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기 술 보 고 서

CANDU9 화재방호를 위한 안전설계지침

Safety Design Guides for Fire Protection for CANDU 9

한 국 원 자 력 연 구 소

제 출 문

한국원자력연구소장 귀하

본 보고서를 CANDU 9 화재방호를 위한 안전설계지침에 관한 기술보고서로 제출합니다.

제목 : CANDU 9 화재방호를 위한 안전설계지침
(Safety Design Guide for Fire Protection for CANDU 9)

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작 성 자 : 이 득 수
장 우 현
이 남 영
A.C.D. Wright (AECL, Toronto)

감 수 위 원 : 석 수 동
(개량중수로개발분야책임자)

책임감수위원 : 김 동 훈 (연구위원)

요 약

인.허가는 규제기관이 원자력 발전소의 부지사용인가, 건설허가, 시운전 및 운영허가서 등을 발급하는데 필요한 안전상의 보증을 제공하기 위하여 수행되는 행위이다.

전통적으로, 캐나다의 규제기관인 AECB는 일반적인 요건만을 제시하는 방안을 채택하여 왔으며, 상세한 규제요건은 인허가 전 과정을 통하여 적용된다. 기존의 발전소에서 발견되는 설계/운전상의 결함자료를 통하여 AECB의 지식이 점점 축적되어, 새로 건설되는 발전소에 적용하고자하는 요건이 점차 증가되는 추세를 보이고 있으며 이것이 CANDU 원자력발전소의 인허가 관행이다.

규제기관이 건설허가를 발급하는 데 있어, 1차적으로 고려하는 사항은 설계내용이 안전요건을 만족시키고 있는가에 대한 확신을 갖는 것이다. 이를 위하여 특정 가상사고에 대한 안전해석이 수행되고 그 결과를 평가할 수 있도록 충분히 개선된 설계가 이루어 져야 한다.

CANDU의 인허가 과정에서 일반적으로 요구되는 몇 가지 정보가 있으며, 그중 안전설계지침(Safety Design Guide)은 발전소의 안전관련계통에서 만족시켜야 할 필수적인 설계요건/표준을 정의하는 설계지침이다. 이들 설계지침은 규제요건에 부합하도록 설계되었는지 확인하고, 일련의 설계결과물(서류)의 포괄성을 보증하기 위하여 규제기관에 의하여 검토된다.

본 안전설계지침에서는 화재로 인한 대중의 방사선학적 위험이 제한치 이하이며 발전소 운영요원이 화재위험으로부터 적절하게 보호될 수 있음을 보증하기 위한 설계요건을 수립하고자 한다. 본 안전설계지침에서는 또한 화재위험을 완화시키는 데 적용될 화재방호를 위한 안전범주를 기술하고, 화재방호 관련 설계업무의 착수, 조정 및 서류화를 위하여 수립될 화재방호계획을 추천하고 있다. 본 안전설계기준에 서술된 화재방호 요건은 설계단계에서 충족시켜야 하며, 추후 규제기관의 규제요건, 코드 및 표준의 변경현황을 지속적으로 추적하여 변경내용이 본 안전설계지침도 반영되어야 한다.

ABSTRACT

Licensing is the activity which is undertaken to provide the necessary assurances of safety to the regulatory agency so that they may issue appropriate certifications for site approval, construction, commissioning and operation of the nuclear facility.

Through tradition, the AECB, regulatory body of Canada, has chosen to issue only general regulations. Specific regulatory requirements are applied through the licensing process. These requirements tends to increase with each new station as the AECB gains more knowledge and data about design/operational deficiencies in existing plants, and this is a traditional licensing practice of the CANDU nuclear power plants.

The regulatory body's primary concern in granting approval to commence construction is to assure itself that the design meets the safety requirements. In order to this it is necessary that the design be in a sufficiently advanced state to enable safety analyses of a specified set of hypothetical events to be performed and their results assessed.

There are several information generally required as part of the licensing process, and among them, Safety Design Guides are guides(prepared by utilities) which defines mandatory design requirements/standards to be met by safety related system of the plant. These design guides are reviewed by the regulatory body to verify compliance with the regulatory requirements and to ensure that the series of documents is sufficiently comprehensive.

This Safety Design Guide establishes design requirements to ensure the radiological risk to the public due to fire is acceptable and operating personnel are adequately protected from the hazards of fires. This safety design guide also specifies the safety criteria for fire protection to be applied to mitigate fires and recommends the fire protection program to be established to initiate, coordinate and document the design activities associated with fire protection. The requirements for fire protection outlined in this safety design guide shall be satisfied in the design stage and the change status of the regulatory requirements, code and standards should be traced and incorporated into this Safety Design Guide accordingly.

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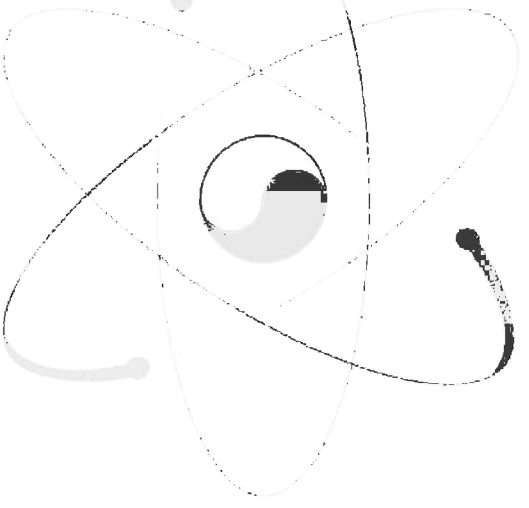
1. PURPOSE

This Safety Design Guide establishes design requirements to ensure the radiological risk to the public due to fires is acceptable and operating personnel are adequately protected from the hazards of fires. Requirements in this Safety Design Guide are applicable to both the Nuclear Steam Plant (NSP) and the Balance of Plant (BOP) except as otherwise stated in this guide.

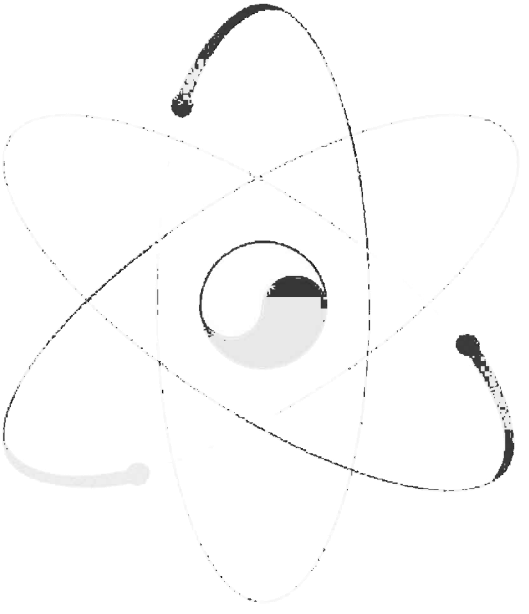
The requirements in this Safety Design Guide are based on CSA Standard CAN/CSA-N293-M87 "Fire Protection of CANDU Nuclear Power Plants", referred to as "the standard". The requirements of the standard are briefly referenced for the convenience of the designer. The designer must consult the standard for the referenced design requirement. The designer should note that the standard includes requirements for protection of the economic investment in the plant, whereas this Safety Design Guide addresses protection of personnel and nuclear safety requirements. This guide includes additional project requirements to ensure the proper interpretation and application of the standard within the scope of safety. Designers may refer directly to the standard for economic protection.



2. COMPLIANCE

Compliance with Safety Design Guides is mandatory. A list of Safety Design Guides is included in Appendix B. Deviations from the requirements identified in this guide may be allowed after an appropriate safety review. All deviations shall be approved and documented by completion of a Safety Design Guide Supplement, form PP-729.

The above recognizes that a safety function can be performed in several alternative ways, and that the designer should be free to choose the most efficient and economical design. It also ensures that any such changes are documented and checked for compatibility with the overall safety philosophy.



3. FIRE PROTECTION PHILOSOPHY

Reports from the operation of nuclear power plants in Canada and many other countries show that fires with moderate or insignificant consequences occur frequently in may plants. Fires have also caused serious economic losses, damages to safety systems or release of radioactive materials in several nuclear power plants. The design principles recognize fire as a design basis event which must be addressed. The approach and criteria used are specified as follows.

The design of the plant shall satisfy the requirements of the CSA standard CAN/CSA-N293-M87 "Fire Protection for CANDU Nuclear Power Plants". These requirements are summarized in this Safety Design Guide, but the designer shall consult the standard for the specific detailed wording of the requirement.

3.1 SAFETY CRITERIA FOR FIRE PROTECTION

The following criteria are applied to mitigate fires which could occur in any part of the plant :

a. Shutdown : At least one of the two Special Safety Systems provided for shutdown shall remain available.
b. Heat Removal : At least one group of systems or equipment to remove decay heat from the core and maintain adequate coolant inventory shall remain available.
c. Containment : The containment boundary shall be maintained for fires that could cause a release of fission products within containment.
d. Monitoring and Control : A control area and control equipment shall remain available and accessible, to the extent that the safety functions can be performed and the status of the plant can be monitored.
e. Support Services : One group of systems needed to provide electrical power, cooling water, instrument air, or other services to maintain the required safety functions shall remain available.

3.2 THE FIRE PROTECTION PROGRAM

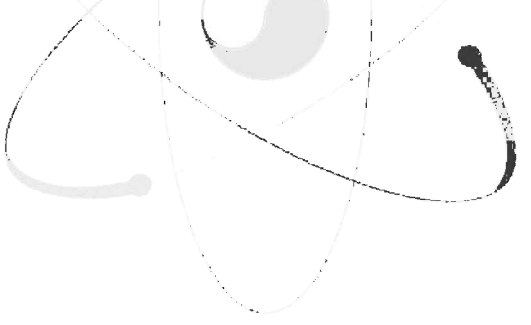
A fire protection program will be established to initiate, coordinate, and document the design activities associated with fire protection, as indicated in Appendix B. This ensures that fire protection measures are applied and documented consistently throughout the plant in a manner which can be effectively passed on to those involved with the construction, commissioning, and operation of the plant.

3.3 DESIGN CONCEPTS

To ensure sufficient systems will remain for each of the safety functions, design measures involving fire prevention, fire detection and extinguishment, and mitigation by separation shall be provided. These measures shall be applied throughout the plant, particularly in areas containing equipment and circuits important to plant safety. Extra efforts shall be given to fire prevention during the early stage of design by reducing, relocating or enclosing sources of combustibles. Fire hazards shall be identified and adequate means of fire detection and extinguishment shall be provided. Consequences of failures of the fire detection and extinguishing systems, coincident with a fire, shall be considered.

The safety philosophy for protection against common cause events is addressed by the SDG-004, "Grouping and Separation". Requirements specific to fire protection are defined in this Safety Design Guide. Within the reactor building, fire protection by separation shall be provided by open spaces between safety systems and fire hazards, and between redundant safety components and circuits. Fire barriers shall be used, where necessary, to augment the spatial separation. In the Group 2 areas of the reactor auxiliary building and the service building, fire separation shall be provided by fire walls to separate the Group 2 areas from the Group 1 areas and to separate the routes and equipment for Group 2A and Group 2B.

In addition to design provisions, detailed fire hazards assessment shall be performed to demonstrate the adequacy of the overall plant design against fires.



4. REQUIREMENTS FOR FIRE PROTECTION

4.1 GENERAL

a. The requirements of CAN/CSA-N293 "Fire Protection of CANDU Nuclear Power Plants" shall be satisfied.

b. Fire protection shall be addressed in design in terms of the following aspects, for which detailed requirements are provided in subsequent sections:

1. fire prevention,
2. fire detection and suppression,
3. mitigation of the effects of fires.

c. Fire protection shall be provided during all plant states, including:

1. Construction and Commissioning,
2. Operation, including maintenance, off-normal, and accident conditions,
3. Decommissioning.

d. Since fire is a common cause event capable of affecting a number of systems in the plant, the requirements of the SDG-004, "Grouping and Separation" shall be applied in establishing fire areas, in addition to the requirements of Section 4.4 below.

4.2 REQUIREMENTS FOR FIRE PREVENTION

As outlined in Clause 5 of the standard, the potential for fires shall be minimized by:

a. limiting the use of combustibles,
b. preventing the ignition of combustibles.

4.2.1 Limiting the Use of Combustible Materials

a. Clause 5.2.1 of the standard specifies the following requirements to minimize the amount of combustibles:
   1. designers shall specify non-combustible materials for systems and components, where practical;
   2. the quantity of combustible materials, or their combustibility, shall be minimized;
   3. buildings shall be of non-combustible construction, with additional requirements listed for:
   - electrical wiring insulation,
   - roof coverings,
   - foamed plastics,

- valve packing,
- all seals,
- air ducting,
- air entry filter,
- high efficiency particulate air filters.
- charcoal filters,
- plastics, paper, paint and varnish used in electrical equipment,
- electrical cable trays and conduits,
- flame spread rating of power and control cables (0.9 m),
- corrosive gas release by power and control cables (less than 14% by weight),
- epoxy lining of the reactor building.

4. the use of flammable and combustible liquids and gases shall be minimized, with further requirements for:

   i. storage and use of flammable and combustible liquids,
   ii. use or presence of hydrogen, deuterium, or tritium,
   iii. prevention of accumulation of flammable mixtures in insulation.

b. Foamed plastics shall not be used for sealing and caulking joints and penetrations, but they may be used as thermal insulation where protected by fire barriers conforming to National Building Code of Canada (1990) Section 3.1.4.2. Thiokol is a combustible sealant. It may be used for sealing construction joints and non-combustible penetrations, but shall not be used in floors and walls designated as fire separation. It shall not be used for sealing any cable penetrations.

c. The potential for substantial (e.g. accumulation of more than 100 litres) leakage of flammable and combustible liquids from process equipment shall be considered in design. For systems circulating these liquids by pumps, the pumps may be provided with automatic shut off on detection of excess flow, low liquid level or low pressure. Alternatively, alarms may be installed on these abnormal conditions to facilitate early manual isolation. Components particularly susceptible to leakage (e.g. bearings, joints, valve packings, drains etc.) may be provided with jackets, splash shields, curbs, drip trays or floor drains as appropriate to prevent the spread of the liquid.
   The motors of the Primary Heat Transport pumps contain substantial quantities of combustible lubricating oil. Uncontrolled leakage of this oil could lead to a significant fire hazard and shall be addressed by appropriate measures, as described above.

d. The flame spread and acid gas evolution of power, control and instrumentation cables shall be in accordance with Appendix A.

e. The following requirements apply to the use or generation of hydrogen :
   1. Bulk storage of hydrogen shall be located outdoors or in detached buildings. Indoor storage cylinders shall be limited to the quantity required for process use only.

2. Provision shall be made to purge components containing hydrogen or other combustible gases with an inert gas (e.g. nitrogen or carbon dioxide) if periodic emptying and filling are required.
3. Means to safely shut off the supply or to limit the flow, in addition to manual shutoff valves at the cylinder or tank outlet, shall be installed on compressed hydrogen storage and distribution systems.
4. Hydrogen (or deuterium gas) generated by normal operation processes shall be eliminated by igniters, recombiners, vented outdoors or purged with an inert gas. For significant volumes the concentration of hydrogen shall be monitored. Alarms shall be signalled to plant operating personnel before the lowest combustible limit is reached.
5. Adequate ventilation shall be provided in areas of hydrogen valve stations and battery banks to prevent accumulation of a combustible mixture. Where installed in enclosed rooms, alarms shall be provided which signal plant operating personnel on the failure of ventilation, or on detection of hydrogen concentration approaching the lowest combustible limit.
6. Igniters to initiate hydrogen combustion in containment following severe accidents shall be located such that the gas flame will not ignite or cause damage to electric cables or other safety equipment required to function following the accidents.

f. Gas and oil fired building heating equipment shall be designed and installed according to the fire protection requirements in Part 6 of National Building Code-1990.

g. The storage and use of welding gases shall be according to Sections 5.6 and 5.18 of the National Fire Code - 1990.

4.2.2 Preventing the Ignition of Combustibles

a. Clause 5.3 of the standard specifies requirements to minimize the hazard of ignition sources, such as the following :

1. spark or flame producing processes,
2. electrical equipment,
3. lightning,
4. grounding of equipment handling flammable liquids.

b. The hot equipment referred to in Clause 5.3.2.2 of the standard shall be equipment operating at temperatures above 180°C. This is a conservatively selected temperature, below which common solid combustibles would not be ignited.

4.3 REQUIREMENTS FOR FIRE DETECTION AND SUPPRESSION

a. The fire detection and the fire suppression systems shall be functionally independent.
b. Clause 6 of the standard lists requirements for the design of fire detection and suppression systems, including the following :

1. selection and location of fire detectors,
2. design of fire signalling systems,
3. requirements for fixed fire extinguishing systems,
4. a requirement for all accessible areas of the plant to be protected by fire hoses and portable fire extinguishers (Clause 6.3.6),
5. design provisions for manual fire fighting.

c. In general, all areas not normally attended shall be provided with fire detectors if even small quantities of combustibles exist or could be introduced by operations.
d. To provide the uninterruptible power supply referred to in Clauses 6.2.3 and 6.5.3 of the standard, Class I, II, or III electrical power may be used, backed up by batteries dedicated to the detection system.
e. In Clause 6.3.2(d) of the standard, unacceptable hazards for fire fighters include intense heat, poor visibility, an integrated radiation dose in excess of 50 milliseiverts (5 rem), or toxic gases. A means of monitoring identified radiation hazards where manual fire fighting will be required shall be provided.
f. In Clause 6.3.4 of the standard, the deleterious effects of discharging fire extinguishing agents, particularly water getting into electrical equipment, shall be assessed as part of the fire hazards assessment.
g. The requirements for manual fire fighting in Clause 6.5 of the standard shall be supplemented by the following :

1. The telephone system may be used as the fire communication system. In addition, two-way radios shall be provided for the fire crew.
2. The provision of equipment for fire fighting and fire fighting personnel protection shall be according to NFPA 27-1981 "Private Fire Brigade".
3. Adequate access shall be provided where manual fire fighting is relied upon to suppress fires in any given location in the plant.

h. The water supply referred to in Clause 6.4.4 of the standard shall include 3200 litres/minute for hose streams.
i. The designer shall identify, in the design documentation,

1. areas where failure of the fire detection also renders the automatic fire suppression system unavailable,

2. single component failures that could render the fire detection and/or the automatic fire suppression system (where applicable) unavailable in a fire zone or in the entire plant.

4.4 REQUIREMENTS TO MITIGATE EFFECTS OF FIRES

a. The National Building Code of Canada and Underwriter's Laboratories Canada (ULC) temperature curves shall be used in establishing the fire rating.

b. Clause 7 of the standard outlines the requirements to ensure that the effect of credible fires in the plant can be mitigated. These include requirements for the plant layout, fire separation requirements for the Special Safety Systems, fire exits, and ventilation design.

c. In addition to the requirements of the standard, the following shall apply:
   1. The routing of cables shall avoid, as far as practical, areas of high temperature or high fire load.
   2. Cable shafts, cable culverts and distribution rooms shall be free of other combustible material and pipes carrying flammable liquids and gases.
   3. Where cables, singly or in groups, cross fire separation structures, (e.g. walls, floors) the penetrations shall be sealed according to methods acceptable to the Underwriter's Laboratories of Canada (ULC) or other recognized laboratories to give a fire resistance as stated in Clause 7.2.1.2 of the standard. The rating shall satisfy the F and H criteria as defined in the referenced ULC standard.
   4. Cable trays shall not penetrate fire separations but shall terminate and be anchored on both sides of the separation wall or floor assembly.
   5. The plant shall be divided into a number of fire areas, corresponding to the separation barriers required by Figures 3 and 4 of the SDG-004 (Grouping and Separation) and as noted in 4.4(3) below. These fire areas shall be established by the use of 3-hour fire barriers, or a combination of open space and fire barriers, such that the most severe fire occurring within a fire area will not spread to another fire area containing safety related equipment, even in the absence of fire suppression measures.
   6. Within each fire area a number of fire zones may be established. These fire zones shall be, in general, separated by 1-hour fire barriers. Where the fire hazard is low, or where the installation of barrier is not practical, fire zones may be separated only by open space. In the latter cases, the primary purpose of establishing fire zones is for the design of fire detection systems.
   7. Fire doors shall be designed such that they are easily identifiable and have pneumatic door closures.
   8. Fire doors which are part of the major fire separations identified in Figure 1 shall have the same fire rating as the fire separation.

d. Failure of fire detection and extinguishing system shall be considered coincident with a fire in each area of the plant.

e. The following specific requirements for each plant area shall apply (refer to Figure 1 for illustration) :

   1. Reactor Building

      i. The perimeter wall and penetrations shall be designed such that fires that could arise from outside the building will not propagate to the inside. As a minimum, cable penetration seals shall have a fire resistance rating of 3-hours.
      ii. The area inside the reactor building can be considered one single fire area for the purpose of design.

iii. The space inside the reactor building may be divided into a number of fire zones for identification of fire origin. These zones need not be separated by fire barriers. However, fire barriers shall be provided, where necessary, for the following cases :

- to separate parallel runs of cable trays where the spatial separation is inadequate. (See SDG-004, "Grouping and Separation")
- to protect safety equipment that is vulnerable to fire. (See 4.4-6(a) of this Safety Design Guide)
- to protect structural steel where it may be subject to fire. (See 7.2.3.4 of the Standard)

iv. The above fire barriers shall be established following a detailed fire hazards assessment, as described in Appendix B of the standard.

v. At least two routes shall be provided for exit from and entry to the reactor building during a fire. The size of airlocks for this purpose shall be adequate for fighters in full protective outfit to move through rapidly.

2. Reactor Auxiliary Building

i. The Group 2 area shall be separated from the Group 1 area by fire walls with a minimum fire resistance rating of 3-hours.

ii. Within each fire area, 1-hour fire separation shall be established between floors, and between areas established as fire zones within each floor (details of fire zones shall be established after a fire hazard assessment).

iii. The main control room and associated equipment rooms shall be in a separate fire zone from other building areas.

iv. Adequate fire separation shall be provided between the Group 2A and Group 2B cable routes leading from the reactor building perimeter wall to the instrument panels in the Group 2 Service Building. This shall be achieved, where practical by a firewall with 3-hour fire resistance rating. In locations where installation of walls is not practical, a combination of sprinkler protection, spatial separation and light-weight fire barriers may be used to give an equivalent level of protection Special considerations shall be given to protect data links which traverse Group 2A and Group 2B areas, and links between the SCA and MCR.

3. Group 2 Service Building

i. Group 2A and Group 2B shall be separated by fire barrier with a minimum fire resistance rating of 3 hours. This physical separation shall extend through the control equipment room. Fire doors shall have the same rating as the fire barrier, and shall prevent the transmission of smoke and fire water between these areas and the Secondary Control Area, to the extent that the required safety functions in these areas are not affected by the fire.

ii. Within the Secondary Control Room, control and display equipment associated with Group 2A and Group 2B shall be in separate cabinets. Cables approaching the cabinets for these Groups shall be separated as far as practical.

iii. One-hour fire separation shall be provided between floors and between areas established as fire zones within each floor (details of fire zones shall be established after a fire hazard assessment).

iv. Fire separation with a minimum fire resistance rating of 3-hours shall be established between the diesel generators rooms and between these rooms and other building areas. Fire shall not be able to propagate from the diesel generator room to other rooms through water accumulation, drainage or HVAC systems.

v. Reliable fire dampers shall be used to ensure that fire and/or smoke will not propagate from either Group 2A or Group 2B to the SCR.

vi. The operator shall be able to access, quickly and safely, either of the Control Equipment Rooms to shut down the reactor if there is a fire in the SCR.

vii. Acid damage caused by a fire in the battery rooms shall be restricted to the separate battery rooms.

4. Group 1 Service Building and Maintenance Building

These buildings shall be, separated from the Reactor Auxiliary Building by 3-hour fire barriers or 6m of open space to prevent the spread of fire, heat and smoke. Where a 3-hour barrier is impractical, two 1-hour fire barriers at both ends of the connecting passage may be used.
Provision of other fire separations shall be in accordance with National Building Code of Canada (1990) Section 3.2.3.

5. Turbine Building

i. The wall facing the Reactor Auxiliary Building and Group 1 service building shall be established as a 3-hour wall, due to the severe fire hazard associated with the turbine generator system.

ii. Provision of other fire separations shall be in accordance with National Building Code of Canada (1990) Section 3.2.3.

iii. Outdoor transformers shall be located at least 15 m from the building; otherwise the facing wall shall have a fire resistance of 1 1/2 hour.

6. Other Buildings

Provision of fire separations shall be in accordance with the National Building Code of Canada (1990) 3.2.3.

f. In addition to the separation requirements specified in SDG-004, the following apply :

1. Special Safety System cable and instrument channels shall be routed as far as practical from equipment identified as having a fire hazard. The following guidelines may be followed :
   - primary heat transport pump motors
     (6 m horizontally and 10 m vertically)

- moderator pump motors
  (2m horizontally and vertically)
- shutdown cooling pumps
  (2m horizontally and vertically).

If the above separation cannot be maintained, each case shall be reviewed and suitable fire barriers may be required to protect the Special Safety System channels from the postulated fire.

2. Fire barriers required for the protection of Special Safety System channels shall be determined on assessment of the postulated fires. Some suitable barriers include solid bottom cable trays, enclosed cable trays, mineral fibre boards, suspended sheet metal, and spray-on fire coatings. Mineral insulated (non-combustible) cables, and cables in conduits may be considered as alternatives, depending on the fire hazard.
3. Redundant mechanical equipment of the Special Safety Systems which do not contain any appreciable combustible materials or fluids are not required to be physically separated from each other for fire protection reasons.
4. Notwithstanding the above general rules, the fire hazards inside the reactor building and in the Group 2 areas shall be assessed, and detailed protection measures shall be based on such an assessment.

g. In addition to the ventilation requirements stated in Clause 7.4 of the standard, the following requirements apply :

1. The ductwork and structural supports required for proper operation of the fire dampers specified in Clause 7.4.3 of the standard shall be protected from gross failure during a fire. These dampers shall be closed automatically by fusible link mechanisms or by electric motors.
2. Separate and independent ventilation systems shall be provided for the Group 1 and Group 2 areas outside the reactor building.
3. The main control room and the secondary control area including the designated access corridor between those two areas shall be designed so that heat, smoke and other toxic gases (including fire extinguishing agents) cannot be readily introduced through the ventilation system, or if such is found to be credible, means shall be provided for rapid purging of air in these areas.

h. The following seismic qualification requirements shall apply, in addition to Clause 7.5 of the standard :

1. Fire suppression systems protecting, or in the area of, seismically qualified equipment shall be qualified to the extent that they will not interrupt the protected equipment by failure or spurious operation.
2. Means to extinguish small fires in areas containing Group 2 systems shall remain available after a DBE, as required by Clause 7.5.4 of the standard. Portable fire extinguishers and fire hose systems qualified to function after a DBE are considered adequate.

(For definitions of earthquake levels and seismically qualified systems, designers are referred to SDG-002 (Seismic Qualification.)

3. Systems which contain quantities of flammable liquids or gases which could be a hazard to seismically qualified systems shall be qualified to remain intact in a DBE or separated from DBE qualified systems by DBE qualified structures or barriers.

i. The provision for fire exits shall be in accordance with the National Building Code of Canada (1990) section 3.4, except the following :

1. Minimum Number of Exits (NBCC Section 3.4.2.1)

The requirement of maximum floor area (200 m2) with 2 exits can not be satisfied in the Reactor Building. The main and the auxiliary air locks will be the only two exits for the Reactor Building.

2. Travel Distance (NBCC section 3.4.2.4 Sentence (3))

The requirement of having a travel distance to an exit from any point in a service space to be less than 50 m can not be satisfied in the Reactor Building.

3. Location of Exits (NBCC section 3.4.2.5 Sentence (1) (f))

The requirement of travel distance to at least one exit to be less than 30 m can not be satisfied in the Reactor Building.

4. Self-closing Devices (NBCC Section 3.4.6.12)

The design of the Reactor Building air locks may not satisfy the requirement of having a self-closing devices for a normally closed exit.

5. Door Release Hardware (NBCC Section 3.4.6.15 Sentence (3))

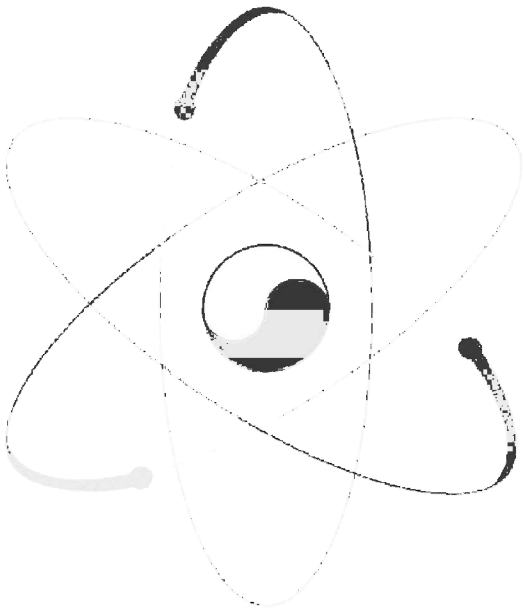
The design of the Reactor Building air locks may not satisfy the requirement of being able to have the door opened readily from the inside without requiring keys, special devices or specialized knowledge of the door opening mechanism.

4.5 FIRE HAZARDS ASSESSMENT

The design requirements in the standard and in this Safety Design Guide are meant to introduce conservative design measures to reduce the occurrence and consequences of fires. Since fires are very dependent on the specific systems and local conditions in the area of occurrence, the adequacy of the fire protection measures shall be evaluated on an area by area basis. The assessment is also useful to justify alternatives or reduced requirements where rigid compliance with design requirements is not practical. The major steps and factors to consider in a fire hazards assessment are provided in the standard. In addition, the following guidelines shall be followed :

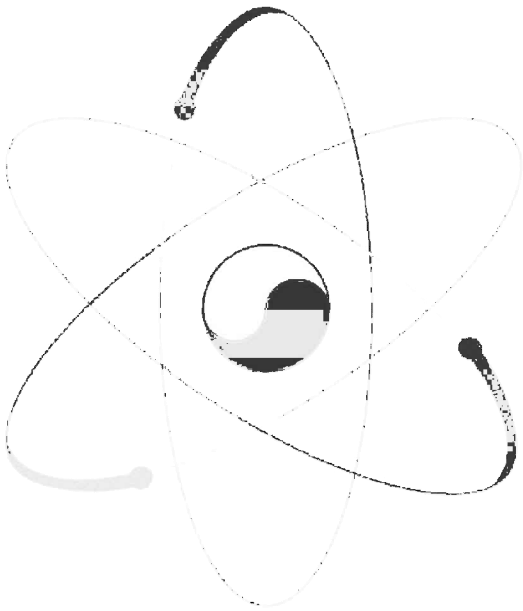
a. In determining the combustibles in an area under assessment, the presence of transient combustibles that could be introduced during plant operation (in particular during maintenance outages) shall be considered. The assumption of transient combustibles shall then be made known to the operations group so proper control procedures could be put in place to not exceed the value credited in the assessment.

b. In crediting actions by plant operating personnel and fire fighting teams, consideration shall be given to the response time, manpower and equipment specific to the operating plant. In the event these specific data are not available, assumptions used in the assessment shall be documented and made known to the operations group so they could fulfil the assumptions made.



5. DOCUMENTATION

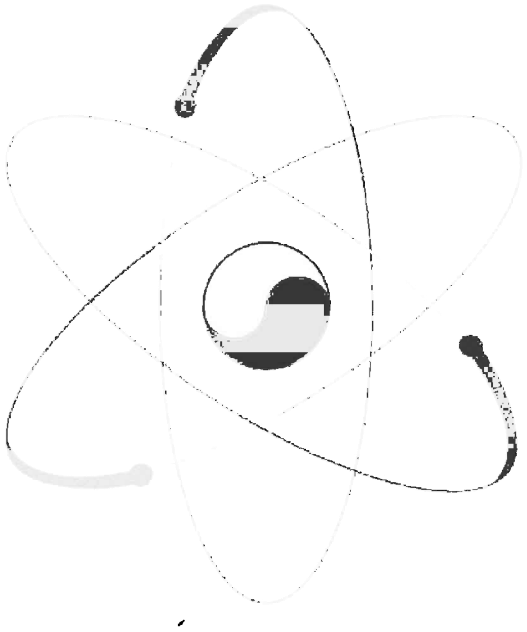
All documents shall comply with CANDU 9 Project Procedures. The documents required to demonstrate an adequate fire protection program are identified in Appendix B. In the fire hazard assessment document, the designer shall provide information on the definition of Design Basis Fires in a fire area.



6. VERIFICATION

The verification of the fire protection program shall include, among other quality assurance requirements for plant systems, the following:

a. Coordination of various design groups to ensure that the intent of this design guide has been understood and followed.
b. Monitoring design changes to ensure they do not violate fire safety requirements.
c. Preparation of a detailed fire hazard analysis of the station, near the final stage of the design of the station. as detailed in Appendix B of the Standard.
d. Preparation of a probabilistic fire hazard assessment to quantify the risk due to fires.
e. Inspection of the station during commissioning to ensure field changes have not violated the intent of this design guide, and that no fire hazard has been overlooked in design.
f. Testing and commissioning of fire equipment to NFPA and CSA standards wherever applicable.



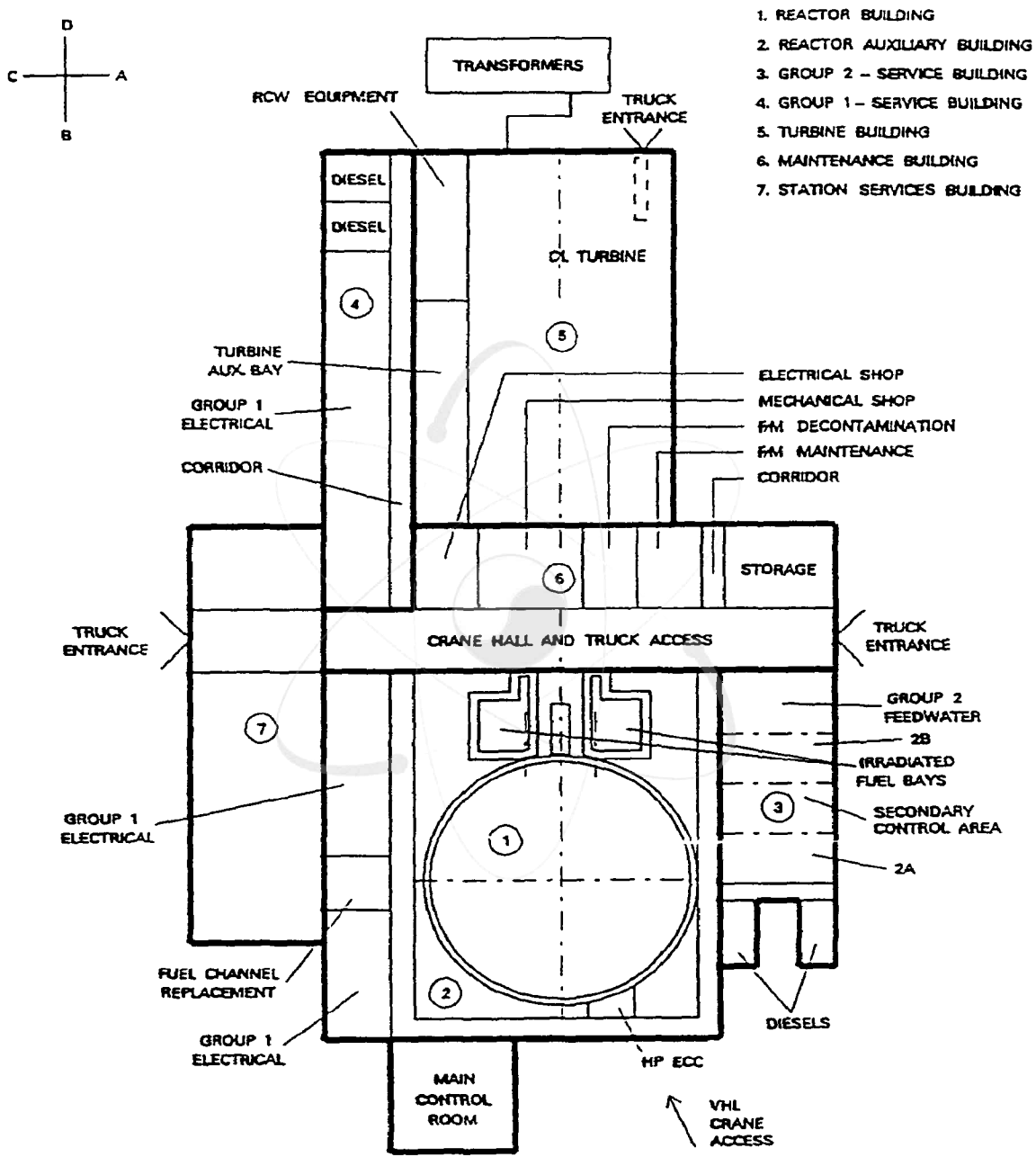


Figure 1 Concept of Fire Separation

APPENDIX A

FLAME SPREAD TEST OF ELECTRIC CABLES

Objective

The objectives of this test is to show that cables in a single tray approximating the condition of use will not readily ignite, and once ignited, will not propagate flame when the pilot flame is removed.

Cables passing the test criteria are better than those that do not in the early stages of a cable fire involving an external ignition source. It should be noted that in a large scale cable fire situation the behaviour of flame retardant cables may not be the same as in single tray tests.

Test Specimen and Conditions

a. A single tray is subjection to test each time.
b. Samples of various sizes of cables should be tested.
c. Aging of cables prior to testing is not necessary.
d. Cable configuration should approximate installed conditions. Trays should be in vertical position.

Test Equipment and Method

These should be according to CSA 22.2 No. 0.3-1985 "Test Methods for Electrical Wires & Cables".

Acceptance Criteria

The length of cable damage beyond the point of flame impingement should be less than 1 m. Damage is identified by charring and embrittlement of plastic material.

DETERMINATION OF ACID GAS EVOLUTION

Objective

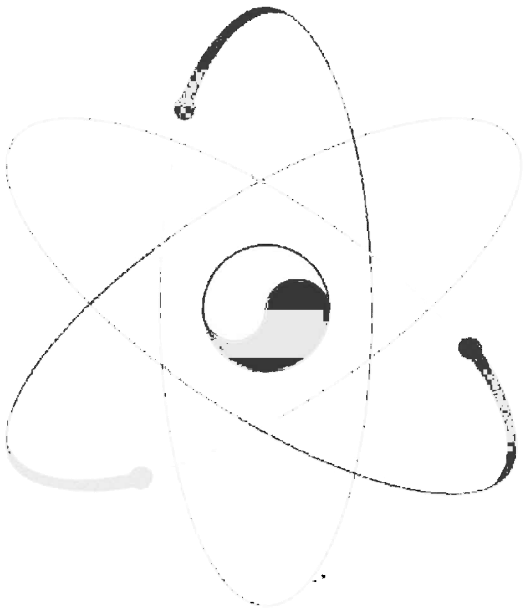
The objective of this test is to show that cables when decomposed under pyrolysis and combustion in air will have a limited contribution of corrosive gases.

Test Specimen and Conditions

a. Specimen should be shredded into small pieces and heated to 900°C for one hour within controlled apparatus.
b. The collection and measurement of product of combustion should be according to good chemistry practice.

Acceptance Criteria

The corrosive gases generated should be less than 14% by weight of the original specimen.



APPENDIX B

FIRE PROTECTION PROGRAM FOR DESIGN

ACTIVITIES	DOCUMENTS INPUT	DOCUMENTS OUTPUT
(1) DEFINITION OF DESIGN REQUIREMENTS - To identify project specific requirements.	· CSA Standard N293.M87 · Project-specific requirements	· Safety design guide SDG-005 (this document)
(2) PRELIMINARY DESIGN PROCESS - To perform a Preliminary fire hazard analysis and, based on it, to develop a conceptual design.	· Preliminary plant design and layout information	· Preliminary fire hazards assessment report. · Conceptual design description of fire detection and fire suppression systems · Fire protection requirements for interfacing disciplines (in various system Design Requirement documents)
(3) DETAILED DESIGN PROCESS - To perform detailed design of fire protection systems and to assist other design disciplines to comply with fire protection requirements.	· Detailed plant design and layout information · Input from interfacing design disciplines	· Design description of fire protection systems · Procurements specifications · Suppliers' documentation · Design Guide supplements
(4) DESIGN VERIFICATION - To demonstrate that design complies with all requirements.	· Relevant design documents · Design review records · Site inspection	· Final fire hazards assessment report · Probabilistic fire hazards assessments
(5) INPUT FOR OTHER STAGES - To pass assumptions, requirements and recommendations to commissioning and operation.	· Fire protection design and assessment documents.	· Final fire hazards assessment report, including guide-lines for commissioning and plant operation

APPENDIX C

LIST OF SAFETY DESIGN GUIDES FOR A CANDU 9 PROJECT

Identification	Title
KAERI/TR-639/96	Safety Related Systems (SDG-001)
KAERI/TR-640/96	Seismic Requirements (SDG-002)
KAERI/TR-641/96	Environmental Qualification (SDG-003)
KAERI/TR-642/96	Grouping and Separation (SDG-004)
KAERI/TR-643/96	Fire Protection Program (SDG-005)
KAERI/TR-644/96	Containment Extension (SDG-006)
KAERI/TR-645/96	Radiation Protection (SDG-007)
KAERI/TR-646/96	Pipe Rupture Protection (SDG-008)

서 지 정 보 양 식			
수행기관보고서 번호	위탁기관보고서 번호	표준보고서 번호	INIS 주제코드 번호
KAERI/TR-643/96			

제목 / 부제	CANDU 9 화재방호를 위한 안전설계지침
보고서 작성자 및 부서명	이 득수 (울진5,6호기 기술관리분야) 외 3 인

발행지	대전	발행기관	한국원자력연구소	발행인	1996. 3
페이지	23	도표	유(0) 무( )	크기	30 x 19
참고사항					
비밀여부	공개(0), 대외비( ), 급비밀		보고서 종류	기술보고서	
위탁연구기관			계약번호		

요약 (300단어 내외)

본 안전설계지침에서는 화재로 인한 대중의 방사선학적 위험이 제한치 이하이며 발전소 운영요원이 화재위험으로부터 적절하게 보호될 수 있음을 보증하기 위한 설계요건을 수립하고자 한다. 본 안전설계지침에서는 또한 화재위험을 완화시키는 데 적용될 화재방호를 위한 안전범주를 기술하고, 화재방호 관련 설계업무의 착수, 조정 및 서류화를 위하여 수립될 화재방호계획을 추천하고 있다.본 안전설계기준에 서술된 화재방호 요건은 설계단계에서 충족시켜야 하며, 추후 규제기관의 규제요건, 코드 및 표준의 변경현황을 지속적으로 추적하여 변경내용이 본 안전설계지침도 반영되어야 한다.

주제명 키워드 (10단어 내외): 화재, 방사선학적 위험, 화재방호, 안전범주, 화재방호계획 화재방호요건, 보호,

BIBLIOGRAPHIC INFORMATION SHEET			
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Title/Subtitle	Safety Design Guides for Fire Protection for CANDU 9
Reporter and Department	DEUCK SOO LEE (UCN 5&6 Technical Coordination Dept.)et al.

Publication Place	Taejon	Pub. Org.	KAERI	Pub.Date	1996. 3
Page	23	Figure and Table	Yes(0) No( )	Size	30 x 19
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Sponsoring Org.			Contract No.		

Abstract (300 words)

This Safety Design Guide establishes design requirements to ensure the radiological risk to the public due to fire is acceptable and operating personnel are adequately protected from the hazards of fires. This safety design guide also specifies the safety criteria for fire protection to be applied to mitigate fires and recommends the fire protection program to be established to initiate, coordinate and document the design activities associated with fire protection. The requirements for fire protection outlined in this safety design guide shall be satisfied in the design stage and the change status of the regulatory requirements, code and standards should be traced and incorporated into this Safety Design Guide accordingly.

Subject Keyword (10 words)	Fire, Radiological Risk, Fire Protection, Safety Criteria, Fire Protection Program, Fire Protection Requirement, Protection.