Health & Safety

NORM Management Practice

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1.0 Purpose

The purpose of this NORM Management Practice is to provide an overview of Cenovus's expectations relating to Naturally Occurring Radioactive Material (NORM) exposure and the management of NORM-contaminated material.

This practice is supported by CEN-EHS047, NORM Field Guide.

2.0 Scope

This practice applies to all Cenovus worksites and encompasses all Cenovus work activities. Contractors working at Cenovus sites where NORM may be encountered are expected to have their own management program in place that offers an equivalent level of awareness and safety.

This NORM Management Practice supersedes any prior revisions and incorporates CEN-EHS045, NORM Awareness Practice (repealed).

3.0 NORM Awareness

3.1 NORM and Radiation

Radiation is electromagnetic energy that originates from a source that can travel through space. Radiation can be broadly categories as ionizing radiation and non-ionizing radiation.

NORM is an example of ionizing radiation. It is material that contains radioactive elements of natural origin. We are exposed to NORM every day from the sky, the air we breathe and the food we eat.

Concentrations of NORM are generally low in sedimentary rocks and the associated liquids and gases. However, activities such as oil and gas extraction and processing can create conditions that allow NORM to accumulate, leading to elevated levels of radiation that may pose a health and safety risk.

To learn more about radiation and NORM, see Appendix A.

3.2 NORM Health & Safety

3.2.1 Health Effects

In addition to natural background radiation exposure, occupational exposure to NORM due to oil and gas activities is unlikely to cause acute symptoms such as radiation sickness or immediate death. However, exposure to NORM, especially if exposure is repeated over a long duration, may cause cancer, tissue changes and/or a shortened life span. While exposure limits for workers and the public have been established based on decades of data, it is advised that exposures be kept as low as reasonably achievable.

3.2.2 NORM Exposure Limits

The occupational exposure limits (OEL) for whole body radiation doses are stated in the following documents:

- Alberta Radiation Protection Regulation (AR182/2003), Schedule 1
- Saskatchewan Radiation Health and Safety Regulations (2005), Table 6

Table 1: Effective Dose Limits

Affected Group	Effective Dose Limit
Incidentally Exposed Workers (most oilfield workers)	1 mSv/year
General Public	1 mSv/year
Occupationally Exposed Radiation Workers	50 mSv/year 100 mSv/5 years

Note that the stated dose limits apply to exposures resulting from work environments only and do not account for radiation exposure from any other source, such as medical diagnosis or natural background radiation. Pregnant occupationally exposed radiation workers have lower limits. Consult Health & Wellness for assistance.

Cenovus workers who come in contact with NORM are incidentally exposed workers, unless otherwise classified. The Cenovus NORM management program will keep workers' incremental radiation dose due to NORM exposure below 1 mSv per year.

3.2.3 Occupational NORM Exposure

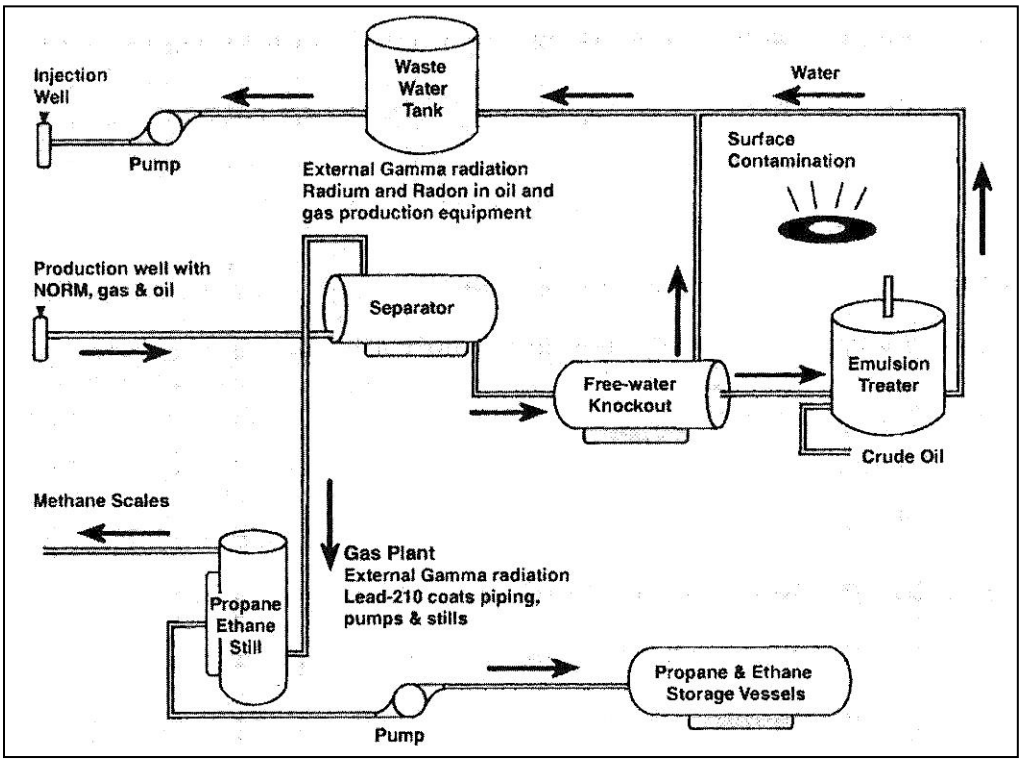
NORM consists of radioactive elements that are naturally present in the earth's crust. In some geological formations, NORM may accumulate in oil and gas process equipment based on the geochemistry of the producing formation and the properties of the liquids and gases that are extracted. Ask your supervisor if a NORM survey has been conducted at your worksite and, if so, what the results indicated.

Exposure to NORM is possible when performing any of the following activities:

- cleaning out NORM-contaminated tanks, vessels, piping and pumps
- changing NORM-contaminated filters
- digging out NORM-contaminated soils
- loading or unloading NORM-contaminated fluids

NORM has been found in the following locations (Figure 11) in measurable amounts:

Figure 1: Potential Locations of NORM



NOTE: Figure adapted from Enform NORM worker level training manual.

3.2.3.1 Liquid Production and Processing

In certain formations, formation fluids contain strontium, barium and/or calcium compounds and trace amounts of radioactive radium. In wellbores, piping, and oil and gas equipment, these compounds precipitate out and accumulate to form sludge and scale at reduced temperature and pressure. As a result, radium may be found having incorporated into the scale and/or is present in the sludge.

3.2.3.2 Gas Production and Processing

Radon gas (radioactive) has a similar boiling point to propane and tends to flow together with propane. Radon is commonly found in propane processing equipment such as deethanizer, reflux pumps and storage bullets. Decay products of radon may also accumulate in points of impaction, such as bends in pipes, valves, orifice plates, etc.

3.2.3.3 Equipment with NORM

Typical oil and gas equipment that may be contaminated with NORM includes the following:

Table 2: Typical Equipment that may be Contaminated with NORM

Produced water equipment	piping, tanks, treaters, surface and downhole pumps, associated filters
Oil equipment	wellhead, piping, pumps, separators, heaters/ treaters, tank bottoms, sludge holding tanks
Gas equipment	propane piping, pumps, filters, storage vessels

Where equipment or material is suspected or found to be NORM-contaminated, a NORM management program will be developed and implemented to ensure proper identification, handling, storage, and disposal of the contaminated equipment and/or material.

3.3 NORM Screening Surveys

NORM emits alpha and beta particles along with small amounts of gamma radiation (See Appendix A for more information). Gamma detection is used as a rapid screening tool to assess an area for the potential presence of NORM. A NORM screening test is performed by a designated NORM Meter User on the external surface of equipment and/or piping without having to take it out of service.

NORM screening surveys will be conducted as follows:

- at most facilities on a schedule as established in CEN-EHS147, Occupational Health Risk Assessment Procedure
- on all equipment and material that is suspected to be NORM contaminated
- at the facility inlet, within one year of fluids from a new reservoir being added to the process stream
- at the wellhead and associated piping, when a new stream is added from a third-party producer

Equipment and material with NORM contamination exceeding twice background levels will be flagged as potentially NORM-contaminated and will be investigated further when the equipment is opened or the material is uncovered.

Information on how NORM is measured can be found in Appendix B.

3.4 NORM Management Classification

NORM screening surveys help to determine the level of protection required for individuals working in and around potentially NORM-contaminated equipment. If NORM contamination is confirmed or suspected, the worksite will develop and implement site-specific procedures based on the NORM management classification (Table 3).

Table 3: Classification of NORM Management

Classification	Health Canada Guideline Levels*	Equivalent Screening Levels*	Actions
	*Above Background Levels		
Unrestricted	< 0.3 mSv/a	< 150 nSv/hr	• No further action is needed
	0.3 mSv/a	*2x background or 150 nSv/hr.*	***Threshold for further investigation***
NORM Management	0.3 – 1 mSv/a	150 – 500 nSv/hr	• Public access restricted • Worker access unrestricted
Dose Management	1 – 5 mSv/a	500 – 2500 nSv/hr	• Worker notification of sources • Work procedures and worker PPE to limit dose • Consider engineering controls • Training • Dose estimation program • Reporting doses to National Dose Registry (NDR) • Assess work site periodically
Radiation Protection Management	> 5 mSv/a	> 2500 nSv/hr	• Formal radiation protection program • Personal radiation dosimetry program • Modified work procedures and provision of PPE to reduce dose

General guidance on protection against NORM is presented in Appendix C. Detailed information on NORM handling is in CEN-EHS047, NORM Field Guide.

3.5 NORM Signage

If NORM is present, warning signs shall be used to alert workers to the presence of NORM-contaminated material or equipment. These signs (Figure 2) are to be conspicuously displayed on the equipment, building and area with exposed or sealed/contained NORM material and may optionally include the trefoil radiation symbol (☢).

Figure 2: Examples of NORM Warning Signs

3.6 Disposal of NORM Waste and Contaminated Surfaces

As a waste generator, Cenovus is required to properly sample and analyze suspected NORM-contaminated waste prior to disposal. Waste material will be segregated from regular waste and subjected to special handling, storage and disposal if one of the following is true:

- the activity of individual radionuclides is above the respective Unconditional Derived Release Limit (UDRL), as listed in Table 4
- the sum of ratios of activity of individual radionuclide and its release limit is greater than 1

Table 4: Diffuse UDRLs for Waste Material

NORM Radionuclide	Unconditional Derived Release Limit		
	Aqueous (Bq/L)	Solid (Bq/kg)	Air (Bq/m^3)
Uranium-238 Series	1	300	0.003
Uranium-238	10	10,000	0.05
Thorium-230	5	10,000	0.01
Radium-226	5	300	0.05
Lead-210	1	300	0.05
Thorium-232 Series	1	300	0.002
Thorium-232	1	10,000	0.006
Radium-228	5	300	0.005
Thorium-228	1	300	0.003
Potassium-40	n/a	17,000	n/a

NOTE: Adapted from *Canadian Guidelines* Table 5.1.

Tools, equipment or scrap surfaces contaminated with fixed, hard-to-remove surface NORM material will be disposed of as NORM waste unless decontamination can reduce levels below that of Table 5 prior to disposal.

Table 5: UDRLs for Surface Contamination of Discrete Sources

Property	Limit
Dose Rate	500 nSv/hr at 50 cm
Surface Contamination	1 Bq/cm^2/100 cm^2 area

NOTE: Adapted from *Canadian Guidelines* Table 5.3.

Table 6: Activity Concentration for an Exempt Material

Radionuclide	Activity Concentration for Exempt Material (Bq/kg)
U-(nat)	1,000
U-238	10,000
Th-234	1,000,000
U-234	10,000
Th-230	1,000
Ra-226	10,000
Pb-210	10,000
Th(nat)	1,000
Th-232	10,000
Ra-228	10,000
Th-228	1,000

NOTE: Adapted from *Canadian Guidelines* Table 6.1.

3.7 Transportation of NORM Material and Contaminated Surfaces

The transport of NORM material is unrestricted provided the material does not exceed the values in Table 4 or Table 5, nor 10 times the values in Table 6.

Otherwise, the transport of NORM material will be subject to the Canadian Guidelines or federal transportation regulations including the Packaging and Transport of Nuclear Substances Regulations and Transportation of Dangerous Goods Regulations.

Cenovus will keep complete laboratory reports and waste records from the initial identification of NORM through to final disposal.

4.0 Roles and Responsibilities

The following responsibilities apply to this practice:

Table 7: Roles and Responsibilities

Role	Description
Cenovus Leadership	• Commission, develop, review and approve the NORM Management Practice for safe storage, use, handling and disposal of NORM. • Ensure NORM Management Practice is reviewed and updated on a three-year cycle or more frequently as required.
Asset Team and Site Leadership	• Ensure all facilities under their control comply with the NORM Management Practice requirements of this and associated procedures. • Ensure training is provided to Cenovus employees potentially exposed to NORM. • Keep records of employee training in the Learning Management System (LMS).
Cenovus Supervisors	• Communicate NORM management control procedures to affected workers. • Ensure the appropriate PPE is available. • Ensure employees use PPE if required. • Respond to worker questions directly or by seeking additional feedback from H&S personnel. • Provide feedback to the asset team and corporate management concerning the value and effectiveness of this NORM Management Practice and all associated procedures. • Ensure workers have been oriented to the hazards of NORM and the controls that are in place. The LMS or other suitable means to track competency may be used for this purpose. • Ensure contractors engaged to do work on Cenovus's behalf have practices to manage NORM hazards that the contractor's employees may encounter while working on Cenovus worksites. • Apply the NORM Management Practice to worksites under their control and establish the necessary competencies for those who may be engaged to support the development and implementation of the practice requirements.
Cenovus Workers	• Familiarize themselves with the NORM Management Practice and all associated procedures. • Be aware of the hazards of NORM exposure and adhere to the controls that are in place to protect their health and safety.

Role	Description
	• Apply recommended practices and procedures, including PPE. • Seek clarification concerning any practice or procedure through their immediate Supervisor. • Reporting to their Supervisor any incidents, and/or unusual conditions regarding potential NORM exposure that may occur during the work, and stopping the work if necessary.
Health & Safety	• Assist the asset team in complying with the NORM Management Practice and all associated procedures. • Respond to questions or concerns relating to the interpretation of the NORM Management Practice and all associated procedures. • Provide assistance to the asset team regarding appropriate NORM measurements.
Health & Safety Solutions	• Provide expertise on NORM monitoring and detection. • Review and provide continuous improvement on the practice.

5.0 Training

The extent and type of training conducted will be determined by the asset team based on site-specific NORM risks at the respective Cenovus worksite and the workers' job responsibilities.

5.1 Training

At minimum, all personnel who will be handling potentially NORM-contaminated systems must be aware of the following:

- potential health effects of exposure
- primary routes of exposure
- procedures for minimizing and controlling exposures and environmental release
- how to measure NORM
- what to do if there is a release of material
- awareness of disposal and transportation requirements

Workers who are designated as a NORM Meter User and therefore having the added responsibilities to conduct field screening surveys must receive additional training by a qualified third-party trainer on the use, handling and care of radiation detection devices.

6.0 Quality Assurance

6.1 Performance Measurement

Compliance with this practice and program effectiveness shall be assessed through program assessments and internal audits, or other measurement criteria as specified in the COMS Assurance Standard. Measurement can also be accomplished through the tracking of appropriate Key Performance Indicators (KPI).

Business functions or departments impacted by this practice must include compliance and program effectiveness verifications in their business assurance program. Performance will be monitored and reported within the responsible departments at least every three years.

Health & Safety Solutions will review Cenovus-wide program KPIs at a minimum every three years in conjunction with program review and update activities.

6.2 Management of Change

Proposed changes to this practice can be directed to H&S Programs and Projects.

6.3 Practice Verification

The document owner will complete and document reviews of this practice, as follows:

- at minimum once every three years
- if there is a significant regulation or industry best practice change that indicates the need for review
- if an incident investigation indicates the causes were related to unclear or inadequate written instructions described within this practice

If frequent and multiple variances are required due to operational needs, the reason(s) will be investigated and the document owner will determine if there is a business need to update the practice.

If submitted MOC requests indicate gaps or significant improvement opportunities, the document owner will determine if there is a business need to update the practice.

7.0 Glossary

Definitions and acronyms for safety documents are described in CEN-EHS243, H&S Definition and Acronym Standard. The following definitions and acronyms are specific to this document:

Table 8: Terms and Definitions

Term	Definition
NORM Meter User	A workers designated as a NORM Meter User has added responsibilities to conduct field screening surveys and must receive additional training from a qualified third-party trainer on the use, handling and care of radiation detection devices.
Sievert (Sv)	a unit of measure for radiation dose
Becquerel (Bq)	a unit of measure for radioactivity

Table 9: Acronyms, Initialisms and Abbreviations

Term	In Full
NORM	Naturally occurring radioactive materials
OEL	Occupational exposure limits
NDR	National dose registry
UDRL	Unconditional derived release limit
LMS	Learning management system
PPE	Personal protective equipment
KPI	Key performance indicators
COMS	Cenovus operations management system
MOC	Management of change
mSv, nSv	millisievert, nanosievert
Bq	becquerel

8.0 References

8.1 External Documents

The following external documents support this practice:

Table 10: External Document References

Document Type or Number	Document Title
Alberta Energy Regulator Directive 055	Storage Requirements for the Upstream Petroleum Industry (to 2001)
Alberta Energy Regulator Directive 058	Oilfield Waste Management Requirements for the Upstream Petroleum Industry (to 2008)
N/A	Canadian Association of Petroleum Producers (CAPP), Naturally Occurring Radioactive Materials (2000)
N/A	ENFORM, NORM Awareness Training: Naturally Occurring Radioactive Materials Awareness (2008)
N/A	Health Canada, The Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee, Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (2011)
N/A	Minister of Public Works and Government Services Canada, Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (2000)
N/A	NORM Waste Management Technical Committee, Technical Report on the Management of Naturally Occurring Radioactive Material (NORM) in Waste (2005)
N/A	Uranium Information Centre Inc. Australia, Radiation and Life (2002)

8.2 Internal Documents

The following Cenovus documents support this practice:

Table 11: Internal Document References

Document Type or Number	Document Title
Policy	Corporate Responsibility Policy
CEN-EHSReg787	Regulatory Definitions and Acronyms
	Nuclear Substance and Radiation Device Licence
CEN-EHS047	NORM Field Guide

Document Type or Number	Document Title
CEN-EHS146	Occupational Health Risk Assessment Practice
CEN-EHS2187	Occupational Exposure Assessment Matrix
CEN-EHS147	Occupational Health Risk Assessment Procedure
CEN-EHS108	Personal Protective Equipment (PPE) Standard
CEN-EHS065	TDG Training and Certification Standard

Appendix A: A Review on Radiation

What is Radiation?

Radiation is electromagnetic energy that originates from a source that can travel through space.

What is Non-Ionizing Radiation?

Radios, microwave ovens, tanning beds, ceramic heaters and laser pointers are examples of devices that emit non-ionizing radiation. They are termed non-ionizing because the radiation emitted does not possess sufficient energy to remove electrons from the object it interacts with.

What is Ionizing Radiation?

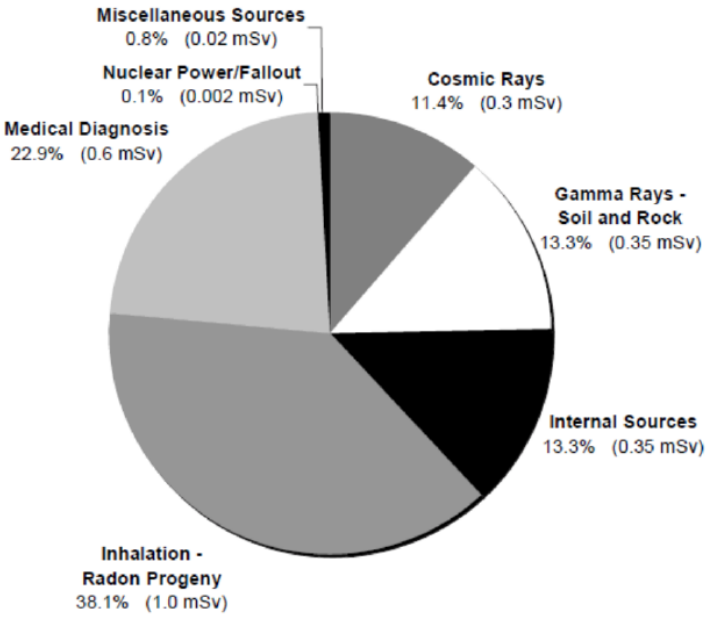
In contrast with non-ionizing radiation, ionizing radiation possesses the energy to strip electrons from the object it interacts with.

Ionizing radiation is emitted by radioactive materials with an unstable nucleus. An unstable nucleus spontaneously disintegrates to form a less unstable atom and will continue the process until a stable nucleus is reached. The disintegration process is called radioactivity or radioactive decay. In the decay process, ionizing radiation is released in the form of gamma ray and/or charged particles.

Exposure to ionizing radiation at low doses over a long period of time can cause damage to tissues or organs and increase the risk of developing cancer.

The average person is exposed to ionizing radiation on a daily basis. Sources of exposure may be grouped as natural or man-made. Common man-made sources of ionizing radiation include medical diagnostic tools such as x-rays and CT scans, and consumer products such as granite counter tops and smoke detectors. Natural sources include cosmic radiation from the sun and outer space, radon at the earth's surface and radiation from within ourselves. NORM makes up part of our exposure to natural sources.

Figure 3: Ionizing Radiation Exposure



Types of Ionizing Radiation

Three types of ionizing radiation/NORM may be released:

1. **Alpha particles** are a relatively heavy and high energy form of ionizing radiation. They have a low penetration depth, meaning particles can be stopped by a piece of paper, a few centimeters of air or the skin. These particles pose a health risk if inhaled or ingested.

2. **Beta particles** have a greater penetrating power than alpha radiation. Most beta particles can be stopped by a few millimeters of metal (e.g. aluminum, steel). They also pose a risk to the body if inhaled or ingested.

3. **Gamma rays** are a form of electromagnetic radiation that sometimes accompanies alpha or beta particle emission. Because it's not charged, a gamma ray is able to penetrate solid materials including vessels, equipment and human tissue. On Cenovus sites, gamma radiation poses little hazard to the body due to the weak energies. Since gamma radiation is easy to detect, its detection is often used to infer the presence of alpha and beta particles.

Appendix B: How is NORM Measured and What do the Measurements Mean?

Screening surveys are used to detect the presence of NORM in the field. If readings recorded during screening are more than twice background — a threshold level referenced by Canadian Association of Petroleum Producers (CAPP) — the measured equipment or surface is considered potentially NORM-contaminated and should be labelled as such.

NORM and ionizing radiation in general can be measured in the field in terms of the activity of the source and the radiation dose (i.e. the amount of radiation absorbed by the body).

Dose is generally expressed in units of Sievert (Sv). A Sievert (Sv) represents the amount of energy absorbed from ionizing radiation adjusted for radiation type (alpha, beta or gamma). Regulatory exposure limits are given in terms of the permitted maximum dose rate, i.e. milli-sieverts per hour (mSv/hr). In the literature, older units such as mrem/hr., mR/hr. and mrad/hr. continue to be used. Dose rate measurements are usually taken with a sodium iodide scintillator to detect the presence of gamma radiation.

NORM can also be expressed as counts (of ionization events) per unit time. The counts can be over any time period, but counts per minute (abbreviated CPM) is generally used for count rate measurement. CPM is therefore the detected rate of ionization events per minute. CPM measurements are usually taken with a Geiger-Muller (GM) detector coupled with a thin-walled window to assess the extent of surface contamination due to alpha and beta radiation.

Individuals performing the surveys should undergo training on the use of the survey meter and be designated a NORM Meter User.

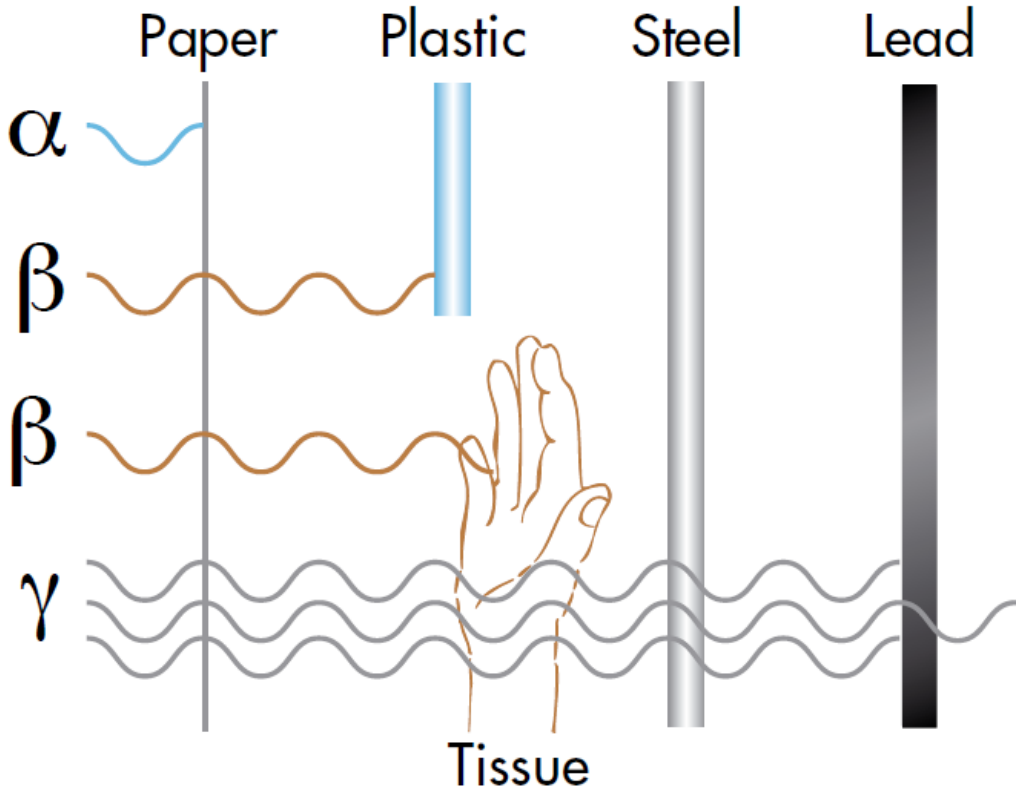
Note that the screening results provide only an indication of NORM contamination and must be confirmed with a radiochemical analysis by a qualified laboratory prior to disposal and transport.

Appendix C: General Guidance on Protection against NORM

Adopting the following practices can help mitigate NORM hazards:

- Establish regular monitoring for potential NORM-affected areas, hazard communications and periodic refresher training.
- If a task may involve contact with NORM, modify existing work procedures to include NORM mitigation steps.
- Minimize the frequency and duration of exposures.
- Maintain arm's length distance. Radiation dose decreases rapidly as the distance increases from the source.
- Use shielding where possible. Radiation is stopped or reduced by shielding. The shielding material necessary to minimize exposure depends on the type of radiation as illustrated below:

Figure 4: Shielding for Different Types of Radiation



NOTE: Figure adapted from International Association of Oil & Gas Producers.

Adopting the following practices can help mitigate NORM hazards (continued)

- If contact with NORM is unavoidable, PPE must be worn to protect against inhalation, ingestion or absorption of radioactive material.
- Prior to eating, drinking or smoking, remove contaminated clothing and wash face and hands thoroughly.
- Minimize dust generation. Don’t grind, sand or wire brush without proper PPE; keep scale wet.
- Do not contaminate the worksite; put poly sheeting down to receive contaminated equipment.
- Store NORM waste in secure and marked storage container.
- Consult Cenovus Occupational Health or a qualified person for further inquiries.