Introduction to MetroDECOM work package 4:

Radioactive waste repositories monitoring

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Scope

- Introduction
- Task 4.1 Radioactive gas monitors for waste repositories
- Task 4.2 On-line measurements of radiocarbon emissions
- Task 4.3 Fibre Optic Thermometry
- Task 4.4 Acoustic thermometry
- Task 4.5 Thermal power of radioactive waste packages
- Final comments

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Introduction to WP4

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- Overall aims
  - The aim of this work package is to develop and implement methods for monitoring the infrastructure of radioactive waste repositories and also the stored wastes. It will involve further development of the gas monitors developed in the JRP ENV09, research into novel temperature measurement methods (e.g. radiation-resistant optical fibres and acoustic thermometry), and research into calorimetric methods for measuring the thermal power of waste packages..
  - A variety of strategies will be investigated
    (i) gas monitoring of ^{3}H and ^{14}C via radiometrics,
    (ii) measurement of ^{14}C by mid-infrared spectroscopy,
    (iii) temperature monitoring with optical fibre technology,
    (iv) temperature monitoring by acoustic measurement, and
    (v) thermal out put of waste packages using air-flow calorimetry

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Tasks within the work package

- Radioactive gas monitors for waste repositories (**NPL**, ENEA)
  - Produce a prototype gas monitoring system for ^{3}H and ^{14}C using gas trapping and liquid scintillation counting
- On-line measurements of radiocarbon emissions (**VTT**, NPL)
  - Monitor ^{14}C gaseous emissions using mid-infrared spectroscopy combined with cavity enhanced techniques
- Temperature/thermal monitoring of repository sites (**LNE**)
  - Measurement of temperature by installed (and hardened) optical fibre/digital sensing as well as calorimetry
- Acoustic thermometry (**NPL**)
  - Robust temperature measurement by monitoring the speed of sound in contained gas

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Task 4.1: Radioactive gas monitors: Objectives

- The aim of this task is to produce prototype radioactive gas monitoring systems for ^{3}H and ^{14}C ready for commercial development and marketing by a manufacturer. This will be achieved by exploiting the EMRP radioactive gas trapping, separation and counting technologies developed in JRP ENV09
- This will involve the miniaturisation of the 'integrating' LSC-based monitoring system, and the incorporation of a commercial real-time gas monitor into the gas separation system.
- The gas monitoring systems will be calibrated with standardised ^{3}H- and ^{14}C-labelled gases, and also exposed to known activity concentrations of ^{222}Rn to determine their response to ambient radon
  - report on use of solid scintillators,
  - real time monitoring system,
  - corrections for radon

Task 4.1 topics; led by NPL

- Design and build of a real time monitoring system
- Field testing of build system
- Use of solid scintillants
- Publication of outcomes

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Task 4.2: On-line measurements of ^{14}C emissions: Objectives

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- Extend work in JRP ENV09 to carry out field measurements. The instrument measures the concentration of ^{14}C gaseous emissions through the detection of $^{14}CO_2$. All gaseous emissions will be converted into CO_2.
  - Construction and testing of converter,
  - construction, testing and validation of IR spectrometer
  - Publication of results
- The spectroscope is based on a technique called cavity ring-down spectroscopy, a spectroscopic technique providing very high sensitivity due to an absorption path length of several kilometres. The absorption lines of the different CO_2 isotopes are used to measure the concentration of each isotope.

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Task 4.2 topics; led by VTT

- Measurement of ^{14}C by non-radiometric means
- Repeatable conversion of carbon compounds to CO_2
- Measurement of $^{14}CO_2$ and also $^{14}CH_4$
- Realisation of field-deployable system
- Publication of achievments

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Task 4.3: Fibre Optic Thermometry: Objectives

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- The aim of this task is to study the metrological performances of Distributed Temperature Sensing techniques (DTS) based on the use of optical fibres, which will be used for monitoring of nuclear waste repositories with radiation resistant optical fibres.
- This will include the development of methods and procedures for the metrological characterisation of DTS systems, and to propose potential *in-situ* temperature calibration methods.
  - determination of operational restraints and parameters,
  - design and operation of test systems – ovens &c,
  - determination of metrological parameters and limits,
  - guidelines for operation of DTS systems
  - proposals for calibration methods

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Task 4.3 topics; led by LNE

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- Determine under what conditions DTS will operate reliably
- Carry out laboratory testing to define operational limits
- Characterise and deliver traceability of measurement by DTS
- Define and publish operational guidelines

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Task 4.4: Acoustic thermometry: Objectives

- Practical Acoustic Thermometry (PAT) has previously been demonstrated in the FISSION as a candidate for radiation-resistant temperature sensors operating at high temperatures (up to 1000 °C).
- The aim of this task is to develop PAT technology and analysis for applications where temperature sensing is required in large extended volumes.
  - determine formats,
  - build and test at NPL,
  - publish outcomes
- Operation depends on measurement of the speed of sound within a gas of known composition, typically argon or dry air, which has a direct interpretation in terms of temperature. Intrinsically the technique returns the average temperature.

Task 4.4 topics; led by NPL

- Determine design characteristic in consultation with nuclear site operators
- Design and build system at NPL capable of operation over distances >100 m
- Measure system characteristics
- Publish results

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Task 4.5: Thermal power of radioactive waste: Objectives

NPL National Physical Laboratory

- The aim of this task is to demonstrate the feasibility of a traceable calorimetric method for the direct measurement of thermal power (up to 500 W) of real size radioactive waste packages (0.175-2 m^3) with an uncertainty of <5 %. This will involve the design of a prototype of large-volume calorimeter for packages of at least 0.175 m3, the establishment of calibration protocols and the evaluation of uncertainties of thermal power measurements. ANDRA will be consulted as end user in order to define the main characteristics (e.g. dimensions, thermal power) of the radioactive waste packages for which they need to measure the thermal power.
  - design of prototype,
  - evaluation and uncertainty analysis,
  - system definition for operation

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Task 4.5 topics; led by LNE

NPL National Physical Laboratory

- Determine design characteristics
- Design, build and test prototype
- Develop measurement and calibration techniques to establish traceability
- Construct electrically driven reference package
- Publish results

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- Sensors for monitoring of repository sites
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Final comments

- Approaches
  - To achieve the aims of this work package, a number of novel techniques are being developed
  - All will allow *in situ* real time monitoring of waste repository sites for a number of key parameters

    Off gas measurements using both radiometric and non-radiometric techniques

    Temperature measurements using digitally based and acoustic measurements

    Thermal output of waste packages using calorimetry
  - These measurement solutions will be developed in the course of the project and deliver relatively strategies that are relatively insensitive to radiation dose

Thank you.
Any questions?

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