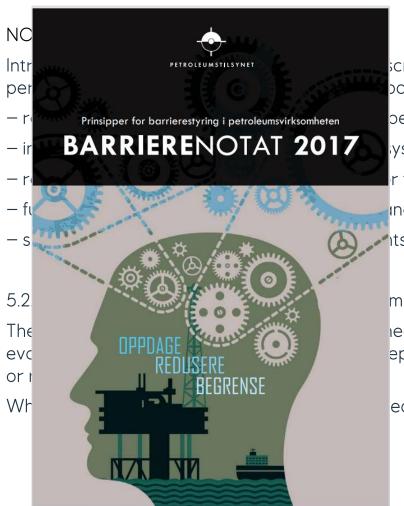


Barrier Management of Marine Incidents: N-005 Annex K

Elizabeth Hostrup, Standard Norge EG-N

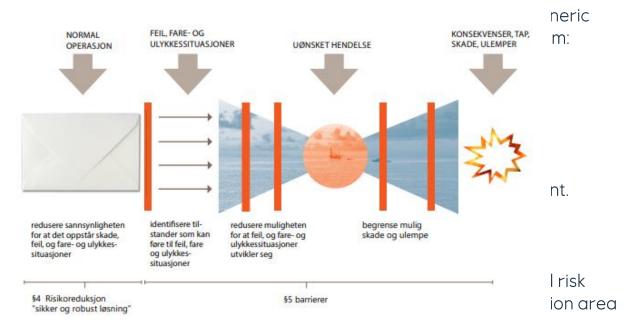


Annex K - Barrier Management Regulatory Framework



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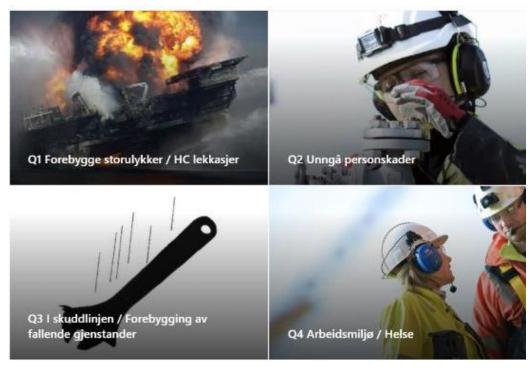
ed, systems and elements necessary for realizing the barrier functions shall be defined.

Barrier memorandum



Annex K - Major Accident Focus













Always Safe



Annex K - Marine System Prioritisation

AkerBP Performance Standards

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

Equinor

Performance Standards for Safety Systems and Barriers

1 - Containment

2 - Natural Ventilation and HVAC.

....

18 – Marine systems and position keeping

19-Avoidance of vessel collisions

20 - Structural Integrity

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....

...

....

24 Marine Systems and Position Keeping

25 Avoidance of Vessel Collision

....

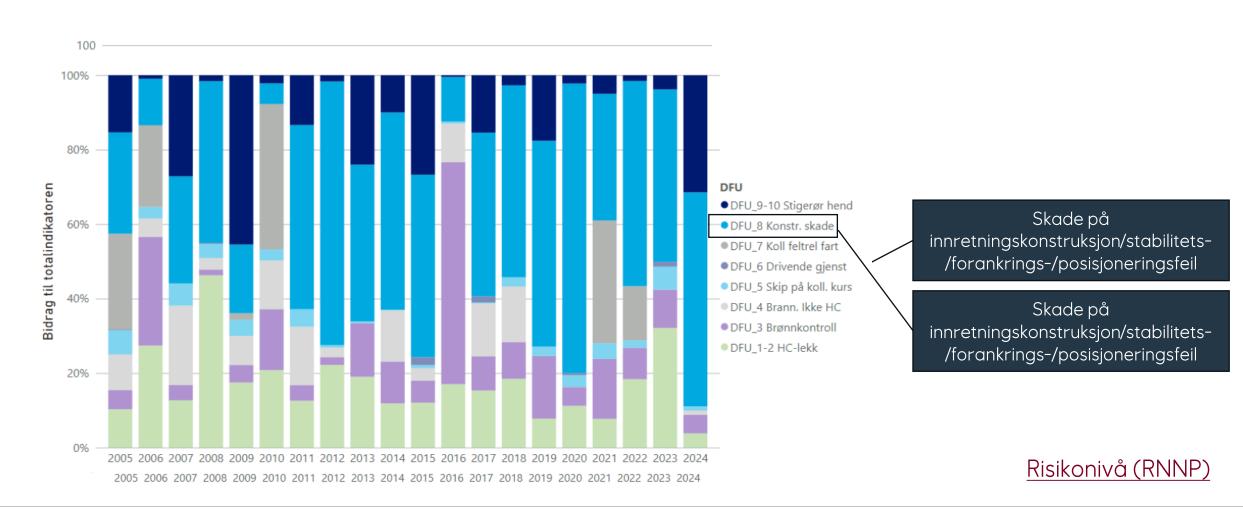
....

27 August 0205



Annex K - Marine System and Offshore Structure Incidents

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



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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

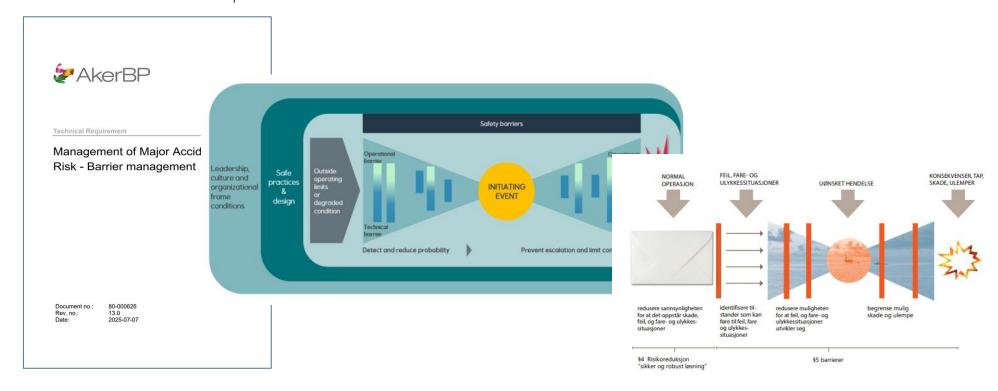
- P-36 2001 11 fatalities.
- P-34 2002.
- Thunder Horse 2003/West Phoenix 2020/Transocean Arctic 2020.
- Typhoon TLP 2005.
- Floatel Superior 2012.
- COSL Innovator 2015 1 fatality
- Åsgard A 2024.



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.	

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Loss of Stability



Identificat Errors in loading computer: Possible Causes lontainment Consequence Reducti Frror in free surface correction Error in hydrostatics or geometry. Error in co-ordinate systems. Error in weight distributions. Ballast contro system Alarms and Error in stability calculations or Error in sensors and measurements giving input to communication Draught sensors loading computer. uter loading comupter. • Error in design stability analysis. **Emergency** power Tank level sensors Errors in original stabliity analysis. Unwanted filling or emptying of and lighting tanks Un-intentional flooding: Loss of • Leakages from the sea. Installation Internal leakages (ballast, fire water, sea water, Leak detection in voids, pumps and valves Escape and Operation outside design limits. considered considered Evacuation cargo). Technical failures in marine control Cracks in the strucutre. water pump Emergency shut • Technical failures in the ballast Unintentional filling from deluge. down control system. Watertight In water lift pump Over and under pressure of tanks. • Technical failures in the ballast Pressure Relief hydraulic system. External leakages from the sea: CCTV in the pu n deck box Snow and Ice. Cracks in the strucutre. Fire or explosion in the hull Pressure se Weather tight openings. • Extreme weather. • Dropped objects. Opeating outside design critera: Alarm Systems (fire v Incorrect weight control. Safety Automati Incorrect ballast system operation. Incorrect weight placement. Incorrect ventilation operation. Technical Barrier interface to Marine Systems Technical failures in control systems. Fire and explosions. Identification Barrier Element Extreme weather: Moving of deck loads. Reduction Barrier Element Green seas. _imitation Barrier Element

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

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

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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)
- <u>Hendelser med stabilitet og ballastering av</u> <u>flytende innretninger (RNNP 2020)</u>

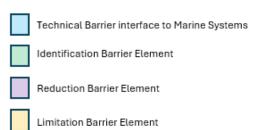
Hovedårsaker

- 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

Identification & Failure, Hazardous or Possible Causes Limitation & Containment Consequence Accidental Scenario Reduction Positioning control system. Detect mooring line failure. Alarms and Failure in anchor or mooring line. communication · Winch failure. Detect extreme offset. DP control system. · Failure in fairleads or gypsies. Emergency power Positioning control system. Incorrect rotation of turret. and lighting Anchor Lines. Loss of well Loss of · Minimal turret rotation due to control. Position increased friction. Escape and Winch system. Loss of primary Failure in reference systems. DP control system. Evacuation · Loss of thrust. containment. · Dailue in DP system software. Gas leakage. Position reference system. Anchor lines. Emergency shut · Failure in DP system equipment. Drifting down · Failure in turret hydraulic system. Containment (flexible risers). ship/facility. Winch system. DP operator error. Pressure Relief Operator error during Position reference system. maintenance. Process safety. · Operator failure in operation of Thrusters. anchor winch. Well integrity. · Extreme weather. Turret and swivel circulation and rotation system.





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. turret system. 	Maritime operational manual. Emergency procedures. Normal operation procedures. Maintenance. Competence and training requirements for personnel.
	DP control system.	

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Annex K – failure, hazardous and accidental scenarios

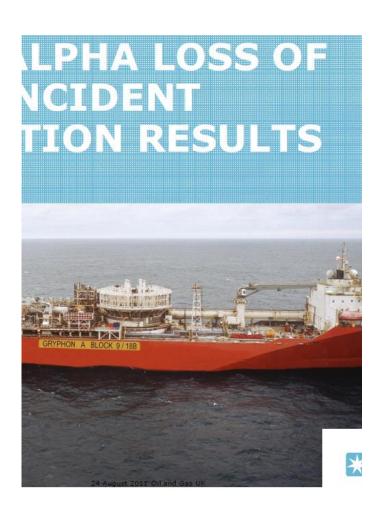
Failure, hazardous or accidental scenario	Offshore structure and marine system barriers	Barrier function	Potential consequences
Ship impact	Position reference systems Offshore structures. Ballast systems.	Reduce probability for ship collisions with impact exceeding design accidental loads. Reduce consequence 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,
	Cargo tank vent system	Reduce the probability for over and under pressuring of cargo tanks.	explosion).

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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









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.





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

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