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DELIVERABLE D4.2

HoT in D&D course for pilot on Moodle

Lead Beneficiary: CTU

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RE	Restricted to a group specified by the Beneficiaries of the A-CINCH project	
CO	Confidential, only for Beneficiaries of the A-CINCH project	

Version control table

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1.1	17/07/2023	Elena Macerata Miroslava Semelová	Corrections
1.2	18/07/2023	Mojmír Němec	Final version and coordinator's approval
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EXECUTIVE SUMMARY

The Hands-on Training (HoT) in Decontamination and Decommissioning (D&D) course is a modular course where the participants will have the opportunity to cover their needs and to gain practical experience. The whole course foresees some theoretical parts to be delivered as distance learning materials available on the CINCH Moodle platform, and onsite activities organized in practical tasks. In particular, the HoT in D&D foresees the following four practical tasks:

1. Decontamination of surfaces and solutions, developed by CTU;
2. Determination of Sr-90 for radioactive waste characterization, developed by JSI;
3. Decontamination of metallic waste and waste conditioning, developed by POLIMI;
4. Application of the CORD process on a metallic sample, developed by IMT.

These tasks should provide students with a basic overview of the chemical procedures used for decontamination of devices, equipment, and materials contaminated with radionuclides. Additionally, parts dealing with separation and determination of significant contaminants are included. The course is compiled as a set of simple and self-standing tasks, each containing one procedure (and its variants), which can be combined into more complex exercise in relation to the chemical properties of the decontaminated material and the monitored radionuclide.

CONTENT

INTRODUCTION

The Hands-on Training course in Decontamination and Decommissioning offers relevant practical activities organized in different practical tasks.

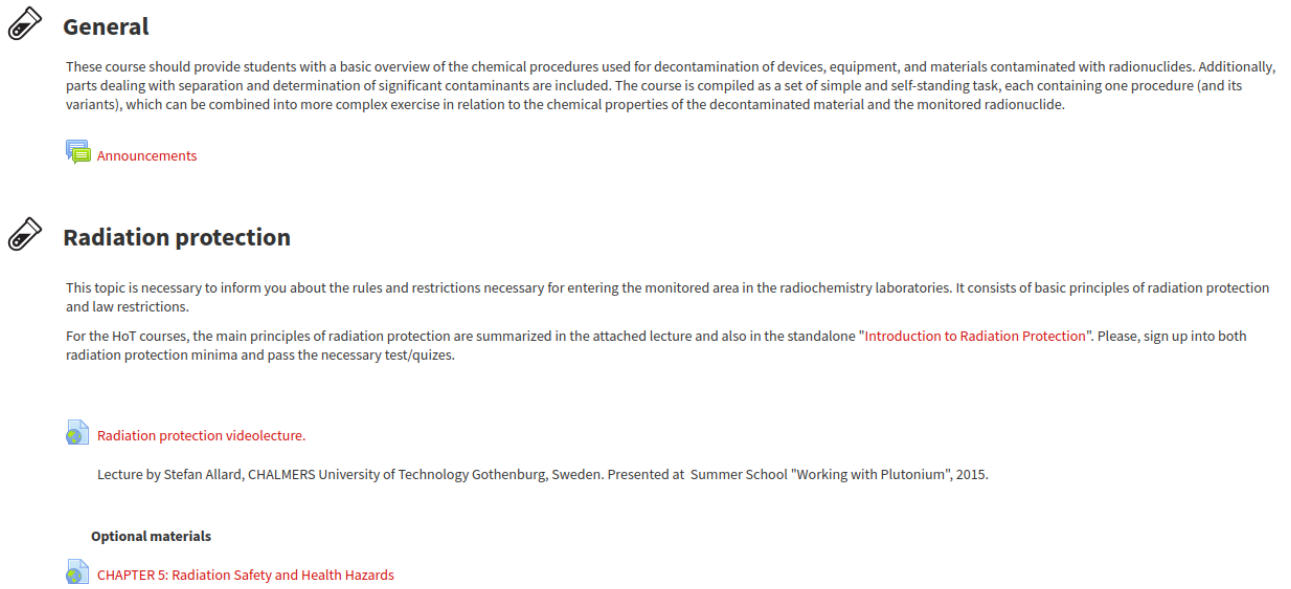
Each of them aims to let the student acquire the knowledge, competences and skills that are necessary to face the decontamination activities that arise from the decommissioning operations.

Presented Moodle structure allows its modular use depending on technical equipment and personal capacities of the hosting laboratory/institute, and as well as HoT in Nuclear Forensics, it was designed in the mode of one task per partner. Such arrangement also allows students to travel and spent more time at one place in practical tasks, learning them in more detail.

Details of the respective HoT tasks were submitted in Deliverable D4.1 HoT in D&D manuals for practical tasks, delivered in M24. This deliverable presents implementation of the HoT into CINCH Moodle structures to be ready for pilot course.

GENERAL PART

This part of the HoT in D&D consists of general description and Radiation protection lecture as well as all the HoT courses, where work in monitored or controlled area, and/or with open radiation sources is expected.



General

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Announcements

Radiation protection

This topic is necessary to inform you about the rules and restrictions necessary for entering the monitored area in the radiochemistry laboratories. It consists of basic principles of radiation protection and law restrictions.

For the HoT courses, the main principles of radiation protection are summarized in the attached lecture and also in the standalone "Introduction to Radiation Protection". Please, sign up into both radiation protection minima and pass the necessary test/quizes.

Radiation protection videolecture.

Lecture by Stefan Allard, CHALMERS University of Technology Gothenburg, Sweden. Presented at Summer School "Working with Plutonium", 2015.

Optional materials

CHAPTER 5: Radiation Safety and Health Hazards

This part is modularly used and introduced according the needs of the HoT and can be modified regarding requirements of the hosting institution.

DECOMMISSIONING AND DECONTAMINATION FUNDAMENTALS - THEORY AND MATERIALS

This represents general part with overview about decommissioning processes, what uses IAEA materials and publications. The reason for their uses includes IAEA role and access to practically all nuclear installation worldwide as well as processes of their decommissioning. Such access represents large knowledge database. IAEA also issued e-learning modules related to planning and implementation of decommissioning and radioactive waste management. Small disadvantage of all these materials is their general use or aiming to public or educated professionals/managers out of the field. Nevertheless, D&D is a very broad and complex field and nuclear chemistry is vital, but small part of the story. Then, it is necessary for any nuclear chemistry or engineering students dealing with D&D to have basic knowledge about the whole field.

Decommissioning and decontamination fundamentals - theory and materials

IAEA Bulletin - Nuclear Decommissioning

The number of nuclear facilities that require decommissioning is expected to increase significantly over the next 10 to 20 years. There is no simple relationship between the age of a facility and the timing of permanent shutdown, as multiple factors, including political and economic forces, can influence this decision. In any case, the decommissioning of a large nuclear facility is a complex process which usually requires a significant timespan, personal and scientific capacities, and budget.This bulletin from April 2023 summarizes challenges and new in D&D for informed readers.

For additional information it is recommended to assign to IAEA Nucleus portal, where various e-learning modules aiming to **Nuclear Education** are available (https://elearning.iaea.org/m2/) . Actually, selection of related e-learning courses is available in this link. Course "**Preparation for Decommissioning**" here , and "**Decommissioning Implementation**" here.

Decontamination methods are widely used in whole industry for decreasing amount of undesired chemical compounds, elements, or radionuclides in the treated volume or surface. Especially in relation to nuclear industry, implementation of the methods, their efficiency ,and costs are supposed to be the key parameters together with secondary waste production and related dose received by personnel or population.
Various decontamination methods exist and their particular chemistry is reflecting origin of the contamination, chemistry of contaminants, and operation conditions (chemical and industrial) of the contaminated device, facility. In case of nuclear power plants, distribution and behaviour of radioactive contamination is based on nuclear reactor operation and, substantially, chemical regimes of the primary circuit. It is possible and recommended to get related information here: Chemistry of cooling circuits of NPP

Optional materials

Co-ordination Network of Decommissioning of Nuclear Installations - reports

Dismantling Techniques, Decontamination Techniques, Dissemination of Best Practice, Experience and Know-how Final Report June 2009

IAEA TECDOC - 1022

TITLE: New Methods and Techniques for Decontamination in Maintenance or Decommissioning Operations

Linked according to IAEA Rights and Permissions.

IAEA TECDOC - 511

TITLE: Decontamination and Decommissioning of Nuclear Facilities (Final Report of Three Research Co-ordination Meetings Held Between 1984 and 1987)

Linked according to IAEA Rights and Permissions.

IAEA TECDOC - 1725

TITLE: Spent Fuel Storage Operation — Lessons Learned.
Linked according to IAEA Rights and Permissions.

IAEA TECDOC 1946

TITLE: Decontamination Approaches During Outage in Nuclear Power Plants - Experiences and Lessons Learned.

Linked according to IAEA Rights and Permissions.

Examples of IAEA TecDocs are included for deeper study as they contain more details about real D&D applications and planning.

PRACTICAL TASKS

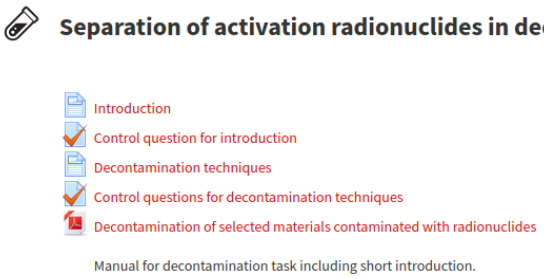
Various decontamination methods exist and their particular chemistry is reflecting origin of the contamination, chemistry of contaminants, and operation conditions (chemical and industrial) of the contaminated device, facility. In case of nuclear power plants, distribution and behaviour of radioactive contamination is based on nuclear reactor operation and, substantially, chemical regimes of the primary circuit.

In the deliverable, selected practical tasks are covering various decontamination methods as examples of various requirements during decommissioning.

All exercises are designed for students with various background in radiochemistry and nuclear engineering and can be adapted according to their chemical skills, knowledge and experience.

1.1 Separation of activation radionuclides in decontamination loop

The decontamination exercise by CTU provides students with practical experience in this field. The exercise consists of several parts/tasks that can be performed separately: characterizing of contamination and material, decontaminating material, handling of spent decontamination solution and continuous decontamination of material. The first three tasks play key role in decontamination processes and correct evaluation of each part is necessary for appropriate radioactive materials handling and management. In this laboratory exercise, the results obtained from the second and the third task are used for designing of continuous procedure in decontamination loop.



Introduction part explains students some fundamentals about contamination and radioactive contaminants, then simple quiz follows to refresh memory. In the next part, description of main decontamination techniques takes place, again followed by simple quiz. After such knowledge refreshment, manual for the task is available.

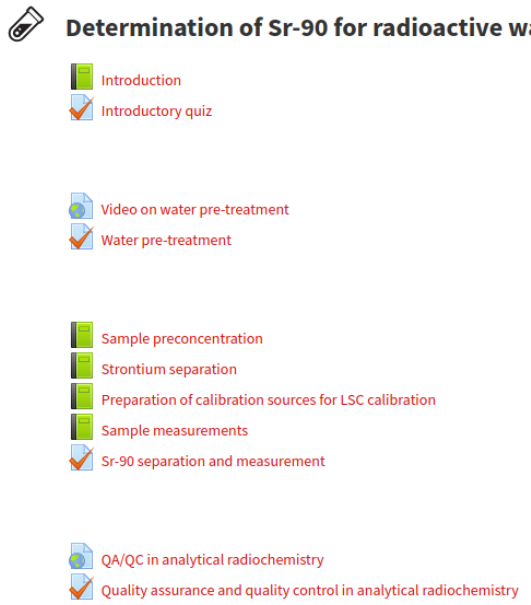
Then, students will be invited to the laboratory, manual will be checked step by step through procedures in touch with the real apparatus. After evaluation that everything is clear and understood to the student, practical work can start according procedures in manual.

Practical aspects of complex cleaning procedures will provide students experience with ideas behind decontamination processes and performance as well as it will improve their laboratory skills. Each subtask is separately evaluated and provides student with overall impact on decontamination process. Obtained results are fundamental in application of continuous decontamination process. Based on the results, students choose the optimal process for the decontamination loop, assemble loop components into the circuit and perform the decontamination within the evaluation.

Greater impact can be expected when modifications of the task are performed. In case of working in groups, sharing results and experiences can lead to the discussions on decontamination methods and parameters that can influence the overall efficiency.

1.2 Determination of ^{90}Sr for radioactive waste characterization

This part is dedicated to JSI laboratory exercise aiming at the determination of ^{90}Sr in different matrices. Indeed, ^{90}Sr is of critical importance in nuclear waste management, environmental monitoring, and radiation protection due to high radiation energy and its similar chemical properties to calcium.



Introduction part covers chemical and nuclear properties of 90Sr. Focus is also placed on interfering radionuclides and proper application of suitable separation and measurement methods. Following quiz evaluates main point of the provided information.

Then video lecture (7:02) on water sample pre-treatment, its importance and requirements take place, where students will learn how to take water sample, filter it and acidify it to stabilise it for storage until analysis. Video lecture is again followed by short quiz.

The next part consists of text information about sample preconcentration, strontium separation, preparation of calibration sources for LSC calibration, and sample measurements; followed by quiz about ^{90}Sr separation and measurement.

The last part explains to students importance of QA/QC in analytical radiochemistry in short video (4:40).

Students in this task could enhance their expertise by learning practical aspects of a radiochemical separation procedure and a radiometric measurement by LSC technique.

1.3 Decontamination of metallic waste and waste conditioning

This part is dedicated to the POLIMI and it is an exercise aiming at the decontamination of metallic waste and the subsequent waste conditioning within the Hands-on Training in Decontamination & Decommissioning. This exercise is addressed to students with various background in radiochemistry and nuclear engineering and based on their chemical skills, knowledge and experience can be adapted to more complex exercise.

Decontamination of metallic waste and waste conditioning (POLIMI)

- Introduction
- Introductory quiz
- Pickling process
- Control questions for Pickling process
- Oxidation
- Control questions for Oxidation
- Electrochemical precipitation
- Control questions for Electrochemical Precipitation
- Conditioning of the radioactive contamination
- Control questions for Conditioning step
- Manual for the practical task

This document contains a detailed description of the reagents, procedures and analytical techniques to be used in the practical task devoted to the decontamination of metallic waste and the subsequent conditioning of the recovered contamination.

- Photos and Videos about experimental steps

In this practical course, students can directly experience the procedures that are used for the superficial decontamination of metallic scraps in the advanced PHADEC-based process, leading to the final release of the metallic materials and the conditioning of the radioactive contamination, minimizing the waste volume and the production of secondary liquid waste. In the course, radioactive contamination is simulated by means of stable isotope of Co, Sr, Cs and Ni.

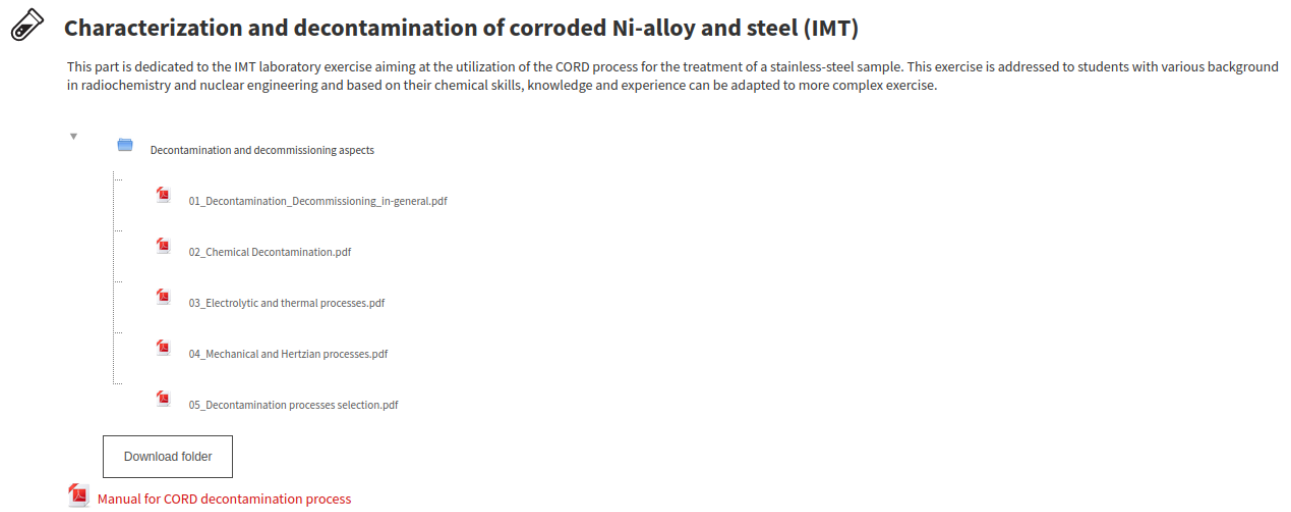
Introduction presents students improved decontamination process PHADEC, developed at POLIMI, and its four main parts, which in the practical exercise ensure the full understanding of the theory behind the experiments by students of various background. However, changes could be done in order to better tailor the course on the students' curricula. Introduction is followed by short quiz.

Then the four parts of PHADEC - Pickling process, Oxidation, Electrochemical precipitation, and Conditioning of the radioactive contamination – are described in more details together with chemical theory. After reading through and understanding – discussion with teachers is included, as well as self-evaluation quizzes – students with the help of manual will start their step-by-step work in laboratory, knowing equipment and obligatory procedures in the radiochemical lab.

Students could enhance their expertise by learning practical aspects of a pickling process and of an electrochemical precipitation. They can gain a better knowledge of the vitrification treatment as conditioning method for nuclear waste. In general, they can improve their skills by fruitfully participating in discussion with students and teachers.

1.4 Application of the cord process on a metallic sample

This part is dedicated to the IMT laboratory exercise aiming at the utilization of the CORD process for the treatment of a stainless-steel sample. This exercise is addressed to students with various background in radiochemistry and nuclear engineering and based on their chemical skills, knowledge and experience can be adapted to more complex exercise.



This task consists of introductory lecture about decommissioning and selection of decontamination methods. Various decontamination methods used in decommissioning are sorted out. In the following manual laboratory task is described in detail – it is an application of industrial process for decontamination of steels and alloys contaminated with radionuclides. While it is not possible to use real materials, the exercise uses artificially corroded and prepared materials.

The efficiency of the decontamination process is highly dependent on many parameters that will be objects of the experimentation and discussion. The activities require at least a basic knowledge of chemistry and some laboratory skills. Students could enhance their expertise by learning practical aspects of the chemical process.

GENERAL CONCLUSIONS

The practical tasks provided within the Hands-on Training course on Decontamination and Decommissioning have been designed as well as the specific actions to be developed during the onsite phase of the course. The manuals describing the reagents, materials, equipment and procedures to be used are complete and as such are implemented to the CINCH Moodle platform together with the necessary parts needed for HoT in D&D pilot run. During pilot run, course and its respective tasks can be updated and upgraded according to the needs of participants and/or capabilities of the hosting laboratory.