Öppen

Plan

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Encapsulation Plant Project - HFE Work Plan

Contents

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1 Introduction

1.1 Background

The aim of the Encapsulation Plant project is to design, build, staff and operate an Encapsulation Plant that will have the capacity to deliver copper canisters filled with spent nuclear fuel to a nuclear fuel repository. The Encapsulation Plant project will perform its objectives in the phases preliminary study, plant configuration, design and purchasing, construction and assembly, organisation and staffing, testing and commissioning, trial operation, as well as completion and documentation.

In summary, the project follows a principal framework for production of the preliminary safety report (PSAR) and plant design according to the following stages:

- Conceptual study, stage E. Identification of basic data to assess the possibility to design and build a plant. Identification of basic data for the PSAR.
- Basic design, stage D. Basis for PSAR, Pre-design and production of an application in accordance with the Swedish Radiation Protection Act (KTL).
- System design, stage C. Completion of the system and detailed design and choice of components etc. for the plant.
- The following stages B and A include activities for construction and assembly, testing and commissioning, trial operation as well as completion and documentation.

For a more detailed project description, see also the Project plan (Document ID 1247160). For a more detailed description of the implementation plan for system and detailed design, also see the Design Manual (Document ID 1255542).

Due to requests of complementary information from The Swedish Radiation Authority given in document ID 1363144 a new project Clink plant configuration has been started. Project Clink will act as a midterm project and deliver requirements for a new plant configuration, after this project Clink will be terminated and the Encapsulation plant project restart and finish the original project goals. From a HFE point of view this means that governing requirements needs to be identified and principal decisions how the requirements will be fulfilled needs to be taken during project Clink.

1.2 Human Factors Engineering requirements

The terminology of Human Factors Engineering (HFE) is used throughout the project and includes and defines both the activities in order to fulfil requirements on including the system perspective of Man-Technology-Organisation (MTO) as well as the design and performance of the final product, e.g. the Local Control Room (LCR). The translation from Swedish concept of MTO (Människa-Teknik-Organisation) includes definitions such as Safety Culture, human reliability, operator performance etc. The definition Human Factors Engineering (HFE) is used for the work process for the MTO-work in the project and the principles for that.

According to the Swedish Radiation Safety Authority's Regulations concerning Safety in Nuclear Facilities (SSMFS 2008:1), the design shall "*be adapted to the personnel's ability to, in a safe manner, monitor and manage the facility and the abnormal operation and accident conditions that may occur*" (Chapter 3, §3). Further, in the general recommendations to the same paragraph, it is stated that "*the design should be adapted to the functions and tasks to be carried out as well as to the capabilities and limitations of human beings"*. Also, "*experts on the man-*

technology-organisation interaction should be engaged to take part in the design, analysis and evaluation of the solutions".

Guidelines and standards for integration of Human Factors within the Design process are also found in e.g. NUREG-0711 and ISO 11064- Part 1. Also, guidelines including Human Factors design principles are described, e.g. in NUREG-0700, ISO 11064 Part 2-6.

In order to fulfil the above requirements, the objective for the Encapsulation Plant Project is to make sure that HFE is an integrated part of the project. This is described within this work plan.

1.3 Purpose of the HFE Work plan

The purpose is to itemise and support the work in the Encapsulation Plant Project in accordance with the objectives and guidelines given for HFE work in the SKB routine SD- 122 "MTO vid anläggningsändringar och nykonstruktion".

The HFE work plan describes a work process for the application and integration of the HFE work into the Encapsulation Plant project. This is achieved by using a systematic working method for planning and implementing HFE-related activities into the various phases described in the Project plan. This helps to create conditions for safe and reliable operation in the plant (Clink), which will not be ready until the trial operation phase.

The aim of the HFE work plan is to integrate the HFE methods in order to establish conditions for the safe and reliable operation and maintenance of Clink, and to prevent ill health and accidents by ensuring that within HFE, the regulatory requirements are met and all knowledge is up-to-date. In order to achieve this, there are working method requirements for the work process, the end product and the skills and competencies for working with HFE.

1.4 Scope and application of the HFE Work plan

The HFE work plan is a reference document to the Encapsulation Plant project plan (SKB Doc id1247160). Also, the HFE Work plan is a steering document for how Human Factors objectives should be handled in the project. The Work plan is a steering document within the tender documentation for the procurement of designers for the project. The plan describes management and technical activities to be performed within the Encapsulation plant project, and management arrangements to be put in place in order to coordinate Human Factors activities to be performed by the designers.

The HFE work plan is a description of what activities the HFE work involves, in the form of which HFE activities are relevant for implementation within the project, important HFE areas to highlight and a description of the organisation and which project resources are involved in the HFE work. The HFE work plan is a guideline for how and where the HFE work is to be performed.

The HFE work plan is applicable for all the design stages of the project. In stage D, an MTO Strategy was written. This HFE work plan has also implemented the issues in the strategy and is meant to be a more detailed plan for the future Human Factors work.

Each designer must prepare an HFE plan that describes how the project's Human Factors requirements are applied, i.e. the Human Factors competences, activities and requirements that will be applied within the design process. The project will prepare an Inspection Programme in order to verify that the design process is integrating HFE activities to a sufficient degree, as well as to validate that the final design (the outcome of the design process) complies with Human Factors standards and guidelines.

1.5 Results

The results of the Human Factors activities are to be described in different analysis reports and are summarized in HFE related design requirements, staffing demands as well as the need for instructions and education programmes for operation and maintenance of the Encapsulation plant.

The specific outcomes of the HFE work, which activities are to be performed and who is responsible for performing the activities needs to be planned and coordinated in more detail together with the designated design contractors.

1.6 Definitions

Clink	Name of the finalized plant, including Clab and the Encapsulation Plant
CKR8	Central control room, Clab
Human Factors (HF)	A scientific discipline that applies systematic methods and knowledge about people to evaluate and improve the interaction between individuals, technology and organizations. The aim is to create a work environment that contributes to achieving healthy, effective and safe operations. For this report it includes concepts such as safety culture, human reliability, operator performance, ergonomics etc.
HFE	Human Factors Engineering, process to implement human factors issues and requirements in the design.
HSI	Human System Interface; including the design of alarms, displays, controls, and other aspects of the interface between different stakeholders and the technical systems to be operated and maintained within the plant
MTO	Man-Technology-Organization, in this project synonym to human factors. The translation from Swedish concept of MTO (Människa-Teknik-Organisation) includes definitions such as safety culture, human reliability, operator performance etc.
LCR	Local Control Room, the specific control room for control and monitoring of the standard handling process in the Encapsulation Plant

2 HFE Concept and Scope

2.1 Stakeholders

The HFE work process is primarily aimed at project managers, sub-project managers, clients and suppliers, as well as at the HFE work group in the Encapsulation Plant project.

The stakeholders for the end product of the Encapsulation Plant project, i.e. the Encapsulation plant, are the different staff groups of both the existing plant Clab as well as any new staff groups that are identified for the new plant. The main end users are the operational staff in CKR8, LCR and the handling technicians, but also other relevant staff groups such as maintenance, decontamination, radiation protection, physical protection.

2.2 Assumptions, constraints and dependencies

General constraints and assumptions for the project are described in the Project plan, Document ID 1247160. Specifically, the following is relevant for the Human Factors work:

The plant shall be designed assuming that operational, maintenance and construction activities shall be joint with the existing plant, Clab. The Encapsulation plant shall co-ordinate with Clab for e.g. control room activities, work space for operators, maintenance work shops, locker rooms etc.

In a clarification meeting, documented in Projekt Clink - Anläggningskonfigurationsfas – Anteckningar MTO document ID 1396911, some questions was raised concerning HF constrains. Due to that a project decision has been taken and established in Project Clink Anläggningskonfigurationsfas - Projektledningsmöte #10 1399295, stating that;

- The design principle for the encapsulation plant shall be that there is a jointly operation and maintenance organisation with Clab
- The encapsulation plant and Clab shall have a combined organisation concerning e.g. control room work, operator workstations, workshops, changing rooms etc.
- The operation and monitoring of the encapsulation plant shall be conducted from Clab.
- During day time shift when encapsulation is in progress the process shall be controlled from local control rooms in the encapsulation plant.

There will be dependencies for the Human Factors work, both within the Encapsulation plant project, between the project and the design contractors as well as between the different design contractors. This can e.g. mean that analysis activities need to be coordinated between different contractors. These dependencies need to be identified and managed throughout the project, specifically before each phase in the project. Particular attention should be paid to the dependence upon stakeholders' involvement in HFE activities such as data gathering, prototyping and user trials.

Further there are dependencies between existing plant CLAB and its operators and the project. Current knowledge from CLAB on operation and supervision are of importance as input in several of the foreseen analysis that has to be conducted.

2.3 HFE Goals and Objectives

The work on HFE involves an integrated development of:

- Interface between humans, technology, and the organisation and physical work environments
- Training, skills, staffing and organisation
- Working method, routines and instructions

An important aspect to consider in HFE work is this integration, to ensure that there is consistency and concordance between a system's integral parts and between different systems. This means that the design of work environments, workplaces and operator interfaces, as well as the design of working methods, instructions and training programmes, must be developed integrated with the system design.

Generic "human-centered" HFE design goals include the following /NUREG-0711/:

- personnel tasks can be accomplished within time and performance criteria
- the HSIs, procedures, staffing/qualifications, training and management and organizational support will support a high degree of operating crew situation awareness
- the plant design and allocation of functions will maintain operation vigilance and provide acceptable workload levels i.e., to minimize periods of operator underload and overload
- the operator interfaces will minimize operator error and will provide for error detection and recovery capability

More specifically, the following objectives for the HFE work within the Encapsulation plant project have been defined:

The implementation of a HFE process

1. The Human Factors activities shall be an integrated part of the design process (this is achieved by implementing the activities described within this Work Plan, but must also be implemented in the overall design process)
2. How the operations and maintenance work in Clab is affected by the Encapsulation plant shall be assessed.

The Encapsulation plant and its included systems shall be designed based on the capabilities and limitations of human beings, this includes the following objectives:

1. Uniform and integrated design of HSIs and instructions
2. Design error tolerant systems (human errounous actions cannot be totally eliminated. Recovery from these types of actions shall be possible and not lead to any direct safety critical situations. Risk assessment in order to identify these types of situations shall be performed.)
3. Type and level of automation shall be assessed and designed considering human capabilities and limitations
4. The design of the alarm system shall consider different aspects for the final plant Clink, i.e. taking new design possibilities into consideration together with the operational experience and use of the existing systems.
5. The layout and design of work spaces shall be performed considering the different tasks to be performed by different personnel groups.
6. The design of work spaces and equipment shall be based on ergonomic principles, e.g. according to ISO 11064 and NUREG 0700.
7. Specific requirements on staffing and skill levels for the operation and maintenance of the total plant (Clink) shall be assessed and identified.

3 Organisation and responsibilities

3.1 Project organisation

The project organisation is presented in the project document “Projekt Inkapslingsanläggning – Organisation”, Document ID 1281493. Within this document, MTO/HFE is represented by the HFE coordinator and HFE support in the project staff. However, it is important to note that also other members of the project organisation are affected by the HFE work.

The different project roles and their mandated Human Factors skill levels is described in the following section.

The project organisation for project Clink plant configuration is described in the projects plan document ID 1378093 and organisation document 1391878.

3.2 Project roles and HF skill levels

The roles and groups in respect of HFE work included in the project organisation for the Encapsulation Plant project are described below. The primary work tasks and skill levels are stated for each role, in accordance with the definitions in "HFE skill areas in plant modifications and new designs", Document ID 1225173.

The overall project roles that are of importance for the project are the Client, the Project Director and any Sub-Project Managers. Their overall responsibilities are described in the SKB routine “SD-002 Projektstyrmodell”. These roles must have a minimum skill level 1 for HFE issues which includes the basic HFE training according chapter 3.2.1.

For the Project Director and Sub-Project Managers, it is also important to have knowledge about the Human Factors methods of performing analysis as well as how to cope with the results of the analysis. It is also good to have basic knowledge about the different aspects that influence human performance in different situations.

Within the Encapsulation Plant Project specific roles are set out within the organisation in order to manage the HFE activities. These roles and their tasks are described below.

Encapsulation Plant Project HFE Coordinator:
The tasks of the HFE Coordinator are to:

- plan how the HFE work requirements are applied in the sub-projects and in the project as a whole
- coordinate the HFE activities
- ensure that any HFE activities performed follow the project plan
- follow up the work with HFE in respect of the project's client
- ensure that the results of HFE activities performed are documented
- coordinate the HFE work for various sub-projects/matters
- ensure that an overall picture is maintained and observed for the project
- in temporary cases see that HFE requirements is included in evaluation of contractors
- plan and coordinate inspections of the contractors’ HFE activities

The HFE coordinator must have a minimum of skill level 2.

HFE Support:
The Encapsulation Plant project has been assigned an HFE support, whose tasks are to:

- carry out and support the HFE activities
- lead the work in the cross-functional HFE work group
- verify that requirements and specifications produced within the HFE area are followed within sub-projects/matters
- lead and document the results of HFE work analyses
- lead and make sure to carry out the level categorisation of current systems
- when necessary participate in evaluation of contractors
- participate in the coordination and inspection of the contractors’ HFE activities

The HFE support must have a minimum of skill level 3. It is also important that the HFE support is given basic knowledge of the overall operational activities in SKB as well as the Encapsulation plant project.

HFE Work Group:
The group's task is to:

- contribute to and participate in the HFE activities
- remittance HFE activities

The group will support the Encapsulation Plant project's HFE coordinator and consist of individuals with skills in the relevant HFE and technical areas, operational and maintenance work, designers, work environment competence etc. Specific analyses also include other project personnel in the group (thus creating cross-functional groups).

The group's composition may vary over time and be adapted to the various HFE activities.

Each individual in the HFE group must have at least skill level 2.

Cross-Functional HFE Work Groups:
As support in the analysis work, different cross-functional work groups will be merged together.
The group's task is to:

- Contribute to the analysis activities.
- Contribute to the overall coordination and dissemination of the results of the Human Factors activities

The group will be led by the project's HFE support and consist of individuals with skills in the relevant HFE and technical areas, operational and maintenance work, etc. Specific analyses also include the end users.

3.2.1 Training Plan

With the aim of creating awareness and understanding of HFE issues within the project, the project staff will undertake basic training in HFE.

The aim of the training is for the project staff to be given the opportunity to identify HFE issues that should be dealt with within the project.

The training is with a specific education for the project before and during the design phase and there is also a specific training for the operators during the validation (see section 9).
The training shall be part of the projects education plan.

4 Human Factors Issues

This section describes the Human Factors issues for the project at the time that the HFE Work Plan was prepared. Significant Human Factors issues that impact upon safety, efficiency and effectiveness of the stakeholders of the system must be identified and managed throughout the lifetime of the project. The resolution of these HF issues will drive the need to conduct HFE activities for the project.

4.1 Overall Human Factors Issues for the Encapsulation plant

In the Human Factors activities that have been performed in the project so far some Human Factors Issues have been identified. They are documented in more detail in the HF Issues list as described in chapter 4.2 below. In summary, the main issues include the following:

- It is important to consider the interface with the existing plant Clab and the working operational organisation there, e.g. walking distances between CKR8, process units, LCR and LACs should be analysed and optimized iteratively according to the task and functional analysis.

- The human factors assessments shall, except from the operational staff groups, also be done for the stakeholders maintenance, decontamination, radiation protection, physical protection etc.
- Specific issues regarding the Local Control Room need to be handled systematically, e.g. concerning the localisation of LCR (blue or white zone depending on the different task and time constraints that will be defined for the operational personnel), the need of secondary functions, shift work and work schedule.
- Type and level of automation of different work stations and equipment in the encapsulation plant needs to be analysed from a human factors point of view. The most important systems and functions where this is of importance have been identified in the niveau categorisation, Encapsulation plant project – Niveau categorisation per system (before stage C), Document ID 1358639.
- Human factors issues for the operation of lifting equipment need to be analysed. Specific issues have been identified within the lifting philosophy, Inkapslingsanläggning, Filosofi Lyftdon, Document ID 1278115 (in Swedish).
- Specific human factors issues for each work station within the encapsulation plant needs to be identified and assessed. This is an important part of the work analysis in the different design stages, see further chapter 5.2.1, and 6.

The above issues need to be analysed and handled at the right level of detail for each design stage. This means that in the updated plan for each project phase, coordination should be done of which analyses are to be performed, by which actor (the project, one or several design contractors) and to which level of detail. The level of detail should be chosen in order to match the overall design stage. The detailed planning of the analysis and handling of specific issues is done according to the project routine SDI-105 “Aktiviteters planering, genomförande och uppföljning inom projekt Inkapslingsanläggning”.

4.2 Human Factors Issues Tracking

In the Encapsulation plant project, identified Human Factors Issues are documented and followed up using the document “Encapsulation plant project – Human Factors Issues Tracking”, Document ID 1372213.

Also, as part of the V&V process, so called Human Engineering Discrepancies (HEDs) should be identified and resolved. HEDs are identified as discrepancies between the design and personnel task requirements, inconsistencies between the design and HFE guidelines and if performance criteria are not met. The management and resolution of this shall be planned in more detail and in concordance with the overall V&V and requirements qualification process in the Encapsulation plant project.

5 HFE Activities

In this chapter the type of activities that need to be performed within the HFE work is described. The activities are divided into management activities and technical activities. The management activities consist of the overall coordination work mostly performed by the HFE coordinator and HFE support within the project. The technical activities are the actual analysis activities that need to be performed in order to fulfil the HFE goals.

All activities that are to be performed within the Encapsulation plant project will be described and planned in more detail in so called Activity Plans, according to the project routine SDI-105 "Aktiviteters planering, genomförande och uppföljning inom projekt Inkapslingsanläggning".

Human Factors activities that are managed and planned by designer contractors shall be handled within their respective management systems. However, coordination with the overall project shall always be a part of the planning of specific activities, e.g. work analyses or verification and validation (V&V) activities.

5.1 Management activities

The management element of the HFE work includes activities such as:

- Updating and maintaining the HFE Work plan. Significant review and updates should be conducted (at least) at the conclusion of each project phase, in order to prepare for the next stage.
- Management reporting to the Project Director/Manager or as dictated by the organisational structure for the project
- Facilitation of working groups. The composition, frequency and terms of reference for these working groups reflects the need for consultation and the level of involvement of external parties, see also chapter 3.2.
- Conducting processes for considering human factors trade-offs within the project.
- Monitoring and controlling progress against the HFE Work Plan
- Management of external resources, i.e. coordination and inspection of the HFE activities performed by the design contractors
- Management of the expected involvement of users to support the programme
- Management of the HF Issues tracking
- Co-ordinating the output of the HF activities with the associated design activities, as well as with the safety assurance activities (e.g. development of the preliminary Safety Report, PSAR).

These activities need to be planned in more detail before the purchasing of design contractors.

5.2 Technical activities

A number of so called technical activities, i.e. HF analyses, are part of any HFE process. The overall activities that shall be performed within the Encapsulation plant project, and according to SD-122, are described below. The specific activities that are to be performed needs to be identified and planned for the different project phases, see chapter 6.

5.2.1 Work Analysis

The activity Work Analysis involves a number of analyses as listed below they are described in more detail in SD-122, for further description there are international guidelines e.g. ISO 11064 series and NUREG-0711:

- Operating experience review
- Niveau categorisation
- Functional analysis
- Functional allocation
- Task analysis one

- Design principles and guidelines
- Task analysis two
- Competence and staffing
- HFE design requirements
- Verification
- Risk assessment
- Validation

The work analysis is performed in cross-functional groups together with end users concerned, under the direction of HFE support or another individual with HFE skills of at least level 3. Analyses have been carried out during earlier stages of the project (see document list in chapter 6) but needs to be supplemented by the time system design begins.

The first level of analyses that will be made are to give a *baseline* and prerequisites for the overall level of the design and plant description (complementing design stage D). This should describe the main tasks to be performed by different staff groups within the Encapsulation plant. This will serve as a basis for future, more detailed analyses throughout the design as well to be used in order to identify and assess changes that may be done in the design, and the consequences this will have for the different user groups and their tasks.

5.2.2 Risk Assessment of the Implementation Plan

The implementation of significant modifications or new systems affect the staff's safe working conditions during the actual installation phase. This is particularly applicable for the stages of the Encapsulation plant project when the implementation means that staff needs to work in both the old and the new systems in parallel. Prior to implementation of a modification or new system, a risk assessment should therefore be carried out in accordance with SD-020 "Risk Management". Specific research questions and Human Factors Issues according to SD-122 also apply.

Together with the project risk coordinator, the HFE work group carries out the assessment, which is based on the task analysis carried out and the installation strategy created in the project. The assessment should be planned and performed iteratively, i.e. on different levels of detail according to the project phases.

The assessment may result in specific measures during the implementation period, e.g. a specific need for education or training for the specific situations and the events that can arise, specific work instructions, communication plans or contingency plans for alternative procedures.

5.2.3 Verification

From a Human Factors perspective, verification means an evaluation that the system meets the specification according to the HFE-related design requirements, together with e.g. alarm philosophy.

Verification is performed continually throughout the project, as the products and systems are developed. In the internal checks carried out once a year by the project the verification is being evaluated.

When the construction and assembly is completed and the phase testing and operation starts it is important from an HFE perspective to verify and make an evaluation that the system meets the specification according to the HFE-related design requirements produced, together with e.g. alarm philosophy.

Verification shall be performed continually throughout the project and design stages, as the products and systems are developed.

During commissioning, verification are performed to ensure that all input HFE areas (user interface, work environment, instructions and training) are produced and evaluated both individually and as a whole with different parts that work well together. If any part is missing, then safe operation cannot be guaranteed, and missing parts must be replaced until a sufficiently high level is obtained.

5.2.4 Validation

In the beginning of the design or at least before system design a validation plan shall be produced that will tell the areas that needs to be validated from a MTO-perspective and possible methods for this. The plan should also include that validation is a part of the design process and how the results will be evaluated and managed within the design.

During the design and construction it is important to do a review of the operation instructions and the interface to assume a real user situation and how the system and operator work.

Validation shall be performed continually throughout the project, as the products and systems are developed. When the construction and assembly is completed and the phase testing and operation starts validation in the real environment of use shall be done which involves an evaluation of whether the system functions suitably for designated use, function and efficiency in a real user situation, i.e. that the interoperability and collaboration between human/machine interface, the instructions, working methods and communications, etc. all meet the operation's objectives.

Validation should be performed by an individual with at least HFE skill level 3 and who is not involved in production of HFE design documentation together with the operators and other necessary staff involved.

During commissioning validations are performed to ensure that all input HFE areas (user interface, work environment, instructions and training) are produced and evaluated both individually and as a whole with different parts that work well together. If any part is missing, then safe operation cannot be guaranteed, and missing parts must be completed until a sufficiently high level is obtained.

5.2.5 Design Implementation

For a new plant, the implementation phase is well defined and carefully monitored by start-up procedures and testing; implementation of plant modifications is more complex. For the Encapsulation plant, both issues for the implementation of the new plant as well as implementation of the changes needed at Clab need to be managed from Human Factors point of view.

For both new and modified designs, it is important to determine that the design that is implemented (i.e. the "as-built" design) accurately reflects the verified and validated design. Different methods of implementation of modernizations are possible and bring different advantages and disadvantages, for a more extensive description of this see more in NUREG-0711.

The objectives of the Human Factors work during this phase is that

- the implementation of plant (changes) considers the effect on personnel performance and provides the necessary support to provide reasonable assurance safe operations

- the as-built design conforms to the verified and validated design that resulted from the HFE design process.

The specific activities to be performed as part of this phase needs to be planned in more detail, but should include risk assessment of the implementation plan from a human factors perspective (i.e. of changes to Clab and its organisation, see also chapter 5.2.2) and a final plant HFE Design verification, e.g. including that all HFE-related issues documented in the issue tracking system should be verified as adequately addressed.

5.2.6 Human Performance Monitoring

A human performance monitoring strategy should be developed and documented throughout the Encapsulation plant project. The strategy should be capable of trending human performance after the implementation to demonstrate that performance is consistent with that assumed in the various analyses that were conducted during the design stages.

If the plant design and implementation requires plant changes (e.g. in Clab) and requires monitoring of actions that are not included in existing training programs, it may be advantageous to adjust the existing training program rather than to develop additional monitoring programs for risk-informed purposes.

More information and guidelines for Human Performance Monitoring can be found, e.g. in NUREG-0711.

6 HFE Schedule

In this chapter, the identified Human Factors activities which need to be conducted during the different phases of the Encapsulation plant project are described. The HFE work is planned in detail, in line with the progression of the Encapsulation Plant project. This can mean that the exact implementation of the HFE work is adjusted in relation to the projects overall needs and requirements. The later phases need to be described in more detail as the project work continues and with future updates of this plan.

The activities implemented are described in SD-122 "MTO vid anläggningsändringar och nykonstruktion" and the process of the various activities in the project are indicated in six phases (the organisation and staffing phases are implemented in parallel and are not given their own detailed section) according to the Encapsulation Plant projects project plan (SKB Doc ID 1247160).

In the following section 6 this is described.

6.1 Preliminary Study

In the start-up phase of the Encapsulation Plant Project a work group was formed in order to identify and summarise on the Human Factors activities performed during design stage D.

6.1.1 Current Situation Analysis

A previous INKA project phase D was conducted and produced a number of HFE documents. Operation and maintenance staff at Clab were involved in producing the documentation.

The document "INKA summary of HFE activities conducted in phase D" with Document ID 1047541 summarises the main activities undertaken.

A GAP analysis “INKA - GAP analysis – ’MTO Strategy’ vs. ’Human Factors activities performed during phase D’”, Document ID 1259202, compares the MTO-strategy (T-SEKA 05/24) produced, with the activities undertaken during phase D.

The table below shows what is required according to SD-122 and what could be compared to what was done in phase D. The HFE work group considers that documents produced previously are relevant, but need to be supplemented or updated where necessary. This will be handled throughout the project as specific HFE activities are planned and performed.

According to SD-122 following steps should be conducted for a category II project as this. Step 0 - 1.1 should be performed by the HFE coordinator and the HFE support and be part of a first design requirements delivery to contractors who are responsible of performing step 2.1 – 2.2.

Steg 0
- Assessment of HFE competence and extent.
- HFE work plan This document

Steg 1
- Operating experience review
- Niveau categorisation SKBdoc 1358639
- Functional analysis SKBdoc 1034654
- Functional allocation SKBdoc 1292696
- Task analysis one SKBdoc 1034654 for system in 200 series, SKBdoc 1292715 for a HAZOP study that has been conducted.

Steg 1.1
- Design principles and guidelines

Steg 2.1
- Task analysis two
- Competence and staffing SKBdoc 1256145
- HFE design requirements

Steg 2.2
- Verification
- Risk assessment
- Validation
- Finishing documentation

6.1.2 HFE Related Design Requirements

Design requirements that are identified as an outcome of the Human Factors activities shall be documented and included in the Encapsulation Plant projects document for requirements.

There are a number of documents and activities performed which need to be included and assessed when the design requirements are compiled. These are described below.

There is a Clab document entitled "Control room philosophy for screen-based CKR Clab", reg no 95-09149, Document ID 1294936. This describes the design basis for the central control room (CKR8) in Clab. However, it has not been verified if all the described principles are still valid in the current implementation of CKR8.

ISO 11064 "Ergonomic design of the control room and related spaces" has also been compared with the CKR philosophy (95-09149) and its use in this project.

A report "Human Factors Design Principles for Clink Local Control Room (LCR)" Document ID 1313580 has been produced and describes human factors design principles for the Local Control Room (LCR) of the Encapsulation Plant. It includes high level requirements and prerequisites where knowledge of the human capabilities and limitations are used to serve a basis for a human-centred design approach of the LCR. Further analyses needs to be performed in order to produce more detailed design requirements. This is also described in the list for Human Factors Issues Tracking, Document ID 1372213.

6.2 Plant configuration

The Swedish Radiation Safety Authority (SSM) has requested a completion of the application to build and operate an Encapsulation Plant, "Begäran om komplettering avseende uppförande och drift av inkapslingsanläggningen (Clink)", SSM2011-3656-18, document ID 1363144. A revision of the plant configuration will be performed within the Encapsulation plant project with respect to this request.

An assessment has been made in order to identify Human Factors Issues within the SSM request, "Projekt Inkapslingsanläggning – SSM begäran om komplettering – MTO-bedömning 121204" document ID 1371023. Specific Human Factors Activities shall be planned and included in the overall project activities. This will also be an opportunity to complement the gaps identified from phase D.

In this phase the baseline task analysis shall be performed. This is described in more detail below.

Further during a clarification meeting within the project it was decided and documented in, Projekt Clink - Anläggningskonfigurationsfas – Anteckningar MTO document ID 1396911;

- That governing HFE requirements needs to be identified and integrated into FPSAR, this also means that important principals for future design aiming at fulfilling those governing requirements identified needs to be taken and implemented in FPSAR.
- One such important decision was taken during the meeting concerning the use of two control rooms, one for CLAB were the main responsibility for operation and emergency handling and one LCR responsible for operation of the encapsulation part during daytime shift.

Initial analysis

As a preparation for the different design steps, a level categorisation of all systems according to HFE levels has been done. This gives the prerequisites for identifying the most important systems and processes of the encapsulation plant to be analysed according to Human Factors issues. The result is documented in the report "Encapsulation plant project – Nivau categorisation per system (before stage C)", Document ID 1358639.

In the next step, an initial functional and task analysis and functional allocation shall be done for the Encapsulation plant. The analysis are performed in cross-functional HFE work groups together with end users concerned, under the direction of HFE support or another individual with HFE skills of at least level 3. Human factors issues such as localisation of the LCR (blue or white zone), walking distances between the different control stations as well as level and type of automation need to be analysed on a relevant level of detail within this phase, as well as any other relevant human factors issues which have been identified and documented in the Human Factors Issues List, Document ID 1372213.

Deadline for finishing of functional analysis is linked with time schedule for the sketch phase in sub-projects and the results is produced in a report.

6.3 Design and Purchasing

6.3.1 Purchasing

The HFE coordinator, together with the Project Director, is responsible for managing any HFE-related requirements and criteria when tenders are evaluated and for approving the end product delivered. The HFE requirements and criteria included in the evaluation depend on how the end product is procured and designed.

The HFE requirements and criteria are valid throughout the design and construction of the Encapsulation plant.

6.3.2 Design

Preparations

The Cross-Functional HFE Work Groups need to be composed (eg competence, number of persons etc) as well as the basic documentation that will be used. It is also important to overview further functions that need to participate eg person that produce safety analysis etc. The competence such as operational working experience from Clab and the Encapsulation laboratory is needed (e.g. special analysis of LCR and CKR8). It is also important when it comes to the decisions concerning type of automation in the encapsulation plant.

Documentation

There are several documents that need to be taken in consideration when working with HFE and in this section some of them are described.

The principles in this document are based on good practice for a human-centred approach for the design of complex systems. There are extensive guidelines in the field, e.g. NUREG /NUREG-0711 2004/, /NUREG-0700 2002/ and international standards, e.g. /ISO 11064:1-7 2000/, /ISO 10075:2 1996/.

In the report “Encapsulation Plant project – Human Factors Design Principles for Clink Local Control Room (LCR) (Document ID 1313580) the appendix 1(Human factors issues for further analysis) gather identified human factors issues which need to be analyzed further. This is also described in the list for Human Factors Issues Tracking, Document ID 1372213. How the human factors aspects (issues) will be managed in the project was discussed in a workshop with the HFE work group together with HFE-support February 6 2012. It is described in a protocol (Document ID 1334246) and some are implemented in this HFE-plan.

The documentation that is produced that describes the design in phase D shall be considered in the analysis work.

The report ”Inledande händelser för Ink” with Document ID 1204743 takes misadventures in consideration.

The report “Encapsulation Plant Control Philosophy” (Document ID 1292696) describes the allocation of where each part of the Encapsulation Plant will be controlled from, i.e. locally (LAC), from LCR, or from CKR8.

The report “Inkapslingsanläggning, Filosofi Lyftdon” (Document ID 1278115) describes design basis for the lifting equipment used in the Encapsulation Plant, such as main cranes and transporters. In the report several Human Factors Issues have been raised.

The documents above give the technical design basis, they need to be evaluated according to HFE design requirements and the demands shall be noted in the projects document for requirements, Encapsulation Plant project – Requirements database, Document ID 1267444

6.3.3 System design

In the results of the functional analysis which systems need to be included in the task analysis and which task analysis methods are best suited for this purpose shall be identified. This is determined by the systems and functions considered and the dependencies between these systems and functions. Specific functions, e.g. the LCR, may need to be analysed using several task analysis methods.

The results of task analysis will be used per system with the aim of specifying the identified design requirements. These requirements supplement the HFE-related design requirements and complement basic documentation to the system description.

The task analysis is preceded iteratively with the functional analysis in the sketch phase. Especially the analysis of LCR needs to be studied in detail.

Deadline for finishing the task analysis is linked with the time schedule for the system design in sub-projects and the result is produced in a report

General HFE related design requirements shall be presented and noted in the projects document for requirements, Encapsulation Plant project – Requirements database, Document ID 1267444.

6.3.4 Detailed design

At the same time as the detailed design is produced the HFE work group will work on refining the degree of detail of the interface, the instructions and training in an iterative process. This entails a need for in-depth work analyses with the aim of specifying requirements produced. These requirements supplement the HFE-related design requirements produced.

Analyses shall be made in order to ensure the human factors principles for the design of alarms and alerts.

6.4 Construction and Assembly

This section will be completed in the upcoming versions of the HFE-plan.

6.5 Testing and Operation (Including Trial Operation)

This section will be completed in the upcoming versions of the HFE-plan.

6.6 Contract & Documentation

The HFE work group produces a report which specifies the work that has been performed and what is remaining.

7 Future HFE Work (Post implementation review)

The HFE work must be continued in focus in the future and this means that the operating organisation utilises experiences of a system in operation after implementation. This often entails identifying new issues and residual points in the system's function, as a result of errors or failures in the interface design, but it is also due to unforeseen problems due to changed working methods, new work tasks, new adjacent systems or changed staffing levels and organisation.

According to the HF Technical activity Human Performance Monitoring, the HF work within the Encapsulation plant project shall identify measures in order to follow up the validity of the design of the plant in operation. However, all the activities to follow up these results in practice lie with the operational organisation of the finalised plant.

List of Revisions

Version	Date	The revision comprises	Performed by	Quality assured	Approved
1.0	2011-05-25	New document	Jeanette Carmström	Anders Nyström	Tomas Rosengren
2.0	2011-11-26	English version	Jeanette Carmström	Anders Nyström	Tomas Rosengren
3.0	2012-06-07	Complete updated English version from workshop 6/2-2012 (se notes Document ID 1334246) with several changes so that the work plan is more specified to the different phases and taken in concern different aspects of analyses that needs to be done to get the best work analysis.	Jeanette Carmström	Aino Mowitz, Anders Wiklund	Tomas Rosengren
4.0	2013-04-12	Revised version in order to prepare for new views on how to manage the HFE activities between the project and design tenders. New overall chapter structure, but sub-chapters for the different design phases (HFE technical activities and schedule) are maintained from the previous version. The new phase for Plant configuration in order to complement the application to SSM has been included (chapter 6.2).	Aino Mowitz	Jeanette Carmström Linda Törnström	Thomas Rosengren
5.0	2013-11-13	Updated due to project clarification meeting in section 1.1 page 3, 2.1 page 6, 3.1 page 7 and 6.2 page 16. See marking on right side.	Magnus Jacobsson	Jeanette Carmström Per Olsson Magnus Nilsson	Tomas Rosengren
6.0		Chapter 8 references deleted since there were no formal references but rather background documentation that now are included in the text.	Se header	Se header	Se header

Appendix 1 – Template for HFE plan

To be completed before Purchasing of Design Consultants.

Appendix 2 – Inspections according to the Proposed Inspection Programme

Outline for inspection issues from NUREG-0711:

The overall purpose of the HFE Inspection Program is to verify that:

- The designer has integrated HFE into plant development, design, and evaluation.
- The designer has provided HFE products (e.g., HSIs, procedures, and training) that allow safe, efficient, and reliable performance of operation, maintenance, test, inspection, and surveillance tasks.
- The HFE program and its products reflect "state-of-the-art human factors principles" and satisfies all specific regulatory requirements.

The objective of this review element is to verify that the designer has an HFE design team with the responsibility, authority, placement within the organization, and composition to verify that the design commitment to HFE is met. Also, the team should be guided by a plan to provide reasonable assurance that the HFE program is properly developed, executed, overseen, and documented. This plan should describe the technical program elements verifying that all aspects of the HSI, procedures, and training are developed, designed, and evaluated on the basis of accepted HFE principles.

Review Criteria

HFE Program Management review topics include:

- general HFE program goals and scope
- HFE team and organization
- HFE process and procedures
- HFE issues tracking
- technical program

Appendix 3 – Template for HFE Start Meeting and Template for HFE Inspections

To be completed before Purchasing of Design Consultants.