

**Fire Protection for CANDU Nuclear Power Plants
CSA N293-07
“Its Impact on Existing, Modified, Refurbished, and New Plant”**

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Abstract:

CSA N293 “Fire protection for CANDU nuclear power plants” has been extensively revised and was reissued in early 2007. N293-07 is planned to be the fire protection standard of reference for the next renewal of the various Canadian nuclear power station “Power Reactor Operating Licenses (PROLs)”. While the new design and installation requirements (Clauses 6 and 7) are not retroactive to existing CANDU stations, there are many other changes to the standard that existing facilities are expected to comply with at the time of their next PROL renewal. All Canadian CANDU stations are encouraged to review N293-07 as soon as possible, and initiate the process and materiel changes required to comply with the new standard by their next station operating license renewal.

This paper reflects one utilities initial efforts in this regard.

1. Introduction:

The Canadian Standards Association (CSA) Standard N293-95, “*Fire Protection for CANDU Nuclear Power Plants*” has been revised and reissued. It is known as N293-07. The new revision is the product of a diverse, knowledgeable, experienced and dedicated team from across the industry who invested considerable time and effort over the past few years to update this essential CANDU standard.

The revision was necessary to reflect the considerable improvements in technology and methodology that the fire protection discipline has experienced over the past decade. During that period the industry as a whole learned valuable lessons with respect to fire (Fire OP(erating) EX(perience))(OPEX) that are captured in the revision. In addition there was considerable input from N293-95 users which further enhanced the new revision.

N293-07, *Fire Protection for CANDU Nuclear Power Plants*, includes updates to make it consistent with the recently revised National Fire Code of Canada (NFCC) 2005 and the National Building Code of Canada (NBCC) 2005. N293-07 recognizes the option of objective based requirements to give the industry more flexibility in the fire protection management of the unique CANDU Nuclear Power Plant designs.

The purpose of this paper is to document and share one utilities initial review of the new revision of this standard as they prepare for N293-07 to become their operating license fire protection standard. The paper identifies some of the more obvious areas requiring attention in existing fire protection programs (See ‘Top 10 List’ 2.9). The next step will be to develop a plan to implement the required changes to the facilities fire protection systems, barriers, materiel condition, and program, prior to the stations next PROL renewal. In addition significant current modifications should be evaluated against N293-07.

Our regulator and Authority Having Jurisdiction (AHJ), the Canadian Nuclear Safety Commission (CNSC), remains the ultimate source of any clarification that your utility may require in this regard.

Format of Paper. The numbers in **(brackets)** throughout this paper reflect the clause and item number which being referred to in N293-07.

Responsibility (4.2):

While licensees may delegate the responsibility of meeting the new requirements, ultimately they are still responsible.

2. N293-07, Fire Protection for CANDU Nuclear Power Plants

2.1 Revision Background

N293-2007, *Fire Protection for CANDU Nuclear Power Plants*, has been revised and reissued. It is available on the Canadian Standards Association (CSA) web site www.csa-intl.org/onlinestore. You are encouraged to carefully review the extensively revised standard, and confirm the impact of the new standard for your utility in the short and long term.

The N293-07 standard sets the minimum requirements (1.1) that CANDU nuclear power plants and their surrounding protected areas must achieve in their fire protection performance. All aspects of CANDU Nuclear Plant site selection, design, equipment manufacture, construction, installation, commissioning, operation and decommissioning are subject to the requirements of the Canadian Nuclear Safety and Control Act and Regulations as managed by the Canadian Nuclear Safety Commission (CNSC). These are detailed in N293 and its associated codes and standards. The CNSC’s mandate is to ensure that the Canadian nuclear industry takes **all reasonable precautions** to ensure the safety of the public, the station staff, and the environment. In some cases this may mean going beyond the requirements specified in the National Building Code of Canada (NBCC), the National Fire Code of Canada (NFCC), and N293-07. The CNSC may impose additional requirements above and beyond those detailed in the aforementioned codes and standards.

N293-07 introduces a new “Fire Protection Concepts” Clause (5) to the standard. Fire protection concepts and performance levels are specified in this new Clause. The specific requirements for achieving the performance levels are detailed in the remainder of the standard, Clauses 6 through 11.

N293-07 contains a comprehensive list of the associated standards, codes and references which guide our industry in this area.

Considerable effort was invested by the Technical Committee responsible for the revision of this standard to make Annex A, (informative only) “Commentary on clauses in CSA N293” as useful as possible in understanding and interpreting this new standard.

2.2 General Requirements (Clause 4)

2.2.1 Effective Date (4.1):

N293-07 becomes effective as noted in the respective utilities Power Reactor Operating License (PROL). The CNSC has served notice that N293-07 will be the standard of reference in the next round of Power Reactor Operating License renewals in Canada. For some stations this may only be a year or two away. It is the responsibility of the station licensee to understand, anticipate, and meet the requirements of this standard when it takes effect. It is expected that any improvements required to meet the new standard will be installed, commissioned, and in service before the new standard comes into effect for each station (next PROL renewal).

Future respective station PROLs should be shorter and simpler with respect to fire conditions in that the N293-07 conveys the specific requirements that must be achieved. Previously these may have been detailed in the station PROLs.

Significant modifications and refurbishment initiatives in existing plant (4.3.2) may invoke the application of the new standard (N293-07) during the CNSC / AHJ approval of a specific change prior to the next station PROL renewal. Consult your station licensing department for their interpretation of the applicability of the existing license reference in this regard. New modifications during this period will be expected to meet the intent of the new standard, or obtain the concurrence of the Authority Having Jurisdiction (AHJ), usually the Canadian Nuclear Safety Commission (CNSC), in areas where the proposed modification does not comply with the specific requirements (4.3.2). In all cases where alternate solutions and performance based designs are factors in a modification, the unit after the modification must meet the requirements of (4.6) “AHJ Concurrence with Alternative Solutions and Performance based Designs” & (4.7) “Documentation Requirements for Alternatives or Performance Based Approaches”.

The ‘design and construction requirements’ in new standard, (Clauses 6) – “Design Requirements for the Prevention and Mitigation of Fires” and (7) “Design and Installation Requirements for Fire Protection Systems”, are not intended to be retroactively applied to existing units (4.3.1).

Key message. Start your review of the implications of the new CSA standard on your station now. Any material changes required to meet the new standard must be installed and in service when the PROs are renewed over the next few years. The different facilities will find their own unique ‘areas requiring improvement’ list (2.9) arising from this review. If in doubt on this matter consult your AHJ / Regulator now.

2.2.2 Safety Assessments

The new standard (4.3.3) requires that both a Fire Hazards Assessment (FHA) and a Code Compliance Review (CCR) be completed and maintained up to date for all operating units. This includes remaining current of all changes and modifications.

The Code Compliance Review (CCR) ensures that the nuclear unit meets all the requirements of the National Building Code of Canada (NBCC) and the National Fire Code of Canada (NFCC) and their associated codes and standards. The FHA and the CCR (4.5.3) must be maintained, documented, and submitted to the Authority Having Jurisdiction (AHJ) which is usually the CNSC. (4.3.3).

All proposed plant modifications (11.2.2) to the approved station design, including changes in fire hazards and to the level of fire protection system capability, shall be reviewed for their potential impact on the current fire safe shutdown capability and or on the protection of radioactive materials outside of the reactor. Where the modification is permanent, the FSSA shall be revised to reflect the change and to demonstrate that the station nuclear safety objectives continue to be met

The Fire Protection Program for the life cycle of the station is required to comply with the requirements of CSA N286 Quality Assurance Standard (5.10).

This includes a systematic approach to staff training that defines the qualifications required for the various levels of responsibility required by the station fire protection program (5.6.3).

2.2.3 Alternatives & Performance Based Approaches

The new standard allows and accepts alternative materials, means, measures, procedures, processes, approaches where they are documented and proven to meet the intent of the new standard, subject to the concurrence of the AHJ (CNSC). (4.4.1). Clause 4.6 elaborates this requirement.

Where alternatives are used, they shall meet the intent, or minimum level of performance required by this standard (Clause 4.6.2).

Where a performance based approach is incorporated in the design of the modification or design of the plant, the intent of sections 4.6 (AHJ Concurrence for Alternative Solutions and Performance Based Designs) and 4.7 (Documentation Requirements for Alternatives or Performance Based Designs) must be maintained and the design methodology and the proposed performance criteria accepted by the AHJ (CNCS) prior to its implementation. (4.4.2).

2.3 Fire Protection Concepts (Clause 5)

The revised standard includes a new section detailing the concepts and performance levels applicable during all stages of station life cycle, and upon which the new standard is based. The remainder of the standard uses the concepts chapter as its basis.

2.3.1 N293-07 applies to all phases of facility design, operation, inspection, testing and maintenance. The purpose of the standard is to ensure that the required fire protection goals, objectives and criteria are achieved during all postulated fire scenarios and failure modes.

The fire protection goals (5.2) remain:

1. minimize the risk of radiological releases to the public as a result of fire,
2. protect the plant occupants from death and injury due to fire, and to
3. minimize economic loss resulting from fire damage to structures, equipment, and inventories.

The remainder of this paper will highlight and quickly review some of the many improvements and clarifications included in N293-07. We encourage you and your facility to review these changes in detail, and share them with your teams, to ensure that there are no surprises when it comes time to renew your facilities PROL.

2.3.2 Fire Separations (5.3.4)

Fire separations or other measures must be used to limit the spread of fire. Spatial separation shall not be used in lieu of the egress, exiting, and fire wall requirements of the National Building Code (NBC) except for inside the containment structure. (6.3.3.2). This may have travel distance implications.

2.3.3 Nuclear Safety Objectives (5.4.1.1)

With respect to a fire event, and worth repeating here:

1. Achieve and maintain reactor sub-critical conditions;
2. Achieve and maintain decay heat removal;
3. Maintain fission product boundaries;
4. Limit the release of radioactive materials stored outside the reactor building.

2.3.4 Fire Safe Shutdown Analysis (5.6):

Compliance with the nuclear safety criteria of Clause 5.4 is demonstrated by a Fire Safe Shutdown Analysis (FSSA). The FSSA shall cover all areas in the Protected Area, assess each fire zone / fire compartment, and address all credible fires through the use of bounding design basis fires.

2.3.5 Buildings Constructed of Non Combustible Material (5.7.1.1)

This may continue to be a concern for re-locatable structures (8.2.3.7) inside the station and temporary buildings (outage trailers, fuel handling maintenance trailers) located immediately adjacent to the station. Temporary trailers outside the station must be located and constructed such that a fire initiating in the trailer will not jeopardize the equipment inside the station, which may be a Fire Safe Shutdown Analysis (FSSA) Screen 3 (a fire zone where one or more of the safe shutdown performance goals can not be achieved if all the FSSA equipment and or cables in the fire zone are assumed to be unavailable (due to the fire)). The outside wall of the station may not be fire rated. (5.7.1.1)

2.3.6 Transient Materials (5.7.1.3)

These are materials that are not part of the design basis of the station (from a fire protection or other point of view), and which may inadvertently jeopardize some of the designed nuclear safety aspects of the station (5.7.1.3). CANDU design depends on spatial separation between cabling routing, equipment location, and redundant systems to ensure that no single accident (such as a fire) can jeopardize more than one success path for the safe shutdown design. For transient material this could be as simple as temporarily parking a forklift load of computer paper in a hallway located between two previously independent cable tray routings. The temporary increase in fire load has short circuited the design assumptions of the nuclear safety safe shutdown design.

2.3.7 Permanent Material Storage (5.7.1.4)

Some facilities are now defining “permanent” as anything longer than four (4) months. Anything less than four months can be adequately managed by the facility transient material program (5.7.1.3).

Some of these storage or general work areas already exist, are not part of the design basis of the station, and may or may not be captured in the station Fire Safety Assessment (FSA). To many employees in the stations these areas have always been there, and have not caused any problems to date (decades). In some cases the owner of the area, the conditions of maintenance, and the concerns regarding the area have been long forgotten by those who operate and maintain the units on a day to day basis. They have become a legacy from the past that needs to be properly understood and maintained to ensure the station nuclear safety design is maintained. To remain in the station, and to ensure they do not violate fire protection design assumptions, the permanent storage areas must be adequately reviewed, analyzed, and approved. Once approved these then become part of the approved design basis for the station.

Plant Design Engineering shall ensure combustible material, dangerous goods, liquids and gases for use by plant operations, maintenance, and stores located and protected minimize the fire hazard threat to nuclear safety, life safety, public safety and the environment. (5.7.1.4)

Another paper at this conference addresses considerations in the redesign of existing stations to accommodate permanent storage areas in existing CANDU stations.

External Fire Threat to station (5.7.2.5 & 5.7.2.6). The potential for fire external to the plant (forest fire, transport or rail accidents) needs to be identified, assessed, and mitigated as per the nuclear and life safety criteria.

2.3.8 Turbine Generator Building (5.7.5.2.2)

New stations will require that the turbine generator building(s) be physically separated from other plant areas (6.3.2.1). Many of us grew up in an era where spatial separation was the only line of defense between turbine accidents and the reactivity deck, and in the intervening years several modifications had to be made to ensure the safety of the reactor (reactivity deck) in the event of a serious turbine generator accident. The intent remains that a fire involving a turbine generator will not spread to other areas (reactor auxiliary bay, adjacent units in earlier multi unit CANDU station designs), or initiate a progressive structural collapse.

2.3.9 Fire Hazard Control (5.7.5)

An approved fire alarm system is required for all buildings within the entire protected area (5.7.3). Note: this is a current “fire protection concepts” item.

An approved fire suppression system is required for the entire protected area, unless it can be demonstrated that the fire protection goals can be achieved using other fire protection measures (5.7.4). Note: this is a current “fire protection concepts” item.

Cable Trays related to nuclear safety are located to facilitate fire detection and suppression activities, so as to prevent the spread of fire. Where manual fire suppression is planned, the cable trays must be designed with adequate clearance between the cable trays to allow for manual fire mitigation (5.7.5.1.5). Note: this is a current “fire protection concepts” item.

Cable Trays are required to be protected so as to prevent the spread of fire.

Note: this is a current “fire protection concepts” item.

2.3.10 Smoke Management 5.7.6

Where the station Fire Hazard Assessment (FHA) determines that the propagation of hot gases and smoke may impact the occupants, plant equipment and or building structures, smoke management systems will be considered. The Main Control Room (5.7.8) complex is a special case which requires that it remain habitable while safe transfer of control is made to the Secondary Control Area.

2.3.11 Fire Protection Program (5.8)

The Fire Protection Programs must define management’s authority and responsibilities, and better integrates the fire protection activities of the various design engineering disciplines, functional groups and other organizations. N293-07 details the required aspects of the Fire Protection Program.

2.3.12 Fire Safety Plan (5.8.4)

The facilities Fire Safety Plan must address all aspects of station operation, outages, modification in both the short and long term.

All activities or work shall be managed to meet fire protection goals of this standard. (5.8.6)

2.3.13 Modifications (5.9)

All proposed modifications will be assessed to determine their potential impact on fire safety.

The **first stage screen** by the design authority will determine the potential of the proposed change to affect the design basis for the station fire protection systems, structures, or components, or its impact on the fire protection goals and criteria (5.9.2 to 5.9.5).

Where the first stage screening indicates a potential impact on the fire protection design basis, goals or criteria, a **second stage detailed assessment** of the proposed change will be required.

Where the first stage screen indicates no potential impact on the fire protection goals of this standard, review by a Third Party Review and or submission to the Authority Having Jurisdiction is not required.

Smoke Management shall be addressed in the Fire Hazards Assessment. (5.7.6)

The Fire Hazards Assessment (FHA) and Fire Safe Shutdown Analysis (FSSA) requirements must be reflected in the station day to day operations and maintenance methods. Station staff must be aware that many areas of the station (about one third) have fire safe shutdown analysis sensitivities, that is, a fire in these areas could jeopardize the stations ability to safely shutdown in an emergency (5.8.3).

Fire Reporting Requirements are now consistent S99 reporting requirements.

Radioactive Material Definition now consistent with Canadian nuclear industry standards.

“Any material containing radio nuclides, where the quantity of the material exceeds the exemption quantity specified in the Nuclear Substances and Radiation Devices Regulations made pursuant to the Nuclear Safety and Control Act”.

“**Operational Change**” (11.2.2) Changes within an operating plant, excluding permanent modifications, which may change to the previously analyzed fire hazards or the level of fire protection.

2.4 Design Requirements Prevention and Mitigation of Fires (Clause 6)

New requirements in the design requirements include:

- 2.4.1 Turbine Generator areas are ‘fire separated’ from the other areas of the plant so as to prevent the spread of fire originating with turbine generator related systems from spreading to other areas of the plant. (6.3.2.1)
- 2.4.2 Turbine Generator building designed so as to prevent progressive collapse of the turbine generator building and the associated spread of fire to the rest of the plant. (6.3.2.3)
- 2.4.3 Turbine Generator Hall / structural steel has 3 hour fire rating, is protected by fire insulation, is equipped with a sprinkler suppression system, and or has a heat removal system (6.3.2.2).

- 2.4.4 Control Room Complex (5.7.8) shall be fire separated from the adjoining plant on all sides, that is top, bottom and all four sides. Fire separations and fire suppression systems shall be used within the control room to limit the effects of fire between equipment within the control room and the unit control panels within the control room. A smoke management system shall be provided. MCR incipient detection is required.
- 2.4.5 Travel Routes Between Control Rooms: Safe passage must be assured for control room staff between the control room and the secondary control rooms. Two (2) independent travel routes to Secondary Control Area (6.7.2) 6.7.1.3 / 6.7.2.1 are required. They must be designed to minimize smoke infiltration to less than 1% of contaminated air, and provided with emergency lighting. They must be maintained clear of combustible / flammable material.
- 2.4.6 New stations will be designed with adequate protected storage and lay down areas in their original design. (6.8.2.1)
- 2.4.7 Fire trucks are a last resort, and not a part of planned defense in depth (7.3.2.1.5)

2.5 Design & Installation Requirements Fire Protection Systems (Clause 7)

- 2.5.1 There must be a control center (Central Alarm and Control Facility (CACF)) in each Secondary Control Area (7.2.1.10)
- 2.5.2 The Main Control Room control center shall be considered the Central Alarm and Control Facility (CACF).
- 2.5.3 The fire alarm system shall be capable of transferring control from the Main Control Room to the Secondary Control Area, and the process included in the emergency procedures (7.2.1.10.3)

2.6 Implementation Fire Protection Program (Clause 8.2.1)

Training required by all who work in the “protected area” to include:

1. Fire protection goals
2. Basic fire protection
3. Life Safety
4. Use of portable extinguishers
5. Emergency procedures
6. Emergency egress route maintenance
7. Fire protection equipment availability
8. Transient Material Permits / Permanent Material / Work Area Approvals / Hot Work
9. Reporting of Fires

2.6.1 Housekeeping (8.2.2) The need to constantly minimize the risk and consequences of fire.

2.6.2 Basic premise Combustible material is not to be stored in Screen 3 FSSA areas.(8.2.3.5.2)

2.6.3 Basis premise Wood only used where there is no other reasonable alternative, and then minimized to greatest extent possible. Fire retardant treatments are required for wood less than 6 inches by 6 inches, and even then it is not to be stored in FSSA Screen 3 areas. (8.2.3.5.4).

2.6.4 Radioactive Material (8.2.3.6)

Shall not be stored with combustible material (8.2.3.6.3)

Radioactive material shall be protected from fires and from fire fighting activities (8.2.3.6.5)

2.6.5 Re-locatable Structures (8.2.3.7)

Re-locatable Structures must be made of non combustible materials (8.2.3.7.2)

Re-locatable Structures must be equipped with a fire alarm system which communicates with the CACF. (8.2.3.7.2)

Re-locatable Structures must be suppressed if located within a building (8.2.3.7.2)

2.6.6. Training

FHA/CCR/FSSA must be integrated into the everyday station culture. Station staff must be aware and respect the design intent of the stations fire sensitive areas (FSSA Screen 3 areas). (8.5.3).

2.7 Fire Response Capability (Clause 10)

Analysis of all possible postulated fires is required to determine industrial fire brigade capability (10.1.4).

Clause 10.8 details the required industrial fire brigade fire response performance criteria.

2.8 Fire Safe Shutdown Analysis (Clause 11)

The Fire Safe Shutdown Analysis shall be reviewed for the potential impact of all station modifications or significant operational changes. (11.2.2)

The FSSA is a living analysis, and must be confirmed or updated at least every five years (11.2.3)

The FSSA Quality Assurance requirements are specified as N286 (11.7.1)

The FSSA assumptions are listed in Clause 11.8.

2.9 **Requiring Attention Now (One Utilities “To Do Now” List)**

(a detailed N293-2007 clause by clause stakeholder review is still required)

2.9.1 Bring FHA / CCR / FSSA up to date now, establish process to maintain for the long term and reissue every 5 years. This includes acquiring and training the staff to manage the FHA / CCR / FSSA in the long term. (11.2.3).

2.9.2 Better manage the FSSA areas with respect to fire protection concerns.

2.9.3 Establish a permanent storage / work area approval process. (5.7.1.4), which will make approved permanent storage / work areas part of the approved station design basis.

2.9.4 Review all current and planned modifications, including refurbishment projects, to ensure the required N293-2007 performance levels will be achieved on restart on the planned timeline.

2.9.5 Establish a process to train Station Staff on fire protection sensitive areas. (5.8.3)

2.9.6 Establish the process to better manager requirement for Third Party Reviews of modifications at early stage.

2.9.7 Improve the usage of performance based design methodologies for station modifications with respect to fire. This should include involving a Third Party Review and the Regulator at early stage. (4.7.1)

2.9.8 Review fire produced smoke management for Main Control Room and Secondary Control Area, and the two routes in between. (5.7.6)

2.9.9 Train Fire Protection Staff / Engineers to N293-2007 standards. (5.6.3)

2.9.10 Establish as ongoing process to maintain and control design basis fire barriers
(6.4.1)

3. Conclusion

N293-07 will be referenced in your station's next Power Reactor Operating License. It may also be the standard of reference for significant modifications before your next PROL renewal date.

The CNSC expects compliance with the new standard when it comes into effect for your station. Modifications required to meet the new standard, or technical evaluations or equivalencies, must be accepted by the CNSC and in place at the date the new standard comes into effect (PROL renewal).

4. References

[1] Canadian Standards Association., N293-07 Fire Protection for CANDU Nuclear Power Plants, Canadian Standards Association, 2007.

5. Acknowledgements:

The author wishes to acknowledge the ongoing support of his previous employer, Bruce Power, in the preparation and review of this paper.

The author also wishes to recognize and thank those who reviewed and commented on the paper. Thanks to Louise Jack, P.Eng, Senior Fire Protection Specialist, Plant Design Engineering, Bruce Power; Steve Cannon, Investor and Media Relations, Bruce Power.