FORM-14159 R000*

Periodic Safety Review - Final Document Review Traveler

Bruce Power™

Bruce Power Document #:	Revision:	Information Classification	Usage Classification
NK29-SFR-09701-00012	R000	Internal Use Only	Information
Bruce Power Document Title: Safety Factor 12 - The Human Factor			
Bruce Power Contract/Purchase Order: 00193829	Bruce Power Project #: 39075		
Supplier's Name: CANDESCO	Supplier Document #: K-421231-00212	Revision: R00	
Supplier Document Title: Safety Factor 12 - The Human Factor			

Accepted for use at Bruce Power by:	**Signature:**	**Date**
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*Associated with BP-PROC-01024, Periodic Safety Reviews

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Bruce Power Document Title:	Safety Factor 12 - The Human Factor	Suppliers Name:	CANDESCO		
Bruce Power Contract/ Purchase Order:	00193829	Supplier Document Title:	Safety Factor 12 - The Human Factor		
Bruce Power Project #:	39075	Supplier Document:	K-421231-00212	Rev #: R00	

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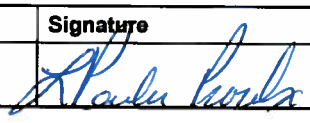
Chip Horton (RegC AR 28563021.02)	VP, Nuclear Operations	Training		23SEP2016

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NK29-SFR-09701-00012

Title: Safety Factor 12 - The Human Factor

File: K-421231-00212-R00

A Report Submitted to Bruce Power

September 20, 2016

Issue R00D0	**Reason for Issue:** For harmonization				
	Author: C. Ngo	Verifier:	Reviewer: Y. Dadashi	Approver:	Date: May 4, 2016
Issue R00D1	**Reason for Issue:** For internal review				
	Author: C. Ngo	Verifier:	Reviewer: Y. Dadashi L. Watt G. Archinoff	Approver:	Date: May 6, 2016
Issue R00D2	**Reason for Issue:** For Bruce Power review				
	Author: C. Ngo	Verifier: G. Buckley	Reviewer: Y. Dadashi L. Watt G. Archinoff	Approver:	Date: May 20, 2016
Issue R00D3	**Reason for Issue:** Addresses Bruce Power review comments and internal verification comments.				
	Author: C. Ngo	Verifier: G. Buckley	Reviewer: Y. Dadashi L. Watt G. Archinoff	Approver:	Date: August 24, 2016

Issue R00	**Reason for Issue:** For use				
	Author: C. Ngo for C. Ngo	Verifier: G. Buckley	Reviewer: Y. Dadashi; L. Watt; G. Archinoff	Approver: L. Watt	Date: Sept 20, 2016
Document Classification: Report			Security Classification: Client Proprietary		

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Acronyms and Abbreviations

ACE	Apparent Cause Evaluation
AIM	Abnormal Incident Manual
AR	Action Request
BEST	Bruce Emergency Services Team
BP	Bruce Power
CANDU	CANada Deuterium Uranium
CFAM	Corporate Functional Area Manager
CNSC	Canadian Nuclear Safety Commission
CROIT	Control Room Operator-in-Training
CRT	Cathode Ray Tube
CSA	Canadian Standards Association
DCP	Design Change Packages
EC	Engineering Change
EME	Emergency Mitigating Equipment
EFD	Event Free Day
ERO	Emergency Response Organization
ESM	Emergency Services Maintainers
EWPS	Emergency Water and Power Supply
FASA	Focus Area Self Assessments
GET	General Employee Training
HEP	Human Error Probability
HF	Human Factors
HFE	Human Factors Engineering
HFEPP	Human Factors Engineering Program Plan
HFESR	Human Factors Engineering Summary Report
HMI	Human-Machine Interface
HRA	Human Reliability Analysis
HSI	Human-System Interface
HU	Human Performance

IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operations
ISR	Integrated Safety Review
LCH	Licence Conditions Handbook
LTEP	Long Term Energy Plan
MCR	Main Control Room
NLO	Non-Licensed Operator
NPP	Nuclear Power Plant
NSCA	Nuclear Safety and Control Act
OSART	Operational Safety Review Team
PRA	Probabilistic Risk Assessment
PROL	Power Reactor Operating Licence
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PSC	Plant Status Control
QA	Quality Assurance
SBR	Safety Basis Report
SCA	Secondary Control Area
SCR	Station Condition Record
SFR	Safety Factor Report
SME	Subject Matter Expert
THERP	Technique for Human Error Rate Prediction
TIMS	Training Information Management System
TPO & C	Training Performance Objectives and Criteria
TQD	Training Qualification Documents

1. Objective and Description

Bruce Power (BP), as an essential part of its operating strategy, is planning to continue operation of Bruce B as part of its contribution to the Long Term Energy Plan (LTEP) (http://www.energy.gov.on.ca/en/ltep/). Bruce Power has developed integrated plant life management plans in support of operation to 247,000 Equivalent Full Power Hours in accordance with the Bruce Power Reactor Operating Licence (PROL) [1] and Licence Conditions Handbook (LCH) [2]. A more intensive Asset Management program is under development, which includes a Major Component Replacement (MCR) approach to replacing pressure tubes, feeders and steam generators, so that the units are maintained in a fit for service state over their lifetime. However, due to the unusually long outage and de-fuelled state during pressure tube replacement, there is an opportunity to conduct other work, and some component replacements that could not be done reasonably in a regular maintenance outage will be scheduled concurrently with MCR. In accordance with Licence Condition 15.2 of the PROL [1], Bruce Power is required to inform the Canadian Nuclear Safety Commission (CNSC) of any plan to refurbish a reactor or replace a major component at the nuclear facilities, and Bruce Power shall:

(i) Prepare and conduct a periodic safety review;

(ii) Implement and maintain a return-to-service plan; and

(iii) Provide periodic updates on progress and proposed changes.

The fifteen reports prepared as part of the Periodic Safety Review (PSR), including this Safety Factor Report (SFR), are intended to satisfy Licence Condition 15.2 (i) as a comprehensive evaluation of the design, condition and operation of the nuclear power plant (NPP). In accordance with Regulatory Document REGDOC-2.3.3 [3], a PSR is an effective way to obtain an overall view of actual plant safety and the quality of safety documentation and determine reasonable and practicable improvements to ensure safety until the next PSR.

Bruce Power has well-established PSR requirements and processes for the conduct of a PSR for the purpose of life-cycle management, which are documented in the procedure Periodic Safety Reviews [4]. This procedure, in combination with the Bruce B Periodic Safety Review Basis Document [5], governs the conduct of the PSR and facilitates its regulatory review to ensure that Bruce Power and the CNSC have the same expectations for scope, methodology and outcome of the PSR.

This PSR supersedes the Bruce B portion of the interim PSR that was conducted in support of the ongoing operation of the Bruce A and Bruce B units until 2019 [6]. Per REGDOC-2.3.3 [3], subsequent PSRs will focus on changes in requirements, facility conditions, operating experience and new information rather than repeating activities of previous reviews.

1.1. Objective

The overall objectives of the Bruce B PSR are to conduct a review of Bruce B against modern codes and standards and international safety expectations, and to provide input to a practicable

set of improvements to be conducted during the MCR in Units 5 to 8, and during asset management activities to support ongoing operation of all four units, as well as U0B, that will enhance safety to support long term operation. It will cover a 10-year period, since there is an expectation that a PSR will be performed on approximately a 10-year cycle, given that all units are expected to be operated well into the future.

The specific objective of the review of this Safety Factor is to determine the status of the various human factors that may affect the safe operation of the nuclear power plant.

1.2. Description

The review is conducted in accordance with the Bruce B PSR Basis Document [5], which states that the review tasks are as follows:

1. The review of human factors (HF) will consider the procedures and processes in place at the nuclear power plant to ensure the following:
    a. Adequate staffing levels exist for operating the plant, with due recognition given to absences, shift working and restrictions on overtime;
    b. Qualified staff are available on duty at all times;
    c. Adequate programs are in place for initial training, refresher training and upgrading training, including the use of simulators;
    d. Operator actions needed for safe operation have been assessed to confirm that assumptions and claims made in safety analyses (for example, Probabilistic Safety Assessment (PSA), deterministic safety analysis and hazard analysis) are valid;
    e. Human factors in maintenance are assessed to promote error-free execution of work;
    f. Adequate competence requirements exist for operating, maintenance, technical and managerial staff;
    g. Staff selection methods (for example, testing for aptitudes, knowledge and skills) are systematic and validated;
    h. Appropriate fitness for duty guidelines exist relating to hours, types and patterns of work, good health and substance abuse;
    i. Policies exist for maintaining the know-how of staff and for ensuring adequate succession management in accordance with good practices; and
    j. Adequate facilities and programs are available for staff training.
2. The following aspects of the human-machine interface (HMI) will be subjected to an overall review to determine if the HMI continues to be satisfactory:
    a. Design of the control room and other workstations relevant to safety;
    b. Human information requirements and workloads; and

c. Clarity and achievability of procedures.

As required by the PSR Basis Document, preparation of this Safety Factor Report included an assessment of the review tasks to determine if modifications were appropriate. Any changes to the review tasks described in this section are documented and justified in Section 5.

2. Methodology for Review

As discussed in the Bruce B PSR Basis Document [5], the methodology for a PSR should include making use of safety reviews that have already been performed for other reasons. Accordingly, the Bruce B PSR makes use of previous reviews that were conducted for the following purposes:

- Return to service of Bruce Units 3 and 4 (circa 2001) [7];
- Life extension of Bruce Units 1 and 2 (circa 2006) [8] [9] [10];
- Proposed refurbishments of Bruce Units 3 and 4 (circa 2008) [11] [12] [13] [14] [15];
- Safety Basis Report (SBR) and PSR for Bruce Units 1 to 8 (2013) [6]; and
- Bruce A Integrated Safety Review (ISR) to enhance safety and support long term operation (2015) [16] [17].

These reviews covered many, if not all, of the same Safety Factors that are reviewed in the current PSR. A full chronology of Bruce Power safety reviews up to 2013 is provided in Appendix F of [18].

The Bruce B PSR Safety Factor review process comprises the following steps:

1. **Interpret and confirm review tasks:** As a first step in the Safety Factor review, the Safety Factor Report author(s) confirm the review tasks identified in the PSR Basis Document [5] and repeated in Section 1.2 to ensure a common understanding of the intent and scope of each task. In some cases, this may lead to elaboration of the review tasks to ensure that the focus is precise and specific. Any changes to the review tasks are identified in Section 5 of the Safety Factor Report (SFR) and a rationale provided.
2. **Confirm the codes and standards to be considered for assessment:** The Safety Factor Report author(s) validates the list of codes and standards presented in the PSR Basis Document against the defined review tasks to ensure that the assessment of each standard will yield sufficient information to complete the review tasks. Additional codes and standards are added if deemed necessary. If no standard can be found that covers the review task, the assessor may have to identify criteria on which the assessment of the review task will be based. The final list of codes and standards considered for this Safety Factor is provided in Section 3.
3. **Determine the type and scope of assessment to be performed:** This step involves the assessor confirming that the assessment type identified in Appendix C of the Bruce B PSR Basis Document [5] for each of the codes, standards and guidance documents selected for this factor is appropriate based on the guidance provided. The PSR Basis Document

provides an initial assignment for the assessment type, selecting one of the following review types:

- Programmatic Clause-by-Clause Assessments;
- Plant Clause-by-Clause Assessments;
- High-Level Programmatic Assessments;
- High-Level Plant Assessments;
- Code-to-Code Assessments; or
- Confirm Validity of Previous Assessment.

The final assessment types are identified in Section 3, along with the rationale for any changes relative to the assignment types listed in the PSR Basis Document.

4. **Perform gap assessment against codes and standards:** This step comprises the actual assessment of the Bruce Power programs and the Bruce B plant against the identified codes and standards. In general, this involves determining from available design or programmatic documentation whether the plant or program meet the provisions of the specific clause of the standard or of some other criterion, such as a summary of related clauses. Each individual deviation from the provisions of codes and standards is referred to as a Safety Factor "micro-gap". The assessments, performed in Appendix A and Appendix B, include the assessor's arguments conveying reasons why the clause is considered to be met or not met, while citing appropriate references that support this contention.
5. **Assess alignment with the provisions of the review tasks:** The results of the assessment against codes and standards are interpreted in the context of the review tasks of the Safety Factor. To this end, each assessment, whether clause-by-clause, high-level or code-to-code, is assigned to one or more of the review tasks (Section 5). Assessment against the provision of the review task involves formulating a summary assessment of the degree to which the plant or program meets the objective and provisions of the particular review task. This assessment may involve consolidation and interpretation of the various compliance assessments to arrive at a single compliance indicator for the objective of the review task as a whole. The results of this step are documented in Section 5 of each SFR.
6. **Perform program assessments:** The most pertinent self-assessments, audits and regulatory evaluations are assessed, and performance indicators relevant to the Safety Factor identified. The former illustrates that Bruce Power has a comprehensive process of reviewing compliance with Bruce Power processes, identifying gaps, committing to corrective actions, and following up to confirm completion and effectiveness of these actions. The latter demonstrates that there is a metric by which Bruce Power assesses the effectiveness of the programs relevant to the Safety Factor in Section 7. Taken as a whole, these demonstrate that the processes associated with this Safety Factor are implemented effectively (individual findings notwithstanding). Thus, program effectiveness, if not demonstrated explicitly in the review task assessments in Step 5, can be inferred if Step 5 shows that Bruce Power processes meet the Safety Factor requirements and if this step shows there are ongoing processes to ensure compliance with Bruce Power processes.

7. **Identification of findings:** This step involves the consolidation of the findings of the assessment against codes and standards and the results of executing the review tasks into a number of definitive statements regarding positive and negative findings of the assessment of the Safety Factor. Positive findings or strengths are only identified if there is clear evidence that the Bruce B plant or programs exceed compliance with the provision of codes and standards or review task objectives. Each individual negative finding or deviation is designated as a Safety Factor micro-gap for tracking purposes. Identical or similar micro-gaps are consolidated into comprehensive statements that describe the deviation known as Safety Factor macro-gaps, which are listed in Section 8 of the Safety Factor Reports, as applicable.

3. Applicable Codes and Standards

This section lists the applicable regulatory requirements, codes and standards considered in the review of this Safety Factor. Table C-1 of the Bruce B PSR Basis Document [5] identifies the codes, standards and guides that are relevant to this PSR. Modern revisions of some codes and standards listed in Table C-1 of the PSR Basis Document [5] have been identified in the licence renewal application and supplementary submissions for the current PROL [19] [20] [21]. Codes, standards and guides issued after the freeze date of December 31, 2015 were not considered in the review [5].

3.1. Acts and Regulations

The *Nuclear Safety and Control Act* (NSCA) [22] establishes the Canadian Nuclear Safety Commission and its authority to regulate nuclear activities in Canada. Bruce Power has a process to ensure compliance with the NSCA [22] and its Regulations. Therefore, the NSCA and Regulations were not considered further in this review.

3.2. Power Reactor Operating Licence

The list of codes and standards related to human factors that are referenced in the PROL [1] and LCH [2], and noted in Table C-1 of the Bruce B PSR Basis Document [5], are identified in Table 1. The edition dates referenced in the third column of the table are the modern versions used for comparison.

Table 1: Codes, Standards, and Regulatory Documents Referenced in Bruce A and B PROL and LCH

Document Number	Document Title	Modern Version Used for PSR Comparison	Type of Review
CNSC REGDOC-2.3.3	Periodic Safety Reviews	[3]	NA
CNSC G-323 (2007)	Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement	[23]	NA
CNSC G-278 (2003)	Human Factors Verification and Validation Plans	[24]	NA
CNSC RD/GD-210 (2012)	Maintenance Programs for Nuclear Power Plants	[25]	NA
CNSC RD-204 (2008)	Certification of Persons Working at Nuclear Power Plants	[26]	NA
CNSC Internal Guide, 2010/08	CNSC Expectations for Licensee Hours of Work Limits - Objectives and Criteria	[27]	NA
CNSC Internal Guide, 2009/05	Requirements for the Requalification Testing of Certified Shift Personnel at Nuclear Power Plants	[28]	NA
Examination Guide EG-1	Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants	[29]	NA
Examination Guide EG-2	Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants	[30]	NA
CSA-N286-05 [31]	Management System Requirements for Nuclear Facilities	CSA-N286-12 [32]	NA

Document Number	Document Title	Modern Version Used for PSR Comparison	Type of Review
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

CNSC REGDOC-2.3.3: This PSR is being conducted in accordance with CNSC REGDOC-2.3.3 per Licence Condition 15.2 (i) [1], and associated compliance verification criteria [2]. Therefore, REGDOC-2.3.3 is not reviewed further in this document.

CNSC G-323: Table C-1 of the PSR Basis Document [5] calls for a high level assessment of the CNSC guidance document G-323. CNSC G-323 ensures the presence of sufficient qualified staff at Class I Nuclear Facilities – minimum staff complement has not been updated since 2008 and has been assessed in the Bruce A Integrated Safety Review [17]. The programs identified in support of G-323 apply also to Bruce B. While CNSC-323 is not assessed per se, the Station Shift Complement – Bruce B [33] is discussed in Section 5.2, Availability of Qualified Staff.

CNSC G-278: Table C-1 of the PSR Basis Document [5] does not require an assessment of CNSC G-278. G-278 was assessed in the Bruce A Integrated Safety Review [17] and has not been revised since that assessment. The programs identified in support of meeting the intent of G-278 also apply to Bruce B. Moreover, this regulatory guide is included in the current licence and accordingly no further assessment of G-278 is performed for this PSR.

CNSC RD/GD-210: Regulatory document RD/GD-210 [25], Maintenance Programs for Nuclear Power Plants, sets out the requirements of the CNSC with regard to maintenance programs for nuclear power plants. It specifies that a maintenance program consists of policies, processes and procedures that provide direction for maintaining SSCs of the plant. RD/GD-210 is in the PROL and accordingly no further assessment of RD/GD-210 requirements is performed for this PSR.

CNSC RD-204: CNSC RD-204 [26] defines requirements regarding certification of persons who work at Canadian Nuclear Power Plants (NPPs) in positions that have a direct impact on nuclear safety. The document specifies the requirements to be met by persons working, or seeking to work, in positions where certification by the CNSC is required. It specifies the requirements regarding the programs and processes supporting certification of the workers that NPP licensees must implement to train and examine persons seeking or holding a certification delivered by the CNSC. CNSC RD-204 remains part of the licence and has not been revised, and therefore has not been assessed as a part of this PSR.

CNSC Internal Guidance: Table C-1 of the PSR Basis Document [5] identifies CNSC internal Guidance regarding the CNSC Expectation for Licensee Hours of Work Limits – Objectives and Criteria and Requirements for the Requalification Testing of Certified Shift Personnel at Nuclear Power Plants. The PSR Basis Document states that these internal guidance documents will not be assessed as a part of this PSR.

CNSC Examination Guide EG-1: Table C-1 of the PSR Basis Document [5] identifies Examination Guide EG-1, Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants [29]. The PSR Basis Document states that EG-1 will not be assessed as a part of this PSR.

CNSC Examination Guide EG-2: Table C-1 of the PSR Basis Document [5] identifies Examination Guide EG-2, Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants [30]. The PSR Basis Document states that EG-2 will not be assessed as a part of this PSR.

CSA N286-12: CSA N286-05 is noted in the PROL (Licence Condition 1.1 [1]). Per the LCH [2], an implementation strategy for the 2012 version is in progress to be submitted to the CNSC by the end of January 2016. CNSC staff have stated that in their view the CSA N286-12 version of CSA N286 "does not represent a fundamental change to the current Bruce Power Management System" and have acknowledged that "the new requirements in CSA N286-12 are already addressed in Bruce Power's program and procedure documentation" [34].

Bruce Power had agreed to perform a gap analysis and to prepare a detailed transition plan, and to subsequently implement the necessary changes in moving from the CSA N286-05 version of the code to the CSA N286-12 version, during the current licensing period [35]. This timeframe will facilitate the implementation of N286 changes to the management system, and enable the gap analysis results from the large number of new or revised Regulatory Documents or Standards committed in the 2015 operating licence renewal. Bruce Power has also proposed that in the interim, CSA N286-05 be retained in the PROL to enable it to plan the transition to CSA N286-12, and committed to develop the transition plan and communicate the plan to the CNSC by January 30, 2016 [36]. Bruce Power further stated CSA N286-12 does not establish any significant or immediate new safety requirements that would merit a more accelerated implementation. The gap analysis and the resulting transition plan were submitted to the CNSC [37]. Per [37], the major milestones of the transition plan to N286-12 are as follows:

- 22 January 2016: Discuss all the regulatory actions and the transition plan at the (Corporate Functional Area Manager) CFAM meeting
- 31 December 2016: Revision of CFAM Program Document(s) [with LCH notification requirements to the CNSC] to comply with CSA N286-12 requirements completed.
- 31 March 2017: Revision of CFAM Program Document(s) [that do not have LCH notification requirements to the CNSC] to comply with CSA N286-12 requirements completed
- 31 December 2017: Confirmation that that all impacted documents in the program suite comply with the requirements of CSA N286-12
- 15 September 2018: Verification via a FASA that previously identified transition Gaps to meeting the requirements of CSA N286-12 have been addressed and effectively implemented
- 14 December 2018: issue notification to the CNSC regarding state of CSA N286-12 readiness, and, implementation date

This Safety Factor therefore has not performed a code-to-code assessment between CSA N286-05 and CSA N286-12 and will not be performing a clause-by-clause assessment of CSA N286-05, since it is in the current licence and there is a transition plan in effect.

3.3. Regulatory Documents

There were additional Regulatory Documents identified in Table C-1 of the PSR Basis Document [5] considered for application to the review tasks of this Safety Factor beyond those identified in the Bruce Power PROL [1] and the LCH [2].

Table 2: Regulatory Documents

Document Number	Document Title	Reference	Type of Review
CNSC G-276 (2003)	Human Factors Engineering Program Plan	[38]	HL
CNSC REGDOC-2.2.2 (2014)	Personnel Training	[39]	CBC
CNSC REGDOC-2.5.2	Design of Reactor Facilities: Nuclear Power Plants	[40]	2SF
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

CNSC G-276: CNSC G-276 Human Factors Engineering Program Plan (HFEPP) provides guidance to assist licensees in developing human factors engineering program planning documentation that demonstrates how human factors considerations are incorporated into activities licensed by the CNSC. Since G-276 was previously considered in the Bruce A Units 1 and 2 Return to Service – Systematic Review of Safety [10], a high level programmatic assessment has been performed as documented in Appendix A.

CNSC REGDOC-2.2.2: CNSC REGDOC-2.2.2 Human Performance Management – Personnel Training was issued in August 2014. Bruce Power has performed a Gap Analysis against CNSC REGDOC-2.2.2 in 2015 which is documented in SA-TRGD-2015-19 [41]. The assessment did not identified any Adverse Conditions, but raised one Opportunity for Improvement (SCR 28501710) to require minor changes to BP-PROG-02.02, Worker Learning and Qualification [42]. The current LCH [2] recommends that Bruce Power refers to CNSC REGDOC-2.2.2 for guidance and prepare an implementation plan in order to meet the requirements of the document. Therefore, Table C-1 of the Bruce B PSR Basis Document [5] required a CBC assessment of this regulatory document to be performed.

A programmatic clause-by-clause assessment has been performed since an assessment against this document has not been performed in the past. REGDOC-2.2.2 [39] sets out requirements and guidance for the analysis, design, development, implementation, evaluation, documentation and management of training at nuclear facilities within Canada, including the essential principles and elements of an effective training system. A clause-by-clause assessment against REGDOC-2.2.2 has been performed and is documented in Appendix B (B.1).

CNSC REGDOC-2.5.2: Table C-1 of the PSR Basis Document [5] identifies CNSC REGDOC-2.5.2 as relevant to Safety Factor 12 but the review is provided in another Safety Factor (i.e. Safety Factor 1). Section 7.21 of REGDOC-2.5.2 [40] is directly applicable to Human Factors. A clause-by-clause assessment of REGDOC-2.5.2, including Section 7.21, has been performed as part of Safety Factor 1, and is not repeated in Safety Factor 12. That assessment shows that Bruce Power is in compliance with Clause 7.21.

3.4. CSA Standards

The Canadian Standards Association (CSA) has issued standards that form the basis of the Quality Assurance (QA) programs for all Canadian nuclear facilities. These high-level documents are used primarily as a foundation or basis on which nuclear utility operators have developed specific, internal policies, programs, and procedures. Specific to this safety factor, a new CSA standard issued in December 2014 has been included and is provided in Table 3: CSA Standards.

Table 3: CSA Standards

Document Number	Document Title	Reference	Type of Review
CSA N290.12	Human Factors in Design for Nuclear Power Plants.	[43]	CBC
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

CSA N290.12: CSA N290.12 covers human factors in design activities related to construction, commissioning, operation, maintenance, inspection, testing, and decommissioning. A clause-by-clause assessment of CSA N290.12 has been performed and is documented in Appendix B (B.2).

3.5. International Standards

The international standards listed in Table 4 are relevant to this Safety Factor and were considered for this review.

Table 4: International Standards

Document Number	Document Title	Reference	Type of Review
IAEA SSG-25	Periodic Safety Review For Nuclear Power Plants	[44]	NA
NUREG-0700	Human System Review Guidelines[1]	[45]	HL
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

IAEA SSG-25: IAEA SSG-25 [41] addresses the periodic safety review of nuclear power plants. Per the PSR Basis Document [5] this PSR is being conducted in accordance with REGDOC-2.3.3. As stated in REGDOC-2.3.3 [3], this regulatory document is consistent with IAEA SSG-25. The combination of IAEA SSG-25 and REGDOC-2.3.3, define the review tasks that should be considered for the Safety Factor Reports. However, no assessment is performed specifically on IAEA SSG-25.

NUREG-0700: NUREG-0700, Human System Review Guidelines, is used by the U.S. Nuclear Regulatory Commission as guidance for the evaluation of interfaces between plant personnel and plant's systems and components. A high level assessment has been performed of this guidance document and is documented in Appendix A (Section A.2).

3.6. Other Applicable Codes and Standards

The codes and standards discussed in the previous sub-sections have been determined to be sufficient for the completion of the review tasks of this Safety Factor. Accordingly, additional codes and standards are not considered in this Safety Factor Report.

4. Overview of Applicable Bruce B Station Programs and Processes

Section provides an overview of Bruce Power programs and processes related to this Safety Factor.

[1] Note: NUREG-0700 is considered a guideline and not a standard. However, the section and table title were retained to maintain consistency with the format of other Safety Factors Reports.

4.1. Key Implementing Documents

The key Bruce Power documents related to implementation of the elements related to human factors, human performance, and ergonomics are indicated in Table 5.[2]

Table 5: Key Implementing Documents

Level 0	Level 1	Level 2	Level 3
BP-MSM-1: Management System Manual [46]	BP-PROG-00.06: Health and Safety Management [47]	BP-PROC-00389: Conventional Safety Programs [48]	BP-SM-00037: Industrial Ergonomics [49]
			BP-SM-00015: Office Ergonomics [50]
			BP-SM-00043: Working in Hot Environments [51]
			BP-SM-00033: Personal Protective Equipment [52]
	BP-PROG-00.07: Human Performance Program [53]	BP-PROC-00617: Human Performance Tools for Workers [54]	
		BP-PROC-00795, Human Performance Tools for Knowledge Workers [55]	
		BP-PROC-00794, Monitoring Human Performance [56]	

[2] Table 5 lists the key governance documents used to support the assessments of the review tasks for this Safety Factor Report. A full set of current sub-tier documents is provided within each current PROG document. In the list of references, the revision number for the governance documents is the key, unambiguous identifier; the date shown is an indicator of when the document was last updated, and is taken either from PassPort, the header field, or the “Master Created” date in the footer.

Level 0	Level 1	Level 2	Level 3
	BP-PROG-01.02: Bruce Power Management System (BPMS) Management [57]	BP-PROC-00166: General Procedure and Process Requirements [58]	
	BP-PROG-01.04: Leadership Talent Management [59]	BP-PROC-00221: Succession Management [60]	
	BP-PROG-02.01: Worker Staffing [61]		
	BP-PROG-02.02: Worker Learning and Qualification [42]		
	BP-PROG-02.04: Worker Development and Performance Management [62]		
	BP-PROG-02.06: Worker/Labour Relations [63]	BP-PROC-00276: Code of Conduct [64]	
	BP-PROG-02.08: Total Rewards [65]	BP-PROC-00005: Limits to Hours of Work [66]	
		BP-PROC-00024: Base Work Week for Management and Professional Staff [67]	
	BP-PROG-08.01: Emergency Measures Program [68]	BP-PLAN-00001: Bruce Power Nuclear Emergency Response Plan [69]	
	BP-PROG-10.01: Plant Design Basis Management [70]	BP-PROC-00335: Design Management [71]	DPT-PDE-00001: Human Factors Minor Change [72]

Level 0	Level 1	Level 2	Level 3
			DPT-PDE-00013: Human Factors Engineering Program Plan [73]
	BP-PROG-10.02: Engineering Change Control [74]	BP-PROC-00539: Design Change Package [75]	
	BP-PROG-11.04: Plant Maintenance [76]	BP-PROC-00699: Maintenance Work [77]	BP-PROC-00694: Maintenance Procedure Development and Revision [78]
	BP-PROG-12.01: Conduct of Plant Operations [79]	DIV-OPB-00001: Station Shift Complement – Bruce B [33]	
		GRP-OPS-00050: Requirements for Station Operating Procedure Development and Revision [80]	
		BP-PROC-00250: Writer's Guide for Station System Procedures [81]	

The Human Performance Program [47] describes Bruce Power's systematic approach to improving human performance through the use of event-free tools, managing defences, and other elements that enhance human performance. Bruce Power's Human Performance Program uses a strategic approach to managing Human Performance by reducing errors and managing defences.

Human Factors deals with understanding the needs and requirements of human-system design such that end users may safely and efficiently interface with given systems. In this regard, Human Factors principles are translated into design, training, policies, principles, and procedures which are all aimed at helping humans perform better with reduced likelihood of human error. The primary focus of Human Factors design activities at Bruce Power is to ensure

design changes support safe, error free and efficient Human Performance. DPT-PDE-00013, Human Factors Engineering Program Plan [73] governs this activity under BP-PROG-10.01, Design Basis Management [70].

Bruce Power's Human Factors Engineering Program, outlined in DPT-PDE-00013 [73], focuses on ensuring that Human Factors is considered in design and provides an input to the development of engineered controls through design as a line of defence. Considering this objective, the implementation of the program resides within Plant Design Engineering and is integrated into Bruce Power's Design Change Package process described in BP-PROC-00539 [75] and is invoked by BP-PROG-10.02, Engineering Change Control [74]. Because Human Factors is integrated into the engineering change control process, Human Factors activities align with the process map identified in Appendix A of BP-PROC-00539 [75]. Human Factors activities depend on the scope of work, and are invoked early in the process of a design change through the identification of stakeholder involvement (HF being a required stakeholder). DPT-PDE-00013 [73] is based upon NUREG-0711 [82], Human Factors Engineering Program Review Model, and conforms with CNSC documents G-276, Regulatory Guide for Human Factors Engineering Program Plans and G-278, Regulatory Guide for Verification and Validation Plans. The NUREG-0711 model is recognized internationally as a well developed, comprehensive model for the review of HF. Inherently, the model proves very useful for design as well. The technical elements listed below and the applications of the elements are described in Appendix B of DPT-PDE-00013:

- HF Program Management (planning);
- Operating Experience Review;
- Functional Analysis and Function Allocation;
- Task Analysis;
- Staffing and Qualification;
- Treatment of Important Human Actions;
- Human System Interface Design;
- Procedure and Training Program Development;
- Design Verification;
- Design Validation;
- Design Implementation; and
- Human Performance Monitoring.

In addition to using engineering to manage defences, the Human Performance Program [53] outlines in Section 4.7 other ways to manage defences including emphasizing tools (with supporting procedures) for:

- Human Performance Tools for Workers, BP-PROC-00617 [54]
- Human Performance Tools for Knowledge Workers, BP-PROC-00795 [55]

- Work Planning, Control, Verification and Validation
- Procedure Alterations, BP-PROC-00811 [83]
- Training and Qualification
- Human Performance Oversight

Safety in the plant is also supported by Bruce Power's Conventional Safety Programs outlined in BP-PROC-00389 [48]. The Conventional Safety Programs provide a framework for identifying, measuring, evaluating and controlling chemical, biological, physical, and ergonomic hazards. The program encompasses over 30 safety manuals, including key ergonomic documents such as BP-SM-00037, Industrial Ergonomics [49]; BP-SM-00015, Office Ergonomics [50], BP-SM-00043, Working in Hot Environments [51]; and BP-SM-00033, Personal Protective Equipment [52].

5. Results of the Review Tasks

The results of the review of this Safety Factor are documented below under headings that correspond to the review tasks listed in Section 1.2 of this document. The review tasks assessed in this section have not changed from those listed in Section 1.2.

5.1. Adequacy of Staffing Levels for Operating Plant

This review task includes review of the programs for adequate staffing levels for operation of the plant, with due recognition given to absences, shift work and restrictions on overtime.

Activities associated with workforce planning are governed by Bruce Power's Worker Staffing program, BP-PROG-02.01 [61]. The objective of the Worker Staffing Program is to recruit, orient, and deploy staff that possess the competencies required for maintaining staffing levels consistent with the requisite organization structure, and includes the subsequent release of staff BP-PROG-02.01 (Section 1.0) [61]. All staffing activities and procedures must fulfill the requirements of all applicable employment legislation including safety, employment equity and diversity, privacy, and human rights (BP-PROG-02.01, Section 4.1) [61]. The same applies to all Collective Agreement obligations. The key elements of the program are as follows:

- fulfillment of all legislative and contractual agreements;
- approval of the organization to hire staff;
- development of approved competencies and selection criteria;
- detailed process for recruitment searches;
- identification of employment conditions; and
- process for hiring, orientation and departure of employees.

In recognition of Bruce Power's value of "Safety First" and the potential impact shift work may have on safety, Bruce Power has implemented a process for monitoring and controlling the

hours of work for all employees. This process is described in BP-PROG-02.06, Worker and Labour Relations [63]. A framework has been put in place to facilitate compliance with the regulatory expectations of the CNSC, as well as any applicable legislative requirements such as those set out in the Employment Standards Act, regarding hours of work and any agreements with applicable unions. Details on the Bruce Power procedure on the limits to hours of work are found in BP-PROC-00005, Limits to Hours of Work [66]. Internal assessments on compliance with the Limits to Work summarized in Section 7.1.1, identified actual violations of authorized staff due to meeting minimum complement and non-authorized staff due to supporting outages. There appears to be variability in violations from quarter to quarter in 2014 and 2015. Bruce Power is maintaining staffing levels but not without violations that do not seem to be decreasing overall, which suggests that the programs need to be more effective in addressing staffing levels particularly around planned outages.

It is concluded that Bruce Power programs do not fully meet the requirements of this review task. Gap SF12-1 has been raised in Table 6 regarding the possibility that adequate staffing levels cannot be maintained without violations that do not appear to be progressively decreasing year over year.

5.2. Availability of Qualified Staff

This review task includes review of the shift complement programs to ensure qualified staff is available on duty at all times.

Bruce Power's Conduct of Plant Operations, BP-PROG-12.01 (Section 4.2.1) [79], states that the normal scheduled, and minimum shift complements for each station operation and for site shall be specified and met to ensure safe operation and compliance with the PROL. Staff must be qualified and fit for duty to be credited as complement [76]. DIV-OPB-00001, Station Shift Complement - Bruce B [33], defines the normal, minimum scheduled and minimum shift complements for operation of Bruce B, in order to ensure safe operation of the nuclear units, both during normal conditions and in the event of a transient that could affect reactor safety. Complements are given for four units operating. This document implements the requirements of BP-OPP-00001, Operating Policies and Principles - Bruce B, 01.5 Station Staffing [84] as well as the staffing requirements of the PROL [1]. As cited in DIV-OPB-00001 [33], the basis for the minimum shift complement is given by B-REP-03600-00001 [85], Analysis of Resource Requirements to Respond to Abnormal Incidents at Bruce B (Section 6.0 of [85], Conclusions). At the start of each shift, each accounting Manager confirms there is at least a minimum complement present in the assigned locations (DIV-OPB-00001, Section 4.1) [33]. There are two situations when complement could go below minimum. The first case is when there is insufficient qualified staff on the incoming shift to relieve the current shift. In this case, violations of minimum shift complement can be avoided by holding staff over until replacement qualified staff can be obtained DIV-OPB-00001 (Section 4.6) [33]. The hold-over of any staff for minimum shift complement should follow the guidelines outlined in GRP-OPS-00055, Fitness for Duty Considerations for Shift Complement Staff Held Over for More Than 13 Hours [86], to mitigate the impact of fatigue and ensure safe and efficient operation of the station. The second situation when a minimum complement violation could occur is during the shift. Due to unforeseen circumstance, for example a minimum complement person becomes ill or injured, or

due to emergency response, the station could find itself below minimum complement. DIV-OPB-00001, Section 4.6 outlines the compensatory measures to minimize the impact of this situation [33].

Persons filling minimum complement positions must have the associated qualification for the role they are performing. Each Bruce B station complement role has an associated set of qualification requirements in TIMS (Training Information Management System). Line Management ensures that crew numbers, experience and skills, including Special Safety System qualifications, are balanced across the five shift crews. Attrition and the integration of junior staff (newly hired and newly certified staff) is managed so as to maximize the opportunity for effective mentoring, as well as the transfer of operating experience and skills (DIV-OPB-00001, Section 4.1) [33]. In addition, the Bruce Power Nuclear Emergency Response Plan, BP-PLAN-00001, [69] identifies support staff levels required in case of an emergency (see Section 7.2.1, Shift and Site Capability, of BP-PLAN-00001). Review and references to emergency staffing is provided in Safety Factor 13.

While Bruce Power's program documentation meets the requirements of this review task, the effectiveness of the program in ensuring the availability of qualified staff is an issue that Bruce Power continues to work on (see Section 5.1, Adequate Staffing Levels).

5.3. Adequacy of Programs for Training

This review task is to confirm that adequate programs are in place for initial training, refresher training and upgrading training, and that this training includes the use of simulators.

The Worker Learning and Qualification program, BP-PROG-02.02 [42], satisfies the worker qualification and worker training requirements of applicable Bruce Power Licences and governing acts, codes and standards as referenced in BP-MSM-1 Sheet 0003, MSM - List of Applicable Governing Acts, Codes & Standards - Sheet 0003, commensurate with Bruce Power's business needs, including commitments made in the PROL application. The Worker Learning and Qualification program ensures conformance with clause 5.3 of N286-05, Management System Requirements for Nuclear Power Plants [31], which states that personnel must be competent at the work that they do. The Worker Learning and Qualification program [42] sets the standard for the entire company on how to ensure that personnel are competent at the work that they do.

The Bruce Power training processes follow a Systematic Approach to Training based on the performance objectives defined in the Institute of Nuclear Power Operations (INPO) document, ACAD 02-001, The Objectives and Criteria for Accreditation of Training in the Nuclear Power Industry [87]. Worker learning and qualification is a continuous endeavor and is in alignment with the following aspects of Bruce Power's Training Performance Objectives and Criteria identified in Section 3.0 of the handbook [88]:

- Training is used as a strategic tool to provide highly skilled and knowledgeable personnel for safe, reliable operations and to support performance improvement.
- Resources and an infrastructure of training processes are applied consistent with the needs to support training program sustainability.

- The initial training program uses a Systematic Approach to Training to provide personnel with the necessary knowledge and skills to perform their job assignments independently.
- Continuing training uses a systematic approach to training to refresh and improve the application of knowledge and job related skills and to meet management expectations for personnel and plant performance. The continuing training program meets the intent of the upgrading training suggested by IAEA SSG-25 [44].

As per BP-PROG-02.01 Section 4.4 [61], Worker Staffing, all new staff must receive a comprehensive two-phase orientation. Phase 1, intended for new employees, is a general orientation activity that must be delivered on the first day of employment. This is followed by two days of General Employee Training (GET) and, when required and the need identified, Orange Badge training, which provides entry level radiation protection training for workers, will be rostered. Phase 2 is a department specific orientation activity that is completed when the employee arrives in the new job/department. The department specific orientation is for new and transferring employees [61].

To support learning and qualification, Bruce Power has a variety of training facilities (see further details in Section 5.10). The training facilities are designed to encourage dynamic learning and as a result incorporate numerous simulators and mock-ups, which include full scope simulators (two for Bruce A and one for Bruce B), Fuel Handling simulator shared by both stations, crane simulator, classroom simulators, live fire mock-ups, rescue training mock-ups, and maintenance shops for electrical, instrumentation and control, electronics, and maintenance training [89].

The full scope main control room (MCR) simulators are used for initial certification training of Bruce Power station staff, examination of staff, and continuing training of certified staff.

Bruce Power's Simulator Validation document, SEC-SIMM-00001, establishes the validation procedure for the full scope Canada Deuterium Uranium (CANDU) control room simulator [90]. The validation procedure is used to confirm that the full scope simulators are capable of providing the correct observable simulated control room responses during the training and testing exercises. The Bruce B Simulator Reference unit is Bruce B Unit 6 (all unit processes within the scope of simulation) and Unit 0 (common and switchyard processes in the scope of simulation) [90].

The Design Change Package process, BP-PROC-00539 [75], ensures that changes to the plant are reflected in the MCR simulator. The Simulator Change Control, SEC-SIMM-00002 [91], is used for documenting changes to the simulator. These procedures provide instructions for development, review, verification, approval, installation, commissioning, and closeout of any modification to the simulator.

A clause-by-clause review of Bruce Power's training program against REGDOC-2.2.2, Personnel Training [39] has been documented in Appendix B (B.1). The results of the clause-by-clause review concluded that Bruce Power's training program, as documented, meets the intent of REGDOC-2.2.2 requirements.

Bruce Power's training program documents meet the requirements of this review task. However, Bruce Power continues to improve upon the training program documents through feedback drawn from self assessments and audits. The internal audit report, AU-2013-00013 [92], discussed in Section 7.2.1.1, identified seven adverse conditions that resulted in corrective

actions and program document revisions to address the issues identified in the adverse conditions.

5.4. Operator Actions Needed for Safe Operation

This review task includes review of the Bruce safety analysis programs to ensure that assumptions and claims made about Operator actions under accident conditions have been assessed and confirmed valid.

Credited Human Actions, which are actions most important to safety, are identified by probabilistic and deterministic analyses.

Section 1.3 and subsequently Tables 1-1 to Table 1-10 of Bruce B Safety Report- Part 3: Accident Analysis, NK29-SR-01320-00002 [93] provide a summary of the operator actions credited for the various accident categories based on deterministic safety analysis. For each accident scenario identified in the tables, the credited operation action time, the unambiguous indicators that inform the operator of the accident, and the station operating context in which the accidents occur are presented. The Bruce B Risk Assessment Report (BBRA), Appendix A6 documents the credited actions identified through PRA [94]. As part of the PRA report submitted to CNSC in 2013 [95], the original list if human interactions documented in the BBRA were reviewed again. A number of human interactions were re-quantified so that instead of suing the preliminary value, a different, usually lower, value was used to remove undue conservatism.

The Level 1 at Power Probabilistic Risk Assessment Guide (PRA) includes use of operating procedures (tests, maintenance, Abnormal Incident Manuals, and Operating Manuals) to identify operator actions and estimate the time available to detect and/or correct [96]. These procedures are referenced either in the PRA database or in human interaction work sheets.

Human interactions that are significant to the PRA results are re-quantified using one or more of the following methods described in the PRA Guide [96]:

A. A final Human Error Probability (HEP) value, which is calculated from a detailed model developed by the HRA Specialist using Technique for Human Error Rate Prediction (THERP) methodology.

B. An HEP value of a similar event modeled in another Station PRA, which is assigned where justifiable.

C. A formal review with plant operators, maintenance staff and / or simulator training staff to confirm that the tasks modeled by the human interactions have been properly understood and that assumptions made in the quantification of the human error probability are reasonable and correct.

   This process may be achieved via formal interviews or a formalized process, such as an expert elicitation process, designed to solicit the expert opinion and judgment of Station Operators.

   As warranted, operating experience concerning human actions may be sought, to augment the expert judgment process, so as to avoid over-reliance on expert

judgment. Additional means of supporting the understanding of human interactions include task-based talk-throughs, walkdowns, field observations and simulator exercises. The range of operator characteristics should be considered with regard to task performance, e.g., stature, strength, hearing, vision, training, qualifications, and certification. Organizational issues should be considered such as normal work location, number of people available to perform the actions, team working, supervision, crew co-ordination, dependent actions and parallel tasks. When soliciting expert judgment, it should also be considered that subjective estimates of task completion times and task performance errors tend to be optimistic.

The primary method employed to re-quantify significant human interactions is through using item A from the list above; that is, one that involves detailed quantification using the THERP methodology. The THERP method consists of performing a task analysis and estimating relevant error probabilities; THERP generates HEPs quantitatively, taking into account performance shaping factors and dependencies between tasks.

One area that has considered use of exercises/validation (item C) is the simplified human reliability analysis process developed for deployment of Emergency Mitigating Equipment (EME) installed as part of Fukushima response [97]. The base HEP used in the PRA for EME deployment is considered to represent the failure probability of a deployment activity that is governed by procedures, plant personnel have been trained on, and has been demonstrated to be feasible through the validation exercise.

While the method described in item C was done for the EME project, it appears the method, which would involve the use of task-based talk-throughs, walkdowns, field observations and simulator exercises to confirm the tasks modeled by safety analysis is not done consistently. Furthermore, there does not seem to be a clear feedback mechanism from training and other departments involved in carrying out emergency drills and simulator exercises to provide input to safety analyses to validate the assumptions modelled. A gap (SF12-2) has been raised in Table 6 to identify this lack of input from training exercises, particularly those modeling accident conditions, to safety analyses to validate assumptions[3].

The Human Factors Engineering Program Plan, DPT-PDE-00013, HFE Program Element 6 covers treatment of important human actions with respect to engineering changes [73]. DPT-PDE-00013 notes that the Risk Assessment is part of the Licensing Basis for both Bruce A and Bruce B and contains human reliability modeling. If design changes impact event sequences in the PRA, human reliability estimates may be affected and these credited human actions are required to be assessed through a Human Reliability Analysis (HRA). Human Reliability Analysis is normally only monitored during a design modification where the Nuclear Safety Risk is at Levels 1, 2 or 3 on a project, or if an Abnormal Incident Manual (AIM) action is impacted due to the potential for, and mechanisms of, human error that might affect plant safety. If the change is found to meet the above level criteria, the affected human actions must be reviewed to determine if they affect the PRA or deterministic safety analysis. In some cases the deterministic safety analysis may include human actions that are credited in the analyses to prevent or mitigate the accidents and transients. These human actions may, or may not, be

[3] It is understood that EME actions are not audited at the same level as activities performed in the plant or the MCR.

found as risk-important by the PRA but are considered deterministically as significant requiring analysis or review. Significant human actions must be addressed in design changes through task analyses and the design of the human-system interfaces (HSIs) as described in DPT-PDE-00013 [73] to minimize personnel errors, support their detection, and ensure recovery capability.

While the Human Factors Engineering Program Plan, DPT-PDE-00013 covers assessment for credited human actions as a result of design changes, the assessment and validation of credited human actions that are not a part of design changes are validated through other activities. Safety Factor 5 (Section 5.7) provides further information on methods used for development and validation of emergency operating procedures and the accident management program at the plant.

Bruce Power Abnormal Incident Manual Project Human Factors Engineering Summary Report (HFESR), B-REP-06700-00002 [98], documents the validation exercises completed to ensure that all credited human actions, as noted in the Bruce B Risk Assessment Report, Appendix A6 [94] and included in AIMs, could be completed safely and within the required time, using minimum complement. It also verified the availability of the required controls, equipment and information. The report did not mention whether the actions noted in the Safety Report [93] were also included in the validation exercises. It is possible that the actions in the Safety Report may overlap with the credited actions noted in the Bruce B Risk Assessment report and included in the AIMs that were a part of the exercises; however, this could not be confirmed. A gap (SF12-3) has been raised in Table 6 regarding the possibility that not all operator actions under accident conditions and the associated assumptions were assessed and validated.

5.5. Human Factors in Maintenance

This review task includes review of the Bruce Power Programs to ensure that human factors in maintenance are assessed to promote error-free execution of work.

Error-free execution of work is promoted through multiple mechanisms working in conjunction within Bruce Power. These include:

- Use of Human Performance tools for maintenance;
- Training and promotion of Maintenance Fundamentals; and
- Consideration and evaluation of HF implications for maintenance during engineering design.

As discussed in Section 4, Bruce Power's Human Performance program describes the approach to reducing errors and managing defences to promote error-free work and optimizing human performance [53]. The Human Performance Program encourages workers to use Human Performance tools identified in BP-PROC-00617 [54] to anticipate, prevent and detect errors before they cause harm to people, plant, property or the environment. These skills, behaviours, and practices apply to all personnel and are supported by Bruce Power's Maintenance Fundamentals as outlined in BP-PROC-00580 [99]. The Maintenance Fundamentals procedure sets forth the expectations for performing, assessing, and reinforcing the Maintenance Fundamentals to ensure maintenance activities achieve industry best

performance. These fundamentals constitute a set of standards and behaviours for all Bruce Power Maintenance Departments across site and include the following key areas:

- Maintenance Personnel Knowledge;
- High-Quality Corrective and Preventive Maintenance;
- Deliberate and Conservative Actions;
- Communication of Technical Information; and
- Ownership of Plant Performance.

Consistent with the strategic approach outlined in the Human Performance Program is the application of Human Factors in design through Bruce Power's site-wide Human Factors Engineering Program Plan, DPT-PDE-00013 [73]. DPT-PDE-00013 outlines a process for considering tasks of users including maintenance personnel in the design of new and modified systems. The process also invokes the use of Bruce Power's Human Factors Design Guide: Maintenance, Inspection, and Testing, B-DG-06700-00003 [100]. The guidelines in this design guide are concerned with design features that can potentially affect preventive and corrective maintenance of systems and promote consideration of HF issues such as task compatibility of equipment design, error-tolerant design, and arrangement and location of items for ease of access.

Safety Factor 2 discusses the implementation of Bruce Power's maintenance programs.

During the Operational Safety Review Team (OSART) mission (see Section 7.2.2.1), it was found that in a few instances, workers performing maintenance activities do not implement human performance techniques to prevent errors including not following some procedures in accordance with station standards [101]. An internal review conducted in 2009 of the Bruce A Maintenance Department's use of Human Performance tools identified that Human Performance tools were not used consistently. Actions associated with improvement opportunities from the internal review were completed. In the May 13, 2016 edition of The Point, Bruce Power has raised SCR 28536003 in response to the finding and as a corrective action will be reinforcing the use of their Core-4 Human Performance tools through dynamic learning activities and also improve maintenance procedure quality.

Additionally, Part IV of NUREG-0700 on Maintainability of Digital Systems covers guidance that is meant to improve maintenance personnel's ability to inspect, test, and service units of equipment, modules, components, and parts. Bruce Power's governance documents B-DG-06700-00003, Human Factors Design Guide: Maintenance, Inspection, and Testing [100] and B-DG-06700-00005, Human Factors Design Guide for Manual Reactor Maintenance Tooling [102] cover the topics addressed in NUREG-0700 directly or reference this document and other guidance documents. Therefore, it is concluded that Bruce Power programs adequately address Human Factors considerations in maintenance.

It is concluded that Bruce Power programs meet the requirements of this review task.

5.6. Competence Requirements for Operating, Maintenance, Technical and Managerial Staff

This review task includes review of training programs to ensure adequate competence requirements exist for operating, maintenance, technical and managerial staff.

As indicated in Section 5.1, the objective of Worker Staffing [61] is to recruit, orient and deploy workers who possess the required competencies. All Bruce Power staff are recruited using current organizational technical and behavioural competencies specified in approved job documents and selection criteria.

The Worker Learning and Qualification program, BP-PROG-02.02 [42], sets the standard for the entire company on how to ensure that personnel are competent at the work that they do. The procedures and job aids required to implement the Worker Learning and Qualification program gain their authority from this program. These procedures and job aids are identified in Section 4.0 of BP-PROG-02.02 [42], and summarized here:

- Implement the necessary controls to ensure personnel are competent to do the work assigned to them. Competencies are assessed through the evaluation of education, training, skills, experience, and ability. Training programs based on the work performed by personnel are systematically developed and implemented so that the required competency is achieved and maintained. Any prerequisite education, experience, and training are identified.
- Implement the intent of the Bruce Power Training Performance Objectives and Criteria (TPO&C). The Bruce Power TPO&C address the intent of both the CNSC and INPO training performance objectives and criteria. The Training Performance Objectives and Criteria handbook, B-HBK-09500-00003 [88], documents the relationship between the Bruce Power and the CNSC performance objectives and criteria. The PROL [1] requires compliance with the CNSC examinations guides EG-1: Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants and EG-2: Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants.
- Require the training elements that support Worker Qualifications approved for inclusion within the Training Qualification Documents (TQDs) be created, managed and conducted in a manner that fully meets the intent of the Bruce Power Training Performance Objectives and Criteria TPO&Cs.

A TQD is a governing document that identifies the prescribed qualifications and training required by Bruce Power personnel to perform assigned tasks independently. The TQD also identifies the training program structure for: Engineering Support personnel, Certified Operator Training, Nuclear Operator Training, Control Maintenance personnel, Mechanical Maintenance personnel, Chemical Technologists and Responsible System Chemists, Radiation Protection Technicians and Health Physicists, and Authorized/Responsible Health Physicists. The TQDs identify all specific qualifications and cross functional qualifications that are required. Employees with the appropriate occupation codes are linked to the required selection of qualifications from the TQD to perform their function by their line supervision.

BP-PROG-01.04, Leadership Talent Management [59], defines, based on business needs, the leadership competencies required of its managers from Vice President to First Line Manager. These competencies are derived from a review of the mission, vision, values and business plans and then translated into specific demonstrable behavioral expectations.

Bruce Power programs meet the requirements of this review task. Although issues were identified in Section 7.1.2 with respect to ensuring that emergency services staff filling roles for minimum staff complement are qualified, corrective actions are in place to resolve the issues.

5.7. Staff Selection Methods

This review task includes review of programs and processes for staff selection to confirm they are systematic and validated.

The objective of the Worker Staffing program, described in BP-PROG-02.01 [61], is to recruit, orient and deploy workers who possess the competencies required for maintaining staffing levels consistent with the requisite organization structure. The program applies to both internal and external hires. Employees must be recruited against current organizational competencies (i.e., technical and behavioural), which are specified in an approved job document and selection criteria. An internal or external search must not commence until these documents are approved and in place. The selection criteria must be reviewed, and updated where necessary, for each recruitment activity. Hiring processes for different employee classifications are detailed in the following specific procedures: BP-PROC-00319, Student Hiring [103]; BP-PROC-00355, Hiring Process (Contractors) [104]; and BP-PROC-00465, Hiring Process (Regular Positions) [105].

Recruitment procedures must include a work/reference check process and pre-placement qualification checks to ensure the candidate meets or exceeds the qualification criteria.

Bruce Power is committed to ensuring there are capable managers and achieves this through both the Succession Management procedure outlined in BP-PROC-00221 [60], which outlines a process for developing successors for key positions and roles as well as the Talent Management process. The Talent Management process for managers described in BP-PROG-01.04 [59], defines how managers are selected for both their leadership and technical skills, and then how managers are on-boarded, managed and developed. It also defines how Bruce Power ensures that a sufficient number of managers with the right leadership and technical skills are available to deliver the business plan, which includes safe operations targets.

Managers are selected based on technical job requirements and the leadership behavioral competencies for the position level. The selection process for managers is part of the general selection process for all employees and is documented in BP-PROC-00465, Hiring Process (Regular Positions) [105], and BP-PROG-02.01, Worker Staffing [61].

BP-PROG-02.02, Worker Learning and Qualification [42], is the program that ensures personnel are competent to do the work assigned to them. Competence is assessed through the evaluation of education, training, skills, experience, and ability. Training programs based on the work performed by personnel are systematically developed and implemented so that the required competency is achieved and maintained. Any prerequisite education, experience, and

training are identified. Evaluation methods are used systematically to assess training effectiveness and modify training to improve personnel and plant performance.

BP-PROC-00213, Training - Administer Training Evaluation [106], defines the methods of evaluating training programs at Bruce Power. It establishes the requirements for collecting, analyzing, and recording the in-training feedback evaluations (by trainees, trainers and line managers) performed on Bruce Power Training Programs. It also establishes the requirements for required reviews of internal and CNSC Audits, Assessments and Reviews, and the requirements for Training Managers (TMs) and trainers to initiate Training Change Requests (TCRs) to document and track identified opportunities to improve Bruce Power Training Programs.

Bruce Power programs meet the requirements of this review task. Although issues were identified in Section 7.1.2 with respect to selecting emergency services staff who were not sufficiently qualified to fill minimum staff complement roles, corrective actions are in place to resolve the issues.

5.8. Fitness for Duty

This review task includes the review of fitness for duty guidelines addressing the hours, types and patterns of work for all Bruce Power Staff and a review of the programs which assess good staff health and substance abuse problems.

Bruce Power has a detailed process outlining the daily, weekly and yearly limits of hours worked per worker type (day worker, rotating shift worker, etc.). This process is documented in Limits to Hours of Work, BP-PROC-00005 [66] and describes the responsibilities to ensure this process is followed to minimize the likelihood of human errors caused by worker fatigue. The process is further supported by reference to the Base Work Week for Management and Professional Staff procedure, BP-PROC-00024 [67], which describes the base work week for management and professional staff. Both documents take authority from the Total Rewards program outlined in BP-PROG-02.08 [65].

Fitness for Duty guidelines, BP-PROC-00610 [107] and Code of Conduct BP-PROC-00276 [64] training are part of the orientation training of all new hires and are part of refresher training for all staff at site. Staff performing functions under the Code of Conduct Procedure, including Supervisors and Managers, will receive ongoing training. Initial and periodic health assessments are conducted for CNSC certified staff as per the Bruce Power Health Surveillance procedure, BP-PROC-00378 [108] to evaluate the impact (if any) of medical conditions on fitness for duty.

BP-PROC-00610 was developed “to meet statutory, regulatory, and licensing requirements” and as such the appropriateness of the fitness for duty guidelines in the procedure and associated checklists are determined by the following documents (BP-PROC-00610, Section 5.1 [107]):

- RD-204 Certification of Persons Working at Nuclear Power Plants, Canadian Nuclear Safety Commission;
- N286-05, Management System for Nuclear Power Plants (Sections 0.2, 0.3, 0.4, 5.3, 5.4); and

- Occupational Health and Safety Act, RSO 1990.

A worker who is unfit for duty may identify their situation to the supervisor, or the supervisor may notice that the worker's behaviour or appearance in the workplace indicates there may be a fitness for duty issue. Another worker may also report concerns regarding a co-worker's fitness to a supervisor. The supervisor performs a preliminary assessment of fitness for duty utilizing the following tools as required:

- Assessing Fitness for Duty Guideline (available on Bruce Power's Employee Wellness intranet page);
- FORM-12987 - Fitness for Duty Checklist - Assessing Fitness for Duty Guideline [109]; and
- FORM-13981 - Fitness for Duty Checklist - Fatigue Assessment [110].

Guidelines specific for assessing fitness for duty for minimum shift complement staff held over for more than 13 hours are provided in GRP-OPS-00055 [86].

The assessment will result in a determination that:

- The worker is fit for duty and may return to work with or without accommodation; or
- The worker is fit for duty and there is a performance issue; or
- The worker is unfit for duty.

When the worker is considered unfit for duty, they will be removed from the work area and a determination will be made for transportation to hospital, the worker's home, or into the care of a responsible person (BP-PROC-00610, Section 4.3 [107]). If the worker is fit for duty, the supervisor will determine whether there is a need for performance management if the worker is not performing to the job performance standards (BP-PROC-00411, Managing Employee Performance [111]). If the worker requires an absence for a fitness for duty issue or has been referred to external medical personnel, the supervisor must ensure they are reviewed for fitness for duty by Employee Wellness on their return (refer to BP-PROC-00071, Injury/Illness Disability Management [112]).

Bruce Power's Fitness for Duty procedure, BP-PROC-00610 [107], describes the approach used by Bruce Power is to resolve problems affecting a worker's performance, health or safety through support, education, counseling and/or treatment. Specifically, BP-PROC-00610 Section 4.4 states, "Bruce Power is committed to helping individuals seek assistance and provides a program for reducing the workplace and human costs associated with substance abuse and various health issues. Workers are encouraged to come forward voluntarily in order to obtain confidential professional counseling and medical assistance; however they must demonstrate commitment to address these issues. While participating in programs, the worker's employment or advancement opportunities will not be affected provided treatment is undertaken which results in satisfactory control/elimination of identified problems." Information and assistance on the Employee Wellness programs and services are described on the Wellness webpage on the Bruce Power intranet [107].

Bruce Power prohibits the use, sale, exchange or possession of illegal substances while on site. Engaging in these activities will be considered cause for corrective action and initiation of the performance management process as per BP-PROC-00411, Managing Employee Performance (see Appendix B of procedure) [111].

Bruce Power's documented programs meet the intent of the review.

5.9. Maintaining Know-How of Staff and Adequacy of Succession Management

This review task includes a review of Bruce Power's programs and procedures for maintaining the know-how of staff and for ensuring adequate succession management in accordance with good practices. BP-PROC-00468 [113], Workforce Planning Process, describes the process that is used to identify positions that will be required in the future, and is regarded as a sub-process for business planning feeder processes. The Human Resources function of Workface Planning is accountable for delivering a 5-year workforce plan, through the annual business planning process and integrating with the recruiting function to develop hiring plans for all divisions across site.

The 5 year business plan is developed in accordance with Business Planning, BP-PROC-00485 [114], and the interfacing procedures. The Executive Team provides the strategic direction to the organization for the development of the business plan. The plan identifies how the company will achieve targeted performance for each identified target by identifying the accountable organizations, resources, and any activities requiring investment beyond core work. Each team's plan is rolled up into a corporate business plan under the direction of the Manager, Business Planning. Workforce planning is an input to business planning and takes into account the activities and resources required to meet the direction set by the executive. Each division identifies the roles, responsibilities, head count, rationale and/or assumptions and the risk and/or impact required to meet the direction laid out. The divisions also identify the labour funding type and any incremental head count they feel is required. The executive team then reviews and challenges the resources and activities as developed by the divisions, considering any potential risks or impacts to the strategic plan, and considers any potential alternatives. Once agreed upon, the workforce plan is input to the final business plan.

The Executive Team, as the highest level management team, identifies which positions are critical from the perspective of needing to have a capable incumbent and/or a ready successor. For positions that are not business critical, succession management will lie with the line organization and be monitored via standard reporting within the line.

For positions that are critical to the business the Worker Development and Performance Management process [62] identifies the approach for worker development and succession planning especially for employees with critical skills. Worker development and performance is linked to business plans and managed through the establishment of personal performance plans**,** BP-PROC-00006 [115]. Also, management succession is outlined in a specific procedure, Succession Management, BP-PROC-00221 [60]. In addition to identifying people who can perform in the position on an ongoing basis, people who can act as an emergency

replacement (“safe pair of hands”) to maintain a position on a short term basis will be identified as a contingency for emergency situations.

To maintain the knowledge of the plant, Bruce Power has placed a strong emphasis on documentation as described in the Controlled Document Life Cycle procedure, BP-PROC-00068 [116]. This document states that a one, two or three-year review cycle is mandatory for all Bruce Power Programs and General Procedures (some maintenance procedure types excepted). In addition, there is flexibility within the procedure to allow staff to submit changes and new requests for procedures prior to review cycle deadline by submitting an Action Request type Document Change Request (using ESuite). The process is described in the procedure development and revision procedure for Maintenance Procedure Development and Revision [78] and the procedure for Requirements for Station Operating Procedure Development and Revision [80].

Bruce Power also has a program in place to identify and collect undocumented knowledge that has the potential to jeopardize the company should the personnel holding it become unavailable through retirement or other causes. This process is documented in Training – Administer Critical Knowledge Retention, BP-PROC-00360 [117].

Bruce Power programs meet the requirements of this review task.

5.10. Adequacy of Facilities and Programs for Staff Training

This review task includes review of the facilities available to support staff training programs.

The objective of the Worker Learning and Qualification program, BP-PROG-02.02 [42], is to ensure personnel are provided with the competencies and qualifications necessary to satisfy the requirements of applicable legislation commensurate with Bruce Power business needs. Moreover, the program follows the Systematic Approach to Training model defined by INPO. The training program is described in further detail in Section 5.3, Adequacy of Programs for Training.

Bruce Power has in-place training facilities, including full scope simulators used for initial certification training of Bruce Power station staff, examination of staff, and continuing training of certified staff.

Full scope main control room simulators are discussed in Section 5.3. Bruce B has one full scope simulator. Other simulators include a fuel handling simulator, classroom simulators and kiosk simulators. The fuel handling simulator is used for training personnel from both Bruce A and B. The classroom simulators are non-interactive displays used for training operators outside of the main control room simulators, while the kiosk simulators are not used for training but are available for the Simulator Support department and select instructors and examiners to develop training and examination simulations, as well as troubleshoot and upgrade the simulators.

In addition to simulators, Bruce Power has dedicated training facilities, both on and off site to provide regular and contract staff the necessary training for their specific roles. These facilities include, but are not limited to the Bruce Learning Center, Bruce Technology Skills Training Centre, and the Kincardine training facility. The list of all of the training facilities is included in the scheduling database and is used to assign the appropriate facility to each course. Included

in these facilities are class rooms, maintenance training shops, station component mock ups and rehearsal spaces.

For example, Bruce Power has a Fire Training facility at site. The facility is used to train Emergency Response personnel on fire fighting techniques. Bruce Power provides general guidelines regarding the use of the facility through SEC-CST-00001 [118]. The guidelines provide instructions covering the day-to-day operation of the Fire Training Field Area to ensure minimal impact on the environment and surrounding buildings from the training exercises.

Bruce Power programs meet the requirements of this review task.

5.11. Human Machine Interfaces for the Design of Control Room and Other Workstations Relevant to Safety

This review task includes review of the Human-Machine Interfaces (HMI) of control rooms and other workstations relevant to safety, to ensure that the design continues to support safe operation of the plant.

The Bruce B Main Control Room and has been in operation for over 30 years and has undergone modifications due to aging, obsolescence, and continuous improvement initiatives. These modifications have been incorporated through on-going improvements. All modifications in the MCR and the Secondary Control Areas (SCAs) undergo Bruce Power's Engineering Change Control process as governed by BP-PROG-10.02, Engineering Change Control [74]. Issues associated with the MCR and SCAs may be raised as a Station Condition Record (SCR) using Bruce Power's Station Condition Record Process, BP-PROC-00060 [119]. The identified adverse condition identified in the SCR may be addressed via another managed process, which may include an engineering change. Any engineering changes that necessitate changes in the MCR and SCAs are addressed through the Human Factors program described in DPT-PDE-00013 [73]. The HF program is supported by various design guides (full list noted in the Human Factors Engineering Program Plan, DPT-PDE-00013 Appendix H [73]) that provide guidance on the design of HMIs to ensure consistency and standardization of existing HMI conventions as well as application of HF principles. Based on this process, it can be concluded that interfaces in the MCR provide appropriate information in a usable format.

Bruce B has four unit Secondary Control Areas and one common Secondary Control area located in the Emergency Water and Power Supply (EWPS) Building. The SCAs are a part of the original design of the station. The SCA requirements are documented in the Bruce B Generating Station Safety Related System and the Two Group Separation Philosophy Design Manual [120]. According to the design requirements for the SCA, the SCA must have sufficient monitoring and control devices necessary to carry out important safety functions independently from the MCR in the event of a common mode failure, which may render the MCR uninhabitable. The design requirements and the fact that the SCA instrumentation and controls are tested regularly to ensure their functionally and availability suggests that the SCA provides operators with necessary and appropriate information.

Safety Factor 1 addresses the adequacy of the design of the plant including the Bruce B MCR, SCA, and emergency response facilities.

In addition to the on-going Human Factors program, Bruce Power conducted an assessment to evaluate the extent to which Bruce Power's design guidance and subsequently MCR and SCA design adheres to modern guidelines for interface design. This analysis work was completed with the objective of identifying improvement opportunities to HF design guidance and where practicable, provides recommendations for the improvement of MCR and SCA design. The results of the review identified that the MCR and the SCA interfaces reviewed are approximately over 73 percent compliant with the clauses in the guidelines reviewed. Any deviations were resolved with the understanding that many represent known stereotypes that are relevant to Bruce Power or the industry in general, and changes would increase the likelihood of error. Improvement opportunities related to modifying guidance and continuing review of items difficult to assess were provided as well. The results of the assessment are summarized in B-REP-06700-00001, Human Factors Review against Modern Safety Standards Human Factors Engineering Summary Report [121].

The adequacy of the HMI in supporting safe operation of the plant is further supported by an Abnormal Incident Manual (AIM) validation exercise that was carried out in 2010. The goal of the exercise was to ensure that all AIMs could be completed safely and within the required time, using the minimum staff complement. The analysis also verified the availability of the required controls, equipment and information. The exercise is summarized in B-REP-06700-00002, Bruce Power Abnormal Incident Manual Project Human Factors Engineering Summary Report [98].

NUREG-0700, Human System Review Guidelines [45], addresses the physical and functional characteristics of HSIs, and as such is denoted as a Human Factors Engineering (HFE) guideline document. NUREG-0700 can be considered as a guidance tool relevant to this review task. A high level assessment is documented in Appendix A (Section A.2), which illustrates that Bruce Power meets the intent of some aspects of NUREG-0700, but that there were a number of issues that could not be resolved with the information that was reviewed. For instance, there do not seem to be governance documents or standards for CRT based displays or for existing alarm systems. These findings have been summarized in Table A1 and a gap (SF12-4) has been identified in Table 6.

Bruce Power's Human Factors program was also reviewed against CSA N290.12, Human Factors in Design of Nuclear Power Plants [43]. The clause-by-clause assessment provided in Appendix B (B.2) demonstrates that overall, Bruce Power meets the intent of CSA N290.12 with some exceptions. A gap (SF12-5) in regards to CSA N290.12 has been identified in Table 6.

Bruce Power programs meet the requirements of this review task, with the exception of those related to the guidance provided in NUREG-0700 and the requirements and guidance provided in CSA N290.12.

5.12. Human Information Requirements and Workloads

This review task includes review of programs and processes to ensure human information requirements and human workload are considered in human system interface designs.

Human-machine interfaces, human information needs and workload are addressed in the Human Factors Engineering Program Plan, DPT-PDE-00013 [73], which is supported by various

Design Guides associated with specific plant systems (see Section 5.11). The overall approach is based on the U.S. Nuclear Regulatory Commission's NUREG-0711, Human Factors Engineering Program Review Model [82]. Human Factors analysts who support the program are qualified in accordance with reference DPT-PDE-00013 [73].

A person holding the HF Consultant Qualification or the HF Specialist Qualification is required to classify all Design Change Packages (DCP) governed by BP-PROC-00539 as well as any other projects for which it has been determined that an HF review is necessary (DPT-PDE-00013, Section 4.2). Significant changes, as determined by this classification process, to human interfaces and workloads require human factors analysis, which may include a review of the human information needs and workload [75]. Human information needs and workloads are reviewed through task analysis and staffing analysis, by a qualified HF analyst.

As described in Human Factors Engineering Program Plan, DPT-PDE-00013 Appendix B and Appendix F [73], task analyses identify the performance demands on personnel and the task requirements for accomplishing functions allocated to them. Appropriate levels of task analysis are applied to design changes in accordance with the complexity and safety significance of the change. This includes analyses that identify the specific tasks needed to accomplish personnel functions, and also the alarms, information, control- and task-support required to complete those duties, roles and responsibilities.

An analysis of staffing examines the organization, number of staff, and the distribution of job responsibilities among staff impacted by the design change (e.g., control room staff, field personnel). Typically, staffing review is done through a validation exercise using the current staffing level or proposed staffing levels. It may also be appropriate to perform a workload analysis, at the discretion of the HF Analyst, based on the requirements of a particular project.

Bruce Power programs meet the requirements of this review task.

5.13. Clarity and Achievability of Procedures

This review task includes review of procedure development and validation processes to confirm clarity and achievability of station procedures.

BP-PROC-00166, General Procedure and Process Requirements [58], specifies the requirements for the administrative process for procedure production and for procedure document formatting and presentation. It establishes standards, methodology and processes with consideration of industry standards such as the AP-907 series and other INPO program guides, as cited by BP-PROC-00166 [58], to ensure Bruce Power practices reflect a strong commitment to nuclear safety and a consistent approach to procedure quality.

Requirements for Station Operating Procedure Development and Revision, GRP-OPS-00050 [80], and Maintenance Procedure Development and Revision, BP-PROC-00694 [78], establish the requirements for requesting, developing, reviewing, validating, verifying, and approving station operating procedures.

BP-PROC-00250, A Writer's Guide for Station System Procedures [81], specifies the requirements for Station System procedure format and writing methodology. Well written

procedures which use consistent structures, styles and language help reduce human error and promote consistent results.

Bruce Power procedures follow the same format and are produced using standard templates. Procedures are structured such that the purpose is clearly stated. Regulatory and management requirements are clearly laid out. Definitions of terms and acronyms are included. Exceptions to the use of the procedures are listed. References and forms associated with the procedure are identified. The procedure states the responsibilities of personnel. A process map is included where applicable to provide an overview of the process described in the procedure.

Validation is a process of exercising procedures performed by a user, prior to initial use, to ensure that they are useable and the language and level of information is appropriate for the individuals for whom they are intended, and that the procedures will function as intended. One or more of the following methods can be used to validate procedures:

- Field Walk Through;
- Mockup/Simulation;
- Table Top Review;
- Comparison; and
- Cross Discipline Review.

Additional information on procedures is found in Safety Factor 11, where it states that each Operating Procedure is reviewed, verified and validated before being approved and distributed for use, consistent with the requirements of GRP-OPS-00050-R002, Requirements for Station Operating Procedure Development and Revision [80].

Bruce Power programs meet the requirements of this review task.

6. Interfaces with Other Safety Factors

There is some degree of interrelationship among most of the 15 Safety Factors that comprise the Bruce B PSR. The following identifies specific aspects of this Safety Factor that are addressed in, or where more detail is provided in, another Safety Factor Report.

- “Safety Factor 1: Plant Design” in Appendix B.2, addresses Clause 7.21 of REGDOC-2.5.2 which is directly applicable to Human Factors. The results of this assessment have been applied directly to the review tasks of this safety factor.
- “Safety Factor 2: Actual Condition of SSCs” in Section 5.6, discusses the implementation of Bruce Power’s maintenance programs.
- “Safety Factor 5: Deterministic Safety Analysis” in Section 5.7, addresses the methods used for development and validation of emergency operating procedures and the accident management program at the plant. In Section 5.5 of “Safety Factor 5” deterministic safety analysis assumptions regarding credited operator actions is discussed.

- "Safety Factor 6: Probabilistic Safety Analysis" in Section 5.1, reviews the existing probabilistic safety analysis including the representations of operator actions.
- "Safety Factor 10: Organization and Administration" in Section 5.3 addresses arrangements for suitably qualified staff, adequate training facilities and programs (as well as review of policies and processes which foster safety culture in Section 5.4).
- "Safety Factor 11: Procedures" in Appendix B.1, assesses compliance against IAEA SSR-2/2 which assesses management of operational safety including human performance considerations related to procedures.
- "Safety Factor 13: Emergency Planning" in Appendix B.1, addresses adequate staffing for emergency planning.

7. Program Assessments and Adequacy of Implementation

Section 7 supplements the assessments of the review tasks in Section 5, by providing information on four broad methods used to identify the effectiveness with which programs are implemented, as follows:

- Self-Assessments;
- Internal and External Audits and Reviews;
- Regulatory Evaluations; and
- Performance Indicators.

For the first three methods, the most pertinent self-assessments, audits and regulatory evaluations are assessed. Bruce Power has a comprehensive process of reviewing compliance with Bruce Power processes, identifying gaps, committing to corrective actions, and following up to confirm completion and effectiveness of these actions. While there have been instances of non-compliance with Bruce Power processes, Bruce Power's commitment to continuous improvement is intended to correct any deficiencies.

For the fourth method, the performance indicators relevant to this Safety Factor are provided. These are intended to demonstrate that there is a metric by which Bruce Power assesses the effectiveness of the programs relevant to this Safety Factor.

Taken as a whole, these methods demonstrate that the processes associated with this Safety Factor are implemented effectively (individual findings notwithstanding). Thus, program effectiveness can be inferred if Bruce Power processes meet the Safety Factor requirements and if there are ongoing processes to ensure compliance with Bruce Power processes. This is the intent of Section 7.

7.1. Self-Assessments

Generally, self-assessments are used by functional areas to assess the adequacy and effective implementation of their programs. The results of each assessment are compared with business needs, the Bruce Power management system, industry standards of excellence and regulatory/statutory or other legal requirements. Where gaps are identified, corrective actions are identified and implemented.

The self-assessments:

- Identify internal strengths and best practices;
- Identify performance and/or programmatic gap(s) as compared to targets, governance standards and “best in class”;
- Identify gaps in knowledge/skills of staff;
- Identify the extent of adherence to established processes and whether the desired level quality is being achieved;
- Identify adverse conditions and Opportunities for Improvements (OFI); and
- Identify the specific improvement corrective actions to close the performance/programmatic gap.

Self assessments within Bruce Power are conducted in accordance with Bruce Power’s Focus Area Self Assessment (FASA) procedure, BP-PROC-00137 [122]. FASAs generate, as an outcome, opportunities for improvements for the Functional Area. The results of the FASAs as well as the suggestions for the opportunities for improvement must be accepted by the CFAM before actions can be carried out. The FASAs that were reviewed are:

- SA-HRS-2014-02 [123];
- SA-HRS-2015-01 [124];
- SA-TRGD-2011-09, Out of Station ERO Complement Qualifications [125];
- SA-BBOP-2008-06, Conduct of Human Performance, Self Checking [126];
- SA-COM-2009-06, Configuration Management and Support Department, Knowledge Worker Human Performance Assessment [127]; and
- SA-TRNG-2013-05, Bruce B Unit 0 Control Room Operator-in-Training (CR011) Phase 5 Skills [128].

The following subsections provide a summary of the findings from the FASAs reviewed.

7.1.1. SA-HRS-2014-02 and SA-HRS-2015-01, Hours of Work

The Hours of Work FASAs, SA-HRS-2014-02 [123] and SA-HRS-2015-01 [124], were conducted to evaluate Bruce Power's compliance with the Hours of Work Procedure, BP-PROC-00005 [66].

SA-HRS-2014-02 identified as an adverse condition that quarterly reporting did not occur in Q2 and Q3. Two SCRs were raised. An SCR for an adverse condition was raised to review the requirement to report quarterly. The other SCR was raised as an improvement opportunity, which involved providing further education to Managers and Employees regarding Hours of Work Procedure through Manager's Message by end of Q1 2015, emphasizing Hours of Work Reporting. Both SCRs were closed with the conclusion for the adverse condition identifying that reporting is required to meet business needs and this will be updated in the next revision of BP-PROC-00005. Review of SA-HRS-2014-02 charts of violations shows that the total number of actual violations was 170 for authorized staff and 430 for non-authorized staff. The highest volume of actual violations by authorized staff occurred in the month of April 2014. Overall, the first quarter and beginning second quarter incurred the most number of violations. Authorized Staff Violations were driven by minimum complement short falls due to sick calls for both Stations in addition to the Active Liquid Waste project and Planned and Forced Outage at Bruce B.

No adverse conditions were identified in the 2015 report, SA-HRS-2015-01 [124]. The report summarized violation charts showing that the total number of actual violations of authorized staff was 133 while the number of actual violations of non-authorized staff was 437. Approximately 62% of the authorized actual violations happened in the second quarter. The report identified that the violations are aligned with outage activity, in particular, the Vacuum Building Outage in April and May. Non-authorized actual violations spiked significantly in February and April. The spike in April was also due to the Vacuum Building Outage. However, it is not clear why there was a spike in February[4]. An SCR was raised for an opportunity for improvement on reporting of hours of work to the Executive Vice President of Human Resources.

Year over year, it appears that there is no decreasing trend in non-authorized actual violations to limits of work. Furthermore, the results suggest that there is considerable variability month over month. However, from 2014 to 2015 there was a drop in actual violations for authorized staff by approximately 22% (down from 3.9% to 3.2% of total report hours of work instances).

Overall, the results from the 2014 and the 2015 Limits of Hours of Work assessments suggest that while Bruce Power is ensuring the availability of qualified staff, adequate staffing levels are challenged as demonstrated by the number of actual violations that are not consistently decreasing year over year. This is addressed in Section 5.1 and identified as gap SF12-1 in Table 6.

[4] Note: Violations due to adverse weather are considered a permitted exception in accordance with BP-PROC-00005 [66].

7.1.2. SA-TRGD-2011-09 Out of Station ERO Complement Qualifications

An assessment of the out-of-station Emergency Response Organization (ERO) complement qualifications was performed to determine whether the minimum complement was being met by qualified staff in the Bruce Emergency Services Team (BEST) organization. The findings from the assessment are documented in SA-TRGD-2011-09 [125]. The assessment was conducted against the minimum complement qualifications for the BEST organization, which are defined in the Bruce B Station Complement, DIV-OPB-00001 [33]. The conclusion from the self assessment was that the BEST organization did not fully understand minimum qualifications requirements necessary to hold a minimum complement position. The conclusion was supported by the following findings:

- People who are not fully qualified are being assigned to minimum complement positions.
- BEST are calling BEST members to work overtime to replace someone who has been assigned a specific ERO minimum complement position without checking to see if the person they are calling actually has the qualification that is needed.
- BEST are hiring Appendix A employees and assigning to them to minimum complement work before they are qualified Emergency Services Maintainers (ESM).

Corrective actions were assigned under an SCR and to date all corrective actions were completed under the SCR with one exception under TCR-4786, which could not be found. TCR-4786 identified an action to perform a Training Needs Analysis to determine what is required for an Appendix A staff to perform complement qualifications for BEST members.

7.1.3. SA-OCP-2012-02 Plant Status Control Processes - Human Performance

Human performance associated with the execution of various Plant Status Control (PSC) processes has plateaued since January 2012 as evidenced by the PSC index at both Bruce A and B. To date in 2012, the PSC index ratings at both stations has improved over 2011 but there were 2 months at Bruce A and three months at Bruce B where the PSC index fell 5% below target (99.5%). Device misposition events (PSC type SCRs) still occur despite control processes built on industry standards.

In 2012, an assessment, SA-OCP-2012-02 [129] was conducted to evaluate compliance to BP-PROC-00617, Human Performance Tools for Workers [54] and GRP-OPS-00038, Bruce A and Bruce B Operations Standards Expectations [130], as well as evaluate Human Performance (HU) behaviours displayed by Operations staff relevant to the execution of Plant Status Control processes. The assessment included interviews (questionnaire) with field and control room operators, field observations and a field supervisor survey.

The following adverse conditions were identified with corrective actions completed under SCR 28315371:

- Regular, over the shoulder reinforcement of PSC and HU expectations was often seen as inadequate even by those expected to complete these observations. The apparent

cause was that paired observations for field observations of PSC execution are rare to non existent. The goal of paired observations is to ensure that field assessments are in fact being completed, the correct behaviours and practices are being reinforced and to ensure top down alignment. Without this practice, verification of consistent reinforcement of correct HU tool use and application of the correct standard is not possible. Three corrective actions described in the assessment were completed under SCR 28315371. These corrective actions involved mandating paired observations for PSC execution during shift and day operations.

- There are numerous Plant Status Control processes which initiate, track and return systems/components to normal status. Some of the processes are tracked electronically in PassPort while others are paper based Configuration changes are tracked in a separate database. A combination of electronic databases and paper systems must be searched and analysed in order to define the plant status at any given time. The process appears time consuming and subject to error. A corrective action was initiated to investigate and benchmark integration of all PSC processes.
- The PSC Program is not managed effectively. The PSC metrics are not well known amongst field staff although most realize improvement in performance is needed. It was noted that the PSC information on the Bruce A and B websites was not up to date or aligned across the two stations. A corrective action was initiated to alignment and effective corporate oversight of PSC standards and metrics, Operations Programs will hold standing representation on the Plant Status Control Committees. As such, Programs will commit to assist in and or coordinate benchmarking activities and resulting program improvement initiatives.

There are no outstanding actions resulting from the FASA.

7.1.4. SA-TRGD-2013-05, Bruce B Unit 0 Control Room Operator-in-Training (CR011) Phase 5 Skills

In 2013, an assessment, SA-TRGD-2013-05, was conducted on the Bruce B Unit 0 Operator training program that had two objectives. The first objective was to assess the design and delivery of Bruce B Unit 0 Control Room Operator-in-Training (CROIT) Phase 5 Skills for compliance and/or alignment with documented work practices. The second objective was to examine the effectiveness of the action steps identified in the Apparent Cause Evaluation (ACE) for AR 26816754. This Action Request (AR) was initiated as a result of the Unit 0 CR0 Initial Simulator-Based Certification Examination conducted in June 2012 where only one of four candidates passed the Initial Simulator-Based Certification Examination. The Candidates who did not pass were scheduled to repeat the simulator phase of training in the spring of 2014.

There were no adverse trends that were identified as a part of the FASA for both Part A and Part B; however, there were a number of improvement opportunities.

An SCR was raised to address eight actions for Part A improvement opportunities. The opportunities for improvement are summarized as follows:

- Update skills course description (TQD-00015) to reflect program changes

- Improve course scheduling administration.
- Improve accessibly for up to date candidate learning materials.
- Improve frequency and use of formative feedback.

As of June 2015, six actions were completed and two were cancelled.

The outcome from the Apparent Cause Evaluation that led to the SCR AR#28316754 generated several action items to improve the instruction and evaluation of the Unit 0 Candidates, specifically during the Simulator Skills and Simulator phases of their initial training. The increase in the time spent training in the simulator along with the station observation saw the two Candidates that were recommended to advance to the CNSC exam receive a clear pass while a third Candidate from the originally lower than expected performance was asked to repeat part of the program and test later. The additional time all three (3) spent in the Simulator allowed for better understanding of the job.

Only one recommendation for improvement was generated for Part B of the FASA. The recommendation was to increase the time and focus on alarm management during skills training. Pre-job briefs with instructors were completed to proactively focus on alarm management regardless of whether it appears to be an issue or not. No Action Request was required and the issue is considered closed.

7.2. Internal and External Audits and Reviews

The objective of the audit process as stated in BP-PROG-15.01 [131] is threefold:

- To assess the Management System and to determine if it is adequately established, implemented, and controlled;
- To confirm the effectiveness of the Management System in achieving the expected results and that risks are identified and managed; and
- To identify substandard conditions and enhancement opportunities.

The objective is achieved by providing a prescribed method for evaluating established requirements against plant documentation, field conditions and work practices. The process describes the activities associated with audit planning, conducting, reporting, and closing-out. The results of the independent assessments are documented and reported to the level of management having sufficient breadth of responsibility for resolving any identified problems (as stated in Section 5.14.2 of [31]).

7.2.1. Internal Audits

Two internal audits were reviewed. AU-2013-00013 [92] was chosen for review as it provides an overview of the effectiveness of Bruce Power's training program and was the most recent audit performed. AU-2014-00011 [132] was chosen as it assesses the effectiveness of Bruce Power's Human Performance monitoring program, which is an important element to promoting error free work.

7.2.1.1. AU-2013-00013 - Training Program

An internal audit was conducted on the Training Program documentation as summarized in AU-2013-00013. The audit found that the documented processes outlined in Revision R012 of the training program (BP-PROG-02.02-R012 [133], Worker Learning and Qualification) were deemed not fully effective. The program does have well defined and controlled Tier 1, 2 and 3 metrics, which are aligned with oversight activities being undertaken through various committees. The existing governance does not fully capture all of the business requirements and expectations. Processes and procedures which implement the program do not always provide full instruction to staff, including the governance for performance monitoring (Tier 4 metrics and performance indicators). In addition, the audit identified:

- Some examples of procedure non-adherence were observed from the sampling of process data and results of work activities.
- Records were not always prepared and located per the expectations of process governance.
- The Corrective Action process, BP-PROC-00060, Station Condition Record Process, is not always fully and effectively utilized by training staff to identify and resolve problems.

The audit identified seven adverse conditions related to:

- Training Program Document, specifically BP-PROG-02.02-R012 [133];
- Training Implementing Documents;
- Oversight of Training Program;
- Training Program Adherence;
- Training Records Management;
- Training Program Corrective Action; and
- Training Program Organizational Manuals.

Each adverse condition has an SCR associated with it. All SCRs are in “Release” status. Since the audit report was issued, the majority of the actions identified across multiple SCRs are complete. There are two open assignments remaining associated with SCR# 28386641 and 28386645 that are due in the September and October of 2016. The changes associated with these actions will require time to take effect.

7.2.1.2. AU-2014-00011 – Monitoring Human Performance

An internal audit, AU-2014-00011 [132], was conducted of the Human Performance Monitoring program to evaluate the completeness of, and compliance to, BP-PROC-00794, Monitoring Human Performance [56]. The scope included a review of Human Performance events that met the criteria for Station/Department/Section Clock Resets as described in BP-PROC-00794 at Bruce A and Bruce B within the last 18 months. Human Performance personnel and other organizational units and processes associated with the Monitoring Human Performance process

were also reviewed as required. Interviews were completed with Human Performance personnel, station management and staff of other organizational units and processes associated with the Monitoring Human Performance process to verify compliance to and completeness of the Monitoring Human Performance process.

The findings suggest that procedure, BP-PROC-00794 [56], was incomplete. It contains gaps in criteria, is missing instructions, and is missing interfaces with corresponding processes that are relied upon for implementation. Gaps were found in conformance to all of the established Bruce Power requirements for document life cycle management and content. Guidance for how to perform the monitoring activities is not provided in the procedure, instead the procedure has a listing of definitions including indicators, targets and the event rate. Incomplete instructions resulted in missing a Station Human Performance Event Free Day (EFD) reset at Bruce A. The following adverse conditions were found.

- Adverse Condition No. 1 - BP-PROC-00794 is deficient in instruction and content alignment with its associated program document and procedures. The procedure is not crafted to conform to the Bruce Power requirements for writing procedures or the INPO basis document (INPO 08-004, [134]).
- Adverse Condition No. 2 – Human Performance EFD Resets are not always declared per criteria in BP-PROC- 00794. HU Event Free Day resets have been inconsistently declared, categorized and reported for events. Failure to appropriately screen, identify and analyze EFD resets reduces our ability to compare ourselves with industry peers, effectively anticipate potential problems and increases the risk for recurring events.

As a result of the audit, five Station Condition Records were initiated. One SCR was cancelled. Three of the SCRs were due to not always declaring an HU EFD reset at Bruce A, Bruce B, and Centre of Site. The actions associated with these SCRs are complete. There is currently an SCR in progress to address the procedural deficiencies associated with BP-PROC-00794.

7.2.2. External Audits and Reviews

7.2.2.1. Operational Safety Review Team Assessment

The International Atomic Energy Agency (IAEA) coordinates internationally-based teams of experts who conduct reviews of operational safety performance at nuclear power plants. This team is referred to as Operational Safety Review Team (OSART). Rather than examining the plant's physical design, OSART team members are tasked with studying the operation of the plant and the performance of the plant's management and staff. OSART focuses more on the human aspect of a nuclear plant rather than the technology behind its operation.

Bruce B was the subject of an IAEA OSART review from November 30 to December 17, 2015. Bruce Power prepared an extensive Advance Information Package primarily for the Team on the important aspects of the operation of Bruce B [89]. The results of the OSART review were finalized in report prepared by the team [101]. The Human Factor cross cuts multiple review areas described in the OSART Report. The review areas in Reference [101] that encompass review tasks associated with Safety Factor 12 are:

- Section 1: The Leadership and Management section, which encompasses the succession planning, workforce planning, and management and leadership development.
- Section 2: The Training and Qualifications section, which assesses the facilities available at site for training and the training process (initial and continuous) including training change management, qualifications and training of certified and non certified staff for operations, maintenance, technical and managerial staff.
- Section 3: The Operations section, which includes review of the operating organization, shift structure and staffing levels as well as overall responsibility distribution during normal operation and accident conditions, procedures to be used during different plant states, and drills and exercises.
- Section 4: Maintenance section, which captures an assessment of the maintenance program including the maintenance strategy, preventative, corrective, and deficient maintenance, outage programs, and the maintenance organization and functions.
- Section 11: Human Technology and Organization Interactions section, which reviews Bruce Power's Human Performance program, Human Factors Engineering program, safety culture, and continuous improvement and learning organization.

The final report identified good practices in 10 areas and five recommendations as published in the May 13, 2016 edition of The Point. The good practice identified that related to Safety Factor 12 was the fact that Bruce Power provides a wide range of training settings such as: Fire Training Facility simulator and Dynamic Learning Activities. This supports the conclusion that Bruce Power has adequate facilities for staff training. There are two recommendations that are applicable to this safety factor: 1) Bruce Power does not have a random alcohol and drug testing program and 2) In a few instances, workers performing maintenance activities do not implement Human Performance techniques to the highest standards.

With respect to the recommendation on random testing, the CNSC currently does not have explicit random alcohol or drug testing requirements, but licensees are required under the Nuclear Security Regulations to maintain an awareness program in which supervisors receive training on how to recognize behavioural changes in workers, including impairment due to alcohol or drugs. In accordance with BP-PROC-00610 [107], a supervisor is required to carry out preliminary assessments of workers using the appropriate fitness for duty tools (see Section 5.8). Negotiations are ongoing with regulatory bodies to develop a random drug and alcohol testing program (The Point, May 13, 2016). This recommendation does not impact the effectiveness review of the Fitness for Duty review task.

The use of Human Performance Tools by the Bruce A Maintenance department was assessed with a focus area self assessment in 2009 [135]. The assessment documented in SA-MPA-2009-02 focused on the shop floor level of understanding and implementation of Human Performance tools (as outlined in BP-PROC-00617 [54]) in the daily work being performed within various maintenance departments. The conclusions from SA-MPA-2009-02, suggested that while Bruce A Maintenance's implementation of Human Performance tools was progressing, with a notable reduction in human performance related events, improvement in the use of human performance tools was needed. SCRs and action requests were initiated and

completed. The observations from the OSART mission suggests that improvements with respect to human performance are still be needed for Bruce B maintenance. The overall recommendation provided to Bruce Power on maintenance work is that the plant should establish enhanced measures to ensure that maintenance workers are complying with station standards for procedure adherence and enforcing expectations for use of human performance techniques to prevent events [101]. Bruce Power has raised SCR 28536003 in response to the finding and as a corrective action will be reinforcing the use of their Core-4 Human Performance tools through dynamic learning activities and also improve maintenance procedure quality.

7.3. Regulatory Evaluations and Reviews

After a licence is issued, the CNSC stringently evaluates compliance by the licensee on a regular basis. In addition to having a team of onsite inspectors, CNSC staff with specific technical expertise regularly visit plants to verify that licensees are meeting the regulatory requirements and licence conditions. Compliance activities include inspections and other oversight functions that verify a licensee's activities are properly conducted, including planned Type I inspections (detailed audits), Type II inspections (routine inspections), assessments of information submitted by the licensee to demonstrate compliance, and other unplanned inspections in response to special circumstances or events.

Type I inspections are systematic, planned and documented processes to determine whether a licensee program, process or practice complies with regulatory requirements. Type II inspections are planned and documented activities to verify the results of licensee processes and not the processes themselves. They are typically routine inspections of specified equipment, facility material systems or of discrete records, products or outputs from licensee processes.

The CNSC carefully reviews any items of non-compliance and follows up to ensure all items are quickly corrected.

7.3.1. Human Factors in Design Desktop Review

A desktop review of Human Factors activities in Engineering Changes was carried out at Bruce Power from August 12 to 16, 2013 [136].

The objective of the desktop review was to verify that Bruce Power is properly taking into account Human Factors in the design processes of a sample of six selected Engineering Change packages. This desktop review was a follow-up to the actions and recommendations raised in the 2012 Type II Inspection on Human Factors in Design.

The review concluded that Bruce Power generally uses the approved process for taking into account Human Factors in the design process, and the Human factors activities generally followed the DPT-PDE-00013, Human Factors Engineering Program Plan [73]. No regulatory actions have been placed on Bruce Power as a result of this desktop review. However, areas for improving the adherence to procedures were noted.

The findings note there was evidence that the prescribed procedure was not followed to carry out the required HF activities but the concerns were alleviated due to those issues being identified already as a part of two SCRs that were closed by incorporating modifications into revisions of the relevant Bruce Power procedures.

Consequently, DPT-PDE-00013 [73] was revised to include a requirement to enter an item in the issues tracking list of the Engineering Change (EC) in question to require a completed signed FORM-11221, Human Factors Minor Change Worksheet [137]. Also, the Design Scoping Checklist, FORM-10700 [138] was modified to clarify that the project must ensure Human Factors is a part of stakeholder involvement. Since SCRs were raised by Bruce Power to address the issues, no regulatory action was raised by the CNSC.

7.3.2. Minimum Shift Complement Licensing Basis and Validation

CNSC staff requested that Bruce Power undertake a comprehensive review of the minimum shift complement using CNSC Regulatory Guide G-323, Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities - Minimum Staff Complement. Regulatory Guide G-323 states, in Section 5.1.1, that “the minimum staff complement is determined by the licensee through a systematic analysis” and that the minimum staff complemented is validated through an integration validation exercise of the most resource intensive event(s). Action Item 080702 was raised to track this issue [139].

In response, Bruce Power conducted validation exercises on all of the AIMs to ensure that all required controls and information are available and accessible and that all tasks can be completed in the time allotted by the minimum complement staff. The exercises are documented in Bruce Power Abnormal Incident Manual Project Human Factors Engineering Summary Report (HFESR), B-REP-06700-00002 [98].

CNSC staff reviewed the report and concluded that although the AIMs Validation Project identified many opportunities for improvement, the information presented did not demonstrate that the objectives of Regulatory Guide G-323 were met [140].

Subsequently, Bruce Power responded by submitting the Licensing Basis for Minimum Shift Complement for Bruce A and Bruce B, which provides a consolidation of the documented licensing basis for minimum complement that historically had been scattered through a number of source documents and correspondence [141].

In addition, on October 16th, 2013, Bruce Power conducted a site emergency exercise with the purpose of demonstrating field operations of a common mode event using minimum shift complement resources and concurrent procedure use.

In November 2015, Bruce Power requested closure of Action Item 080702 based on information submitted in support of previous closure requests [142]. In the correspondence Bruce Power asserted that the minimum shift complement is capable of responding to the most resource-intensive conditions under all operating states including normal operations, anticipated operational occurrences, design basis accidents, and emergencies. As of the end of December 2015, a response from the CNSC has not been received.

7.3.3. CNSC Type II Compliance Inspection Report: BRPD-AB-2013-017 - Non-Licensed Operator Training Program at Bruce Power

CNSC staff conducted a Type II inspection of the Certification Training Program for Non-Licensed Operators at Bruce Power from October 28 to 31, 2013 [143]. The purpose of the inspection was to verify compliance with licence requirements in the Bruce A and Bruce B PROLs in place at the time of the inspection and CSA N286-05 [31]. The inspection identified a number of strengths in the implementation of the Non-Licensed Operator training program, as well as some minor areas for improvement.

Overall, CNSC staff concluded that the current Non-Licensed Operator (NLO) training program follows the Systematic Approach to Training and meets the regulatory requirements of the Bruce A and B PROLs and CSA N286-05 [31].

CNSC staff identified two action notices and six recommendations to be raised as a result of this inspection.

Bruce Power responded to the inspection in NK29-CORR-00531-11494 [144] by agreeing to:

- Review, verify and update, in TIMS database, all the Terminal Learning Objectives related to NLO training such that job performance perspective characteristics are incorporated.
- Working down the backlog of required reviews and revisions to NLO training materials.

These actions are still in progress and are due to be complete in March 2017. Bruce Power has agreed to implement all recommendations as stated.

7.4. Performance Indicators

Performance indicators are defined as data that are sensitive to and/or signals changes in the performance of systems, components, or programs.

The following performance indicators related to human factors work are monitored:

- Percentage of Design Change Packages that were screened by a human factors analyst prior to moving to the “approved” stage (the goal is 100%).
    - 100% of DCPs were screened for HF in 2014 and 2015. Up until the end of April 2016, 93% of the DCPs were screened.
    - Note: The results exclude DCPs for procedural alterations and equivalent modifications (i.e. equivalent replacement of parts)
- Percentage of Design Change Packages with human factors work completed at the “closed” stage (the goal is 100%).
    - The number DCPs with a status of HF complete was 89% for 2014 (tracked only from August 2014 onwards), 92% for 2015, and 84% for 2016 (as determined by the end of April 2016.

Key human performance indicators are also monitored to determine human performance program effectiveness in the prevention of events. The key indicators are:

- Human performance event free days for Bruce A, Centre of Site, and Bruce B;
- Human performance clock resets; and
- Human performance event rate.

For instance, at Bruce B two station, 32 department, and 2323 section clock resets have been recorded in 2015.

Additional performance indicators related to training for security, emergency response organization and emergency and protective services personnel are also monitored.

In addition to the performance indicators monitored by Bruce Power, the CNSC produces an annual report on the safety performance of Canada's NPPs. The report for 2014, CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2014, issued in September 2015 [145], summarizes the 2014 ratings for Canada's NPPs in each of the 14 CNSC Safety and Control Areas, including human performance management. The human performance management Safety and Control Area covers personnel training, personnel certification, and work organization and job design. For 2014, the Bruce B rating for the human performance management Safety and Control Area was "satisfactory".

8. Summary and Conclusions

The overall objectives of the Bruce B PSR are to conduct a review of Bruce B against modern codes and standards and international safety expectations, and to provide input to a practicable set of improvements to be conducted during the MCR in Units 5 to 8, as well as U0B, and during asset management activities to support ongoing operation of all four units, that will enhance safety to support long term operation. This specific objective has been met by the completion of the review tasks specific to the human factor.

No specific strengths were identified specific to the Human Factor.

Table 6 summarizes the key issues arising from the Integrated Safety Review of Safety Factor 12.

Table 6: Key Issues

Issue Number	Gap Description	Source(s)
SF12-1	A review of internal self assessments on hours of work suggests that Bruce Power is maintaining staffing levels but not without violations that do not seem to be decreasing overall. Therefore, while programs for ensuring adequate staff levels are adequate, they are not being effectively implemented.	Sections 5.1 and 7.1.1
SF12-2	Lack of input from training exercises, particularly those modeling accident conditions, to safety analyses to validate assumptions.	Section 5.4
SF12-3	A review of Bruce Power documentation could not confirm that all operator actions under accident conditions have been assessed and confirmed valid. While it is clear that all credited human actions, as noted in the Bruce B Risk Assessment Report and included in AIMs were validated, it is not clear whether human actions identified in the Bruce B Safety Report were a part of the credited human actions validated.	Section 5.4
SF12-4	The design of the control room and other workstations relevant to safety may not meet some of the guidance provided in NUREG-0700.	Section 5.11 Microgaps against guidance clauses: NUREG-0700 – Part 1 NUREG-0700 – Part 2

Issue Number	Gap Description	Source(s)
SF12-5	Bruce Power Human Factors Engineering Program[5] does not meet some of the requirements and guidance in CSA N290.12.	Section 5.11 Microgaps against requirements clauses: CSA N290.12 – Clause 4.1.2 CSA N290.12 – Clause 4.1.6 CSA N290.12 – Clause 4.3 (Gap 1, Gap 2) CSA N290.12 – Clause 6.3.1 CSA N290.12 – Clause 6.5.3 CSA N290.12 – Clause 6.5.4 CSA N290.12 – Clause 7.1 Microgaps against guidance clauses: CSA N290.12 – Clause 5.2.1 CSA N290.12 – Clause 5.2.2 CSA N290.12 – Clause 5.2.3 CSA N290.12 – Clause 5.2.4 CSA N290.12 – Clause 5.3.1 CSA N290.12 – Clause 5.3.2 CSA N290.12 – Clause 5.3.4 CSA N290.12 – Clause 5.4.2 CSA N290.12 – Clause 5.4.4 CSA N290.12 – Clause 5.5 CSA N290.12 – Clause 6.1.6 CSA N290.12 – Clause 6.2.2 CSA N290.12 – Clause 6.3.2 CSA N290.12 – Clause 6.3.3 CSA N290.12 – Clause 6.4.1 CSA N290.12 – Clause 6.4.2 CSA N290.12 – Clause 8.5 CSA N290.12 – Clause 8.6 CSA N290.12 – Clause 8.8 CSA N290.12 – Clause 8.9 CSA N290.12 – Clause 8.11 CSA N290.12 – Clause 8.12

The overall conclusion is that, with the exception noted in Table 6, Bruce Power's programs meet the requirements of the Safety Factor related to the Human Factor.

[5] Please note that this review was performed against DPT-PDE-00013-R008. This document was revised in June 2016 to ensure that it aligns with the requirements of CSA N290.12-14.

9. References

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Appendix A – High-Level Assessments Against Relevant Codes and Standards

A.1. CNSC G-276, Human Factors Engineering Program Plan

The procedures for incorporating HF into the design process are in place and meet the CNSC Guideline, G-276. The Human Factors Engineering Program Plan, DPT-PDE-00013 [73], describes the human factors considerations and activities that will be implemented to ensure that the system or licensable activity is designed and evaluated according to established human factors principles and practices. DPT-PDE-00013 as a Human Factors Engineering Program Plan outlines an HF program applicable site-wide that meets the intent of every clause of G-276 as stated in Section 5.1 of DPT-PDE-00013. Furthermore, DPT-PDE-00013 identifies the expectations for the development of an HF plan consistent with G-276 for Bruce Power engineering projects using a graded approach.

A.2. NUREG-0700, Human System Review Guidelines

NUREG-0700, Human System Interface Design Review Guidelines [45] is used by the U.S. Nuclear Regulatory Commission as guidance for the evaluation of interfaces between plant personnel and the plant's systems and components. The review guidelines address the physical and functional characteristics of human-system interfaces (HSIs) and as such are denoted as Human Factors Engineering (HFE) guidelines. NUREG-0700 can be considered as a guidance tool for the review of the following Safety Factor review item:

The following human–machine interface should also be reviewed:

- Design of the control room and other workstations relevant to safety;

When the units were designed and commissioned over thirty years ago, HFE was in its infancy in Canada and it was not routinely applied in engineering projects. However, Bruce Power was designed with a set of station conventions. These conventions are mainly captured in the following Bruce Power guidelines.

- B-DG-06700-00001, BNGS Human Factors Minor Change Design Guidelines [146]; and
- B-DG-06700-00003, Human Factors Design Guide: Maintenance, Inspection and Testing [100].

Bruce Power also provides guidelines for the modification and development of computer based interfaces and reactor maintenance tooling that reflect more recent conventions. These guidelines are:

- B-DG-06700-00004, Human Factors Design Guide For Computer Interfaces [147]; and
- B-DG-06700-00005, Human Factors Design Guide for Manual Reactor Maintenance Tooling [102].

In principle, the guidelines were developed with consideration to modern design guidance for controls and interfaces while supporting operators in the performance of their tasks in the existing plant. The guidelines incorporate existing station conventions and reference applicable national codes. In addition, where appropriate these guidelines refer to U.S. or other international guidelines.

The early Bruce Power design guidelines did not contain reference sections; as such, NUREG-0700 is not explicitly cited in these documents, but it is possible that it provided guidance in the design. The uses of these guidelines are governed by Bruce Power's site-wide Human Factors program outlined in DPT-PDE-00013 [73], which was prepared with consideration to NUREG-0700. As such, these guidelines are applied to engineering changes. DPT-PDE-00013 also encourages the use of NUREG-0700 for guidance where Bruce Power guidelines do not provide guidelines on particular Human System Interface components. B-DG-06700-00005, Human Factors Design Guide for Manual Reactor Maintenance Tooling is the only Bruce Power guideline that references NUREG-0700, specifically. While NUREG-0700 is not referenced, B-DG-06700-00003, Human Factors Design Guide: Maintenance, Inspection and Testing considers best practices in DOE-HDBK-1140-2001, Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance [148], which has overlapping guidance with NUREG-0700. In addition to these guidelines, BP-PROC-00389, Conventional Safety Programs [48] lists a suite of safety manuals that are not specific to HSI design but cover topics such as Industrial Ergonomics, Office Ergonomics, Working in Hot Environments, and Personal Protective Equipment etc.

The scope of this high level review is to ascertain the applicability of the sections of NUREG-0700 to Bruce Power systems, summarize alignment of Bruce Power guidance to NUREG-0700 sections, subsequently summarize the alignment of applicable Bruce Power systems to NUREG-0700 and establish whether there is a potential gap in guidance.

Part I of NUREG-0700 provides guidelines for the basic HSI elements: information display, user-interface interaction and management and controls. The guidelines associated with basic HSI elements for Bruce A are outlined in:

- B-DG-06700-00001, BNGS Human Factors Minor Change Design Guidelines [146]
- B-DG-06700-00004, Human Factors Design Guide For Computer Interfaces [147]

Bruce Power performed a review of certain sections of NUREG-0700 against specific Bruce Power guidelines and subsequently against Bruce B MCR and SCA panels to determine the extent of alignment to the NUREG-0700 guidance and possible deviations. The scope of the review is provided in B-PLAN-06700-18MAR2010 [149] and the results of the review are provided in B-REP-06700-00001, Human Factors Review against Modern Safety Standards Human Factors Engineering Summary Report [121].

The review was conducted for B-DG-06700-00001 and DPT-PDE-00033, Bruce 5-8 NGS Human Factors Minor Change Design Guidelines for Cathode Ray Tube (CRT) Displays [150]. The review was against over 600 clauses in NUREG-0700, but only represented some sections in Part 1, likely due to the fact that some sections within NUREG-0700 are applicable to technologies not employed within Bruce B.

The results of this review identified that B-DG-06700-00001, is at least 78% compliant with NUREG-0700 clauses reviewed and DPT-PDE-00033 is estimated to be 41% compliant with NUREG-0700. The MCR and SCA interfaces reviewed are approximately between 73% and 80% compliant with NUREG-0700 and MIL-STD 1472F [151]. All deviations were dispositioned in the report and it was noted in the report that many deviations represent known stereotypes that are relevant to Bruce Power or the industry in general, and changes may have the potential of increasing the likelihood for error.

A limitation of the review is that there were no field HSIs reviewed, which means that there was no review done of field HSIs that are referenced in the Abnormal Incident Manuals (AIMs), against modern guidelines. However, validation exercises were performed to ensure that all credited human actions, as noted in Appendix 6 of the Bruce B Risk Assessment Report [94] and included in AIMs, could be completed safely and within the required time, using minimum complement with the HSIs that are in place. This activity is documented in the Bruce Power Abnormal Incident Manual Project Human Factors Engineering Summary Report (HFESR), B-REP-06700-00002 [98].

Part II of NUREG-0700 provides guidelines for reviewing seven systems: alarm system, safety function and parameter monitoring system, group-view display systems, soft control systems, computer-based procedure systems, and computerized operator support systems.

Based on the definition and descriptions of computer-based procedures, group-view display systems, and computerized support systems, there is no evidence that Bruce Power has such systems. NUREG-0700 guidance associated with these systems is not applicable to Bruce Power. The development and guidance associated with paper-based procedures are discussed in Safety Factor 11, Procedures.

NUREG-0700 provides guidelines on alarm definition, processing, control and management, response, testing, etc. Bruce B has two separate alarm annunciation systems: 1) An MCR annunciator system for close surveillance, routine checks, and immediate action in case of abnormal conditions; and 2) Local field annunciators for surveillance in the field.

The MCR alarm annunciation system consists of computer-driven Cathode Ray Tubes (CRT) and printers, plus illuminated window annunciators, which operate independently of the computers. The annunciation CRTs are the primary source of alarm information for the station and the printers provide a permanent record of all computer generated alarm messages. The window annunciators operate in parallel with the computer-driven CRTs and printers to bring the operator's attention to important alarms or to general system alarms [152].

The field annunciation system consists of local annunciators. B-DG-06700-00001 provides some guidance for annunciation with the focus on characteristics of window annunciation and B-DG-06700-00004, Human Factors Design Guide for Computer Interfaces also provides guidance on annunciation; however, this guideline does not apply to the Digital Control Computer (DCC) or the special CRT-based displays in the MCR. NK29-DG-29-60300-001, Main Control Room and Field Panel Annunciation to address aspects of DCC alarms and BP-PROC-00250 provides guidance on the development of alarm response ([81]). While guidelines exist for the Bruce B annunciation system, no review of the existing system against a modern guideline has been conducted to date. A review of the Bruce B alarm system was not

included in B-REP-06700-00001, Human Factors Review against Modern Safety Standards Human Factors Engineering Summary Report [121].

As discussed in Safety Factor 1, Plant Design, Bruce B uses the Safety System Monitoring Computers (SSMCs) to present information to aid control room personnel during abnormal and emergency conditions in determining the safety status of the plant. The guidance provided in NUREG-0700 section on Safety Function and Parameter Monitoring System should apply to the SSMCs. The SSMCs were upgraded under Capital Project 34141. The B-REP-66468-0001, Human Factors Engineering Summary Report for Bruce B SSMC System Replacement Data General MP200 [153] referenced an earlier version of NUREG-0700 for the analysis documented in the report. At the time, the project could not incorporate the human factors recommendation arising from this program. Despite having done an analysis with input from NUREG-0700, the final upgraded system did not incorporate recommendations that may have contributed to alignment with NUREG-0700 guidelines.

Soft Control Systems are used throughout Bruce B but are differentiated between soft controls that are used in the MCR such as the DCC-X and DCC-Y, and SSMC, which have their own conventions as described in the previous sections and Soft Control Systems that are used outside of the MCR for local control and monitoring systems. B-DG-06700-00004, Human Factors Design Guide for Computer Interfaces [147] is the guidance that would be considered for the design of HFE aspects of Soft Control Systems outside of the MCR. B-DG-06700-00004 does not reference NUREG-0700 or any other guidelines so alignment with guidelines, standards, or codes could not be established for the guidance document or for the soft control systems that exist at Bruce Power.

Bruce Power's communication systems consists of a conventional telephone system, a public announcement system, radio system, maintenance and suit telephone system, and computer-based systems (e.g., email, messaging etc.) [154]. In addition, an approved design still exists for a pneumatic messenger system. NUREG-0700 does not provide any guidance on pneumatic messenger systems or computer-based systems and therefore is not applicable to these types of communication systems. Radio system modifications are in progress for Bruce A, Bruce B, and Centre of Site for Operations and Emergency Services under EC 62649. The expectation is that since these projects will be completed under BP-PROG-10.02, Engineering Change Control [74], which will involve Human Factors as a stakeholder. Upgrades to the Maintenance and Suit Communications Systems are also underway (EC 46251). However, this EC was classified as HF 'None'. No modifications are scheduled for the public address system or the conventional telephone system as both systems were installed and continue to be maintained by Bell Telephone [154]. At this point, it cannot be determined whether the existing communication systems align with the intent of applicable NUREG-0700 clauses.

Part III of NUREG-0700 contains guidelines for the review of workstations and workplaces. Currently, with the exception of providing guidance on the placement of display or control components, little guidance is provided on the design of workstations in the available Bruce Power design guidelines. However, DPT-PDE-00013 [73] references NUREG-0700 as a source of information for guidance when their guidance is lacking. In accordance with DPT-PDE-00013 [73], the Human Factors Analyst can provide NUREG-0700 guidance where applicable or through the governance in BP-PROC-00389, Conventional Safety Programs [48], use BP-SM-00015, Office Ergonomics [50], which helps to match the office workstation environment to the

abilities of the worker. BP-SM-00015 was prepared in consideration of well established provincial guidelines. In general, Bruce Power meets the intent of NUREG-0700 section on Workstation Design.

Workplace Design at Bruce Power is governed by a multitude of documents including national building code and national labour code. Conformance to these codes and standards are governed by BP-PROC-00389 [48]. Specific guidance for work environments applicable to the Bruce B NGS can be found in, but not limited to, the following guidelines and safety manuals:

- B-DG-06700-00003, Human Factors Design Guide: Maintenance, Inspection and Testing [100];
- BP-SM-00063, Workplace Signs [155];
- BP-SM-00043, Working In Hot Environments [51];
- BP-SM-00039, Noise Measurement, Control and Hearing Conservation [156]; and
- BP-SM-00071, Industrial Lighting Requirements [157].

In general, Bruce Power meets the intent of the NUREG-0700 section on Workplace Design.

Part IV of NUREG-0700 has only one section. The section on Maintainability of Digital Systems covers guidance that is meant to improve maintenance personnel's ability to inspect, test, and service units of equipment, modules, components and parts. Important characteristics for maintenance personnel include instrument cabinets and racks, equipment packaging, fuses and circuit breakers, labeling and marking, adjustment controls, test points, and service points. Guidance for the Maintainability of Digital Systems can be found in:

- B-DG-06700-00003, Human Factors Design Guide: Maintenance, Inspection and Testing [100]; and
- B-DG-06700-00005, Human Factors Design Guide for Manual Reactor Maintenance Tooling [102].

B-DG-06700-00005 directly references NUREG-0700 and other guidance documents and B-DG-06700-00003 covers the majority of the topics in this NUREG-0700 Section. In general, Bruce Power meets the intent of the NUREG-0700 section on Maintainability of Digital Systems.

While this high level review illustrated that Bruce Power meets the intent of some aspects of NUREG-0700, there were a number of issues that could not be resolved with the information that was reviewed. These are reflected in the gaps presented in Table A1. All the gaps described in Table A1 are categorized as gaps in guidance.

Table A1: Gaps against NUREG-0700

NUREG-0700 Section	Gap Description
Part 1 Section 1 – Information Display Section 2 – User Interaction Management Section 3 – Controls	No guidelines identified for CRT based displays for Bruce B, even though such technologies are in use for the display of information. Therefore, it is not clear for engineering changes that are applied to such systems, what guidelines are to be used and the extent to which the review conducted against NUREG-0700 applies to Bruce B. This gap also applies to Part 2, Soft Control Systems.
	Field components, particularly those that would be referenced in emergency procedures (i.e. AIMS), were not reviewed against NUREG-0700 or any modern standards or guidelines.
Part 2, Alarm Systems	It is not clear whether the existing alarm system aligns with the intent of NUREG-0700 or other modern standards or guidelines.
Part 2, Safety Function and Parameter Monitoring System	Final upgraded SSMC system did not incorporate recommendations that may have contributed to alignment with NUREG-0700 guidelines.
Part 2, Soft Control Systems	B-DG-06700-00004, Human Factors Design Guide for Computer Interfaces does not reference NUREG-0700, nor does it reference any other guideline, standard, or code.
	As a result of B-DG-06700-00004, Human Factors Design Guide for Computer Interfaces not referencing any guideline, standard, or code for source of the guidance, it could not be established whether soft control systems are reviewed against NUREG-0700 or any other modern guideline or standard.
Part 2, Communication Systems	It is not clear whether the existing communication system aligns with the intent of applicable NUREG-0700 clauses or other modern standards or guidelines.

Appendix B – Clause-By-Clause Assessments Against Relevant Codes and Standards

This appendix presents the clause-by-clause assessments that are performed for this Safety Factor. The PSR Basis Document provides the following compliance categories and definitions for clause-by-clause assessments:

- Compliant (C) – compliance has been demonstrated with the applicable clause;
- Indirect Compliance (IC) – Compliance has been demonstrated with the intent of the applicable clause;
- Acceptable Deviation (AD) – Compliance with the applicable clause cannot be demonstrated; however, a technical assessment has determined that the deviation is acceptable. For this case a detailed discussion and explanation shall be included in the PSR documentation;
- Gap – system design and/or operational improvements may be necessary;
- Guidance: A potential programmatic, engineering, analytical or effectiveness gap found against non-mandatory guidance;
- Relevant but not Assessed (RNA) – The PSR Basis Document defines RNA as "the particular clause provides requirements that are less strenuous than clauses of another standard that has already been assessed". The definition also includes the guidance portion of clauses in which a gap has already been identified against the requirement;
- Not Relevant (NR) – The topic addressed in the specific clause is not relevant to the safety factor under consideration but may well be assessed under a different Safety Factor; and
- Not Applicable (NA) – The text is not a clause that provides requirements or guidance. Also used if the clause does not apply to the specific facility.

B.1. CNSC REGDOC-2.2.2, Personnel Training

In support of the review tasks listed in Section 5, a detailed assessment of REGDOC-2.2.2 has been performed in Table B1.

Table B1: CNSC REGDOC-2.2.2, Personnel Training

Article No.	Clause Requirement	Assessment	Compliance Category
2.	The training system developed and implemented by each licensee shall adhere to the following two fundamental principles: 1. Performance-oriented: Training is preparation for performance on the job. All instruction that is subject to this regulatory document shall focus on essential knowledge, skills and safety-related attributes required to meet job requirements and nuclear-safety-specific needs throughout the lifecycle of the facility. 2. Systematically developed: Training shall be defined, produced and maintained through an iterative and interactive series of steps, leading from the identification of a training requirement to the confirmation that the requirement has been satisfied.	The Worker Learning and Qualification program (BP-PROG-02.02) satisfies the worker qualification and worker training requirements of applicable Bruce Power Licenses and governing acts, codes and standards as referenced in BP-MSM-1 Sheet 0003, MSM - List of Applicable Governing Acts, Codes & Standards - Sheet 0003, commensurate with Bruce Power's business needs including commitments made in Bruce Power's Power Reactor Operating Licence (PROL) application and requirements included in PROL 18.00/2020. As described in BP-PROG-02.02, training programs based on the work performed by personnel shall be systematically developed and implemented so that the required competency is achieved and maintained. Any prerequisite education, experience, and training shall be identified. All training processes and content should comply with the training performance objectives and criteria (TPO&C) as stated in handbook B-HBK-09500-00003. BP-PROG-02.02 states that the procedures and job aids required to implement the Worker Learning and Qualification program shall allow the training elements that support Worker Qualifications, to be created, managed, and conducted using	C

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		a Systematic Approach to Training (SAT) implemented. The Bruce Power training processes shall follow a Systematic Approach to Training to meet the requirements of B-HBK-09500-00003 R000, Training Performance Objectives and Criteria. Specific SAT requirements that allow this are documented in implementing procedures and handbooks. The SAT methodology developed by Bruce Power satisfies the requirements for an iterative and interactive approach to the design of training. This is further illustrated in the assessment of other clauses in this regulatory document.	
3.	Licensees shall ensure workers who carry on licensed activities are qualified to do the work assigned to them through the use of a training system to systematically analyze, design, develop, implement, evaluate, document and manage new training and the revision of existing training, including continuing training. It shall be used whether the training is defined, designed, developed, implemented, evaluated, recorded and managed internally by licensees or externally through vendors or contractors. Requirements included in this section are to be applied in a manner that is commensurate with risk. All requirements shall apply but the associated training-related processes and procedures may vary depending upon the safety significance and complexity of the work being performed. In considering safety, factors to be examined include the relative importance to	In accordance with this clause and CNSC RD-204, Certification of Person working at Nuclear Power Plants, Bruce Power ensures that workers who carry out licensed activities are qualified to do the work assigned to them through the implementation of the training program outlined in BP-PROG-02.02, Worker Learning and Qualification. Certified personnel have the responsibility for the supervision of workers carrying out licensed activities. Training activities associated with certification have an independent stream of relevant procedures that govern the design, development, evaluation and management of personnel who are certified. The numbered items are addressed as follows: 1. Bruce Power identifies performance requirements of a job duty or area relating to a licensed activity by conducting job analyses as described in BP-PROC-00203, Training - Preparing a Job Analysis and BP-PROC-00510, Certification Training - Job Analysis for Certification Training Programs.	C

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	safeguards and security; the magnitude of any hazard involved; the lifecycle stage of the facility; the type of facility or licensed activity; the particular characteristics of the facility or licensed activity (e.g., remote location, densely populated areas with easy access to qualified workers); and any other relevant factors. This regulatory document will serve as a performance-based guideline for licensees holding Class II Nuclear Facilities and Prescribed Equipment licences or Nuclear Substances and Radiation Devices licences. Licensees shall: 1. identify all performance requirements of a job or duty area relating to licensed activities by conducting a job analysis to determine all of the tasks involved 2. define and document the necessary general worker training, initial job training and continuing training requirements for workers, based on a task analysis of the knowledge, and skills required to perform each task and the safety-related attributes required to perform their duties	Initial training and continuing training objectives are outlined in BP-PROG-02.02. 2. Defining general worker training, initial job training, and continuing training requirements for workers is one of the primary objectives of the training program as outlined in BP-PROG-02.02, Worker Learning and Qualification. The task analyses procedure that outlines the process for determining these training requirements are described in BP-PROC-00204, Training - Prepare a Task Analysis and BP-PROC-00511, Certification Training - Task Analysis for Certification Training Programs. 3. Bruce Power has a number of design and development procedures that are elaborated on in the assessments against guidance clauses that are specific to these activities (see clause assessments for Section 5.2 and 5.3). 4. Trainers have training programs that were developed using the systematic approach to training that is implemented for all jobs at Bruce Power. Trainer qualifications are defined in the Training Qualification Document (TQD). Specifically TQD-00039, Trainers, Certification Instructors, and Certification Examiners Training and Qualification Description. This TQD has objectives, job analysis, and needs analysis associated with them. 5. Bruce Power has a suite of Trainee Evaluation procedures	

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	3. ensure that appropriate training is designed, developed and implemented to meet the qualification requirements 4. ensure that trainers meet and maintain documented qualification requirements, particularly in the areas of subject matter expertise and instructional skills 5. ensure that formal evaluations are used to confirm and document that all trained workers are qualified to perform their duties 6. implement a training change-management process that will systematically analyze procedural and equipment changes, changes in job descriptions, and operating experience feedback (including facility and industry-wide events), in order to identify changes to the tasks and task lists and to assess potential training implications leading to training modifications 7. ensure continuing training is provided to workers as deemed necessary through the job and task analyses processes, and that it includes updates to training programs stemming from the change-management process as identified	that encompass a variety of evaluation methods that are elaborated in the assessments against guidance clauses that are specific to the evaluation activities (see clause assessment for Section 5.5). 6. Bruce Power's process for training change control is described in BP-PROC-00209, Training - Administer Training Change Control. 7. Continuing training is administered through BP-PROC-00653, Training - Administer Continuing Training. Each job family training qualification description identifies the continuing training that is needed. Any changes to continuing training is identified through training effectiveness evaluation and implemented through the training change control process described in BP-PROC-00209. 8. The process for training effectiveness evaluation is outlined in BP-PROC-00213, Training - Administer Training Evaluation. 9. Workers records are maintained through Bruce Power's Training Information Management System as described in detail in another clause assessment (see clause assessment for Section 4.0). 10. The level of training required related to nuclear safety is	

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	through the training needs analysis process 8. evaluate training regularly and incorporate the results of the evaluations into a training improvement process 9. ensure that workers' records in support of training and qualifications are established and maintained 10. ensure that workers have a level of training related to nuclear safety corresponding to the duties of their position and employment, including but not limited to radiation safety, fire safety, onsite emergency arrangements, and conventional health and safety	determined through analyses as described in earlier statements of this assessment (see also clause assessments for Section 5.1).	
4.	Licensees shall develop and manage documentation related to all phases of their training including analysis, design, development, implementation and evaluation. Licensees shall maintain records on the training and qualifications of all workers. These records shall be managed and controlled, and may be requested by CNSC staff at any time. Additionally, workers' supervisors and managers shall have immediate, unencumbered and readily available	Bruce Power manages documentation related to all phases of their training through a number of document databases as well as other mechanisms. There is no single document that describes how all analyses, design, development, implementation and evaluation is conducted but instructions regarding documentation are embedded throughout training procedures. Training documentation for all phases of training including analysis, design, and development can be found through the following mechanisms (this list is not exhaustive): o All controlled training documents must follow BP-	C

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	access to the workers' qualification records related to work being assigned or performed. The training record for each worker, including temporary workers and contractors, shall include all qualifications and certifications granted by or relied on by the licensee to fulfill requirements of this document and that are related to the duties of the worker at that facility. Records shall include expiration dates for time-sensitive qualifications and certifications, and all requalification or recertification requirements.	PROC-00068, Controlled Document Life Cycle Management and as such will be filed in accordance with this procedure. The exception being that migration of documents from BATMAN database into Controlled Documents is on-going. o The Training Data Management (TDM) database provides document number assignments (i.e. For Training Needs Analysis (TNA), job analyses, and task analyses), and analyses templates. o Completed TNA documents are filed in accordance with RRA 00403, Training Needs Analyses and Request for Performance Analysis Services and Training (REPAST) Documents as described in BP-PROC-00175, Prepare a Training Needs Analysis or Repast Document. o Certification Training maintains its Job and Task Analyses in the Bruce Authorization Training Management (BATMAN) database o Certification Training Records are filed and retained in accordance with BP-PROC-00574, Certification Training - Filing and Retention of Certification Training Records. o Data used to define qualification structure is entered into the Training Information Management System (TIMS) and documented in a Training Qualification Description	

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		(TQD). The Training Information Management System (TIMS) is a corporate wide application that provides the training and qualification status of all personnel who operate, maintain and provide technical support services for the safe and efficient operation of the power generating stations. Line Management, and the Training Support and Services Division (TSSD) use the application and associated reporting mechanisms to maintain training programs, employee qualifications, training plans, capability profiles and training schedules. BP-PROC-00214, Training - Administer TIMS, outlines how access to the TIMS database is established and how information in the TIMS is managed. The following is a summary of the records that are available to all staff that have access to TIMS through the Bruce Power Intranet including temporary workers and the workers' supervisors: Qualification Registers: Returns Employee qualification information in one of two report formats, either by all the qualifications an employee is linked to or by qualification(s) and all the employees linked to that qualification. The register also provides information regarding the Employee Qualification Status as well as the expiration date for qualification.	

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		Qualification Matrix: Returns a list of all qualifications that a supervisor's employees are linked to, for which location, and their qualification status. Employee Credits: Returns a list of employee credits in one of two formats, either a list of all employees whom have a credit in a specific PEL or a list of all the PELS an Employee has. The credits are linked to specific qualifications. Required and Planned Training: This report enables the users to see any required or upcoming training. If a Program Element (PEL) has a requalification period it will show the expiry date.	
5.	The systematic approach to training (SAT) is a proven and highly successful education and training methodology, which licensees may adopt to meet the requirements in section 3.0 of this regulatory document. SAT is also widely known as the instructional systems design model (ISDM) or analysis, design, development, implementation and evaluation (ADDIE) model. A SAT-based training system provides interdependent functions consisting of analysis, design, development, implementation and evaluation. This cyclic process (see figure 1) allows training to be systematically analyzed, defined, designed, developed, implemented,	The statements in this clause are informational. There are no guidelines or requirements identified in this clause.	NA

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	evaluated, documented and managed – in order to not only meet operational and organizational requirements, but also to react quickly to changes in those requirements. Figure 1: Overview of a systematic approach to training		
5.1	The analysis phase is the foundation of any training course or training program and includes inputs from operational staff, end-users, subject-matter experts and training development experts. Its purpose is to specify the required outcome of the training in terms of essential on-the-job performance as defined by role documents, procedures or written instructions. The analysis should consider the following points: • rationale and purpose of training • scope of the training • target audience • training method • location of the training • timeframe for completion of the training The fundamental processes of the analysis phase	The description of consideration points for analyses are provided in the assessments for the various clauses. - Rationale, purpose, and scope of training as well as target audience (see clause 5.1.1, 5.1.2, and 5.1.4) - Training method (see 5.2.2, 5.2.3, 5.2.4, and 5.2.5) - Timeframe for completion of training (see 5.1.4) - Training location may be dictated by the requirements for training, especially considerations for the use of simulators and/or on-the-job training (see clause 5.2.1)	C

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	are briefly described in the following paragraphs.		
5.1.1	A training needs analysis (TNA) is often triggered by a performance gap or deficiency that has identified training as the solution. A TNA can be used to systematically assess job performance requirements against existing performance (gap analysis) and identify specific areas that require training. A TNA may also be used to assess skills and knowledge gaps created by engineering design and equipment changes, operational changes, revised procedures, and modifications to regulatory requirements.	Bruce Power prepares training needs analyses using BP-PROC-00175, Training - Prepare a Training Needs Analysis or REPAST Document. The TNA is used to support Training Change Requests (TCR) of all natures. A TNA shall be used if Line and Training Management are uncertain whether training is an appropriate intervention, or what specific intervention is appropriate. Guidance for the preparation and content in TNA is provided in Appendix C of the procedure. TNA shall be performed for any TCR associated with: - Any request for a change to a Cross-Functional Training Program or element. - Any significant intent change to an existing training program driven by any reason (e.g., plant design, business process or procedural changes that may pose a significant business risk or significantly impact worker task performance). - A worker performance deficiency that poses a significant business risk or has caused a significant business loss to Bruce Power.	C

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		- Regulatory required training needs analysis.	
5.1.2	To identify all performance requirements of a job or duty area, a job analysis should be conducted to determine all of the tasks involved with all states of the nuclear facility, including normal operations, accident conditions and emergencies. The end result of a job analysis is a list of tasks that should be completed to perform the job correctly. Task difficulty, importance and frequency are considered to determine which tasks need to be part of training and to determine the initial and continuing training content. A task analysis is conducted to determine the method of task performance and associated knowledge, skills and safety-related attributes. While the knowledge and skills should be determined for each task, safety-related attributes need not be developed for each task but can be developed collectively and documented for a job or duty area.	Bruce Power prepares job analyses using BP-PROC-00203, Training - Preparing a Job Analyses and BP-PROC-00510, Certification Training - Job Analysis for Certification Training Programs. The job analyses procedures outline a procedure, which includes guidance on collecting and recording job information, defining the scope, defining the analysis team, and considerations and activities for developing the task list. Once a validated task list is generated, the task list is rated by at least two job incumbents as to the difficulty, importance, and frequency of each task using criteria identified in an appendix of the procedures. The task analyses procedures that outlines the process for determining these training requirements are described in BP-PROC-00204, Training - Prepare a Task Analysis and BP-PROC-00511, Certification Training - Task Analysis for Certification Training Programs. The task analyses procedures outlines the process for identifying the task details as well as the knowledge and skills required to perform the task. Duty areas associated with the task are also identified. Safety related attributes are collectively identified for a Training and Qualification Description (TQD). TQDs are the governing documents that provide an overview of the qualifications and training for a particular Bruce Power work group.	C

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5.1.3	Terminal learning objectives (TLOs) are statements of the tasks that the workers must be able to demonstrate after completing the training. TLOs should be measurable and define exactly when, what and how well the trainee must be capable of performing on the job upon completion of the training. A terminal learning objective should include the following: • Performance statement: states the task to be performed • Condition statement: describes conditions under which the performance must be completed • Standards: state the measurable criteria that describe how well the performance should be completed	Bruce Power has BP-PROC-00206, Preparing Learning Objectives, which is what is used to prepare TERMINAL objectives and ENABLING objectives. Terminal objectives are defined as a statement describing the trainee's expected performance on a specific task upon completion of training. A terminal objective shall contain at least one job-related condition, action, and standard. BP-PROC-00206 is currently being revised to include guidance on writing objectives such that measurability and completion are included as criteria for a standard. The revision is scheduled to be completed by the end of June 2015.	C
5.1.4	A target audience analysis determines the numbers and categories of workers to be trained and, where possible, the characteristics of the individuals who will receive the training (e.g., current job experience and prior background, experience, education and training). This information ensures that the training is designed, developed and implemented at the correct level, and assists with determining any necessary training prerequisites, including the minimum entry	Bruce Power training program does not explicitly describe a target audience analysis, however, it does outline a process with respect to developing Training and Qualification Descriptions. This process is outlined in BP-PROC-00216, Prepare a Training and Qualification Description. The procedure outlines the expectations associated with the development of TQDs. The TQD content requirements relevant to this clause include providing the entry level	IC

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	level education and training.	criteria, the roles and accountabilities associated with the training program for the TQD, the various levels of qualifications necessary, list of qualifications, suggested schedule for completion of qualifications and a list of positions (job documents and assignments) of the employees who are required to be linked to each qualification. TQDs identify all specific qualifications and cross functional qualifications that are required. Employees with the appropriate occupation codes are linked to the required selection of qualifications from the TQD to perform their function by their line supervision. Linking employees to required qualifications generates the training demand. Additionally, BP-PROG-02.02 states that line managers are responsible for developing capability profiles to meet business objectives. Capability profiles define the minimum number of qualifications required by a gang or responsibility centre to accomplish its normal work program over the course of a year.	
5.2	The design phase should include the selection and description of the training and an environment that will enable the trainees to achieve the TLOs determined in the analysis phase. The design phase starts with the results of the analysis phase and ends with a plan for the development of the training. The design phase takes the output from the analysis phase and specifies how the information will be presented and how the knowledge, skills and safety-related attributes will be tested.	Bruce Power's design and development processes are governed by separate procedures applicable to non-certification training and procedures associated with certification training. With respect to the relationship between the analysis phase and the design phase, there is an explicit relationship identified in BP-PROC-00512, Certification Training - Training Design for Certification Training Programs.	C

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	The fundamental processes of the design phase are briefly described in the following paragraphs.	Task statements are produced as one of the outputs of job and task analyses. The task statement from the approved Job and Task Analyses shall be considered equivalent to a Terminal Learning Objective (TLO). The task statement implicitly contains all of the requirements of a TLO. The job-related condition(s) are embedded in the procedure (s), action(s) are embedded in the task statement which is linked to the task performance, and the standard(s) for performance which are governed by GRP-OPS-00038, Bruce A and B Operations Standards and Expectations. In BP-PROC-00216, Prepare a Training and Qualification Description, Section 4.2 describes the contents of a TQD. This section outlines the need to list all job analyses associated with the TQD with the intent to state which qualifications address which tasks in the job analyses. The qualifications taken from the analyses are used to populate Section 5.0 of the TQD and a training program overview is developed.	
5.2.1	As a result of the analysis phase, the target audience should have been broadly defined. During this phase, the trainee characteristics should be further described in terms of their entry-level knowledge, skills and safety-related attributes, and those characteristics likely to affect their responses to particular instructional activities. Information obtained in this process will guide subsequent decisions such as those regarding appropriate instructional sequences,	Within Bruce Power, the audience is defined through the development of the Training Qualification Descriptions (TQD) with input from the job and task analyses. The TQD provides information with respect to entry level criteria, skills and training required by Bruce Power personnel to perform assigned tasks identified in a specific TQD independently. The TQD also identifies the training program structure and outlines the program elements (i.e. Course, exam, field checkout, job performance measure, administrative requirements and entry level requirements) required for each	C

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	methods and media, and help tailor the training to trainees' needs and learning characteristics.	qualification. BP-PROC-00512, Certification Training - Training Design for Certification Training Programs outlines the design process for certification training programs. An output of the analysis phase includes a validated task list. During the design phase, a key activity outlined in BP-PROC-00512 is selecting the task training relevant to each task in the validated task list. Experienced training and operations SMEs will analyze the task list and determine the most appropriate training setting and required level of training performance for each task. Training settings for certified candidate training are selected both at the Terminal Learning Objective (TLO) task level and at the knowledge Enabling Learning Objective (ELO) level. The selections of task training settings and of task minimum training performance will be recorded in the task-to-training matrix (started during the job analysis phase of Systematic Approach to Training [SAT]). Tasks from the list can be assigned ratings that will determine whether there will be simulator training and/or On-the-Job training. In addition, all tasks will be assigned training modules to meeting knowledge objectives. The modules typically consist of candidate materials, classroom instructor materials, and simulator instructor materials. A task assignment to a module means that the preponderance of the knowledge required to perform the task is covered in that module.	

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		The process identified in BP-PROC-00512 also outlines activities associated with: - designing a means for documenting performance during training implementation (i.e. Designing qualification cards), - developing, approving, and distributing training objectives (this entails mapping tasks and objectives to modules), - grouping and sequencing the modules based on learning objectives, and - specifying performance evaluations	
5.2.2	The instructional program design determines the knowledge, skills and safety-related attributes required to perform a task. These knowledge, skills and safety-related attributes lead to enabling objectives (EOs), which document the knowledge, skills and safety-related attributes. These EOs are then grouped and sequenced into the order most suitable for learning.	Bruce Power has BP-PROC-00206, Preparing Learning Objectives, which is what is used to prepare TERMINAL objectives and ENABLING objectives. Enabling objectives, according to this procedure, may contain conditions, actions, and standards as appropriate to communicate the performance expectation. The process for grouping and sequencing the objectives order most suitable for learning for certification training programs is described in BP-PROC-00512.	C
5.2.3	EOs are the principal units of learning and constitute a major step towards achieving the associated TLOs. As sub-components of TLOs, EOs represent manageable units of work: units that are coherent in terms of logic, learning of	Bruce Power has BP-PROC-00206, Preparing Learning Objectives, which is what is used to prepare TERMINAL objectives and ENABLING objectives. The procedure outlines the requirements for both types of objectives to have the three essential parts stated within the objectives.	C

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	work, and that have a suitable scope and are appropriate for testing learning progress. Like a TLO, an EO is composed of three essential parts: • Performance statement: an observable action normally stated as one action associated with a single verb. If the action is complicated or if more than one verb is used, then the EO needs to be broken down further into other EOs with simple actions. • Conditions statement: a description of the setting or conditions under which the task is to be performed. Ideally, the conditions should mirror those in the workplace where the operation is performed. • Standard: one or more measurable criterion stating the level of acceptable performance of the task in terms of quantity, quality or time limitations. It should answer questions such as “How many?”, “How fast?” or “How well?”	Although, for all intents and purposes, terminal objectives are defined through task statements generated from task analyses as described in BP-PROC-00512, Certification Training - Training Design for Certification Training Programs.	
5.2.4	A learning assessment plan describes the use of formal evaluations within the qualification program. The learning assessment plan determines how progress towards, and achievement of, the required performance is checked and verified. While an assessment should be based upon the performance defined in the TLOs or EOs, limiting factors (such as time)	Bruce Power's training program does not seem to explicitly call for learning assessment plans in the training design procedures reviewed. However, BP-PROC-00512, Certification Training - Training Design for Certification Training Programs outlines an activity to specify performance evaluations, which satisfies the intent of a learning assessment plan.	IC

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	may not permit direct observation of the full range of desired performance. The assessment plan describes how a valid and reliable sample of trainee performance will be measured and evaluated.	Task performance for certification training programs at the "individual perform" level is evaluated using performance evaluations. Performance evaluations for certification training programs are implemented using the following processes: Comprehensive Test Scenarios (CTSs): This type of performance evaluation is used to evaluate trainee performance during simulator progress tests and milestone examinations. These documents are dynamic scenarios consisting of integrated sequences of malfunctions that simulate a succession of abnormal plant conditions, failures or upsets, and that require the candidate to demonstrate the generic abilities, including directing the station response team. These evaluations will be used during the simulator skills phase of certification training. Refer to BP-PROC-00569, Certification Training - Development and Administration of Comprehensive Simulator-Based Examinations for Initial Certification Training Programs, as a guideline to develop a CTS. Performance Evaluations (PEs): This form of evaluation is used to evaluate trainee competence in simulator and on-the-job training settings. For non-certification training, BP-PROC-00207, Prepare a Job Performance Measure (JPM) describes the process for developing job performance measures that identifies:	

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		- Terminal Objectives. - Training Session Directions. - Evaluation Session Directions. The JPM document may contain a separate section for a Pre-Task Knowledge Assessment for the training session. Enabling objectives shall be identified if a Pre-Task Knowledge Assessment is used. The JPM document may contain a separate section for a Post-Task Knowledge Assessment for the evaluation session. Enabling objectives shall be identified if a Post-Task Knowledge Assessment is used. Need SME Input: Are the TQDs more appropriate "backbone" for lesson assessment plan?	
5.2.5	The instructional strategy is the combination of media, methods and environment used in the delivery of training. The advantages and disadvantages of each instructional strategy, as applied to the TLOs and EOs, should be examined to ensure that the most effective solution is selected to produce graduates capable of performing tasks as indicated in the TLOs.	Bruce Power is in the process of developing a training qualification and program design procedure. As an interim measure B-HBK-09500-00009, Training - Qualification Design, was recently issued. A project is underway to develop and issue a procedure to replace the handbook. BP-PROC-01001, Training - Training Design, has been reserved and the procedure will be issued before the end of 2016. Considerations for instructional strategy will be included in the development of this procedure.	C

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5.2.6	On-the-job training (OJT) requirements should be considered when one or more of the TLOs may not be suitable for traditional instructional methods. If OJT is necessary, then OJT learning objectives, complete with performance statements, conditions and standards, should be produced. Subsequently, each OJT learning objective should be formally assessed using on-the-job evaluation.	BP-PROC-00512, Certification Training - Training Design for Certification Training Programs identifies the process for determining when On-the-Job training may be suitable for certification training. Often On-the-Job training is not done without equivalent simulator training. Bruce Power implements On-the-Job training through BP-PROC-00211, Administer On-the-Job Training (OJT) and On-the-Job Evaluation (OJE) and through BP-PROC-00207, Training - Prepare a Job Performance Measure.	C
5.2.7	The training development plan documents the decisions made during the design phase. Outcomes and decisions regarding items covered in sections 5.2.1 through 5.2.6 should be documented and used during the development phase.	BP-PROC-00512, Certification Training - Training Design for Certification Training Programs identifies that a training development plan will be produced as a part of the design phase. Training development plans for each facility and position-specific training program are developed. As a minimum, the development plan will include the grouped and sequenced module design documents as well as a simple milestone bar chart (e.g., Gantt chart) to indicate major development activities. The development plan will be reviewed on a regular basis with the Certification Training Section Managers and the Training Program Review Committee Chair to ensure program requirements are met.	C
5.3	The development phase involves the procurement or production of effective instructional materials in accordance with the training development plan.	This clause is informational only.	NA

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	The fundamental processes of the development phase are briefly described in the following paragraphs.		
5.3.1	Instructional materials should support the learning activities. Such items include instructor lesson plans, interactive courseware such as computer-based training and training aids of all types including equipment, references, job aids and testing materials. The instructional materials should include the following, where necessary: • Trainee manuals: These are reference handbooks to be used and often retained by the trainees. • Instructor guides: These are instructional specifications for use by the instructor during training preparation and delivery. They outline the specific training steps that must be used to satisfy the training development plan. • Handouts: These additional aids can supplement the trainee manuals in areas identified as difficult and/or particularly important. • Computer-based training or other media: These are to be used where they are the recommended solution based on the instructional analysis and the selection of the instructional strategy.	Bruce Power's process for the development of instructional materials are contained in the following procedures, which meet the expectations of the clause: - BP-PROC-00208, Training - Prepare Lesson Plans, Course Material, and Training Aids - BP-PROC-00201, Training - Prepare Questions & Answer Banks, Test Sample Plans, Test Plan Plans - BP-PROC-0752, Training - Prepare and Administer Computer Based Training - BP-PROC-00513, Certification Training - Training Development for Certification Training Program - BP-PROC-00566, Certification Training - Standards and Methodology for Certification Training Progress Tests - BP-PROC-00568, Certification Training - Development and Administration of Comprehensive Written and Oral Examinations - BP-PROC-00569, Certification Training - Development and Administration of Simulator Based Examinations for Initial Certification Training Programs	C

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	• Question banks and some sample tests: When used during the training, these should include guidance on where and when they should be used.		
5.3.2	Assessment tests, which address the requirement for formal evaluation, cover both progress and final testing. In general, there are two types and both should be developed. Knowledge or cognitive assessments: Usually written, these tests can include multiple choice, multiple response, dichotomous or binary (e.g., yes/no; true/false), matching, resequencing, and open-ended questions. Performance or skill-based assessments: These are practical tests based on realistic scenarios of the most important and significant skills and safety-related attributes derived from the TLOs and EOs.	This clause is informational and it is clear from the assessment of previous clauses and the references to procedures in those clauses that Bruce Power develops knowledge-based assessments as well as performance or skill-based assessments.	C
5.3.3	To assess the effectiveness of the training and related materials, these materials should be reviewed by subject-matter experts, tested with individuals who are representative of the target training audience, and approved by the appropriate managers. The training and instructional materials should be revised according to the findings of the trials.	Bruce Power provides governance for Pilot Deliveries. A Pilot Delivery, as described in BP-PROC-00208, is a trial or dry run of a course. Usually it is used to evaluate the adequacy of new or revised lesson plans, course materials and / or training aids. BP-PROC-00208 provides guidance with respect to pilot	C

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		deliveries as follows: "The Training Manager may approve a Lesson Plan and training material for specific deliveries, such as pilot deliveries, by writing the specific approval time period on the cover page(s). Pilot deliveries are conducted at the discretion of the Training Manager. Subject Matter Experts (SME) as required to perform "Technical Quality" reviews (FORM-11279). Training - Lesson Plan Training Quality Review Check Sheet." Pilot deliveries are also identified in BP-PROC-00513. BP-PROC-00513 states that "...effectiveness of the developed training materials should be tested in pilot training deliveries using a typical Instructor and group of students for whom it is intended and the material revised based on the evaluation feedback. If the training program schedules do not allow for this small group evaluation, then the first implementation of the developed materials should be closely monitored and evaluated for areas for improvement. The training materials shall then be revised based on the evaluation feedback."	
5.4	The implementation phase is to enable the trainees to successfully perform the tasks to the standards defined in the TLOs. This phase encompasses both the instructor preparation phase as well as the actual delivery of the training.	Bruce Power governance associated with the implementation phase is encompassed in over 20 procedures listed on Bruce Power's intranet. Procedures can be found for certification training and non-certification training implementation that cover initial training, continuing training, and remedial training. Only procedures that address the bulleted items in the clause are identified here:	C

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	It should include: • lesson plans based on the training development plan and the instructor guides prepared during the development phase • set-up of the training environment • continual monitoring to ensure that learning is taking place • arrangements for follow-on training, where necessary	- The development of lesson plans is addressed by BP-PROC-00208, Prepare Lesson Plans, Course Material, and Training Aids. - Set up of the training environment is covered through the implementation of BP-PROC-00212, Administer Training Delivery - Learning Governance Committee has a mandate to continually monitor that learning is taken place in accordance with government regulations and Bruce Power policy. This is outlined in the B-HBK-09500-00002, Learning Governance Oversight Committees Handbook. - Follow-on training in the form of continuing training and remedial training is outlined in: - BP-PROC-00568, Administer Continuing Training - BP-PROC-00572, Remedial Training for Certification Training Program - BP-PROC-00576, Conduct of Continuing Training Re-Certification Training	
5.5	The evaluation phase involves the assessment of the effectiveness and efficiency of the training as delivered and verification of whether the trainees have mastered the TLOs and acquired the competence needed to perform the job safely.	Training effectiveness evaluation is governed by four main documents. These are: - B-HBK-09500-00003, Training and Performance Objectives & Criteria - B-HBK-09500-00005, Training Performance Objectives	C

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	The evaluation phase includes the following: • Formal trainee evaluation: The trainees' abilities to perform the tasks, as defined in the TLOs, should be measured through tests and assessments. This activity can be included as a process within the implementation phase. • Content and delivery: All course content and instructional strategies, methodologies and activities, including trainee evaluations, are monitored and assessed so that corrective actions can be taken if necessary. Sources of feedback include the trainees, the instructors, the support staff and the responsible managers and supervisors. • Effectiveness: This means the graduates' ability to perform, in the workplace, the tasks for which they were trained. The primary sources of this information are the graduates and their supervisors. Additionally, information may be available through various sources ranging from needs assessments and lessons-learned reports to incident reports and rework statistics. Managers and supervisors should have continuous input to the training. • Change management: In accordance with the principles of a SAT methodology, inputs such as new or revised regulatory requirements, engineering design and equipment changes, operational changes, revised procedures,	Evaluator Reference Manual - BP-PROC-00213, Training - Administer Training Evaluation - BP-PROC-00595, Training Fundamentals In addition to the governing documents, the bulleted points of this guidance clause are addressed through activities embedded in other procedures as well. As an example, instructions associated with change management (i.e. Change to TQDs, changes associated with qualifications, and program elements, training material) are embedded throughout the training procedures and managed through the training documentation management mechanisms discussed in a previous clause (i.e. TIMS, BATMAN, Controlled Document Life Cycle procedure).	

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	modifications and operating experience feedback (including facility and industry-wide events) should be regularly fed into the appropriate processes through the analysis phase.		

B.2. CSA N290.12, Human Factors in Design of Nuclear Power Plants

In support of the review tasks listed in Section 5, a detailed assessment of CSA N290.12 has been performed in Table B2.

Table B2: CSA N290.12, Human Factors in Design of Nuclear Power Plants

Article No.	Clause Requirement	Assessment	Compliance Category
4.1.1	HF in design shall be planned. --- Note: Good practice includes HF in design planning starting at scoping, and the majority completed before the end of preliminary engineering. Best practice includes HF in design planning being completed before the start of preliminary engineering. Detailed planning for HF in design evaluations (refer to Clause 8.6), may be conducted when sufficient detailed design information is available.	All engineering changes are classified to identify the HF level of effort. Annunciation only and design guide only classifications do not require planning. Minor changes require minimal planning and are governed by following DPT-PDE-00001. HF Major Packages do require planning either by following Appendix C template for "Small Majors" or a standalone Human Factors Engineering Program Plan will have to be prepared for packages classified as "Large Major". DPT-PDE-00013 states that "ideally HF should start immediately at the conceptual design phase. The goal is to have the HF work on the project completed before the detailed design work is finished."	C
4.1.2	Plans for HF in design activities shall be revised when needed. --- Notes: 1) Plans for HF in design activities should reflect the entire project scope. 2) Examples include when more design	Provision for the revision of HF in design activities is not identified explicitly in DPT-PDE-00013.	Gap

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	detail is available or when project scope or strategy change.		
4.1.3	Planning for HF in design should determine methods, analyses, evaluations, project interfaces, and tools.	This is understood through the HFE program management element discussed in Appendix B of DPT-PDE-00013. Planning would include discussions of other elements in Appendix B, which encompass methods, analyses, evaluations and tools. Appendix K provides information on project interfaces. In addition, the guidance provided in G-276, which is invoked in DPT-PDE-00013 recommends outlining methodology, analysis, evaluations, and project interfaces.	C
4.1.4	For multiple modifications, the aggregate impact on human performance should be considered.	The assessment of the aggregate impact of multiple modifications is discussed in DPT-PDE-00013, Appendix K, item 4: Human Factors Programs.	C
4.1.5	The risks of interim configurations on human performance and the mitigating measures should be considered. --- Notes: 1) Interim configurations may refer to a) partially installed systems; b) systems installed in only one unit of a multi-unit station; and c) new HSI installed with original HSI serving as temporary back-up.	While interim configuration is not mentioned explicitly, DPT-PDE-00013, Appendix B, Element 11: Design implementation meets the intent of the clause. It is recognized that design modifications will be implemented in a variety of ways (and as a result yielding interim configurations). Examples of different implementation strategies include those identified in the notes of this clause.	IC

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	2) Concerns with interim configurations include a) confusion/distraction due to redundant or non-functional HSIs; and b) workload demands. 3) Potential impacts to be considered include a) procedural needs; b) training needs; and c) personnel qualifications and certifications.		
4.1.6	Planning for HF in design shall consider constraints and drivers. --- Notes: 1) This includes a) HF-related constraints such as operating policies and principles; b) HF-related drivers such as goals for performance improvement; and c) considerations related to construction, commissioning, operation, maintenance, and decommissioning. 2) For the purposes of this Clause, "shall	Discussion on constraints and drivers planning for HF in design is not included in any Bruce Power Human Factors documentation.	Gap

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	consider" means that the user evaluates the impact and documents any decisions (e.g., no action, operating procedures, and design features).		
4.2.1	HF in design activities shall be applied in a graded manner. --- Note: The scope and depth of the HF in design planning, analyses, and evaluation are determined through a graded approach.	DPT-PDE-00013 Section 4.2, Classification discusses the application of a classification system for DCPs that meets the intent of a graded approach.	C
4.2.2	The HF-related criteria and the process used for grading shall be defined.	DPT-PDE-00013 Section 4.2, Classification provides the process and criteria for assigning DCPs to different classifications.	C
4.2.3	The graded approach should choose HF-related criteria based on risk and complexity. --- Notes: 1) Examples of risks include nuclear safety, conventional safety, production, environment, and security. 2) Examples of sources of complexity include design, task, implementation, and project.	The rationale identified in Section 4.2 includes considerations for nuclear risk (references BP-PROC-00539) and complexity (e.g. number of components; systemic changes, affect on annunciation).	C
4.3	Planning for HF in design shall define a) HF in design roles, authorities, and resources within the project organization and the	a) DPT-PDE-00013 Section 7.0, Responsibilities, outlines different roles and responsibilities for Human Factors.	Gap

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	HF in design reporting relationships; --- Note: Examples of authorities include preparers, reviewers, approvers, acceptors, and design authority. b) supporting resources necessary for HF in design work; and Note: Examples include intended users and simulators. c) provision for continuity. Note: This applies to lengthy projects to address potential turnover of the project team.	b) supporting resources necessary for HF in design work has not been identified c) provision for continuity is not discussed	
4.4	Planning for HF in design shall define the following communications: a) information; and --- Note: Examples are plans, recommendations, design notes, analysis results, etc. b) interfaces. --- Note: This includes project interfaces and regulatory interfaces that may be governed by the organization's framework for regulatory	a) Discussed through DPT-PDE-00013, Appendix B elements and Section 7.0 Responsibilities but information exchange is covered in Appendix K and L. b) Interfaces are discussed in Appendix B elements and responsibilities and explicitly discussed for HF analysts and BP HF interface in Appendix L. Framework for regulatory communication is discussed in DPT-PDE-00013 Appendix K.	C

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	communications.		
4.5.1	Planning for HF in design shall identify a) mandatory documents such as regulatory documents, licensing documents, design standards, design organization's policies and procedures applicable to HF in design; and --- Note: Where standards do not fully apply, applicable parts should be clearly indicated. --- b) HF in design guidance documents. --- Notes: 1) This may include any guidance documents that need to be developed. 2) Guidance may be found in documents such as design manuals and studies.	DPT-PDE-00013 identifies relevant statutory, regulatory, and licensing requirements. Design organization's policies and procedures are identified (i.e., BP-PROC-00539 and DPT-PDE-00001). External industry standards are also identified. Note: Internal design guidelines are identified in Appendix H. Appendix H is referenced in Section 4.2 but not in Section 5.0, References and Associated Forms. Additional note: No statement regarding the expectations for identifying applicable design guidelines for project level HFEPPs in Appendix B, HFE program management. Appendix H is only referenced for the Classification of "Design Guide Only". However, it is understood that during planning, that the planning requirements for the HSI design element would include identifying applicable design guidelines.	C
4.5.2	Planning for HF in design should specify the order of precedence of the source documents identified.	DPT-PDE-00013 Appendix B, Element 7 suggests: "The design guides, which capture existing practice, will be followed whenever possible. Where current design guides and current usage do not provide sufficient guidance,	C

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		additional accepted industry standards and guidelines may be applied." This implies that the 'internal' design guides take precedence over industry standards and guidelines.	
4.6	Planning for HF in design shall specify the approaches for identifying and tracking HF in design issues with the system design or the design process. --- Notes: 1) An example is an issues tracking record. 2) Disposition of HF in design issues should be addressed in a timely manner to facilitate their incorporation in the design. 3) Dispositions include justification of acceptability.	DPT-PDE-00013, Appendix B, "Tracking of HFE Issues" Section outlines the approach for identifying and tracking HF in design issues. Note: Approaches for identifying HFE issues are also described in other HFE elements such as analysis, design, verification and validation.	C
4.8	HF in design activities should be integrated with the overall schedule. Note: CSA N286 requires that HF in design activities are scheduled. --- Note: For the purposes of this Clause, "shall consider" means that the Clause is evaluated for impact and any decisions documented.	DPT-PDE-00013, Appendix K, General Human Factors Work Guidelines, Timelines states: "Where it is not appropriate to link activities to a specific date, they may be linked to other activities in the project schedule (e.g., validation will occur prior to issuing any DCNs)."	C

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5.1.1	HF in design shall consider the following interfaces: a) procedure development; b) training development; c) safety analysis; and d) staffing. --- Note: HF in design may identify other interfaces as necessary.	a) The interface with procedure development is discussed in Appendix B, Element 8 & 9: Procedure and Training Program Development. The extent of the interface involves providing information from HF analyses (see Clause 5.1.2) to the development group. b) The interface with training development is discussed in Appendix B, Element 8 & 9: Procedure and Training Program Development. The extent of the interface involves providing information from HF analyses (see Clause 5.1.2) to the development group. c) The interface with safety analysis is described in Appendix B, Element 6: Treatment of Important Human Actions. Only changes or new systems that are identified as nuclear safety risk level 1, 2, or 3, or has impact on an Abnormal Incident Manual action is reviewed to determine the effect on Probabilistic Risk Assessment or Deterministic Safety analyses. Design is addressed to ensure that human actions that are affected are designed appropriately to minimize errors, support detection, and support recovery from errors. d) Staffing - the interface with staffing is described in Appendix B, Element 5: Staffing and Qualification. Staffing is often discussed in conjunction with training.	C
5.1.2	The information common to both HF in design and other disciplines should be shared. --- Note: Examples of information that may be shared are	Since the HF program is embedded in the design change process, information is made available to all disciplines involved with a project. In addition, Appendix B identifies how HF interfaces with a	C

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	a) functional analyses; b) task analyses; c) operating experience; d) staffing analyses and strategies; e) operational analyses and strategies; f) design assumptions concerning HF (e.g., user characteristics and personal protective equipment); g) factors affecting human performance (e.g., ambient temperature, task lighting, task complexity, team dynamics, quality of procedures, and training); h) human performance requirements (e.g., task completion times, task accuracy); i) procedures; and j) training materials, including analyses, lessons, and evaluation information.	discipline on issues related to an element in the HF program.	
5.2.1	HF in design should consider the scope, content, and usability of procedures in relation to SSCs being designed. --- Note: Attention should be paid to human error scenarios that might arise as a result of a new design, or as a result of differences with an older design. These should be considered as inputs for	DPT-PDE-00013, Appendix B, Element 8 & 9: Procedure and Training Program development mentions that procedures and training development is beyond the scope of Bruce Power's site wide HF program. However, information from HFE reports are provided as input to project staff as input to procedure and training program modification and development. While Bruce Power has procedures and processes in place for the development of procedures to ensure clarity and	Gap

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	the development or revision of procedures.	achievability of procedures, the relationship with the Human Factors program does not suggest that HF in design considers the scope, content, and usability of procedures.	
5.2.2	Procedure development personnel may participate in HF in design evaluation activities.	There is no documentation or guidance to suggest that procedure development personnel may participate in HF in design evaluation activities. However, the documentation also does not exclude this possibility and in fact, often personnel that produce procedures or have a significant input into the technical content of procedures are subject matter experts or end users that may participate in HF in design evaluations. This is not documented as a requirement or guidance in either DPT-PDE-00013 or any Bruce Power procedures.	Gap
5.2.3	HF in design should consider the following information: a) equipment manufacturer standard operating and maintenance instructions; and b) plant operating and maintenance instructions.	Bruce Power's Human Factors program, as described in DPT-PDE-00013 does not provide guidance on the sources of information other than regulatory, process and design references.	Gap
5.2.4	HF in design should collaborate with the procedures development discipline to identify and develop procedures.	DPT-PDE-00013, Appendix B, Element 8 & 9: Procedure and Training Program Development mentions information exchange with procedure developers, however, collaboration on the identification and development of procedures is not explicitly discussed.	Gap
5.3.1	HF in design should review the scope, content, and timing of training in relation to new or updated tasks and systems.	DPT-PDE-00013, Appendix B, Element 8 & 9: Procedure and Training Program Development describes information exchange with training personnel, however, it does not	Gap

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	--- Note: This can help the HF practitioner to understand the skills and qualifications of the users.	discuss reviewing scope, content, and training in relation to new or updated tasks and systems.	
5.3.2	Training development personnel may participate in HF in design evaluation activities.	There is no documentation or guidance to suggest that training development personnel may participate in HF in design evaluation activities. However, the documentation also does not exclude this possibility and in fact, often personnel that produce and/or deliver training materials or have a significant input into the technical content of training are subject matter experts or end users that may participate in HF in design evaluations. This is not documented as a requirement or guidance in either DPT-PDE-00013 or any Bruce Power procedures	Gap
5.3.3	HF in design should consider the following training information: a) training needs analysis; b) job/task analysis; c) training design; d) training implementation; and e) training effectiveness evaluations.	DPT-PDE-00013, Appendix B, Element 4: Task Analysis and in Appendix F: Task Analysis for Major Projects, Job Safety Analysis can be used to gather information on the perceived risk areas of a task by the groups performing them. No other input information including training information is discussed in Bruce Power HF documentation. However, Appendix F: Task Analysis references COG-96-348, which suggests training manuals as a source of information.	IC
5.3.4	HF in design may collaborate with the training development discipline to identify and develop training.	There is no documentation or guidance to suggest that HF in design may collaborate with the training development discipline to identify and develop training.	Gap
5.4.1	HF in design shall consider the human actions	Consideration of human actions important to safety is	C

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	important to safety within the safety analysis in relation to the systems being designed. --- Note: The goal is to ensure that credible human actions are included, and that credible estimates of human performance are used in the analyses.	addressed in DPT-PDE-00013, Appendix B, Element 6: Treatment of Important Human actions. This section encourages the design to pay special attention to those plant scenarios, risk-important Human Actions, and HSIs that the PRA/HRA highlights as vital to plant safety and reliability.	
5.4.2	Safety analysis personnel may participate in HF in design evaluation activities.	There is no documentation or guidance to suggest that Safety Analysis may participate in HF in design evaluation activities. However, the documentation also does not exclude this possibility.	Gap
5.4.3	HF in design should consider the following safety analysis information: a) human actions credited in deterministic safety analyses; b) task times assumed in the safety analysis; and c) human reliability analysis.	a) DPT-PDE-00013, Appendix B, Element 6: Treatment of Important Human actions mentions the review of human actions if they affect the PRA or deterministic safety analysis. b) DPT-PDE-00013, Appendix B, Element 5: Task Analysis and Appendix F, Task Analysis for Major projects mentioned time and timeline analyses. Task times assumed in safety analysis is not mentioned explicitly. c) DPT-PDE-00013, Appendix B, Element 6: Treatment of Important Human Actions mentions monitoring and generating HRA (if not already developed) based on nuclear safety risk level.	C
5.4.4	HF in design should collaborate with the safety analysis discipline to identify and analyze human actions.	The interface with safety analysis does not infer collaboration to identify and analyze human actions.	Gap
5.5	HF in design should consider staffing information to ensure that human actions are completed	Staffing information is considering as described in DPT-PDE-00013, Appendix B, Element 5: Staffing and Qualification.	Gap

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	safely and efficiently for the full range of plant conditions and tasks, including a) characteristics of people who carry out tasks associated with the system being designed; --- Note: Characteristics include the qualifications, experience, skills, knowledge, training, anthropometry, gender, fitness, strength, and age of each type of system user or stakeholder. --- b) minimum staff complement; c) staffing levels and staffing goals; and d) impacts of shift schedules.	The analysis considers the organization, number, and distribution of job responsibilities among staff impacted. The characteristics of the personnel who carry out the tasks within a person's job responsibilities is governed by the Worker Learning and Qualification program, BP-PROG-02.02 and is defined in a worker's Training Qualification Document (TQD). HF reviews the potential change to qualifications in conjunction with training. DPT-PDE-00013 does not explicitly discuss the impact of shift schedules. While Bruce Power has Fitness for Duty guidelines, BP-PROC-00610 and a process for Limits of Hours of Work, BP-PROC-00005, these processes do not assess whether a shift schedule has an impact on human performance.	
6.1.1	HSIs and functionality shall be treated not only as an assembly of discrete controls, indicators, systems, or SSCs, but also as an integrated whole. --- Notes: 1) While this is important for all work requiring HF in design effort, it is particularly critical for control centres. 2) Control centres are those areas designed for coordinated team responses. These include	This clause statement pertains to a HSI design principle, which would be embodied in the design guidance references identified in Appendix H of DPT-PDE-00013 and not explicitly discussed in Bruce Power Human Factors documentation. Furthermore, Bruce Power's Human Factors program is integrated into the design change process. Therefore, the extent to which an integrated whole is considered is subject to the scope of a design package. Within a package, HF considers the integrated whole through applying guidance found in Appendix H references. The review of the impact of a design to interfacing systems outside the scope of the design change package is the	AD

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	main control rooms, secondary control rooms, and emergency response facilities. 3) Certain field-based areas may be treated as control centres.	responsibility of the Assigned Design Engineer (ADE) as per BP-PROC-00539, Design Change Package (Section 7.0, Responsibilities). DPT-PDE-00013 may apply to projects outside of the modification procedures where it is deemed that a HF review would provide added benefit. For changes outside of BP-PROC-00539, the determination as to whether the HF review is required will be made by the department manager or above the line requesting the work in conjunction with the Manager, Plant Design Engineering.	
6.1.2	HF in design should progress in an iterative manner. --- Note: As more design data and details become available, they are incorporated.	DPT-PDE-00013 references NUREG-0711 and models the HF program after the NUREG-0711 HFE program elements, which are designed to progress in an iterative manner.	IC
6.1.3	HF in design should use established and systematic practices.	DPT-PDE-00013 references NUREG-0711 and models the HF program after the NUREG-0711 HFE program elements. NUREG-0711 is well established and the program elements were designed to ensure a systematic approach to Human Factors would be applied to design. Appendix H also identifies references to an standards, guidelines, and reference textbooks for conducting analyses and evaluations.	IC
6.1.4	HF in design activities should engage a representative subset of users. --- Notes:	The engagement of a representative subset of users is discussed in DPT-PDE-00013, Appendix D: Operating Experience Reviews for Major Projects and in Appendix G: Validation for Major projects.	C

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	1) Examples of users include field operators, panel operators, maintainers, laboratory technicians, shift managers, and emergency responders. 2) The level, manner, and rigour of user involvement varies commensurate with the grading. 3) Users can provide useful inputs to operating experience review (OER), analysis, and evaluation.	DPT-PDE-00001 also discusses the engagement of users in Section 4.5, Step 1 - Human Factors Minor Change Worksheet: Check out Operating Experience and in Section 4.10, Step 6 - Human Factors Minor Change Worksheet: Validation and Final Checks.	
6.1.5	HF in design should consider the following barriers to human error: a) eliminate the need for that particular task or task step (e.g., automation); b) provide hardware/software interlocks; c) provide design features to promote the correct operation (e.g., additional visual coding); d) provide design features to alert the operator to the error (e.g., additional annunciation); e) procedural changes or warnings; f) additional training; and g) tools aimed at behavioural modification. --- Note: These are listed in order of decreasing effectiveness, although some of these could be	Guidance on the barriers to consider for HF in design is not discussed in Bruce Power's Human Factors program. However, this is design guidance that HF specialists or HF consultants would give based on their training and qualifications. The knowledge and experience expectations for these HF practitioners are defined in DPT-PDE-00013, Definitions and Acronyms.	AD

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	combined to increase effectiveness. The last three should be considered weak barriers.		
6.1.6	HF in design should consider the impact of combining existing systems and new systems on a) human performance; and b) processes and procedures.	While this is considered in DPT-PDE-00013, Appendix B, Element 11: Design Implementation as a variant of how design implementation could take place, the intent of this clause is meant to consider existing and new systems during design and not implementation only. This guidance is not discussed or considered in earlier stages of design in Bruce Power's Human Factors program.	Gap
6.1.7	The results of HF in design activities shall be documented in such a manner that the HF-related design rationale is provided as a basis for informed decisions. --- Note: This includes a) descriptions of HF in design activities carried out; b) the results of those activities; and c) dispositions of HF in design results and recommendations.	DPT-PDE-00013 requires that all HF activities are documented in passport (see Appendix I: Passport V10 Attribute Meanings), in Appendix C Major Projects Human Factors Plan/Report (for small majors) or in a Human Factors Engineering Summary Report. Specifically, Appendix B: Tracking HFE Issues, Element 7: HSI Design, and Element 10b discuss the need to identify deviations (i.e. to design guidance or plan) and the rationale be documented. Furthermore, Appendix K: General Human Factors Guidelines identifies decision making mechanisms should situations arise where key stakeholders do not concur on an issue. The outcome of the resolution process must be recorded in a revision to the HFESR (for majors) or FORM-11221 (for minors) or in the notes for Attribute 7C (for design guide only changes).	C
6.2.1	The graded approach shall be applied during scoping and conceptual design as required.	DPT-PDE-00013 Section 4.2, Classification discusses the application of a classification system for DCPs that meets the	C

Article No.	Clause Requirement	Assessment	Compliance Category
		intent of a graded approach	
6.2.2	The following HF in design activities should be started during scoping and conceptual design: a) OER; b) functional analysis; c) development or selection of HF in design source documents; d) a statement of the operational purpose of the system and the operational requirements under all anticipated conditions; --- Note: This may include a description of the a) working environment; b) plant command and control philosophy; c) staffing concept with an indication of the required personnel capabilities and responsibilities; and d) human-system performance requirements. --- e) identification of scenarios to be analyzed; ---	DPT-PDE-00013 does not provide guidance on when activities should be started except to suggest that the HF should start immediately at the conceptual design phase (Section 4.0) and that specific activities should be linked to dates or other activities in a project schedule.	Gap

Article No.	Clause Requirement	Assessment	Compliance Category
	Note: Inputs to be considered include a) plant, system, and equipment states; b) degraded equipment conditions; c) human actions important to safety; d) operating experience; e) operating procedures; and f) requirements for personal protective equipment. --- f) identification of SSC requirements to support necessary human actions; and --- Notes: 1) Examples of SSC requirements include a) parameters necessary to supervise SSCs; b) parameters necessary to confirm automatic safety actions; and c) controls necessary to manually carry out operator-initiated actions. 2) Necessary human actions include specific activities within operations, maintenance, testing, repair, and inspection that are judged as required for successful outcomes.		

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	--- g) assessment of design concepts and options. --- Notes: 1) The assessment should consider human performance requirements, capabilities and limitations, task requirements, HSI performance requirements, and other design considerations. 2) Consideration should be given to user-configured displays, annunciations, and set-points to ensure safe and appropriate use.		
6.3.1	High-level HF-related requirements shall be documented during early/preliminary design.	DPT-PDE-00013 does not provide guidance on when high level HF-related requirements shall be documented.	Gap
6.3.2	The following HF in design activities should be started during early/preliminary design: a) task analysis; b) modelling, mock-ups, or prototyping of user interfaces; c) evaluations; --- Notes: 1) Examples include	DPT-PDE-00013 does not provide guidance on when activities should be started except to suggest that the HF should start immediately at the conceptual design phase (Section 4.0) and that specific activities should be linked to dates or other activities in a project schedule.	Gap

Article No.	Clause Requirement	Assessment	Compliance Category
	a) usability testing; b) checking against HF in design source documents; and c) inspection-based methods, such as heuristic evaluations. 2) HF-related evaluation of vendor products should be included in the technical specification. --- d) input to specifications and bid evaluations; --- Note: Considerations include a) time necessary for procurement; b) time necessary for the evaluation of vendor submissions; c) technical exceptions; and d) equivalency evaluations for obsolete SSCs. --- e) participation in the assessment of human actions and error consequences; and ---		

Article No.	Clause Requirement	Assessment	Compliance Category
	Note: Examples of assessments include a) human reliability analysis (as part of probabilistic safety assessment); b) safety analyses; c) hazard and operability studies; d) assessments of constructability, operability, maintainability, and safety; and e) failure modes and effects analyses. --- f) assessment of the feasibility of human actions in the deterministic safety analyses.		
6.3.3	The following activities should be completed during early or preliminary design: a) OER; b) development or selection of HF in design source documents; c) functional analyses; and d) a statement of the operational purpose of the system and the operational requirements under all anticipated conditions.	DPT-PDE-00013 does not provide guidance on when activities should be started except to suggest that the HF should start immediately at the conceptual design phase (Section 4.0) and that specific activities should be linked to dates or other activities in a project schedule.	Gap
6.4.1	The following HF in design activities shall be	DPT-PDE-00013 does not provide guidance on when activities should be completed except to suggest that the HF	Gap

Article No.	Clause Requirement	Assessment	Compliance Category
	completed during advanced or detailed design: a) detailed HSI design; b) confirmation of the feasibility of human actions important to safety in the probabilistic and deterministic safety analyses; and c) where applicable, design integration of COTS products.	work should be completed before the detailed design work is finished.	
6.4.2	The following HF in design activities should be completed during advanced or detailed design: a) analyses to confirm the ability of the human to perform necessary actions; b) usability testing; c) verification; --- Note: Verification should be carried out before the design is released for construction. --- d) validation; and --- Note: While validation is important during design, validation activities could be split between detailed design and implementation. --- e) output of HF in design analyses for the	DPT-PDE-00013 does not provide guidance on when activities should be completed except to suggest that the HF work should be completed before the detailed design work is finished.	Gap

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	development of training manuals, operating procedures, and commissioning procedures.		
6.5.1	For designs with HF impact, HF in design shall identify activities to be integrated with design implementation. --- Note: An example for installation includes hold points for inspection.	While DPT-PDE-00013, Appendix B: Design Implementation section does not explicitly identify activities to be integrated with design implementation, it does state that: "Required review and support will be identified based on the method selected." In the context of the paragraph, "method" refers to the method for implementing the engineering change. "Support" in the sentence has been interpreted to include activities to be identified as integrated with design implementation.	IC
6.5.2	Changes initiated during implementation shall be reviewed for their impact on the HF aspects of the design.	DPT-PDE-00013, Appendix B, Element 11: Design Implementation suggests that during design implementation, any areas where implementation activities may impact negatively on human performance will be reviewed to ensure adequate protection against error will be available. Additionally, Appendix I: Passport V10 Attribute Meanings suggests that even if HF work is complete, it does not preclude the possibility that further HF work will be performed due to field change notices applied to the project.	C
6.5.3	Evaluation of the as-built design shall be performed. ---	DPT-PDE-00013, Appendix B, Element 11: Design Implementation suggests that the design be implemented in a manner that ensures that the as-built design conforms to the verified and validation design. However, there is no	Gap

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	Notes: 1) Examples include equipment location, accessibility, panel layouts, instrument configuration, identification, and indication. 2) The HF in design plan should specify the need for participation in a walk-down. ---	discussion on evaluation of the as-built design. For example, Appendix B, Element 11 mentions that design verification will be conducted but does not suggest what it should be conducted on. The presumption, based on the content of Element 11 is that the design verification is conducted on the design as presented in design documentation.	
6.5.4	HF deficiencies identified during commissioning shall be addressed prior to declaring the system available for service. --- Note: Deficiencies may be addressed by a) changing the design; b) correction of the installation; or c) provision of a disposition.	DPT-PDE-00013 provides clear guidance on the close out of a design change notice and subsequently a design change package only when the HF work is complete and the issues resolved (DPT-PDE-00013, Appendix B, Tracking of HFE Issues, Appendix K: General Human Factors Guidelines, and Appendix I: Passport V10 Attribute Meanings). However, BP-PROC-00539, Section 4. 9.1 Close-out discusses the expectations for close-out as being within a certain number of days of AFS as opposed to prior to the declaration of AFS. Specifically, BP-PROC-00539, Section 9 states: "Permanent Design Change packages (DCN, DCPS) shall be closed out within 120 days of Operations Acceptance (i.e., the date Milestone 710 OPS FIN AFS is signed off), or in the case of DCN EQUV, AND DCPE EQUV they shall be closed out within 120 days of Maintenance AFS (i.e., the date Milestone 680 is signed off). For vendor produced closeout packages, the vendor must deliver the package to the Bruce Power RDE within 90 days of AFS. This corresponds to our internal requirement that Bruce Power Drafting deliver the drawings to the RDE within	Gap

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		90 days. DCPs shall be closed out within 30 days of the last of all the other DCNs being closed out (i.e., the date the DCN status has been set to COMPLETE or CANCELLED)."	
7.1	The rationale for the selected analysis techniques shall be documented. --- Notes: 1) Examples of analysis techniques (see Annex B) are a) OER; b) functional analysis; c) task analysis, as follows: i) human error analysis; ii) workload analysis; iii) physical demands analysis; and iv) communications analysis; and d) link analysis. 2) The output of one analysis may be used as input to another analysis.	DPT-PDE-00013 discusses the rationale for selecting tasks and scenarios to analyse and provides flexibility for various techniques that can be used (e.g. Appendix B, Element 4: Task Analysis) but it does not mention providing rationale for the analysis techniques that should be used and that this rationale must be documented.	Gap
7.2	Analysis recommendations shall be addressed. ---	All issues must be addressed as stated in DPT-PDE-00013, Appendix B, Tracking of HFE Issues. This section suggests that issues that should be flagged include any HF concerns that cannot be resolved in the short term due to insufficient	IC

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	Note: Recommendations can be addressed by a) incorporation into the design; or b) provision of a disposition.	information, issues relating to design tradeoffs, or any other factors that could influence the timeliness of the HF resolution. Furthermore, Appendix K: General Human Factors Guidelines identifies decision making mechanisms should situations arise where key stakeholders do not concur on an issue. The outcome of the resolution process must be recorded in a revision to the HFESR (for majors) or FORM-11221 (for minors) or in the notes for Attribute 7C (for design guide only changes). Appendix I: Passport V10 Attribute Meanings also provides guidance on setting Attribute 7C HF complete to 'Y' when there are no outstanding recommendations on the DCN completed. While DPT-PDE-00013 focuses on addressing issues as opposed to recommendations, issues are often accompanied by recommendations.	
8.1	The HF in design evaluations should determine if the design a) conforms to HF design requirements and source documents; b) supports user performance; and c) supports operational goals.	The extent to which the design conforms to HF design requirements and source documents as well as supports user performance and operational goals is determined through the verification and validation activities that are described in DPT-PDE-00013, Appendix B, Element 10a: Verification and Element 10b: Validation.	C
8.2	Detailed HF in design evaluation planning should be documented prior to evaluations. ---	Guidance associated with detailed evaluation planning is stated in DPT-PDE-00013, Appendix G: Validation for Major Projects.	C

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	Notes: 1) This is often an activity that is separate from the initial HF in design planning. Evaluation planning requires a level of design detail typically not available during initial HF in design planning. 2) Considerations for evaluation planning include a) the number of trials; b) the diversity of evaluation measures (subjective and objective measures); c) acceptance criteria; d) tasks to be evaluated; e) number of participants and their characteristics; and f) training. 3) For a high-fidelity evaluation, the testbeds, procedures, users, and scenarios should closely match the final configuration.		
8.3	Where an evaluation is performed, it shall be against criteria selected for the design. --- Note: Examples of criteria include HF in design requirements and source documents.	DPT-PDE-00013, Appendix G: Validation for Major Project discusses pass and fail criteria but does not refer to criteria that may be driven by HF requirements and source documents. However, Appendix B, Element 10a: Design Verification identifies the need to verify that the design meets task support verification (all information and controls identified in earlier analysis are present) and HF design verification (HF	C

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		guidelines are met).	
8.4	Situations that challenge human performance should be included in the evaluations.	DPT-PDE-00013, Appendix G: Validation for Major Projects provides guidance on scenario selection, which takes into account situations that challenge human performance.	C
8.5	Evaluations should be conducted throughout the project. --- Notes: 1) Evaluations can provide data to guide the detailed design. 2) Where appropriate, certain HF-related evaluations can be performed during installation and commissioning.	DPT-PDE-00013 does not provide detailed guidance for when evaluations might be conducted throughout the project.	Gap
8.6	The following evaluation approaches (see Annexes C and D) may be used: a) usability trials; b) inspection-based evaluations; c) verification; and d) validation.	DPT-PDE-00013, Appendix B and Appendix G describe verification and validation activities but does not preclude the usability trials and inspection-based evaluations.	Gap
8.7	The scope, method, and details of evaluations should consider a) importance of tasks;	DPT-PDE-00013, Appendix G: Validation for Major Projects, describes the approach for the validation method, scenario selection (scope), and fidelity of the evaluation to consider. While the document does not specify the bulleted items in the clause explicitly, it is understood that the guidance in itself is	C

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	b) past experience with similar tasks; c) similarity to existing designs and tasks; d) expected task difficulty, including time pressures, task complexity, and cognitive effort; e) extent of the modification or design; f) a range of operational contexts; g) evaluation platforms; and h) fidelity of the test environment.	not the validation plan, which is generated at the project level.	
8.8	Where available, the evaluation test subjects should be independent from the design team for the final and late-stage evaluations.	This guidance could not be found in Bruce Power Human Factors documentation. The independence of subject matter experts that may be recruited to be involved in validation exercises is not explicitly discussed.	Gap
8.9	An HF practitioner independent from the design team should review the plans for the final or late-stage evaluations.	This guidance could not be found in Bruce Power Human Factors documentation.	Gap
8.10	Evaluation recommendations shall be addressed. --- Note: Recommendations can be addressed by a) incorporation into the design; or b) provision of a disposition.	DPT-PDE-00013 emphasizes in several areas throughout the document the need to address and close out issues and recommendations. For example, in Appendix B, Tracking of HFE Issues suggests that issues that should be flagged include any HF concerns that cannot be resolved in the short term due to insufficient information, issues relating to design tradeoffs, or any other factors that could influence the timeliness of the HF resolution. Appendix I: Passport V10 Attribute Meanings also describes	C

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		the documentation of outstanding issues in passport attributes.	
8.11	For evaluations of COTS products, or where a largely pre-developed design is being considered, the HF in design should define the HF-related requirements and criteria against which the design is to be evaluated. --- Note: Examples of bases for requirements and criteria include a) analysis of the adequacy of the HF in design work carried out by the vendor; b) establishing user requirements for the product, including transfer of training issues; c) analysis of tasks and intended context of use for the COTS product; d) consideration of interfaces of the product with other plant systems; e) identification of usability, safety impact, and human performance issues in the anticipated contexts of use; and f) impacts on maintenance, training, and procedures.	BP-PROC-01003, Commercial Grade Dedication outlines a process for acceptance of commercial grade items for use in nuclear-safety related applications. The process does not explicitly identify HF in design as an input in defining critical characteristics for design that are essential to an item form, fit, and function and the Bruce Power HF program as described in DPT-PDE-00013 does not reference this procedure.	Gap
8.12	Where COTS products are proposed and there is foreseeable impact on HF, evaluation of the potential COTS options should be carried out.	BP-PROC-01003, Commercial Grade Dedication outlines a process for acceptance of commercial grade items for use in nuclear-safety related applications. The process does not	Gap

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		explicitly identify HF in design as an input in defining critical characteristics for design that are essential to an item form, fit, and function and the Bruce Power HF program as described in DPT-PDE-00013 does not reference this procedure.	