Features of a Typical Human Factors Engineering Program Plan (HFEPP)

This lecture provides an introduction to the possible contents for a project HFEPP and provides some examples for the suggested contents for different sections of such a document. This information would provide a good starting point for the development of a new HFEPP should you need to initiate a HFE based design project.

HFEPP Scope or Purpose

- The Human Factors Engineering Program Plan (HFEPP) is the ***key guiding Human Factors Engineering (HFE) document*** for a project and represents the comprehensive management and technical approach used to ***integrate*** the HFE data and principles.

- The HFE activities in the HFEPP should enhance all of the human component contributions towards the achievement of overall ***project safety*** and ***production performance goals.***

- The HFEPP identifies the HFE ***basis, standards, requirements, design processes*** and ***schedules*** necessary to ***integrate HFE*** throughout the design of the ***entire*** plant.

- This HFEPP is based on an ***evolutionary design process*** that seeks to evolve and improve the designs of the subject project (i.e. it is iterative and revisable).

- The HFE Based Design Approach is important for ***enhancing design barriers*** against the occurrence of events which could cause undue risk for the safety of the public or the plant staff.

- The HFEPP assigns HFE activities a level of ***equal priority*** to that of other system design engineering activities.

- The program plan should ensure that ***human design considerations*** are addressed, resolved and documented throughout all stages of ***system definition, design, development, verification*** and ***validation.***

- The plan should specify HFE ***activities*** and ***design processes*** which will result in ***effective Human-Systems Interface*** (HSI) designs which can be ***consistently*** and ***safely operated*** and ***maintained*** in an operational environment and which are compatible with ***human information*** requirements, capabilities and limitations.

HFEPP Scope or Purpose...continued

- The HFEPP outlines the design processes for the ***integration*** of human factors into the ***detailed design*** of the project with a focus on the ***control centre areas*** (i.e. Main Control Room (MCR) and Secondary Control Area (SCA)).

- The plan also outlines the HFE design process to ensure plant-wide ***work area layouts*** address human ***operational*** and ***maintenance*** requirements from both ***physical*** and ***cognitive*** perspectives.

- This plan identifies the relevant ***design information*** and ***design inputs*** necessary to aid the development of station specific design and the subsequent operational practices required by the operating utility.

- The purchasing utility shall be responsible for the development of the finalized plant operational practices due to the station specific nature of the final design.

- The utility shall also ensure that the development of those practices is ***consistent*** with the initial definitions (e.g. staff roles, responsibilities, emergency operating procedures, etc.) used or developed as part of the project design

Typical Project HFEPP Scope Section Contents

- The project's Human Factors design team ***functional relationship***, supporting ***HF resources***, the ***HFE roles*** and ***responsibilities*** for project managers and designers.
- HFE ***reference materials***, support to design areas, ***guidance principles*** and processes, control methodology, milestones and documentation.
- The extent to which HF design processes and HFE has been ***incorporated*** into the overall design (e.g. this is of interest to reviewers, regulators, customers, etc.)
- HFE project ***work activities*** and ***design processes*** utilized
- That ***design assumptions*** and ***constraints*** shall be identified as part of the system design documentation.

Reasons for Documenting the HFE activities and design processes

- Operator and maintainer tasks are ***capable of being performed*** under the designated plant state ***conditions*** and within acceptable levels of system ***performance.***
- System/equipment processes of design and acquisition are provided ***with relevant HFE information*** such as those pertaining to ***safety & stress*** factors, ***physical & cognitive*** characteristics, anthropometrics and system interface requirements.
- Human System Interface (HSI) designs support ***operator awareness*** and vigilance with system processes.
- ***Allocation*** of requirement ***functions*** to operators (i.e. ***manual operations***) is in accordance with human cognitive & physical abilities.
- HSI's are designed to ***minimize*** the likelihood for ***operator errors***, to minimize the ***impact*** of those errors which do occur and to provide mechanisms, as practical, for ***human error elimination***, ***reduction***, ***accommodation***, ***detection*** or ***recovery***.
- The use of appropriate HFE ***Design Guides*** in support of project HFE tasks and activities to ensure that ***project goals*** are addressed.

Example HFEPP Source Documents

- Several documents and strategies were considered when forming the basis for the CANDU 9 HFEPP.

- Early work had been done as research by the ***CANDU Owners Group*** (COG) to produce a guide entitled 'A Guide for the Development of Project Specific Human Factors Engineering Program Plans'.

- In addition to this Canadian document, other international Human Factors guidance documents were used as a ***primary source*** of HFE design criteria or as a ***checklist*** for completeness for the development of the HFEPP.

- ***EPRI*** NP-3659 (1984) ***Human Factors Guide for Nuclear Power Plant Control Room Development***, Palo Alto, California
- ***NUREG***/CR- 5908 (1994) ***Advanced Human Systems Interface Design Review Guideline***, USNRC, Washington, D.C.
- ***NUREG***-0700 (1981) ***Guidelines for Control Room Design Reviews***, USNRC, Washington, D.C.
- ***EPRI*** NP-4350 (1985) ***Human Engineering Design Guidelines for Maintainability***, EPRI, Palo Alto, California
- ***NUREG***-0711 (1994) ***Human Factors Engineering Program Review Model***, USNRC, Washington, D.C.
- ***IEC***-964 (1989) ***Design for Control Rooms of Nuclear Power Plants***

Human Factors Organizational Structure and Responsibility

- Overall responsibility must be central to the project so that the ***necessary authority*** is allocated project wide (i.e. Project Director, etc.).
- Organizational location for the ***HFE specialists*** as well as administrative and technical ***reporting*** must be identified.
- Design ***processes*** must be provided to ensure that the project means are in place to identify, acknowledge, analyze, correct or control, and report HFE issues.

Typical HFE Design team responsibilities

- Identification and development of human factors engineering ***plans***, ***processes***, ***procedures*** and ***design guides***.
- Ensuring and demonstrating ***compliance*** of design activities to the approved HFE plans and project procedures including successful integration of activities throughout all stages of the design process.
- HFE Reviews, where applicable, of design engineering ***change proposals*** for identification of potential human performance issues.
- ***Performance assessments*** of HFE design, development, test and evaluation activities.
- Initiation, recommendation, and provision of ***solutions for problems*** encountered in the implementation of HFE activities.
- ***Verification*** of the implementation of human factors design team engineering corrective recommendations that had been approved by project management.
- Identification, documentation, notification and ***tracking*** of HFE design concerns and issues
- ***Planning*** of HFE design team activities and milestones.
- On-going ***training for designated project staff*** (from all disciplines) in support of necessary HFE design tasks.
- Assist/participate in ***operating experience reviews*** as required

Typical HFE Design Team project work activities and deliverables

- Prepare ***detailed work schedules*** and ***deliverables*** in conformance with HF plans.
- Implementation and documentation of appropriate HFE activities throughout the design process in an ***auditable manner***.
- Formal ***review*** and ***comment*** of CANDU 9 system design documentation in support of HF design principles.
- HF technical review of ***project change requests*** and provision of requested design inputs.
- ***HFE support***, consultation, direction, training to system engineers as required.
- ***Tracking*** of significant HFE trade-off issues and appropriate management of trade-off rationale as required.

Human Factors Engineering Level of Effort

- An ***integrated design effort*** should be utilized throughout the project work to ensure that ***HFE design principles*** and criteria are ***implemented*** wherever practicable with respect to all systems, subsystems, equipment and layouts.
- HFE considerations in the design should include ***human cognition***, ***information needs*** & requirements along with traditional concerns related with ergonomic and anthropometric design issues.
- A ***two-Level of effort HFE approach*** was chosen to effectively use HFE staff resources and to achieve maximum safety, production and maintenance design benefit from the HFE considerations.
- The two-level allocation decision, ***Level A*** or ***Level B***, assignment of a design area to the lower level can be ***upgraded*** to the more intensive HFE level as the system design progresses and additional information becomes available.
- The highest level of HFE involvement is referred to as ***Level A***. Level A design areas are those systems, subsystems, equipment and layouts which require ***direct*** and ***detailed HFE design team support***.
- Level A design areas typically represent areas where human involvement is known to be ***intense*** and ***important*** to the achievement of plant ***safety***, ***production*** or ***maintenance*** goals.

Characteristics of Level A HFE Work Topics

- ***HSI*** designs within the ***control centre areas*** (MCR or SCA).
- Operational Experience Review (OER) information indicating ***significant human performance issues*** with the reference design or known occupational health & safety issues.
- ***Significant changes*** in the plant control and automation (i.e. function allocation changes)
- Systems/ Areas aiding the supervision and/or control of operational and maintenance activities which could significantly ***influence safety*** or ***production goal achievement.***
- Significant ***HFE design team concerns*** resulting from assessments, reviews or project feedbacks

Typical design work areas for Level A HFE designation

- The ***Main Control Room*** (MCR) including the work control area, shift supervisors office, control equipment room, etc. Direct HFE design team support will be given to associated room ***layouts***, ***panel/console design*** and to ***control***, ***display*** and ***annunciation*** interface designs.
- ***Secondary Control Area*** (SCA) - direct HFE design team support will be given to the secondary control room layouts, panel/console designs and to control, display and annunciation HSI designs.
- ***Remote field panels*** and control areas.
- Process and Control Systems ***HSI's*** designated for the control centre area
- Control Centre ***Communications*** to field (from the control centre) and the generic implications for plant-wide communication systems.

Characteristics of Level B HFE Work Topics

- ***Level B*** HFE design team efforts encompass ***all*** of those ***areas*** which have ***not*** been ***allocated to Level A***.
- Generally, ***Level B*** design areas are not viewed as requiring direct HF design support as they exhibit a proven or ***acceptable performance record*** (as per OER findings) combined with a ***relatively low level of human interactions***.
- The designation of project design areas to Level B HFE is ***not rigid***. If during the design, Level B design areas are seen to warrant Level A HFE attention, these design areas ***can be re-allocated*** to Level A.
- Level B design areas will receive ***HF design support via system designer*** adherence to project procedures, HFE Design Guides, and HF design team review recommendations.
- The HFE design tasks for Level B areas are under the direct control of the system designer. The HFE tasks involved generally relates to the ***design and layout of systems and equipment*** with regard to human ***operations*** (including inspection & testing), ***maintenance***, and ***commissioning*** requirements.
- The HFE design team will provide the project designers with ***HF consultative support*** as requested, HF revisions to project procedures, HF design guides and basic HF training to facilitate designer identification and resolution of HFE design issues.
- The HFE design team will participate in formal design documentation reviews or perform spot-check audits of ***approximately 15% of the Level B systems*** to ensure that HFE procedures and principles are appropriately applied.

Human Factors Design Tasks - Guiding Principles

- This section describes the major ***HFE design principles*** that will be used throughout the project design.

- The principles identify ***fundamental human characteristics*** that play an important role throughout the design when establishing the design requirements and solutions.

- Many of these principles have ***no specific design solution***, they represent issues that ***should be considered*** and applied as appropriate.

- Guiding HFE design principles can be applied to the project design ***via the use of HFE Design Guides*** (utilized by all designers) and by applying ***HFE expertise*** to specific design problems.

General HFE Considerations

- Due to the ***dynamic nature*** of the plant processes, the human operator's role of ***supervisory control*** is of great importance as is the maintainer's role in ***detecting maintenance issues***.
- Human operators possess some invaluable attributes over that of machines such as ***deducing the cause*** of events, ***reason effectively with uncertainties*** and are capable of ***conceptual organization***
- Human operators provide a level of ***system flexibility*** that is not achievable through automation alone.
- Manual operator actions can ***enhance the immunity of the plant*** against system and equipment failures and unlikely failure combinations.

Three specific HFE design constraints and considerations areas

- Supervisory Control and Plant Automation
- Basic Human Cognitive and Physical Characteristics
- Minimize Human Error

Supervisory Control and Plant Automation HFE Considerations

- The human operator must have appropriate ***control of all aspects of plant operation*** consistent with the his or her licensed authority for personnel, plant safety and production responsibilities.
- The ***degree of automation*** should be consistent for similar functions across all plant systems compatible with realistic operator capabilities and limitations.
- The degree of function automation should promote ***operator awareness*** and ***vigilance*** for the target system as appropriate.
- The human operator should be aware of the ***performance of automated systems*** so as to maintain an accurate and up-to-date mental model of the plant to smoothly allow ***operator intervention*** following inadequate system performance conditions.
- The information provided must be sufficient for the operator to reasonably predict or ***anticipate the system's performance*** and thereby be able to ***identify*** instances of ***abnormal behavior*** in a timely manner (e.g. conditions indicating an automated system's function - availability, initiation, termination, progress toward achieving functional goals, margins, safety and production functional or performance problems).
- The ***equipment layout*** and the information provided must facilitate the performance of ***on-line maintenance*** activities.

Basic Human Cognitive and Physical Characteristics HFE Considerations

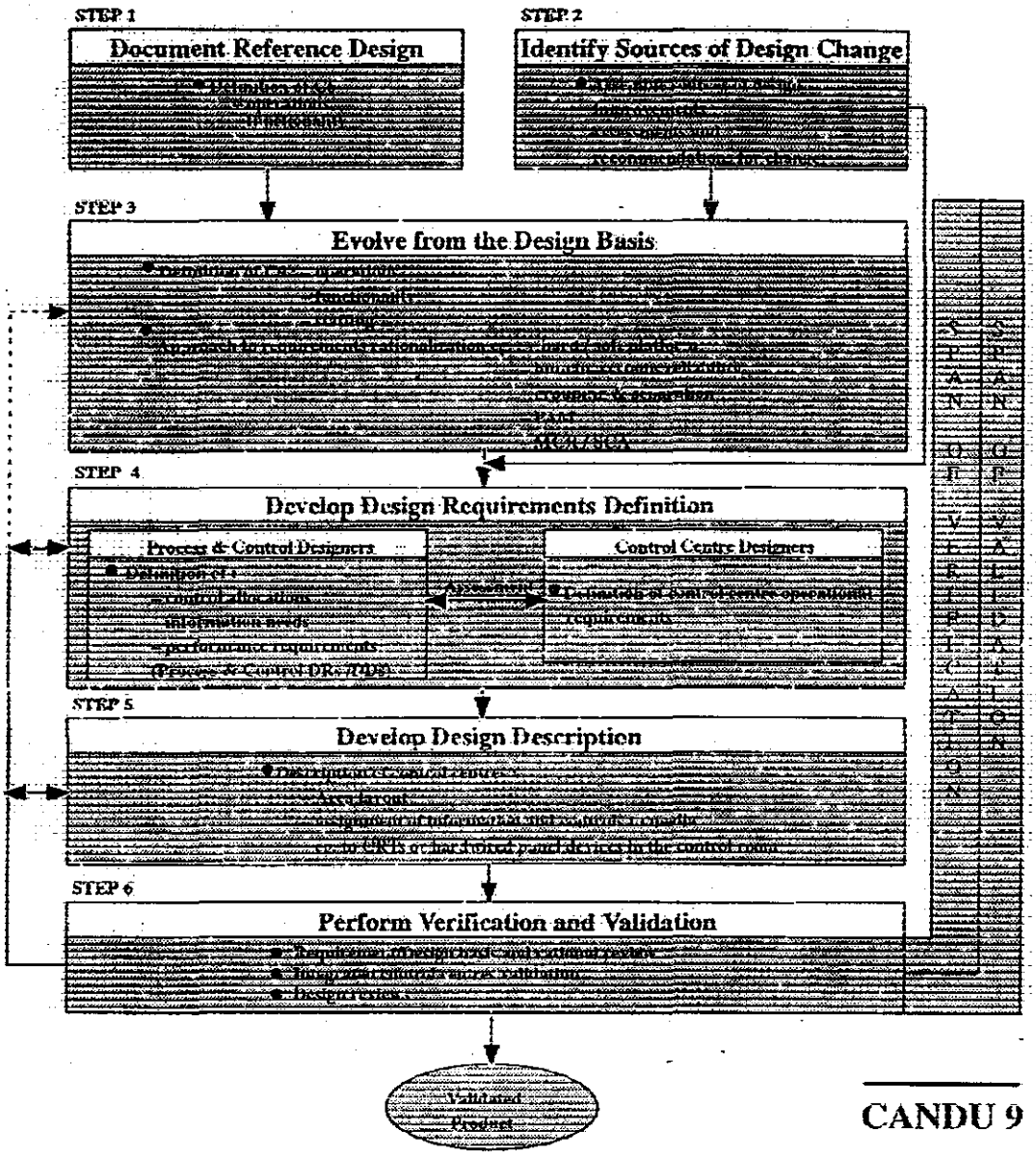
- Adopt a ***known model of human decision making*** for the project and ensure that project practices are supported by this model.
- Support known ***operational*** and ***maintenance*** expectations
- Minimize detrimental human performance effects due to ***psychological*** and/or ***physiological*** stress
- Minimize the demands for operator ***short term memory*** use.
- Maximize the effectiveness of storing and retrieving information from ***long term human memory***.
- Maximize the ***effectiveness of human attention*** (i.e. stress, repetition, prompts, feedbacks, readability, understandability)
- Accommodate the capacity for humans to ***process information with minimal error*** (i.e. human ***perception***, ***decision making***, ***response performance*** rates).
- Promote a high level of ***plant state situational awareness*** for both the operator and technical/maintenance staff.

Minimize Human Error HFE Considerations

- Conducting Operational Experience Reviews (OER) for both operations and maintenance tasks will assist designers in ***avoiding known design problems***.
- Design to ***eliminate human error*** - where human error is known to occur due to specific design features, then implement an ***alternative design*** known to eliminate the error potential where practicable.
- Design to ***reduce the probability of human error*** - it is not possible to eliminate all probability for human error. However, proper selection of design features ***suggested by the HFE Design Guides*** can significantly reduce the probability for human error.
- Design to ***accommodate human error*** - where no alternative design feature can be employed to reduce the probability of human error and the likelihood of an error is considered unacceptable, then the designer must ***choose additional design features*** or functions that will ***accommodate the human error*** or its impact. This could be accomplished by ***error-catching techniques*** or the development of a ***more error tolerant*** system.
- ***Error-catching*** techniques can include ***two independent approvals***, ***double key entries***, ***interlocks***, detailed ***annunciations*** and absence of expected annunciation alarms.
- Improving human ***error tolerance*** includes improved operational & maintenance displays and annunciations with ***greater predictive/warning capability*** as well as developing a ***more robust system***.

Principles for Integrating HFE into Level A Design Areas

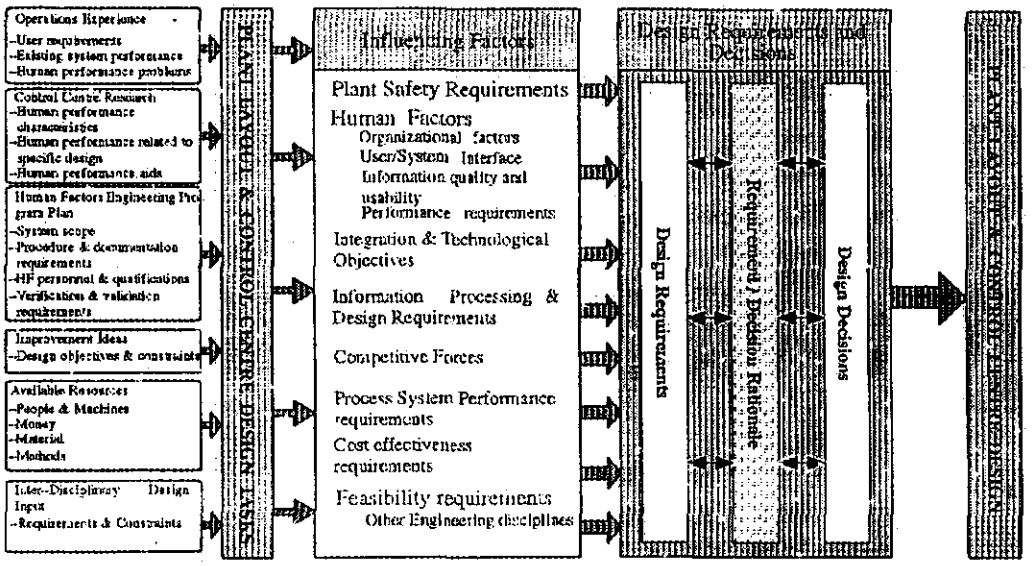
- The HFE design process should be ***reiterative*** (continually checking design process outputs against the associated inputs).
- The products and the work processes used to develop those products should be ***auditable***.
- Document the ***Reference Design*** (i.e. where did the design come from)
- Identify ***Design Changes*** and the sources of those changes (i.e. change rationale)
- ***Evolve*** the design from the documented Design Basis
- Develop the ***Design Requirements Definitions*** (i.e. ***what*** the design will do)
- Develop the ***Design Description*** (i.e. how the design is achieved).
- Perform ***Verification*** and ***Validation***
- Due to the iterative nature of the design process, activities in several steps can be expected to be conducted at the same time. For example, verification and validation activities are on-going and span all design activity steps and are conducted throughout the life of the project.



The CANDU 9 HFE Level A Design Process Logic FlowChart

Human Factors Trade-Off Issues

- Design processes must assess design ***trade-offs*** (i.e. conflicting requirements so that all discipline's goals can not be achieved), for all disciplines, at various levels of detail throughout the design life-cycle.
- The HFE design criteria trade-offs should be assessed to determine if the trade-offs warrant further review and consideration.
- For a given HFE trade-off condition, if it is not possible to implement ***adequate HFE design criteria*** (via assessment with accepted HFE design practice, standards, guidelines, OER information) and compensatory design alternatives are insufficient, then an ***HFE Issue Form*** must be completed.
- The HFE Issue Form will outline the nature of the ***HFE issue***, detail the ***associated rationale***, and summarize the ***final disposition*** of the issue.
- It is not expected that many HFE Issue Forms will be required throughout the project life-cycle as the normal design process should provide adequate HFE coverage.



Flow Chart to represent a design requirements Trade-Off Rationale

Milestones and Documentation that the HFEPP should Identify

- The sequence and ***interaction*** of the design ***project documents*** related to human factors engineering. The provision of a ***design document hierarchy diagram*** is particularly useful.
- How the HFE work will be ***planned***, ***scheduled*** and ***reported***.
- A list of HFE work and ***deliverables***, organized as ***Level A*** or ***Level B***, that will be completed by the HFE design team in support of the project goals.
- A summary of all required project ***HFE training*** for design staff.
- An interpretive explanation for the ***project use*** of the human ***decision making model.***

HFE Design Guides

- Project HFE Design Guides should be produced in accordance with the project procedures to document ***human factors principles***, ***criteria*** and ***methodology*** for designated aspects of system designs.

- These design guides will be used for the development of ***design requirement*** documents (i.e. ***what*** the design entails) and ***design description*** documents (i.e. ***how*** the design features will be implemented).

As a minimum, the following human factors design guides should be provided for a project:

- Maintenance, Inspection and Testing
- Function Analysis
- Panel Layout and Device Selection
- Annunciation
- Computerized Hardware
- Computerized Display and Control

Typical HFEPP Table of Contents

1. ***Scope*** or Purpose of the HFEPP
2. Program ***Source*** and ***Reference*** Documents
3. Project HFE ***Organizational Structure*** and Responsibility including HFE Team Support, Level of Effort and HFE Design Tasks
4. ***Guiding Principles*** (Automation, Cognitive & Physical Characteristics, Minimizing Human Error)
5. ***Integrating*** HFE into ***Level A*** Design Areas
6. ***Integrating*** HFE into ***Level B*** Design Areas
7. Project ***Maintenance*** Assessment
8. Plant ***Layout*** and Equipment Arrangement
9. Project Documentation ***Configuration Control*** Methodology
10. ***Human Factors Issues***, Disposition and ***Tracking*** System
11. ***Operations Experience Review*** Documentation, Action and ***Tracking System***
12. ***Human Factors Documentation***, ***Deliverables***, ***Milestones*** and ***Schedule***

HFEPP Appendices:

Appendix A The Project Human ***Decision Making*** Model and Explanation

Appendix B The Human Factors Engineering ***Issue Form***

Appendix C The Project Design ***Documentation Hierarchy***

Appendix D Related HFE ***Abbreviations*** and ***Definitions***