

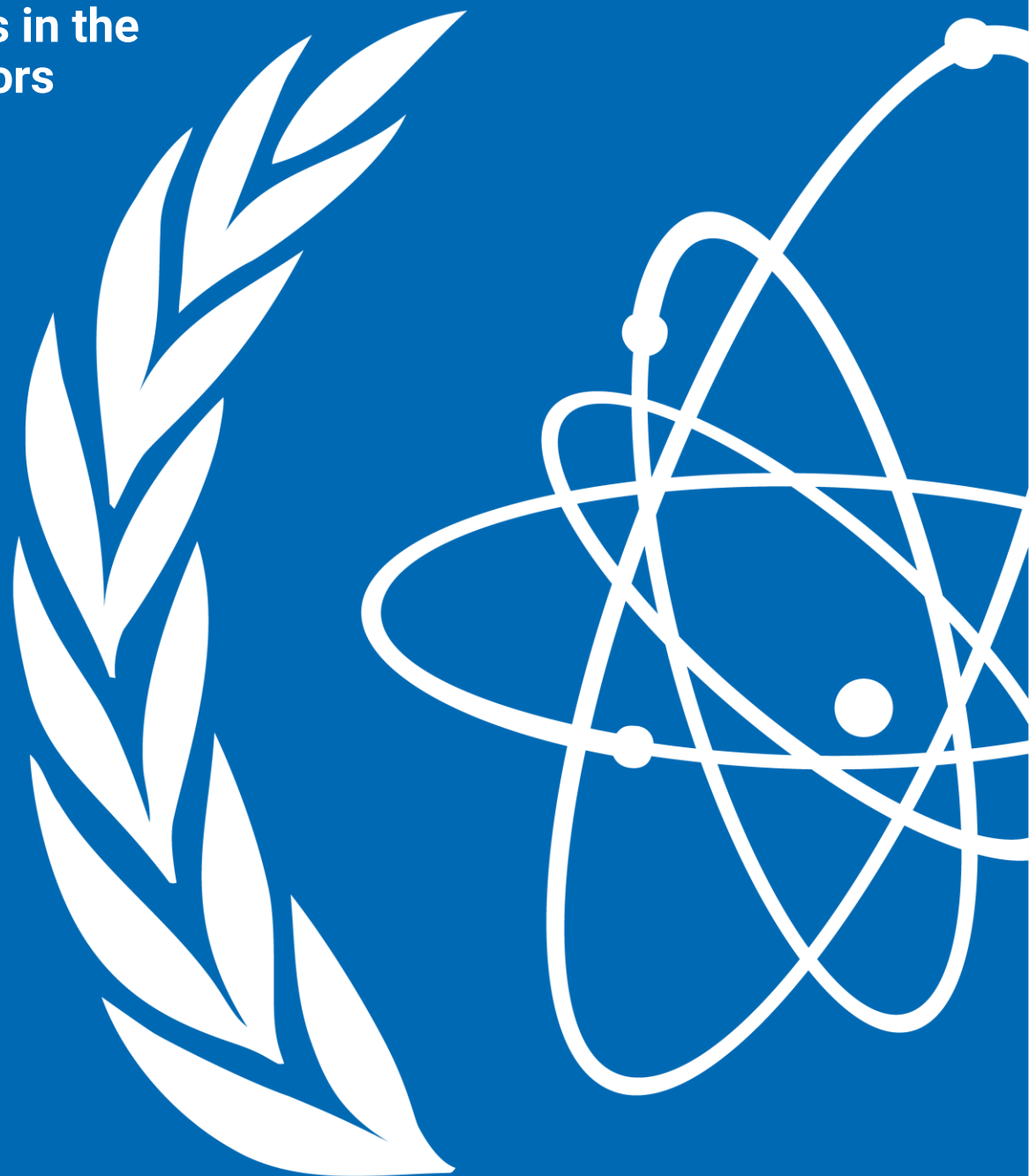
Regional Workshop on Safety Benefits and Challenges in the Development of the Adoption of Small Modular Reactors

IAEA Safety standard (SSG-51) for MCR design and application to the SMR

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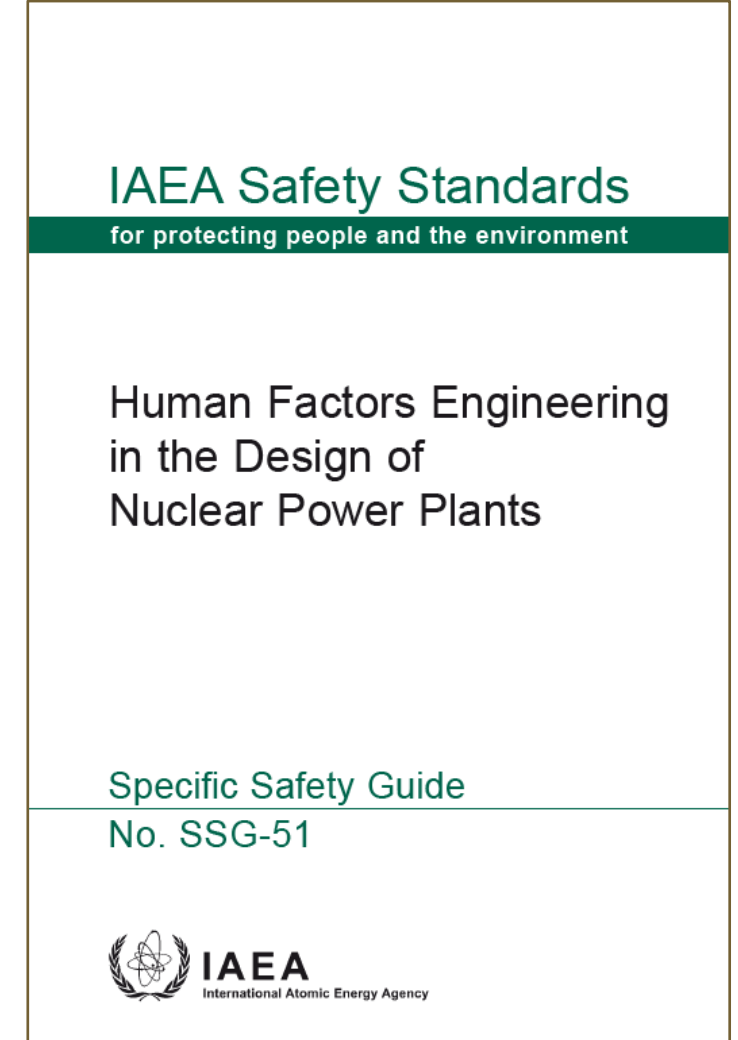
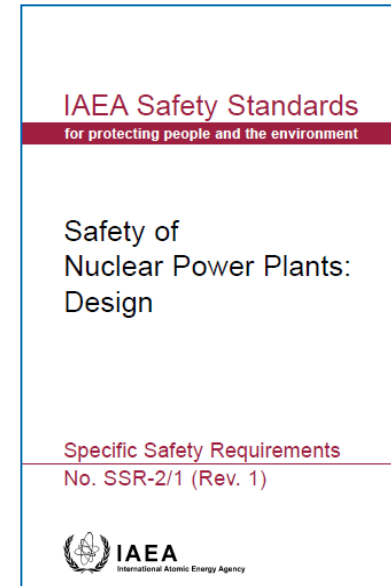
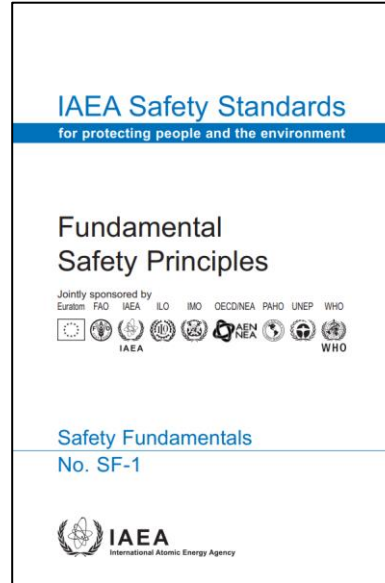


IAEA Safety Standard Hierarchy

Safety Fundamentals

Safety Requirements

Safety Guides



What is Human Factors Engineering

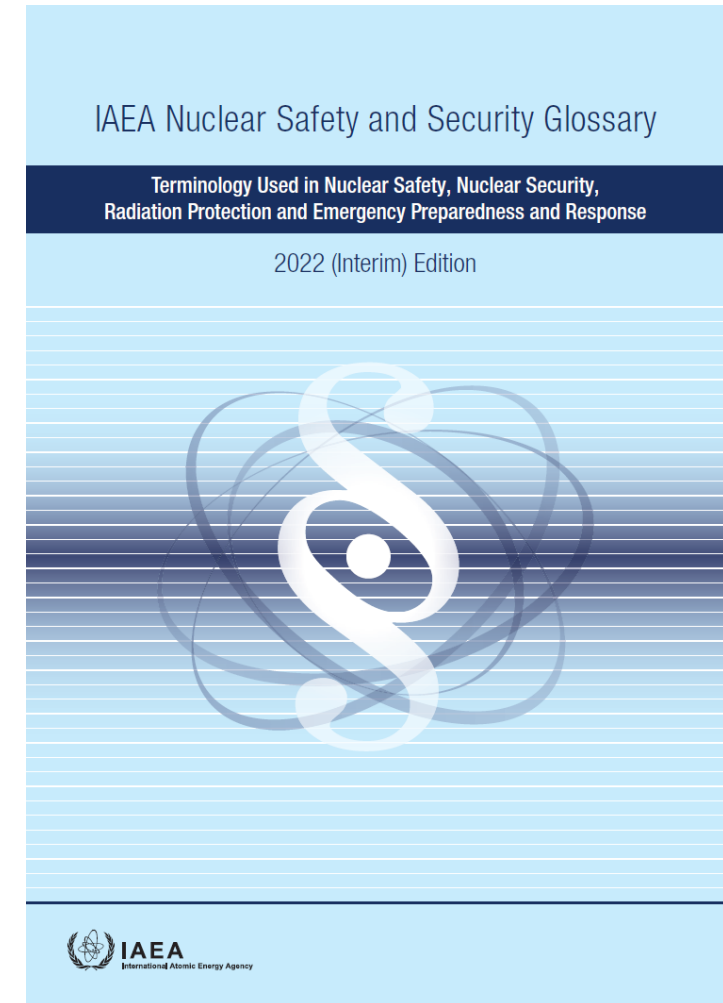
human factors engineering

Engineering in which factors that could influence human performance and that could affect safety are understood and are taken into account, especially in the design and operation of facilities.

human-machine interface

The part of a system through which personnel interact with the system to perform their functions and tasks.

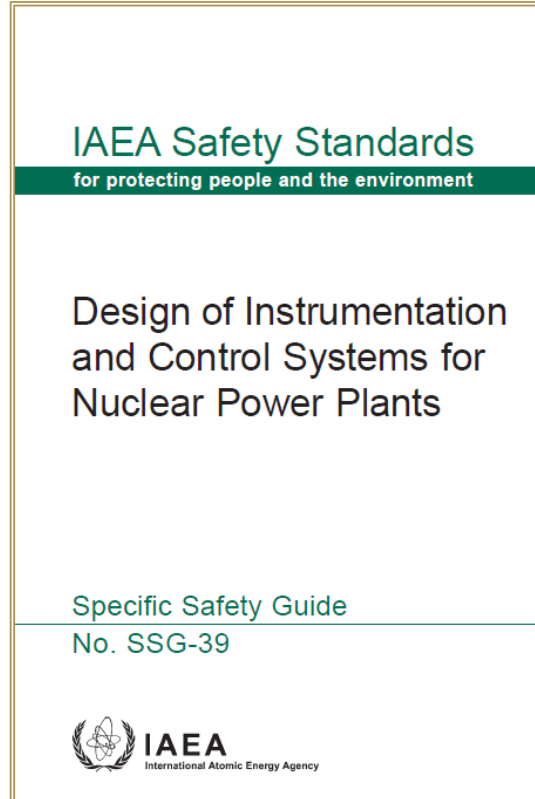
i) The human-machine interface constitutes the interface between personnel and plant systems, including procedures, communication systems displays, alarms and controls.



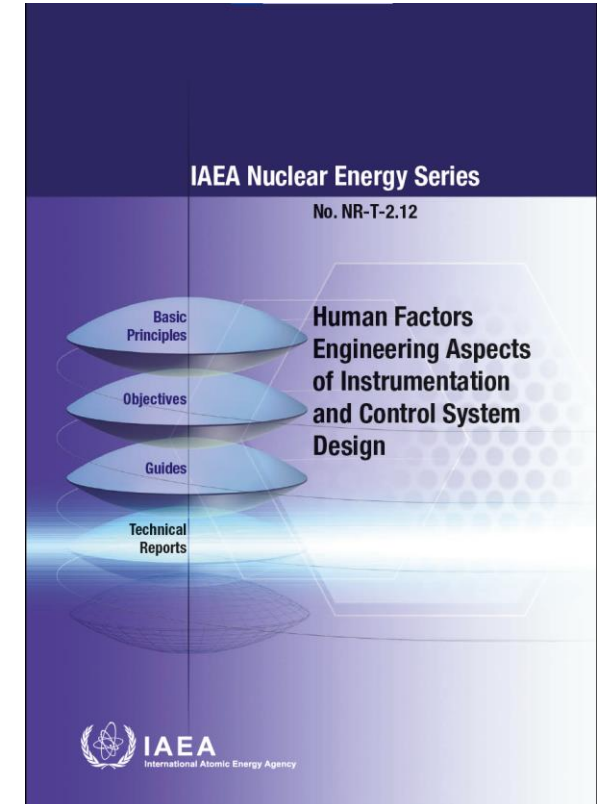
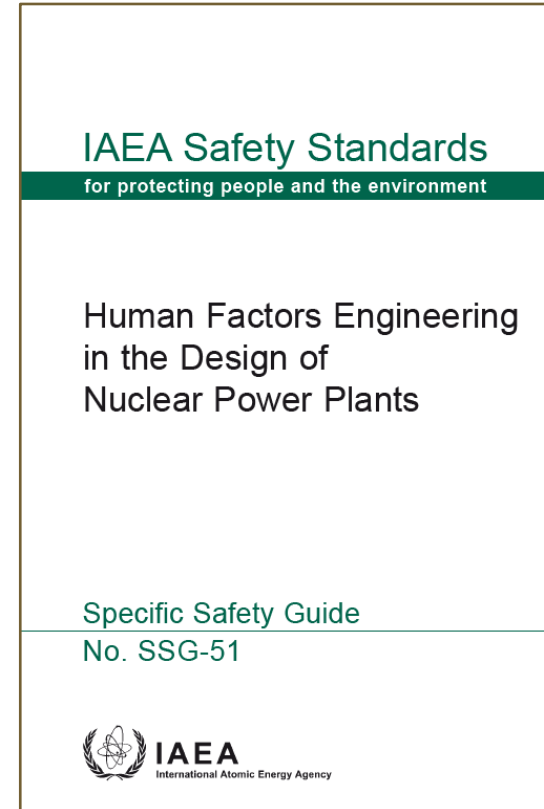
IAEA Publication about HFE



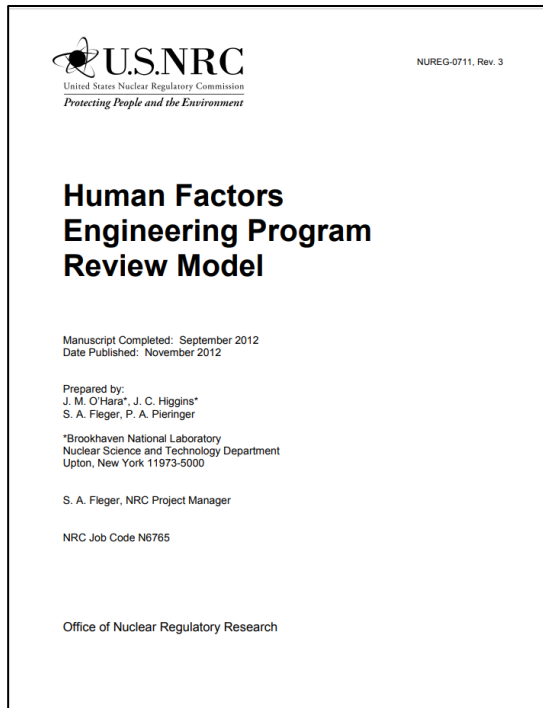
SSR-2/1
Systematic consideration of human factors, including the human-machine interface, shall be included at an early stage in the design process for a nuclear power plant and shall be continued throughout the entire design process.



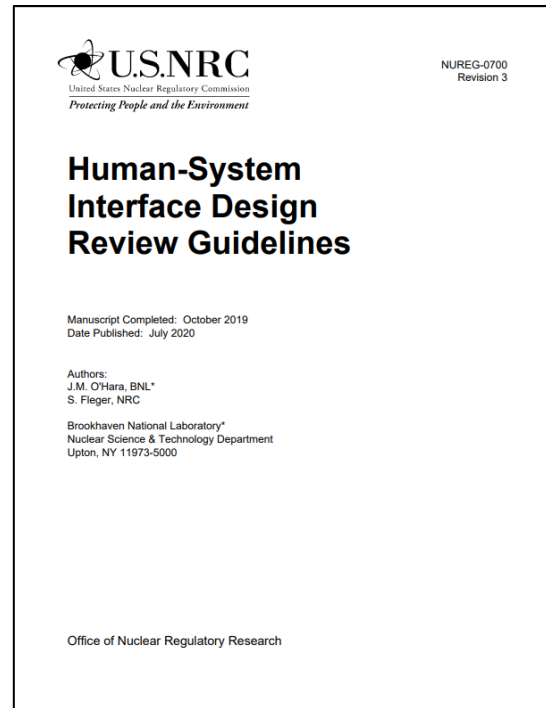
Chapter 8.
CONSIDERATIONS
RELATING TO THE
HUMAN-MACHINE
INTERFACE



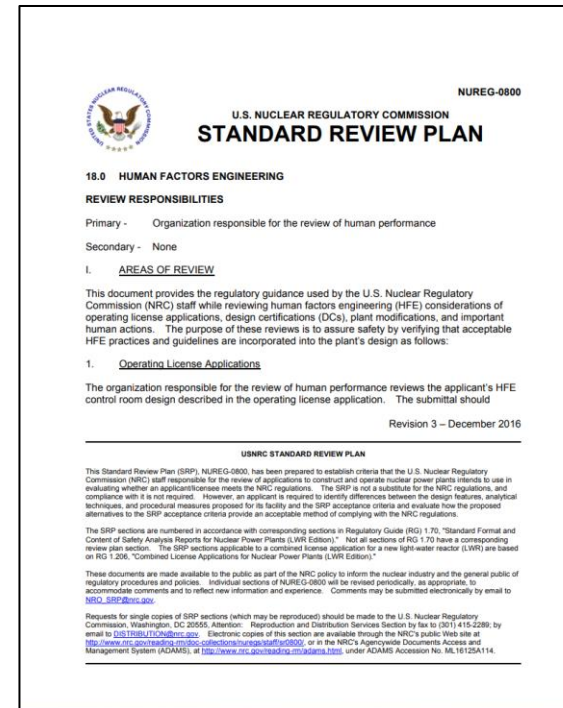
NUREG Series about HFE



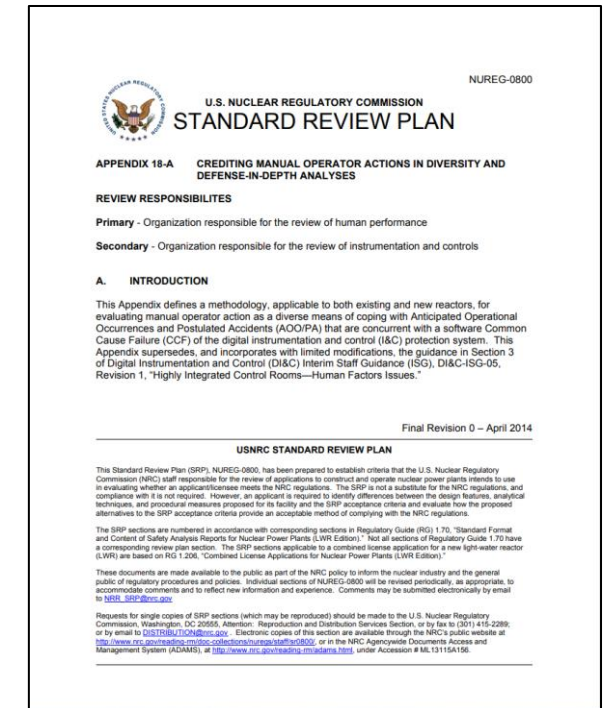
NUREG-0711. rev3



NUREG-0700. rev3



NUREG-0800. Ch18 rev3
Standard Review Plan
for the review of safety analysis reports for
nuclear power plants : LWR edition



NUREG-0800. Ch18-A, Rev0

Specific Safety Guide SSG-51

Date published: 2019

Provides a structured approach and guidance on Human Factors Engineering (HFE) to design 'correct' human machine interface

- Minimize the risk of human errors
- Optimize human performance
- Treatment of important to human actions
- Implement human and organizational factors

Incorporates relevant HFE operating experience feedback

- The NEA/IAEA system for operating experience
- The Fukushima-Daiichi accident

Ensures consistency with relevant IAEA Safety Standards (GSR Part 2, GSR Part 4, GSR Part 7, SSR-2/2, GSG-3.1, GS-G-3.5, and SSG-39)

IAEA Safety Standards

for protecting people and the environment

Human Factors Engineering
in the Design of
Nuclear Power Plants

Specific Safety Guide

No. SSG-51



HFE activities (SSG-51, NUREG 0711)

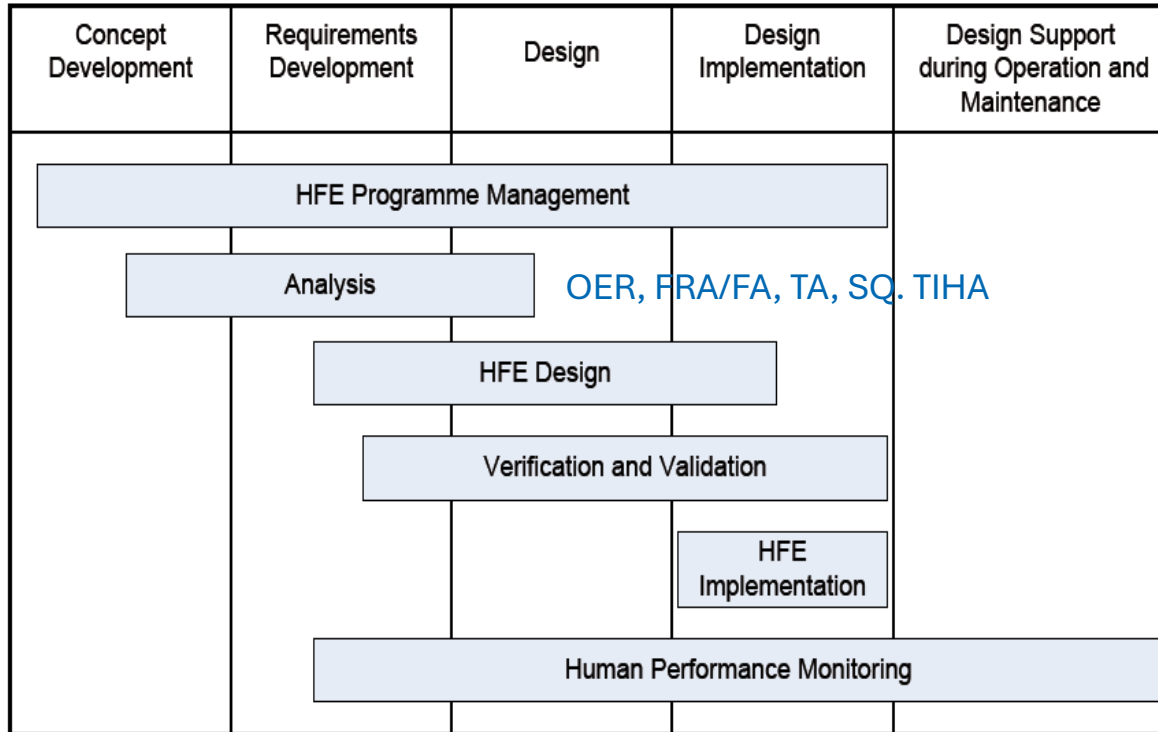


FIG. 1. An example of a generic engineering project, indicating when human factors engineering (HFE) activities are undertaken.

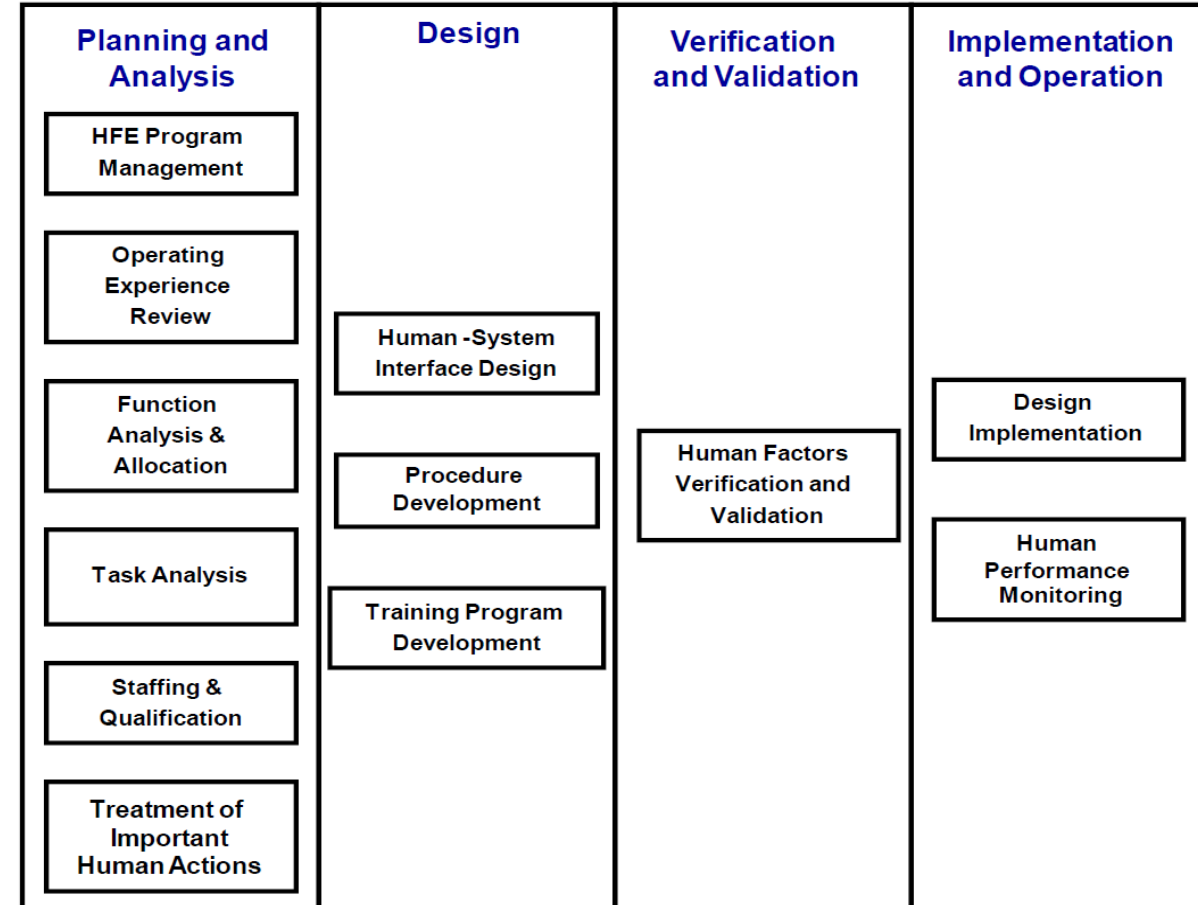


Figure 1-1 Elements of the HFE program's review model

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SSG-51

Chapter 4.Design

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Requirements from SSR-2/1

4.2. Paragraph 5.55 of SSR-2/1 (Rev. 1) [1] states:

“The design shall support **operating personnel** in the **fulfilment of their responsibilities** and in the **performance of their tasks**, and shall **limit the likelihood and the effects of operating errors on safety**. The design process shall give due consideration to plant layout and equipment layout, and to procedures, including procedures for maintenance and inspection, to facilitate interaction between the operating personnel and the plant, in all plant states.”

4.3. Paragraph 5.56 of SSR-2/1 (Rev. 1) [1] states:

“The human-machine interface shall be designed to provide the operators with **comprehensive but easily manageable information**, in accordance with **the necessary decision times and action times**. The **information** necessary for the operator to make decisions to act shall be **simply and unambiguously presented**.”

Requirements from SSR-2/1

4.81. Requirement 65 of SSR-2/1 (Rev. 1) [1] states:

“A control room shall be provided at the nuclear power plant from which the **plant can be safely operated in all operational states**, either automatically or manually, and from which measures can be taken to **maintain the plant in a safe state** or to **bring it back into a safe state after anticipated operational occurrences and accident conditions.**”

4.82. Paragraph 5.57 of SSR-2/1 (Rev. 1) [1] states:

“The operator shall be provided with the necessary **information**:

- (a) To assess the general state of the plant in any condition;
- (b) To operate the plant within the specified limits on parameters associated with plant systems and equipment (operational limits and conditions);
- (c) To confirm that safety actions for the actuation of safety systems are automatically initiated when needed and that the relevant systems perform as intended;
- (d) To determine both the need for and the time for manual initiation of the specified safety actions.”

Layout of the main control room(4.109~4.113)

4.109. The main control room should have **sufficient space** to allow the main control room staff to perform all necessary actions, while **minimizing the need for operator movement** in abnormal and accident conditions.

4.111. The layout of **workstations** and consoles in the main control room:

- Should permit **full view of all control and display panels** (including alarm displays);
- Should facilitate **verbal communication** from operators at the workstations to **any point** in the main operating area;
- Should permit access to workstations without the need to overcome obstacles;
- Should permit efficient, unobstructed movement and communication.

Application of human factors engineering in the design of workstations (4.62~4.74)

4.62. The design of **workstations** should take into account characteristics relating to the reach, vision and comfort of operators, such as:

- Workstation height;
- Inclination of benchboards, angle and depth of consoles, and workstations that can be adjusted for sitting and standing;
- Control device location;
- Display device location;
- Layout of control and display devices at a console or workstation;
- Size and legibility of text and graphics;
- Space for legs and feet.

4.63. The height of a console should allow **operators to see over its top** (e.g. to see shared displays and other operators).

4.69. A mirror image layout of panels, controls and indicators should be avoided in order to prevent ‘left–right’ confusion on the part of operators.

Design of human–machine interface controls (4.42~4.49)

4.43. HMI controls may be implemented as ‘**soft**’ controls (see paras 4.50–4.61) for multiplexed control devices or dedicated control devices, or for a combination thereof.

4.45. Controls should provide **optical and/or acoustic feedback** within an adequate time to indicate that the system has received a control input.

4.47. The HMI should ensure that the likelihood of unintended actuation is minimized by requiring deliberate action for the execution of actions that can have negative consequences (e.g. a confirmation button and a plastic cover over the switch).

Design considerations for soft controls (4.50~4.61)

4.50. Soft controls are implemented using **video display units together with a pointing device** (e.g. a mouse, track ball, light pen or touch capability), or a combination of a video display unit with a set of dedicated controls.

4.52. Soft controls should be used for interactions such as selecting a plant variable or component to be controlled, providing the control input and monitoring the system's response.

4.61. **In order to avoid errors** when executing a command, **the sequence of control** should comprise selection of the control, selection of the command and validation of the command.



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SSG-51 Chapter 8. Computerized Procedures

8. APPLICATION OF HUMAN FACTORS ENGINEERING IN DESIGN FOR COMPUTERIZED PROCEDURES

8.1. Computerized procedures might be used to support the operating personnel in **monitoring and detection, situation assessment, response planning and response implementation tasks** by transforming paper based procedures into digital form, so as to provide **different levels of functionality, including varying levels of automation.**

8.5. Computerized procedures systems are of three types:

- **Type I** systems represent an equivalent reproduction of paper based procedures and do not receive any processed or real time information.
- **Type II** systems augment procedures with dynamic embedded process data.
- **Type III** systems provide the capabilities of Type II systems and include **embedded soft controls** to manipulate plant equipment. Type III systems could include the capability **for automated sequences of steps** that automatically carry out the actions described in the procedure.

8. APPLICATION OF HUMAN FACTORS ENGINEERING IN DESIGN FOR COMPUTERIZED PROCEDURES

8.20. The computerized procedures system can **suggest which procedure to use**, but the responsibility for this decision should lie with the operators, who should take this decision on the basis of the plant status. This applies to Type II and Type III computerized procedures.

8.21. The computerized procedures system should **notify** the operator **when the plant status necessitates entering a procedure**, exiting a procedure or transitioning from one procedure to another.

8.24. The computerized procedures system might **automatically process certain steps within a procedure**. Results of the automatic processing of steps should be **highlighted** to the operator. The computerized procedures system should indicate those steps (e.g. time dependent steps and process dependent steps) for which continuous monitoring by the operator is necessary. The computerized procedures system should alert the operator when expected conditions in these steps are reached. In addition, the computerized procedures system should indicate whether the monitoring of parameters has stopped or is still ongoing.

8. APPLICATION OF HUMAN FACTORS ENGINEERING IN DESIGN FOR COMPUTERIZED PROCEDURES

AUTOMATIC SEQUENCING OF STEPS IN COMPUTERIZED PROCEDURES (8.34~8.42)

8.34. The highest level of computerized procedures is automation (i.e. automated sequences of steps that carry out the actions described in the procedure). Automation of the sequences of procedure steps is only applicable to Type III procedures.

HOLD POINTS IN AUTOMATED SEQUENCES OF STEPS (8.43~8.51)

8.43. An automated sequence of steps could include a hold point, which is a predefined point in the procedure at which the progress of the procedure will halt, and the operator will be requested to acknowledge the status of the automated sequence and to authorize the procedure to continue.

INTERRUPTION OF AUTOMATED SEQUENCES OF STEPS (8.48~8.51)

8.48. Upon interruption of automated sequences of steps, the computerized procedures system should allow the operator either to transition safely from automatic to manual execution or to resume automatic execution.

IAEA activities in 2025

- **Technical Meeting on Safety Considerations in the Use of Artificial Intelligence in Nuclear Power Plants with a Focus on Human Factors Engineering and Instrumentation and Control Systems**
- **2025.11.10 to 14, Republic of Korea**
- The purpose of the event is to provide a platform for Member States to advance discussions on the safety implications of the use of artificial intelligence in the nuclear field, with a focus on the design of nuclear power plants. The event will aim to compile relevant information for future updates to Human Factors Engineering in the Design of Nuclear Power Plants (IAEA Safety Standards Series No. SSG-51) and Design of Instrumentation and Control Systems for Nuclear Power Plants (IAEA Safety Standards Series No. SSG-39).
- **Revision of SSG-39 and SSG-51 will be started in 2026**



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Thank You