Naturally Occurring Radioactive Material – The Facts

1. What is NORM?

Radiation can be useful. In everyday life, we encounter useful sources of radiation such as in the sensors of most domestic smoke detectors. In oil exploration, natural background radiation can help us to discriminate between shale and sandstone, and helps to identify rock formations and effectively target reservoirs.

Natural background radiation is all around us. It comes from cosmic rays, from the air we breathe and the food and water we consume. Rocks, including the rocks from which oil and gas are derived, contain trace amounts of naturally occurring radioactive elements such as uranium and thorium, trapped within mineral grains.

The isotopes of these elements slowly undergo natural radioactive decay to produce other radionuclides referred to as 'daughter radionuclides'. Some of these daughter radionuclides, such as isotopes of radium and radon, have very different physical and chemical properties to their parents. Radon is gas and radium can be soluble in water.

Naturally occurring radioactivity is a by-product of oil and gas production that has to be managed. During the production of oil and gas, they can be transported to the surface and sometimes accumulate to levels where special precautions are required.

Materials such as scales (hard deposits that block piping and other equipment) that contain elevated levels of radionuclides are generally called NORM – Naturally Occurring Radioactive Material.

You may also come across names such as TENORM – (Technologically Enhanced NORM), LSA scale (Low Specific Activity scale) and SCO – Surface Contaminated Object, all of which essentially refer to the same type of hazard – materials that are measurably above natural background radiation, making additional precautions necessary.

NORM radioactivity cannot be seen, felt, or measured without specialist equipment. It never reaches levels where it poses an acute danger to health but long term exposure increases the cumulative risk to the individual.

> The oil and gas industry rigorously follows national and international requirements that apply to all forms of radiation – protecting our workforce and the wider environment.

2. Where does NORM occur?

As NORM in the oil industry is closely linked to the way in which we extract oil and gas, we can provide industry-specific guidelines on where to look for NORM and how to keep the risks As Low As Reasonably Practical – the ALARP principle.

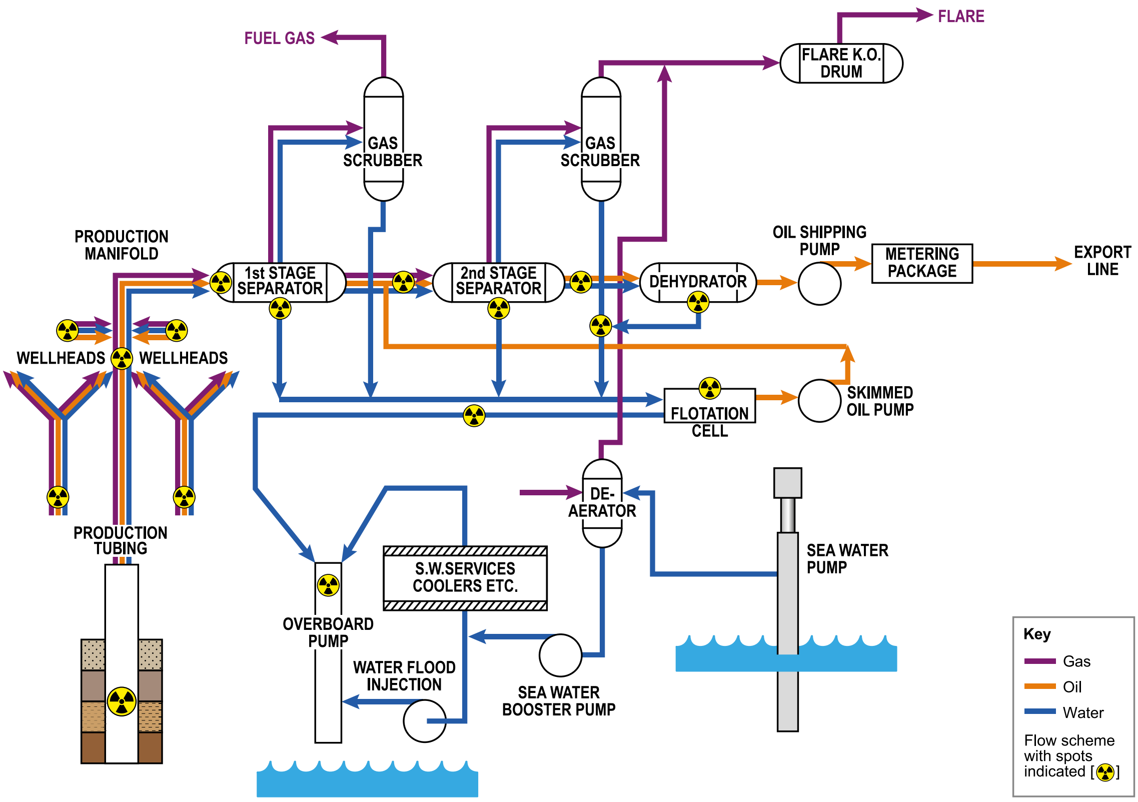
As oil and gas (along with water and other gases) are extracted, they pass through a number of production steps, each introducing changes such as temperature and pressure. These changes lead to the accumulation of radionuclides. Radionuclides are often in waste deposits such as scales, sludge, and coatings. Radon is a heavy inert gas, which can accumulate in tanks and separation systems. Its decay products can also form coatings.

Predicting where NORM will form is complicated. Conditions within a production facility change over time, and with them the presence and location of NORM. Wells from similar locations and geological formations can have different levels of radionuclides present.

NORM also occurs in coal and mineral mining, steel manufacture and fertilizer production. The issue of NORM across industrial sectors is generally covered by similar legislation.

Tank sludge

Pipe scale



Some of the typical locations where NORM is encountered in an offshore oil and gas facility.

3. How is radiation measured?

Radioactive isotopes decay spontaneously to produce 'daughters', which in turn may also be radioactive.

There are three types of decay – **alpha**, **beta** and **gamma** with characteristic properties and energy. The rate of decay is expressed as the 'half-life' – the time taken for the activity of an individual isotopes to halve.

In the context of NORM, those isotopes with half-lives ranging from tens to thousands of years are most important as they persist in the environment long enough to interact with people.

The key measurements for NORM are activity and dose:

- **Activity** is normally measured in Becquerels (Bq) and is the total amount of radiation present
- **Effective Dose**, normally measured in Micro-Sieverts (μSv) is a measure of risk and takes in to consideration the type of radiation and nature of the exposure.

Getting the units of measurement right is critical to effective NORM risk management. Some countries, such as the United States of America, prefer to use older (non-SI) units of measurement such as the Curie (for activity) and Rem (from Dose). Conversion is relatively straightforward, but done incorrectly it leads to under or over estimation of risks.

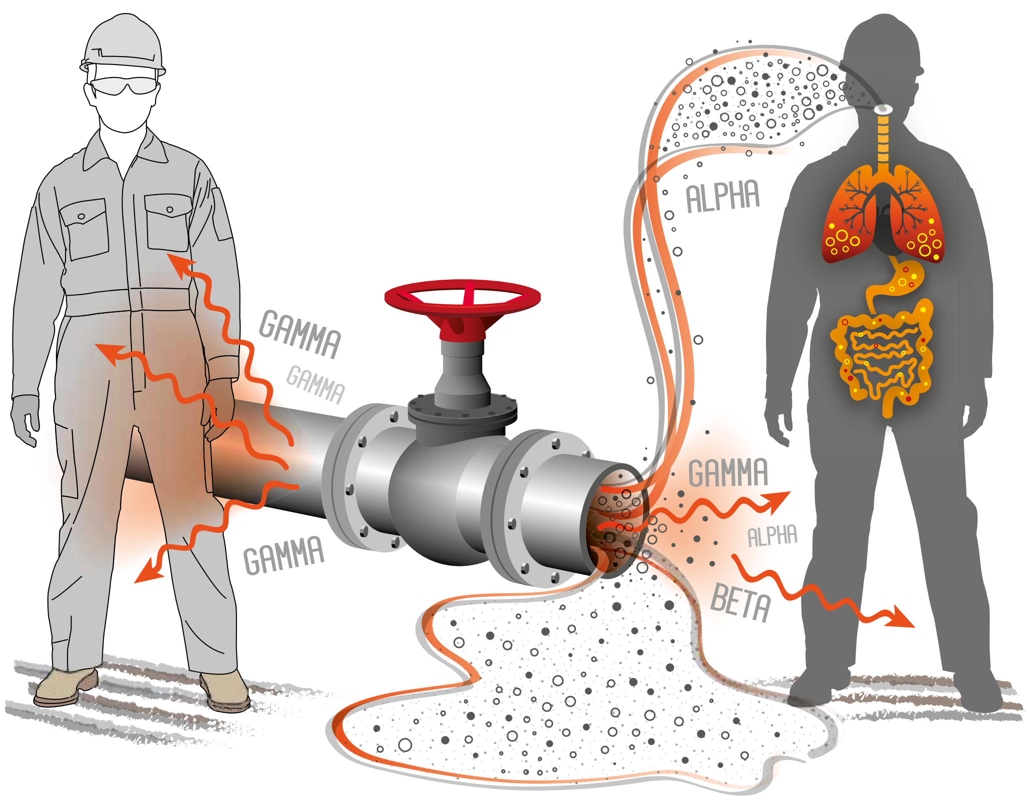
4. How are people exposed to NORM?

There are two ways in which personnel can be exposed to radiation emitted by radioactive material, including NORM:

- **irradiation** from external sources
- **contamination** from inhaled and ingested sources.

Exposure to NORM is therefore managed through a combination of the time spent working in a NORM-contaminated area (irradiation), the distance from a source (irradiation) and appropriate use of personal protective equipment (contamination).

Irradiation **Contamination**



Gamma rays can escape vessels and pipes, increasing the risk of irradiation

Alpha particles are slow and heavy, they pose the greatest risk when ingested or inhaled

Beta particles can penetrate further, but typically have less energy

All three types of radiation can be encountered from a single source of NORM

5. Health effects of NORM – how big is the dose?

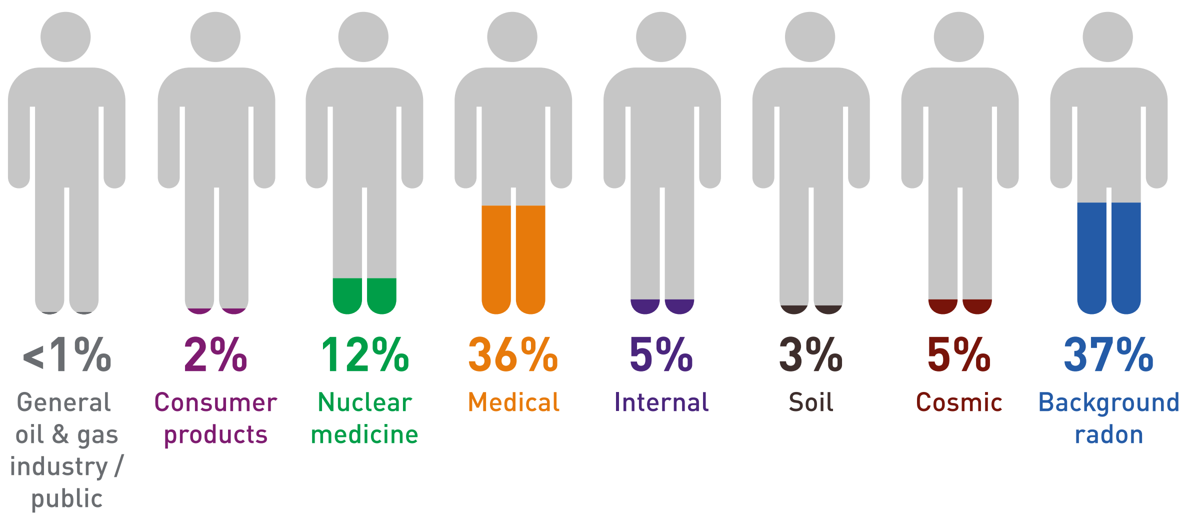
The effective dose from NORM for general oilfield workers represents less than 1% of their annual exposure to radiation. For the purposes of radiological protection, oilfield workers are therefore considered to be members of the general public.

For personnel handling production waste, the effective additional annual dose from works with NORM can reach a maximum of up to 15% of their annual exposure to radiation.

The exact exposure varies from person to person depending upon their job. If necessary, individual exposure levels can be measured (along with all other sources of radiation encountered) but this is seldom required.

When oil and gas companies employ specialist contractors to monitor, clean and dispose of NORM, these workers are subject to additional legislation and health monitoring.

The risk to general members of the public from NORM is very low.



6. Does NORM harm the environment?

The majority of natural radionuclides coming from an oil or gas reservoir never become entrained within other materials to become NORM. They either dissipate naturally or are returned to rock formations deep underground.

Water that is co-produced with oil and gas can contain radionuclides such as radium in solution. Much of this water is re-injected to rock formations deep underground. Where this produced water is discharged to the sea or other surface waters, it combines with the normal background radiation and rapidly dissipates. Significant elevated levels of radiation cannot be measured in sea water in the vicinity of oil platforms.

In some jurisdictions, such as the OSPAR region (the north east Atlantic and the North Sea), oil and gas producers are required to monitor and report these discharges. They are combined with other industrial sources to provide an overall measure of man-made releases of radioactive material.

Whilst there is currently heightened interest in unconventional oil and gas production – using techniques such as hydraulic fracturing (fracking) – the levels of radionuclides encountered and the activity of associated NORM wastes fall within the range of activities seen in conventional oil and gas production.

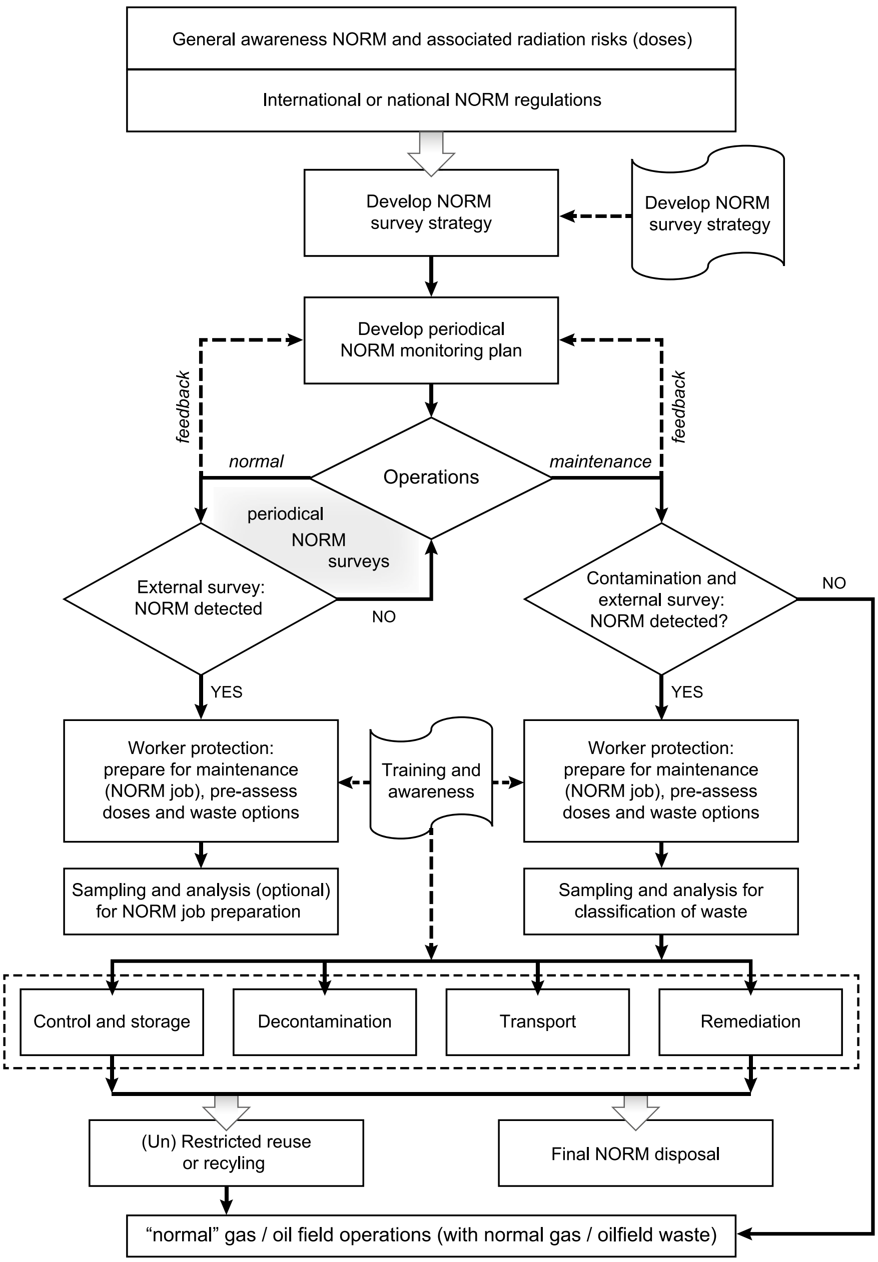
Radon in natural gas has either decayed away to background levels or been dissipated long before it reaches the point of use. Gas facilities that have a build-up of radon are carefully vented before servicing. The radon dissipates into the atmosphere.

7. What controls are needed for NORM?

Where NORM is expected, a management plan is required to monitor and control the risk in an appropriate and proportionate manner, complying with relevant national and international legislation.

As the occurrence of NORM can change over time, these plans are reviewed regularly and sites routinely monitored.

NORM can occur alongside other direct hazards, such as working in confined spaces, black dust (combustible iron sulphide). A comprehensive safety management system includes consideration of NORM.



8. What can be done with NORM wastes and contaminated equipment?

Equipment containing NORM can be routinely decontaminated as part of its service schedule or at the end of its working life. This may be either done *in situ* or by transporting it to specialist contractors for maintenance. Decontaminated equipment is routinely re-used or recycled.

Transportation of NORM, both within country and internationally, is strictly regulated following practices that apply to all sources of radiation.

Land contaminated with historical NORM wastes can often be successfully remediated and the NORM sent for disposal.

NORM separated from equipment can be disposed of in a variety of ways. The selection of disposal methods is highly dependent upon in-country preferences and national legislation and availability of specialist waste handling services.

Further reading

For a more detailed assessment of NORM, its origins, management and risks, IOGP has published an updated copy of its Report 412, *Managing Naturally Occurring Radioactive Material* which is free to download from http://www.iogp.org/pubs/412.pdf

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