

Suggestions on the Application of NBCC in Fire Hazard Analysis of CANDU NPPs

Jaehwan kim^{a*}, Jaehyung Ryu^a

^aANAS Co., Ltd., 610, Samsung Industry-academic cooperation Bldg., Pusan National University

*Corresponding author: jh.kim@anas.co.kr

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1. Introduction

The National Building Code of Canada (NBCC) is a model code governing the design and construction of buildings in Canada [1]. It classifies buildings by occupancy and establishes design requirements for structural form, height and area limitations, fire-resistance ratings, and individual elements such as doors, dampers, and penetrations, thereby providing a framework of standards to ensure the structural and safety performance of buildings. Because the CANDU nuclear power plants (NPPs) introduced in Korea were designed by Atomic Energy of Canada Limited (AECL) of Canada, the NBCC was also applied to the design of these plants. Among the wide-ranging requirements of the NBCC, this paper summarizes and presents the matters that must be considered from the perspective of Fire Hazard Analysis (FHA) for CANDU NPPs.

2. Application of NBCC in FHA

FHA for an NPP refers to a quantitative or qualitative risk analysis performed to examine the risk of postulated fires in each fire area and to evaluate the adequacy of fire prevention and fire protection measures, in order to demonstrate that the safe shutdown capability of the reactor is ensured and that the potential for release of radioactive material to the environment is minimized in the event of a fire in the reactor and associated facilities. In 1987, the Canadian Standards Association (CSA) established CAN/CSA-N293-M87 (hereafter “M87”) [2], a standard for fire protection of CANDU NPPs, which includes guidance on fire hazard analysis. The fire protection design of CANDU NPPs currently operating in Korea was based on this standard.

2.1 Provisions Directly Citing the NBCC

As shown in Table I, M87 requires compliance with the NBCC for certain specific items. Although exceptions and supplementary provisions are specified for each clause, the essential requirements must, at a minimum, satisfy the NBCC requirements.

Table I: Directly Cited NBCC Provisions in M87

Clause	Main Content
5.2.1.(a)	all buildings = noncombustible construction
5.2.1.(b)	limited amounts of combustibles

Clause	Main Content
7.2.3.1	provision of automatic or manual fire extinguishing systems
7.3.2	provision for the exit
7.4.3	fire dampers for fire separations (ducts)

2.2 Considerations from Defence-in-Depth Perspective

M87, Clause 4.4 (Defence-in-Depth Approach), specifies that the following defence-in-depth concept for fire protection is applied to ensure fire safety: (a) covers matters that can prevent fires in advance, such as restrictions on ignition sources and combustible materials and procedural controls; (b) covers means for promptly detecting and suppressing a fire once it occurs; and (c) covers means for limiting or mitigating the effects of a fire, such as isolation by structures.

- (a) Fire prevention;
- (b) Fire detection and suppression; and
- (c) Limiting or mitigating the effects of fires.

Therefore, in addition to the directly cited provisions in Section 2.1, it is advisable to extract from the NBCC the matters that should be considered from a defence-in-depth perspective and to review their applicability.

2.3 Preliminary Review of Applicability by NBCC Parts

A preliminary review was conducted, based on the parts of the NBCC, to determine whether the matters required by M87 are addressed. Because the NBCC does not consolidate fire protection related requirements into a single dedicated Part, the detailed requirements of each Part were reviewed to determine applicability.

Table II: Preliminary Review of NBCC Parts

Part	Title	Main Content	R*
1	Definitions of Words and Phrases	Definitions of terms	Not
2	General Requirements	Contains provisions of an administrative nature	Not
3	Use and Occupancy	Health and fire safety	R
4	Structural Design	Design calculations and the methods	Not
5	Wind, Water and Vapour Protection	Groundwater, condensation, penetration of wind and rain	Not
6	Heating, Ventilating and Air-conditioning	HVAC system design	R

Part	Title	Main Content	R*
7	Plumbing Services	Plumbing system design	Not
8	Safety Measures at Construction and Demolition Sites	Only construction and demolition sites	Not
9	Housing and Small Buildings	Small building size/height limits	Not

*R : Required

2.4 Presentation of Key NBCC Considerations

The NBCC basically classifies buildings by occupancy and presents the requirements to be applied for each occupancy. Under the NBCC building classification, an NPP may be classified variously by fire zone according to fire load, and fire zones with low fire load fall under Group F, Division 3 (Power Plants).

As a result of reviewing the detailed requirements of each Part of the NBCC, the matters that M87 specifically requires to be directly cited can be summarized as follows: (1) where a building or part thereof is required to be of noncombustible construction, it shall be constructed of noncombustible materials; (2) duct-related equipment shall be constructed of noncombustible materials; (3) penetration sealants, fire doors, and fire dampers shall be products that have passed testing in accordance with the relevant ULC requirements; (4) every building shall have an adequate water supply for fire-fighting purposes; (5) every building shall be provided with standpipe and hose systems; (6) portable fire extinguishers shall be provided at appropriate locations; (7) automatic fire suppression systems shall be installed where required; (8) lighting shall be provided for corridors and other principal routes of access leading to exits, and except in special cases, at least two exits shall be provided on each floor, (9) exit signs shall be provided above exit doors meeting certain conditions; and (10) the design, construction, installation, and testing of fire protection system shall comply with the relevant NFPA Codes.

2.5 Additional Considerations

Beyond the matters described in Section 2.4, additional considerations are as follows. (1) if a code not cited in the NBCC is to be used, equivalency must be demonstrated. For example, the NBCC specifies CAN4-S104-M80 [3] as the standard for fire door testing; however, if a revision issued after CAN4-S104-M80, or another standard such as ASTM or UL, has been applied, and equivalency evaluation against CAN4-S104-M80 must be performed to demonstrate its validity. (2) although fire-resistance ratings are basically assigned to fire walls in the design of an NPP, for structures that were not assigned a fire-resistance rating at the design stage but which need to be further subdivided into fire areas, the fire-resistance rating may be determined by reference to NBCC Supplement 2 (Fire-Performance Ratings) [4]. (3) because CANDU NPPs have numerous mezzanine floors with grated

flooring, and because the delineation of floors is important when evaluating fire protection system, criteria for treating a mezzanine as a single floor (e.g., an area-ratio criterion) may be utilized. (4) matters required by M87 such as the storage and use of flammable and combustible liquids and the placement of hydrants and fire extinguishers may need to be reviewed against the National Fire Code of Canada (NFCC) [5].

3. Conclusions

Because CANDU NPPs were designed by a Canadian company, they are designed based on the NBCC rather than domestic building codes. M87, the fire protection standard for CANDU NPPs introduced domestically, requires that certain items satisfy NBCC requirements. The NBCC covers a broad range of building design matters, and its detailed requirements are structured by citing external standards such as NFPA, CSA, and ULC. It is appropriate to determine the fire area classification, and to review, on that basis, the items for which M87 requires compliance with the NBCC. In addition, since the NBCC states that other codes or standards may be applied, even if not cited in the Code, provided their validity is demonstrated through an equivalency evaluation, such an evaluation should be performed as necessary to demonstrate validity from a fire protection standpoint. It should be noted, however, that because M87 imposes, in some respects, stricter requirements than the NBCC – such as additional restrictions – M87 takes precedence from a fire protection standpoint. It is expected that reflecting the results of this NBCC review in the fire hazard analysis of CANDU NPPs will contribute to improving the reliability of the results.

REFERENCES

- [1] National Research Council of Canada, National Building Code of Canada, 1985
- [2] Canadian Standards Association, CAN/CSA-N293-M87, Fire Protection for CANDU Nuclear Power Plant, 1987
- [3] Underwriters' Laboratories of Canada, CAN4-S104-M80, Standard Method for Fire Tests of Door Assemblies, 1980.
- [4] National Research Council of Canada, Supplement to the National Building Code of Canada, Chapter 2 "Fire Performance Ratings", 1985
- [5] National Research Council of Canada, National Fire Code of Canada, 1985