Elizabeth Hostrup, Equinor

Annex K – Barier Management

Standard Norge

Annex K - Barrier Management Regulatory Framework

Management Regulation §5 Barriers

Barriers shall be established which at all times can:

a. identify conditions that can lead to failures, hazard and accident situations,

b. reduce the possibility of failures, hazard and accident situations occurring and developing,

c. limit possible harm and inconveniences.

Where more than one barrier is necessary, there shall be sufficient independence between barriers.

Annex K - Barrier Management Regulatory Framework

NORSOK S-001

Intro: Each clause of this NORSOK standard describes r ty

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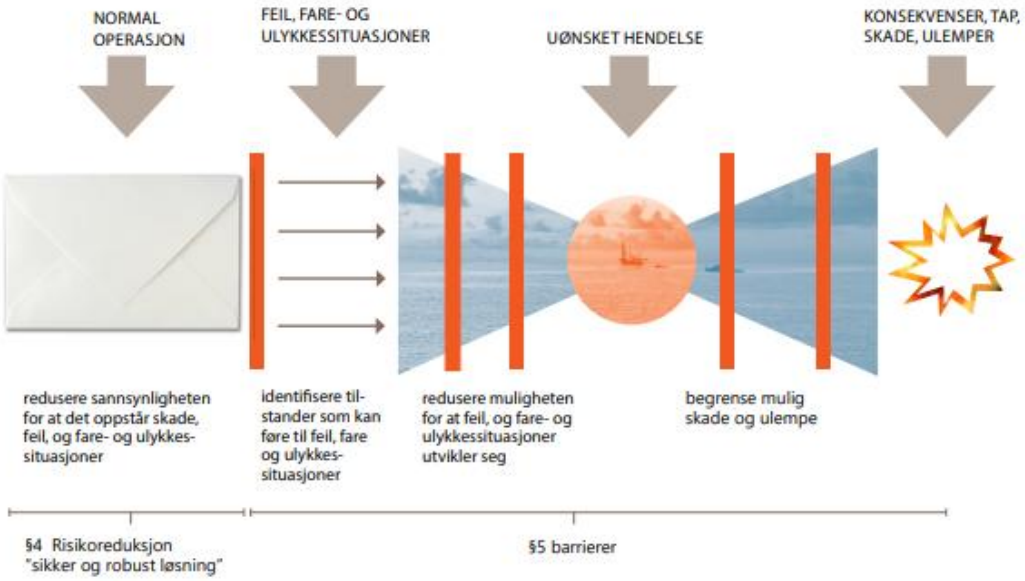
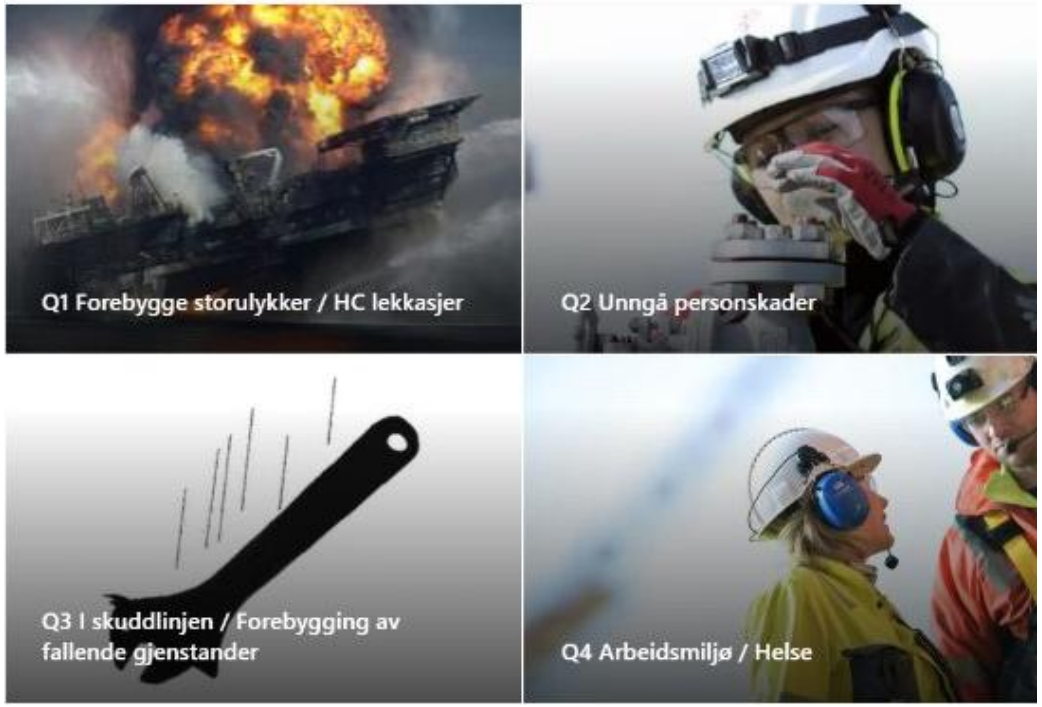


- survivability requirements defines requirements for th nction in or after a design accidental event.

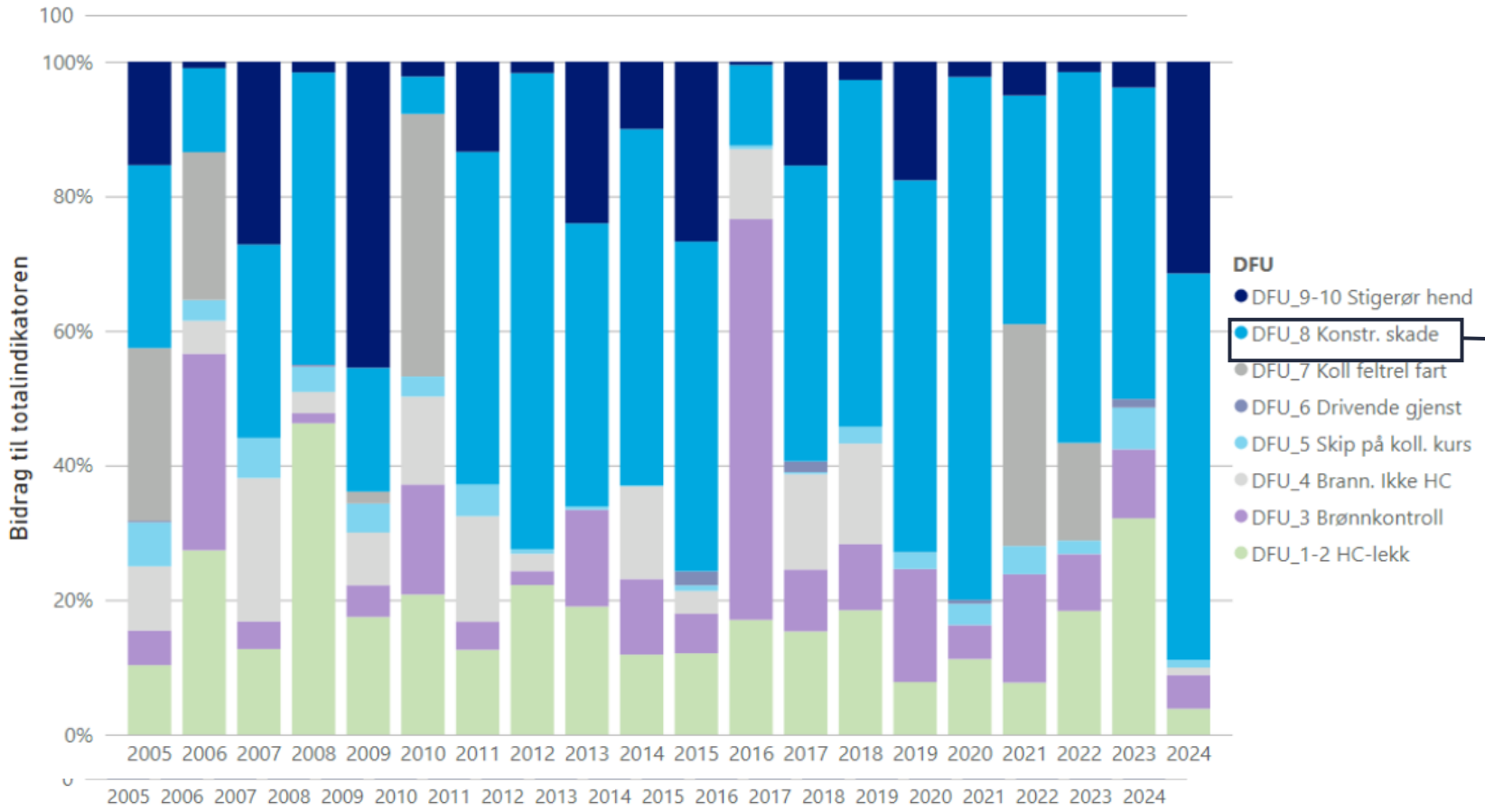
Annex K - Major Accident Focus



Annex K – Marine System Prioritisation

AkerBP Performance Standards	Equinor Performance Standards for Safety Systems and Barriers	NORSOK S-001
▪ 1 – Layout and arrangement ▪ 2 –Structural integrity ▪ …. ▪ 15 Loss of containment ▪ 16 Barriers to prevent ship collisions ▪ … ▪ 31 Bilge and ballast ▪ 32 Station keeping ▪ 36 Offloading operation	▪ 1 – Containment ▪ 2 – Natural Ventilation and HVAC ▪ …. ▪ 18 – Marine systems and position keeping ▪ 19-Avoidance of vessel collisions ▪ 20 – Structural Integrity	▪ …. ▪ …. ▪ …. ▪ 24 Marine Systems and Position Keeping ▪ 25 Avoidance of Vessel Collision ▪ …. ▪ ….

Annex K – Marine System and Offshore Structure Incidents



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Skade på innretningskonstruksjon/stabilitets-/forankrings-/posisjoneringsfeil

Annex K – Marine System and Offshore Structure Incidents

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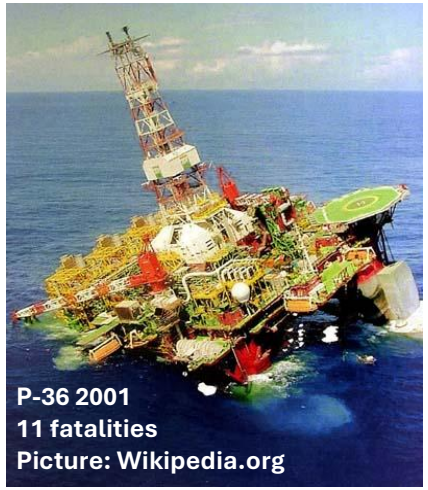

P-36 2001
11 fatalities
Picture: Wikipedia.org


P-34 2002
Picture: news.bbc.co.uk

Thunder Horse 2003
Picture: commons.wikimedia.org


Typhoon TLP 2005
Picture: flickr.com


Picture:

Floatel Superior 2012
Picture: Havtil.no

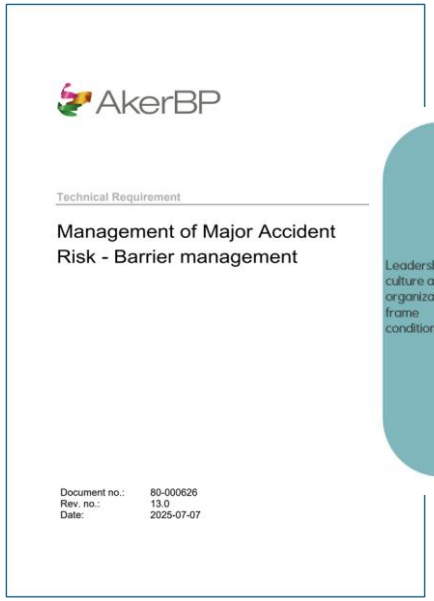

COSL Innovator 2015
1 fatality
Picture: Havtil.no

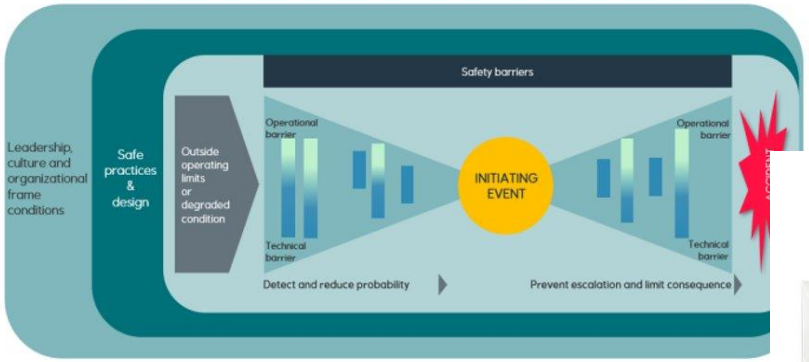

Åsgard A 2024
Picture: Havtil.no

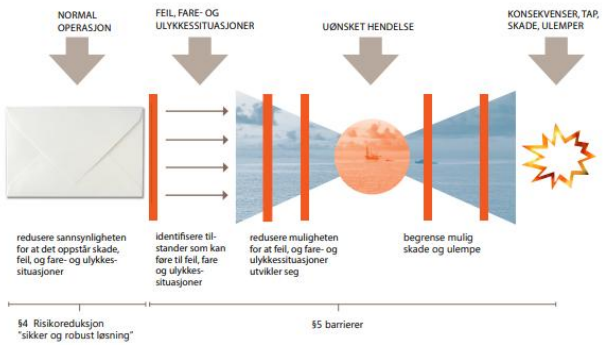
Annex K – Barrier Definition

Barrier: A barrier in this annex is defined as **a functionality to protect** in a failure, hazardous or accidental scenario.

- Identify a failure, hazardous or accidental situation.
- Reduce the possibility for escalation.
- Limit the extent of the consequences.







Annex K – Marine System Barrier Identification

- Barriers shall be designed such that any single technical failure, or any single operator failure, will not impact the overall functionality of the barrier.
- Barriers shall be continuously managed throughout the life of a facility to ensure safe orientation of failures and accidental events when they arise.
- There shall be a clear identification of all barriers and barrier elements that are either non-functional or have reduced performance

Alvheim
Photo akerbp.com

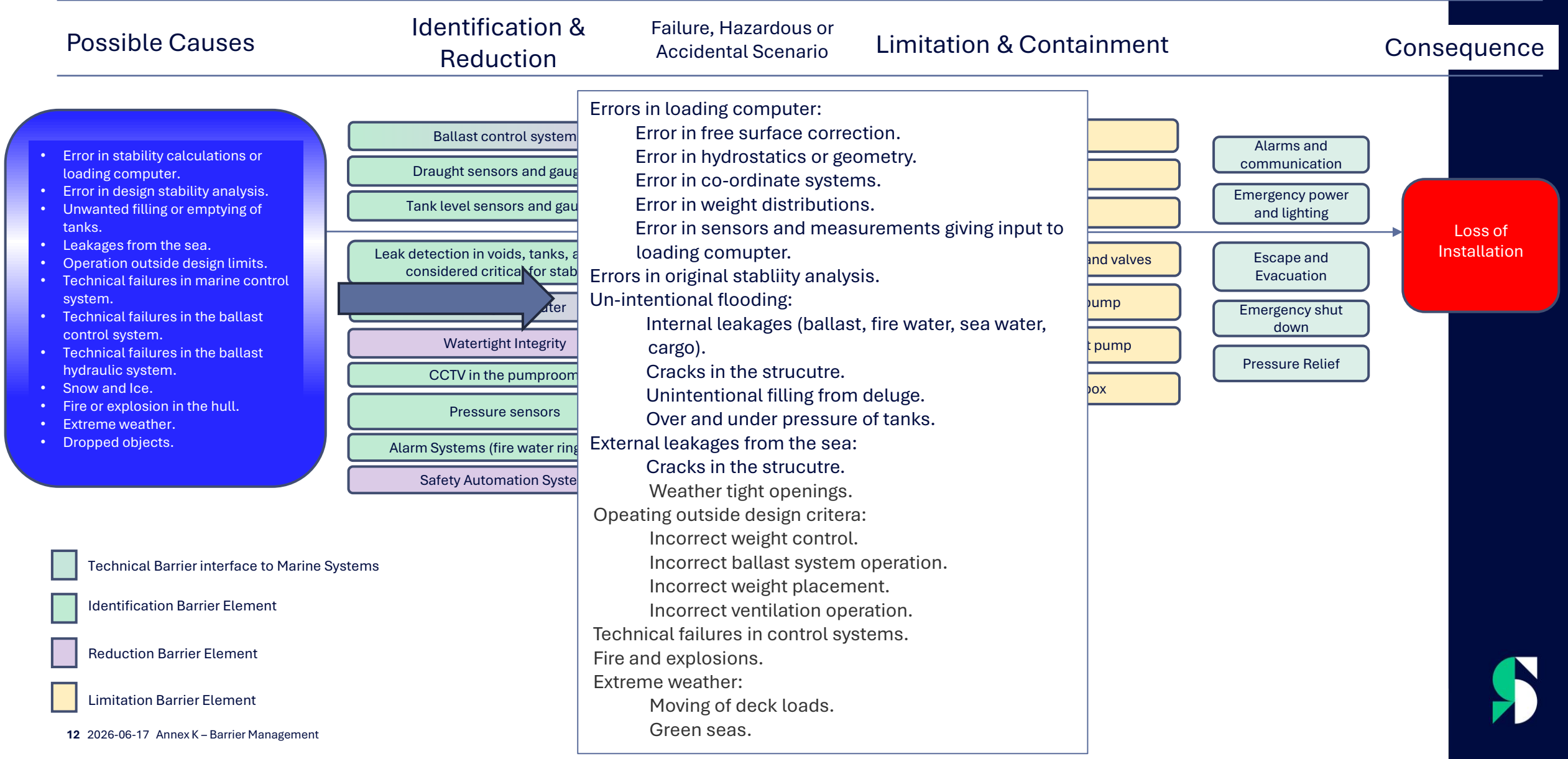
Ivar Aasen
Photo akerbp.com

Norne FPSO
Photo Anne-Mette Fjærli, Equinor

Annex K – failure, hazardous and accidental scenarios

Failure, hazardous or accidental scenario	Offshore structure and marine system barriers	Barrier function	Potential consequences
Loss of stability	Weight and stability control.	Monitor the weight distribution and stability of the facility to enable proper ballasting.	Loss of facility.
	Ballast system.	Distribute ballast water to maintain stability within acceptable limits. Maintain structural loads within design margins.	
	Watertight and weathertight integrity.	Reduce probability for ingress of water, and uncontrolled internal leakage between compartments on the facility.	
Loss of position	Position reference system	Monitor the movement of the facility to enable proper positioning.	Loss of primary containment from connected risers or well (leak, fire, explosion). Drifting facility.
	Position keeping systems	Reduce probability for loss of position exceeding the safe operating envelope.	
Loss of primary containment (LOPC) (leak, fire, explosion)	Offloading system	Reduce probability for leakage during offloading operations	Loss of primary containment (leak, fire, explosion).
	Offshore structures	Withstand design accidental loads for fires, explosions.	

Loss of Stability



Annex K – DSHA Loss of Stability_Watertight Integrity

Barrier Function	Technical Barrier Elements (Annex K, Section 4.5)	Operational and Organisational Barrier Elements
Reduce probability for ingress of water, and uncontrolled internal leakage between compartments on the facility. Maintain the watertight division of compartments and rooms within the hull. Prevent progressive filling of spaces following a hazardous event. Ensure stability of the facility to allow for safe evacuation. Ensure survival of the facility. Ensure righting to a safe condition.	▪ Watertight doors; ▪ Weathertight doors; ▪ HVAC damper required to be weathertight and watertight; ▪ Remote control from the CCR of watertight doors and HVAC valves and dampers; ▪ Watertight closing means (watertight doors, hatches, openings to ensure watertight integrity in the hull); ▪ Master switch and all relevant control system components; ▪ Master switch for emergency closure of watertight segregations; ▪ Sensors and alarms that form part of the control console for watertight and weathertight segregations; ▪ Valves on inlets and outlets to the sea; ▪ Valves between watertight compartments; ▪ Hydraulic systems for operation of watertight and weathertight closing means; ▪ Weathertight and watertight closure means on air-pipes.	▪ Maritime operational manual. ▪ Emergency procedures. ▪ Normal operation procedures. ▪ Maintenance. ▪ Competence and training requirements for personnel. 

Annex K – DSHA Loss of Stability_Ballast Control

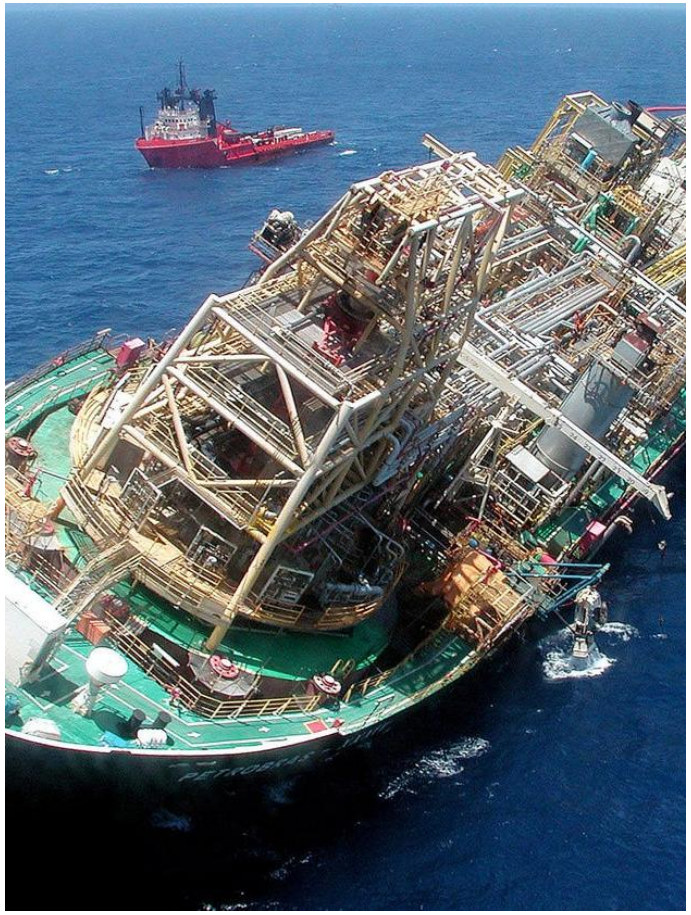
Barrier Function	Technical Barrier Elements (Annex K, Section 4.3)	Operational and Organisational Barrier Elements

Distribute ballast water to maintain stability within acceptable limits.
 	
Maintain structural loads within design margins
 	
Ballast a facility ensuring depth, stability and structural integrity design criteria are not exceeded.
 	
Ballast a facility to a safe condition following an incident with unexpected immersion, trim or list.
 	
Monitor and empty water from unexpected filling of spaces.
	▪ ballast and bilge control systems, inclusive of all automation components:
	  ▪ in the control room;
	  ▪ at local panels;
	▪ atmospheric pressure sensors;
	▪ draught sensors and gauges;
	▪ tank level indicators:
	  ▪ main sensors;
	  ▪ secondary tank level indicators, including sensors, bubble pipes and sounding pipes;
	▪ sensors for the measurement of trim, heel and list;
	▪ pressure sensors and alarms for ballasting;
	▪ pressure sensors indicating over and under pressure in ballast tanks;
	▪ barrier valves on inlets and outlets to the sea in bilge and ballast systems;
	▪ two-way communication system between CCR and pump room, including CCTV where installed;
	▪ .....
		▪ Maritime operational manual.
		▪ Emergency procedures.
		▪ Normal operation procedures.
		▪ Maintenance.
		▪ Competence and training requirements for personnel.

Annex K – failure, hazardous and accidental scenarios

Failure, hazardous or accidental scenario	Offshore structure and marine system barriers	Barrier function	Potential consequences
Ship impact	Position reference systems Offshore structures. Ballast systems.	Reduce probability for ship collisions with impact exceeding design accidental loads. Reduce consequence of a ship collision.	Loss of stability. Loss of position. Loss of structural integrity. Loss of primary containment (leak, fire, explosion).
Loss of structural integrity	Offshore structures	Withstand design accidental loads for impact (ship collisions, helicopter crash, dropped and swinging objects), fires, explosions and environmental loads (wind, waves, green sea, snow/ice, earthquake etc.) Withstand design loads through lifetime (effects of corrosion and degradation).	Loss of stability. Loss of primary containment (leak, fire, explosion).
Tank explosion	Inert gas system	Reduce the probability for ignitable atmosphere in the cargo tank headspace.	Loss of stability. Loss of primary containment (leak, fire, explosion).
	Cargo tank vent system	Reduce the probability for over and under pressuring of cargo tanks.	

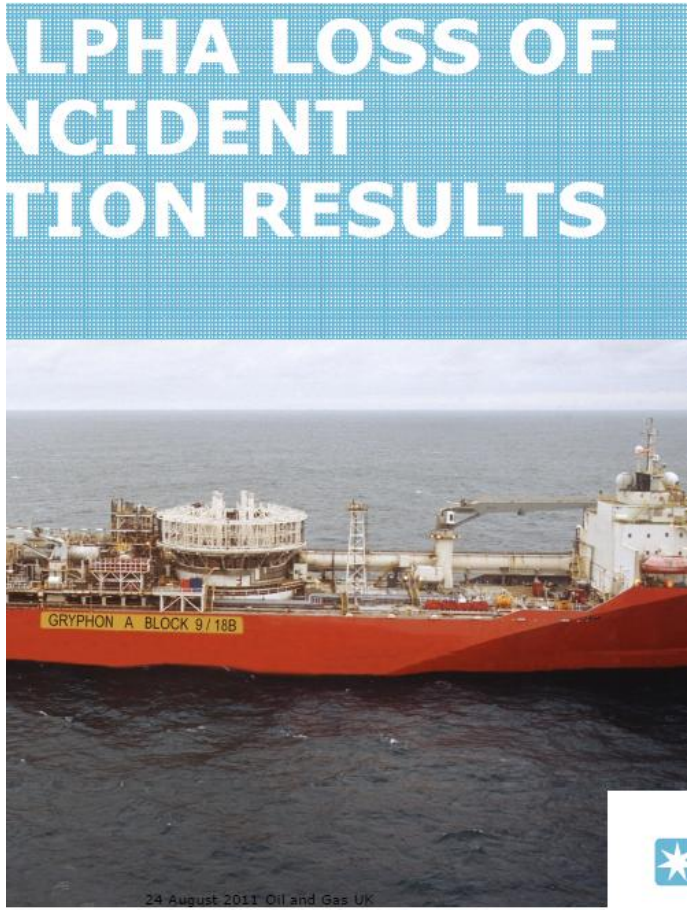
Annex K – Barrier Management and Emergency Preparedness



- Marine systems
  - Have functionality in both normal operation and accidental situations.
  - Not like other barriers: inert gas systems, fire water systems etc. that activate in the event of an accident.

- Marine systems are complex.
  - not an automatic system response in the event of an incident.
  - control system logic needs to be understood to co-ordinate marine systems in emergency situations.
  - they require human intervention and need system understanding.
  - they are technical and operational barrier elements that need to work together to form a barrier function.

- Annex K: Interfaces between the barrier management and emergency preparedness shall be identified.



Annex K – Offshore Structure Barrier Identification

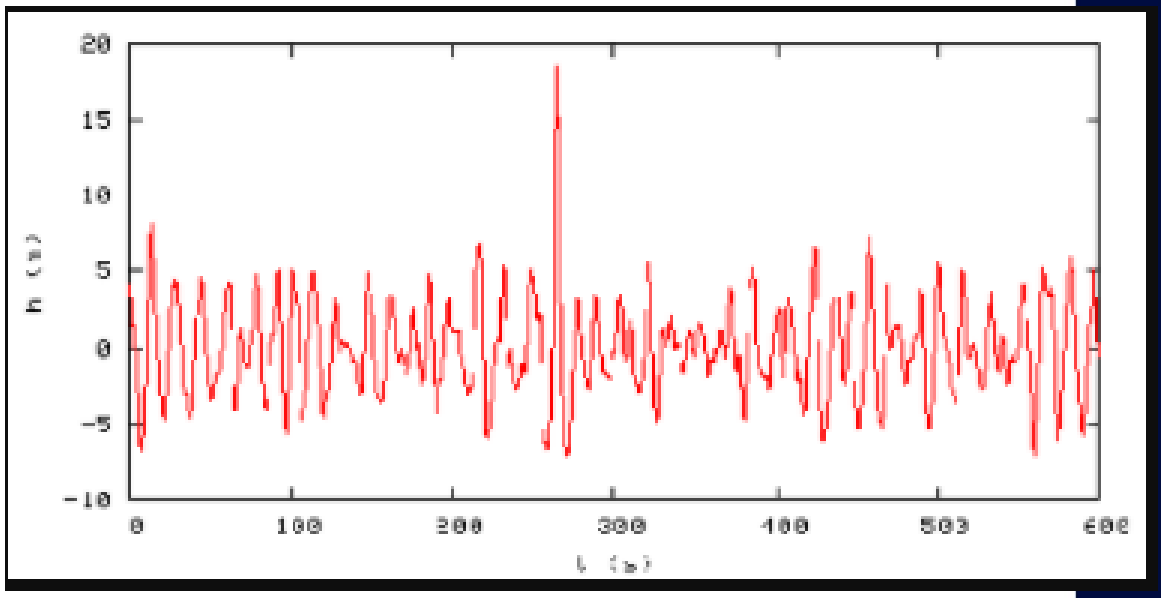
- Integrity of offshore structures is documented mainly through analysis, supported by inspection data.
- Offshore structural analysis shall be updated to reflect changes in accidental loads.
- The extent of structural degradation and the impact on offshore structural integrity shall be known.
- Degradation of offshore structures can cause major accidents, with little or no external hazards present
- Load bearing structures have a function in normal operation and in accidental situations.

Sleipner
Photo equinor.com

Annex K – Offshore Structure Barrier Management

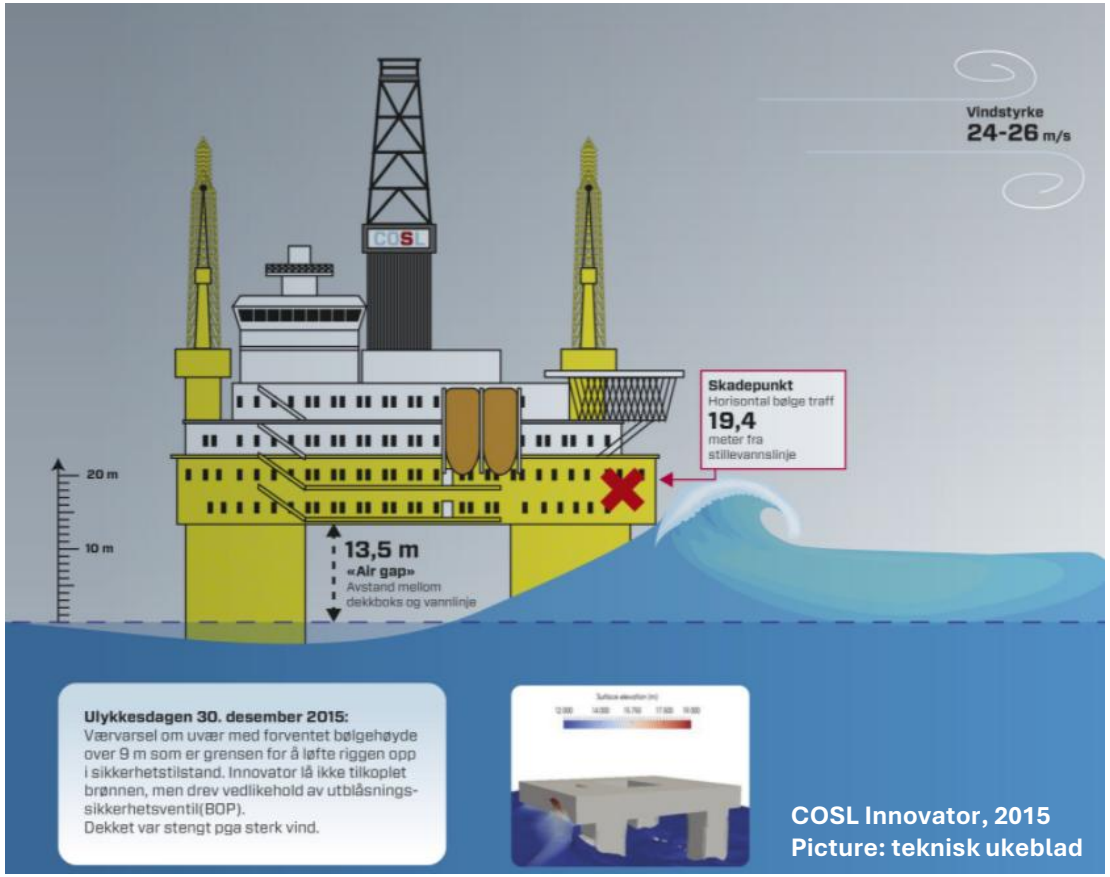
Hurricane Andrew (1992), Lili (2003), Ivan (2004), and Katrina and Rita (2005)

Annex K – Offshore Structure Barrier Management



Draupner E, 1995 (New Year wave)

Annex K – Offshore Structure Barrier Management



COSL Innovator, 2015
Picture: teknisk ukeblad


Åsgard A 2024
Picture: Havtil.no

Annex K – Offshore Structure Barrier Management

- Offshore structure and marine system comprise a significant portion of major accident risk potential.
  - …but have not had as great a focus as perhaps containment, process safety, gas detection and fire detection.
  - major accidents have happened, and similar incidents are happening.

- We need to continue to learn incidents.
  - Annex K outlines a systematic approach to ensuring this learning is captured, stored and managed though life.
  - Bow ties offer an effective approach to mapping required functionality for protection from failure, hazardous and accidental situations.
  - Linked also to emergency preparedness required functionality.

- Offshore structure and marine systems are complex:
  - have functionality in both normal operation and accidental situations in contrast to barriers for fire and explosion.
  - handling requires a good situational awareness, often with the need for manual intervention and activation of control measures.

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Standard Norge

FØLG OSS PÅ