OFFSHORE NORGE

100 – Offshore Norge Recommended guidelines for detection of acute discharges to sea

Revision no. 4, January 2023

PREFACE

This guideline is supported by Offshore Norge forum for Climate and Environment. It has also been approved by the director general.

The responsible manager in Offshore Norge is the manager environment, who can be contacted via the switchboard at +47 51 84 65 00.

This guideline has been revised with a broad participation from various professional circles within the operating companies. Updated information has been gathered from relevant suppliers of detection systems in 2022.

This revision has been carried out in consultation with the Norwegian Environment Agency (NEA) and the Petroleum Safety Authority Norway (PSA) and is owned by Offshore Norge.

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1 INTRODUCTION

1.1 Purpose

The purpose of this guideline is to recommend processes for establishing and maintaining systems used to detect acute spills, pursuant to the requirements laid out in the Activities Regulations (AR) §57. The term "system" used in AR §57 is synonymous with "barrier detection of acute spills" in this guideline. The barrier shall be managed in the same way as other safety-related barriers in the industry under the Management Regulations (MR) §5 and following the same standards and principles described in the NORSOK S-001 Standard. The barrier shall function satisfactorily in relation to the incident risk and the environmental risk represented by the activity.

Acute spills are illegal pollution and must be detected as swiftly as possible. Depending on the severity scale, the Petroleum Safety Authority Norway (PSA) must receive notification or a report of the spill in accordance with the Management Regulations §29.

1.1 Delimitation

Acute spills include both acute pollution and smaller spills which may lead to significant pollution over time.

The process of establishing or revising a suitable leak detection barrier consists of identifying the risk associated with an acute spill, and choosing detection methods and performance requirements for technical, operational, and organizational barrier elements. It is an iterative process, and the requisite assessment results must be documented and made available in good time for design and purchase.

The guideline is relevant for leak detection establishment and assessment relating to the detection of acute spills to sea from:

- offshore field developments/production facilities
- various stages of an offshore development/production facility (from the exploration phase to the cessation of activities and decommissioning of the installation).

Onshore facility operations are not included in this guideline.

This guideline does not cover follow-up measures once an acute spill has been detected and confirmed, but the methods incorporated into the barrier may be used wholly or in part in any potential mapping of the spill quantity, its characteristics, and its spread in accordance with AR §57.

1.2 Definitions and abbreviations

Acute spills

All unintentional spills from offshore operations which are not permitted pursuant to or in accordance with The Pollution Control Act. All types of unintentional spills are included, even if they do not constitute significant pollution early on.

Acute pollution

"Acute pollution refers to significant pollution which occurs suddenly, and which is not permitted in accordance with the provisions in or pursuant to this Act" (The Pollution Control Act §38). Significant pollution is defined in the guideline to Management Regulations §34 as "causing, or having the capacity to cause, harm or disadvantages to the Environment above and beyond what may be considered minor."

ALARP assessments

As Low As Reasonably Practicable (ALARP) – is a documented and systematic assessment process according to which the responsible party shall choose the technical, operational, or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results, provided the costs are not significantly disproportionate to the risk reduction achieved (cf. the Framework Regulations §11). The risk reduction measures (RRM) shall be reasonably proportionate to the probability of acute pollution and the scope of the harm and disadvantages that may occur (cf. Pollution Control Act §40).

Acceptance criteria

Pre-defined criteria which denote the maximum acceptable risk of acute spills pursuant to the Management Regulations §9. The criteria shall be met regardless of cost. Further risk reduction shall always be assessed according to BAT/ALARP.

Barriers

Measures designed to detect faults, hazardous situations, and incidents, also to reduce the possibility of these situations escalating, and to limit harm and disadvantages.

Barrier function

Barrier detection of acute spills shall detect acute (unintentional) spills as early as possible.

Barrier element

The barrier function is protected by barrier elements which may be technical, operational or organizational. A number of relevant technical barrier elements are listed in the attachment to the guideline.

BAT assessments

Best Available Technique (BAT). An evaluation process which aims to find the best available technology for a specific purpose, based on a cost-benefit approach. To be carried out in accordance with the company's internal requirements and with Offshore Norway guideline 147.

Detection

Detection in this document means the discovery of leaks and acute pollution.

Detection time

The time from when an incident (leak) occurs until the first alarm/discovery. The subsequent course of events, i.e., verification, mapping, mobilization of measures, is not included in the detection time.

Detection system

The term “system” (cf. Activities Regulations §57) is in this guideline synonymous with “barrier detection of acute spills”.

DFU

Defined situations of hazard and accident (DSHA) which form the basis for establishing the activity’s emergency preparedness. In relation to acute spills, the term is usually applied for dimensioning incidents leading to acute pollution or risk of a major incident, based on quantitative risk analyses.

LDB

Leak Detection Barriers. Barrier function, associated barrier elements, and performance requirements can collectively detect actual acute spills which may occur from the facilities, cf. Activity Regulations §57 definition of the system. Relevant technical barrier elements are described in the guideline attachment. The barrier shall also provide sufficient information on small leaks which may, over time, constitute pollution of significance.

Function requirements

Describes the primary barrier requirements so that the barrier fulfils its task or role. The function requirements are adapted to the risks and needs specific to the facility.

Performance requirements

Verifiable requirements relating to the performance of each individual barrier element to ensure that the intended/required barrier function is effective.

1.3 References

- The Pollution Control Act. This Act exists to protect the outdoor environment against pollution and to reduce the quantity of waste and to promote better waste management. LAW-1981-03-13-6. Ch. 6. Acute pollution, excepting §39, duty to provide notification. For notification and reporting, the Management Regulations §29 applies (Notification and reporting of hazardous and accident situations to the supervisory authorities).
- The activities Regulations: Regulations relating to conducting petroleum activities.
- The management Regulations: Regulations relating to management and the duty to provide information in the petroleum activities and at certain onshore facilities.
- The facilities Regulations: Regulations relating to design and outfitting of facilities, etc. in the petroleum activities.
- The framework Regulations: Regulations relating to health, safety and the environment in the petroleum activities and at certain onshore facilities.
- Offshore Norge. Recommended guidelines for BAT for the NCS. (Guideline 147).
- Offshore Norge, 070 Guidelines for the Application of IEC 61508 and IEC 61511 in the petroleum activities on the continental shelf (Recommended SIL requirements)
- NORSOK S-001 Technical safety. Standard.no
- NORSOK S-003 Environmental care. Standard.no
- DNV-RP-F302. Recommended practice. Selection and use of subsea leak detection systems.
- API 1130 Computational Pipeline Monitoring for Liquids Pipelines.
- PSA Barrier note 2017. Principles for barrier management in the petroleum activities.

2 Acceptance criteria

Acceptance criteria must be established for major accident and environmental risk associated with acute pollution (cf. requirements in Management Regulations §9 and Framework Regulations §11). The acceptance criteria is a measurable threshold for acceptable risk for a given facility or a barrier. Above this threshold, risk reduction measures shall be implemented regardless of cost. Below this threshold, the risk shall be further reduced by the application of BAT/ALARP assessments (see Fig. 1).

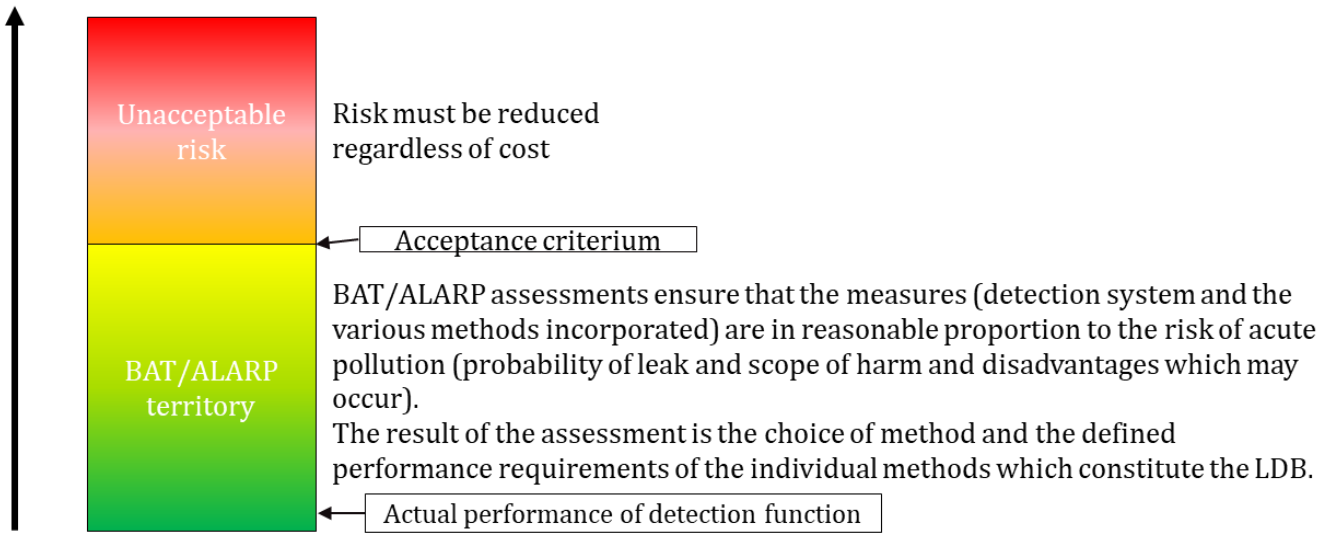

FIGURE 1: CHART ILLUSTRATING THE CORRELATION BETWEEN ACCEPTANCE CRITERIA AND BAT/ALARP ASSESSMENTS PRIOR TO SELECTION OF LDB BARRIER ELEMENTS.

Existing acceptance criteria for major accidents are not necessarily relevant to risk management in the case of lower-risk acute spills. Acceptance criteria for acute spills and leaks with a lower potential for harm may also be established if deemed beneficial for risk management by the operator.

For leaks that do not impact the facility but which may, for instance, pose a threat to shipping traffic, an F-N criterium may be defined (the F-N criteria lines show the relationship between the frequency and severity of accidents in terms of tolerability, where F represents the cumulative frequency per year, and N represents no or more fatalities).

The acceptance criteria shall be installation-specific and risk-based. They shall cover the facility as a whole, including additions to infrastructure such as new tie-backs. The requirements must be formulated to support the decision-making processes relating to risk analyses and risk assessments when establishing/assessing an LDB.

Risk reduction measures shall be implemented regardless of cost if a risk exceeds the acceptance criteria. A BAT/ALARP assessment shall be carried out at a lower risk level to ascertain whether the measure(s) will have a good risk reduction effect relative to the associated costs (see Fig.1).

3 Establishing barrier detection

The scope of methods incorporated into the LDB shall be reasonably proportional to the probability of acute pollution and the scope of the harm and disadvantages that may occur (cf. Framework Regulations §11).

Fig. 2 below illustrates the recommended process when evaluating the scope of the LDB and the choice of methods to be incorporated into the barrier.

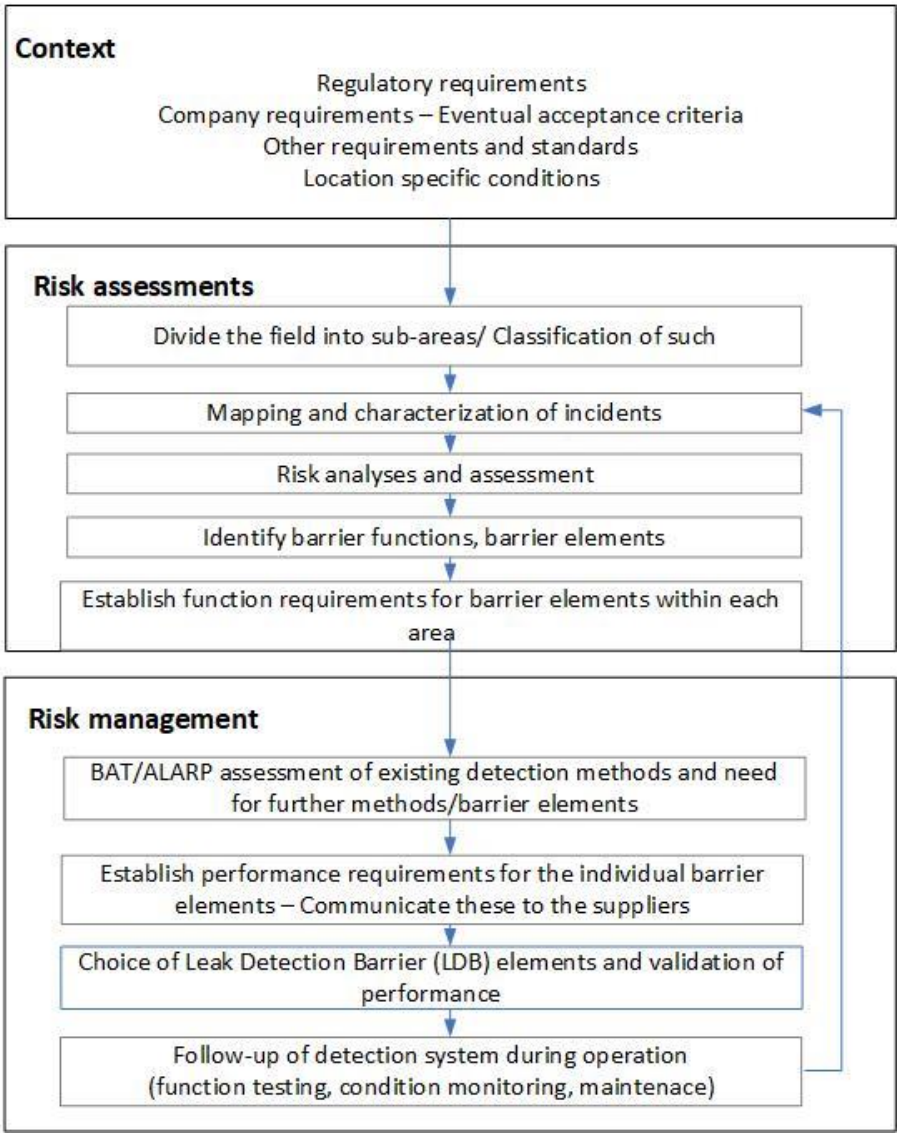

FIGURE 2: DIAGRAM OF PROCESS FOR RISK EVALUATION ASSOCIATED WITH ACUTE SPILLS AND CHOICE OF BARRIERS FOR LEAK DETECTION.

Requirements, input, and results will vary somewhat through a field's lifetime, from the planning phase until the end of the field. Many barrier elements and functions may already be available due to a collaboration between the operators, or they may already be incorporated into other activities on the field. Examples of this are satellite detection, ROV inspection, and process monitoring. The performance of these elements and functions must be assessed in relation to the functional and performance requirements defined by the risk analyses.

For new fields, the operator should develop a leak detection philosophy as early as practicable in the planning phase to describe the plan and the intention for leak detection for the field/installation (for follow-up in the design phase/project development), cf. DNVGL-RP-F302.

The following chapters provide further details for each stage of the process.

3.1 Context

The first stage of the process will be to check all conditions relevant to an LDB assessment. These include regulatory requirements and guidance, standards, company-specific requirements, design and condition of the field/facility, existing available detection methods, and environmental resources in nearby areas.

3.2 Divide field into sub-areas/zones and classify such areas

The field or installation is divided into sub-areas. Typical risk areas are risers, platform safety zones, pipelines (production lines and export pipelines), load lines and seabed templates. The sub-areas are then classified with regards to risk.

3.3 Mapping and characterization of incidents

Within each sub-area, possible incidents are identified which may lead to leaks and/or significant acute spills. Significant incidents are often described as defined situations of hazard and accident (DSHA). They are included in the environmental risk and emergency preparedness analyses. Potential leakage sites include e.g. connection points, christmas trees, etc.

Identified incidents are described in characteristics such as type of medium, hole size, and pressure levels. For actual leakage sites, leakage scenarios are broken down into calculated oil leaking rates, pressure response, and gas, oil, water ratio, etc. Incidents having a lower rate than those detectable through the process control (e.g., pressure and/or rate measurements) are carried forward to the next phase (risk analyses).

3.4 Risk analyses and assessment

Risk analyses are carried out to acquire sufficiently detailed information about the possible consequences of identified incidents within each sub-area. The results are used to evaluate the risk. They identify essential barrier elements and functions that may help to prevent, control, and reduce the risk.

Risk evaluation includes the assessment of:

- Compliance with any acceptance criteria or other minimum requirements.
- Uncertainty relating to input data, method, and results.

Risk analyses are based, inter alia, on identified leak incidents from the previous phase and on location-specific input such as environmental resources, sea depth, and wind/current conditions. The spread of a spill in the water masses and on the sea surface is modelled. When assessing potential consequences to environmental resources on the sea surface and/or in the water column, the threshold values in the ERA (Early Risk Analysis) Acute software tool for environmental risk management are recommended. A lower threshold value or a longer leak duration may also be applied to illustrate chronic effects. The results of these analyses will form the basis for assessing the risk relative to the acceptance criteria, determining the detection capacity on the surface, seabed, and water column, and establishing barrier functions.

Suppose risk matrices are used in the analyses. In that case, consequence categories must be established for smaller leaks, which may, over time, lead to significant pollution. Figure 3 below illustrates an example of such a risk matrix where the consequence categories are denoted as polluted areas. The example also shows how the primary functional requirements are defined and distributed in the risk matrix (see Ch. 3.6 below).

Consequence category	Area (km^2)	10^{-6} - 10^{-5}	10^{-5} - 10^{-4}	10^{-4} - 10^{-3}	10^{-3} - 10^{-2}	10^{-2} - $5x10^{-2}$	$5x10^{-2}$- $2.5x10^{-1}$	$2.5x10^{-2}$- $5x10^{-1}$	$>5x10^{-1}$
		Probability per year							
		<0.001%	0.001-0.01%	0.01-0.1%	0.1-1%	1-5%	5-25%	25-50%	>50%
Insignificant (1)	0	*years*	*years*	*years*	*years*	*years*			
Minor (2)	1-100	*year*	*year*	*year*	*year*	*month*			
Moderate (3)	100-500	*month*	*month*	*month*	*month*	*week*			
Considerable (4)	500-1500	*week*	*week*	*day*	*day*	*day*			
Serious (5)	1500-3000	*day*	*hour*	*hour*	*hour*	*hour*			
Very Serious (6)	3000-6000	*min*	*min*	*min*	*min*	*min*			
Catastrophic (7)	> 6000	*min*	*min*	*min*	*min*	*min*			

FIGURE 3: AN ILLUSTRATIVE RISK MATRIX WHICH CAN BE USED TO ESTABLISH FUNCTIONAL REQUIREMENTS. THE AREA SHOWS CONTAMINATED TERRITORY ABOVE CERTAIN THRESHOLD VALUES. THE CATEGORIES MUST BE ASSESSED BASED ON AREA VULNERABILITY.

3.5 Identify barrier functions and barrier elements

Necessary barrier functions are assessed and established based on context, identified incidents within each risk area, and risk assessment. Barrier elements needed to establish specified

barrier functions shall be defined accordingly and include the organizational, operational, and technical aspects of the barrier function.

3.6 Establish function requirements

The functional requirements are the minimum requirements for fulfilling the barrier function or role. These are based on the installation-specific risk analysis. Studies about leakage scenarios, oil spread modeling, and conditions of nearby surroundings support the definition of functional requirements. A primary requirement is that the LDB can reliably and sufficiently quickly detect acute spills within each risk area if the emission may cause harm.

A typical function requirement for leak detection from seabed facilities might be the maximum detection time for a given emission size and type within the risk areas of the subsea production and transport system.

The function requirements must be weighed up against the existing acceptance criteria at a company level and must be consistent with them.

3.7 BAT/ALARP assessment of existing detection methods and need for further barrier elements

Based on the primary function requirements, actual barrier elements are identified to cover a sub-area.

Other field-specific existing detection methods, such as satellite monitoring, or emergency preparedness vessels, radar systems, and ROV inspection, may be repurposed and used as barrier elements. Their performance must be measured against any acceptance criteria and function requirements. Even if these existing methods meet the established requirements, further measures must always be considered through the BAT/ALARP process.

The attachment to this guideline describes well-known methods applied in leak detection. It summarizes the technology status regarding the available information at the time of revision. Technological developments and testing are ongoing continuously. The attachment may, therefore, not include specific innovative methods, or may include techniques that are considerably more advanced than indicated.

The attachment aims to illustrate what is both certified and commercially available, as well as technologies which need further development by the time of revision. For further information, we also refer to the suppliers´ specifications and to DNV GL´s recommended process for leak detection (DNVGL-RP-F302-2019).

In addition to technical barrier elements in LDB, operational and organizational aspects must also be assessed. These may be operative routines for the detection, evaluation, notification,

and reporting of spills. Routines and their associated competence requirements ensure that the barrier´s function and performance are maintained and verified. Technologies enabling fully automated detection and reporting will always have limitations. Manual routines are, therefore, an essential part of the barrier.

3.8 Establish performance requirements

Verifiable performance requirements must be defined and documented for each barrier element (technical, operational, and organizational) to ensure that the barrier function is fulfilled in operations. Technical performance requirements may refer to areal coverage (template, riser, pipeline, etc.), sensitivity (rate/time of detection), robustness (availability/up-time), reliability (genuine/false alarm), and accuracy (mapping, estimated rate, location).

The installation-specific function requirements for the barrier element covering an area should be used as a basis. The sum of performance requirements for barrier elements must be equal to or more stringent than the functional requirements for the barrier.

3.9 Choice of Leak Detection Barrier (LDB) elements and validation of performance

The various methods incorporated into the LDB must be compared to identify the most suitable technique (BAT/ALARP assessment). The selection of the best available technology must be documentable.

Final performance requirements for specifically selected techniques/methods are defined based on the capacities and limitations of the technique in question. The level usually is significantly more stringent than the specified functional performance requirements. Significant factors affecting performance may include:

- Gas oil ratio (GOR).
- Water depth.
- Differential pressure.
- Background level/noise.
- Quality of flow measurement.
- Wind/wave conditions.
- Natural methane leaks out from the seabed.

Performance must be tested and documented at the time of installation. Verified performance must be followed up during operations.

3.10 Follow-up of detection system, LDB, during operation

All sensor systems depend upon monitoring and maintenance. All sensors incorporated into LBDs must be provided with test reports confirming specific performance giving due consideration to local conditions and a description of testing and maintenance procedures.

The consequences of faults and interruptions during maintenance and repair periods must be considered during the planning phase. Established routines must be in place to compensate for the loss or failure of barrier elements. These may include extra inspections in weather conditions, causing reduced performance in certain technical barrier elements. Separate routines may be needed for unfavorable detection conditions or operations carrying an increased risk of acute spills.

Proper training in the use of the barrier and associated procedures is necessary for those in charge of operations and maintenance. It shall include understanding the purpose of the barrier (function and performance), limitations, and capabilities.

Revisions from version 03 – 2020

This guideline was last revised in 2020 (version nr. 3). In the current version (version nr. 4) all texts and diagrams have been revised following supervisory collaboration, informational exchanges between the operators and dialogue with the authorities. The most important updates may be summarized as follows:

- The clarification is made that leak detection is a barrier like other safety barriers and shall be managed as such in accordance with NORSOK-S-001
- There is a new chapter on acceptance criteria
- There is a revised description of the process to assess and establish the leak detection barrier
- The attachment has been revised based on experiences with various sensors at the field, and as a result of active information-gathering from the suppliers through various channels