Barrierestyring marine hendelser: N-005 Annex K

Barrier Management of Marine Incidents: N-005 Annex K

Elizabeth Hostrup, Standard Norge EG-N

Annex K – Barrier Management Regulatory Framework

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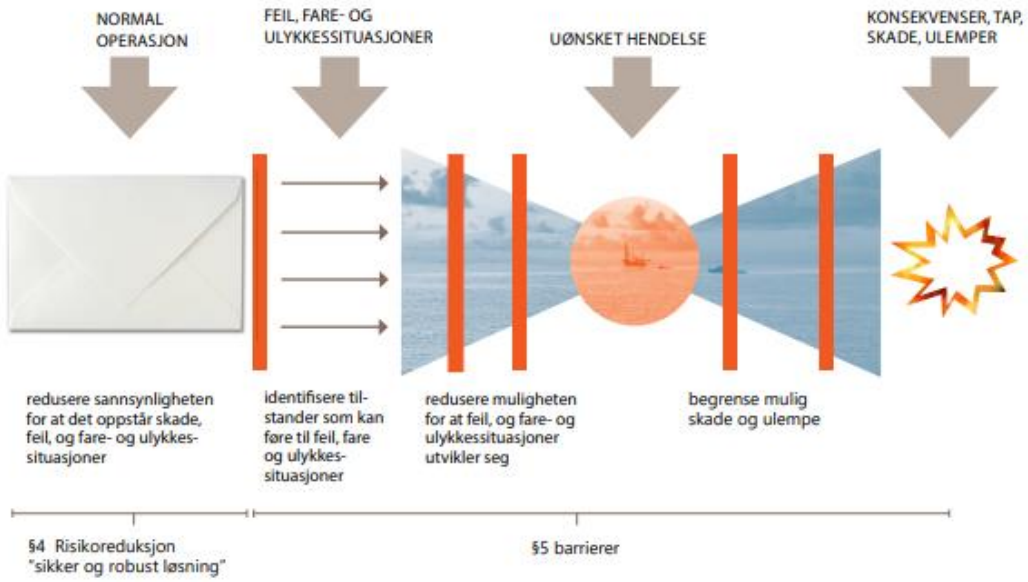
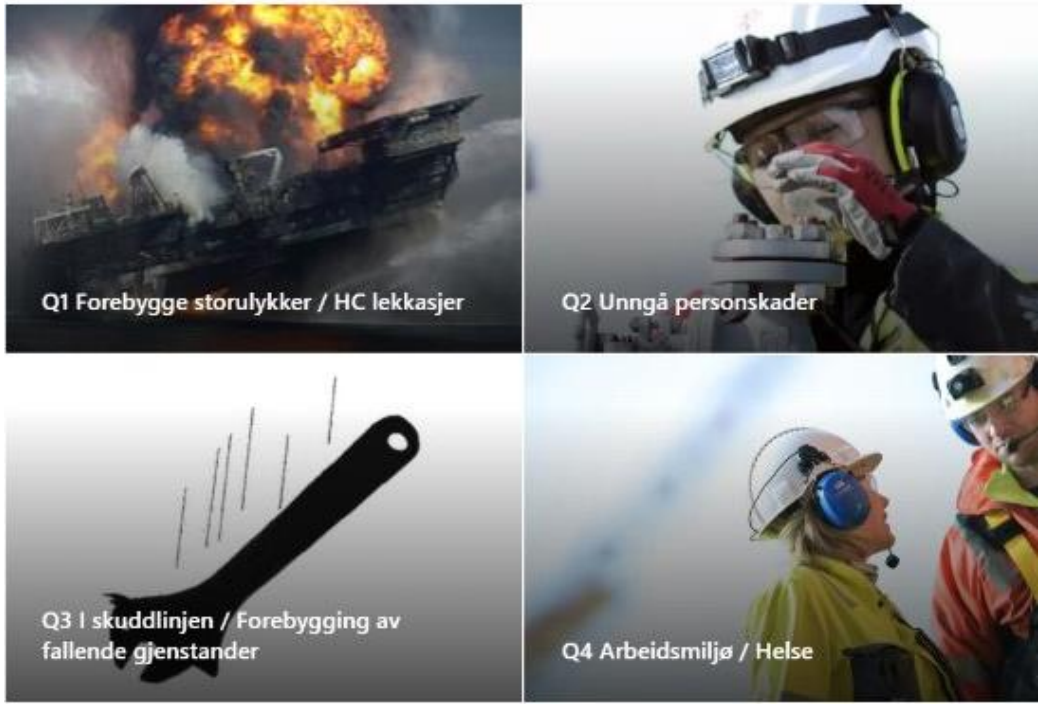
Wh ed, systems and elements necessary for realizing the barrier functions shall be defined.



Barrier memorandum

Annex K – Major Accident Focus



equinor AkerBP vår energi ConocoPhillips

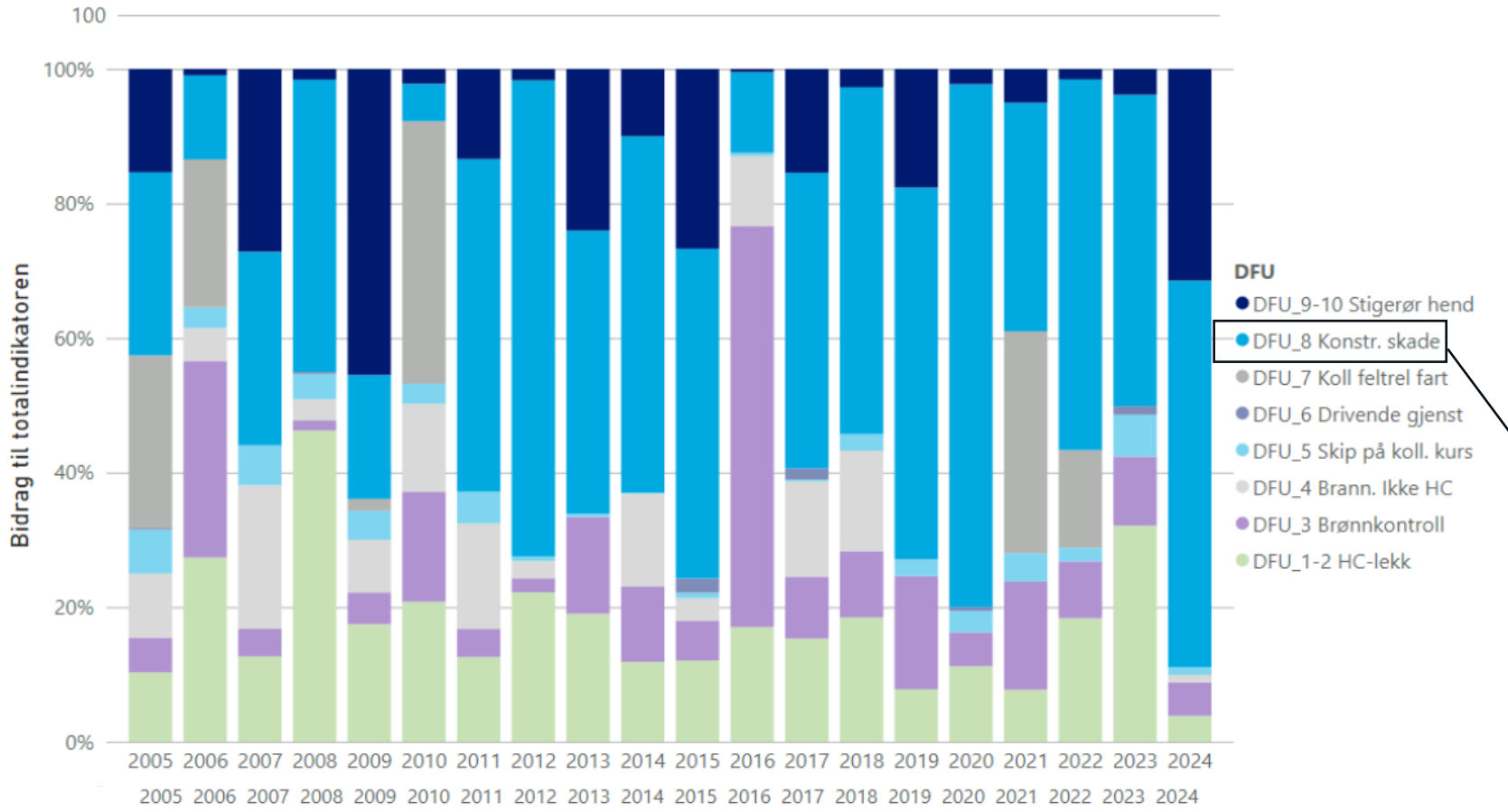
Always Safe

Annex K – Marine System Prioritisation

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

Annex K – Marine System and Offshore Structure Incidents

Design Situations of Hazard and Accident (DSHA) = Major Accident Hazards (MAH) = Definerte fare- og ulykkessituasjoner (DFU)



Skade på innretningskonstruksjon/stabilitets-/forankrings-/posisjoneringsfeil

Skade på innretningskonstruksjon/stabilitets-/forankrings-/posisjoneringsfeil

Risikonivå (RNNP)

Annex K – Marine System and Offshore Structure Incidents

- Sea Gem 1965 – 13 fatalities.
- Alexander L Kielland 1980 – 123 fatalities.
- Ocean Ranger 1982 – 84 fatalities.
- Glomar Java 1983 – 81 fatalities.
- Secrest 1989 – 91 fatalities.

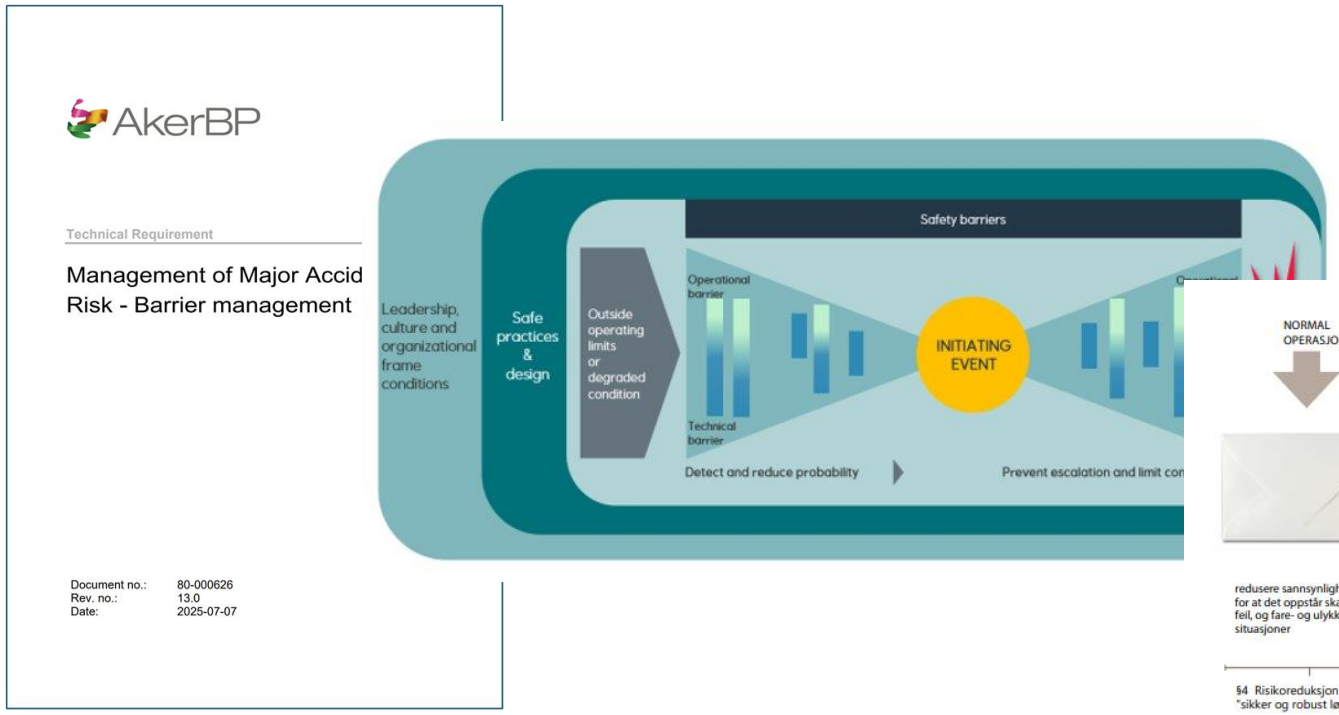
Annex K – Marine System and Offshore Structure Incidents

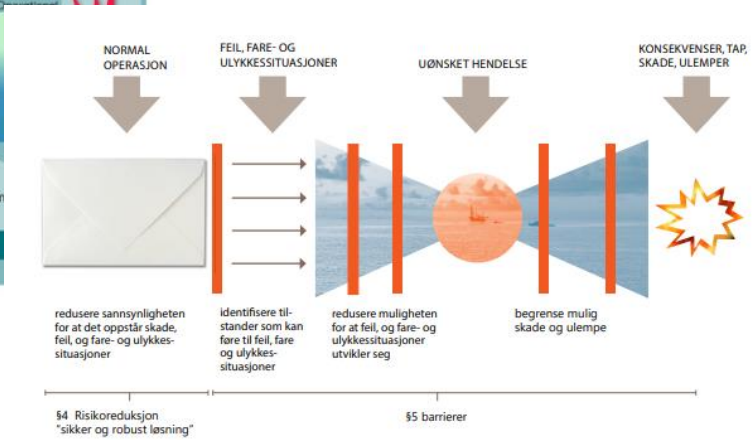
- P-36 2001 – 11 fatalities.
- P-34 2002.
- Thunder Horse 2003/West Phoenix 2020/Transocean Arctic 2020.
- Typhoon TLP 2005.
- Floatel Superior 2012.
- COSL Innovator 2015 – 1 fatality
- Åsgard A 2024.

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.

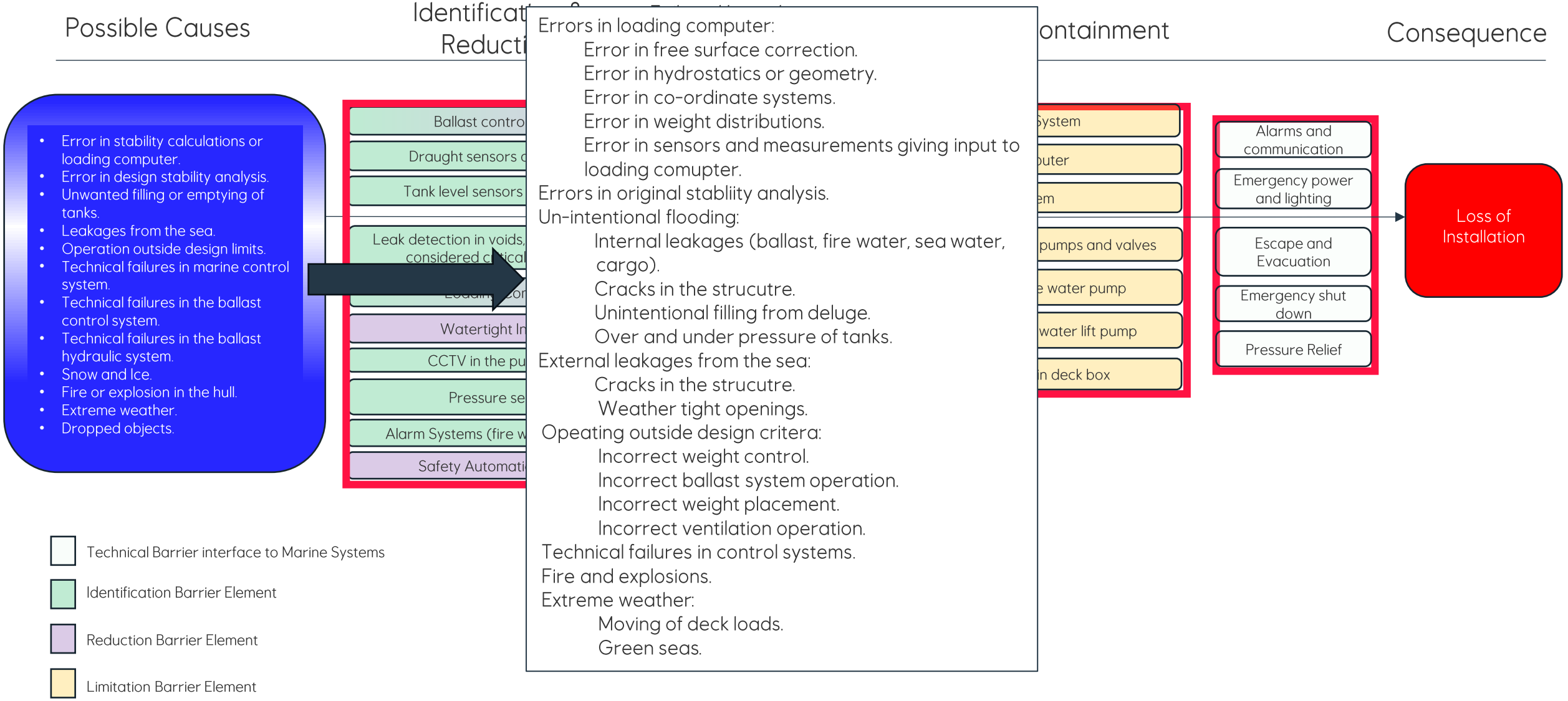




Annex K – failure, hazardous and accidental scenarios

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 - barrier element 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

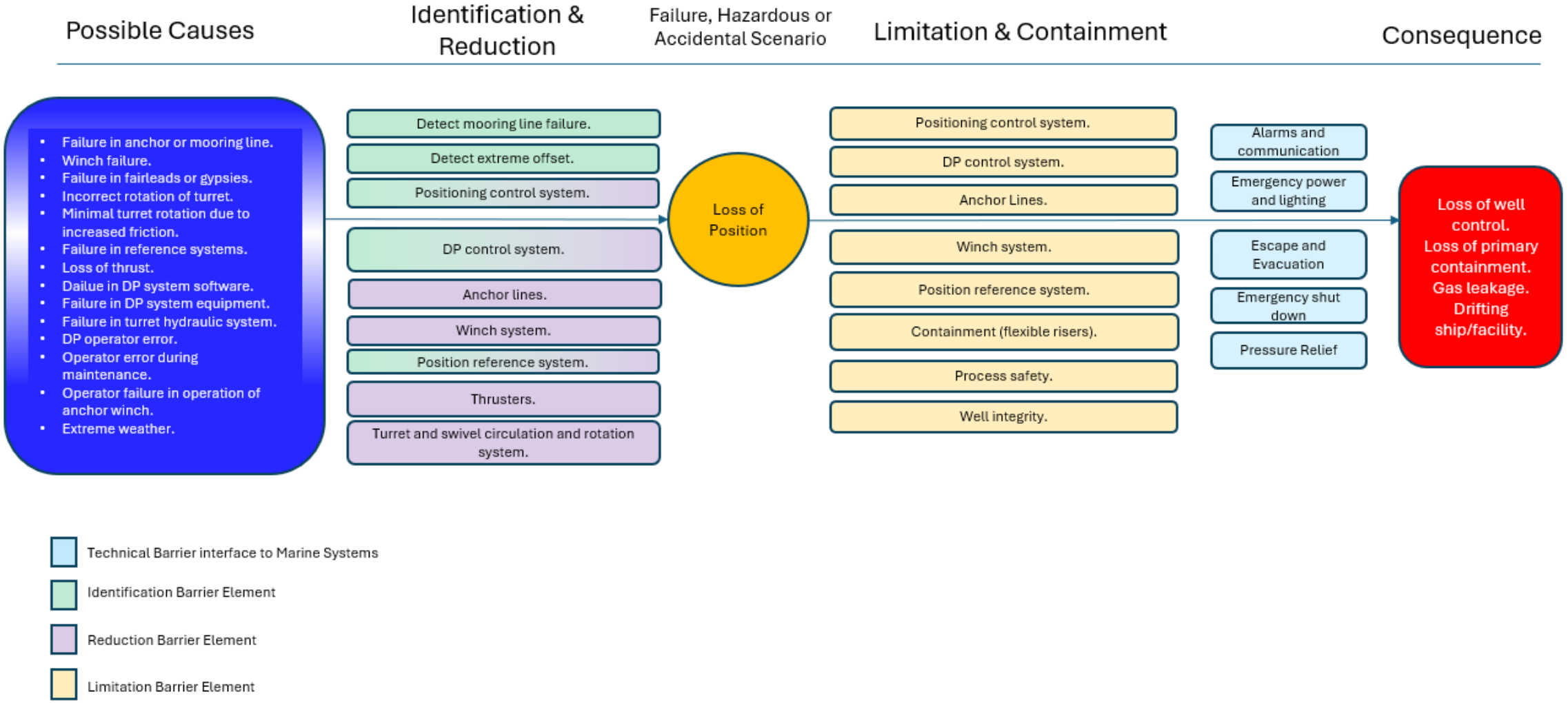
Distribute ballast water to maintain stability within acceptable limits.
 	
Maintain structural loads within design margins
 	
Ballast a facility ensuring depth, stability and structural integrity design criteria are not exceeded.
 	
Ballast a facility to a safe condition following an incident with unexpected 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.

Større hendelser med vann på avveie		
Innretning	Hva	Årsaker
Petrobras P-36 Semi	Tap av innretning i 2001	(1) og (7)
Petrobras P-34 FPSO	34° krengning i 2002	(5) og (9)
Thunder Horse Semi	20° krengning i 2005	(7), (8) og (9)
Typhoon TLP	tap av innretning i 2005	(4)
Aban Pearl Semi	tap av innretning i 2010	(7), (8) og (9)
Deepwater horizon Semi	tap av innretning i 2010	(1), (3) og (7)
Jupiter 1 Semi	tap av innretning i 2011	(7) og (8)
Kolskaya jackup,	tap av innretning i 2011	(4) og (7)
West Venture Semi	Brudd på brannvannsrør i 2000	(3)
Åsgard B Semi	Kollisjon, punkterte oppdriftstank i 2000	(11)
Polar Pioneer Semi	Operatørfeil / feilballastering i 2002	(5) og (9)
Snorre B Semi	krengning pgav vektforskyvning i 2003	(3)
Gjøa Semi	krengning under slep til feltet i 2010	(5), (6) og (12)
Åsgard A FPSO	Vannfylling av pumperom i 2011	(3) og (8)
Scarabeo 8 Semi	7° (12°) Krengning i 2012	(3)
Floatel Superior Semi	Krenging på grunn av skade på ballast tank	(11) / (4)
Veslefrikk B Semi	Utilsiktet vannfylling i sementrom i 2011	(3)
Transcocean Winner Semi	utilsiktet vannfylling av void i 2011	(7)
Songa Encourage Semi	Utilsiktet vannfylling av pumperom i 2017	(3) / (8)
Norne FPSO	Negativ intaktstabilitet under lossing 2016/19	(10)
Transocean Spitsbergen Semi	Vannfylling i 2018	(3) og (6)
Cosl Promoter	Utilsiktet åpning av ballastventiler	(9)

Arne Kvitrud, Ptil
- Case studies of stability accidents (2013)
- Hendelser med stabilitet og ballastering av flytende innretninger (RNNP 2020)

Hovedårsaker
1. Eksplosjon, hull i skrog, skade på kritisk utstyr, flytter store vekter (2)
2. Brann påvirker bærestruktur eller skader kritisk utstyr (0)
3. **Fylling av rom fra interne kilder eller mot sjø (8)**
4. **Miljølaster, utilstrekkelig strukturell integritet (3)**
5. **Programmerings feil i kontroll system (3)**
6. Kortslutninger som påvirker styring (2)
7. **Mangelfull vanntett integritet, eskalerer vannfyll. (7)**
8. **Teknisk feil / operatørfeil pumper og ventiler (5)**
9. **Teknisk feil på HPU system (5)**
10. Feilballastering på grunn av mangelfull kompetanse (1)
11. Kollisjon eller grunnstøting (2)
12. Feil / mangler i stabilitets beregninger (1)

Loss of Position



Annex K – DSHA loss of position – mooring failure, loss of position control

Barrier Function	Technical Barrier Elements (Annex K, Section 4.6)	Operational and Organisational Barrier Elements

Reduce probability for loss of position exceeding the safe operating envelope.
 	
Main a facility's position, haul the facility between positions.
 	
Monitor line tensions, lengths and drift in accordance with allowable tolerances.
 	
Prevent rupture of the risers, BOP, drill pipe.
 	
Prevent collisions through limiting offset.
 	
Provide both release of anchor lines and emergency hauling possibilities in the event of an accident.
	• mooring system:
	  • anchors;
	  • mooring lines;
	  • fairleads;
	• winching system:
	  • anchor winches including brakes and sensors;
	  • winch control systems and emergency stop;
	  • emergency release system on winches (semi-submersible with drilling);
	  • deluge system.
	• position reference system and sensors (e.g. HPR and GNSS);
	• position keeping sensors:
	  • vertical reference sensors (heave, roll, pitch);
	  • heading reference sensors;
	  • line tension sensor and length sensor;
	  • wind sensors.
	• alarms:
	  • offset measurement system including alarms;
	  • line tension and line breakage monitoring system including alarms.
	• turret system.
	• thruster system.
	• DP control system.
	• …..
		• Maritime operational manual.
		• Emergency procedures.
		• Normal operation procedures.
		• Maintenance.
		• Competence and training requirements for personnel.

Annex K – failure, hazardous and accidental scenarios

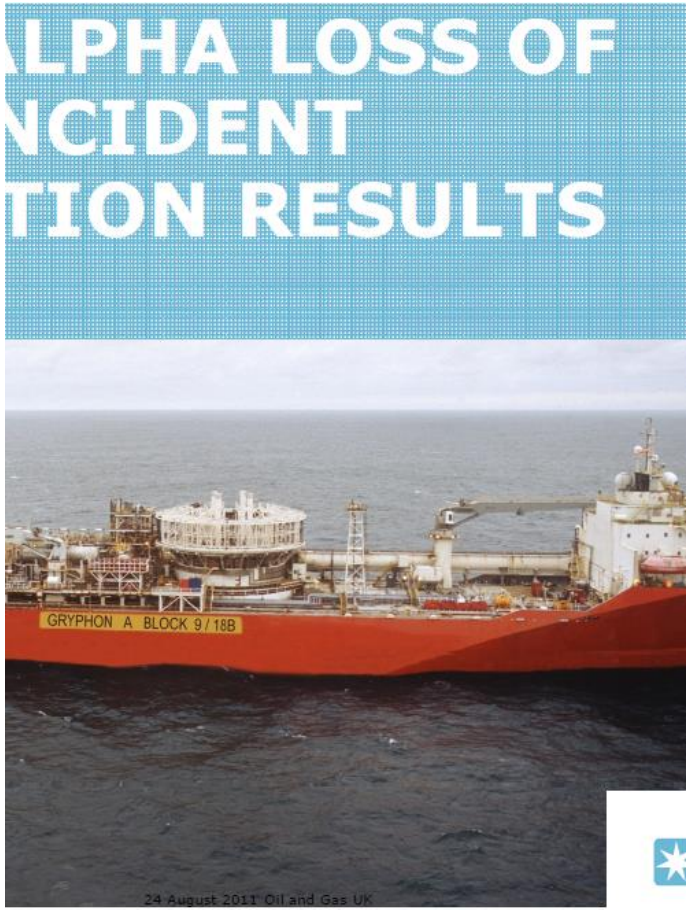
Failure, hazardous or accidental scenario	Offshore structure and marine system barriers	Barrier function	Potential consequences
Ship impact	Position reference systems Offshore structures. Ballast systems.	Reduce probability for ship collisions with impact exceeding design accidental loads. Reduce consequence 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 system and emergency preparedness shall be identified.



Annex K – Marine System and Offshore Structure 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 – Offshore Structure Barrier Management

- It is not possible to test offshore structures physically as with other technical barriers. Integrity of offshore structures is documented through analysis.
- 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 and Marine System Barrier Management

- Offshore structure and marine system incidents (maritime og konstruksjons hendelser) 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.

NORSOK N-005 Annex K

Elizabeth Hostrup, Leading Advisor Marine Concepts