

OIL & GAS

Large Scale LNG Experimentation at the Spadeadam Testing and Research Centre

Dan Allason

26 April 2016

Ungraded

Introduction

- Major Hazard Test Site
- Operation since 1970's
- History of Large Scale Experimentation projects
 - Hydrocarbons (liquid and gaseous)
 - Products / Procedures
 - Validation of models



Ungraded



LNG Properties

- LNG: 1 volume of liquid will produce 600 volumes of gas.
- Thermodynamic behaviour of LNG varies significantly due to composition.
- LNG is a cryogenic liquid with a boiling temperature of between -166°C and -157°C at atmospheric pressure.
- Cannot be stored at typical process conditions without boil-off.
- At the boil off temperature and with a surrounding atmospheric pressure, the density of the natural gas vapour is denser than air (increases risk of explosions).

LNG Experiments

- Generally funded by industry partner
- Research related to specific hazard or to knowledge gap
- Product Tests developed to suit client requirements
- Not at liberty to publish results for most cases unless specifically permitted / requested to do so

LNG Experiments

■ Research

- Explore specific phenomena to better understand hazard
 - Pool Fire
 - Jet Fire
 - Outflow
 - Explosion
 - Dense Gas Dispersion
 - Liquid Spread / Boil Off
 - Rapid Phase Transition (RPT)
 - Rollover
- Apply learning to enhance and validate modelling

■ Product Testing

- Prove products fit for purpose
 - PFP
 - Transfer Systems
 - Gas Detection Systems
- Develop Solutions
- Cryogenic issues: extreme temperatures / liquid behaviour

Research: Explosion

- Project MEASURE: relates to design of process facilities
 - Joint Industry Project, current
 - Subject to Commercial Confidentiality
 - Highly Instrumented
 - Aims to better understand the interactions between process modules (Safety Gaps)
 - Has specific applicability to FPSO's where space is at a premium
 - Large interactions for not great changes in gap



Ungraded

Research: Outflow / Dense Gas Dispersion

- LNG Fueling Forecourt Transfer and Release project on behalf of Shell
- 1", 2" and 3" release sizes. Pressures up to 9barg.

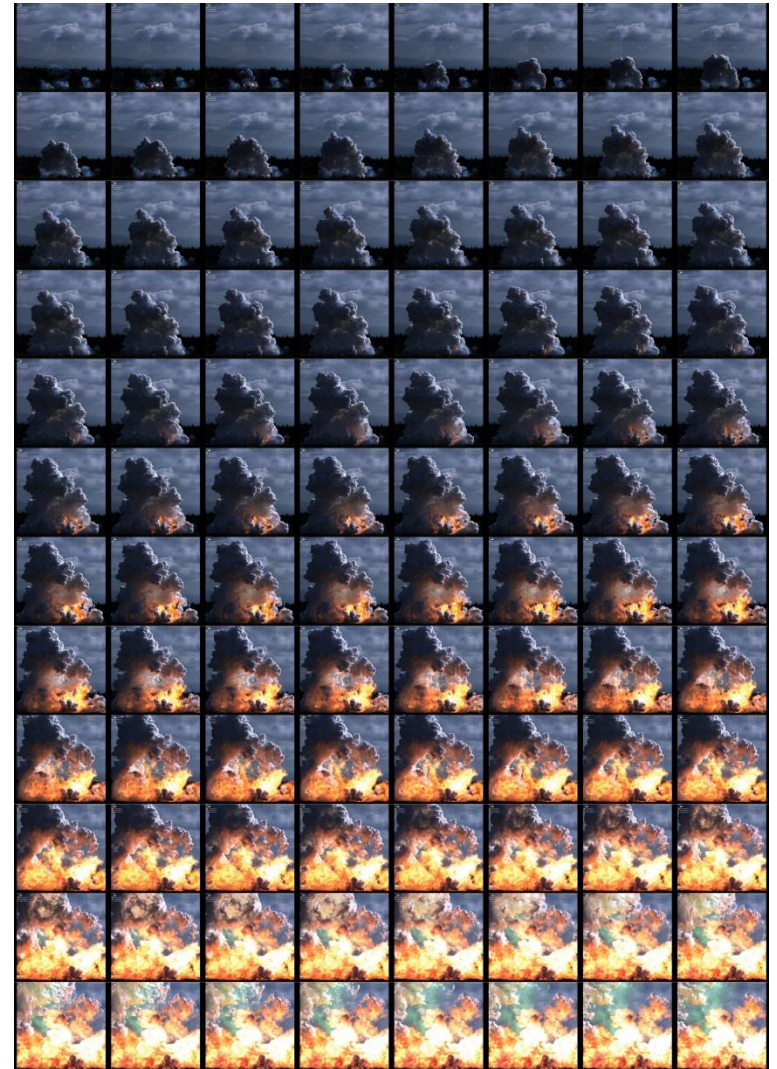


- Investigate outflow conditions, dispersion distances, impacting jets
- Large safety distances for experimentation

Ungraded

Research: BLEVE

- Forecourt Refuelling scenario
- Again, on behalf of Shell
- 1-2Te LNG @ 5-13barg in equilibrium
- Initiation by Explosive Charge
- Thermal Radiation / Overpressure / HSV
- 4 Experiments



Ungraded

Research: Outflow / Dense Gas Dispersion

- Investigate outflow conditions when venting LNG
- British Gas
- Up to 130barg
- Gaseous conditions



Ungraded

Research: Rapid Phase Transition

- Rapid Phase Transition
- Initially spill forms vapour boundary between water and LNG
- Disruption of boundary causes change in heat transfer method – nucleate boiling
 - Wave action
- Hard to reproduce results
 - Composition important
- Propagation speeds $\sim 240\text{m/s}$



Research: Pool Spreading

- On behalf of Shell
- Pool spreading from rapid spill
- Ground level thermocouples
- Video recordings



Ungraded

Research: Pool Fire



← ■ LNG in Low Wind

■ LNG in High Wind



- Investigate consequences of pool fire
- Thermal radiation, boil off rate measurements
- Safety Case for Partington Facility

Ungraded

Product Testing: Cryogenic Exposure

LARGE DIAMETER FLEXIBLE MARINE HOSE TESTING TO BS EN 1474

Hose manufacturers have been seeking approval for hoses up to 20" diameter

Tests on Prototype Hoses include:

- Tensile Test (ambient and **cryogenic**)
- Twist Test (ambient and **cryogenic**)
- Ambient pressure cycle test
- Bend Test (ambient and **cryogenic**)
- Impact Test (ambient and **cryogenic**)
- Crush Test (ambient and **cryogenic**)
- **Cryogenic** Fluid Compatibility
- Weight
- Ambient pressure and leak test
- **Cryogenic** Pressure and Leak Test
- Burst Test (ambient and **cryogenic**)
- **Cyclic temperature** and pressure testing
- **Cryogenic** bending fatigue tests
- Wear test – outer layer
- Ambient flow rate test
- Submersion test
- Buoyancy test
- Electrical continuity test
- Dimensional checks (length, ID, OD)
- Cleanliness check
- Marking plate verification

Ungraded

Product Testing: Cryogenic Exposure

LARGE DIAMETER FLEXIBLE HOSE TESTING TO EN 13766

Standard encompasses hoses of diameter between 1" and 10".

Tests Include:

Hose Film and Fabric

- Elongation (**cryogenic**)

Hose

- Diameter

Hose Assemblies

- Proof Pressure
- Bend
- Sequence of hydrostatic tests
- Security of end fittings (**cryogenic**)
- Change in length
- Burst
- Twist
- Crush Recovery
- Ozone resistance
- Thermal ageing
- Low temperature flexibility
- Electrical Resistance
- Leak Tightness

Ungraded

Product Testing: Cryogenic Exposure → Explosion → Jet Fire



Spillage



Ignition

Peak overpressure up to 4bar
Duration also variable

- Single sample can be subjected to all tests
- JF is in accordance with ISO 22899-1 (except orientation)
- Whole method not standardised....yet

Ungraded

Jet Fire



FUTURE RESEARCH / Testing

- LNG Dispersion JIP
 - Bunkering Stations transfer and storage scenarios
 - Quantify Hazards
 - Scope defined by industry partners
- BLEVE
 - Bunkering Stations and upwards (13Te)
- High pressure releases
 - Product Testing
- Further Explosion Research
 - Water Curtains in Safety Gaps (DOWSES)
 - Turbulent Jet Explosions (AIRRE)
- Standardised Cryo Exposure Testing

Large Scale LNG Experimentation

Dan Allason

daniel.allason@dnvgl.com

+44 (0)20 381 64140

www.dnvgl.com

SAFER, SMARTER, GREENER

Ungraded