Development of a New Emergency System for High Pressure Gas Transfer Arms

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KIVI Engineering Society

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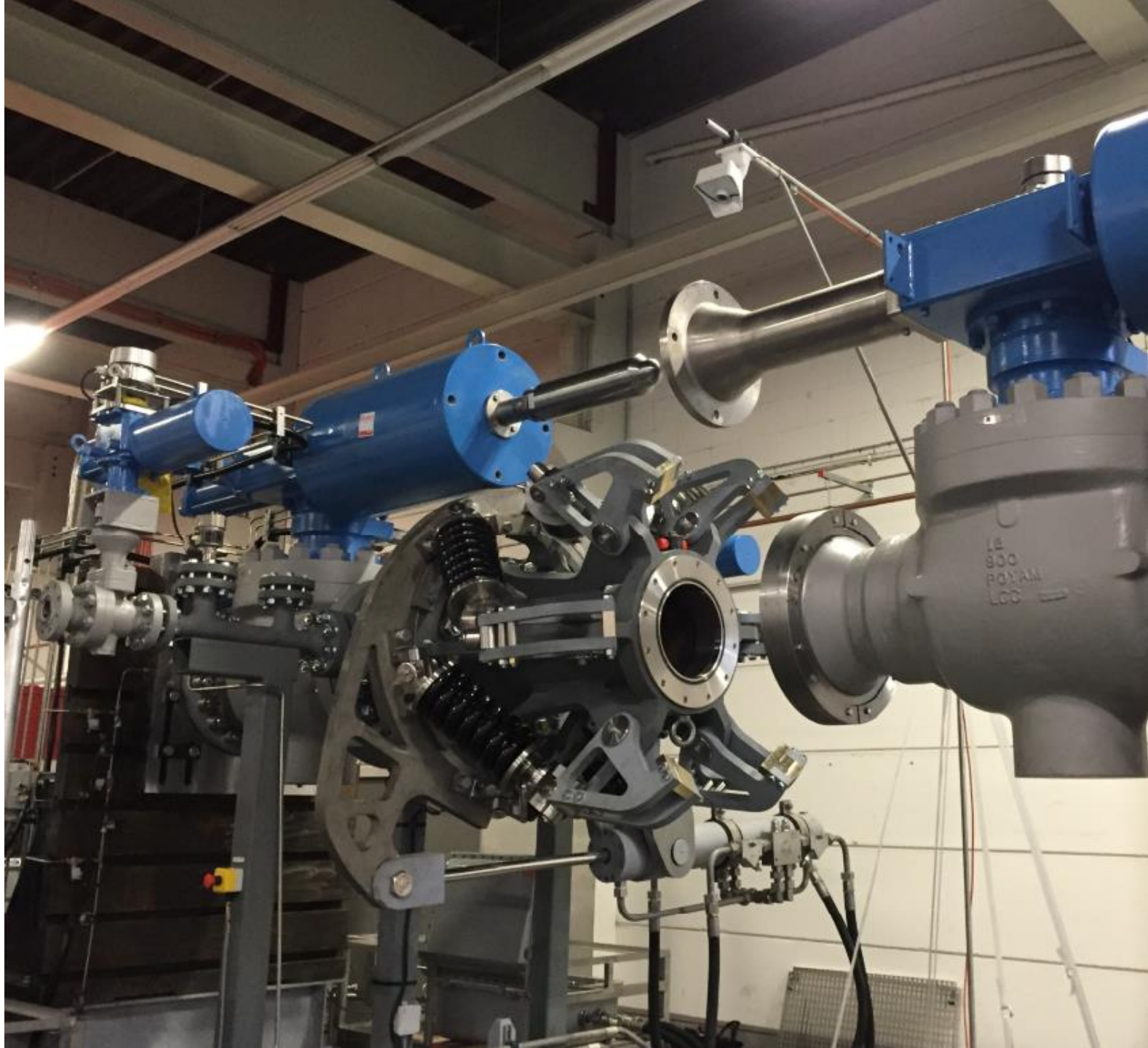
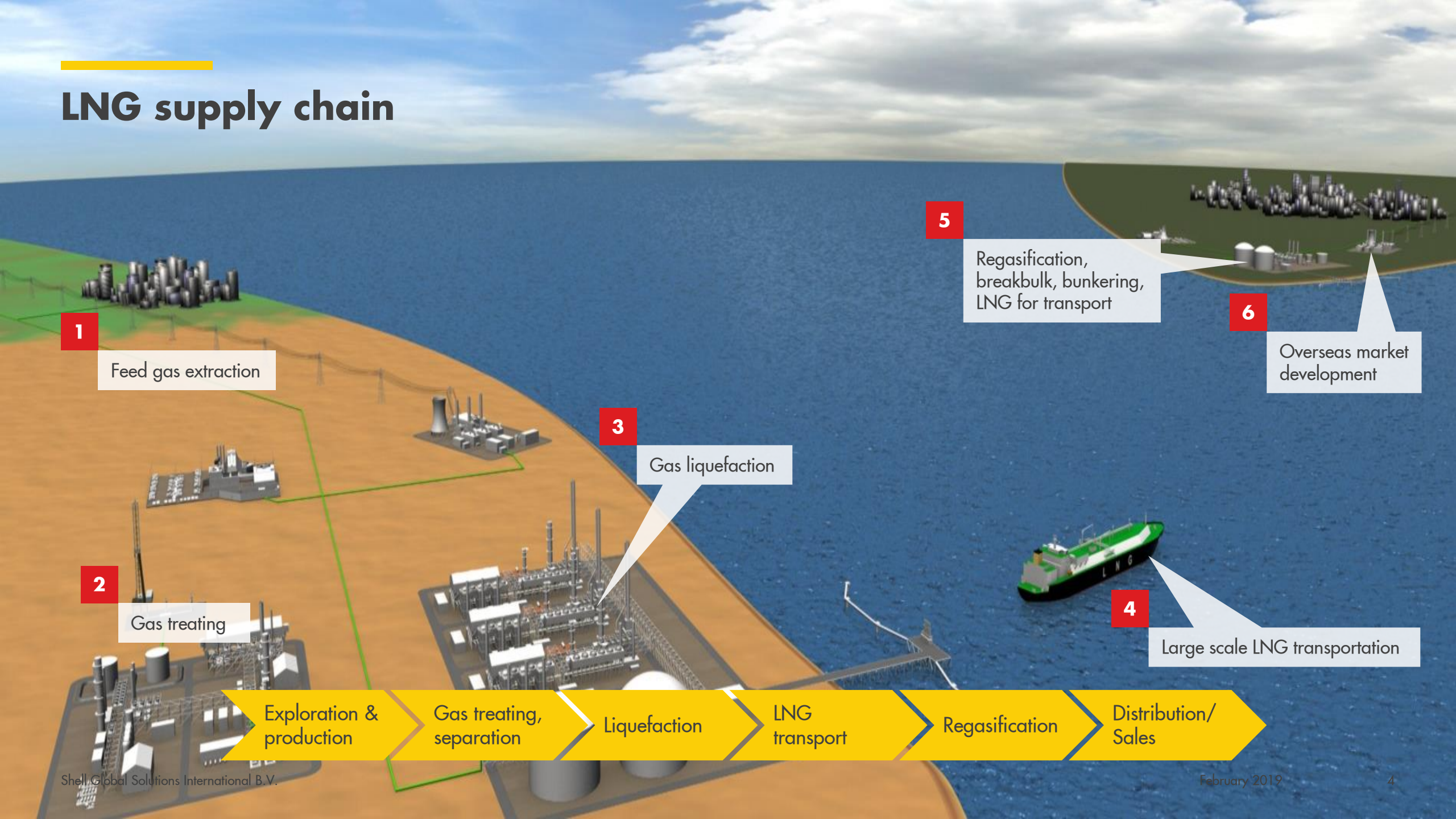
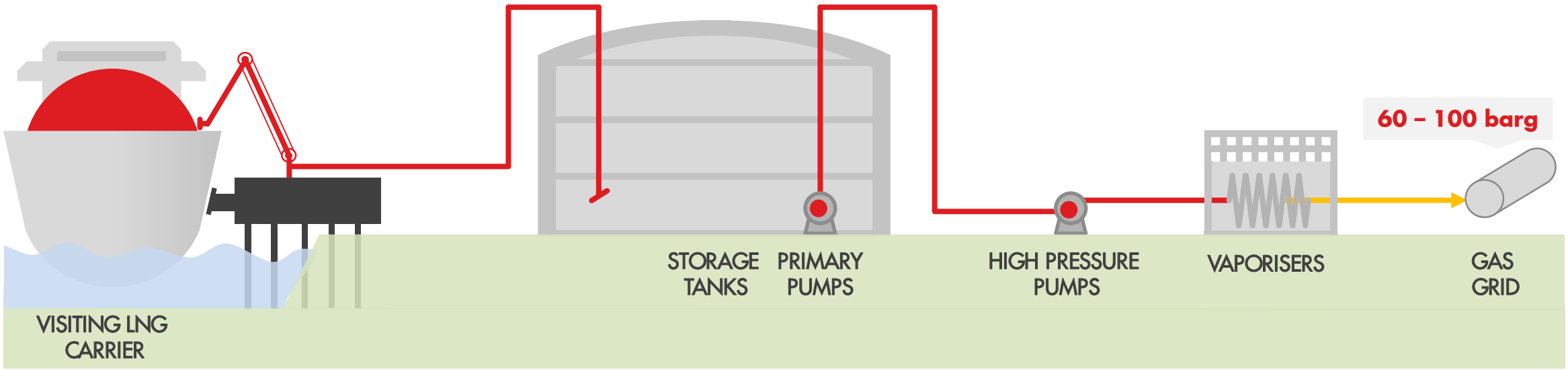


1.0 Background

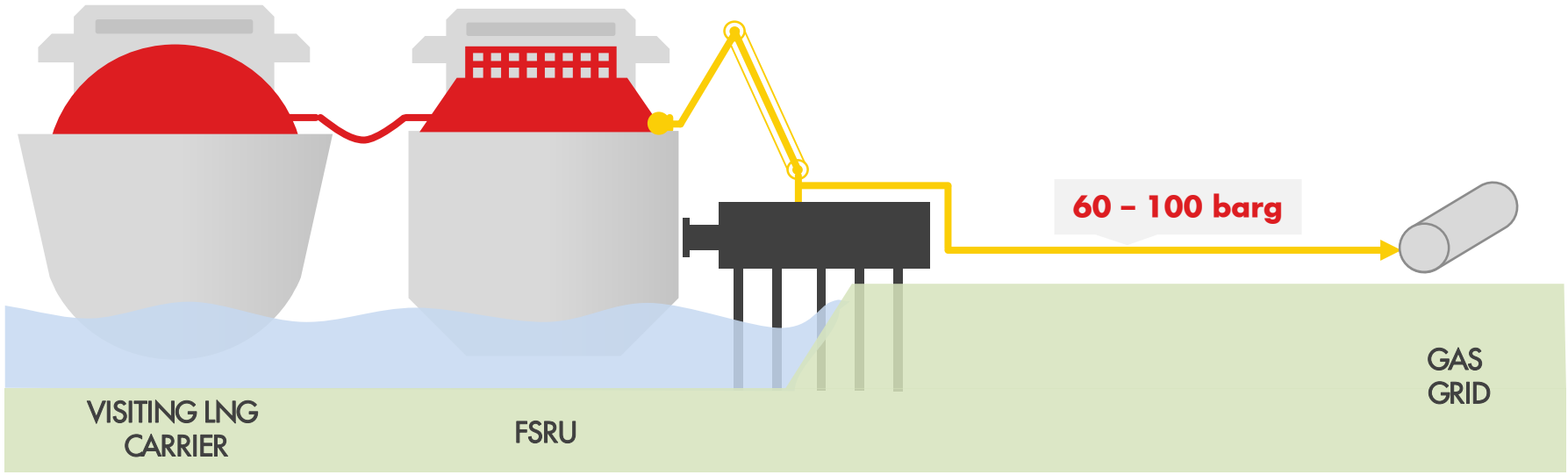
LNG supply chain



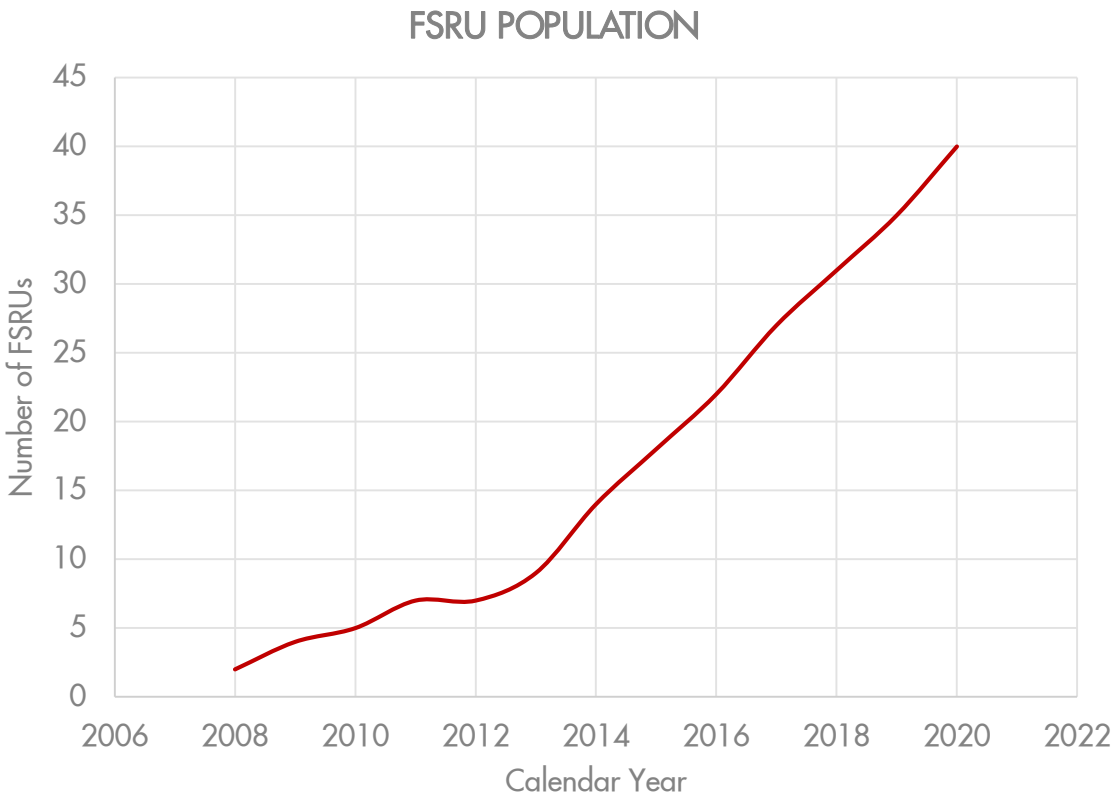
Onshore LNG regasification terminals

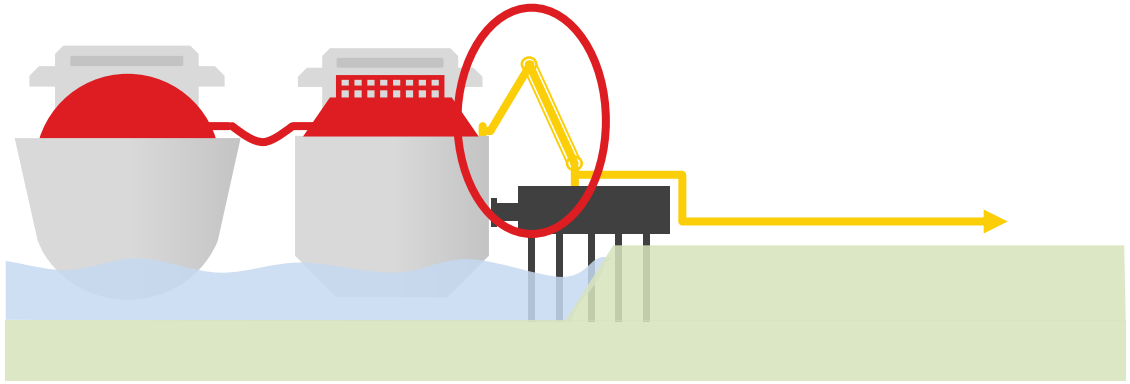


Floating storage & regasification units (FSRU)



FSRU population



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Marine loading arms

- Mechanical structure supporting of a set of **articulated pipes.**
- Designed to operate within a specific envelope
- An **emergency release system** (ERS) protects the arm in case of excessive movement
- The **ERS** is able to automatically isolate the arm from the ship and then disconnect

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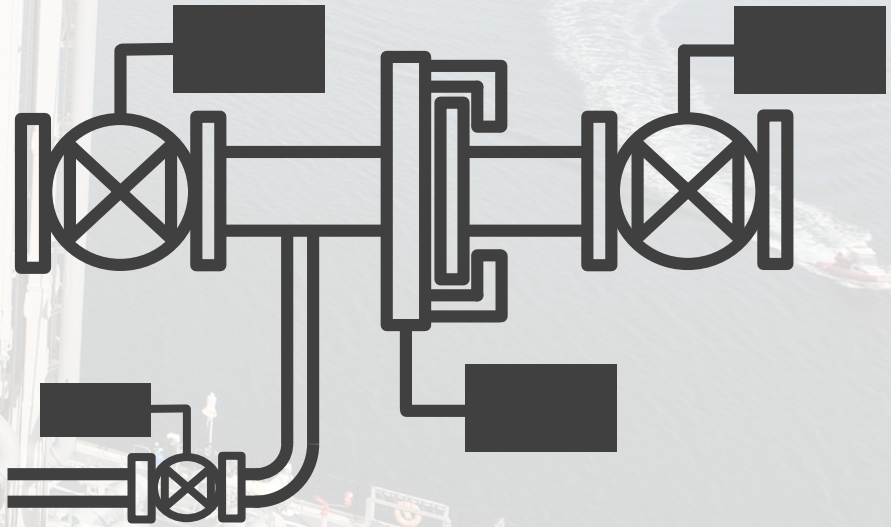
Emergency release system

LNG

Pressure < 5 barg

High Pressure Gas



Pressure <100 barg

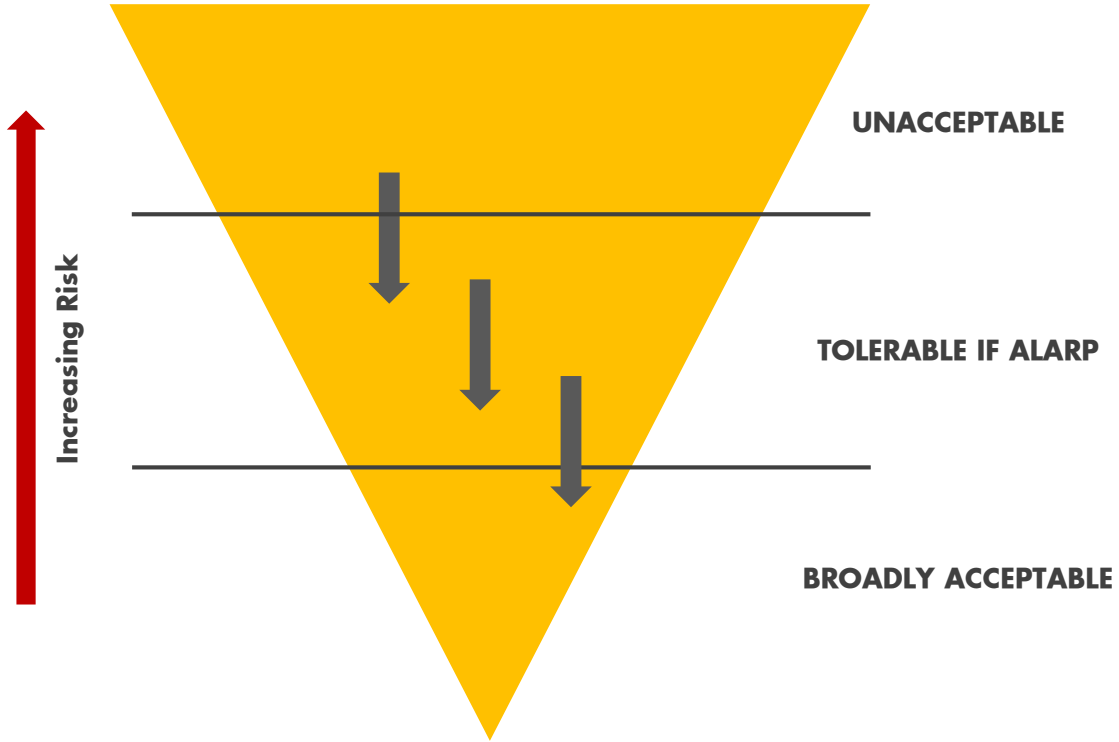
Managing Technology Risks

2.0

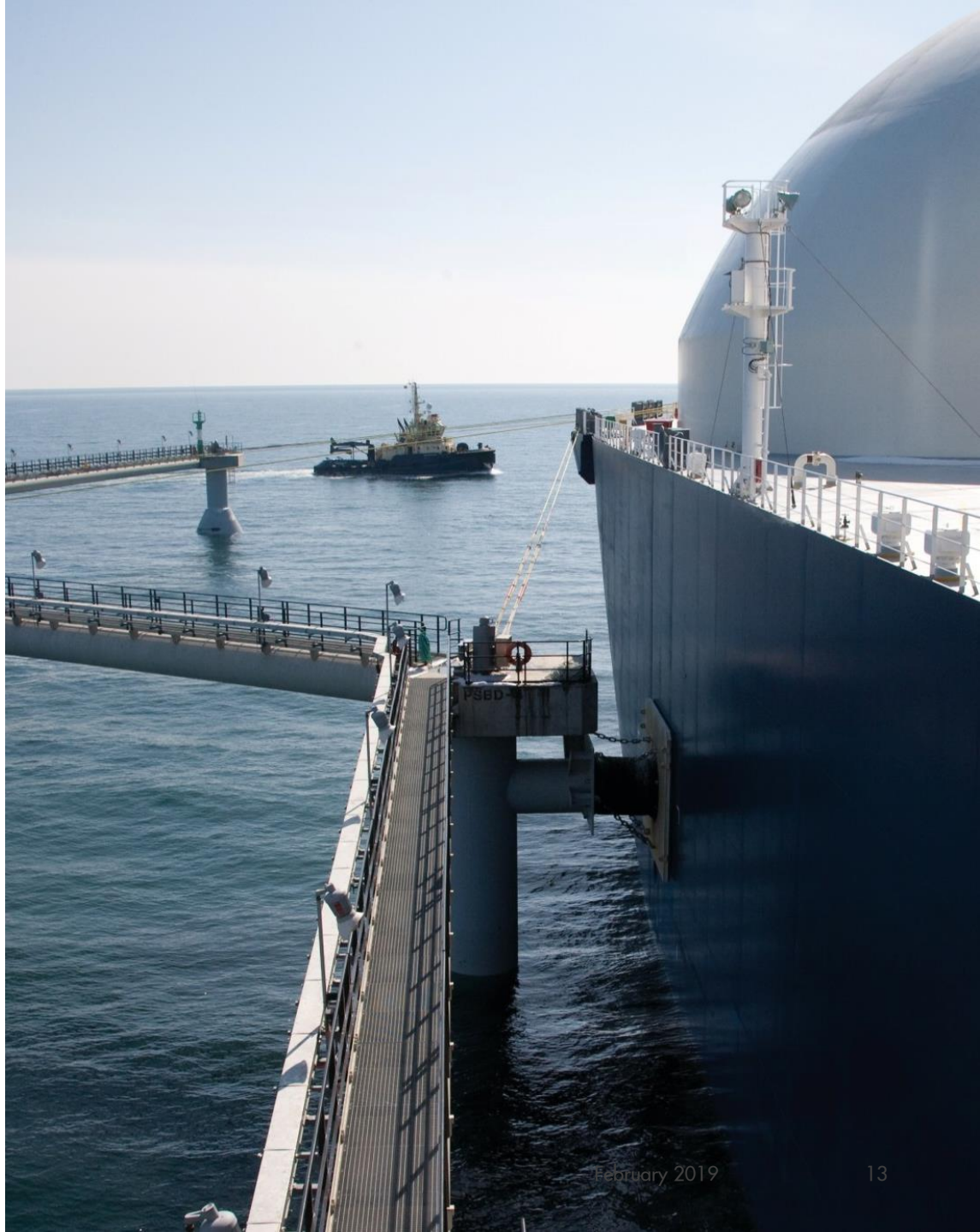
Technology development release

- **New technology** undergoes a thorough review process before **first project deployment**
- The goal is to assess **level of maturity** and to understand the associated **technical risks**

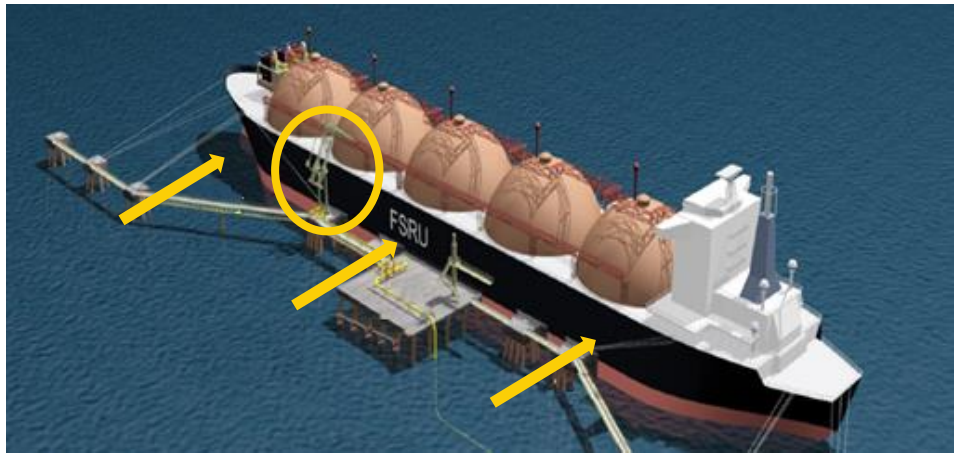
Risk management



"ALARP is achieved when risk is reduced to a level at which the cost and effort (time and trouble) of further risk reduction are grossly disproportionate to the risk reduction achieved."



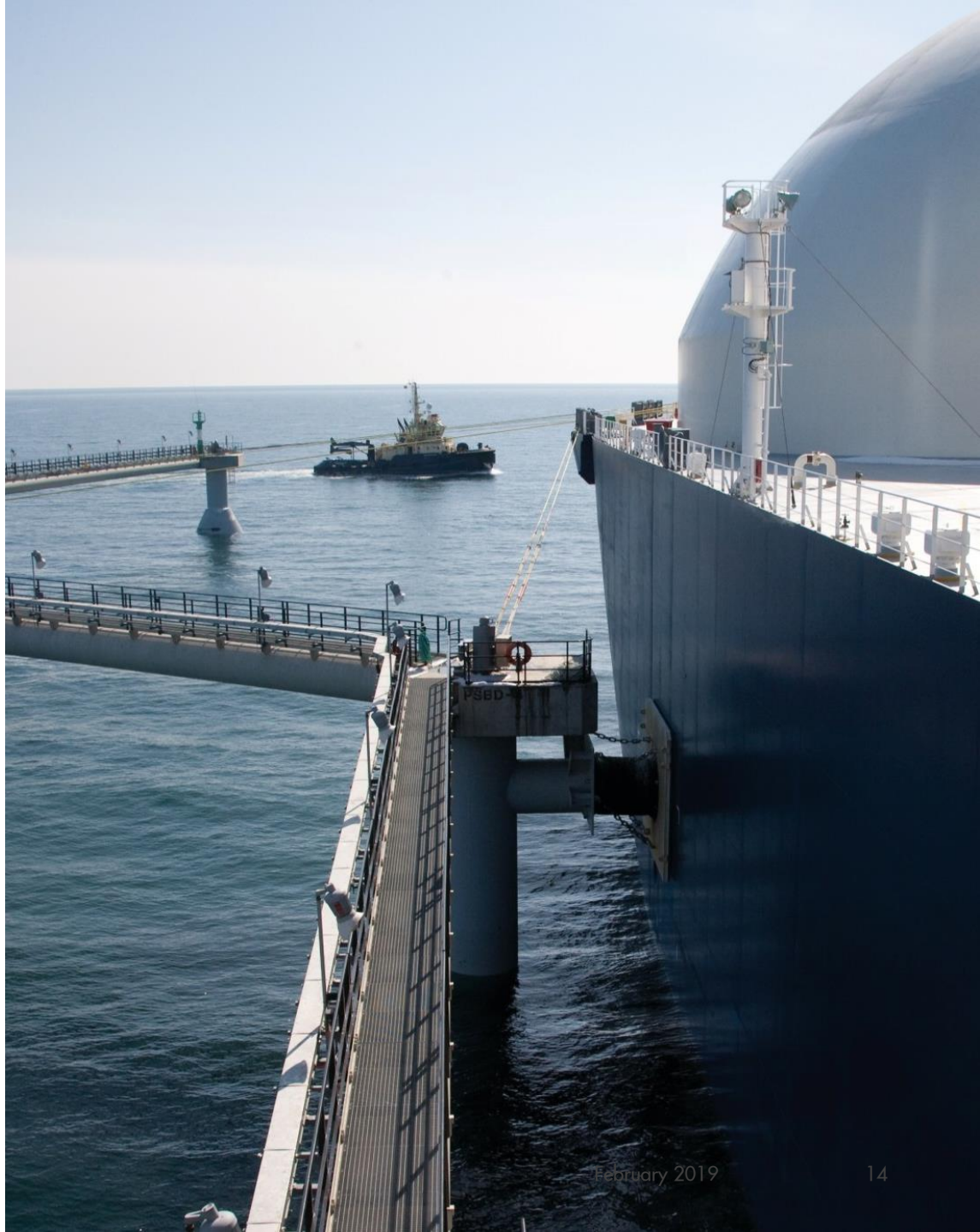
Initiating events



Floating Storage and Regasification Unit (FSRU)

- Extreme waves/currents/winds
  - Tropical cyclone
  - Squalls
  - Tsunami
- Earthquake
- Ship Collision
- Human error of commission
  - FSRU Engine testing
  - Ballasting Procedure
- Accidental Release of Mooring Hooks
- Rupture of a FSRU Mooring Line

THE RISK RETURN FREQUENCY CHANGES WITH THE SPECIFIC FSRU LOCATION

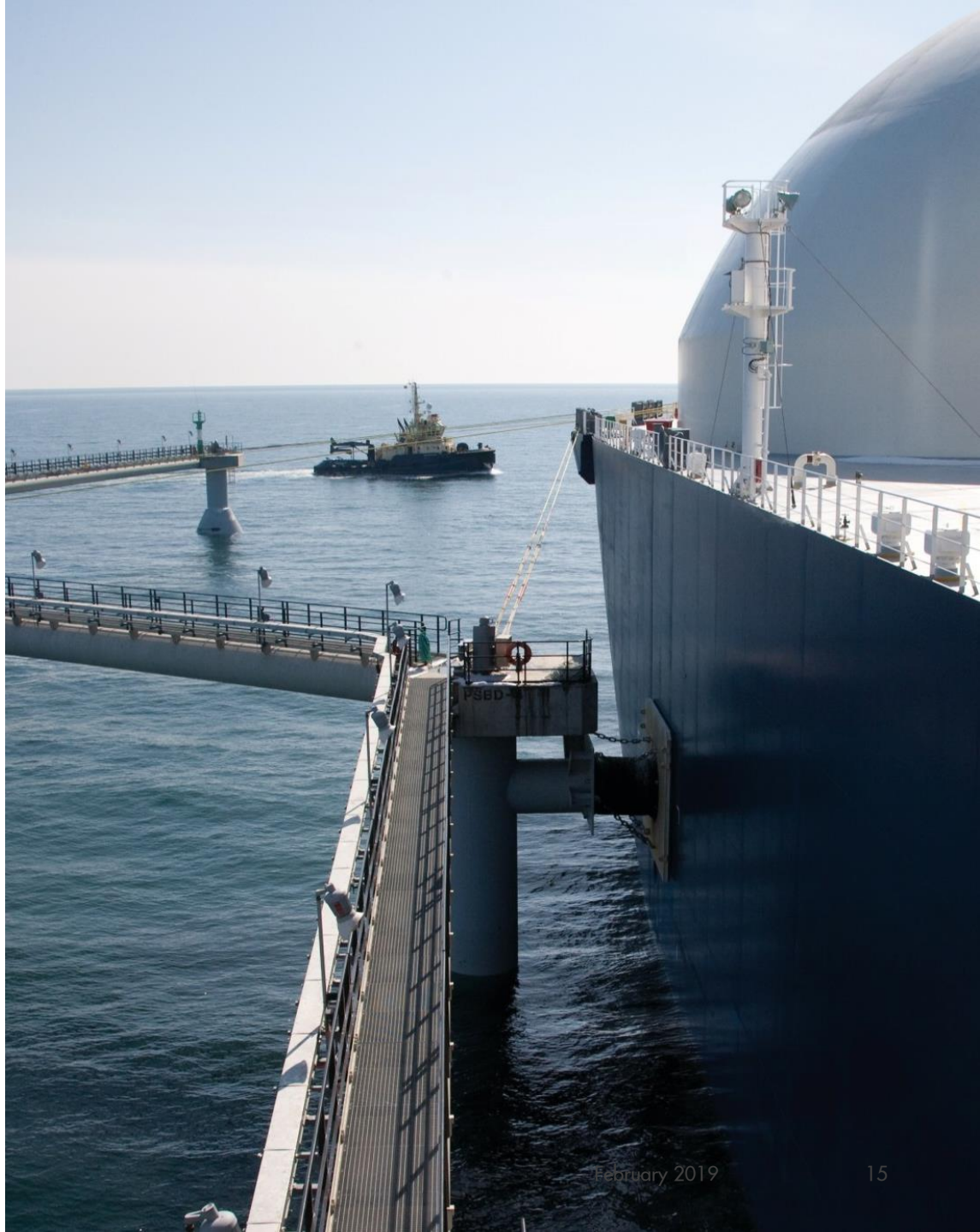


The hazard

- **Flammable substance.** There is a potential for ignition leading to fire, explosions, etc.

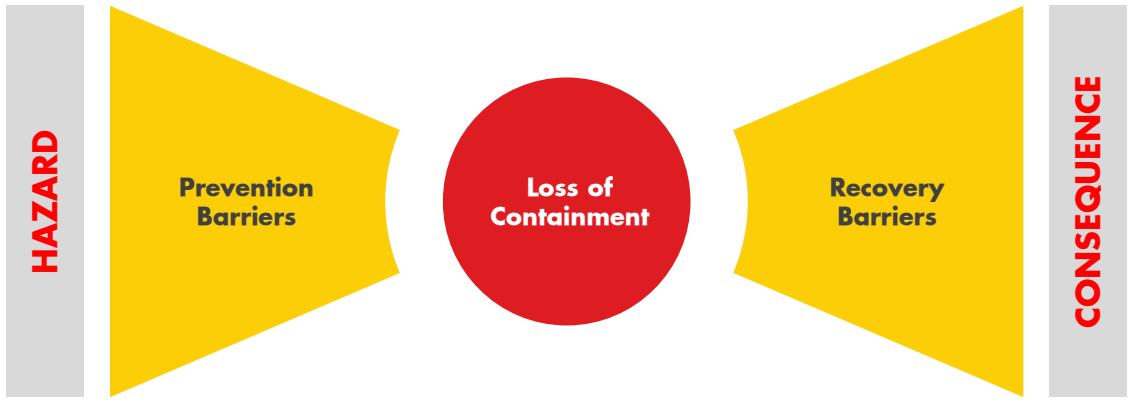
- **Pressurised gas** in large volume. Being compressible, gases can store significant potential energy that could lead to a violent and destructive set of events if rapidly released, due to the effect of the explosive decompression and reaction forces (even without ignition).

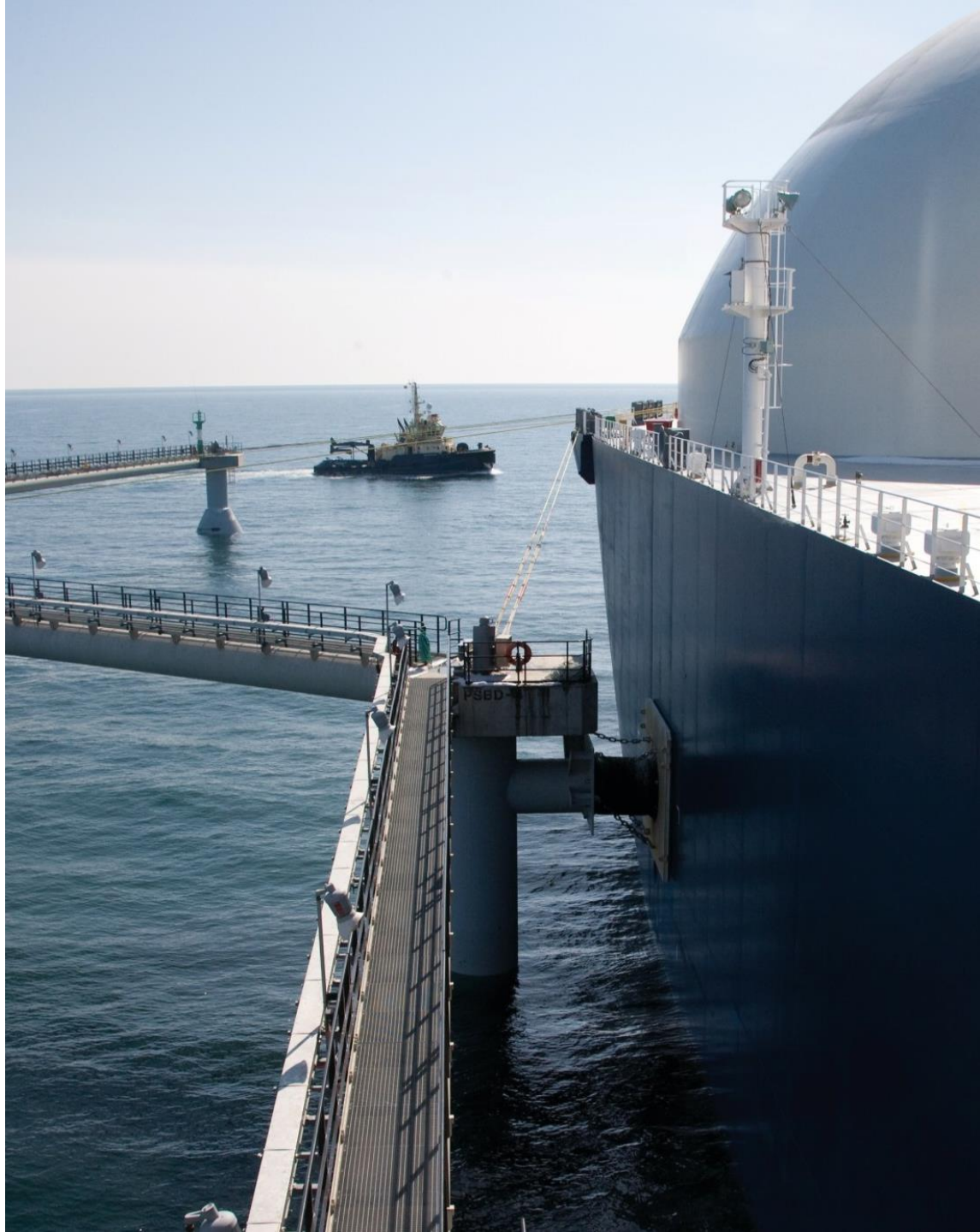
THE CONSEQUENCE SEVERITY IS IMPACTED BY THE POTENTIAL ENERGY OF THE SYSTEM



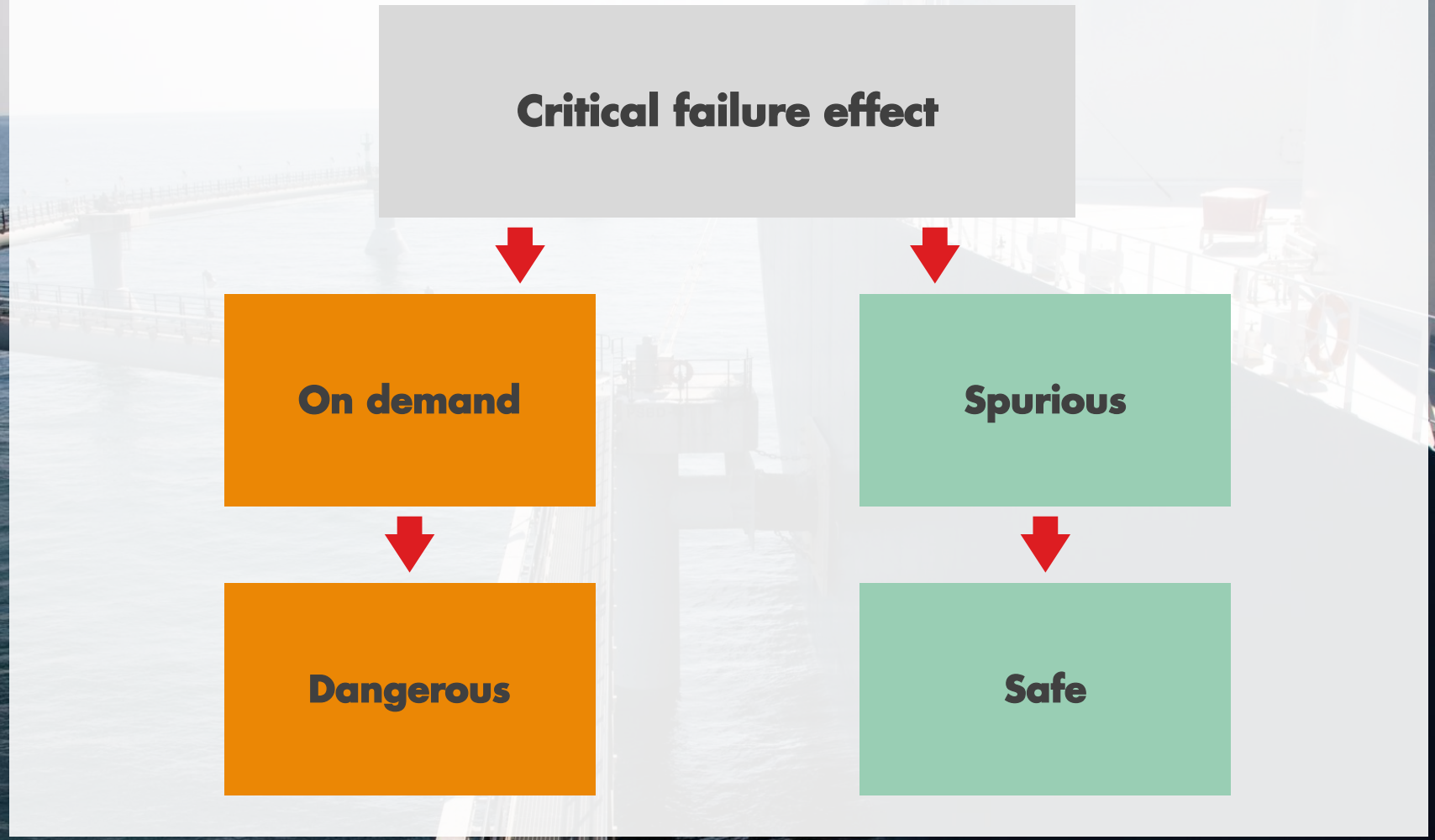
Safety barriers

- A safety barrier is an element that **prevents, controls or mitigates a risk**
- The risk reduction of a barrier is measured by its **probability of failure on demand (PFD)**
- A **risk assessment** process establishes whether the arms require an **emergency release system** (ERS) and determines its required **risk reduction target**.



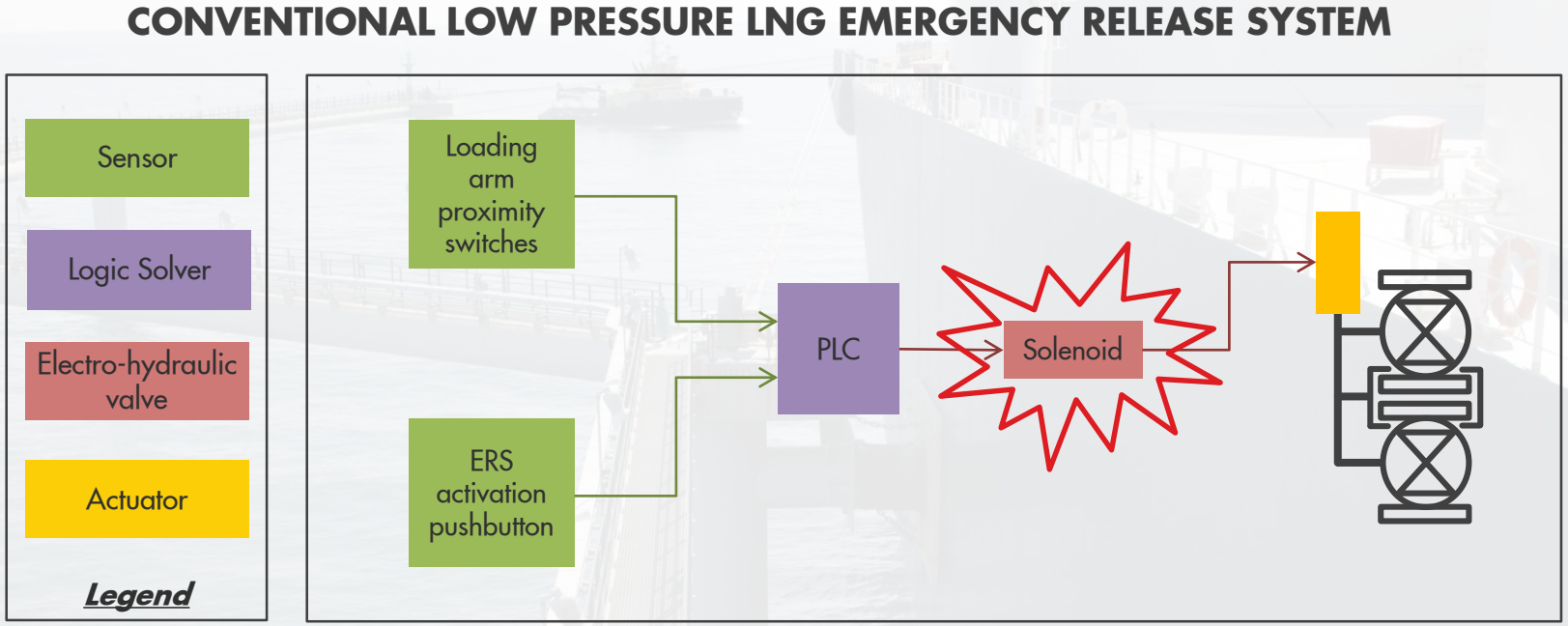


Safety hardware critical failures



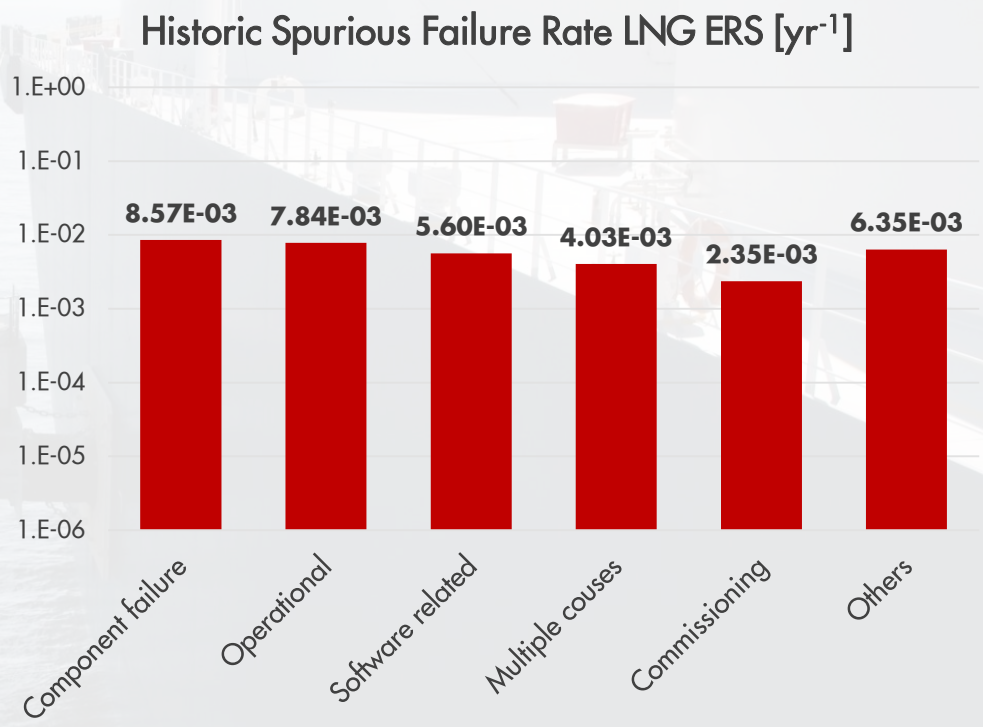
Spurious ERS activation incident during LNG transfer to shore

Risk of spurious ERS activation



History of spurious ERS activations during LNG transfer operations

Cause of Release	Number of Incidents	% of Reported Incidents
Component Failure	9	28%
Operational	8	25%
Software related	5	16%
Multiple causes	3	9%
Commissioning	1	3%
Others	6	19%
Total	**32**	**100%**



Data collected since 1995

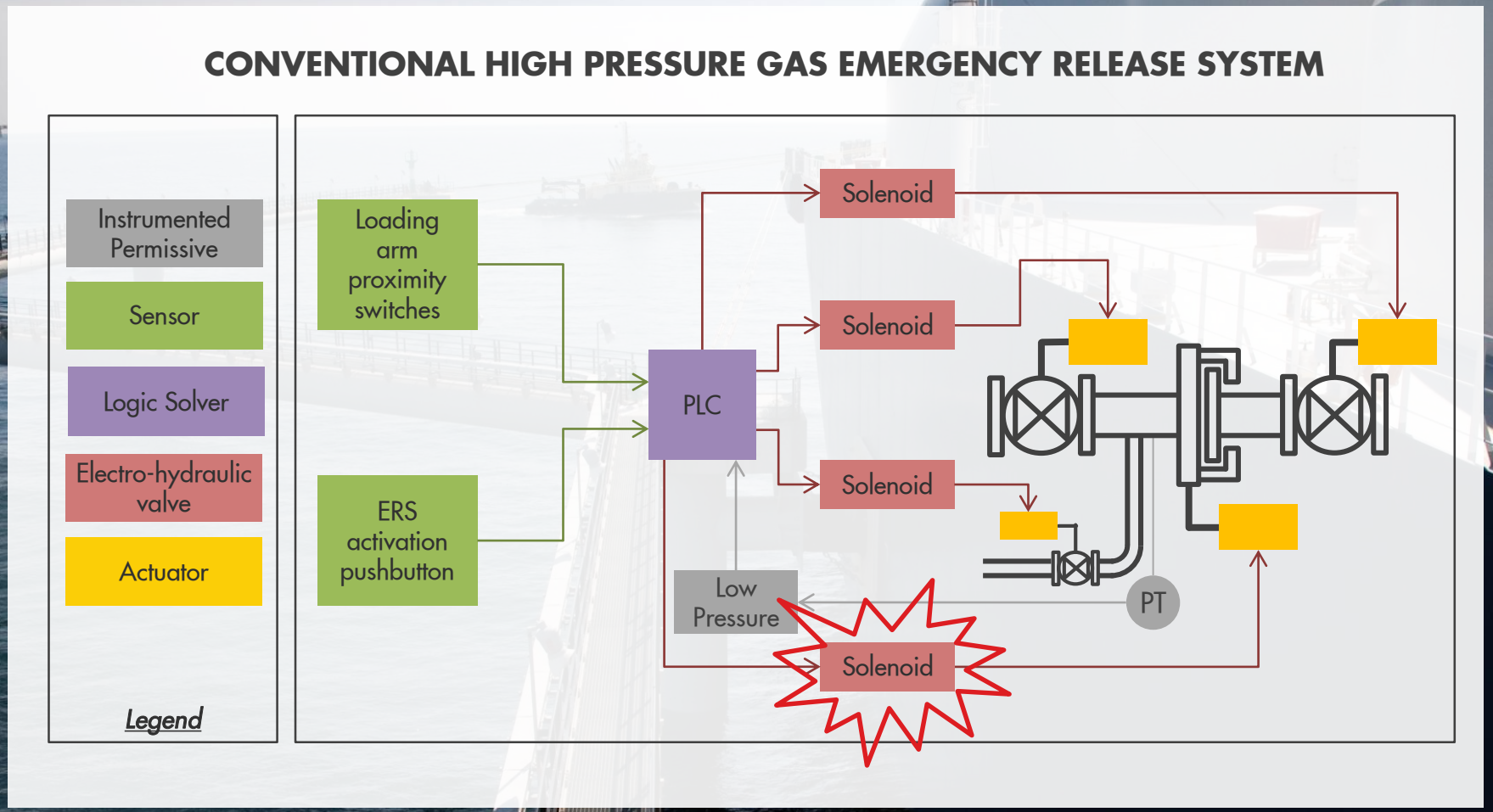
Component Failure: a spurious activation as a result of a hardware failure.

Operational: a spurious activation as a result of human error.

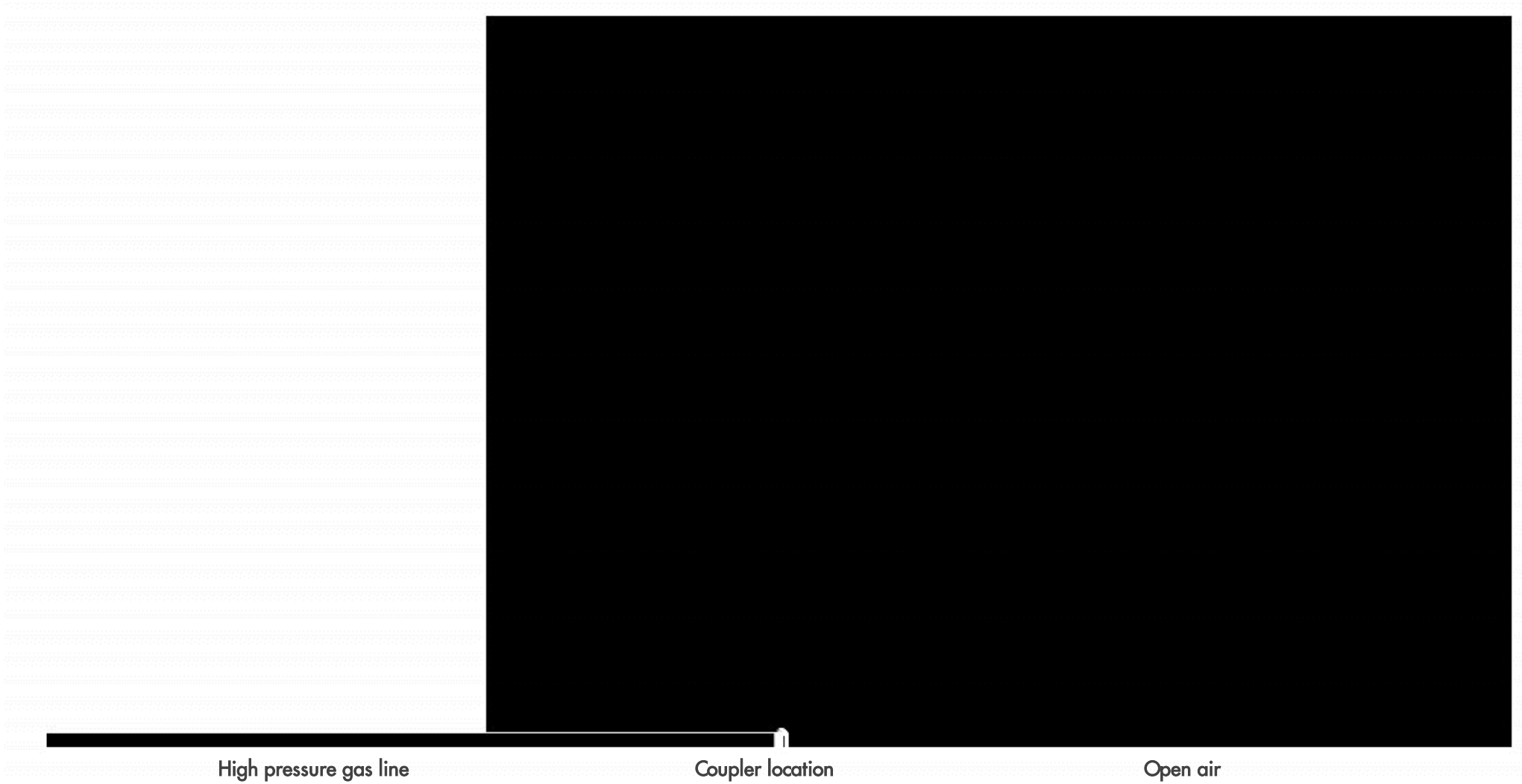
Software Related: a spurious activation as a result of a software fault.

Data source: LNG Emergency Release Systems. Recommendations, Guidelines and Best Practices [Report] / auth. SIGTTO. - [s.l.] : Witherby, 2017

Risk of spurious disconnection

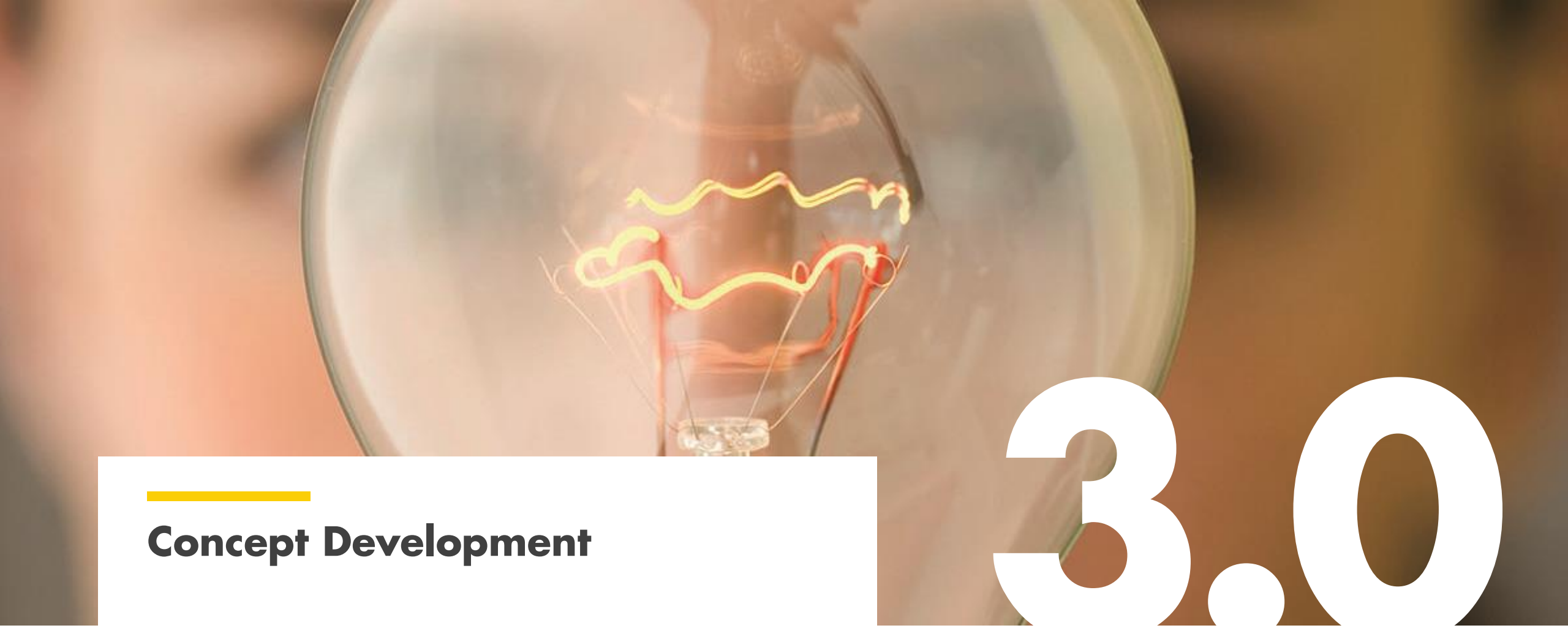


CFD explosive decompression of high pressure natural gas



Pneumatic test accident Shanghai LNG import terminal. Feb. 2009

Safety hardware critical failures



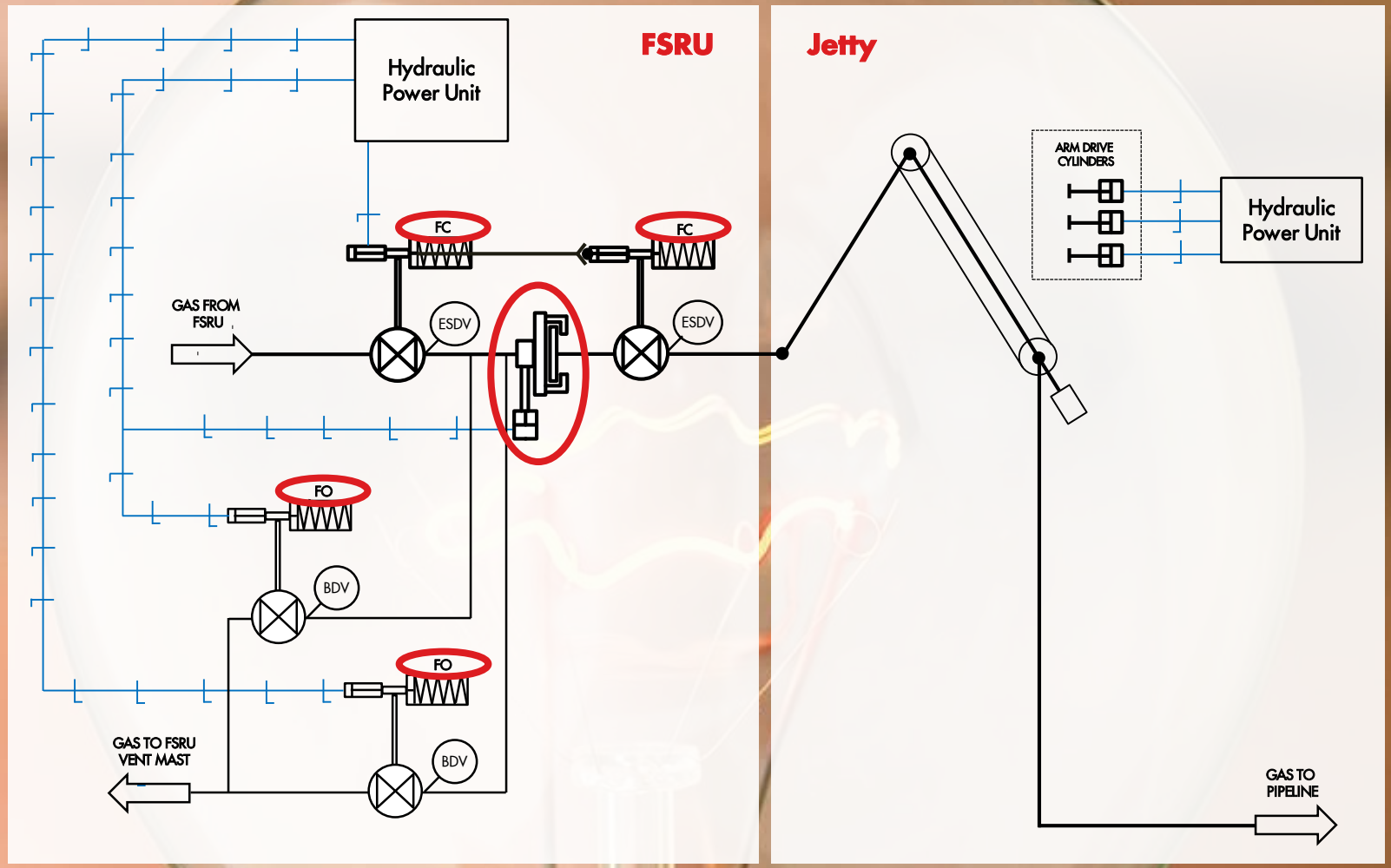
3.0

Concept Development

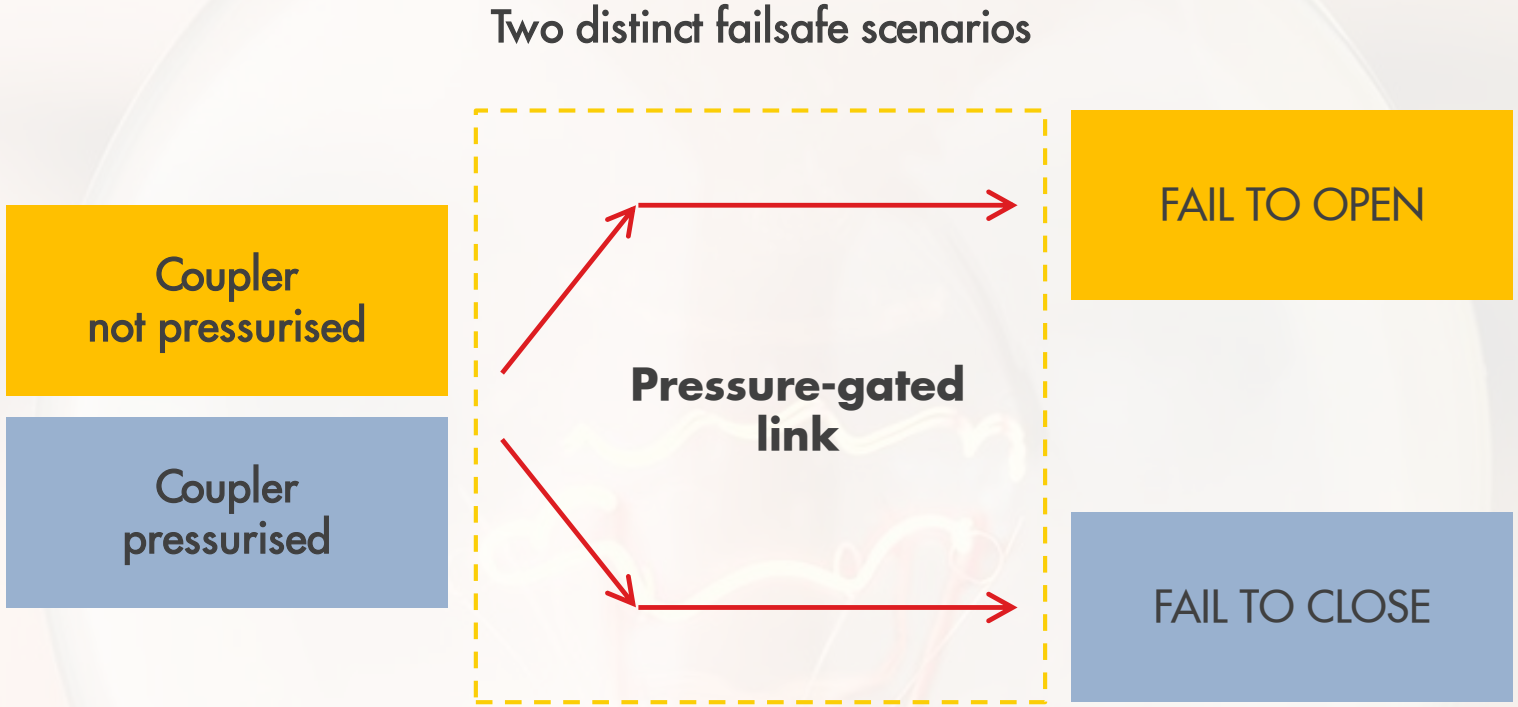
Design Objectives

- Integrity to achieve the required PFD:
  - Component selection
  - Architecture design
  - Testing frequency
- Sufficient spurious fault tolerance

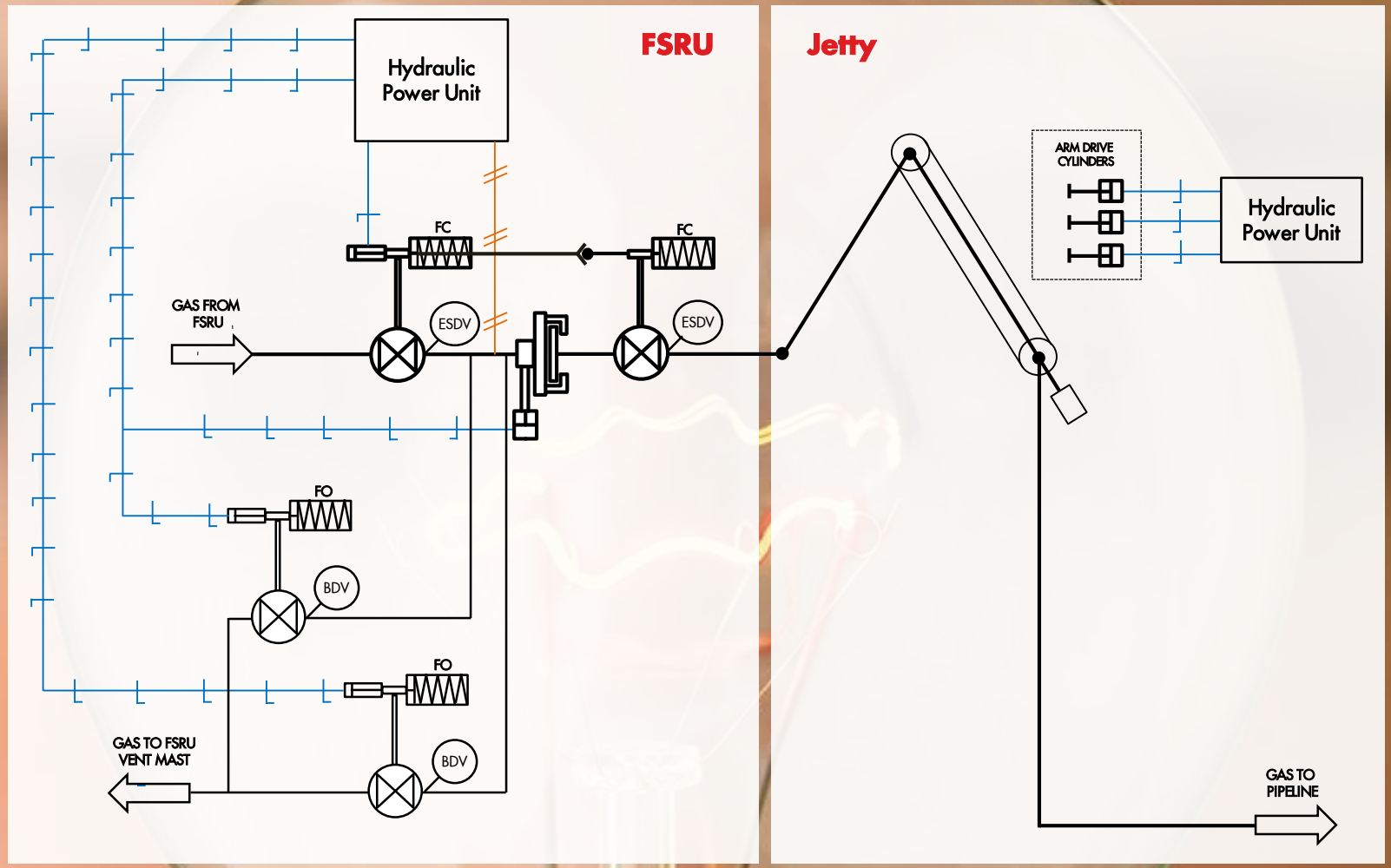
HP ERS concept design features



Required failsafe operation of the coupler



Pressure-gated link connection



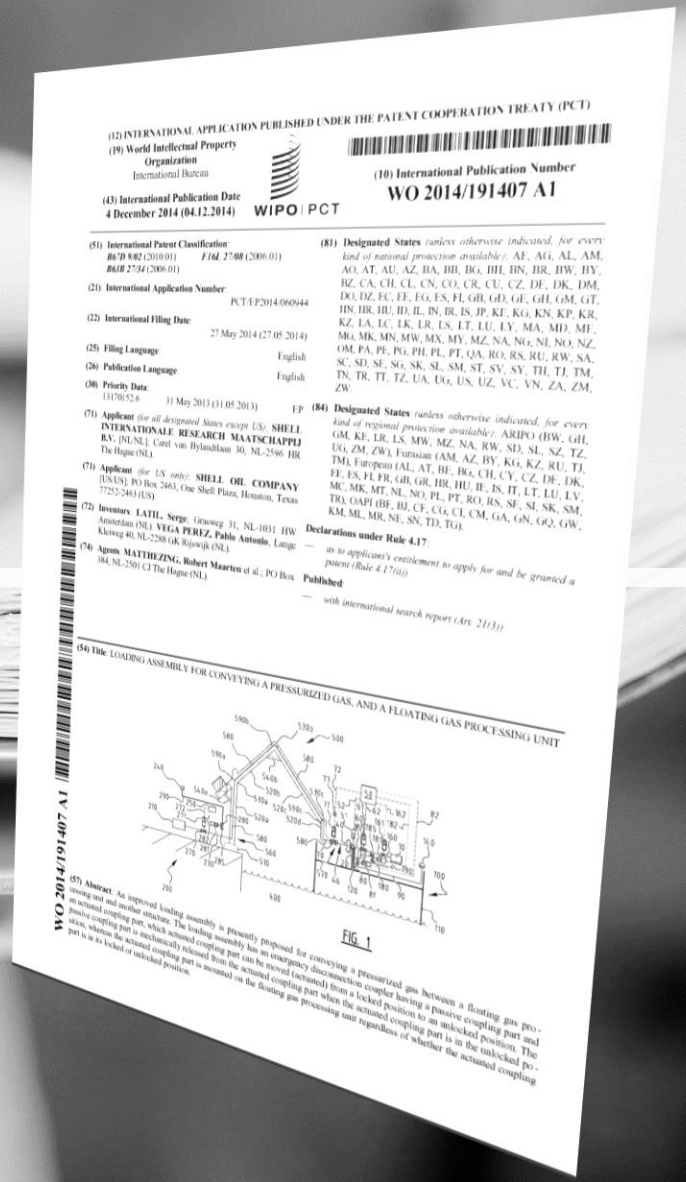
Proof of Concept

4.0

Proof of concept

Intellectual Property

1



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(10) International Publication Number
WO 2014/191407 A1

(43) International Publication Date
4 December 2014 (04.12.2014)

WIPO | PCT

(54) Title: LOADING ASSEMBLY FOR CONVEYING A PRESSURIZED GAS, AND A FLOATING GAS PROCESSING UNIT

FIG. 1

Proof of concept

Intellectual Property

1

2

Contracting Strategy

Proof of concept

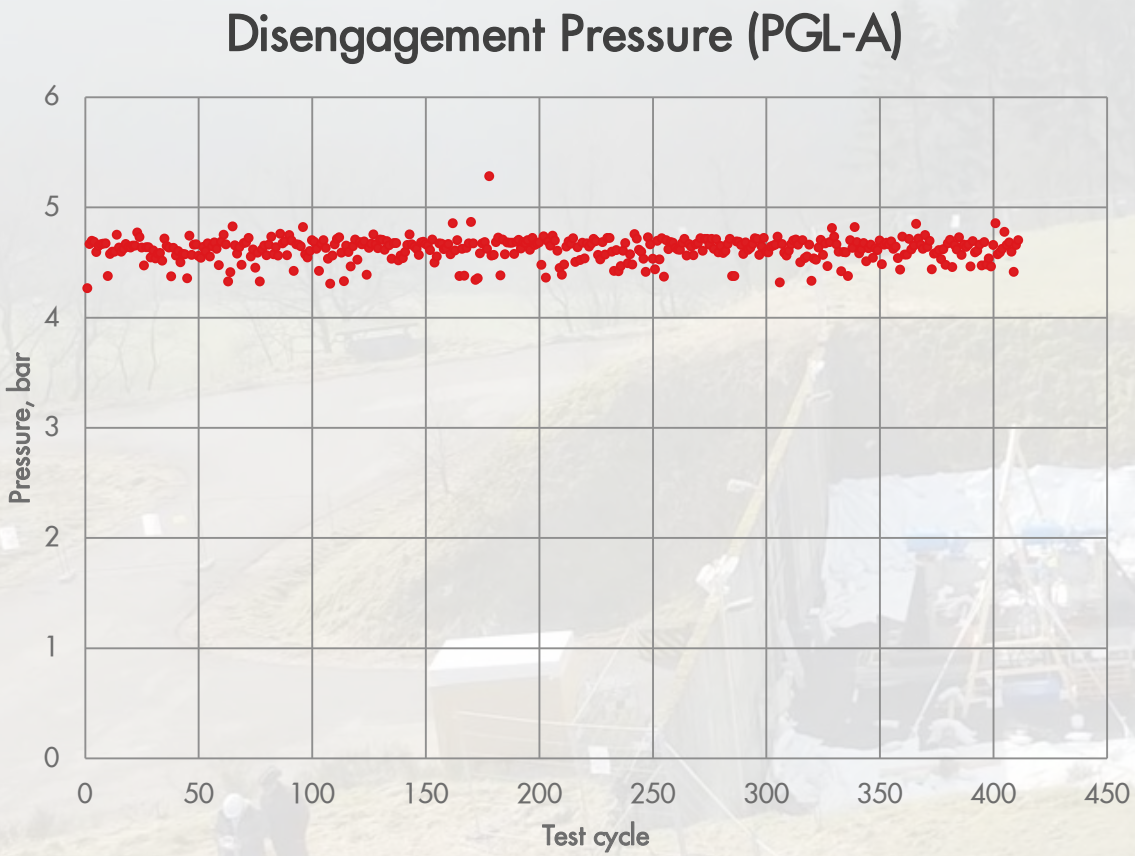
Proof of concept

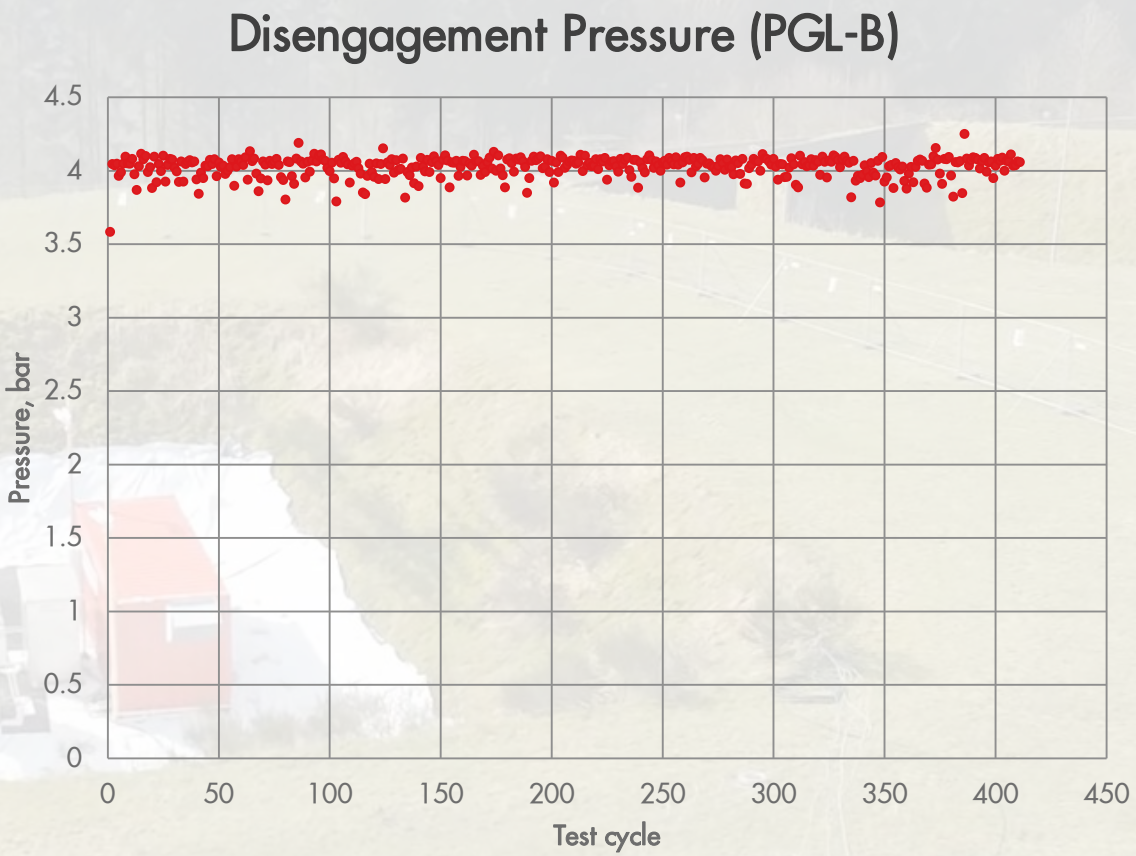
Proof of concept

Proof of concept

HP ERS testing

Key test results



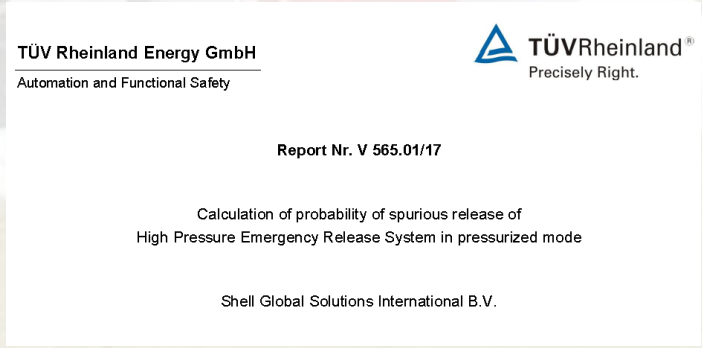


Design validation and certification

- Rigorous design review (FMEA, HAZID, HAZOP, etc.)
- Successfully tested simulating emergency release at real pressure conditions
- 500 testing cycles
- Design and testing supervised and certified by TÜV Rheinland:

PFD: SIL 2 capability

SPT: 3.5E-6 yr^{-1}



TÜV Rheinland Energy GmbH
Automation and Functional Safety

TÜVRheinland®
Precisely Right.

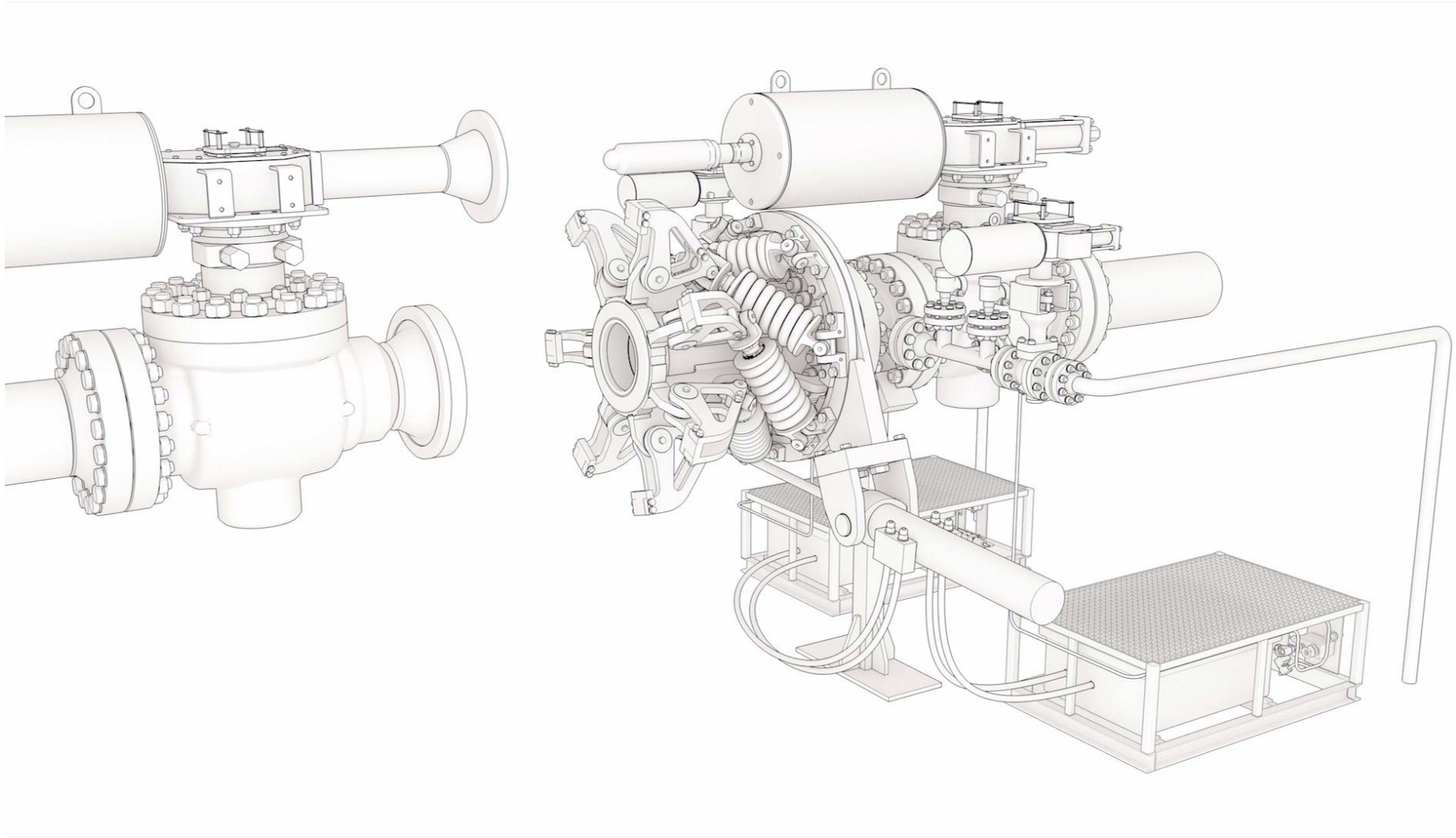
Report Nr. V 565.01/17

Calculation of probability of spurious release of
High Pressure Emergency Release System in pressurized mode

Shell Global Solutions International B.V.

HP gas transfer arm connection

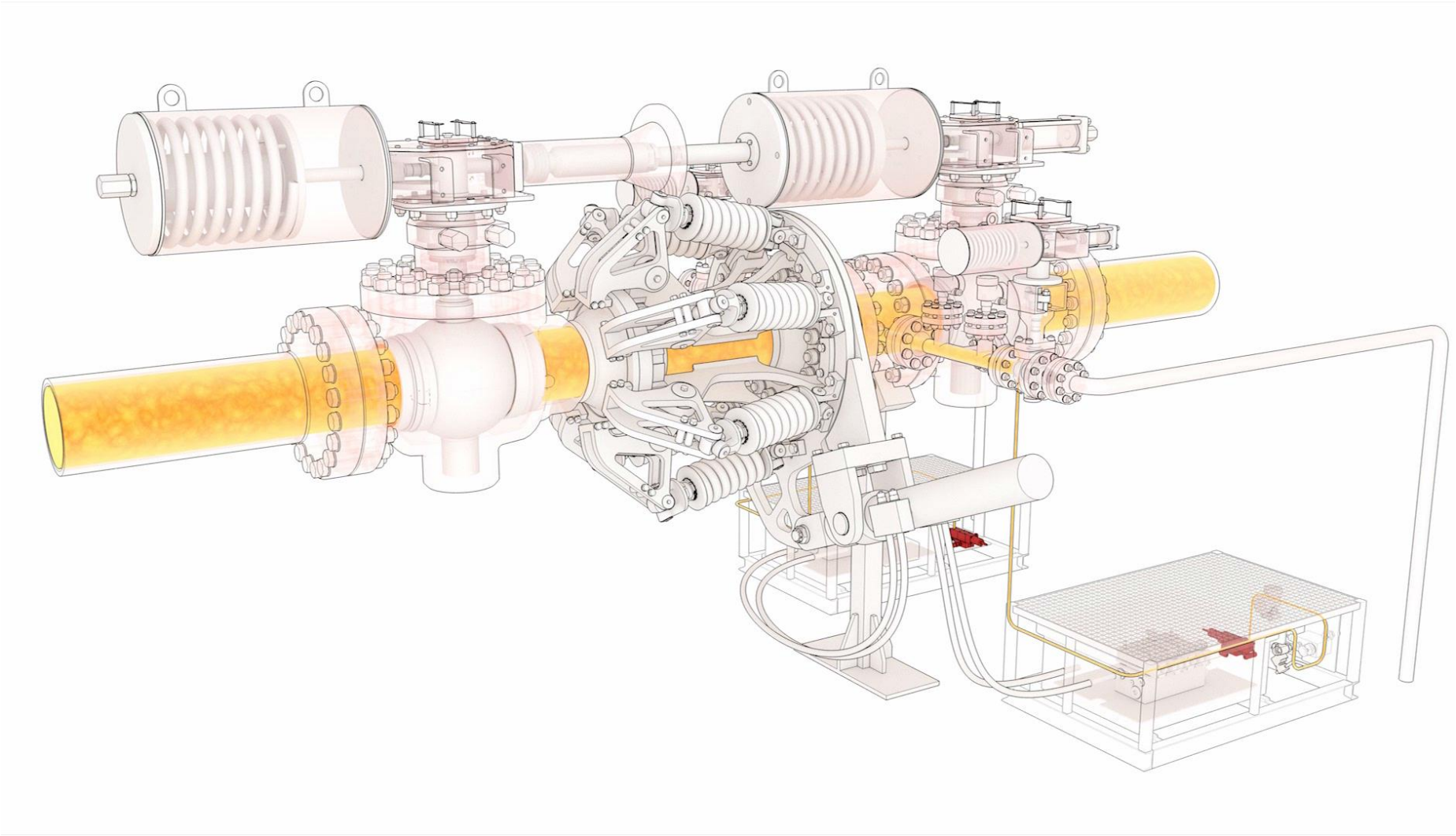
ARM SIDE



FSRU SIDE

HP gas transfer arm emergency release

ARM SIDE



FSRU SIDE

5.0 Commercialisation and Advocacy

Commercialisation

- Shell retains ownership of the Shell HP ERS IP
- Shell HP ERS commercialised by Emco Wheaton under license
- Third parties have full access to Shell HP ERS
- Shell HP ERS can be retrofit in existing HP gas transfer arm

Advocacy

TARGET GROUPS

- Shell Project Partners
- FSRU Owners & Providers
- Classification Societies
- Loading Arms OEMs
- Industry Groups
- Technical standards working groups
- Industry Exhibitions and Conferences