ONTARIO POWER GENERATION

System Design Requirements

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Title:
PRELIMINARY DESIGN REQUIREMENTS FOR THE DARLINGTON HEAVY WATER MANAGEMENT BUILDING WEST ANNEX

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Darlington Nuclear

System Design Requirements

SCI: 38000

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Revision Summary

Revision Number R000	
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R000	Initial Issue.

1.0 Purpose and Scope

The purpose of this document is to establish the design requirements for an annex to the Darlington Nuclear Generating Station (DNGS) Heavy Water Management Building (HMWB) to address the following business needs:

- Transfer and store the full volume of Moderator, Primary Heat Transport (PHT) and PHT auxiliary systems for two units.
- Additional storage capacity to provide adequate flexibility to segregate different streams of Heavy Water (D2O).
- Equipment and systems for the handling, cleaning, testing and disposal of Heavy Water storage drums to reduce OPG Nuclear's drum backlog and improve station efficiency and safety.
- Permanent office space to accommodate Heavy Water Management Building/Tritium Removal Facility (HWMB/TRF) personnel.

The facility shall be identified as the Heavy Water Management Building West Annex, herein referred to as the "West Annex".

2.0 Design Requirements

The West Annex shall include the following:

- Building
- Storage and Process Systems
- Drum Handling System
- Office Space

The West Annex shall enclose storage and process systems, the drum handling system and the office space, and shall be located inside the protected area, immediately west of the HWMB. The West Annex may be a standalone building or may be physically attached to the HWMB.

2.1 Functional Requirements

2.1.1 Building

Functional requirements for the West Annex Building are as follows:

2.1.1.1 House, protect and support equipment and staff required for the Heavy Water Management functions stated herein.

2.1.1.2 Prevent the loss of heavy water and the escape of radionuclides beyond the D2O storage areas.

2.1.1.3 Provide appropriate accessibility and spacing for safe installation, operation and maintenance of equipment.

2.1.1.4 Provide protection shielding from high hazard radioactive work areas.

2.1.1.5 With exception of the Office Space, the Building shall be classified as Radiological Zone 3.

2.1.1.6 Provide access for transport trucks to accommodate loading and unloading shipments of tritiated Heavy Water.

2.1.1.7 Accommodate system connections between the West Annex and the HWMB.

2.1.1.8 Protect against fires and smoke throughout the Building through the use of a fire and smoke detection system and a fire suppression system.

2.1.1.9 The Building shall be constructed with provisions to meet the requirements of the National Building Code of Canada (NBCC) including Zone 1 seismic requirements.

2.1.1.10 The portion of the structure that encloses the Heavy Water storage tanks shall be seismically qualified to Category “D” standards in a Design Basis Earthquake (DBE) as defined in the Nuclear Safety Design Guide, NK38-DG-03650.2B.

2.1.1.11 Provide meters for identifying the amount of electricity consumed in the Building. This requirement shall be validated in the Conceptual Design Report (CDR).

2.1.1.12 With the exception of the Office Space, the concentration of tritium in air shall be continuously monitored within the Building.

2.1.1.13 Maintain limits of groundwater collection during construction and operation of the Building through the use of a drainage system.

2.1.1.14 Provide fume hoods around areas of high chronic emissions including sampling, drum pressure testing and cleaning areas.

2.1.1.15 Control air leaving the Building from contaminated or potentially contaminated areas for iodine, C14 and particulate through a contaminated exhaust stack.

2.1.1.16 Ventilation shall ensure air flow from lower radiological zones to higher radiological zones only.

2.1.1.17 Provide a heating system, ventilation system and air conditioning system to maintain and control conditions.

2.1.1.18 Include a public address (PA) system to distribute voice instructions, and emergency warning signals to all areas of the Building based on input from Unit 0 or HWMB/TRF Control Rooms.

2.1.1.19 Provide a system for interface between phones and information technology (IT) systems in the building and the main DNGS telephone and IT system.

2.1.1.20 Include provisions for collection and segregation of active, inactive and sewage waste streams.

2.1.1.21 Curbs and active drainage sumps shall be provided to enable recovery of tritiated Heavy Water in spills or leaks.

2.1.1.22 Provide domestic hot and cold water for personnel water needs, including emergency eye wash stations and showers.

2.1.1.23 Provisions for breathing air for personnel protection equipment (PPE).

2.1.1.24 Provision to house control equipment room panels, cubicles, racks, receptacles, junction boxes and field panels required for instrumentation in the Building.

2.1.1.25 Provisions for elevators and lifting devices including cranes, monorails and hoists for personnel, and for drum and equipment handling.

2.1.1.26 An electrical power system shall provide various classes of electrical power and miscellaneous electrical services to satisfy requirements of the Building.

Electrical power will be required to supply equipment such as pumps, compressors, chilled water units, heaters, motorized valves, lighting receptacles, relays, controllers, alarms, annunciating devices, and to systems such as heating, ventilation and air conditioning (HVAC), PA, fire and smoke detection, control systems, office and motor control centre loads.

Specific power classification requirements shall be established in the CDR.

2.1.1.27 A grounding system shall provide a means of protection for personnel, equipment and the electrical power system.

2.1.1.28 The lighting systems shall include the following three subsystems: operational lighting, emergency operational lighting and emergency safety lighting.

2.1.1.29 Adequate protective relaying and auxiliary control logic circuits shall be provided to maintain the integrity of the electrical power system and to protect personnel from electrical hazards.

2.1.2 Storage and Process Systems

Functional requirements of the West Annex Storage and Process Systems are:

2.1.2.1 Through connections to the D2O Supply System (SCI 38110), Downgraded D2O System (SCI 38500) and D2O Cleanup System (SCI 38410), receive, store and send Heavy Water to the following systems:

a) Station Upgrader (SUP) (SCI 38430)

b) Moderator System (SCI 32100)

c) PHT D2O Transfer (SCI 33850)

d) D2O Supply (SCI 38110)

e) Downgraded D2O Transfer (SCI 38500)

f) D2O Cleanup (SCI 38410)

g) Tritium Removal Facility product/feed (SCI 39000)

h) D2O drums (SCI 38910)

This requirement shall be validated in the CDR.

2.1.2.2 The West Annex shall be designed to ensure maximum flexibility in transferring and storing Heavy Water. Tank sizing, configuration and interconnections shall be established in CDR.

2.1.2.3 Tanks shall be provided with valves to permit isolation and draining of each tank.

2.1.2.4 Provide the ability to flush or drain the Heavy Water transfer piping.

2.1.2.5 Provide pressure and vacuum relief of the Heavy Water storage tanks.

2.1.2.6 Provide flexibility to allow parallel use of either ion exchange column of the existing D2O Cleanup System. The modification shall allow clean up of water from the existing Downgraded System or from drums and storage tanks in the West Annex. This requirement shall be validated in the CDR.

2.1.2.7 Provide Instrument Air cover gas for all Heavy Water storage tanks.

2.1.2.8 Provide Instrument Air for the operation of all pneumatic equipment including Instrumentation and Control (I&C).

2.1.2.9 Provide the capability to obtain samples from all Heavy Water storage tanks.

2.1.2.10 Provide the capability to circulate the contents of each Heavy Water storage tank.

2.1.2.11 Provision for preventing D2O freezing in case of a loss of the primary heat source shall be provided.

2.1.2.12 Heavy Water shall be recovered through condensation from the Heavy Water storage tank and drum venting exhaust air and transferred to the Downgraded D2O System.

2.1.2.13 Provide leak detection capability to detect any leaks or spills from the Heavy Water storage tanks and drums.

2.1.2.14 Control valves shall be provided with local position indication as required.

2.1.2.15 Measurement and indication of the D2O levels and inventory in each tank shall be provided locally and in the HWMB/TRF Control Room.

2.1.2.16 An alarm shall be provided in the HWMB/TRF Control Room when each storage tank reaches the high and low levels.

2.1.2.17 Provide control and status indication of each pump at a local field panel. Indication of discharge pressure of each pump shall also be provided.

2.1.2.18 Provide the capability for liquid poison addition to the Heavy Water. This requirement shall be validated in the CDR.

2.1.2.19 Transfer collected liquid D2O to the Downgraded D2O System (SCI 38500) or to the Active Liquid Waste System (SCI 79710).

2.1.2.20 Provision for automatic control of sump pumps.

2.1.3 Drum Handling Systems

Functional requirements of the West Annex Drum Handling Systems are:

2.1.3.1 Store full and empty Heavy Water drums and allow for easy access to each drum.

2.1.3.2 Segregate and shield drums with high radiation fields where required.

2.1.3.3 Provide equipment for pneumatic testing, cleaning and disposal of empty drums.

2.1.3.4 Provide a fixed hoisting device for the insertion/removal of drums into/out of the overpack used for shipments. Specific drum models shall be established in the CDR.

2.1.3.5 Accommodate the use of various drum handling equipment for efficient management of the drum inventory. In particular, drum carts and a forklift shall be used to manage the drum inventory.

2.1.3.6 Accommodate transportation vehicles and loading/unloading of drums between the vehicles and standard shipping containers.

2.1.3.7 Provide emergency decontamination facilities as required.

2.1.4 Office Space

Functional requirements of the West Annex Office Space are:

2.1.4.1 Provide permanent work stations and offices for HWMB/TRF personnel use.

2.1.4.2 Provide support services for HWMB/TRF personnel including washrooms in compliance with OHSA and NBCC requirements.

2.1.4.3 Provide an IT network within the building and connections to the DNGS information management system for local intranet and off-site internet access.

2.2 Performance Requirements

Performance Requirements of the West Annex are as follows:

2.2.1 Building

2.2.1.1 Including maintenance considerations, life expectancy of the West Annex must be 40 years from the available for service (AFS) date.

2.2.1.2 As a minimum, one emergency eye wash station and one emergency shower shall be provided in close proximity to the Drum Handling Systems.

2.2.1.3 Cabling from the electrical power system to the motor loads shall be designed such that the voltage at the motor terminals shall not be less than 90% of the motor rated voltage under normal operating conditions and 80% of the motor rated voltage under start-up conditions.

2.2.1.4 Service and process receptacles shall accommodate the following:

a) 120 Vac, single-phase, 3-wire

b) 600 Vac, 3-phase, 4-wire

2.2.1.5 According to the NBCC, the Building shall be designated as a multiple occupancy building based on the following classifications:

a) With exception of the Office Space, the Building shall be classified as Group F, Division 2

b) The Office Space shall be classified as Group D

2.2.1.6 As required to support all loads in the West Annex, the electrical power system shall include:

a) A Main Supply Transformer

b) 600/347 Vac and 280/120 Vac

c) 48 Vdc and 45 Vdc

d) Cabling, transformers and distribution hardware

2.2.1.7 The electrical power system shall provide an alternate power source for essential loads.

2.2.1.8 With the exception of office areas, ensure that negative pressure is maintained within the Building in order to prevent leakage of D2O and isotope products to the environment.

2.2.1.9 Foundation pile driving shall be completed according to the Geotechnical Report in progress.

2.2.1.10 Foundation slab and retaining walls shall consider the following loads:

a) Dead loads

b) Live loads and environmental loads from superstructure

c) Lateral soil pressure and surcharge live loads during construction at grade floor

d) Hydrostatic loads

e) Thermal loads

2.2.1.11 Penetrations in walls, floors and ceilings shall be sealed, and materials used in shall possess acceptable leak tightness properties.

2.2.1.12 Concrete Design shall satisfy the requirements of CSA A23.3, Design of Concrete Structures, in addition to the NBCC.

2.2.1.13 Structural Steel shall be designed according to the “limit states” and satisfy CSA S16, Design of Steel Structures, in addition to the NBCC.

2.2.1.14 Steel roof decking shall carry full dead and live loads and conform to CSA S136, North American Specification for the Design of Cold-Formed Steel Structural Members.

2.2.2 Storage and Process Systems

2.2.2.1 The West Annex shall store 2100 m^3 of D2O as follows:

		Required Storage Capacity
Refurbishment Needs	Moderator System	700m^3
	Heat Transport System and Auxiliaries	800m^3
Refurbishment and Operational Improvements Needs	Downgraded D2O	200m^3
Operational Improvements Needs	Moderator System, TRF Feed, SUP Product	200m^3
	Heat Transport System and Auxiliaries, TRF Product	200m^3

2.2.2.2 Tank configuration for the 200 m^3 of Downgraded D2O activities shall be as follows:

a) 2 x 25 m3 and 1 x 50 m3 downgraded dirty D2O tanks

b) 2 x 25 m3 and 1 x 50 m3 downgraded clean D2O tanks

2.2.2.3 All Heavy Water storage tanks shall be designed with a margin of 10%, resulting in a requirement of 2310 m^3 of total storage space.

2.2.2.4 Trucks shall be unloaded at a rate of 2.0 L/s and drums shall be unloaded at a rate of 0.5 L/s using instrument air as the motive force.

2.2.2.5 The venting system shall minimize D2O loss and tritium releases to the outside atmosphere such that airborne tritium emissions are below the action levels for DNGS.

2.2.2.6 Provide transfer pumps for the Moderator, PHT and Downgraded D2O storage tanks.

2.2.2.7 Maintain the cover gas pressure in the Heavy Water storage tanks at 13.8 kPag.

2.2.2.8 Provide indication of the fire and smoke detection system to a fire panel in the Building and to the Unit 0 fire panel as well.

2.2.2.9 Alarms, based on derived air concentration limits, shall sound locally, as well as in the HWMB/TRF Control Room.

2.2.2.10 An audible alarm shall be provided locally and in the HWMB/TRF Control Room if either the emergency shower or the eyewash station is operated.

2.2.2.11 Provision for removing total organic carbon (TOC) contaminants from the Heavy Water. This requirement shall be validated in the CDR.

2.2.3 Drum Handling Systems

2.2.3.1 Provide adequate space for the storage of 300 full and/or empty 209.3L (46 imperial gallon) D2O drums.

2.2.3.2 At minimum, the Drum Handling System shall be able to empty six or fill ten 209.3 L (46 imperial gallon) drums in one hour.

2.2.3.3 Requirements for the inspection and testing of Heavy Water drums shall be as in TRANS-TS-03459.TR18-0008, Industrial Packaging Type 2 (Type IP-2) Transportation Packaging (Stainless Steel Drums). Drum Handling systems shall be designed to ensure the capability of meeting the requirements of Division 2C of this specification.

2.2.4 Office Space

2.2.4.1 The Office Space shall include offices for the following uses and designed according to the requirements of N-INS-08965-10049, Design and Layout of Office and Computer Workstation Environments.

a) One (1) conference room (occupancy to be established in the CDR)

b) One (1) field operator office (stratum I/II)

c) One (1) supervising nuclear operator office (stratum I/II)

d) One (1) field shift operating supervisor office (stratum I/II)

e) One (1) section manager office (stratum III)

f) One (1) manager office (stratum IV)

g) Four (4) hotelling stations (stratum I/II)

2.2.4.2 The Office Space shall be designed as separate Radiological Zone, permitting an open office concept with the necessary support services, as required, such as HVAC, water, sewer, lighting, fire protection, LAN, PA, electrical, emergency exits, phones, and stairwells, to meet the JHSA office space requirements.

2.3 Interfacing Systems

Analysis of interfacing systems shall be completed in the CDR.

2.3.1 Basic Requirements Imposed on Electrical Power Supplies

a) 600/347 Vac Power Distribution System shall be used to satisfy the requirements of 2.1.1.26, 2.1.1.29, 2.2.1.4, 2.2.1.6 and 2.2.1.7.

b) 208/120 Vac Power Distribution System shall be used to satisfy the requirements of 2.1.1.26, 2.1.1.29, 2.2.1.4, 2.2.1.6 and 2.2.1.7.

c) 48 Vdc and 45Vdc instrument supply shall be used to satisfy the requirements of 2.1.1.26, 2.1.1.29, 2.2.1.4, 2.2.1.6 and 2.2.1.7.

d) Building Electrical Services including lighting and 208/120Vac receptacles shall be used to satisfy the requirements of 2.1.1.26 and 2.1.1.28.

e) Cable Support Systems (SCI 57000) including Conduits and Fittings (57300) and Cable Trays (SCI 57400) shall be used to satisfy the requirements of 2.1.1.26 and 2.2.1.3.

f) Grounding (SCI 57600) shall be used to satisfy the requirements of 2.1.1.27.

2.3.2 Basic Requirements Imposed on Instrumentation and Control (I&C)

a) The Fire & Smoke Detection system (SCI 67870) and a Fire Suppression System shall be used to satisfy the requirements of 2.1.1.8 and 2.2.2.8.

b) The Fixed Area Alarming Tritium Monitors (FAATM) (SCI 62341) shall be used to satisfy the requirements of 2.1.1.12.

c) The Fixed Gaseous Effluent Radioactivity Monitoring System (SCI 67989) shall be used to satisfy the requirements of 2.1.1.15.

d) The Public Address and Maintenance Communication Systems (SCI 60215 and SCI 60230) shall be used to satisfy the requirements of 2.1.1.18.

e) The Telephone system (SCI 60220) shall be used to satisfy the requirements of 2.1.1.19.

f) The Local Area Network (LAN) (SCI 69040) shall be used to satisfy the requirements of 2.1.4.3.

g) The D2O Leak Detection System shall be used to satisfy the requirements of 2.1.2.13.

h) The Active Plant Drainage System (SCI 67971) shall be used to satisfy the requirements of 2.1.1.20 and 2.1.1.21.

i) The Demineralised Water System (SCI 67425) shall be used to satisfy the requirements of 2.1.3.3.

j) The Domestic Water System (SCI 67270) shall be used to satisfy the requirements of 2.1.1.22.

k) The Steam & Condensate System shall be used to satisfy the requirements of 2.1.1.17.

l) The Ventilation System shall be used to satisfy the requirements of 2.1.1.14, 2.1.1.15, 2.1.1.16 and 2.1.1.17.

m) The Air Conditioning System shall be used to meet the requirements of 2.1.1.17.

n) The existing D2O Management System Computer Hardware (SCI 69791) shall be used to meet the requirements of 2.1.1.24.

o) The Common Instrument Air System (SCI 67516) shall be used to satisfy the requirements of 2.1.2.7, 2.1.2.8, 2.1.2.14 and 2.2.2.7.

p) The Breathing Air System (SCI 67513) shall be used to meet the requirements of 2.1.1.23.

q) The Service Air System (SCI 67511) shall be used to satisfy the requirements of 2.1.3.3 and 2.2.3.3.

2.3.3 Basic Requirements Imposed on Radioactive Waste Management

a) The Active Drainage System (SCI 79710) shall be used to satisfy the requirements of 2.1.1.20 and 2.1.1.21.

2.3.4 Basic Requirements Imposed on Non-Radioactive Waste Management

a) The Inactive Plant Drainage System (SCI 79110) shall be used to satisfy the requirements of 2.1.1.20.

b) The Sewage System (SCI 79120) shall be used to satisfy the requirements of 2.1.1.20.

2.3.5 Basic Requirements Imposed on Service Water Systems

a) The Demineralized Water System (SCI 74250) shall be used to satisfy the requirements of 2.1.3.3.

b) The Domestic Water System (SCI 72700) shall be used to satisfy the requirements of 2.1.1.22.

c) Chilled Water shall be used to satisfy the requirements of 2.1.2.12.

d) The Fire Suppression System shall be used to satisfy the requirements of 2.1.1.8.

2.3.6 Basic Requirements Imposed on Compressed Air Systems

a) The Common Instrument Air System (SCI 75160) shall be used to satisfy the requirements of 2.1.2.72.1.2.8, 2.1.2.14 and 2.2.2.7.

b) The Service Air System (SCI 75110) shall be used to satisfy the requirements of 2.1.3.3 and 2.2.3.3.

c) The Breathing Air System (SCI 75130) shall be used to satisfy the requirements of 2.1.1.23.

2.3.7 Basic Requirements Imposed on Civil Structures

a) The Heavy Water Management System Structures (SCI 23800) shall be used to satisfy the requirements of 2.1.1.7.

2.3.8 Other Requirements

a) The D2O Supply System (SCI 38110) shall be used to satisfy the requirements of 2.1.2.1.

b) The D2O Cleanup System (SCI 38410) shall be used to satisfy the requirements of 2.1.2.1 and 2.1.2.6.

c) The Downgraded D2O Transfer System (SCI 38500) shall be used to satisfy the requirements of 2.1.2.1.

d) The Personnel and Portal monitors (SCI 62321) shall be connected to the LAN network described in 2.1.4.3 as required.

e) The Ventilation System shall be used to satisfy the requirements of 2.1.1.14, 2.1.1.15, 2.1.1.16 and 2.1.1.17.

f) The Air Conditioning System shall be used to satisfy the requirements of 2.1.1.17.

g) The Steam & Condensate System shall be used to satisfy the requirements of 2.1.1.17.

h) An Auxiliary Steam and Condensate System shall be used to satisfy the requirements of 2.1.2.11.

2.4 Design Limits and Strength Requirements

2.4.1 The design and operating conditions for the Heavy Water storage tanks and piping shall be as per existing HWMB facility.

2.4.2 Vacuum conditions for Heavy Water storage tanks shall be addressed in the design.

2.4.3 Materials for storage and process systems, including I&C equipment, shall ensure resistance to corrosion consistent with handling tritiated heavy water.

2.4.4 Electrical equipment shall be designed and analysed for short circuit and other electrical transient conditions as required.

2.4.5 The Building shall be designed to sustain all permanent, temporary, equipment, abnormal, environmental and casual loads in all combinations.

2.4.6 Loads, for which design limits and strength requirements shall be established, include:

a) Dead

b) Design Live

c) Equipment

d) Moving Concentrated

e) Pipes, Cable Pans, Ducts and Others

f) Snow

g) Wind

h) Earthquake

i) Crane or Monorail

j) Rain

2.4.7 The building and its structural steel components shall be checked for serviceability limit states as per the NBCC.

2.4.8 Steel members and anchor bolts shall conform to CSA G40.20/G40.21, General requirements for rolled or welded structural quality steel/Structural quality steel.

2.4.9 Welding of structural steel to conform to CSA W59, Welded Steel Construction and OPG Welding Standard N-STW-04800-10000.

2.4.10 Structural steel design shall make use of high strength bolts, nuts and washers that conform to ASTM A325.

2.4.11 Reinforcing bars shall conform to CSA G30.18, Carbon steel bars for concrete reinforcement.

2.4.12 Structural concrete material requirements shall conform to CSA A23.1/A23.2, Concrete materials and Methods of Concrete Construction/Test methods and standard practices for concrete.

2.5 Seismic Requirements

The portion of the structure that encloses the Heavy Water storage tanks shall be seismically qualified to Category “D” standards in a Design Basis Earthquake (DBE) as defined in the Nuclear Safety Design Guide, NK38-DG-03650.2B.

Seismic qualification of the West Annex shall be in accordance with CSA N289.1, General Requirements for Seismic Design and Qualification of CANDU Nuclear Power Plants and CSA N289.3, Design Procedures for Seismic Qualification of Nuclear Power Plants.

The portion of the building that includes Office Space shall be constructed with seismic provisions to satisfy the requirements of the NBCC.

2.6 Design Constraints

2.6.1 Compared to the HWMB, design of the West Annex shall be improved to facilitate ease of operation and maintenance activities.

2.6.2 An area limited to approximately 24.5 m (East-West) x 50 m (North-South) is available for construction of the West Annex. This shall be validated in the CDR.

However, the proximity of this available area to the existing Standby Generator Oil Storage Tanks may be a constraint under the National Fire Code of Canada (NFCC).

2.6.3 Installation, operation and maintenance of all systems in the West Annex shall not have a negative impact on the performance of the existing systems. Similarly, the installation, operation and maintenance of the existing systems shall not have a negative impact on the performance of the West Annex.

2.6.4 The equipment and systems in the West Annex shall be designed to integrate with the existing systems.

2.6.5 Design of the Office Space, as well as the Building, shall incorporate options for Leadership in Energy and Environmental Design (LEED) where practical and cost-effective.

2.6.6 The existing Heavy Water recovery chillers, 0-38110-HX1/HX2, are currently known to be undersized. Any modifications to this system shall include upgrading the equipment.

2.6.7 No penetrations shall be made through the existing HWMB containment dyke or through a new seismically qualified dyke.

2.6.8 Equipment and systems shall be designed to ensure minimal holdup of Heavy Water in process piping.

2.6.9 Systems shall be designed to minimize D2O loss through leakage.

2.6.10 Systems and equipment shall incorporate human factors.

2.6.11 Unless otherwise stated, connections to storage and process systems and interfacing systems shall be between the West Annex and existing HWMB.

2.7 Environmental Requirements

The West Annex shall minimize adverse impacts on the Environment.

2.8 Reliability Requirements

Process and drum handling systems shall be designed to ensure target unavailability of the system is less than 10^{-3} (ie. out-of-service for a maximum 8 hours per year). This shall be validated in the CDR.

2.9 Maintainability Requirements

Process system and equipment layout shall be designed for ease of maintenance to the extent possible.

Process system and equipment maintenance shall not alter the system design basis.

2.9.1 Storage and Process System Maintainability Requirements

2.9.1.1 Accessibility shall be provided for maintaining equipment with minimal occupational exposure to hazards.

2.9.1.2 Provide for draining piping, equipment and components that require periodic or emergency maintenance.

2.9.1.3 Simplified isolation of failed equipment and components shall be provided.

2.9.1.4 Provide for maintenance of equipment under normal system operation as required.

2.9.1.5 Safety and emergency switches shall be conspicuously identified and ergonomically located to facilitate identification, maintenance and operation in emergency situations.

2.9.1.6 Heavy Water storage tanks shall be arranged to facilitate inspection.

2.9.1.7 Equipment configuration shall be similar to existing arrangements to facilitate maintainability.

2.9.1.8 Systems shall be designed and routed so that personnel can perform in-situ repairs without having to assume awkward working positions.

2.9.1.9 Appropriate platforms, handrails, ladders, or other means of access and egress shall be provided to allow safe and continuous transition to all operation, inspection and maintenance areas.

2.9.1.10 Storage and Process Systems shall not in any way obstruct the maintenance or removal of equipment.

2.9.2 Drum Handling Maintainability Requirements

2.9.2.1 Drum handling equipment shall permit use with ideal body mechanics.

2.9.2.2 Drum Handling Systems shall accommodate all drum configurations during handling, testing and transportation.

2.9.2.3 Drum Handling Systems shall be designed to maximize positive work flow through receiving, storage and processing.

2.9.3 Panel Maintainability Requirements

2.9.3.1 Panel location shall facilitate unobstructed personnel interaction (ie. does not require reaching over other equipment or cabinets to operate or maintain).

2.9.3.2 Labels, annunciation and abbreviations shall follow existing station guidelines as outlined in:

a) D-ED-01520-10001, Darlington Equipment Identification

b) NK38-MAN-60310-10001, Annunciation Design Guide, regardless of applicability to Heavy Water Management systems

c) NK38-MAN-06700-10001, HFE Design Guideline for MCR Panels and Local Control Panels

2.10 Periodic Inspection Requirements

Periodic Inspection Program (PIP) requirements shall be established in the Detailed Design of the facility.

2.11 Safety Requirements

2.11.1 Conventional Safety Requirements

2.11.1.1 Design shall ensure compliance with the requirements of the Industrial Regulations as stated in the Ontario OHSA.

2.11.1.2 Construction shall comply with the requirements of the Construction Regulations as stated in the Ontario OHSA.

2.11.1.3 Design and construction shall ensure compliance with the NBCC.

2.11.1.4 Design and construction of shall also comply with the requirements set out in the OPG Policies and Procedures governing Occupational Safety and Human Factors.

2.11.1.5 Electrical design and construction shall be performed in accordance with applicable electrical safety codes including CSA C22.1, Canadian Electrical Code.

2.11.1.6 Electrical equipment shall be CSA approved and site electrical work shall be inspected and approved by the Ontario Electrical Safety Authority as required.

2.11.1.7 Electrical equipment shall provide adequate isolation capabilities and barriers to allow safe working access consistent with the requirements of the applicable design/manufacturing standards and codes, and current station work protection standards.

2.11.1.8 Electrical equipment shall be fabricated from materials that do not contain Polychlorinated Biphenyl (PCB).

2.11.1.9 The Office Space shall be designed to eliminate the need for hearing protection.

2.11.1.10 Equipment including hazardous material and drum handling, and compressed gas cylinders shall be designed to minimize conventional safety hazards during operation. For example, musculoskeletal disorders.

2.11.1.11 Indication of equipment and component failures shall be provided.

2.11.1.12 All exposed rotating equipment shall be provided with adequate machine guards for personnel protection.

2.11.2 Radiological Safety Requirements

The West Annex shall be designed to satisfy the requirements of the Radiation Protection Program covered in N-PROG-RA-0013, Radiation Protection.

The West Annex shall be designed to minimize tritium uptake by personnel performing normal system operation and maintenance.

Radiological zoning classification of the West Annex shall meet the radiological zoning requirements of OPG.

2.11.2.1 Shielding

Shielding shall be provided for the Heavy Water storage tanks. This requirement shall be validated in the CDR.

All shielding equipment shall provide sufficient protection to reduce exposure amounts and rates to less than the limits set out in the Dose Limits and Exposure Control, N-PROC-RA-0019.

2.11.2.2 **Radiation Monitors and Alarms**

FAATMs shall be provided in the storage areas in accordance with the Radiation Protection Program. These alarms will sound locally and in the HWMB Control Room.

Design of hazard monitoring systems, including area, emissions and environmental monitoring, shall meet the requirements of N-RPP-03415.1-10001, Radiation Protection Requirements – Nuclear Facilities.

2.11.2.3 **Breathing Air**

Provisions for breathing air shall be provided in the storage tank and drum handling areas.

2.11.2.4 **Contamination Control, Venting and Zoning**

2.11.2.4.1 Ventilation systems shall be designed and operated to minimize:

a) The accumulation of airborne radioactive contamination in areas routinely occupied by personnel;

b) The spread of airborne radioactive contamination from any zone to another of lower number

2.11.2.4.2 Decontamination supplies shall be accessible and located near all contamination monitors and in the loading bay.

2.11.2.4.3 Doors leading to tank and drum storage areas shall minimize the spread of airborne contamination throughout the building.

2.11.2.4.4 The storage tanks shall be located in a concrete dyke, with an impervious floor that has adequate storage capacity in case of tank ruptures.

2.11.2.4.5 The West Annex shall be designed to minimize occupational dose according to the As Low As Reasonably Achievable (ALARA) principles.

2.12 Constructability Requirements

2.12.1 Continued operation of the HWMB/TRF shall be maintained throughout all construction activities related to the West Annex.

2.12.2 Design for constructability, which includes ease of construction, material storage and handling, and logical sequencing shall be ensured.

2.12.3 Pre-fabrication and modular design features shall be incorporated.

2.13 Regulatory Requirements, Codes and Standards

All work performed must meet the applicable laws, standards and codes of Canada. The following codes and standards are to be satisfied. Any deviation shall ensure that the intent of the code/standard is met and shall be subject to approval.

2.13.1 Canadian Sources

a) CSA N285.0-08/N285.6 SERIES-08 Update 2: General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants/Material Standards for Reactor Components in CANDU Nuclear Power Plants

b) CSA B51-09: Boiler, Pressure Vessel, and Pressure Piping Code

c) CSA N286-05: Management System Requirements for Nuclear Power Plants

d) CSA N286.7-99: Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants

e) Canadian General Standards Board as applicable

f) Canadian Electrical Safety Act

g) CSA C22.1-09: Canadian Electrical Code, Part 1, Safety Standards for Electrical Installations. Including “Ontario Amendments to the Canadian Electrical Code, Part 1, C22.1 latest edition”

h) CSA C22.1-09: Canadian Electrical Code, Part 2

i) CSA 289.1-08: General Requirements for Seismic Design and Qualification of CANDU Nuclear Power Plants

j) CSA 289.3-10: Design Procedures for Seismic Qualification of Nuclear Power Plants

k) CSA Z299 Series: Quality Assurance Program Requirements

l) CSA Z432: Safeguarding of Machinery

m) CSA Z460: Control of Hazardous Energy – Lockout and Other Methods

2.13.2 United States Sources

a) American National Standards Institute (ANSI) as applicable

b) American Society of Mechanical Engineers (ASME) including:

i. Boiler and Pressure Vessel Code, 2010

ii. B31.1-2010: Power Piping

c) American Society for Testing and Materials (ASTM) as applicable

d) Institute of Electrical and Electronics Engineers (IEEE) as applicable

e) National Electrical Manufacturers Association (NEMA) as applicable

f) Air Movement Control Association (AMCA) as applicable

2.13.3 Ministry of the Environment/Environment Canada

a) Canadian Water Act

b) Canadian Environmental Assessment Act

c) Ontario Environmental Protection Act and Regulations

d) Ontario Water Resource Act

2.13.4 Ministry of Labour

a) Canadian Health and Safety Regulations

b) Hazardous Product Act

c) Ontario Occupational Health and Safety Act

d) Industrial Safety Act

2.13.5 Fire Safety Regulations

a) National Fire Code of Canada 2010

b) CSA N293-07: Fire Protection for CANDU Nuclear Power Plants

c) National Fire Protection Act (NFPA) as applicable

2.13.6 Regulatory Sources

a) Power Reactor Operating License – PROL 13.15/2013

2.13.7 Building Requirements

a) National Building Code of Canada 2010

b) CSA A23.3-04: Design of Concrete Structures

c) CSA S16-09: Design of Steel Structures

d) CSA W59-03: Welded Steel Construction

e) CSA S136-07: North American Specification for the Design of Cold-Formed Steel Structural Members

f) CSA A23.1-09/A23.2-09: Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete

g) CSA G30.18-09: Carbon Steel Bars for Concrete Reinforcement

h) CSA G40.20-04/G40.21-04: General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel

i) National Standard of Canada, Steel Structures for Buildings

2.14 Other Requirements

2.14.1 Systems shall be designed, classified and registered to meet the requirements of CSA N285.0/N285.6 Update 2.

2.14.2 Systems affected by reclassification shall meet the requirements of CSA N285.0/N285.6 Update 2 through the use of appropriate isolation boundaries.

2.14.3 All buried and overhead services shall be mapped and confirmation of location and operating status shall be established regardless of available documentation. As required, a plan for relocation, demolition and decommissioning of such services shall be completed.

2.15 Comparison with Similar Systems in Other Generating Stations

a) At DNGS, the existing D2O Supply System is located in a separate building, while at Bruce Nuclear (BNPD) the corresponding system is located in the Services Building, which is part of the powerhouse.

b) At BNPD, the system is vented to the atmosphere, whereas at DNGS, process exhaust gasses are sent through a condenser to recover Heavy Water.

c) At DNGS, Moderator and PHT Heavy Water are segregated for tritium control, while at BNPD, a common transfer pump system is used for both types of Heavy Water.

d) At Pickering Nuclear Generating Station (PNGS) and BNPD, storage tanks are installed horizontally, while at DNGS, the tanks are oriented vertically.

2.16 References

2.16.1 Miscellaneous Documents

Document Number	Document Title
N-PCH-09701-10001	Refurbishment, Operational Improvement & Long Term D2O Storage
NK38-DG-03650.2B	Common Mode Incidents – Seismic Design
NK38-REP-D1274014	Heavy Water Management Building Seismic Analysis
NK38-MAN-03480-10001	Environment Manual
NK38-DD-66100	Main Control Room Panels
NK38-D4H-66100 SERIES	Control Centre Nameplate Options
NK38-DD-66300.1	Man-Machine Interface Display Design Overview
NK38-DD-66300-02	Man-Machine Interface CRT Display
NK38-MAN-60310-10001	Annunciation Design Guide
N-MAN-06700-10000	Human Factors Design Guideline: Maintenance, Inspection And Testing
NK38-MAN-06700-10001	HFE Design Guideline For MCR Panels And Local Control Panels
D-ED-01520-10001	Darlington Equipment Identification
N-MAN-06700-10002	Human Factors Engineering Guide For Vendors
N-PROG-RA-0013	Radiation Protection
N-PROC-RA-0014	Radiological Zoning, Personnel/Material Monitoring And Transfer Permits
N-PROC-RA-0015	Contamination Control
N-PROC-RA-0027	Radioactive Work Planning, Execution And Close Out
TRANS-TS-03459.TR18-0008	Industrial Packaging Type 2 (Type IP-2) Transportation Packaging (Stainless Steel Drums))
NK38-CALC-50000-10002	Darlington NGS Short Circuit Analysis
NK38-REP-50000-002	AC Arc Hazard Analysis For OPG Darlington NGS

2.16.2 Standards

Document Number	Document Title
N-STI-69000-10000	Software Categorization
N-STM-01110-10001	Nuclear Construction Requirements

Document Number	Document Title
N-STM-01110-10002	Design And Construction Requirements
N-STM-01110-10003	Piping Standards Manual
N-STM-01110-10005	Tubing Design Guide
N-STM-04940-10006	Steel Valves Nominal Pipe Size 3 And Larger For Critical Service
N-TSI-60431-10000	Pressure Transmitters For Nuclear Service
N-STD-OP-0031	Monitoring Of Radioactivity In Effluents

2.16.3 Design Manuals

Document Number	Document Title
NK38-DM-33850	D2O Transfer System
NK38-DM-38500	Downgraded D2O Transfer
NK38-DM-23800	Heavy Water Management Building
NK38-DM-38110	D2O Supply
NK38-DM-38410	D2O Cleanup
NK38-DM-57600	Grounding
NK38-DM-65000	Electrical Control Of The Powerhouse Electrical Power Systems
NK38-DM-57000	Cable Support Structures
NK38-DM-79710	Active Plant Drainage
NK38-DM-79110	Inactive Drainage
NK38-DM-79120	Sewage System
NK38-DM-72700	Domestic Water
NK38-DM-74250	High Pressure Demineralized Water
NK38-DM-75160	Common Instrument Air
NK38-DM-75130	Breathing Air
NK38-DM-75110	Service Air
NK38-DM-39300/39400	TRF, Digital Distributed Control System Hardware/Software Design
NK38-DM-67989-10001	Fixed Gas Radioactivity Effluent Monitors
NK38-DM-62341	Instrumentation And Control FAATM

Document Number	Document Title
NK38-DM-62321	Personnel And Portal Monitors
NK38-DM-67870	Fire And Smoke Detection
NK38-DM-60215/60230	Public Address/Mtce Comm

2.16.4 Flow Diagrams

Document Number	Document Title
NK38-F0H-38110-0001	D2O Management Bldg. D2O Supply System Flow Diagram
NK38-F0H-38110-0003	D2O Management Bldg TRF Outgoing And Incoming Tritiated D2O Facility Flow Diagram
NK38-F1H-38110-0004	D2O Management Bldg. Drum And Bulk Loading/Unloading Arrangement For D2O Flow Diagram
NK38-F0H-38410-0001	D2O Management Bldg. D2O Cleanup System Flow Diagram
NK38-DRAW-38410-10002	D2O Management Building D2O Cleanup System U.V. Oxidation Flow Diagram
NK38-F0H-38500-0002	C.S.A. D2O Management & F.F.A.A. Bldg. Downgraded D2O Transfer Syst. Flow Diagram
NK38-F0H-72700-0007	T.H., T.A.B., R.A.B., D2O Management Bldg & T.R.F. Domestic Water System Flow Diagram
NK38-F0H-73690-0002	D2O Management Bldg. Ventilation System Supply Air Flow Diagram
NK38-F0H-73690-0003	D2O Management Building Ventilation System Contaminated Exhaust Air Flow Diagram
NK38-F0H-74250-0002	Units 1-4, FFAA & D2O Mgmt. Bldg High Pressure Demineralized Water Flow Diagram
NK38-F1H-75110-0006	D2O Mgmt & TRF Bldg & TRF Annex Service Air System Air Distribution Flow Diagram
NK38-F1H-75130-0006	D2O Mgmt, TRF Bldg & TRF Annex Breathing Air System – Air Distribution Flow Diagram
NK38-F1H-75160-0004	D2O Mgmt & TRF Bldg Common Instr Air System Air Distribution Flow Diagram
NK38-F5H-78110-0009	D2O Management Bldg & TRF Fire Protection System Flow Diagram
NK38-F1H-79110-0011	D2O Management & TRF Bldgs Inactive Drainage System Flow Diagram
NK38-F1H-79110-0012	D2O Management Bldg & TRF Roof Drainage Flow Diagram
NK38-F0H-79710-0003	D2O Management Building Active Plant Drainage Flow Diagram

2.16.5 Drawings

Document Number	Document Title
NK38-D1H-10249-1343	Yard Services Area No. 1343
NK38-D1S-53300-0008	4.16 KV & 600 V Distribution System Class II, III, IV (D2O/ TRF Bldg.) – Comprehensive 1-Line Diagram
NK38-FEX-53300-0501	Electrical Power Distribution HWMB & TRF 600V Classes II, III & IV 53320-BUC55 & 53340-BU94
NK38-FEX-53300-0502	Electrical Power Distribution Common 600V Classes III 0-53330-BU73 & BU74
NK38-F2S-53520-0007	D2O Management Building 120/208 VAC Class II Distribution System Schematic (1-Line) Diagram
NK38-F2S-53530-0003	D2O Management Building 120/208 VAC Class III Distribution System Schematic (1-Line) Diagram
NK38-F2S-53540-0004	D2O Management Building 120/208V Class IV Distribution System Schematic (1-Line) Diagram
NK38-D0S-56000-0084	D2O/TRF Building 347/600V AC CL II & CL II Ltg, 120/208V Recpt. & CL II Ltg. Connection Wiring Diagram
NK38-D1S-56000-0118	D2O/TRF Building 120/208V AC CL IV Recp Wiring Connection
NK38-D0S-57600-0002	Station Main Ground Key Plan
NK38-D1S-67369-5001	D2O Heavy Water Management Building Ventilation System Fan Control O-7369-F1 & -F3 Elementary Wiring Diagram
NK38-D1S-63811-5018	D2O Supply System Local Annunciator 0-63800-AN1 Elementary Wiring Diagram
NK38-FXX-69791-0501	Heavy Water Management Systems Computer Hardware Block Diagram
NK38-D5A-23860-0001	D2O Management Bldg. Plan At El. 87.000 M Reference Drawing List
NK38-D5A-23860-0002	D2O Management Bldg., Plan At El. 94.000 M
NK38-D5A-23860-0003	D2O Management Bldg., Plan At El. 100.000 M
NK38-D5A-23860-0004	D2O Management Bldg., Plan At El. 107.800 M