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# Planning document: List of contents DOPAS Training Workshop 2015
by learning units and followed by general content items

## General information[1] for DAY 1

- **ID Number: D1 0** List of abbreviations, DOPAS Training materials conditions for use

# 1 Learning Unit 1: From requirements to the design basis of plugs and seals (DAY 1)

### 1.1 Understanding requirements management and their application for plugs and seals design basis (TOPIC 1); D1

The role of plugs and seals in geological disposal. Different timelines, different host rocks (case of clay and crystalline repository concepts) - Duration: 20+20 minutes by Jacques Wendling and Pär Grahm.

Starting point of the lectures:

What is a plug and what is a seal? (An interactive question to start with), Where are they used and for what purpose? How do they differ? Immediate Answer: Closure of repository or its parts and

[1] The ID numbers refer to the numbers of the training material Powerpoint presentations D indicating the training day number and the first number indicating the Learning Unit number (1-4) or other activities (5-11).

why we need closure? The rest of the questions should be addressed in the following two lectures.

### 1.1.1 The Purpose of Plugs and Seals in Clay - Jacques WENDLING (J.W.), ANDRA (20 min)

- **ID Numbers: D1 1.1.1a; D1 1.1.1b**
- Rapid summary of the role of seals in Andra's repository (10-15 min)

  E.g. Andra's concept for safe disposal (pictures, figures) - concept of isolating and containing the high level waste and potential other waste types in Cígéo, the pillars on which the "passive" and "retrievable" disposal concept of Andra is based, special characteristics of the chosen host rock environment, the layout and underground structures (=openings) that need to be closed and when; the purpose, lifetime and challenges related to closure in clay, different types of closure elements in the French concept (plugs and seals). Explanation of DOS and DAC.
  - Main global function of the repository [The concept of geological disposal for isolation and containment of waste (the safety concept)]
  - Role of the host rock
  - Role of the excavations => need of a sealing system
    - Different type of seals, but more or less same design
- Time scale affected to the functions (5 min)
  - In relation with the activity of the wastes (describe also the type of waste/s to be disposed off)
  - Repository includes HLW => several million years
  - Seals favourable characteristics should last the same duration => limited to 1 M years in practice
  - In a case of the seal's function is less than 1 M years than something else needs to take over the safety function of the seal like in the case Finnish and German case the backfill maintains or takes over the safety function

- Different functions of the seals - a function time of less than 1 Million year. In the Finnish case the function is not needed afterwards
  - In the German case 50 000 years, but then something else takes over the function of the seal when the seal is not included
  - Foreseen time when the geological disposal facility will finally be closed

- Specificities linked to Nagra's concept (eventually 5 min)
  - Waste types in the repository e.g. codisposal or only HLW/SF
  - ALL plug and seal types,
  - General layout of repository,
  - Underground structures/openings to be closed,
  - Lifetime of seal and repository,
  - What takes over the safety function after the seal's lifetime is over?,
  - Pilot monitoring?, role of closure in such a case,
  - Other Nagra specifics) e.g. A comparison of the Nagra concept - describing the level in which it is similar to the French concept and different. Explanation of especially about the differences and the different uses of plugs and seals in Nagra's concept (in Opalinius clay)

Learning aid: If possible, please take a sample piece of BURE clay with you to pass around the material among the students.
Presentation needs: a videoprojector and computer with MS Powerpoint, whiteboard and markers (or Flipchart and markers)

### 1.1.2 The Purpose of Plugs and Seals in Crystalline Rock - Pär Grahm ( P.G.), SKB (20 min)

- **ID Number: D1 1.1.2**
- Posiva's (and SKB's) concept for safe disposal (for the isolation and containment of radionuclides), waste types to be disposed off (spent fuel, direct disposal)

- The pillars that make up for passive safety of the repository, the concept of safety function
- The KBS-3 multibarrier concept and the components of the concept
- The influence of the host rock environment (crystalline rock) plugs and seal especially
- Disposal facility (construction and closure in phases) - overall layout, types of underground structures (=openings) that need to be closed (different type of tunnels, shafts, auxiliary rooms, investigation boreholes); the lifetime of the repository and when (after how long) it will be closed
- The different types of plugs and seals needed (case: ONKALO, SFL)
- Role/s of closure of a repository, types of plugs and seals, their function, the function of the deposition end tunnel plug, design lifetime needed, contribution to the backfill safety function; mechanical and hydraulic performance, temperature during curing of concrete, against prevailing loads; function of the different types of materials in the plug (concrete, clay ...)

<u>Learning aid:</u> Take a sample piece of ONKALO mica gneiss and potentially Äspö granite with you to pass around among the students (not a big piece).
<u>Presentation needs:</u> a videoprojector and computer with MS Powerpoint

- Further discussion about why closure is required?
  *(If you ask this from the audience, then at least following things should start to pop-up and lead to the question of requirements: closure is needed because the waste is hazardous for a long time; closure isolates from the environment, how well does it isolate?, closure restores the disturbed environment close to its original state (need to establish an environmental baseline); closure makes it more difficult to access the repository with purpose or unintentionally; plugging enhances the performance of the other barriers like backfill (in KBS-3 especially); ....) => moving to the students´ reflective exercise*

## 1.2 Requirements - understanding and applying them (TOPIC 2)

including the (K) understanding of requirements management systems and their applications to plugs and seals and (S) developing a basis and (S) scoping an experiment from a project management perspective.

### 1.2.1 Sources of requirements. Student reflection activity - Marjatta Palmu (PMP) POSIVA, P.G., J.W. (20 min)

- Ask the students based on the previous to talk with their neighbour for about 5 - 7 minutes about what is a requirement in general and what is their source? Where do they come from for the plugs and seals? (Answers should include things that you have presented in the presentations (safety requires), protection of humans and the environment, avoidance of harm or hazards to human and the environment; regulators, potentially society, standards, international organisations (EU, IAEA, etc.)
- Student replies can be marked on a flip chart as they respond (to keep for later reference during the day)

Presentation needs: flip chart with paper and couple of markers

### 1.2.2 Requirements management as a system (general introduction) - PMP (20 min)

- **ID Number: D1 5.2.2 (About Posiva) and D1 1.2.2** (updated)
- Starting point from the discussion: How does one translate these identified requirements into practical designs and solutions?
- Explain the V-model of requirements coming from systems engineering and software engineering introduced more widely by IEEE Computer Society in the end of 1970's

- The requirements side structure, hierarchy of the system and the verification and validation at each hierarchy level;
- Description of the generic content of the different levels of requirements, their main content and from where each level is derived from (to be covered in more detail in the following case presentations)
    - Stakeholder requirements (owners, authorities, society, ...)
    - System requirements (the safety concept, safety function)
    - Subsystem requirements (from the system and the safety functions of the subsystem)
- How to write and interpret requirements (format of a requirement, traceability to source, potential attributes, workshops and review)
- Setting a baseline and change management due to the iteration cycle;
- The use of software to manage requirements has become essential for both managing the attributes, links between requirements and changes to requirements
- Use figure of a generic model and applications especially in waste management in the Nordic programme (sources e.g. OECD/NEA workshop and other presentations, STUK's current development work with Fortum),
    - Give an example of requirements coming from stakeholder requirement to specification (example from Posiva) and simplified examples of individual component verifications (from SKB's canister lab)
- Related concepts are configuration management (applied in nuclear field), functional analysis (originally only in JW's presentation), and requirements engineering. The Japanese QFD (Quality Function Deployment) - one of the quality tools also applies a similar approach.

Requirements management learning outcomes after this learning session is over:

- Identify and list major sources of requirements for geological disposal and for closure
- Understand and ability to describe the major elements of the general concept of requirements management (various elements of it) and its objectives orally or in written form/figures

- Discuss the collection of requirements and their different hierarchy.

Presentation needs: a videoprojector and computer with MS Powerpoint

### 1.2.3 The Design Basis (TOPIC 3) development work flow for Plugs and Seals - Application of requirements management system to plugs and seals and developing a design basis from them. - P.G. (30 min)

- **ID Number: D1 1.2.3, D1 1.2.4** (Poster updated to DOPAS Seminar 2016 version, originally IGD Geodisposal conference poster)
- Explain what was done in DOPAS WP2 to come up with the workflow description (use WP2 slide material) for plugs and seals from requirements to conceptual design, basic design and detailed design bases.
    - from policy decisions to stakeholder requirements
    - constraints by waste types and host rocks
    - plug system requirements and safety functions (case KBS-3 mentioned, details explained later)
    - loads for the subsystem to resist, design and material understanding
    - modelling of performance, coming up with the conceptual design
- Continue to run through the (work flow poster for Geodisposal conference, updated) starting from conceptual design to basic design and to design basis for a plug, emphasize the DOMPLU and KBS-3 example and refer to the fact that Andra carries this out in a bit different way that is explained later by J.W.

Learning aids: Attach the work flow conference poster **(ID Number D1 1.2.4)** to the learning materials distributed to the participants

Presentation needs: a videoprojector and computer with MS Powerpoint, flipchart/whiteboard and markers

## 1.3 Developing a design basis for an experiment (TOPIC 3 continues to cover the work flow)

### 1.3.1 Case Example of the Czech experiment EPSP - Marketa Dvorakova (M.D.), SÚRAO (30 min)

- **ID Number: D1 1.3.1**
- Reasons and safety concept of the Czech experiment, types of wastes for disposal, the plans for different types of plugs and seals in the repository (types of underground openings)
- The objectives of the experiment and existing requirements, task division between different partners
- How the experiment was planned (the requirements) and what was the outcome of the planning in terms of design
- Explain the features of the different system/subsystem components of the EPSP
- What modelling including parameters (M, H, T?), material and other pre-understanding and knowledge was needed for the design and implementation
- (remember that the participants will see the experiment in practice in Josef)
- What is the current state of the experiment, related risks, and expected outcomes from the experiment (also in terms of parameters), how is the success of the experiment judged/assessed?

Presentation needs: a videoprojector and computer with MS Powerpoint

### 1.3.2 Scoping the DOMPLU experiment (TOPIC 3). Moving from the initial design to an experiment in place - P.G. (30 min)

- **ID Number: D1 1.3.2**

- Scoping an experiment for a project plan to address (all or some) requirements by using work breakdown structure (WBS) of project management.
- The subprojects in an experiment project - what is included in the project plan, how to transfer the design into an experiment in place; what is included in the implementation/construction of the experiment e.g.
  - modelling
  - design - as a whole and individual components; material selections
  - location, measurements, design adaptation
  - instrumentation and data handling
  - procurement
  - method tests, assemblies and related testing, construction of the plug and related components and auxiliary structures, measurements
  - quality assurance, work safety, documentation
  - data collection and analysis
  - ....
  - dismantling (life time of the experiment?)

<u>Presentation needs: a videoprojector and computer with MS Powerpoint; flipchart + markers</u>

### 1.3.3 <u>EXERCISE 1</u>: Group work on WBS method in scoping an experiment or a technical development project - P.G. (15 min+ 50 min +15 min+10 min) - Closing DAY 1

**ID Number: D1 1.3.2 full version**
Introducing the Exercise (15 min)

- Explain the use of WBS and project management approach to designing an experiment based on the previous process information (as an example a project structure template could be shown) - if desired, such a template could be given in an electronic form in advance with the lecture materials) (15 min)

- Students work on the exercise incl. preparing the presentation of the results (50 min)
- Presenting the exercise results (students) - in two-three groups or more, tutor to decide (smaller groups work faster) - a total of 15 min.
- Summary and feedback on exercise by the tutor P.G. (10 min)

Presentation and exercise needs: Flipcharts or Whiteboards, post-it notes, markers and pens

# 2 Learning Unit 2: Preparation of an in-situ or full-scale plug or sealing experiment (DAY 2)

## 2.1 How to come up with a coherent demonstration program for plugs and seals? (DAY 2 - TOPIC 4)

Includes presenting the development of a coherent demonstrator programme (K[2]) for plugs and seals, the role of instrumentation and monitoring in such an experiment including a hands-on exercise (S) in Josef Underground laboratory.

### 2.1.1 Theoretical basis to Andra's iterative safety assessment process and the latest safety assessment round - J. W. (45 min) - DAY 2 morning before lunch

- **ID Number: D2 2.1**

[2] K; S, C refer to Knowledge, Skills, Competence - see D7.2 report and its Appendix II-6 on Learning Outcomes and the Appendix II-5 Guide for Tutors for more details.

- Theoretical basis of Andra's iteration cycle type procedure for safety assessment (45 min, before lunch)
    - Initial knowledge/design
    - Functional analysis
    - Disposal System Specifications
    - Eventual evolution of design : technological development and tests
    - Phenomenological analysis
    - Use of all the previous points for
        - Risk analysis during operational period
        - Qualitative safety assessment during post closure period
    - Performance assessment
    - Safety calculations
    - Review
    - Analysis of the outcomes of the review to define a new program of knowledge acquisition and/or technological development
    - Beginning of a new iteration cycle

### 2.1.2 Actual case example about the last round of safety assessment iteration in Andra's demonstrator programme in clay (FSS,) - Explicit description of the last iteration cycle - J.W. (35 min) - DAY 2 after lunch

- **ID Number: D2 2.1** continues
- Lecture type up to review of outcomes
- Interactions with the students to find out what was Andra's response
- Description of the real actual program for seals in terms of experimental, demonstrator and simulation program
- Focus on FSS (and REM, the two) experiments inside DOPAS, REM in more detail later.

Presentation needs for both: a videoprojector and computer with MS Powerpoint; whiteboard or flipchart with markers

## 2.2 The role of instrumentation and monitoring in an experiment - Jiri Svoboda J.S. (60 min) - DAY 2 (TOPIC 5)

- **ID Number: D2 2.2**
- The role of instrumentation in an experiment (can be also more generic) , several uses
- How to select what parameters to measure?
- What type of sensors and instruments are available and implemented in DOPAS (and in EPSP as a case example)? - pressure, temperature, volume, strain, stress, pH, leakage, ... show in practice
- How to select your instruments? How to collect data? How to process data? - in relation to EPSP
    - Introduction (10 min)
        - Why monitoring
        - Measurement chain
        - What is sensor
        - Analogue vs digital
        - How to get data out
        - Data collection, storage, presentation
    - Why and how in the experiment (10min)
        - Why monitoring
        - What to measure
        - How to measure
        - How often measure
        - What to do with measured data (data interpretation) ?
        - Typical failures
    - Common sensor types and their principles (15min)
        - Deformation (strain)
        - Pressure
        - Temperature
        - ...
    - EPSP – how it is done... (25min)

- Overall EPSP
- What is measured, why and where
- Sensor selection
- Technology used
  - Sensors
  - Data loggers
- DAQ + Measurement sytem
- Online demo

- Short note about Exercise 2 (monitoring and data path – same system as for EPSP)

Learning aids: examples of various sensors, measurement components, cables, data logger(s), internet / wireless network
Presentation needs: computer, projector, PowerPoint, flipchart/whiteboard, markers

### 2.2.1 EXERCISE 2: Installing thermometers in Josef (Jiri Svoboda, 240 min) - DAY 2 (afternoon, last lecture /exercise of the day)

- **ID Number: D2 2.2.1**
- Please list major steps of installation and what is needed to do this.
  - Introduction into exercise and experiment used (15min presentation)
  - Short demonstration of sensor used (5min)
  - Manufacturing of probe (assembly, testing, sealing) (75 min)
    Probe consisting of several thermometers will be manufactured by each group.
- *Break + getting ready/equipped into underground + transfer into underground (30min)*
  - Probe installation into the rock in the underground (45 min)

- Connection to data logger and measurement network (20min)
- Heater start & first measurements (30min)
- *Clean-up & Transfer out (20min)*

- All the work will be under supervision and assistance of CTU staff. Certain parts to be done by CTU staff (as borehole drilling) or by the students at their own risk.
- The data will be processed on DAY 4
- The experimental setup in the underground has to be prepared before exercise. E.g. current experimental setup at Josef URL will be refurbished for the exercise.
  - *type of sensors, the purpose of the sensors, expected outputs*
  - *practical installation work*
  - *what needs to be considered in advance (plan for the sensor locations?, tools needed? instructions for installment*
  - *actual installation, problem solving during installation (e.g. electrical connection)*
  - *sensor intactness, sensor testing (quality assurance against breakage, replacement of faulty sensors, use of duplicate sensors)*
  - *connections to measurement units , activities related to the measurement units*
  - *data input and output checks, test readings?*
  - *Two options - thermometers with heater tube; other one just the installment into curing concrete*
  - *sensors connected to network, need student computers for the exercises*
- Some information given on how the exercise will continue on Day 4. What needs to be taken with them to Josef by the students (computers, etc.)

Learning aids: material for probe manufacturing (sensors, cable, protective tube, …)
Equipment and tool, instruction needs: electrical workshop, data logger(s), experimental setup (in the underground), drilling machine, computers

Computers (students can take their computers underground, but not necessary)? In such a case: the tolerance of the equipment that is required for taking them underground needs to be informed to the students - also for insurance coverage) - not needed, but can be taken at own risk (generally no problems as Josef does not have a water problem)

# 3 Learning Unit 3: Design of a seal for an experiment/ demonstrator within the broader context of RD&D programmes (DAY 3 - DAY 4)

How to move from initial design in an iterative manner to the final experiment design and construction (to the as built state) and assess the outcome?

Designing (K) a sealing component for an experiment or demonstrator and the role of safety assessment and performance assessment (K) of closure as a design input
Introducing the use of individual tests e.g. metric test as a means to contribute material and process understanding and to the performance assessment (K, S)

This unit addresses how to move from the initial design in an iterative manner to the final experiment design and construction and how to assess the outcomes (K). Further the learning unit addresses the behaviour of plug component materials (K) and provides practical materials' related testing exercises in a laboratory setting (S, C).

- includes the handling and interpretation process of data acquired (S, C) from the Josef Gallery hands-on monitoring exercise.
- includes introduction to laboratory and other types of tests to increase understanding of materials and processes in disposal
- includes an introduction to safety assessment (K) and the role of safety case taking into consideration the differences in the time perspectives (K).

## 3.1 What is the state of the art in the demonstrator (RD&D) programs today? (DAY 3) TOPIC 6

### 3.1.1 Andra's scientific programme and its current state. The main questions replied to for the next safety assessment report (DAC 2017) and after the submission of DAC? J.W. (45 min) - DAY 3

- **ID Number: D3 3.1.1**
- Andra's actual scientific program (10 min)
  - Includes experiments, demonstrators, simulation
  - Long lasting experiment (REM: 20+ years) and demonstrator (FSS 3 years)
  - Not all data available for DOS (2015) and DAC (2017) dossiers
- Main questions to be addressed before the DAC (15 min)
  - Not possible to go further than FSS in terms of technological feasibility
  - Possibility to go further in terms of scientific knowledge (REM, SET, NSC, BHN, … : all Bure URL experiments directly linked to seals)
- Main questions to be addresses after the DAC (15 min)
  - Technological issues : Scale 1 in real situation : pilot industrial phase in CIGEO before introducing waste packages
  - Observation issues : long lasting measures (up to 100-150 years) in real pilot plant context to confirm numerical simulation on this time scale (gain of an order of magnitude compared to today available data)
  - Scientific issues : Bure URL long lasting experiments, including REM (part of DOPAS)
- Nagra's view points related to similar main questions to be added to this:
  - e.g. the approach to R&D plan/programme (what type of plan, when updated, how does it address demonstrators;
  - where does the DOPAS experiments fit into, what are Nagra's next steps in terms of closure demonstrators/experiments after the DOPAS project => towards licensing a facility

Presentation needs: a videoprojector and computer with MS Powerpoint; whiteboard or flipchart with markers; slides from Nagra

### 3.1.2 Plugs as a part of the demonstration programmes in Nordic countries (YJH and FUD and in the stages of licensing) - including alternatives - Petri Koho, KHPT (50 min) with some slides from P.G.) DAY 3

- **ID Number: D3 3.1.2**
- Posiva's scientific programme YJH (origin Posiva 2000-14) and the role of closure and the specific role of deposition tunnel end plug in safety
- Explanation of the similar Swedish FUD programme,
- Joint work on plugs SKB-Posiva; What has been done historically in-situ and in demonstrations for closure (e.g. Prototype repository, Canadian shaft sealing),
- What is the influence of the host rock (crystalline rock) for the experiment, what about the site related constraints (repository site/URL; regulator's role on quality assurance...), influence of other components in the concept (like need for new materials e.g. Self compacting concrete (SSC), related method tests, a table on comparison of the properties of the developed concretes vs. normal concrete), discussion about the functions of the concrete in comparing the properties, low pH concrete and its development); challenges of monitoring (e.g. do we make a hole in the plug or not? how much does it disturb the system), stray materials, challenges in instrumentation => also influencing the distances between the demo tunnel and design considerations
- Why now both DOMPLU and POPLU experiments? What is now needed for the licensing (Posiva's RTD programme for closing open questions towards operating licence; feedback from construction license application) => FISST, Yhteistoimintakoe (YT-test),
- Future cooperation areas between SKB and Posiva
- SKB's future plans

Presentation needs: a videoprojector and computer with MS Powerpoint; whiteboard or flipchart with markers

## 3.2 Behaviour of plug components and materials (DAY 3) - TOPIC 7

### 3.2.1 The use of individual tests to complement existing material and process knowledge (case of REM metric experiment) Andra's contribution in terms of REM experiment and how to integrate the results in the safety procedure (DAC) **- J.W. (20 min)**

- **ID Number: D3 3.2.1**
- REM experiment (15 min)
    - Why REM?
    - REM description including instrumentation (to be decides where FSS instrumentation, too, relates to material)
    - Simulation of resaturation
    - First results at 09-2015
- How to use the future result in terms of safety procedure (5 min)
    - Seals concepts at Andra (rapid repetition)
    - Permeability of the core
    - Swelling pressure of the core
    - Resaturation time of the core

Presentation needs: a videoprojector and computer with MS Powerpoint; whiteboard or flipchart with markers

### 3.2.2 Instructions for laboratory Exercises 3-4 on material behaviour, Petr Večernik, Katerina Videnska and Dagmar Trpkosova - ÚJV 3 DAY

- Division into laboratory groups if needed (4 people in each group; depends on the number of students)
- General instructions for both exercises given and the basis of the exercises

### 3.2.3 <u>EXERCISE 3:</u> Stress test of concrete (ÚJV team)

- **ID Number: D3 3.2.3** (See **Appendix II-3** in DOPAS D7.2 report by Palmu & al.)
- Types of samples (forms, properties)
- Types of tests
- Standards and measurement procedure
- Calculations
- Outcome of tests and result interpretation (calculation)
- Verification of material properties

<u>Learning aids:</u> cement/concrete samples, laboratory equipment, lab coats, note sheets, pencil, calculator
<u>Presentation needs:</u> computer, Powerpoint, projector, flipchart/whiteboard and markers

### 3.2.4 About ÚJV and the role of pH in the Czech plug system and a summary on the use of the work in the Czech safety assessment/case (demonstrator programme), ÚJV team - DAY 3

- **ID Numbers: D3 3.0 and D3 3.2.4**
- pH in concrete and in the plug components - types of interaction (chemical influencing the mechanical properties of bentonite?), Influencing factors on pH level

- Testing methods used for material selection, variation in pH and its influence - practical examples
- pH follow-up on site after the construction,
- Countermeasures against unfavourable pH influences

Presentation needs: computer, Powerpoint, projector, flipchart/whiteboard and markers

### 3.2.5 EXERCISE 4: Interaction of concrete with bentonite, ÚJV team - DAY3

- **ID Number: D3 3.2.5** (See **Appendix II-3** in DOPAS D7.2 report by Palmu & al.)
- Purpose of testing, types of interaction between concrete and bentonite, Influencing factors
- Methods of study of interaction (standard methods, work instructions)
- Outcomes of the test
- Impact of the interactions
- Observation of interacted samples; description of observations
- Discussion of exercise results (can be combined with the presentation to follow).

Learning aids: fine grain cement, concrete and bentonite materials, laboratory equipment, accuracy scales, laboratory coats, note sheets, pencil, pen, calculator, pH meter, pH electrodes, material mixers, solution (distilled water)
Presentation needs: computer, Powerpoint, projector

## 3.3 Introduction to Safety Assessment and Integration of the experimental work and process modelling in the safety assessment/ safety case - André Rübel (A.R.), GRS (90 min) DAY 4 morning - (TOPIC 8)

- **ID Number: D4 3.3**

- What is safety? ("a teaser" for educational discussion as a starter)
  - Discussion on how can safety be proven (show compliance with the regulation, no future dose in the very long run)
  - Timescale of evolution of geology
  - Time scale of evolution of life forms and change in human behaviour
  - Dose concept
  - Today humans as measure (with some variations)
- Quantitative analysis of repository needed
  - Proof of safety
  - Calculation of quantifying parameters
  - Comparison with regulatory limits
  - Main message: Safety Assessment is no prognosis of future human radiation exposure
  - Improvement of system understanding
  - Optimisation of repository concept
- Challenges that require simplification
  - Large scale problem
  - Heterogeneous system
  - Long time scale
  - Spatial and temporal variable properties
  - Complex interaction between different processes
  - Large uncertainties
- Procedure for model development
  - Site description (geology, hydrogeology, hydrology, repository concept)
  - Site evolution
  - FEP Catalogue
  - Scenario development (expected evolution, division by probability)
  - Calculation model
  - Process model (part of the system and/or short term)

    - Integrated long term safety assessment model (full system, full assessment period of 1 Mio. years)
    - Consequence analysis
- Types of process models (with examples of questions and processes regarding plugs and seals) - DOPAS related
    - Hydraulical (H)
    - Mechanical (M)
    - Thermal (T)
    - Others
    - Coupling of processes
    - Codes used in DOPAS
    - Possible example from DOPAS (refer to the REM test, another example, too)
- Safety assessment
    - Types of indicators (safety/performance)
    - System decomposition into compartments (near-field, far-field, biosphere)
    - Examples for simplification from process towards integrated model
    - Dealing with uncertainties
    - Types of uncertainties
    - Monte Carlo methods
    - Sensitivity analysis
    - Plugs and seals in integrated models
    - GRS integrated simulations as example from DOPAS

Learning aids: conceptualisation of time (teaser cartoon, use of the previous outcomes of discussion and the movie screened on Day 3, Marjatta to provide)
Presentation needs: computer, Powerpoint, projector, flipchart/whiteboard and markers?

### 3.4 Monitoring for performance assessment of experiment components (Thermal processes) - Exercise 2 continues - J.S. CTU (105 min) - DAY 4 afternoon, last exercise of the day) - (belongs to TOPICS 5 & 8)

- **ID Number: D4 3.4 (continuation of EXERCISE 2 (D2 2.2.1))**
- Raw data collection (measured data and sensor data)
- Sensor data calibration data explanation
- Processing sample data using spreadsheet
- Collection of processed data of several sensors
- Graphic analysis of several sensors
- Comparison of results
- Conclusion

Learning aids: access to measurement system, computers, excel, gnuplot, text editor, wifi
Presentation needs: computers and excel (participants need these, too), projector, powerpoint, gnuplot, flipchart/whiteboard, markers

# 4 Learning Unit 4: Construction Feasibility of a plugging experiment (DAY 4 morning and noon, early afternoon + DAY 5 morning)

### 4.1 Practical underground work concerns in setting up an in-situ or full-scale experiment (TOPIC 9)

Includes the practical (S) and technical concerns related to the construction work and work methods in setting up an in-situ or full-scale experiment (K). Experiment and work related risks are identified and discussed as a part of this learning unit. (S, C)

### 4.1.1 Risk management for large-scale experiments and work underground - P.G. (20 min)

- **ID Number: D4 4.1.1**
- The process of risk management - identification, prevention, mitigation, recovery
- Special features of risk management of large scale experiments and underground work
- Practicalities related to risk management

Presentation needs: computers and projector, Powerpoint, flipchart/whiteboard, markers

### 4.1.2 Case example of POPLU experiment (recipe development, method tests and casting, start slot location + RSC and design; moving into real repository construction, as built vs. design) - KHPT (40 min)

- **ID Number: D4 4.1.2**
- Experience of the POPLU experiment
  - POPLU case a form of a story from the beginning to today and what is planned ahead, participants to identify and contrast with the original risk management plan an realised risks in the exercise, do not emphasize especially the risks, since the participants are asked to identify them in their Exercise 5.

Learning aids: use of videos, other visuals
Presentation needs: computers and projector, powerpoint, flipchart/whiteboard, markers

### 4.1.3 EXERCISE 5 Two groups: Identifying and prioritizing risks for full-scale experiments G1: DOMPLU and G2: POPLU (DAY 4 afternoon)

- **ID Number: D4 4.1.3**
- Instructions for handling and reporting the Exercise 5

Learning aids: do we wish to provide a risk identification template as a structural tool for the students? (no, open tabletop exercise on flipcharts using partial brainstorming)
Presentation needs: computers and projector, Powerpoint, flipchart/whiteboard, markers

### 4.1.4 Feasibility of a seal in a clay rich host environment. How to adapt the technological process including alternative concept/s - Régis Foin (R.F.) Andra (40 min) - DAY 4 afternoon

**ID Number: D4 4.1.4**
Including the presentation of the alternative concept (hydraulic cuts and SET demonstrator and explaining how the risks of the experiment were identified and how the alternative concept is a way to manage or mitigate risks (i.e risk identification and management perspective included in presenting these topics)

- Preparation of the emplacement (10 min)
  - Feasibility of the hydraulic cuts
  - Feasibility of the concrete liner dismantling
- Containment walls realization (12 min)
  - Fabrication of low pH concrete and shotcrete
  - Low pH concrete emplacement
  - Low pH shotcrete emplacement
  - Final grouting
- Swelling clay core realization
  - Nominal solution with concrete liner dismantling (10 min)
    - Fabrication of the admixture
    - Transport and storage
    - Quality verification
    - Filling operations

- Alternative solution with hydraulic cuts (5 min)
  - Fabrication of components
  - Specific filling of hydraulic cuts
- Safety aspects (3 min)

Learning aids: bentonite pellet samples
Presentation needs: computers and projector, MS-Powerpoint, flipchart/whiteboard, markers

## 4.2 Working methods underground and for experiments (DAY 5 morning) - TOPIC 9 continues

### 4.2.1 Lessons learned from the experiments until today (K) - PANEL on experiences, constraints and lessons learned - SKB (P.G.), Posiva (KHPT), Andra (Régis), RWM (Dean), GRS (André), CTU (Jíri), SÚRAO (Marketa) representatives (75 min)

- **ID Number: D5 4.2.1**
- First around 5-10 minute introductions to DOMPLU, POPLU underground working methods (especially slot, casting, cover against rock fall, ...), CTU/SURAO (shotcreting the plug part), FSS construction of the plug (10 min), ELSA related methods (more testing methods) - some of this may be repetition as a summary
- Round table discussions on prequestions and by students - 30-40 min for discussion and questions
  - What do you consider the major challenges concerning the working methods?
  - What working methods would you also adopt in the future? What worked very well?
  - Measurements, quality assurance, approvals by regulator, ...
  - How did you carry out method tests? What could be improved in the method tests? What type of standard tests was available and what tests would still need to be developed? (examples: concrete mock-ups for casting, contact grouting; earth radar for casting, reinforcements),
  - Practical procurement experiences? Suggestions for improvement?

- Major lessons learned?
- Closing summaries from each experiment (DOMPLU, POPLU, EPSP, FSS).

Presentation needs: computers and projector, powerpoint, flipchart/whiteboard, markers, table and name cards for the panel table - layout arrangement, facilitator (PMP or other volunteer)

## 4.3 How to further apply the lessons learned for the future - DAY 5, TOPIC 10

### 4.3.1 The use the DOPAS experiences in a waste management programme not yet in the demonstration stage or without a site (K, S) - Case of RWM - Dean Gentles (D.G.) RWM (75 min) - DAY 5 morning

- **ID Number: D4 4.3.1**
- List of content to be provided (a summarising perspective in the presentation taking inputs related to the four learning units)
- current pre-design for three different geologies, how they have been designed
- plugs and seals in the system,
- take the learning from the experiments, the different requirements
- assumptions in the RWM designs
- lessons learned from the experiments of DOPAS and how they are incorporated in RWM design

Presentation needs: computers and projector, MS-Powerpoint, flipchart/whiteboard, markers

### 4.3.2 Preparing for ELSA experiment - A.R. (45 min) DAY 5 morning

**ID Number: D4 4.3.2**

Further a case summary is provided in how these activities are implemented in the preparation of a full-scale experiment to be implemented following the four existing DOPAS experiments (K, S) for the ELSA shaft sealing that is not yet an in-situ experiment.

- Safety concept of repository in salt (major difference in the concept compared with others)
    - Some words about Gorleben as potential site in Germany for 30 years
    - Specifics of  as a host rock - Salt as the dry, impermeable host rock, timescale 10-50 000 years
    - Objective to avoid the contact of external waters with the waste
    - The Shafts/Drifts as potential pathways for inflowing waters
    - When and under which conditions the convergence and compaction of salt backfill reaches low permeability → resulting in a long-term barrier (include also an explanation of the potential compaction (precompaction, further compaction activities?) and other phases that the backfill structure must undergo)
    - Additional barrier needed for time until compaction state is reached (approx.. 10.000 years) → sealing structures like for shafts
- The Concept of shaft sealing for Gorleben = ELSA concept and related material and host environment understanding (Be aware of the site specificity of the concept)
    - Reasoning behind the use of different materials for the sealing structure
    - Geochemical stability of different materials in the host rock environment
- Work in Phase 2 (in DOPAS) in preparing for ELSA continuation
    - Test of additional materials (bitumen) as a component of the structure
    - Selection of methods for pre-compaction of crushed salt
    - Geochemical stability of salt and sorel concrete (explain the specificities of these types concretes, contract with potentially the other concretes in the other experiments especially if they differ also in other than geochemical and mechanical aspects)
    - Mechanical stability of salt concretes

- Future phases for ELSA
  - Multiple experiments for different sealing elements vs. one large experiment (decision still to be taken? or all?)
- Summary on besides the work done in the phase 2, what other contributions has the other work in the DOPAS project given to the German programme, has is created ideas on the planning of the next phase of the work (see your previous bullet point) - the changes in the German R&D plan reflected by the legislation, not all yet decided

Learning aids: salt and sorel concrete samples, salt host rock
Presentation needs: computers and projector, PowerPoint, flipchart/whiteboard, markers

# 5 Orientation to the Training Workshop (DAY 1 morning)

## 5.1 Welcome & Introduction to the training workshop programme - Radek Vasicek (R.V. ), CTU (30 min)

- **ID Numbers: D1 5.1.1 and D1 5.1.2**
- Welcome, short introduction to CTU and self, and to the locations where the course will be held
- Run through the programme, logistics (of the day and the week)
- Whom to turn to in case of need of information
- Introduction of tutors present, short round of introductions of the participants: name, country and organisation (more detailed will be done in the icebreaker)
- Link to the document storage and the passwords (reminder)
- Other matters, e.g. wifi access, emergency procedures, ....

Learning aids: programme and maps for transport print outs, name tags for participants, table name tags, list of contact information, partipant lists for signing (daily)

## 5.2 Introduction to DOPAS Project - PMP (30 min)

- **ID Number: D1 5.2.1**
- General presentation
- Partners, timing, objectives
- Concept of DOPAS
- Different experiments and work packages matrix
- Where are we now, figures of experiments
- Where to find more information
- Euratom support

Presentation needs: computers and projector, powerpoint, flipchart/whiteboard, markers, YouTube from Posiva site on time ("meeting" the Coordinator)

## 5.3 Icebreaker, course objectives and concept of time - PMP (45 min) - DAY 1

- D1 - See **Appendix II-4** in D7.2 report
- Instructions to select your pair to be given (use of short words).
- Introduce yourself to your pair, discuss your objectives for the training
- Join with another pair, introduce your pair to the others, discuss your objectives, write different objectives - each on single white A4 paper in block letters, post them on the wall. Look at what others have posted, group similar objectives together. Then spend the remaining time to discuss what time means to you, to your work, to disposal and to the society. From which perspective should you look at time?
- Finally prepare to introduce the group members to the others and your objectives and your thoughts about the concept of time.

Presentation aids: plain A4 white paper, group division copies, markers, painters tape, camera for documentation of results / pictures; use of a "puzzle" to find your pair in the beginning (requires participants to take contact with each others in the very beginning).

# 6 Orientation to Josef URC and Underground Laboratory - R.V. & J.S. ( 110+15 min) (DAY 2 morning)

## 6.1 Practicalities and advice to studying and acting in Josef (R.V.)

- ID Numbers: D2 6.1a-b Safety instructions (not provided, site specific, always repeated by host)
- History, location in Czech Republic, practical site logistics above ground
- Required protective gear, work safety rules, behavioral rules inside Josef and in entering Josef
- Contact persons in case of questions
- What to do in case of emergency
- Other

## 6.2 Presentation of Josef Geology and the EPSP experiment, Michal Roll and J.S. (50 min with the previous)

- **ID Numbers: D2 6.2a-c**
- Complementary information to Marketa's presentation
- Videos from the previous work stages of the EPSP, pictures in timely order following the steps of the experiment setup process from the location improvement, construction of different components and installation of instrumentation, and about what can now be seen on the location

### 6.3 Visit to the EPSP experiment location (60 min) with relevant explanations by CTU - R.V. & J.S. & M. R. & Lucie Hausmannova

### 6.4 Introduction to the week's exercises and division of the participants into groups (2) for preparing and reporting Exercises 2-5 on Day 5 (PMP & Radek, 15 min)

- **ID Numbers: D2 6.4** (see also D7.2 report)

### 6.5 Picnic (DAY 2 closing of the day) - appr. 2 hrs

# 7 Introducing SÚRAO's programme on siting and deep geological repository (K), and information activities to the general public (K, S). - DAY 3 afternoon - total 60 min

## 7.1 SÚRAO's site selection programme - Lukas Vondrovic, SÚRAO

- **ID Numbers: D3 7.1a**
- Introduction to SURAO and the site selection programme
  - The disposal strategy for heat-generating nuclear waste in the Czech Republic assumes the direct disposal of spent fuel in steel-based canisters in crystalline host rock at a depth of 500m.
  - The total waste package inventory will be approximately 6000 containers with spent nuclear fuel and 3000 concrete containers with other radioactive waste.
  - The operational phase of the repository will be 80 years or so and the opening of the repository is planned for 2065.
- Potential host rock and locations, disposal concept
  - Following initial screening of a number of localities in the early 1990s, RAWRA/SURAO (The Czech Radioactive Waste Authority) defined 7 areas (Fig. 1) to be subjected to further multidisciplinary investigation.
  - The localities were chosen based on the Swedish concept due to similarities between the geological conditions of that country and the Czech Republic. Six of the localities are located in granitic rock (with a crystallization age of between 515-320Ma) and one is made up of high-grade metamorphic rock (migmatites, granulites). All the potential sites are located in geologically stable environments with a minimum of faults and high levels of predictability in terms of the rock environment.
- Stages of the siting programme, timing, activities
  - SURAO, in its capacity as the national waste repository authority, runs three key projects which are focused on the site selection process.

- The first of the projects is dedicated to scientific support for safety assessment evaluation purposes and includes the construction of synthetic geosphere models (e.g. hydrogeological models, structural-geology models, geotechnical models etc.) and the evaluation of the localities in terms of various criteria (e.g. safety, socioeconomic, political etc.). The result will consist of the creation of detailed safety assessment reports for each potential locality.
- The second project concerns the engineering aspects of the future repository, the stability of the engineered barriers and an initial feasibility study.
- Both of these projects require primary data that will be provided by the third project called “Exploration of 7 localities, phases I, II, III” which is a classical terrain-based project focused on obtaining primary geological data.
    - Phase I (2014-2016) involves the gathering of surface-based data only (e.g. geological mapping, hydrogeological analysis, geophysics etc.) and will result in a reduction of the number of potential localities to 3 or 4.
    - Phase II (2017-2019) will involve deep borehole drilling for the verification of the geophysical data, and further complex geological investigation work, following which the number of candidate localities will be reduced to 2.
    - Phase III (2020-2025) will focus on providing data based upon which the government will select a final site in 2025.
    - In addition, important primary data for the Exploration project will be provided by RAWRA’s underground generic research program.

## 7.2 SURAO's deep geological repository programme - L Kovacik, SÚRAO

- **ID Numbers: D3 7.1b**
- Disposal concept and the timing of implementation
- Work on the individual engineered barriers
- The Czech safety case for the deep repository

- Budget and provisions for funding
- EPSP as part of the Czech programme

### 7.3 SURAO's information activities to the general public (incl. presenting the information centre) - Lucie Steinerova, SURAO - DAY 3

- **ID Numbers: D3 7.2**
- Public outreach and governance principles related to the site selection
- Public attitudes towards geological disposal
- Examples of interest from SURAO's information activities

## 8 Movie night: Into eternity and discussion on the movie - PMP, DAY 3 evening, around 3 hrs at SURAO information centre

Discussion questions on the movie:

- Your impressions about the movie? Have you seen it before/seen it for the first time?
- What did the director try to convey to the audience?  How did he succeed?
- What did you like about the way of presenting the xxx (concept of time? the difficulty of knowing about the future? the way of communicating about the repository? handling of uncertainty?)
- What would you have changed in the way of presenting xxx? Why?
- Could this movie provide support for the deep repository? Would it make you uneasy about the repository?
- Did this meet what you expect from a documentary? Yes/No - Why?
- Can you separate the movie as an artwork from making a statement?
- Other comments?

Perpectives on the movie: What is known of ONKALO, final disposal after thousands of years? Is it revealing itself slowly like the moose in the film? Are the people excavating it? Metaphores for the future? Humans thinking they would find something of value behind the "final curtain?" How can information be preserved about the repository? Should it be preserved?

Learning aids: Movie copy the movie DVD e.g. from web shops or producer, permission to present from Magic Hour Films, and DVD player (or computer and speakers) and projector needed. Magic Hour Films is able to provide the movie in several language versions on request.

# 9 Josef Cathedral visit (DAY 4 closing of the day) - appr. 1 - 1.5 hrs

Some small snack after visit and return to Prague
(Group dinner in Prague decided on the spot)

# 10 Exercise reporting by participants (K, S, C) - DAY 5

## 10.1 Presentation and commenting of the exercises 2-5 to the participants and tutors (who are present - (75 min)

- The group exercise final reports are available for potential trainers at request from the DOPAS Project coordinator (only).
- Exercise 2 is presented by both groups time 15 min each including commenting. Exercise 3, 4 max 10 min per exercise including discussion,
- Exercise 5 presented by both groups max. 10 min each including discussion

## 10.2 Instructions for returning exercises - R.V. & PMP (15 min)

- Instructions for reporting - format, length, content expected, delivery date by 2 October 2015.
- Returned exercises qualify for a completion certificate, otherwise only participation to training workshop certificate

## 11 Assessment, feedback and summary of training workshop (C) - PMP & tutors present (60 min) DAY 5

- **ID Number: D5 11 and Appendix II-4 in D7.2 report.**
- Review the frame of the DOPAS project and the workshop's relation to it
- Feedback questionnaire collection from students, time to fill out (or email) - needs to be prepared (electronic?)
- Ask students to reply to open questions on a blank piece of paper

  Now I know about ...

  I did not feel I understood the following content ....

  I would have liked to have ...

  After this training workshop I would like to learn more about...

- Direct assessment on the attainment of the goals set by the participants in the beginning of the training workshop - PowerPoint, discussion with the students
- **Repeat important delivery dates, delivery addresses for exercises and mailing addresses for certificates**

Learning aids: plain A4 papers, pens, feedback forms printed, Presentation needs: objectives from day one on ppt, photos

# 12 Closing

# 13 Tutors' tasks after workshop

- Review of the exercises (DL from participants 2 October 2015) - agreement on the division of exercises (TBD)
- Signing of certificates (TBD)
- Feedback meeting from the training workshop (via telecon on 24 September or 14 October as a back-up)
- Review of the Workshop deliverable D7.2 for the EC (date TBD)