DNV·GL

OIL & GAS

Large Scale LNG Experimentation

at the Spadeadam Testing and Research Centre

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Introduction

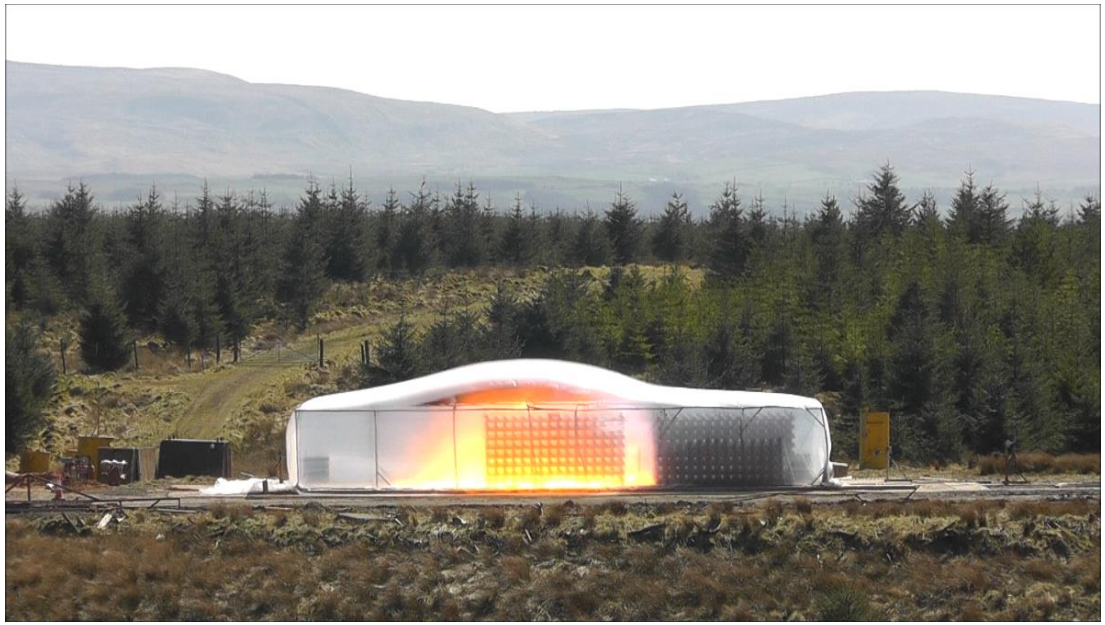
- Major Hazard Test Site
- Operation since 1970's
- History of Large Scale Experimentation projects
  - Hydrocarbons (liquid and gaseous)
  - Products / Procedures
  - Validation of models

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)
  - 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 (BP, DNV GL, Equinor, Exxon Mobil, Gexcon, GRTGaz, Shell, Total)
  - 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 change in interactions for not great changes in gap



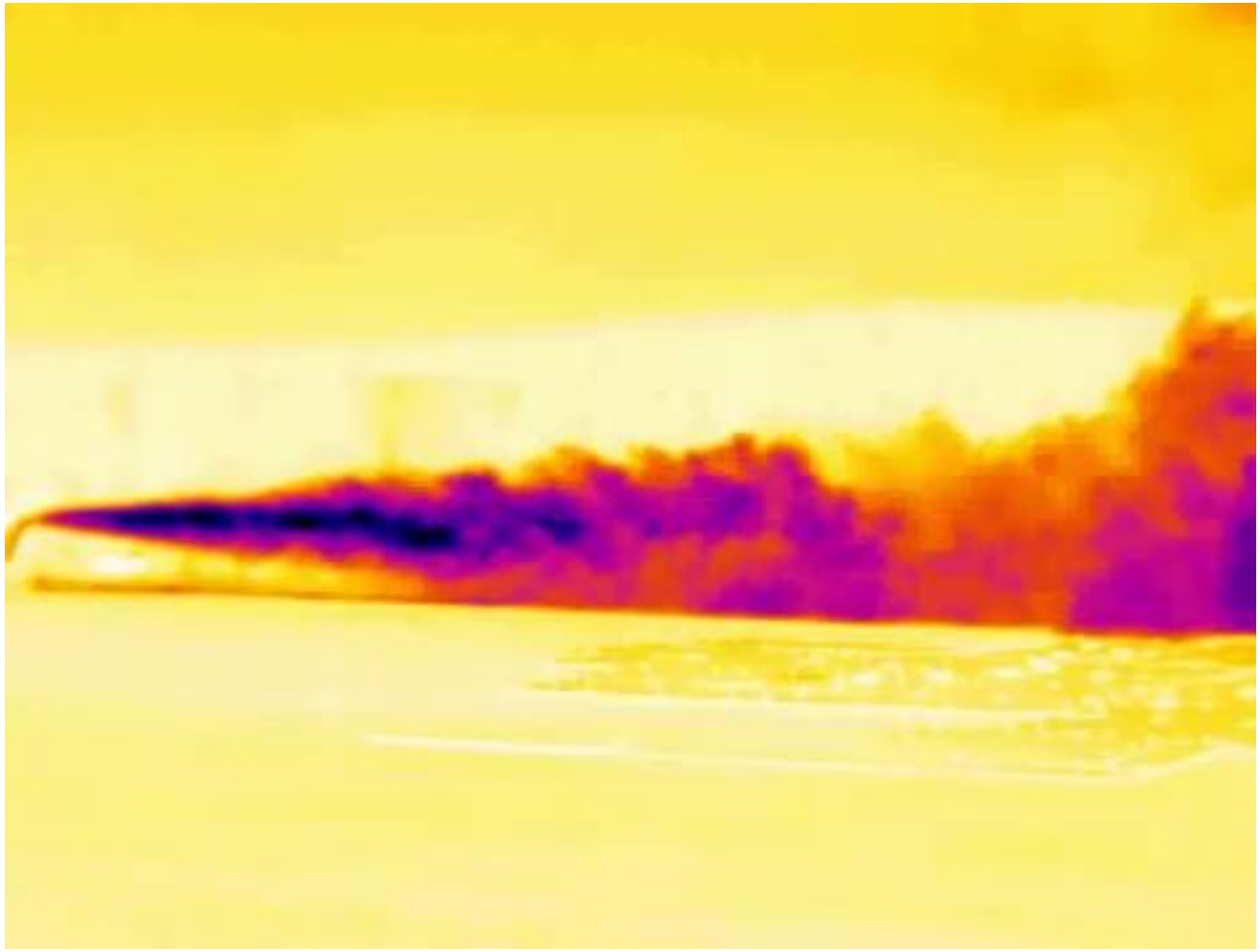
Research: Outflow / Dense Gas Dispersion

- 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

Research: Outflow / Dense Gas Dispersion

Research: Outflow / Dense Gas Dispersion



Research: BLEVE

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

Research: BLEVE

Research: Outflow / Dense Gas Dispersion

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

Research: High Pressure Outflow Plume Properties / Dispersion

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 ~240m/s

Research: Pool Spreading

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

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 High Wall Bund Facility

Product Testing: Cryogenic Exposure

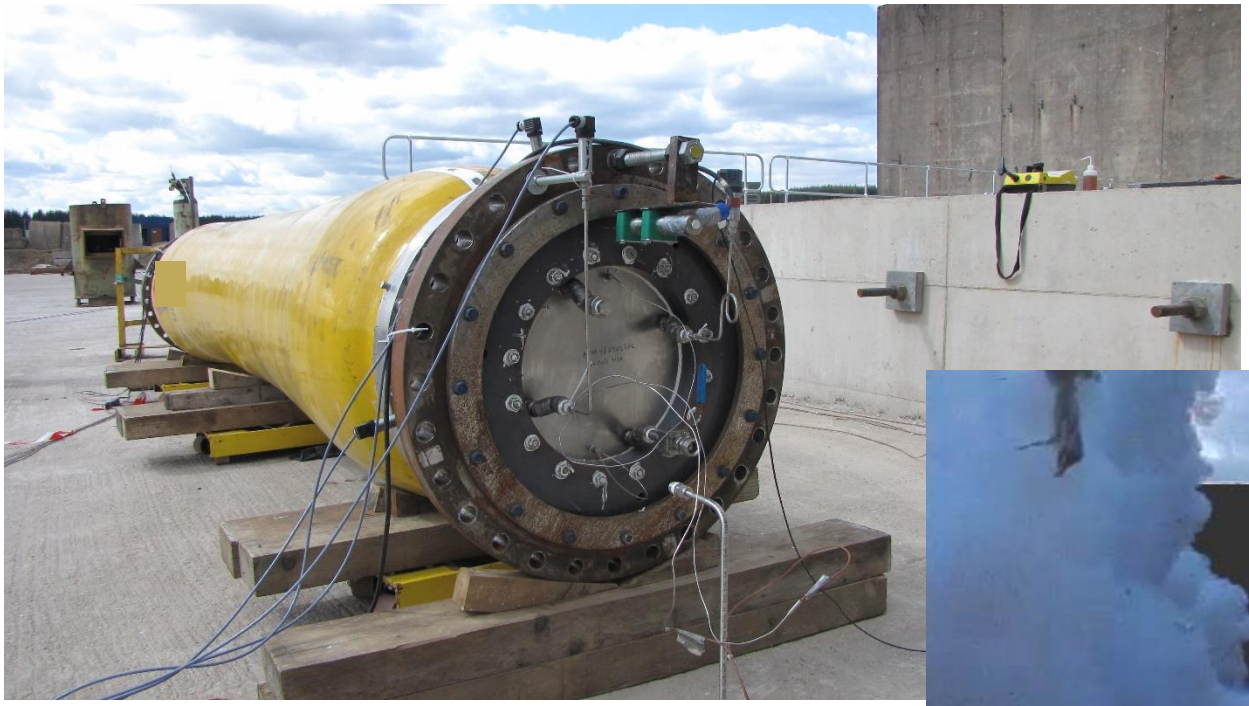
LARGE DIAMETER FLEXIBLE MARINE HOSE TESTING TO BS EN 1474

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

Product Testing: Cryogenic Exposure



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

Jet Fire

Large Scale LNG Experimentation

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