HANDBOOK

SAFE HANDLING OF NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

OFFSHORE NORGE

This handbook is developed on behalf of Offshore Norge with the aim of ensuring that work involving personnel contact with naturally occurring radioactive material (NORM) in the oil industry, is conducted safely and in full compliance with applicable regulations and guidelines. In Norway, the term LRA refers to what is commonly known internationally as NORM.

The reference group used consisted of the following members:

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Manager for the marine environment is responsible for this handbook in Offshore Norge. The handbook has been presented to Offshore Norge's Climate and Environment Forum.

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1 NORM AND OCCURRENCE

What is NORM?

NORM refers to naturally occurring radioactive material. Produced water from oil and gas production can contain small amounts of radioactive substances such as radium and lead. Such radioactive substances are a by-product of oil and gas production, as they naturally exist in the reservoirs. These can be deposited or precipitated along with insoluble salts in various parts of a treatment plant for oil-water separation.

The radioactivity from these precipitations is low, providing low radiation or dose rates to the surroundings. In this handbook, the term NORM will be consistently used, though other terminologies such as low-specific activity (LSA) scale may also be frequently encountered. LSA scale is commonly used in the oil and gas industry, referring to low radioactive scale deposits. In Norway, the term LRA refers to what is commonly known internationally as NORM or LSA scale.

Scaling can significantly block fluid flow as shown in the picture.

Photo by Odd Erik Dingsøy, Safeclean AS

The figure below illustrates a hydrocarbon separation plant for produced water, highlighting the areas with the highest likelihood of NORM presence. The gas processing side does normally not have NORM, but dust deposits with low radioactive lead (Pb-210) may occur.

Remember that all hydrocarbon-containing systems can contain NORM

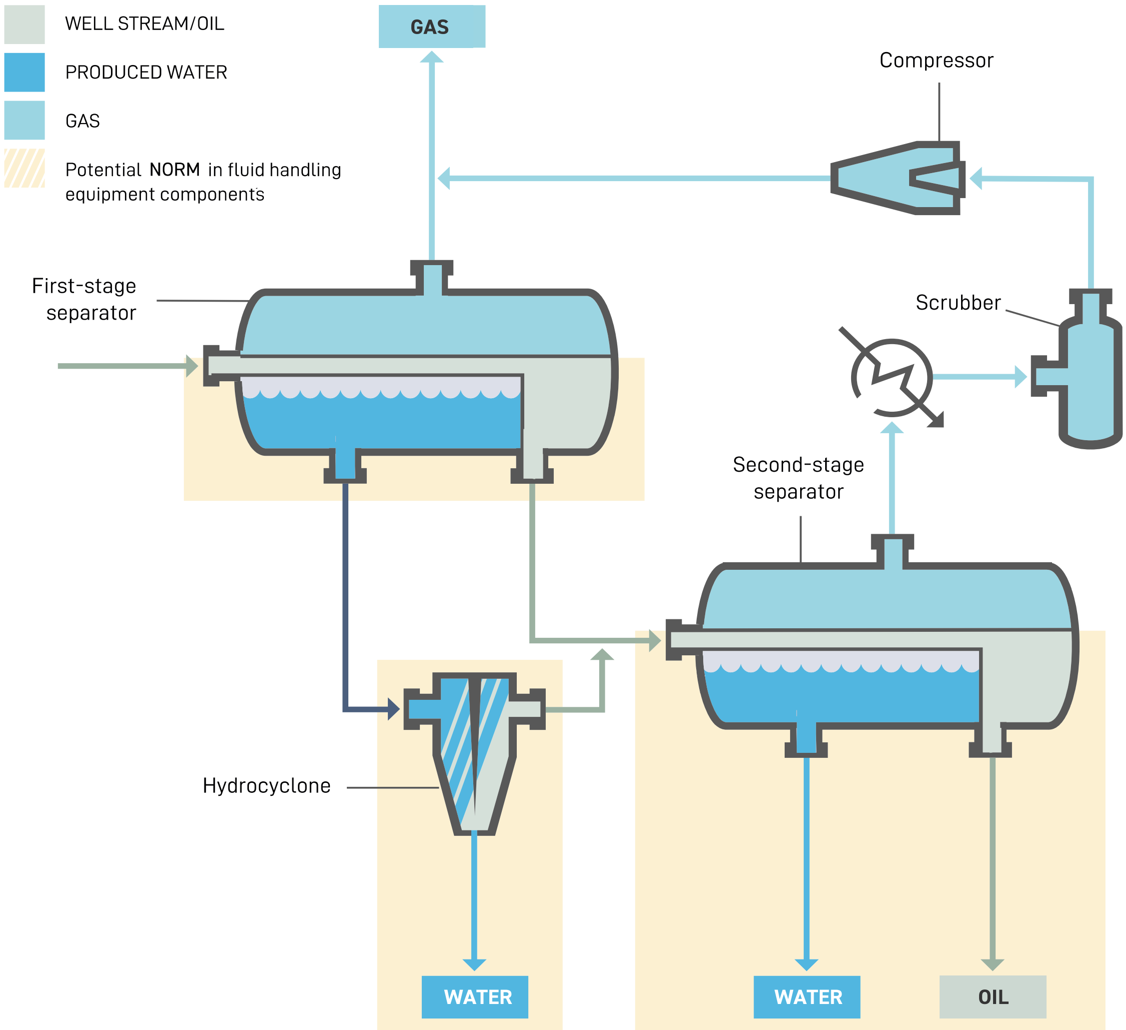


Photo: Odd Erik Dingsøy, Safeclean AS

2 HANDLING OF NORM AND NORM CONTAMINATED EQUIPMENT

Measurement of NORM: For information on measurement methods and equipment, see Offshore Norge's guideline 093 - Recommended guidelines for waste management in the offshore industry.

THE WORKSITE

Appropriate protective equipment
must be selected based on a risk assessment

Labelling:
Clear labelling with radiation warning signs

Exposure level:
Dose rate in micro sievert per hour (microSv/h) shall be assessed

7.5 mSv/h

Dose rate:
If the dose rate exceeds 7.5 microSv/h, the area should be secured with barrier tape

Dust:
If the risk assessment indicates a risk of dust, the area should be secured with barrier tape

Personnel limitation:
The number of personnel is limited to those involved

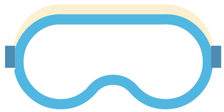
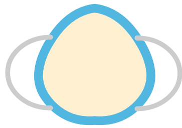
NORM must be kept moist
throughout the work operation to avoid dust formation

Prevent spill spread:
Have barriers to prevent spills from spreading

Remember to keep NORM moist during handling

PERSONAL PROTECTIVE EQUIPMENT

Exposure is mainly through the respiratory tract, which is most relevant regarding contact with NORM. The following table provides the recommended requirements for personal protective equipment when working with NORM or NORM-contaminated equipment:

Activity:	 Safety Glasses	 Respiratory Protection
Measure for NORM before job starts (Dose rate measurement)	Regular safety glasses	Minimum half-mask (clean-shaven) with P3 filter Beard – powered/assisted respiratory protection with loose-fitting headpiece
Measure for NORM before job starts (Puck method)	Regular safety glasses	Minimum half-mask (clean-shaven) with P3 filter Beard – powered/assisted respiratory protection with loose-fitting headpiece
Handling NORM/performing job with risk of NORM exposure	Goggles or full-face mask	Half- or full-face mask with P3 filter (clean-shaven and job planned for less than 60 minutes) Beard or when the job is planned for over 60 minutes – powered/assisted/turbo-based respiratory protection with P3 filter

 Gloves	 Shoes	 Workwear
Suitable/regular protective gloves	Regular safety shoes	Regular workwear
Gloves with minimum certification: EN 421 Protective gloves against ionizing radiation and radioactive contamination certified	Regular safety shoes	Regular workwear
Gloves with minimum certification: EN 421 Protective gloves against ionizing radiation and radioactive contamination certified	Rubber boots/safety shoes with water-resistant upper leather	Disposable coverall suit, minimum type 5, with additional certification: EN 1073-2 Protective clothing against radioactive contamination - Part 2: Requirements and test methods for non-ventilated protective clothing against radioactive particle contamination certified

The protective gear regime comes into effect when NORM is suspected, or when the dose rate is more than 3 times the background radiation (2 times on land).

Additional protective gear may be added depending on the nature of the work.

GOOD WORK PRACTICES WHEN WORKING WITH NORM

It is important to have good work practices when working with NORM or NORM-contaminated equipment. Make sure that:

- NORM does not enter the body through the mouth and nose
- Keep NORM material moist at all times
- Avoid dust, close tubing and pipe ends with protectors and cover open ends
- Wash hands and face thoroughly before eating or drinking

PERSONAL DOSIMETERS

Experience shows that personal doses above background levels have not been detected in workers who regularly handle NORM (LRA in Norwegian), such as employees at the NORM repository in Gulen.

Work with NORM will therefore not result in dose levels exceeding the limit for personnel categorized as not occupationally exposed. (0.25 millisievert per year from a single occupational activity/company).

It is not necessary to wear personal dosimeters while working with NORM

COMPLETION OF WORK OPERATIONS

After the work is completed, the area should be cleaned, the waste taken care of, and the area surveyed using a contamination monitor. The following list may be helpful when the work assignment is completed:

- Collection: All sludge residues are collected as well as possible
- Waste containers: Sludge residues are transferred to barrels with lids and clamping rings
- Closed transport containers: NORM is packed in closed transport containers
- Tight plastic: NORM-contaminated equipment is wrapped in tight plastic
- Sealing: All pipe ends are sealed securely with either plugs, protective cover, or tape (duct tape) or a combination of these
- Cleaning:
  - The area is cleaned to ensure normal background radiation level
  - Equipment is cleaned and waste is placed in waste containers
  - Clothing is rinsed and potential waste is placed in waste containers
- Measurement of dose rate: The work area, equipment, and clothing are checked for radioactivity before leaving the work area

TEMPORARY STORAGE

For temporary storage, the following requirements apply:

- The area: Approved area for such storage
- Suitable containers: NORM is temporarily stored in suitable containers where:
  - sludge is stored in drums or barrels with lids and clamping rings
  - pipes, valves, and similar are stored in containers with lids, and covered with water to 10 centimeters above the contents in the container
- The radiation protection coordinator is notified before the temporary storage is emptied or moved

LABELLING THE TEMPORARY STORAGE AREA

- Labelling: If specific activity is over 10 Bq per gram, the load carrier is labelled with a hazard label for class 7.
- Fencing off: If the dose rate measured immediately on the outside of the waste containers exceeds 7.5 microSv/h, the storage area is secured off with barrier tape and radiation signs are put up.

WORK CLOTHES ARE NOT CONSIDERED NORM-CONTAMINATED MATERIAL

Work clothes used during the handling of NORM should NOT be considered radioactive material.

Regular coveralls are washed and cleaned like other workwear. Disposable coverall suits are discarded as regular waste unless they are flame-retardant. Flame-retardant clothes follow a separate waste procedure.

Disposable suit is not NORM waste.

3 WORK PERMITS AND SAFE JOB ANALYSIS

Inspecting for the presence of NORM does not require a work permit, provided that Ex-safe measuring equipment is used. More extensive work and handling of equipment with proven NORM requires work permit (WP) level 1. To complete WP 1, it is appropriate to conduct a safe job analysis (SJA), which includes the review of the following checklist:

	YES	NO
Have all involved been informed about the risks and hazards with NORM?		
Is the work area sufficiently ventilated?		
Are both a radiation monitor and radiation signs available?		
Is safety barrier equipment such as barrier tape or chain available?		
Is the dose rate in microsieverts per hour measured in the work area?		
Can NORM be kept moist at all times?		
If no, do we have alternatives to keep it moist?		
Do we have facilities to prevent NORM spills at the workplace?		
Do we have appropriate equipment to clean the workplace after the assignment is completed?		
Are all involved equipped with appropriate personal protective equipment for the specific job to be done?		
Are all informed that hands and face should be washed thoroughly before various breaks are taken?		
Are there enough waste containers for collecting sludge?		
Are there suitable containers for pipes, valves, and similar?		
Is there enough sealing material to seal openings in pipes and other equipment?		
Are closed and approved transport containers available?		
Can the dose rate at the intermediate storage site exceed 7.5 microSv/h?		
In the event of an accident, does everyone know who should be notified?		

	Comments
How many people are necessary for the work operation?	
In case of suspicion of inhalation of NORM dust, who should be notified?	
How long will the job take?	
In which types of accidents should the Norwegian Radiation and Nuclear Safety Authority (DSA) be notified?	

4 ACCIDENTS AND DEVIATIONS IN HANDLING NORM

ACCIDENTS DURING HANDLING OF NORM

In the event of an accident, notification shall be made according to the current emergency plan, and the following measures shall be implemented:

- Collection of spill: All NORM should be collected as soon as possible in case of spill or leakage
- Inhalation of NORM: If there is suspicion that personnel have been exposed to NORM dust through inhalation for a longer duration (over several hours), a medical assessment should be conducted.

REPORTING DEVIATIONS RELATED TO NORM

All deviations from authority requirements and operator companies' internal requirements are registered in the companies' monitoring system for unwanted incidents.

Reporting to the authorities follows its own requirements found in the emergency plan for the facility.

Examples of events that should be notified to the DSA may include:

- Container with NORM gone astray
- Spill with NORM outside the monitored area
- Serious or repeated breaches of protective measures, personnel exposure
- Transport accident
- Break-in at the storage facility

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Emergency telephone to the Norwegian Radiation and Nuclear Safety Authority:

(+47) 67 16 26 00

5 COMPLETING FORMS

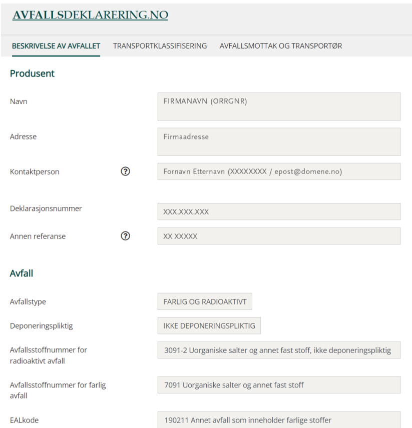
DECLARATION FORM FOR HAZARDOUS WASTE AND RADIOACTIVE WASTE

The declaration form for hazardous and radioactive waste should always be completed for NORM waste. The Norwegian waste number should be applied along with the European waste code, an EAL code which is a six-digit number. Offshore Norge's guideline 093 - Recommended guidelines for waste management in the offshore industry provides information about various waste numbers.

For NORM, the waste number always starts with the number 3. The number after the dash indicates waste disposal route. 1-digit for national repository.
The numbers used are:

- 3025 – 1 or 2; oil-contaminated sludge/sediments/deposits, etc.
- 3081 – 1 or 2; mercury-containing sludge with radioactivity
- 3091 – 1 or 2; radioactive sediments from descaling activities

EAL code 130502 is used for 3025 and 3081, while EAL 190211 is used for 3091.


AVFALLSDEKLARERING.NO

BESKRIVELSE AV AVFALLET | TRANSPORTKLASSIFISERING | AVFALLSMOTTAK OG TRANSPORTØR

Produsent

Navn	FIRMANAVN (ORRGNR)
Adresse	Firmaadresse
Kontaktperson	Fornavn Etternavn (XXXXXXXX / epost@domene.no)
Deklarasjonsnummer	XXX.XXX.XXX
Annen referanse	XX XXXXX

Avfall

Avfallstype	FARLIG OG RADIOAKTIVT
Deponeringspliktig	IKKE DEPONERINGSPLIKTIG
Avfallsstoffnummer for radioaktivt avfall	3091-2 Uorganiske salter og annet fast stoff, ikke deponeringspliktig
Avfallsstoffnummer for farlig avfall	7091 Uorganiske salter og annet fast stoff
EALkode	190211 Annet avfall som inneholder farlige stoffer

Oil-contaminated materials (7022) can also contain NORM and should in that case be declared as radioactive.

SEA TRANSPORT OF NORM, COMPLETING THE DANGEROUS GOODS FORM IMDG AND LABELLING

The transport regulations differ from other regulations regarding NORM waste. It is only when NORM waste has a specific activity of 10 Bq/g and above, that a dangerous goods document should be issued. This means that it is only in cases where there is reason to believe that the specific activity is over 10 Bq/g that the International Maritime Dangerous Goods (IMDG) form should be used.

TRANSPORT BARRELS/DRUMS AND TRANSPORT CONTAINERS FOR NORM OVER 10 BQ/G

Forms:

"Declaration form for hazardous waste and radioactive waste"

Dangerous goods form, IMDG. Text always in English.
An example of filled text might be:

UN 2912, Radioactive Material, NORM - I, Class 7, 1000 kg
Radium 226, Solid, Activity: 30 MBq
Lead - 210, Solid, Activity: 5 MBq
Category: I – White
All packed in one
Type IP - 1 package, 15 barrels in Steel Container
EmS: F-I, S-S
Return form, a manifest with information as in the Bill of Lading.

Labelling:

Hazard labels 25 x 25 cm, also called "square marking"
Class 7 I – white (dose rate on the outside < 5 microSv/h)
No transport index TI necessary for this hazard class

NORM/LSA-CONTAMINATED EQUIPMENT

Definition of LSA-contaminatied equipment offshore is when the dose rate is 3 x higher than background radiation.

Marking:

Pack and package as in the chapter on packing.

Remember IMDG form only when there is reason to believe that the waste is over 10 Bq/g.

Class 7 II – yellow can be disregarded in NORM context. For contaminated equipment with measured results between 1 – 10 Bq/g, a comment is added in the return document.

NORM-contaminated equipment is marked with a hazard label class 7 (over 10 Bq/g)

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WHAT IS RADIOACTIVITY?

As an example, imagine a pipe, a valve, or other equipment that has been cut, and inside are the radioactive substances radium and lead.

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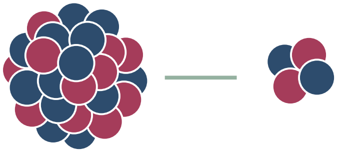
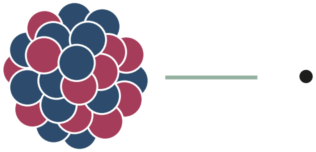
Radium – 226, Radium – 228, and Lead – 210 are the main radioactive substances found in NORM.



AN ALPHA PARTICLE consists of two protons and two neutrons



A BETA PARTICLE is an electron

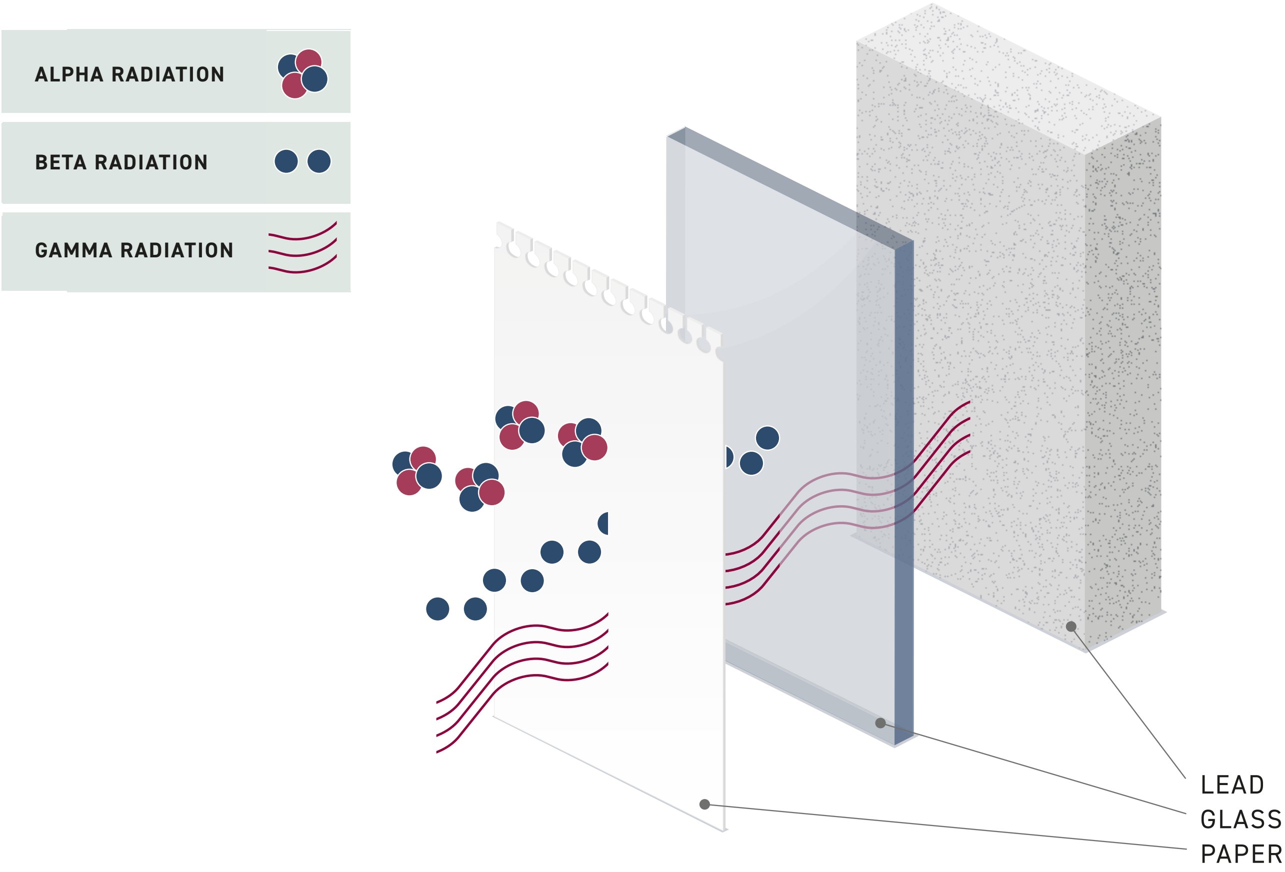
A GAMMA RAY is pure energy

Radioactive substances emit radiation by particles from the atomic nucleus splitting off either in the form of energy-rich alpha particles or as the somewhat less energy-rich beta particles. In addition, gamma radiation is produced because the nuclear particles optimize their escape by stealing a bit of mass from the atomic nucleus and converting this into pure energy, into gamma rays. In short, we can say that radioactivity is a mechanism where a heavy unstable atomic nucleus rids itself of energy by emitting matter in the form of alpha or beta particles and adjusts its energy level by emitting gamma rays.

With this radiation, the content of radioactive substances decreases. Some decrease quickly while others decrease slowly. For thorium and uranium found in reservoir rocks, it will take billions of years before they are gone. The number of nuclear particles in the atomic nucleus that split off each second is called activity and is measured in becquerel (Bq). Specific activity in becquerel per gram (Bq/g) is the number of becquerels found in one gram of sample, and the sum of the specific activity of radium and lead forms the basis for classifying NORM.

Waste under 1 Bq/g is not defined as radioactive waste
Waste over 1 Bq/g is radioactive waste
Waste over 10 Bq/g is radioactive waste that must be stored in repository

The activity in becquerel does not distinguish between alpha-beta-gamma radiation. To be able to say something about possible adverse effects on people and the environment, the term dose is used with the unit Sievert. The dose number in Sievert (Sv) takes into account the type of radiation, which organs are irradiated, whether the radiation is short-term or long-term, distance from the radiation source, and other factors. The dose rate is measured in nano- and microsieverts per hour, and is typically written as nanoSv/h and microSv/h.



The heavy energy-rich alpha rays can be stopped by a sheet of paper. Beta particles can penetrate skin but are easily stopped by clothes. Gamma radiation penetrates steel and concrete but is largely stopped by 10 centimeters of lead.

A simple and good measure to reduce possible doses when working with radioactive material is to maintain distance. The dose decreases with the square of the distance from the source, i.e., if one doubles the distance between oneself and a radioactive source, the dose decreases to a quarter.

Maintaining distance from radiation sources is a good measure to limit any radiation doses.

Safe handling of NORM in the oil and gas industry is possible by:

1. **Following the recommendations given in this handbook**
2. **Not eating or drinking during work with NORM**
3. **Ensuring good hygiene by washing hands and face afterwards**

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