



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

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The Hague, February 2019

Content of the presentation

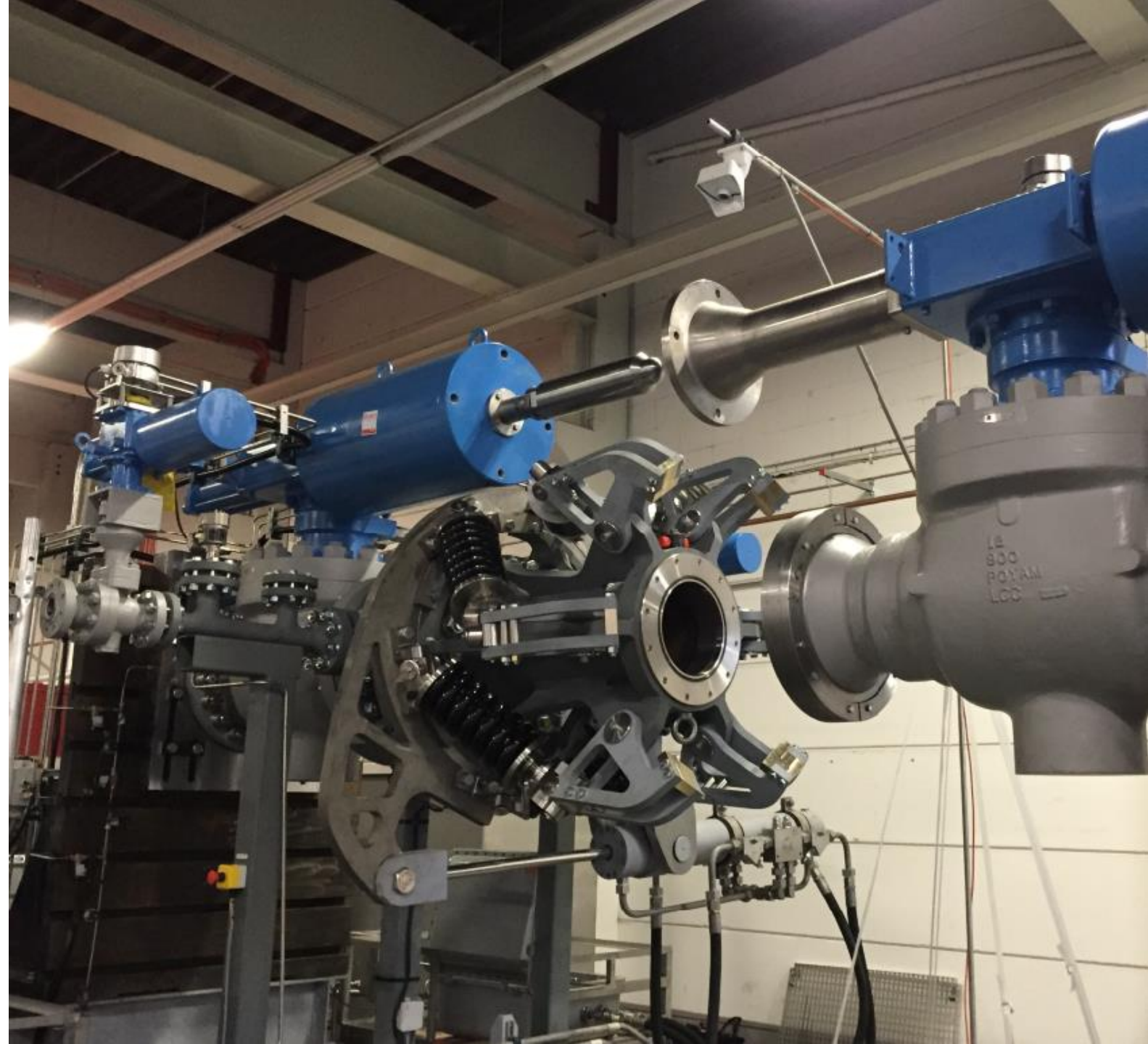
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5 Commercialisation and Advocacy

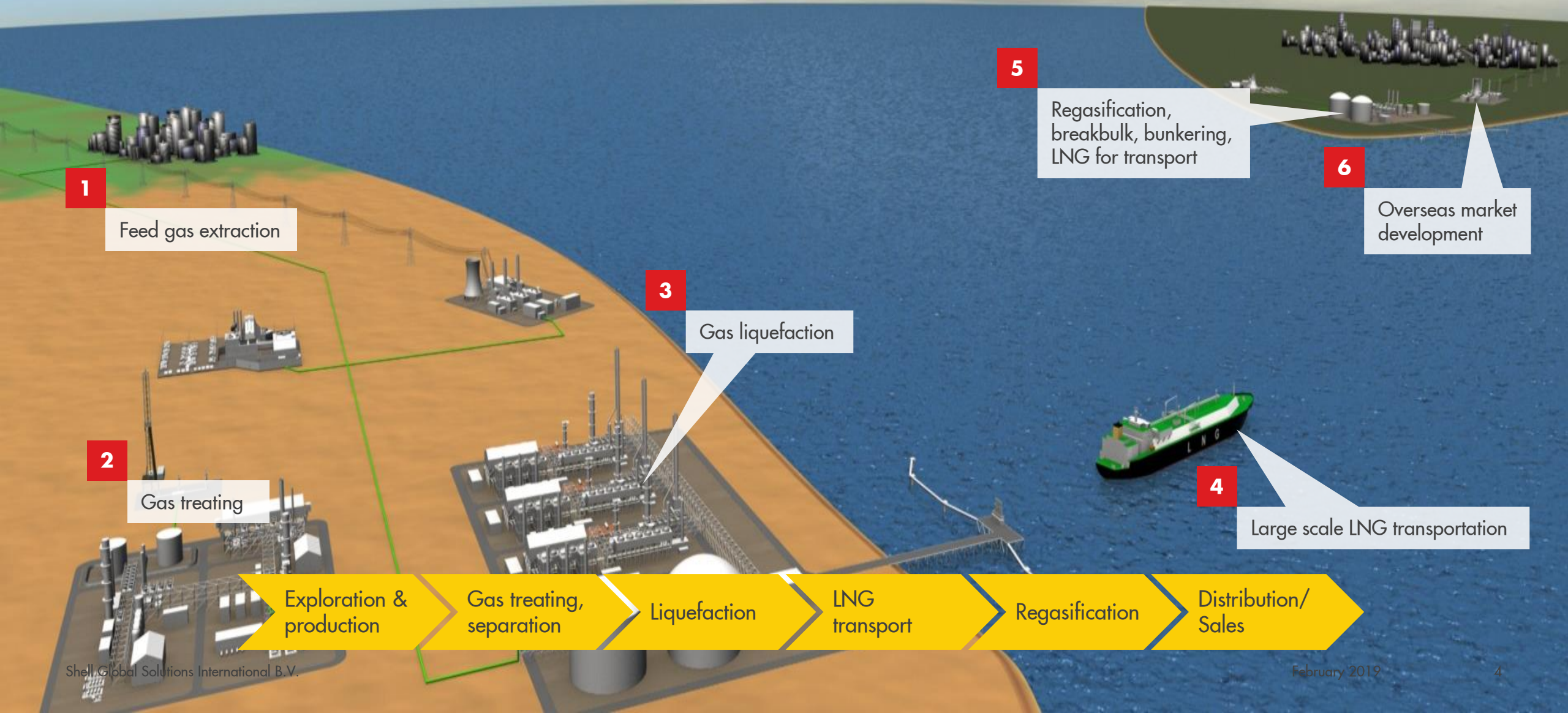




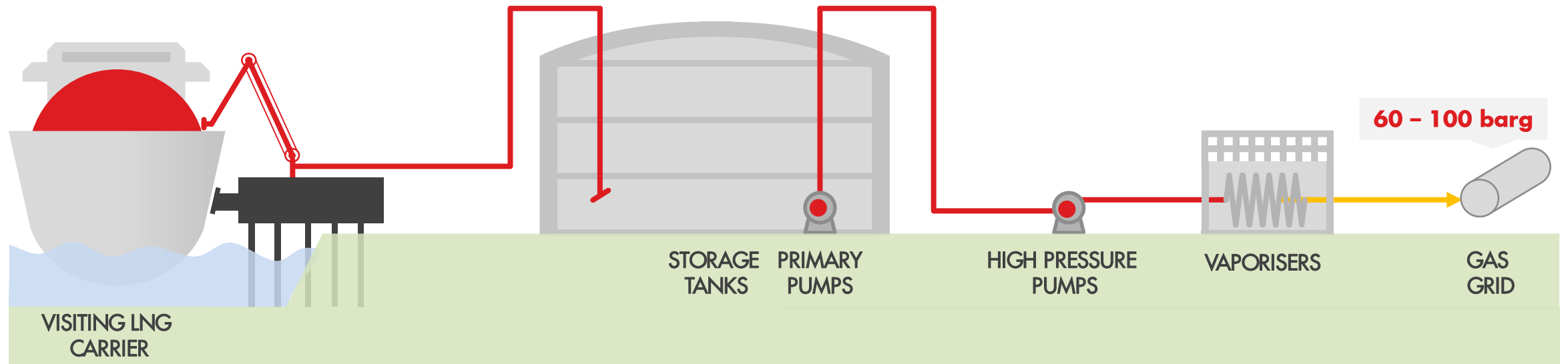
Background

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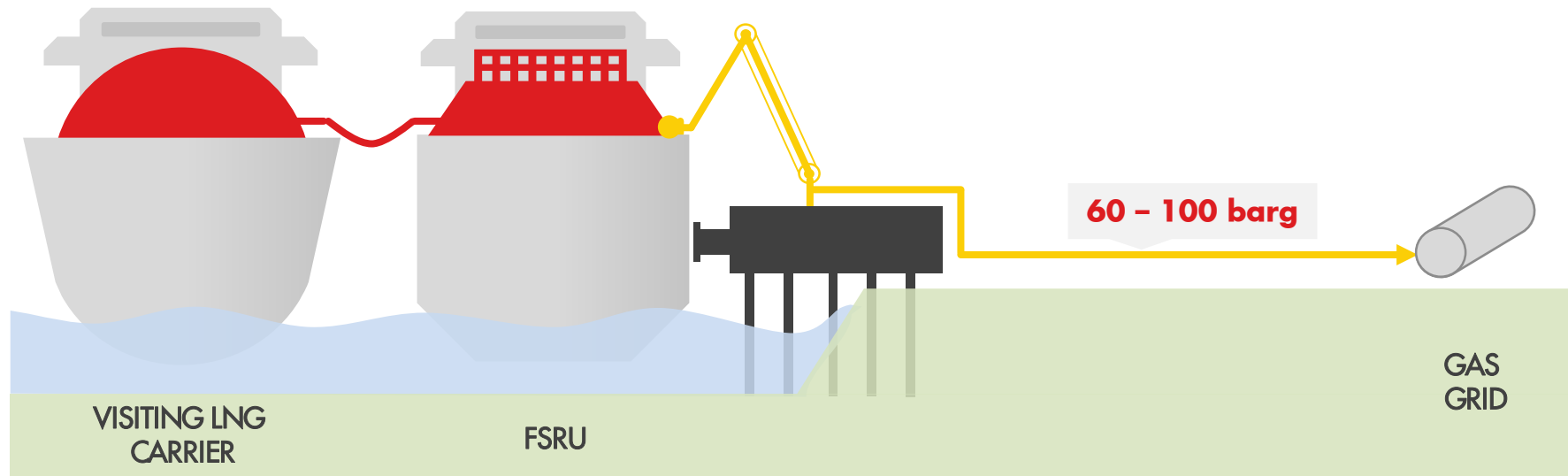
LNG supply chain



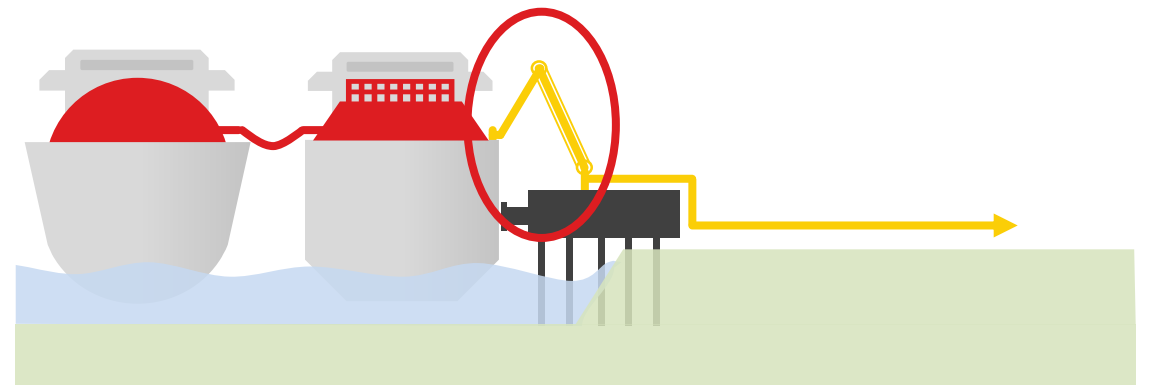
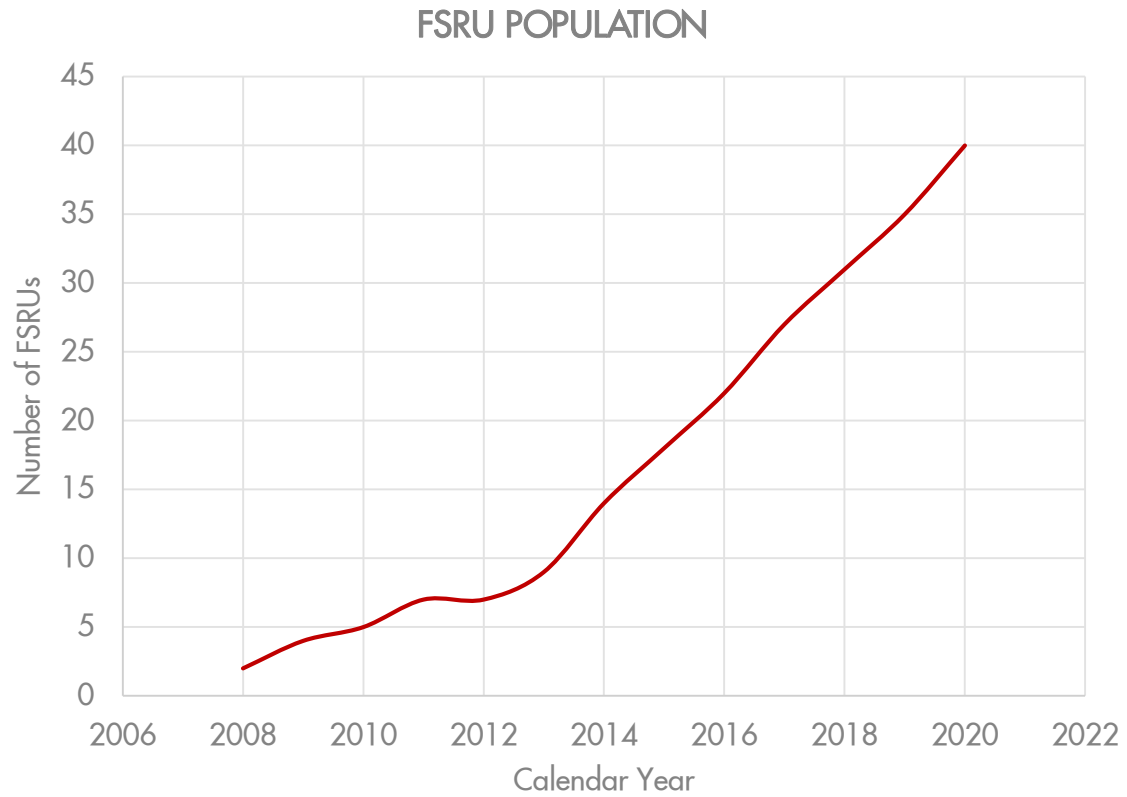
Onshore LNG regasification terminals



Floating storage & regasification units (FSRU)



FSRU population







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

Marine loading arms

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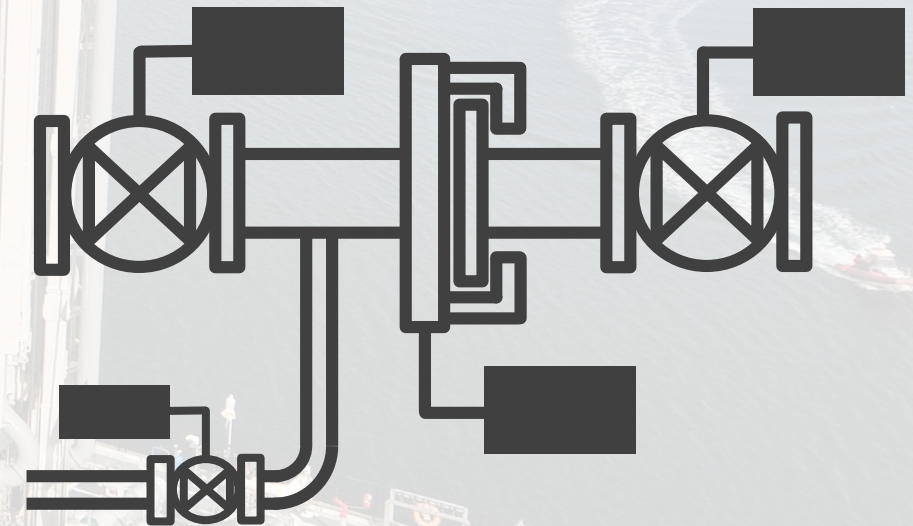
Emergency release system

LNG



Pressure < 5 barg

High Pressure Gas



Pressure < 100 barg



2020

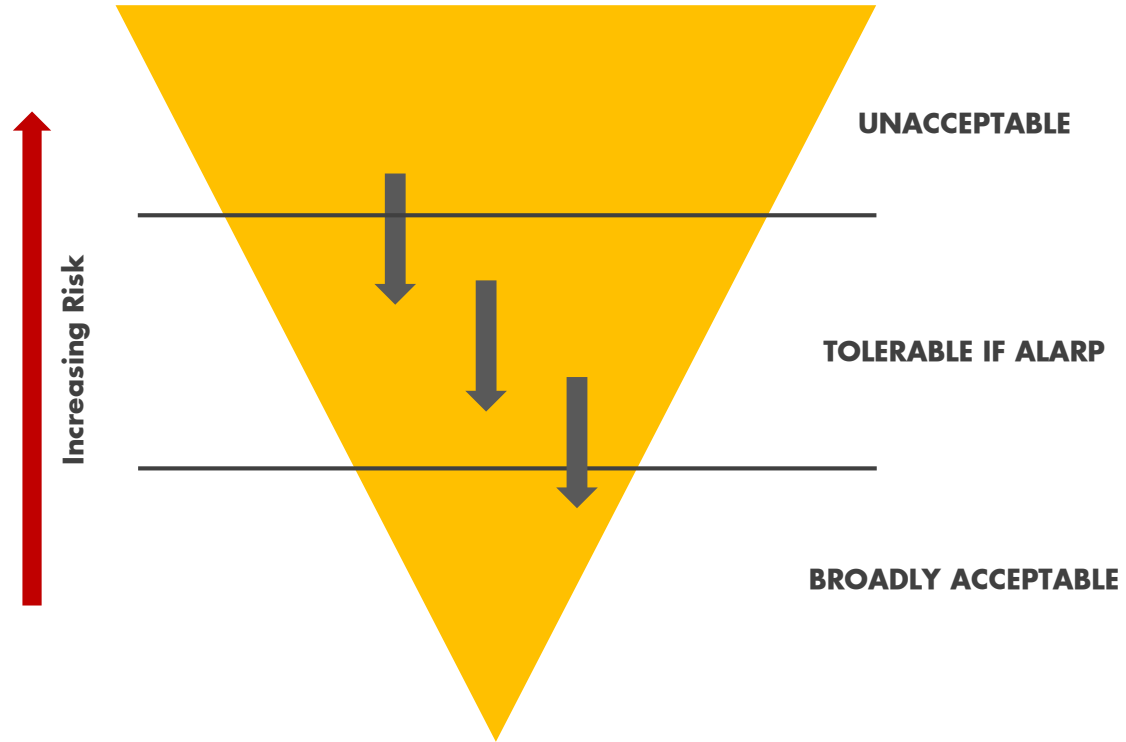
Managing Technology Risks

Technology development release

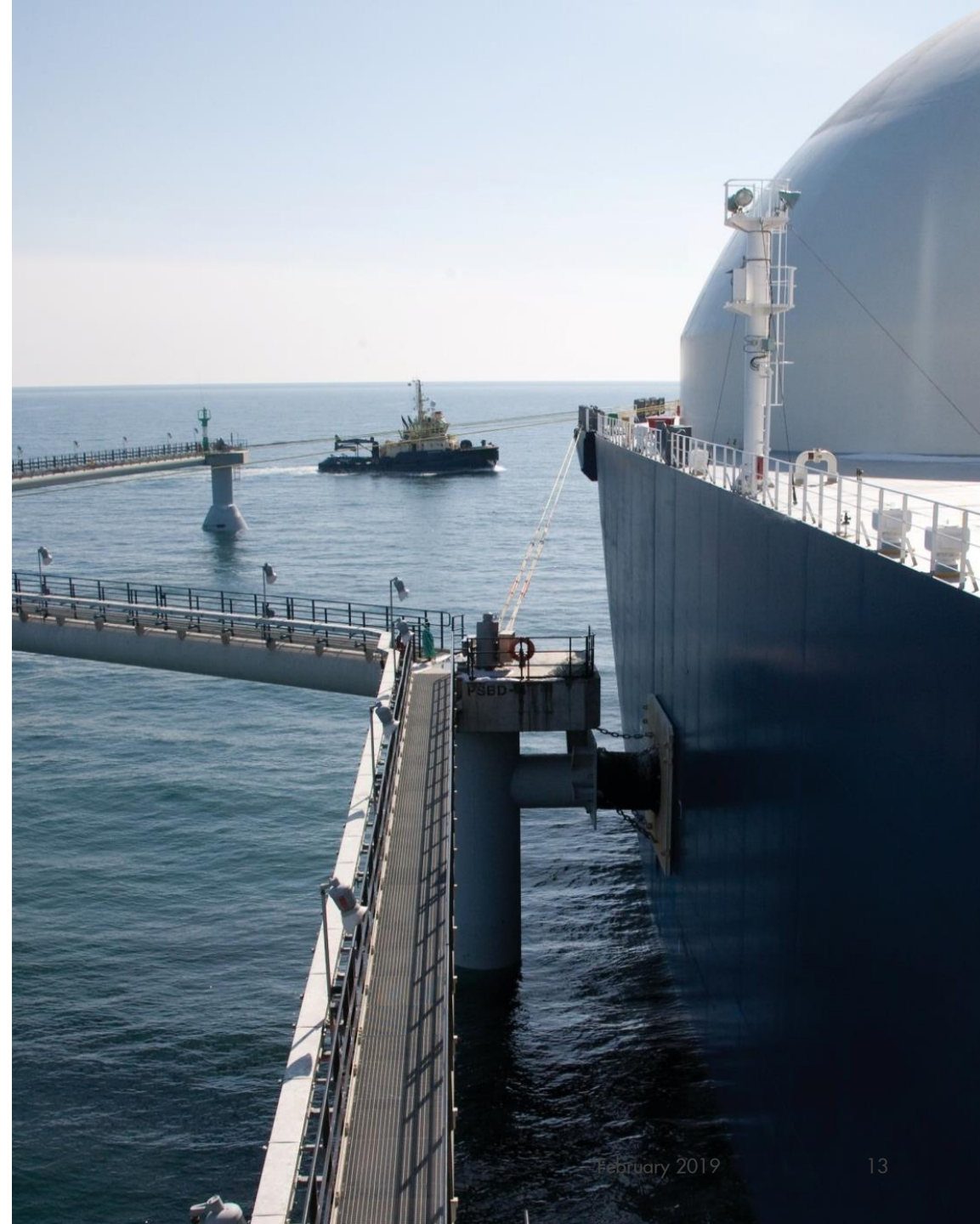
- New technology undergoes a thorough review process before first project deployment
- The goal is to assess **level of maturity** and to understand the associated **technical risks**



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.”



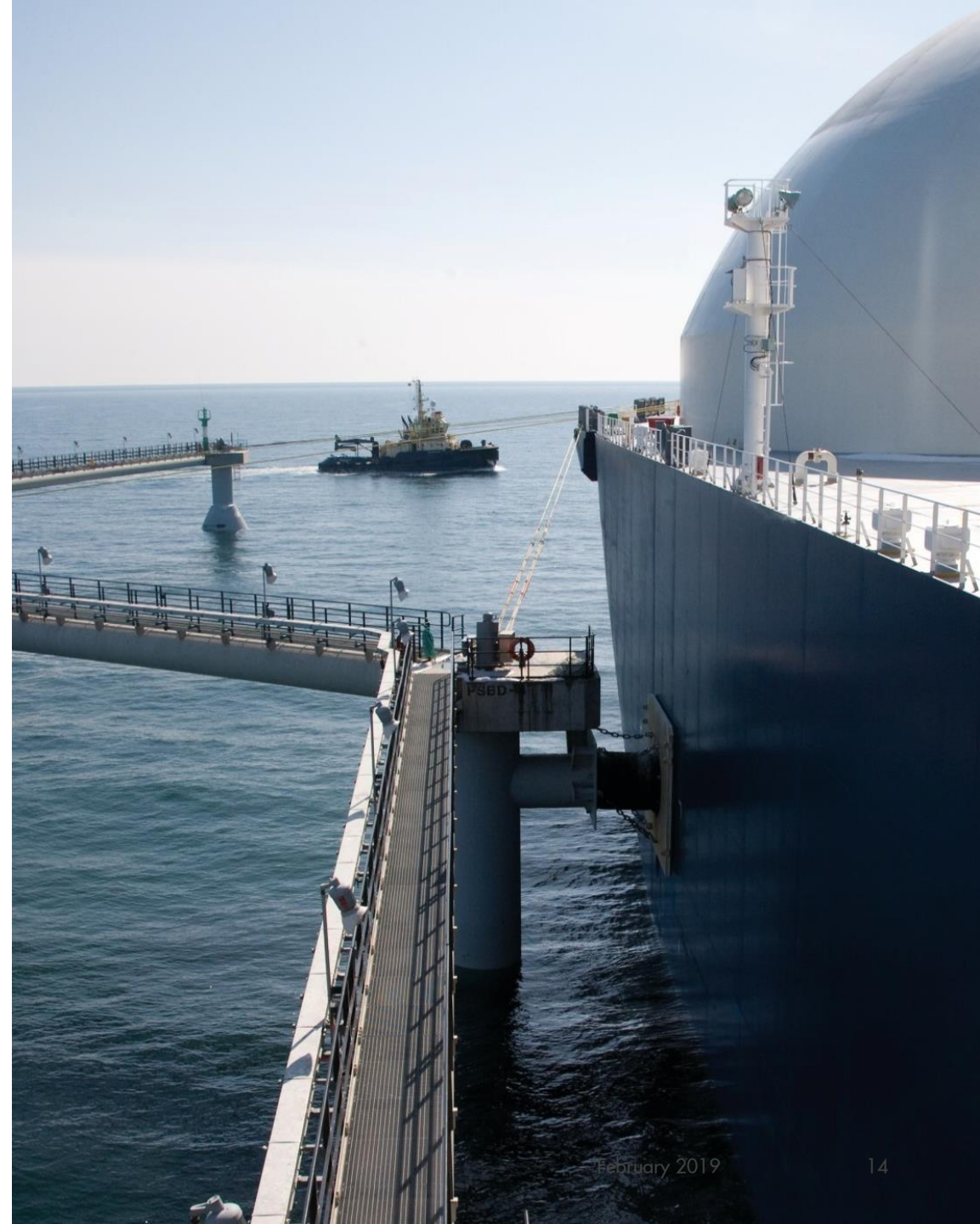
Initiating events



◀ 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

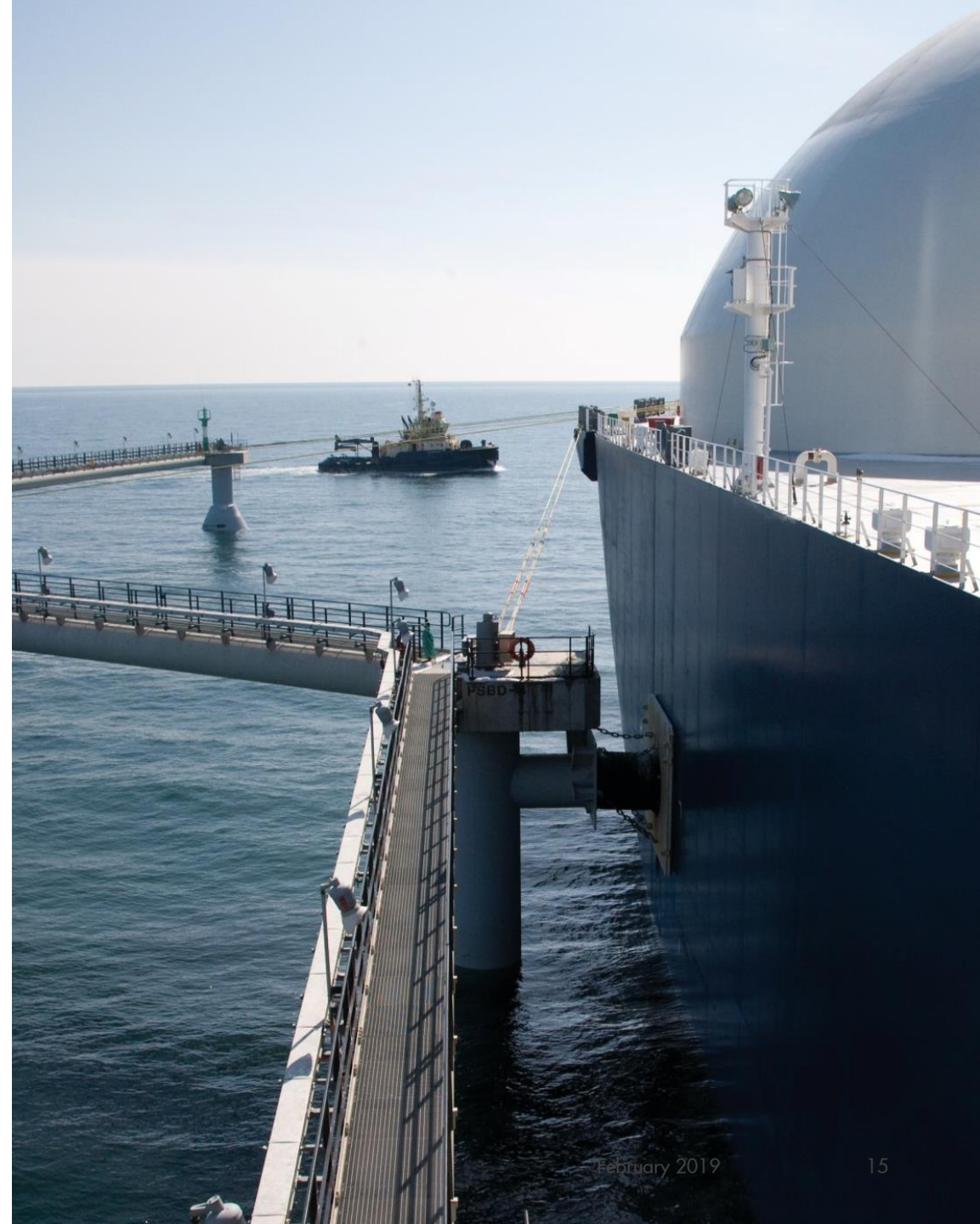


The hazard



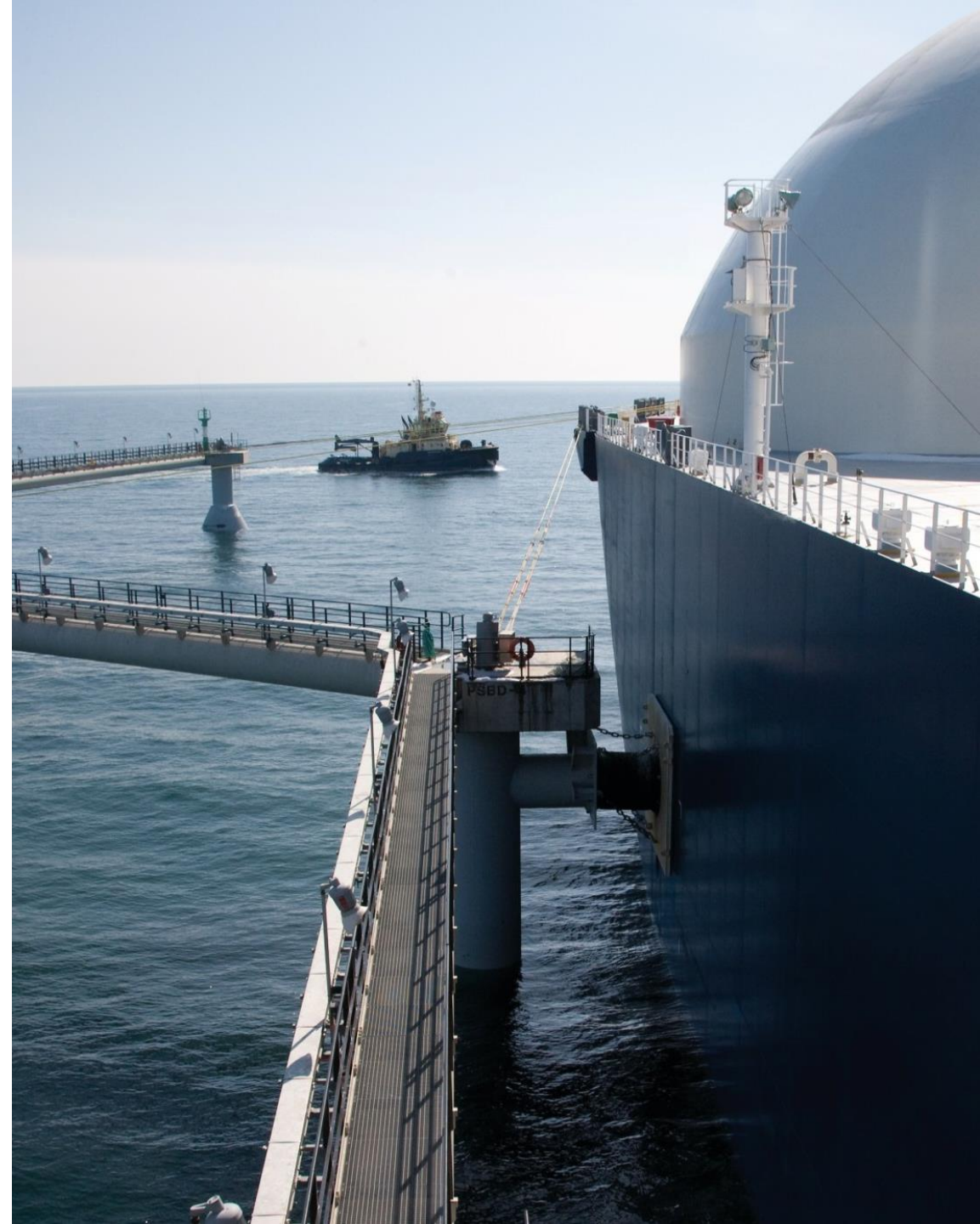
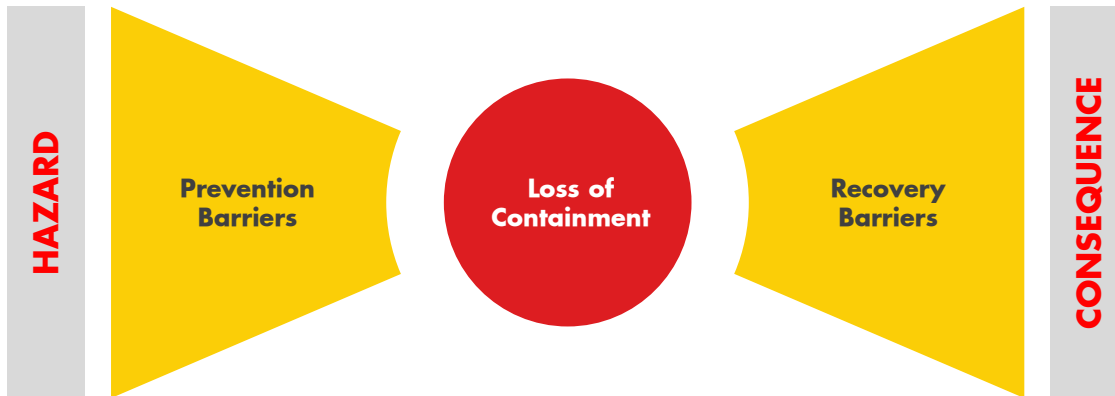
- **Flammable substance.** There is a potential for ignition leading to fire, explosions, etc.
- **Pressurised gas** in large volume. Being compressible, gases can store significant potential energy that could lead to a violent and destructive set of events if rapidly released, due to the effect of the 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

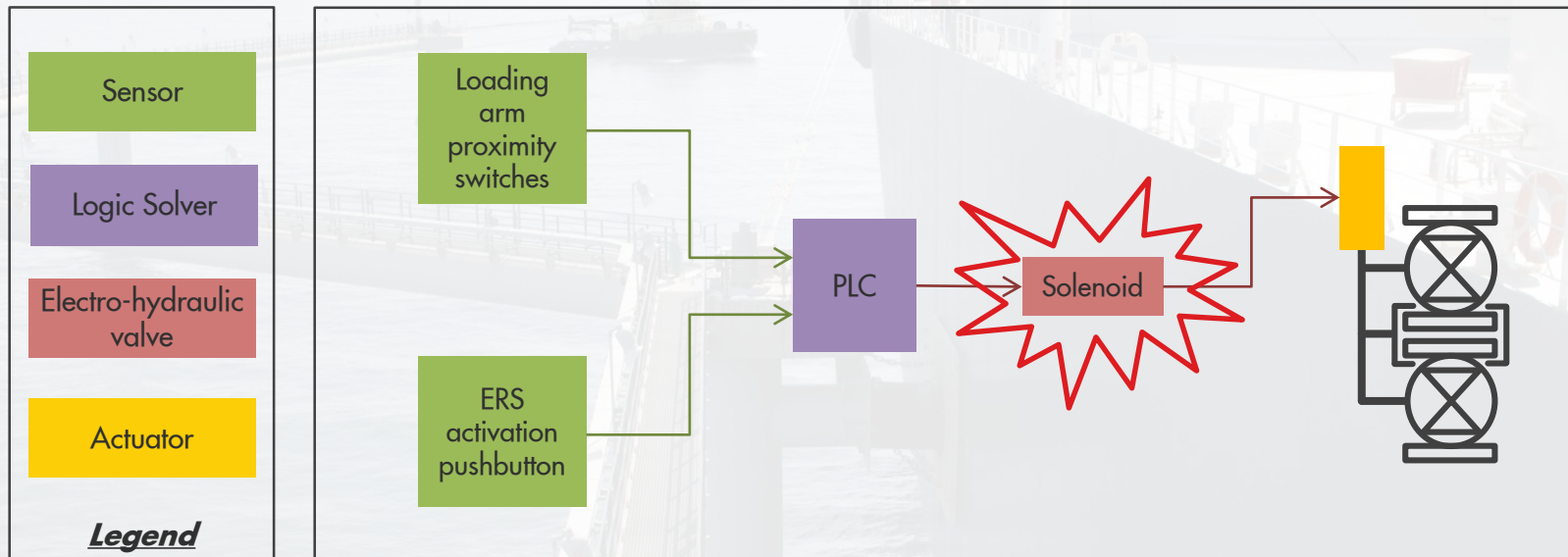


Spurious ERS activation incident during LNG transfer to shore



Risk of spurious ERS activation

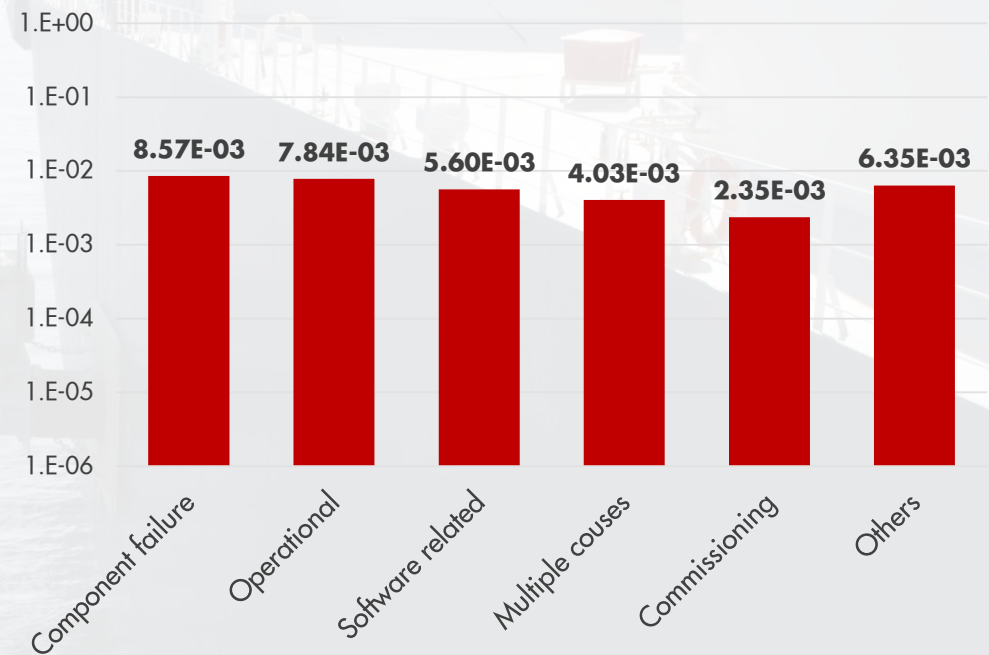
CONVENTIONAL LOW PRESSURE LNG EMERGENCY RELEASE SYSTEM



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%

Historic Spurious Failure Rate LNG ERS [yr⁻¹]



Data collected since 1995

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

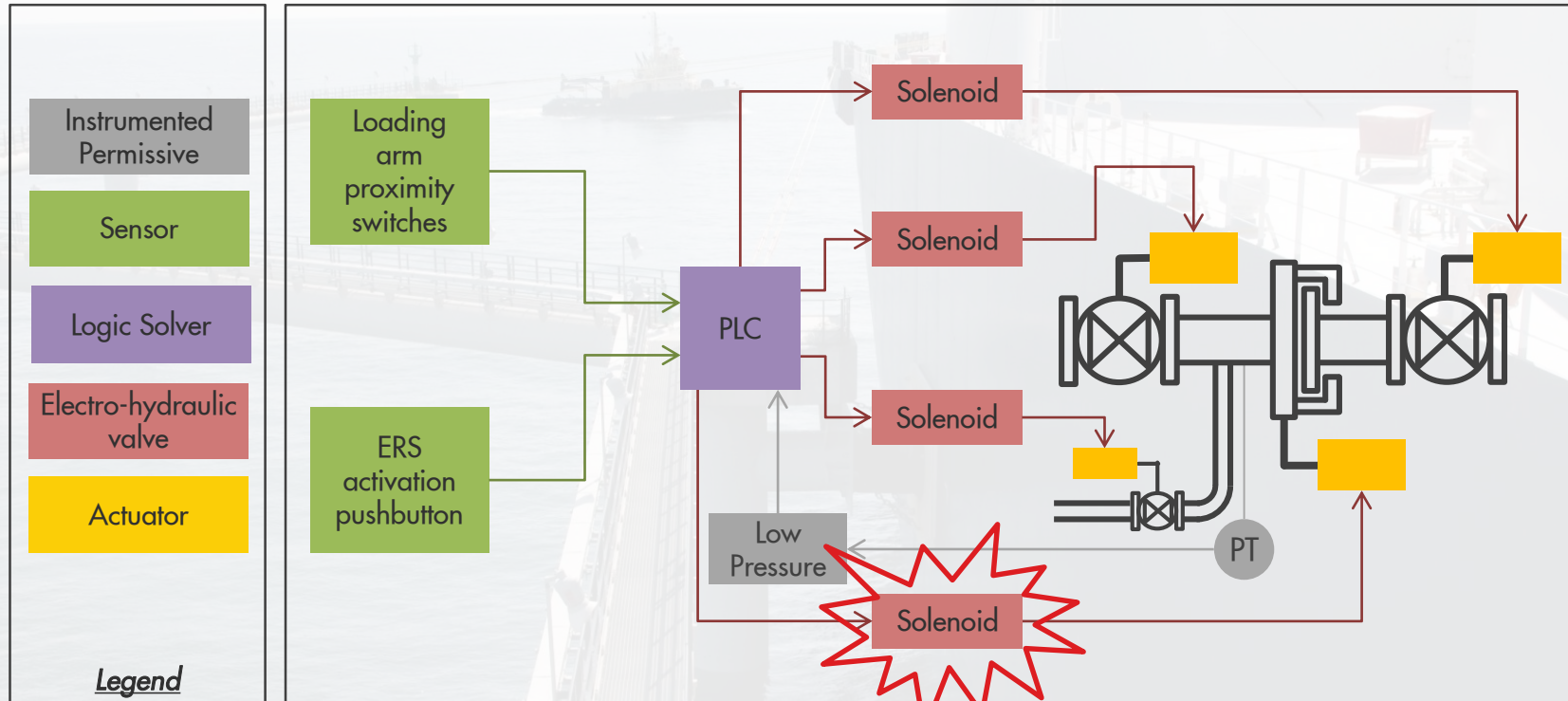
Operational: a spurious activation as a result of human error.

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

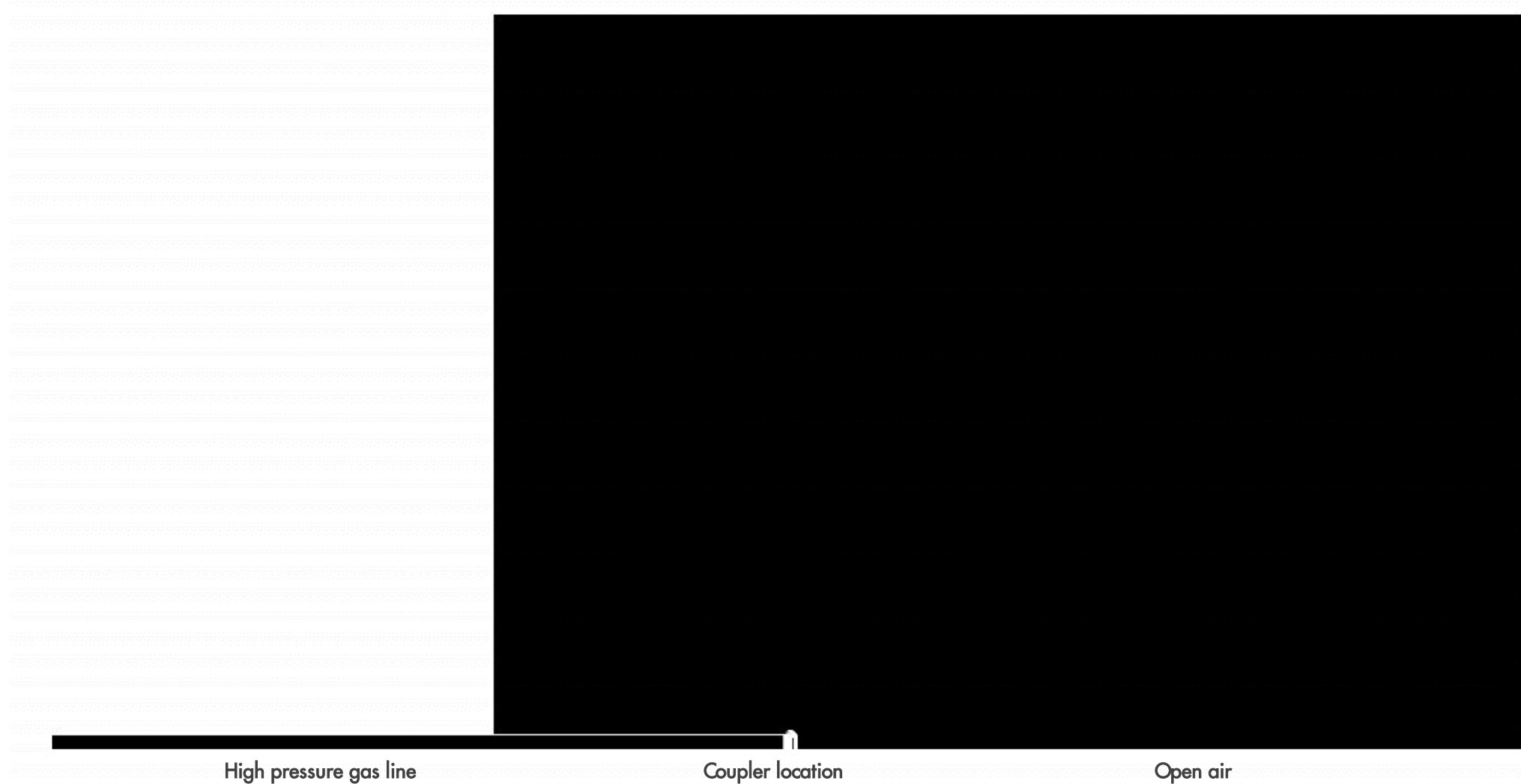
Data source: LNG Emergency Release Systems. Recommendations, Guidelines and Best Practices [Report] / auth. SIGTTO. - [s.l.] : Witherby, 2017

Risk of spurious disconnection

CONVENTIONAL HIGH PRESSURE GAS EMERGENCY RELEASE SYSTEM



CFD explosive decompression of high pressure natural gas



Pneumatic test accident Shanghai LNG import terminal. Feb. 2009



Safety hardware critical failures





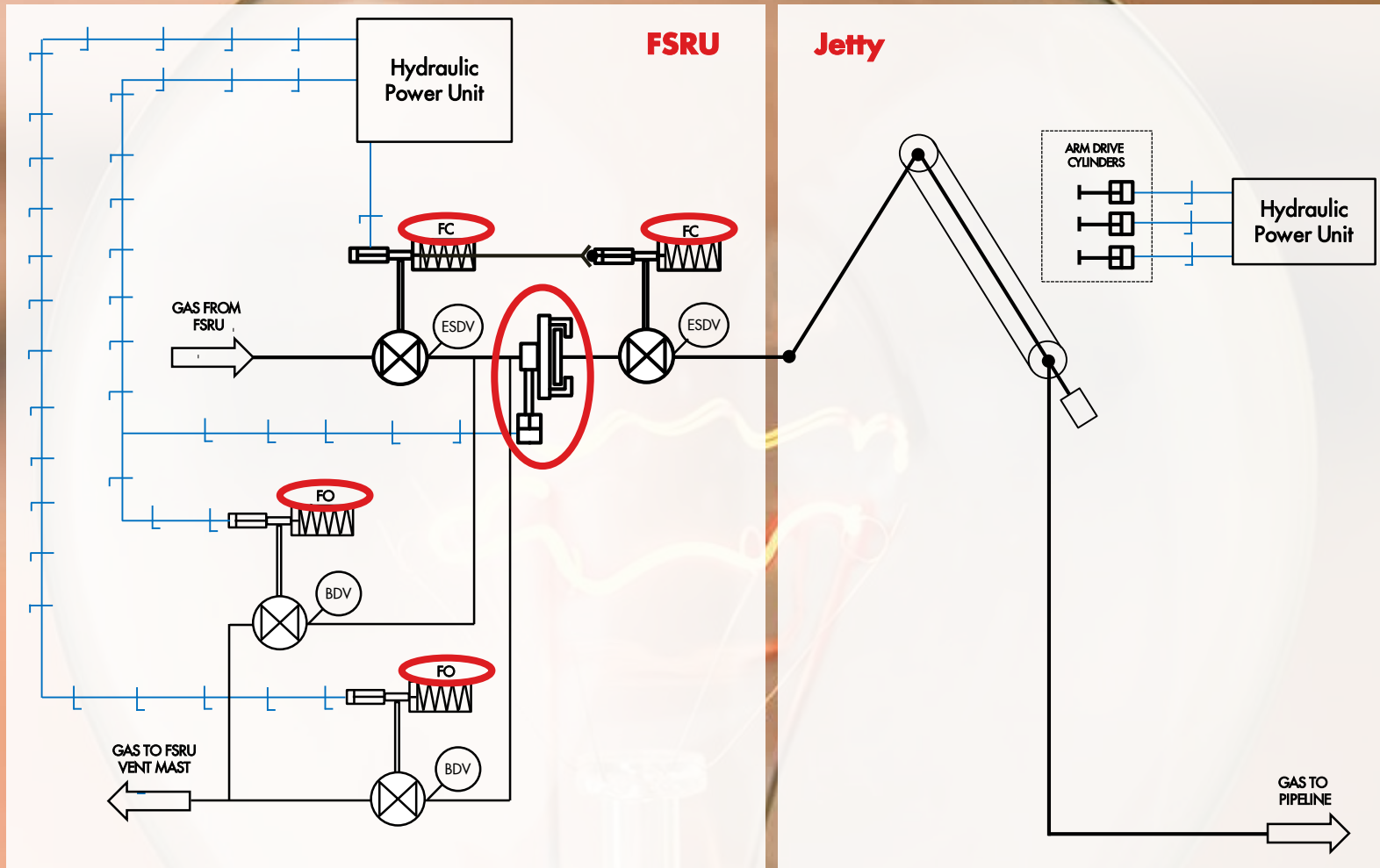
Concept Development

3.0

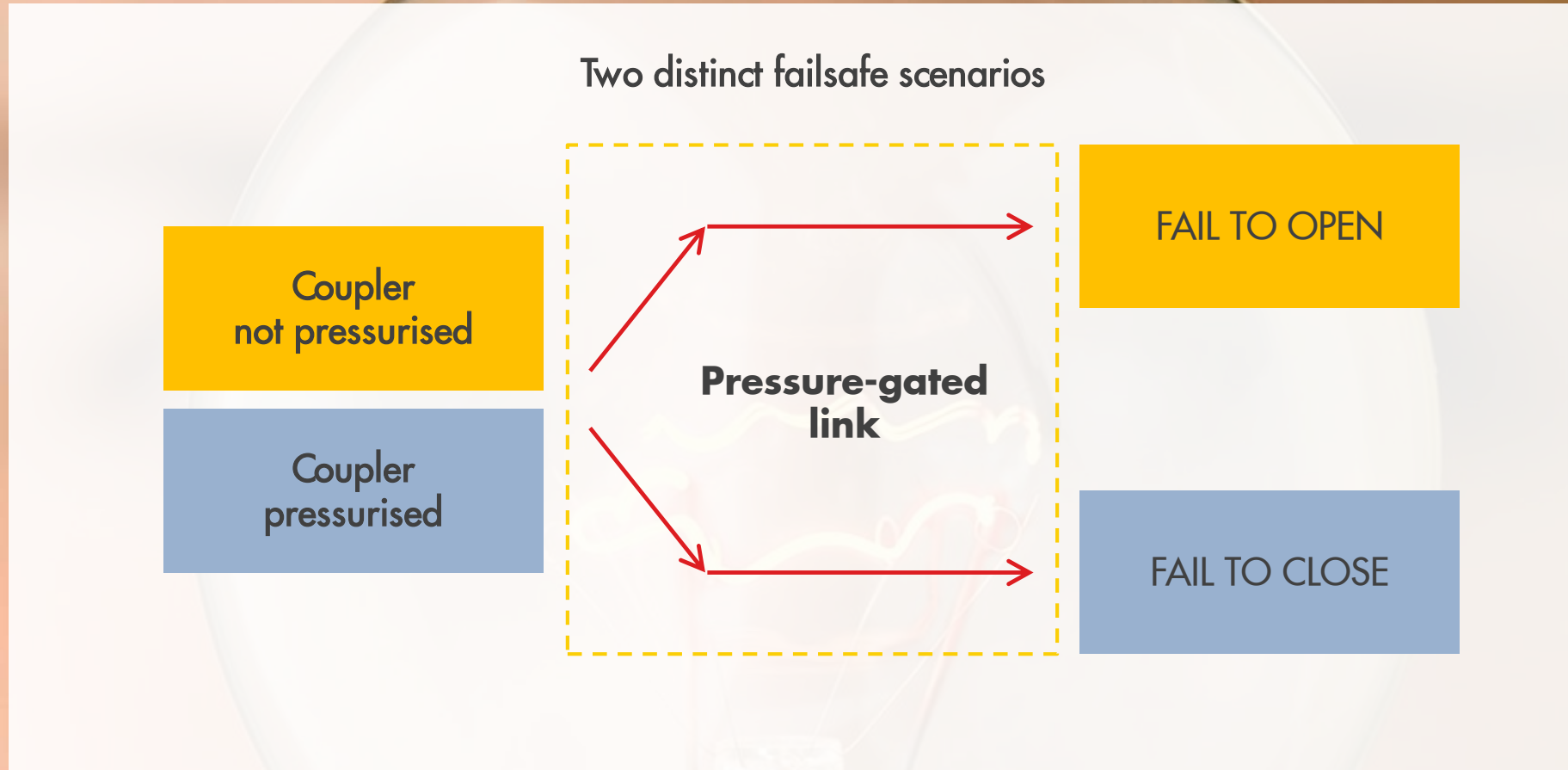
Design Objectives

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

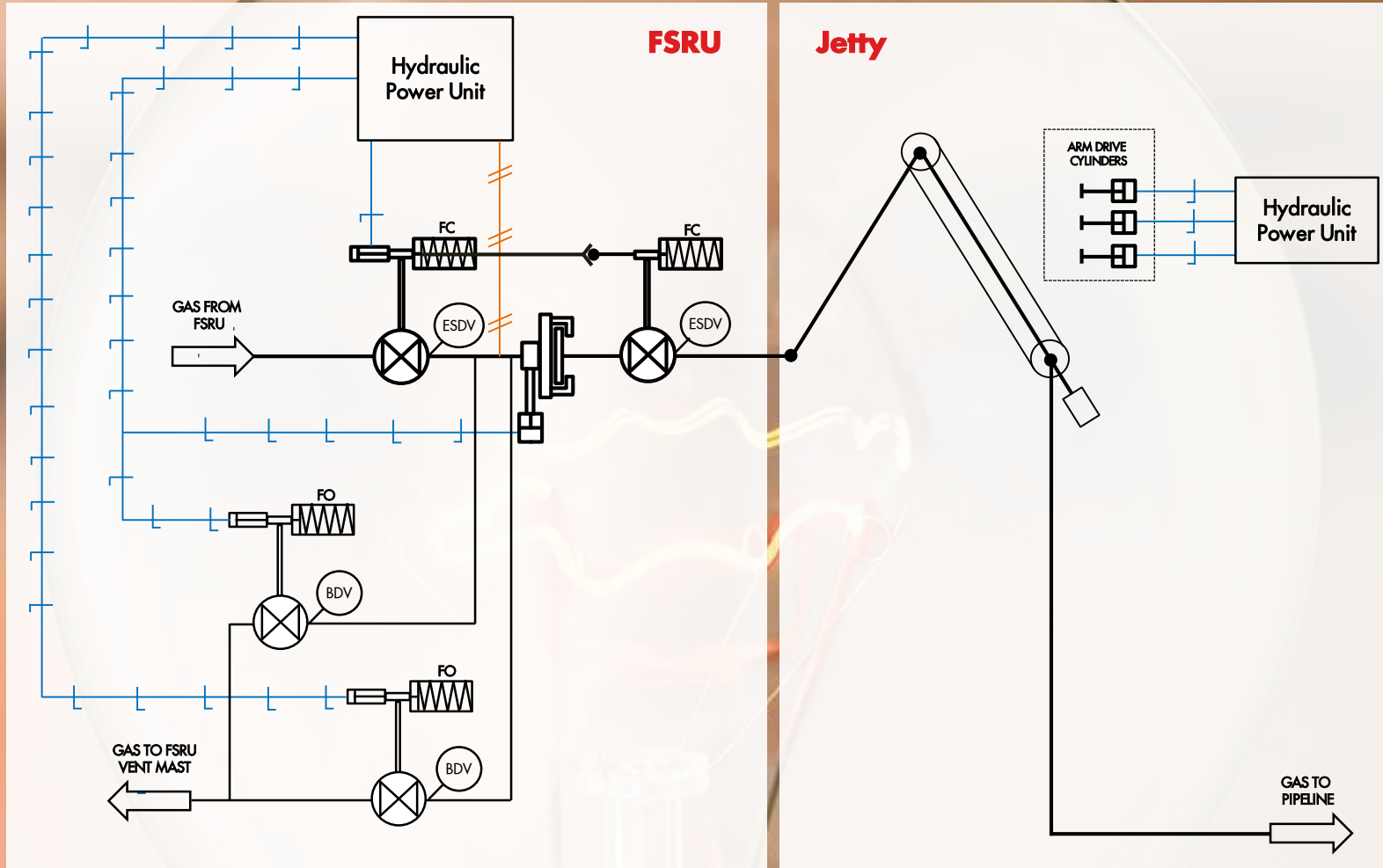
HP ERS concept design features



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

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

WIPO PCT

(10) International Publication Number
WO 2014/191407 A1

(51) International Patent Classification
B67D 27/02 (2006.01) F1M 27/08 (2006.01)
B67D 27/04 (2006.01)

(21) International Application Number
PCT/EP2014/060944

(22) International Filing Date
27 May 2014 (27.05.2014)

(25) Filing Language
English

(26) Publication Language
English

(30) Priority Data
13190524 31 May 2013 (31.05.2013) EP

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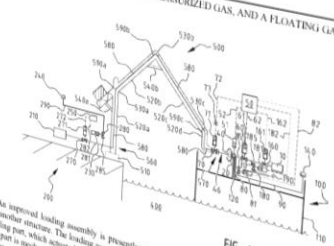
(74) Agents: MATTHEZING, Robert Maarten de; PO Box 384, NL-2501 CJ The Hague (NL)

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)

Declarations under Rule 4.17
— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
— with international search report (Art. 21(3))

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



(57) Abstract: An improved loading assembly is proposed for conveying a pressurized gas between a floating gas processing unit and another structure. The loading assembly has an emergency disconnection coupler having a passive coupling part and an actuated coupling part which actuated coupling part can be moved (actuated) from a locked position to an unlocked position. The actuated coupling part is mechanically released from the actuated coupling part when the actuated coupling part is in the unlocked position. The actuated coupling part is actuated on the floating gas processing unit regardless of whether the actuated coupling part is in a locked or unlocked position.

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Proof of concept

1 Intellectual Property

2

Contracting Strategy



Proof of concept

**Intellectual
Property**

1

2

**Contracting
Strategy**

3

**Detail
Engineering**

Proof of concept

**Intellectual
Property**

**Detail
Engineering**

**Contracting
Strategy**

**Testing
Protocol**

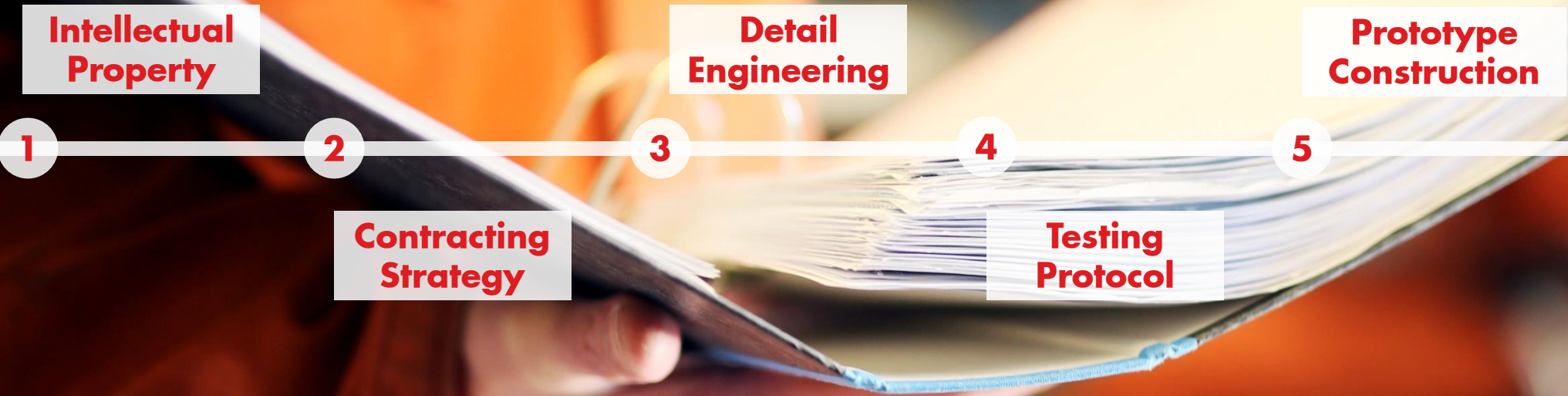
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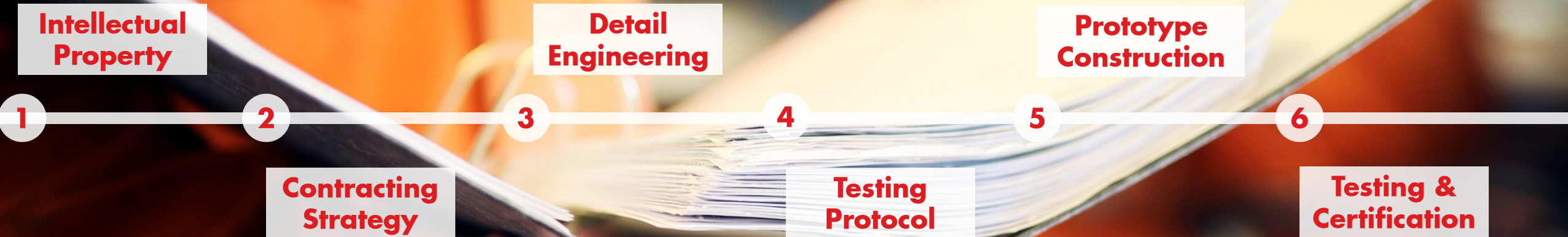
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Proof of concept



Proof of concept

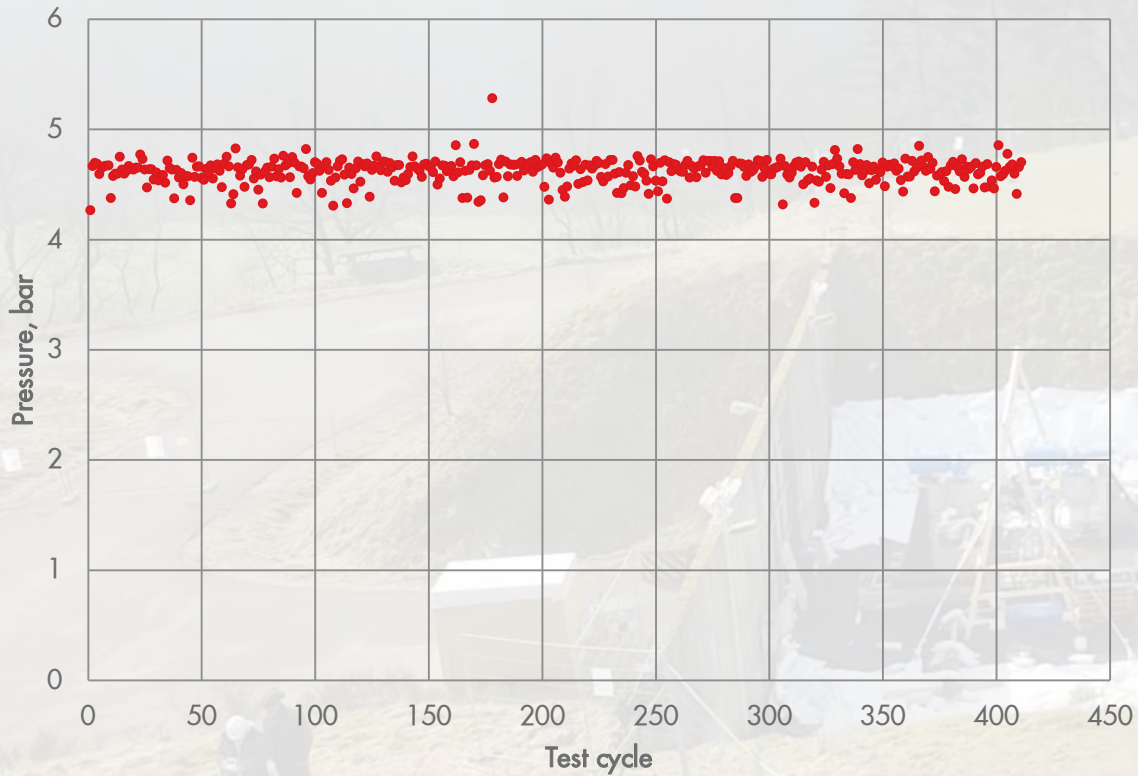


HP ERS testing

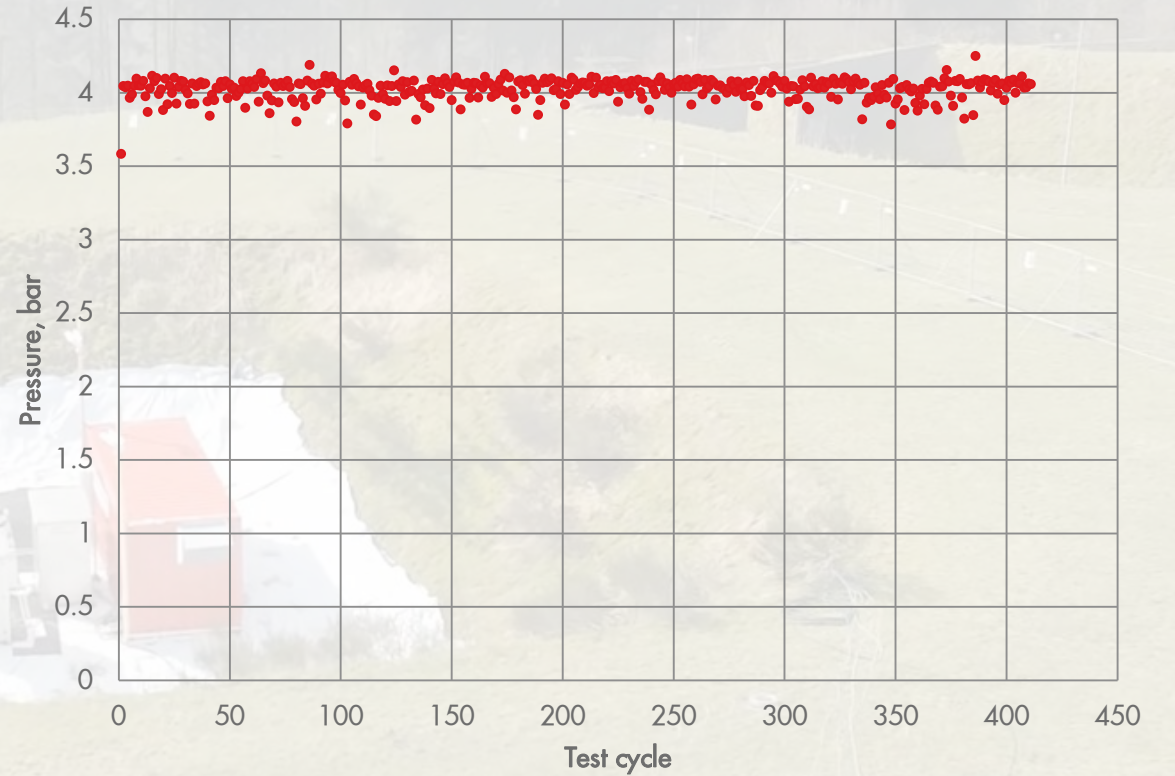


Key test results

Disengagement Pressure (PGL-A)



Disengagement Pressure (PGL-B)



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®
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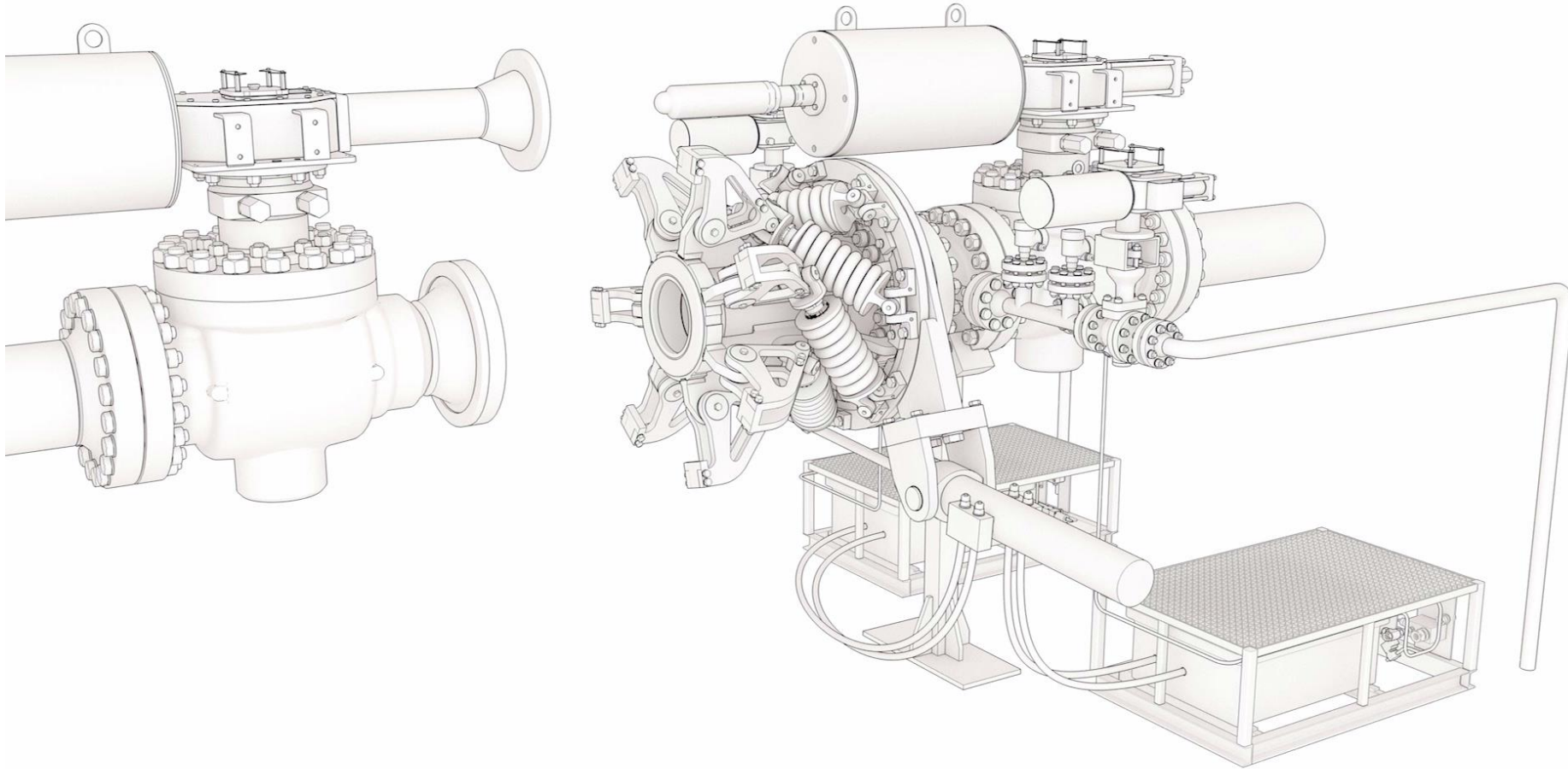
Report Nr. V 565.01/17

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

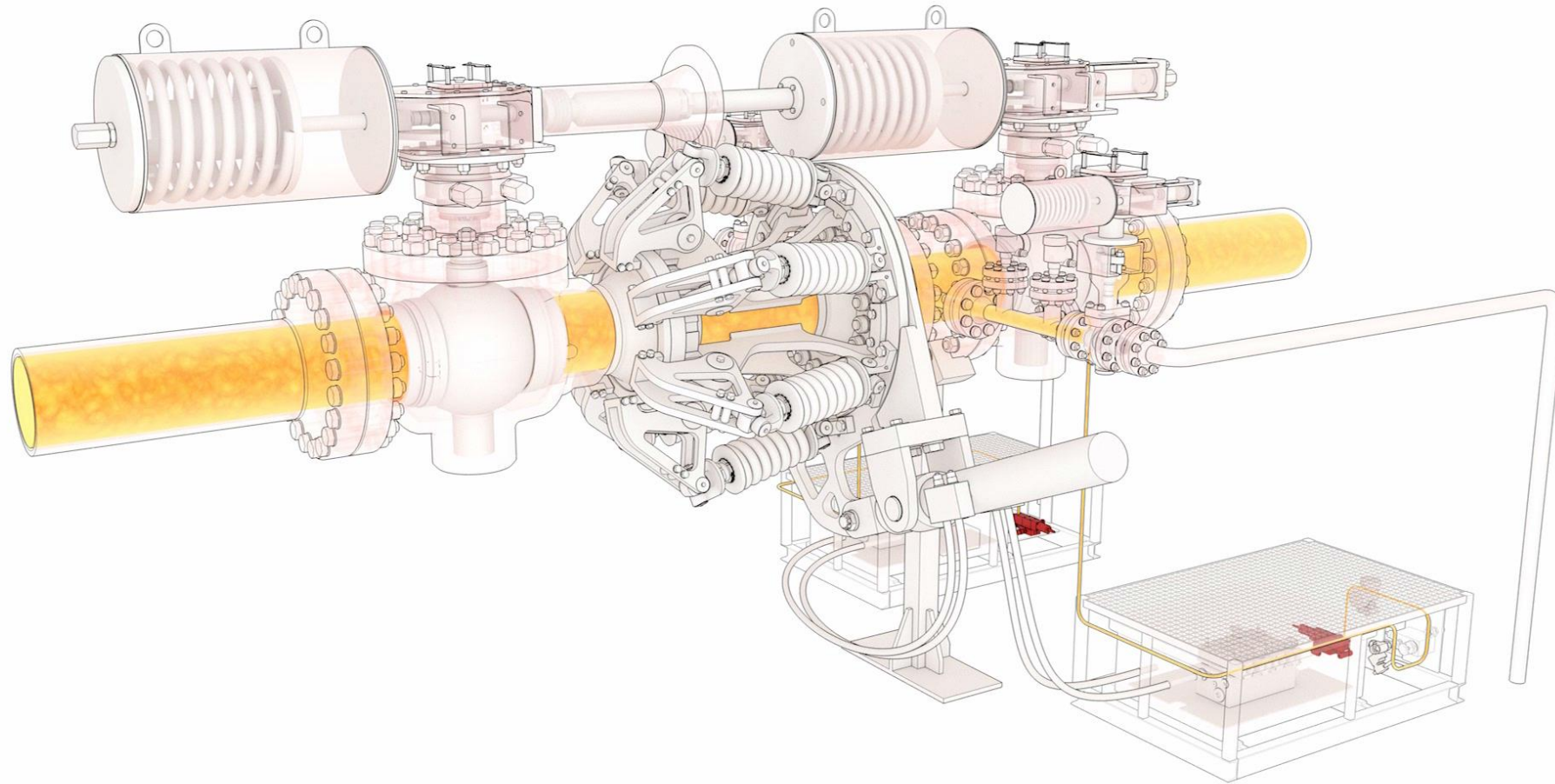
**ARM
SIDE**



**FSRU
SIDE**

HP gas transfer arm emergency release

**ARM
SIDE**



**FSRU
SIDE**



Commercialisation and Advocacy

5.0

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

TARGET GROUPS

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

