001 26 TN7 Singlified Network for Analysis of Response to Dynamic Likeding Fire and Blast UKDGA 2002 2003 2004 TNS Prostor of Parag Inform subject to Fran-well Explosions 2005 TN9 2006 Human Factors Guide TN10 2007 40.45 cel SDOP N for David Mandama Suity to Exploring Localing 27 2008 FFTF 33P PNU Nowater 2009 2010

Key Explosion and Fire Research Project

EFEF JIP - 27th JIP in the World Explosion and Fire Engineering of FPSOs

Coordinators:

- Pusan National University, Korea
- Nowatec AS, Norway

Partners:

- DSME, SHI, HHI, ABS, KR, LR
- Gexcon, CompuIT, USFOS, UK HSE, NTUA

Quantitative Gas Explosion Risk Assessment and Management (1/2)



EFEF JIP Procedure for Explosion Risk Assessment and Management (2/2)



Design loads with exceedance curve

analysis under explosion

EFEF JIP Fire Risk Assessment and Management (1/2)



EFEF JIP Procedure for Fire Risk Assessment and Management (2/2)



Design loads with exceedance curve

Fire CFD simulation

Applied Example: VLCC Class FPSO Topsides





Effect of Gas Cloud Volume on Maximum Overpressure – Comparison between EFEF JIP and Existing FPSO Practices



Design Explosion Loads with Exceedance Curves



Design Explosion Loads – Comparison between EFEF JIP and Existing FPSO Practices



Design Fire Loads with Exceedance Curves





Nonlinear Structural Consequence Analysis – Escape Route



Trends in Risk Assessment



CFD Explosion Simulations



Gas Explosion Tests with or without Water Sprays (1/2) - Importance of Risk Management



Without water sprays

With water sprays

Source: © The Steel Construction Institute, Fire and Blast Information Group

Gas Explosion Tests with or without Water Sprays (2/2) - Importance of Risk Management



Source: © The Steel Construction Institute, Fire and Blast Information Group

Explosion and Fire Test Facilities under Construction in Korea

