Health and Safety Executive

NUCLEAR DIRECTORATE

GENERIC DESIGN ASSESSMENT – NEW CIVIL REACTOR BUILD

STEP 3 HUMAN FACTORS ASSESSMENT OF THE EDF AND AREVA UK EPR

DIVISION 6 ASSESSMENT REPORT NO. AR 09/031-P

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EXECUTIVE SUMMARY

This report presents the findings of the Human Factors (HF) assessment of the EDF and AREVA UK EPR Pre-Construction Safety Report (PCSR) (Ref. 1) undertaken as part of Step 3 of the Health and Safety Executive's (HSE) Generic Design Assessment (GDA) process.

This report for the UK EPR presents the results of the Nuclear Directorate's (ND) Step 3 assessment of HF. It provides an overview of the safety case presented in the PCSR; the standards and criteria adopted in the assessments; and an assessment of the human based safety claims as presented in the safety case.

The scope of the HF assessment is detailed in the Project Initiation Document (PID) (Ref. 7) which states that the GDA Step 3 HF assessment will be more aligned to the level of detail undertaken during GDA Step 2 (focused on the safety 'claims'), due to the delayed commencement of the ND assessment in HF (June 2009).

The approach to the assessment of HF was to confirm that the EDF and AREVA PCSR clearly presents the contribution of human actions to safety on the nuclear power plant (NPP). This formed the focus of the assessment. In addition assurance was sought that EDF and AREVA have HF analysis to support the human based safety claims (for ND assessment during GDA Step 4); that the age of this supporting analysis is not a detriment to their risk assessment when compared to modern standards; that the standards used are appropriate; and that there has been an adequate integration of HF into the NPP design and PCSR and supporting documents.

EDF and AREVA's safety arguments are set out principally in the PCSR. Chapter 18.1 of the PCSR details the HF engineering programme, which is a description of the HF work being undertaken for the Flamanville 3 (FA3) EPR development. This sub chapter outlines the HF programme, activities and interactions, but does not present safety analysis and argument in a structure that provides a clear identification of the 'claims, arguments and evidence', or clearly highlight the human based safety claims. Furthermore there does not appear to be an explicit link between the Probabilistic Safety Assessment (PSA) and HF work.

However, EDF and AREVA have been able to present a consolidated overview of what they consider the human contribution to safety to be via presentation, and our assessment of the Human Reliability Assessment (HRA) for the Level 1 PSA concludes that there is sufficient consideration and modelling of pre-fault human failures events (HFEs), HFEs contributing to initiating events and post fault operator actions, which gives us a level of confidence in EDF and AREVA's understanding of the human contribution to safety. This enables me to progress my assessment in GDA Step 4, and to target my effort at those areas where the human contribution to safety is greatest. My focus for GDA Step 4 will be to fully assess the arguments and evidence base underpinning the human based safety claims.

From the perspective of Human Factors, I recommend that the EDF and AREVA UK EPR proceed to Step 4 of the GDA process.

LIST OF ABBREVIATIONS

ASEP	Accident Sequence Evaluation Program
ASP	Accident Sequence Precursor
BMS	(Nuclear Directorate) Business Management System
CNSC	Canadian Nuclear Safety Commission
EA	The Environment Agency
EDF and AREVA	Electricité de France SA and AREVA NP SAS
FA3	Flamanville 3
GDA	Generic Design Assessment
HEP	Human Error Probability
HF	Human Factors
HFE	Human Factors Engineering
HFE	Human failure event
HFI	Human Factors Integration
HRA	Human Reliability Analysis
HSE	The Health and Safety Executive
IAEA	The International Atomic Energy Agency
INEEL	Idaho National Engineering & Environment Laboratory
MMI	Man-machine Interface
ND	The (HSE) Nuclear Directorate
PCER	Pre-construction Environment Report
PCSR	Pre-construction Safety Report
POP	Plant Overview Panel
PSA	Probabilistic Safety Assessment
RI	Regulatory Issue
RIA	Regulatory Issue Action
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
SAP	Safety Assessment Principle
SPAR-H	Standardized Plant Analysis Risk-Human Reliability
SSC	System, Structure and Component
SQEP	Suitably Qualified and Experienced Person
TAG	(Nuclear Directorate) Technical Assessment Guide
THERP	Technique for Human Error Rate Prediction

LIST OF ABBREVIATIONS

TQ	Technical Query
US NRC	United States Nuclear Regulatory Commission
WENRA	The Western European Nuclear Regulators' Association

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1 INTRODUCTION

1 This report presents the findings of the Human Factors (HF) assessment of the EDF and AREVA UK EPR Pre-Construction Safety Report (PCSR) (Ref. 1) undertaken as part of Step 3 of the HSE Generic Design Assessment (GDA) process. The assessment has been undertaken in line with the requirements of the Business Management System (BMS) document AST/001 (Ref. 2) and it's associated guidance document G/AST/001 (Ref. 3). AST/001 sets down the process of assessment within the Nuclear Directorate (ND) and explains the process associated with sampling of safety case documentation. The Safety Assessment Principles (SAPs) (Ref. 4) have been used as the basis for the assessment of HF associated with the UK EPR design. The SAPs require that HF on a nuclear power plant or nuclear chemical plant site be identified and considered in safety assessments. Ultimately, the goal of assessment is to reach an independent and informed judgment on the adequacy of a nuclear safety case.

2 The approach taken to the HF assessment for GDA Step 3 was more aligned to the level of detail undertaken for GDA Step 2; focused on the safety 'claims', with some amplification. There was no HF assessment work undertaken for GDA Step 2, and assessment work did not commence until June 2009, resulting in the HF technical assessment programme being significantly behind other disciplines.

3 The scope of the assessment for HF is detailed in the ND Project Initiation Document (PID), (Ref. 7), which states that the main focus will be on identifying the human based safety claims to gain an understanding of the human contribution to safety. In addition I have assessed the availability and age of supporting analysis (or substantiation), judged the appropriateness of the standards applied and considered the adequacy of the level of Human Factors Integration (HFI).

4 It should be noted that due to the delayed start of the HF assessment and the sampling nature of our work, not all aspects of the assessment scope have been covered in the same level of detail.

2 NUCLEAR DIRECTORATE'S ASSESSMENT

2.1 Requesting Party's Safety Case

5 The following documents have formed the basis of my assessment:

- UK EPR PCSR Sub-chapter 18.1 Human-Machine Interface;
- UK EPR PCSR Chapter 4.4 Human Reliability Analysis (HRA);
- UK EPR PCSR Chapter 4.5 Qualitative Dependence Analysis;
- Material presented via presentation titled 'HF Kick-off Meeting'; and
- Material presented via presentation titled: 'HRA meeting: Human Factors in the Level 1 UK EPR PSA'.

6 Sub-chapter 18.1 describes the safety objective of the HF programme, outlines the scope of activities covered by the programme, describes the integration method and the HF engineering process and teams, and cites in some detail the design principles applied. Sub chapter 18.1 states that the HFE programme presented is a description of what has been implemented for Flamanville 3 (FA3); an EPR currently under construction in France, and adds that *'..many aspects of this programme relating to plant design and resulting features are applicable to the UK EPR'*, and that *'[the HFE programme]..presents an approach that could potentially be reproduced or adapted for EPR development in the UK'*. However, EDF and AREVA have not committed to undertaking this exercise.

7 Sub-chapter 18.1 states that the scope of the HFE programme includes operational and maintenance activities, the design of 'locations' including control rooms and local to plant equipment (including isolation and testing activities), and is applied to plant operation and control and work area design and layout. Further detail is provided on discrete work packages including allocation of function, human reliability, the use of operational experience feedback (from existing N4 plants), task / functional analysis, input to the human machine interface design and workspace layout and the validation programme. For each area there is a description of the work that is proposed and for some areas there is a description of the approach taken to the analyses.

8 Section 1.4 of sub-chapter 18.1 covers 'human reliability' and it is here that I would expect to see the link between the PSA HRA work and the HFE programme. However, this section is limited to how the overall HFE programme can contribute to reducing human error potential, without being targeted at those areas where the human contribution to safety is greatest. Section 1.4.2 highlights that *'in future design studies, the extent to which human error contributes to the general level of risk will be analysed and evaluated as part of the probabilistic safety assessment*'.

9 There is a statement that '*the systems are designed so that no short term operator intervention is needed if an accident occurs. The criterion is that no operator action from the main control room is required for the first 30 minutes after an initiating event; and no action at the site itself for the first 60 minutes. This criterion provides adequate operator response times without significant time stress which could lead to human error. The systems are designed so that passive and / or automated processes replace human action in that time*'. This is a key aspect of their safety argument for the UK EPR, and is consistent with our Safety Assessment Principles (SAPs).

10 There is a description of the HFE team and an outline of the role of the HF specialists. It is stated that the role of specialists is to integrate into the design:

- relevant operating experience feedback from existing plants;
- the HF perspective regarding design studies and choices, including reviewing design studies;
- requirements derived from HF standards and principles; and
- HF studies evaluating design choices, particularly involving user trials.

11 A description is provided of the links with other technical disciplines and how HF issues are integrated into their work activities. Also noted is that the HF 'Coordinator' is attached to the Technical Director for the EPR project, in the Nuclear Engineering Department.

12 A series of design principles are provided, which includes a description of the roles (tasks) of the operators, the operational philosophy, automation principles, information presentation and alarms, main control room equipment and workstations, detail on the remote shutdown station and technical support centre and information on the working environment requirements.

13 Chapter 4.4 describes the approach and scope of the human reliability analysis (HRA). It sets out the methods used and the approach to pre-accident errors and post accident tasks. Information (description) is also provided on their approach to dependency modelling, which appears to include the application of bounding values or (human performance) limiting values.

14 Chapter 4.5 is a dedicated section on qualitative dependence analysis, which includes a very limited description of their approach to human error dependencies.

15 Presentation material provided at the HF inaugural meeting largely replicated that presented in sub-chapter 18.1, with additional content relating to how the HFE

programme delivers the UK SAPs on HF. The SAPs alignment simply refers to the relevant section of the PCSR, and provides relevant extracts.

16 Presentation material provided at the topical meeting on the HRA aspects of the PSA provided useful and detailed information on the scope and approach to the HRA, together with relevant Level 1 PSA results. Sensitivity results from the assessment of the impact of pre-accident human errors are included, together with the minimal cutsets relating to human errors contributing to initiating events and post fault human errors. A table presenting the results of importance analysis relating to post fault actions is also included.

17 The topical meeting on HRA also presented the EDF and AREVA consideration of post fault human actions for the Level 2 PSA. This is essentially a qualitative description of the severe accident approach, including an outline of the roles of the emergency response team, a very high level description of the Standardized Plant Analysis Risk-Human Reliability (SPAR-H) HRA method applied to the Level 2 PSA together with a replication of the SPAR-H dependency rating system.

2.2 Standards and Criteria

18 SAPs have formed the basis of the HF assessment of the UK EPR. The SAPs recognise that *"…the human contribution to nuclear safety can be positive or negative, and may be made during facility design, construction, operation, maintenance, and decommissioning"*. They require that *"a systematic approach to understanding the factors that affect human performance, and minimising the potential for human error to contribute to faults should therefore be applied throughout the entire facility life-cycle. Assessments of the way in which individual, team, and organisational performance can impact upon nuclear safety should influence the design of the plant, equipment, and administrative control systems. The allocation of safety actions to human or engineered components should take into account their differing capabilities and limitations. The assessments should demonstrate that the interactions between human and engineered components are fully understood, and that human actions that might impact upon nuclear safety are clearly identified and adequately supported."*

19 The principal SAPs relevant to this stage of the HF assessment are:

EHF.1 A systematic approach to integrating human factors within the design, assessment and management of systems should be applied throughout the facility lifecycle.

EHF.2 When designing systems, the allocation of safety actions between human and technology should be substantiated and dependence upon human action to maintain a safe state should be minimised.

EHF.3 A systematic approach should be taken to identifying human actions that can impact on safety.

EHF.10 Risk assessments should identify and analyse human actions that might impact on safety.

SC.4 A safety case should be accurate, objective and demonstrably complete for its intended purpose.

EKP.3 A nuclear facility should be so designed and operated that defence in depth against potentially significant faults or failures is achieved by the provision of several layers of protection.

EKP.5 Safety measures should be identified to deliver the required safety function(s).

ESS.8 A safety system should be automatically initiated and normally no human intervention should be necessary following the start of a requirement for protective action.

FA.9 Design Basis Analysis (DBA) should provide an in put to the safety classification and engineering requirements for systems, structures and components performing a safety function; the limits and conditions for safe operation; and the identification of requirements for operator actions.

FA.13 The PSA model should provide an adequate representation of the site and its facilities

FA.14 PSA should be used to inform the design process and help ensure the safe operation of the site and its facilities.

20 The latest revision of the SAPs is consistent with The International Atomic Energy Agency (IAEA) Standards and the Western European Nuclear Regulators' Association (WENRA) Reference Levels (Ref. 8). In addition ND Technical Assessment Guides (TAGs) provide an interpretation of the SAPs, and have been applied to my assessment where relevant. For GDA Step 3 I have applied TAGs in the area of Human Factors Integration (HFI) (Ref. 9), Early Initiation of Safety Systems (Ref. 10), and Guidance on the Demonstration of ALARP (Ref. 11).

21 The UK also applies the fundamental principle of reducing risk to As Low As Reasonably Practicable (ALARP). This principle is at the forefront of assessment and my judgement on using the principles in the SAPs is always subject to consideration of ALARP. In the area of HF, ALARP arguments are often not explicit; they are inherent in the establishment and use of relevant good practices and standards. Of relevance to this assessment is guidance in the TAG on the demonstration of ALARP (Ref. 11) which states that *"the good practice or standard should be up-to-date, taking account of the current state-of-the-art: any practice or standard more than a few years old, or not subject to active on-going monitoring and review or not written by acknowledged experts may be suspect"*.

2.3 Nuclear Directorate Assessment

22 The approach taken to the assessment of HF for GDA Step 3 is more aligned to the level of detail undertaken for GDA Step 2; focused on the safety 'claims' with some amplification, as no HF assessment work was undertaken on the UK EPR until June 2009. As a result there are no considerations or output from GDA Step 2 to form the basis of this assessment for GDA Step 3.

23 My assessment has been undertaken with the assistance of Technical Support Contractors (TSCs), and it is important to note that due to the sampling and targeting nature of assessment, not all aspects of my assessment have been covered in the same level of detail.

2.3.1 Observations on the Strengths of the PCSR

24 The material that has formed my assessment basis provides a clear description of the HFE programme that is in place at FA3, and the scope of the HRA for the UK EPR. If the FA3 HFE programme is replicated for the UK EPR, it would provide me with a level of confidence that the type and range of HF analyses that I would expect should be available for assessment during Step 4. In addition, through their presentation of the HRA scope, I have a level of confidence that EDF and AREVA understand the human contribution to safety. I particularly note the clarity provided on the role of the operator

and operating philosophy, and the position of the HF team within the EPR project organisation, which facilitates technical influence at the right level.

2.3.2 Observations on the Weaknesses of the PCSR

25 The PCSR does not present an adequate safety case for HF for the UK EPR. The documentation presented for assessment does not provide a clear identification of the claims, arguments and evidence, and there is very limited and often no analysis or arguments presented in the PCSR chapters that I have considered.

26 The PCSR material considered is essentially descriptive and does not present the output or results of the HF analyses in a risk or safety framework. As a result it is difficult to link the HFE programme with the PSA results, to gain an understanding of the safety relevance of the HFE work.

27 I have largely relied on the material presented at the topical meeting on HRA to inform me of the human contribution to safety. I would expect EDF and AREVA to use this as a starting point to link their HFE programme work to the PSA.

2.3.3 Identification of the Human Based Safety Claims

28 This was the main focus of my assessment and fundamental to a safety claims based assessment strategy. Clarity on the human based safety claims provides confidence that EDF and AREVA fully understands the human contribution to safety and where human error can present a safety challenge, and that they have targeted their HF engineering and safety analysis work appropriately. This in turn provides a mechanism for EDF and AREVA to demonstrate that the risks from human error have been reduced to ALARP. Furthermore, precision on the human based safety claims ensures that key assumptions and requirements can be transferred and understood by the licensee organisation, and be translated into the operating regime (training and procedures for example).

29 Transparency of the human based safety claims enables me to target my subsequent assessment work (for GDA Step 4) on a proportionate basis to the human contribution to safety. This aspect of my assessment sought assurance that the PCSR provides a complete statement on the human based safety claims. This should include:

- the potential for latent human failures induced through maintenance, calibrations, inspection and testing;
- requirements associated with plant alignments, active monitoring and control and contributors to initiating events; and
- post fault operator requirements including fault diagnosis, manual activation of systems, detection of automatic system failure, manual back up of systems, and initiation of the emergency plan.

30 The UK EPR plant is an evolution of recent French and German 4-loop PWRs and benefits from being able to take advantage of extensive operational experience of these plants. The evolution is intended to reduce overall plant risk and in particular to improve the man-machine interface (MMI) and extend response times for operator actions. Consequently the UK EPR design benefits from the knowledge gained from previous PWRs, in terms of the understanding of faults and plant risks, and from extensive operational experience including simulator studies and post-fault responses and procedures. This reduces the level of uncertainty over the consideration of human actions relating to plant safety. It also provides greater confidence in the degree of understanding and consideration of human failure events that the UK EPR HRA has been based on.

31 I have worked with ND's PSA assessor and through our assessment of the Level 1 and Level 2 PSA HRA we have a clear understanding of the human contribution to safety on the UK EPR. In addition during a technical topic meeting on HF in the UK EPR PSA, EDF and AREVA presented their consideration of pre-fault human errors, human errors contributing to initiating events and post fault operator errors, which further enhanced my understanding of the human based safety claims. Furthermore, I am confident that EDF and AREVA have a good understanding of the contribution of human actions to safety.

2.3.3.1 Pre Fault Human Errors

32 EDF and AREVA have quantified pre fault errors via the Accident Sequence Evaluation Program (ASEP) HRA method, provided a list of those pre-fault errors included in the PSA, and undertaken a sensitivity study to show the risk impact of these errors.

33 However, it appears that only classic 'maintenance' activities have been explicitly modelled (refer to the table at para. 35), as EDF and AREVA state that calibrations are *"not assessed as pre-fault human error in the UK EPR PSA"* and that they are *"assessed as part of the failure rate of the instrumentation"*. Although this is a common practice, I would expect EDF and AREVA to provide a judgement on the contribution of human error to the failure rate of the instrumentation, such that the overall failure probability remains the same, but there is some clarity on the human error proportion. I will take this forward during GDA Step 4. However, I do recognise that EDF and AREVA have highlighted this omission themselves.

34 EDF and AREVA also state that *"no common causes between pre fault human errors (are) modelled"*. Human error dependency is a particular issue in maintenance activities, as it is likely that the same maintainer (or maintenance team) will be undertaking work on similar or the same equipment items (valves in series for example) in similar locations within a shift. I accept that there are implied common cause failures in the equipment failure rates; however, I will be expecting EDF and AREVA to explicitly consider this issue during GDA Step 4, and to show a contribution in the PSA model.

35 The sensitivity analysis results (based only on those maintenance actions included) shows that the pre fault human errors have a negligible impact on the overall risk:

Basic Event ID	Description	Failure rate (/demand)	Ranking	Risk Increase Factor
AAD1001LMEC4	Manual valve left in wrong closed position in AAD (SSS)	3×10^{-2}	67	1.51
RCV5214VPMEC2	Manual valve left in wrong closed position in RCV (CVCS)	3×10^{-4}	199	6.94
RCV5297VPMEC2	Manual valve left in wrong closed position in RCV	3×10^{-4}	200	6.94
RBS4150VBMEC2	Manual valve left in wrong closed position in RBSD (EBS)	3×10^{-4}	275	3.13

2.3.3.2 Human Errors Contributing to Initiating Events

36 EDF and AREVA report that their consideration of human errors contributing to initiating events is based on EDF experience and international operating experience. They state that the main human errors contributing to initiating events are spurious draining during mid loop operation (uncontrolled level drop) and boron dilution. For each of these events, EDF and AREVA have set out the contribution to the core damage frequency

and provided the minimal cutsets. These two events will be considered in detail during GDA Step 4; particularly the qualitative substantiation element.

2.3.3.3 Post Fault Human Errors

37 EDF and AREVA highlight that they have also applied the ASEP HRA method for their consideration of post fault human errors. They note that operator actions required within 30 minutes are not credited/considered in their (deterministic) safety analysis, which is what I would expect, but are modelled in the PSA if they are a back up to an automatic action, there is a clear indication to the operator, and the time window is more than 10 minutes. Although this is not unreasonable at face value, I would expect to see additional analysis to demonstrate the feasibility of these post fault actions.

38 A list of the post fault operator actions modelled in the PSA has been provided in response to the PSA led to TQ-EPR-133 (Ref. 18) on HRA. Sensitivity and importance analyses have also been provided which helps to identify the key post fault human actions. These are:

- bleed (for bleed and feed) -12 actions;
- feed -1 action;
- isolation of dilution – 7 actions;
- secondary cool down (partial cool down; secondary cool down or fast cool down actions) – 6 actions;
- isolation of V-LOCA – 3 actions;
- actions in response to fuel pool accidents (restoration of cooling) – 5 actions; and
- 8 diverse human actions for different fault sequences.

39 There appears to be some implicit consideration of the potential for operator fault mis-diagnosis in that this is an element of the ASEP calculation relating to the discrete post fault actions modelled. What is missing is an explicit consideration of the potential for operator mis-diagnosis to aggravate a fault. I will consider this is detail during GDA Step 4.

40 The scope of the post fault actions included also considers a limited number of actions performed outside of the control room and dependency modelling. This is what I expect, and I will consider the dependency modelling in particular during GDA Step 4.

2.3.3.4 Post Fault Human Errors in the Level 2 PSA

41 The Level 2 PSA employs the SPAR-H HRA method to evaluate the task human error probability. I am unclear at this stage why two separate HRA methods have been employed for the Level 1 and Level 2 PSA, and I will consider this further during GDA Step 4. In addition, EDF and AREVA state that they have adapted the SPAR-H methods to accommodate a *"more complex decision chain"*. This adaptation of a HRA technique will require clarification and assessment during GDA Step 4.

42 EDF and AREVA state that they have considered the dependency between Level 1 and Level 2 operator actions, and this is what I would expect. Our PSA assessor has considered this element and has no issues at this stage.

43 It appears that EDF and AREVA have identified the human actions required, classified the action type, described the decision and validation chain, decomposed the tasks and provided a quantification of the human error probability (HEP) for each step, then considered the dependency to provide a resultant HEP. At face value this appears to be

a thorough treatment of post fault errors for the Level 2 PSA, and broadly in line with what I would expect.

2.3.3.5 Availability and Age of Supporting Analysis (Substantiation/Analysis of the Human Based Safety Claims)

44 This aspect of my assessment is supported by my consideration of the human factors integration (section 2.3.5 of this report refers). The aim of this aspect of the assessment is to determine whether the scope of HF analyses is available to underpin / substantiate the human based safety claims, for assessment during GDA Step 4.

45 PCSR sub chapter 18.1 largely refers to proposed HF work, and there are few references to actual HF analysis work that is currently available for assessment. However, in the presentation material relating to the HF inaugural meeting, it is highlighted that there is a document planned for submission in April 2010 that will detail the HFE process *"adapted to British Context".* This document appears to provide a vehicle for the presentation of the HFE material in a safety context, and to link the HF work with the PSA. As a result I have raised Regulatory Observation (RO) RO-UKEPR-038 (Ref. 19) which states "*the current PCSR for the UK EPR (UKEPR-0002-181 Issue 02) does not present the safety case for Human Factors in a recognisable UK structure, i.e. the 'claims', 'arguments' and 'evidence' chain of reasoning. As a result ND is not able to link the human factors engineering (HFE) work that is described in PCSR sub chapter 18.1 to the safety claims made on human actions. By not framing the HFE work in a safety or risk context, we are unable to target our assessment on a proportionate basis to those areas where human actions are important to safety*." EDF and AREVA are required to submit documentation that clearly defines the role of human actions on the UK EPR (i.e. the safety 'claims') and justifies those actions via human factors analysis (i.e. the 'arguments and 'evidence'). This RO was issued towards the end of Step 3, and I am engaged in dialogue with EDF and AREVA on its resolution.

46 The HF inaugural presentation also included a list of documents that appear to be HF analysis, for example: 'Modelling of operator actions – EPR project'; 'EPR MMI – Evaluation of the operating principles based on the computerised MMI – Report on the 2005 complementary test programme'; 'Human Factor Approach applied to the fuel handling activities' and 'Human Factor Evaluation Programme of the EPR Operational Features'. However, this list does not present a complete catalogue of all of the HF analysis reports that I would expect. As a result I have raised TQ-EPR-512 (Ref. 18) which states…"*Please supply a complete list of all of the Human Factors analysis reports available to support the EPR design, as this is not provided in the current PCSR and is required for our Step 4 GDA assessment."*. This TQ was raised towards the end of GDA Step 3 and as a result I have not yet received a response.

47 I recognise the planned submission of a detailed report on HRA (in response to TQ-EPR-133) currently scheduled for 12th December 2009. EDF and AREVA state that that this report will provide (for each action modelled in the PSA):

- the preliminary description of the (human) action;
- the associated scenario / plant configuration;
- the main alarms and cues that shall be available to the operator;
- the calculation of the human error probability (HEP); and
- the importance of the human action in the PSA.

Although this report may provide further insight into the derivation of the HEPs, I do not consider that it will provide a full substantiation of the HEPs, based on the outline

content cited above. Therefore, there will remain a need to link together the HFE work and the PSA / HRA.

2.3.4 Appropriateness of Standards / Methods

48 In the documentation reviewed there are very few cited public standards; the majority are proprietary and in French, and consequently for GDA Step 3 I am not able to comment on the suitability of the standards base for the UK EPR HF programme. I have raised TQ-EPR-502 (Ref. 18) which states: *"Please provide a complete listing of the standards and methods applied to the UK EPR Human Factors analyses. Where these standards and methods are proprietary, or where they have been superseded by updates, please provide a benchmark of the standards and methods against best practice and modern standards. In addition please provide a justification of why the use of proprietary or older methods and standards is appropriate, or else update the relevant HF analyses. Please note that this is important from an ALARP perspective in the UK."*. This TQ was issued towards the end of GDA Step 3, and as a result I have not yet received a response.

49 For Level 1 Probabilistic Safety Assessment (PSA), the HRA was based on the methodology developed in the Accident Sequence Evaluation Program (ASEP) HRA Procedure, and for the Level 2 PSA the Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) method was applied.

50 EDF and AREVA state that SPAR-H is, *"a well known and validated approach"*. Although it can be said to be fairly well known, I am not aware that it been validated, and neither has ASEP (pp. 9-5 and 9-6 and Table 9-1 in Swain, 1987 (Ref. 12)). The only assessment of SPAR-H that has been published and that I am aware of is a summarised peer review in Table I-1 to I-19 in Gertman et al (2004) (Ref. 13), which is contained within the Idaho National Laboratory report describing the method.

51 SPAR-H works in a significantly different way to ASEP. ASEP is derived from THERP (Technique for Human Error Rate Prediction), which has been 'validated' in a quantitative manner (Kirwan et al, 1997) (Ref. 14) and by effective and widespread use in civil nuclear applications over 25+ years. ASEP is designed to be much simpler to apply than THERP and it is largely conservative in principle and in application. The authors of SPAR-H state that the method evolved from the Accident Sequence Precursor (ASP) (not to be confused with ASEP) HRA methodology (Byers et al, 2000) (Ref. 15) that was developed for the U.S. Nuclear Regulatory Commission (US NRC) in 1994 by the Idaho National Engineering and Environmental Laboratory (INEEL) (Blackman and Byers, 1995) (Ref. 16). Other than to compare their overall opinions on the potential combined strengths of possible human reliability influencing factors with other pre-existing HRA methods, SPAR-H originators did not state how their multipliers were derived. However, steps have recently been taken by Idaho National Laboratory to explain the origin of these factors. These steps are described in Boring and Blackman (2007) (Ref. 17).

52 I will consider any impact of use of the HRA methods together with our PSA assessor during GDA Step 4, and particularly the use of different HRA methods for the Level 1 and Level 2 PSAs.

2.3.5 Human Factors Integration (HFI)

53 This aspect of my assessment was undertaken in accordance with the TAG on HFI, which states that:

- *"Human factors integration (HFI) is a good practice approach to the application of human factors to systems development. As a methodology it provides an organising*

framework to help ensure that all relevant HF issues are identified and addressed. In addition the HFI approach has a management strategy that aims for timely and appropriate integration of human factors activities throughout the project.

- *'Integration' means "…a combination of parts …that work well together..". Therefore HFI requires that HF is an integral part of a project, and is not carried out in isolation.*
- *The level of HF integration should be commensurate to the size of the project, and take account of the safety reliance on humans and the consequences of human error, together with the novelty and complexity of any new technology*".

54 This aspect of my assessment therefore focused on the range of activities undertaken by the EDF and AREVA HF engineering programme, with some consideration of the use of Suitably Qualified and Experienced Personnel (SQEP), where possible. This would provide me with a level of confidence that the type of analysis I would expect for a project of this size is available, and is likely to be of a suitable quality.

55 From the information provided in sub chapter 18.1 of the PCSR, it appears that there is an extensive and appropriate HFE programme in place for FA3. Should this be transferred to the UK EPR project this would provide me with a level of confidence that HF can be effectively integrated into the design. I would be particularly interested to determine whether the UK EPR HFE programme accounts sufficiently for national differences (e.g. population stereotypes, colour coding expectations) and that this be documented in a target audience description as part of the HFI plan. At the end of Step 3 there does not appear to be any UK (EPR) specific HFE programme in place, although I note the plan for the April 2010 document 'HFE process adapted to a British Context'.

56 EDF and AREVA have described a significant team of staff employed on HF work for FA3; however, there is no information suggesting that a replicated team will be available for the UK EPR project. Therefore, I am not able to comment on the sufficiency of the proposed HF team to deliver effective HFI in this Step 3 assessment. I do take confidence from the description of the role of the HF specialists and their position within the project, and I assume that as they are titled 'HF specialists' that they will have the appropriate qualification and experience in the field to deliver high quality technical HF input.

57 It appears that there is a disconnect between the HFE work (proposed for FA3) and the PSA HRA work.

2.3.6 Additional Assessment Area – Novel Technology

58 It is important to identify the application of new or novel technology that may present HF issues that have not been considered previously in the UK. Should this be the case, I may have to undertake research to determine current and best practice, to enable me to form a regulatory judgement. In addition for GDA Step 4 I would ensure that EDF and AREVA have fully analysed and understood the potential human factors and reliability issues relating to such technologies.

59 It appears that none of the proposed technology is inherently novel. There are aspects of the design where it can be considered that new technology is applied and is a significant element of the design philosophy. These are discussed briefly below:

60 A Plant Overview Panel (POP) is proposed. This is a large information display that is back projected onto one of the control room walls. The POP should be fully visible from all the normal operating positions and all the information on it should be legible from these positions. This will require assessment using British anthropometric data, and I would expect to see user trialling to provide confidence that the POP achieves its function of supporting operator situation awareness.

61 The UK EPR approach to alarm handling appears to have moved somewhat; enabling operators to interrogate set points and potential causes and consequences for example. This information will be presented on screen as an alarm sheet, which will also provide procedural guidance about the responses to be taken. The detail of the alarm philosophy and presentation will require my consideration during GDA Step 4.

62 VDU-based soft controls are intended, which permits active control of the plant via interactive graphical user interfaces. This will require explicit consideration during GDA Step 4.

63 Computerised procedures are proposed. Although there is some operating experience available and a considerable body of research available, the detail of their deployment will require assessment during GDA Step 4.

2.3.7 International Regulators' Assessments

64 The Multi-national Design Evaluation Programme (MDEP) has recently convened a grouping of experts on HF and held its inaugural meeting. I am representing the UK on this forum, which will provide an opportunity for information exchange on regulatory assessment, including that for the UK EPR design. In addition I am committed to visiting the United States Nuclear Regulatory Commission (US NRC) and Canadian Nuclear Safety Commission (CNSC) in December 2009 to exchange technical assessment information relating to the HF aspects of the UK EPR. I also plan to liaise with STUK and ASN regarding their assessments of the HF aspects of the UK EPR during GDA Step 4. This meets our desire and commitment to be cognisant of international regulators' assessments of the reactor designs seeking a generic design certificate in the UK.

2.3.8 Research Requirements

65 EDF and AREVA have indicated their intention to apply the MERMOS method for the HRA aspects of the site specific PCSR. This method has not been applied to any HRA assessment in the UK to date. Therefore, ND will require a regulatory position on the use of this method to inform NPP risk assessment in the UK. I propose to commission an independent expert review of the method to inform the regulatory decision making and judgement of ND technical assessors.

2.3.9 Plans for Step 4

66 The focus for GDA Step 4 will be on assessing the EDF and AREVA response to the Regulatory Observation.

67 However, in the interim I will begin to assess the supporting HF analyses (the arguments and evidence) for the UK EPR, and continue my assessment of the HRA.

68 I will also continue to probe the HFI process and the standards and methods applied to the design and safety analysis.

69 I will engage Technical Support Contractors to undertake independent analysis and to support my assessment.

2.3.10 Potential Exclusions

70 Currently there are no indications for potential Exclusion resulting from the HF assessment.

3 CONCLUSIONS AND RECOMMENDATIONS

71 I judge that the information presented by EDF and AREVA for the HF aspects of the UK EPR is not adequate when compared against UK safety case expectations. There is no structure that presents the safety case in terms of the claims, arguments and evidence chain of logic.

72 The material presented provides a good description of the FA3 HFE programme, and the HRA topical meeting, together with our own work on the PSA and HRA, provided clarity on the human based safety claims for the UK EPR. However, there is no link between the HRA and HFE work, and indeed currently there is no UK specific HFE programme in place.

73 At the end of Step 3 I am unclear on what HF analyses are available for assessment in Step 4, and I await a response to TQ-EPR-512 (Ref. 18).

74 I am also unable to comment on the suitability of the standards base for the UK EPR HF work at the end of Step 3, and I await a response to TQ-EPR-502 (Ref. 18).

75 However at the end of Step 3 I am positively engaged with EDF and AREVA on their intentions for the resolution of RO-UKEPR-038 early on in GDA Step 4. It is on this basis that from the perspective of Human Factors, I recommend that the EDF and AREVA UK EPR proceeds to Step 4 of the GDA process.

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Annex 1 – Human Factors – Status of Regulatory Issues and Observations

RI / RO Identifier	Date Raised	Title	Status	Required timescale (GDA Step 4 / Phase 2)
Regulatory Issues				
None.				
Regulatory Observations				
RO-UKEPR-038	28/10/09	EDF and AREVA is required to submit documentation that clearly defines the role of human actions on the UK EPR (i.e. the safety 'claims') and justifies those actions via human factors analysis (i.e. the 'arguments and 'evidence').	On going	GDA Step 3 – by March 2010