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METHODS FOR MONITORING OF *NORM* ON EQUIPMENT OFFSHORE AND ONSHORE

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Introduction

Build-up of NORM on production equipment in the Norwegian petroleum industry is a growing problem. According to Norwegian legislation, equipment containing scale with activity concentration over 10 Bq/g of ^{226}Ra, ^{228}Ra or ^{210}Pb shall be classified as radioactive.

For production tubes a classification method based on external measurements of the doserate using a standard doserate monitor is used [1]. This methods is, however, not applicable on other types of equipment such as valves, pumps and miscellaneous tubulars. Components containing NORM have on several occasions been discovered at companies performing repairs and maintenance.

Deposits containing ^{210}Pb with specific activity well above the exemption level have been found on equipment used in gas production. This is in contrast to earlier studies in the Norwegian sector [2], high specific activity lead has however been seen elsewhere [3]. Operative methods for detection and classification of equipment with deposits containing ^{210}Pb have been evaluated in this study.

In response to this problem a research project has been initiated by the Norwegian Oil Industry Association in order to find suitable monitoring methods and ensure that all contaminated components are taken care of.

Monitoring methods

Emphasise has been put on selection of simple and reliable monitoring methods. The methods must be suited for field measurements offshore and onshore.

It is difficult to find an accurate, simple and low-priced measuring method to classify contaminated equipment using the measuring equipment that exist on the marked today. The methods described are conservative so that any fault classification will result in classifying a component as radioactive rather than below the exemption level.

Two measurement strategies are recommended to cover different monitoring situations, direct β-measurements and gross γ- or β- measurements of scale samples taken from the contaminated components.

On sites where NORM contaminated components are considered a real problem, both methods should be available. Gross γ- or β-measurements will provide the most reliable results, but this method requires scale samples that not always are available. A β-contamination monitor should also be available for direct measurements on the interior surface. For sites where NORM contaminated components are rare and the monitoring resources limited, it may be considered sufficient to rely on direct measurements of β-radiation only.

Direct measurement of β-radiation

In a situation where operational aspects are of high importance, a direct measurement will be the best choice. Direct measurement does not require sample taking and the result will be available immediately. Measurement of β-radiation on the interior surface will provide sufficient accuracy in classification of the component. The method is simple, reliable and does not require high personnel or high monetary resources. It is suited both for on- and offshore applications. The method is also applicable for deposits containing ^{210}Pb.

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The count rate – activity relation
A relation between the instrument reading, given in CPS or Bq/cm², and specific activity of a NORM deposit on the surface will have to be established for the instrument and probe combination applied. The procedure is to measure the count rate from 2-4 samples having specific activities in the range 5 Bq/g – 20 Bq/g. The measured rates corrected for background are then to be plotted against specific activity as shown in Fig.1.

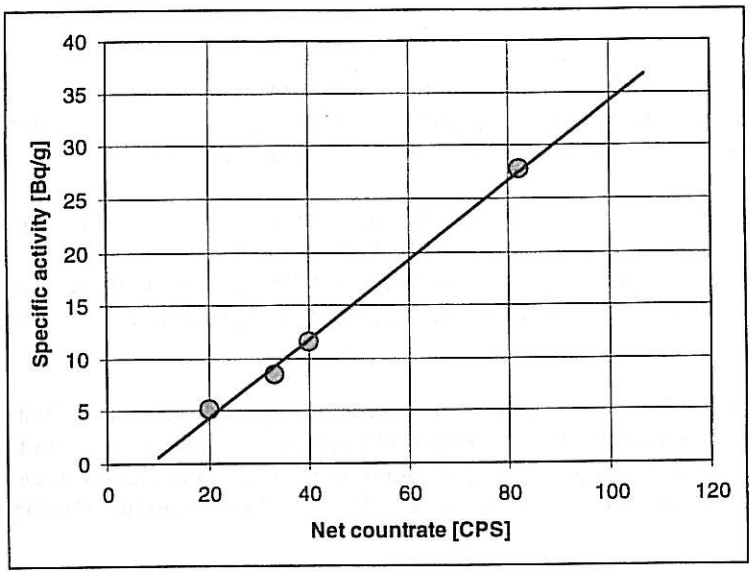

Fig.1. Calculation of specific activity from measurement of internal β-count rate

Detection limit and classification
The detection limit is typically found to be about 2 Bq/g for sulphate scale containing ^{226}Ra and ^{228}Ra in the ratio 3:1. For ^{210}Pb the detection limit is about 5 Bq/g. These limits are however dependent on the probe and its efficiency for detection of β-radiation. The numbers are based on a scale layer of 2 mm or more. Internal β-count rate measurements can be us ed to classify the component according to exemption levels. If a specific activity close to the exemption level is found, the component should be treated as radioactive until a better specific activity determination is achieved. The same applies if the scale thickness is less than 2 mm.

Gross γ- or β-measurements of scale samples
The other proposed method is based on gross γ- or β-measurements of a scale sample. When it is possible to take a sample and the time requirements for a result allows it, this indirect method will provide a good estimate of the specific activity. The method is reliable and relatively easy to implement in an operational environment. The method is suited both for on- and offshore applications. Gross γ- or β-measurements are performed using a set-up as sketched in Fig. 2. The idea of this procedure is to compare the measured sample with a set of LSA scale standards.

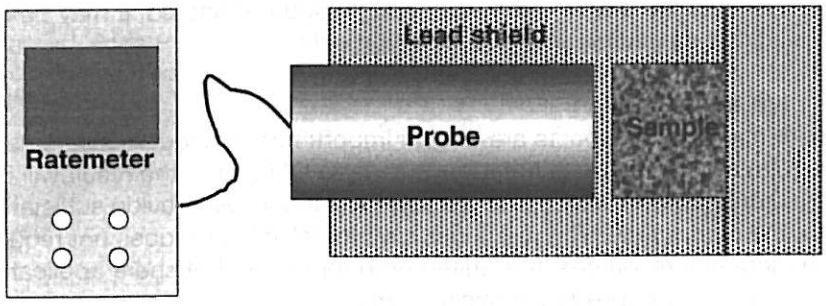

Fig. 2. Set-up for LSA scale sample measurement

The dose rate/count rate – activity relation
In order to compare a sample against the standards with known specific activity, a relation between observed dose rate and specific activity must be established. The procedure for this is to use a set of standard samples that have been analysed using high-resolution γ-spectroscopy. The ratio between ^{226}Ra and ^{228}Ra should be kept close to the typical value 3:1. The samples should cover activities from 5 Bq/g to 20 Bq/g. The samples must be weighted and sealed to reduce radon emanation. The standards are then to be measured in the described set-up. The observed dose rate or count rate should be corrected for background and the mass of the sample.

Detection limit and classification
The γ-probes used in this measurement strategy will typically have detection limits in the range 5 nSv/h to 1 μSv/h. Concerning the specific activity of the sample, the detection limit will be about 1 Bq/g, well below the exemption level. The method is therefore well suited for classification purposes of components containing Ra-scale. The doserate probes are however less suited for measurement of low-energy γ-rays as emitted from ^{210}Pb. Using γ-probes is therefore not recommended for this scale category. Using a β-sensitive probe, the detection limit should be about 1 Bq/g for LSA scale containing ^{226,228}Ra and about 2 Bq/g for ^{210}Pb deposits.

Conclusions
In this project, we have focused on simple operational methods for determining specific activity of deposits on components. The proposed methods are found to have sufficient precision for on-site measurements. The methods are conservative, components with depositions having specific activity close to the exemption level are likely to be classified as radioactive.

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