AECL EACL

Safety Design Guide

FIRE PROTECTION

ACR

108-03650-SDG-005

Revision 3

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1. PURPOSE

This Safety Design Guide establishes design requirements to ensure the radiological risk to the public and plant staff due to fires is acceptable, and plant 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 [Reference 1] "Fire Protection of CANDU Nuclear Power Plants" and on recommendations, reflecting international experience, from IAEA Guide 50-SG-D2 [Reference 2] "Fire Protection in Nuclear Power Plants". The requirements are briefly referenced for the convenience of the designer. The designer must consult the CSA Standard and IAEA Guide for the referenced design requirements.

This guide includes additional project requirements to ensure the proper interpretation and application of the CSA Standard and IAEA Guide within the scope of safety.

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, AECL form 0729-00.

3. FIRE PROTECTION PHILOSOPHY

This section of the Safety Design Guide describes the safety concepts and safety design philosophy used to develop the safety requirements. It is to be considered as information for the interpretation and application of safety requirements listed in Section 4.

Reports from the operation of nuclear power plants in Canada and many other countries show that fires with moderate or insignificant consequences occur relatively frequently in many plants.

3.1 The Fire Protection Program

A fire protection program is established to initiate, coordinate, and document the design activities associated with fire protection, as indicated in Appendix A.

3.2 General Safety Criteria for Fire Protection

As required by CAN/CSA-N293 and recommended by IAEA Guide 50-SG-D2, the following safety functions must be maintained to mitigate the effects of fires, which could occur in any part of the plant:

a) Shutdown: At least one of the two Safety Systems provided for shutdown shall remain available.

   SDS1 and SDS2 must be physically separated so a fire which causes a loss of function of one of them does not cause a loss of function of the other.

b) Heat Removal: At least one system or division[1] of components within a system to remove decay heat from the core and maintain adequate coolant inventory shall remain available.

   Either the safety related heat removal system or division must remain available for any fire; refer to Safety Design Guide 108-03650-SDG-004 [Reference 3].

c) Containment: The containment boundary shall be maintained for fires that could cause a release of fission products within containment.

d) Monitoring and Control: At least one control area shall remain accessible and habitable. The Main Control Room (MCR) shall remain accessible and habitable for any fire not involving the MCR, and the Secondary Control Area (SCA) shall remain accessible and habitable for any fire affecting the MCR (For two-unit ACR™*, SCA remains accessible and habitable if there is a fire in shared MCR). In addition, the control equipment shall remain available to the extent that the safety functions can be performed and the status of the plant can be monitored.

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[1] Divisions are redundant sets of components within a given safety related system that are physically and functionally independent from each other for performing the safety functions.

* ACR™ (Advanced CANDU Reactor™) is a trademark of Atomic Energy of Canada Limited (AECL).

e) Support Services: One division of systems to provide electrical power, cooling water, instrument air, or other services to maintain the required safety functions shall remain available.

3.3 Design Concepts

The following design concepts are applied to ensure that the essential safety functions can continue to be performed until the fire is extinguished:

a) Design measures involving fire prevention, fire detection, fire suppression, and fire mitigation are applied throughout the plant. These measures minimize the use of combustible materials and potential ignition sources in areas containing safety related systems, ensure reliable detection of fires when they do occur, provide suitable fire extinguishing systems, and mitigate the effects of fire.

b) A Fire Hazards Assessment is prepared during the plant design to identify the types and quantities of combustible materials in the plant during normal operations and outages, their location, the details and location of fire detection and suppression systems, and the presence of fire barriers and their rating. This information is used in the design of the fire protection systems, for the probabilistic safety assessment for fire events, and for fire protection planning in the operating plant.

c) Within the reactor auxiliary building, redundant safety related systems or divisions are separated by fire barriers, as conceptually shown in Figure 1. Each safety related system or division can perform the necessary safety functions for a credible fire that may occur in the other system/division, consistent with the separation concept as described in 108-03650-SDG-004 “Separation of Systems and Components”. Safety related system or division, redundant systems are separated by locating them in physically separate areas provided with fire barriers, as conceptually shown in Figure 1.

d) Within the reactor building, fire protection is provided by spatial separation (generally by a distance of 6 m between systems and components of the redundant safety related systems or their divisions), supplemented by an evaluation or analysis in areas of high fire loading or where the distance separation cannot be maintained. Fire barriers may be used, where necessary, in lieu of spatial separation.

e) In the following areas major fire barriers or fire walls are provided to prevent the spread of fire as shown schematically in Figure 1 (The following item numbers 1) ~ 7) correspond to the number in Figure 1.):

   1) between the reactor building and the reactor auxiliary building, due to the difference in fire separation between the redundant safety related systems or divisions in these two buildings;

   2) between the redundant safety related systems or their divisions of the reactor building and reactor auxiliary building, to ensure that at least one system/division of the redundant safety related systems or their divisions can perform the essential safety functions;

3) between the reactor auxiliary building and the control building including the Main Control Room (MCR), to enable operating staff to remain in the MCR from a fire immediately adjacent to the MCR (except those within the MCR or affecting all support services and cable routes to the MCR);

4) between the reactor auxiliary building and the Secondary Control Area (SCA), to protect equipment in the SCA from a fire immediately adjacent to the SCA;

5) between the reactor auxiliary building and connected buildings, to protect safety related systems in both systems/divisions;

6) between standby diesel generator enclosures and the surrounding areas that contain safety related components, to protect those components from a significant fire hazard; alternatively, the standby generators can be located in a separate building with the equivalent of a 3 hour fire separation or 6 m of distance from other buildings containing safety related equipment;

7) between the turbine building and the connected buildings that contain safety related components, to protect the reactor auxiliary building and any radioactive waste storage areas from a fire in the turbine building.

f) Within each of the areas separated by the major fire barriers, as noted above, internal fire barriers may be provided between floors, to slow the progress of a fire and enable fire fighting activities to be performed and plant staff to be evacuated, in accordance with the National Building Code of Canada, or local regulations applicable to the plant location.

g) For fires that impair the availability of the Main Control Room, the operator would shut the reactor down, move to the Secondary Control Area and maintain the plant in a safe shutdown condition until the fire is extinguished and the availability of the MCR is restored.

h) A route from the MCR to the SCA must be identified and protected from fires that cause the MCR to become unavailable.

i) The fire resistance rating of barriers can be based on a standard time-temperature curve, such as specified by the National Building Code of Canada or ISO 834-1 [Reference 4]. These are considered to be conservative for a nuclear plant due to the non-combustible properties of most structures and equipment. For a plant located at a site where fire protection regulations require a detailed calculation of fire loading, the assessment will include detailed analysis of the fire loading within each fire area, and detailed analysis to establish the fire resistance rating for the fire barriers. Fire detection and extinguishing systems are considered to be available to limit the spread of fire in the entire plant, except where there is no combustible materials.

j) Fire suppression systems are provided as follows:

1) For areas continuously occupied by plant personnel, manually initiated fire suppression systems or portable fire extinguishers may be used (e.g., MCR).

2) In the reactor building, a manual fire suppression system, such as a fire hose system and fire extinguishers, is provided for all areas, and may be supplemented by either manually

initiated or automatic fixed suppression systems, if these are shown to be necessary by the fire hazards assessment.

3) In normally inaccessible areas of the reactor building (e.g., reactor vault areas), a potential fire may be shown to burn itself out without causing loss of the essential safety functions, otherwise automatic suppression system will be provided.

4) In the reactor auxiliary building, automatic fire suppression systems are provided, except where shown to be unnecessary by the fire hazards assessment (e.g., very little combustible materials, or no safety related equipment in the fire area).

5) In the turbine building, automatic fire suppression systems are provided for areas of high fire hazard (i.e., turbine generator, auxiliary lube oil and hydrogen cooling systems).

k) Fire detection systems are provided for areas of the plant that contain combustible materials.

l) Accumulations of heat, smoke, toxic gas and unburned gases in areas where safety related equipment or operator action is required to perform a safety function are prevented.

m) The generation of smoke and heat is minimized by limiting the quantity of combustible materials in the reactor building and in areas containing systems that perform a safety function during a fire.

4. REQUIREMENTS FOR FIRE PROTECTION

4.1 General

a) The requirements of CAN/CSA-N293 "Fire Protection of CANDU Nuclear Power Plants" and Safety Design Guide 108-03650-SDG-004 "Separation of Systems and Components" shall be satisfied. The recommendations from IAEA Guide 50-SG-D2 "Fire Protection in Nuclear Power Plants" (or in its revised form, draft DS 306, when issued) shall be addressed in the design of the ACR systems.

b) Fire protection shall be addressed in design in terms of the following aspects:

   1) fire prevention,

   2) fire detection and suppression,

   3) mitigation of the effects of fires.

4.2 Requirements for Fire Prevention

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) The amount of combustibles shall be minimized as follows:

   1) designers shall specify non-combustible materials for systems and components, where practical;

   2) the quantity of combustible materials (i.e., materials other than concrete and steel) and their combustibility, shall be minimized, particularly in areas where safety related systems or components are located;

   3) buildings which contain safety related systems and equipment shall be of non-combustible construction, as defined by the National Building Code of Canada, and shall comply with requirements listed in CAN/CSA-N293 for:

      - fire retardant properties for electrical wiring insulation,
      - roof coverings,
      - foamed plastics,
      - air ducting,
      - air filters,
      - high efficiency particulate air filters,
      - charcoal filters,

- plastics, paper, paint and varnish used in electrical equipment,
- electrical cables, cable trays, and conduits, etc.

4) the use of flammable and combustible liquids and gases in areas near safety related systems shall be minimized and shall comply with requirements in CAN/CSA-N293 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) The potential for substantial (e.g., accumulation of more than 100 litres) leakage of flammable and combustible liquids and gases from process equipment shall be considered in design. For systems circulating these liquids by pumps, consideration shall be given for providing the pumps with automatic shut off on detection of conditions indicating escape of the liquid from the system, such as excess flow, low liquid level or low pressure. Alarms shall also be installed to detect these abnormal conditions to facilitate early manual isolation and correction of the condition. Components particularly susceptible to leakage (e.g., bearings, joints, valve packings, drains, etc.) shall be provided with jackets, splash shields, curbs, drip trays, floor drains, or other measures as appropriate to prevent the spread of the liquid.

   The motors of the heat transport pumps can 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.

c) The flame spread and acid gas evolution of power, control and instrumentation cables shall be in accordance with CSA 22.2 No. 0.3 [Reference 5] or an internationally accepted standard for fire resistance rating of cables such as ASTM E-119 [Reference 6] and IEEE 383 [Reference 7]. (Note that the flame spread test may not represent the actual behaviour of the cables in specific applications, such as on vertical runs of cables.)

d) 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 minimum 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 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) Hydrogen control devices (e.g., passive autocatalytic recombiners) to limit hydrogen content to below the deflagration limit within any significant enclosed compartment of the containment following an accident shall be provided in the reactor building.

e) Designers shall ensure that the quantity, type and location of combustible materials are listed in the Fire Hazard Assessment.

4.2.2 Preventing the Ignition of Combustibles

a) The design shall identify and reduce potential ignition sources, such as the following:

1) spark or flame producing processes,

2) hot equipment (e.g., over 177°C) located near combustible materials and fluids,

3) electrical equipment located near where flammable vapours explosive dust may accumulate,

4) static electric sparks (i.e., by grounding equipment handling flammable liquids).

b) Outdoor transformers, the switchyard, and all structures housing safety related systems shall be protected from lightning.

4.3 Requirements for Fire Detection and Suppression

a) The fire detection and the fire suppression systems shall be functionally independent of each other, although fire suppression systems may be actuated by the fire detection system.

b) The requirements of CAN/CSA-N293 shall be followed and IAEA Guide 50-SG-D2 (or its revised current form) requirements shall be addressed.

c) Fire detection systems shall be designed to function appropriately under high pressure conditions in the building (e.g., building pressure test).

d) In general, all areas not normally attended, or as determined in the Fire Hazards Assessment, shall be provided with fire detectors even if only small quantities of combustibles exist or could be introduced by operations.

e) An uninterruptible power supply shall be used. This may be supplied from the Class I or II electrical power. In addition, the power supply shall be backed up by batteries dedicated to the detection system in case the plant power supply is lost.

f) Unacceptable hazards for fire fighters include intense heat, poor visibility, an integrated radiation dose in excess of 50 millisieverts, or toxic gases. Fixed fire-extinguishing systems shall be considered for installation at these locations. These shall have automatic actuation

unless it can be shown that sufficient time is available for an operator to manually actuate the system without violating the design objective.

g) The deleterious effects of discharging fire extinguishing agents, particularly water getting into electrical equipment, shall be assessed as part of the fire hazards assessment. Adequate NEMA rating shall be specified for electric equipment of safety systems that may be subject to water spray. For personnel safety, breathable clean agents (e.g., Inergen etc.) shall be preferred where a gaseous suppression system is used.

h) Fire extinguishing systems shall be provided to cope with all fire hazards identified in the fire hazards assessment.

i) The requirements for manual fire fighting shall be supplemented by the following:

   1) The telephone system may be used as the fire communication system. In addition, two-way radios or cellular phones shall be provided for the fire crew, which are compatible with plant control and monitoring systems (i.e., acceptable from an electro-magnetic interference point of view).

   2) Adequate access shall be provided where manual fire fighting is relied upon to suppress fires in any given location in the plant.

j) The water supply system shall be designed hydraulically to ensure that adequate flow and pressure are available for at least two hose streams, plus the most demanding sprinkler system.

k) 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) 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 - Underwriter's Laboratories of Canada (ULC) or ISO 834-1 temperature curves shall be used in establishing the fire resistance rating of fire barriers. Alternatively, a curve may be established by a detailed fire load analysis that takes into account combustibles on both sides of the barrier.

b) The design requirements of CAN/CSA-N293 to mitigate the effects of fire shall be followed, and IAEA Guide 50-SG-D2 (or its revised current form) requirements should be addressed.

c) The routing of cables for safety related systems shall avoid, as far as practical, areas of high temperature or high fire load as determined in the Fire Hazards Assessment.

d) The failure of structural supports for cable trays shall not affect both redundant safety related systems or their divisions cable trays or equipment of both redundant safety related systems or their divisions needed to mitigate the event.

e) Cable shafts and cable culverts shall be free of other combustible material and pipes carrying flammable liquids and gases. The cable distribution room and electrical panels shall limit other combustible materials and pipes carrying flammable liquids and gases.

f) Where cables 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. The rating shall satisfy the F, H, and T criteria as defined in the referenced ULC standard. A non-combustible sealing material should be used, where practical.

g) The effects of hot shorts and heating during a fire on the current carrying capacity of cables shall be considered in the design, particularly in enclosed areas, in terms of their potential effect on safety related systems performing essential safety functions.

h) Cable trays shall not penetrate the major fire separations shown in Figure 1, including those between redundant safety related systems or their divisions, but shall terminate and be anchored on both sides of the separation wall or floor assembly, so failure of the cable trays and supports during a fire or earthquake will not destroy the integrity of the fire separation.

i) The plant shall be divided into a number of fire areas by the separation between redundant safety related systems or their divisions, and by fire barriers shown on Figure 1. These fire areas shall be established by the use of 3-hour fire barriers, such that the most severe fire occurring within a fire area will not spread in less than 3 hours to another fire area containing safety related equipment.

j) If the fire event can cause equipment damage that could prevent a required safety function from being performed (e.g., a reactor trip), the channels shall be separated by a three hour fire barrier, or another channel shall be provided in a different fire area to perform the safety function, or a fire analysis shall be performed to show that the two channels will not be damaged by the same fire.

k) Within each major fire area (e.g., MCR, SCA), additional fire barriers may be established (usually with a 1 hour rating) to protect cable routes, or to separate redundant equipment, or to ensure plant staff evacuation, as required by the National Building Code of Canada.

l) Security systems shall be designed to ensure that the necessary safety and security functions can be performed during and after a fire.

m) Fire zones shall be established for the purposes of assessing the fire hazards in a local area, or for the design and location of the fire detection system. Fire zones may be separated by fire barriers or by open space. (Note that fire areas are defined as a fully enclosed space by a rated fire barrier.)

n) Fire doors shall be designed to be easily identified and shall have automatic door closures.

o) Fire door and frame sets shall have the same fire rating as the fire separation.

p) In fire areas where safety related systems or components are required to maintain their function during a fire within the fire area, a means of ventilation shall be provided to remove heat, smoke, toxic gas, and unburned gases from the area and exhaust them outside the

building. For example, this applies to the reactor building, which is one fire area and where safety related equipment is required to maintain its function.

q) There shall be no pathways for smoke propagation between the redundant safety related systems or their divisions or between the fire areas (e.g., MCR, SCA), such as drains or unisolable ventilation ducts. Appropriate means of ventilation isolation shall be provided.

r) 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 so that fires that could occur on either side of the wall will not propagate to the other side. As a minimum, penetration seals shall have a fire resistance rating of 3 hours.

ii) The area inside the reactor building shall be considered one single fire area for the purpose of design.

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

- to separate parallel runs of cable trays where the spatial separation is inadequate and a fire hazard exists. (See 108-03650-SDG-004),
- to protect essential safety related equipment that would otherwise be damaged by fire as shown by a fire hazard assessment,
- to protect structural steel where it may be subject to failure due to fire.

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 fire fighters in full protective gear.

2) Reactor Auxiliary Building

i) Redundant safety related systems or divisions shall be separated by fire separations with a minimum fire resistance rating of 3 hours to protect against fire propagation. Each redundant system/division shall also be protected from the effects of smoke propagation from the other system/division.

ii) Within each fire area, fire separations shall be established in accordance with the National Building Code of Canada or as established by the fire hazard assessment, and IAEA Guide 50-SG-D2 (or its revised current form) requirements should be addressed.

iii) Within redundant safety related systems or divisions, the odd and even electrical distribution subsystems shall be in separate areas to ensure that the electrical supply to the Main Control Room is maintained in the event of fires.

iv) The Main Control Room, Secondary Control Area and associated equipment rooms shall be in separate fire areas from other building areas.

v) Within the Main Control Room and Secondary Control Area, control and display equipment associated with redundant safety related systems or their divisions shall be in separate cabinets. Cables approaching the cabinets for these redundant safety related systems or their divisions shall be separated as far as practical as indicated in 108-03650-SDG-004.

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

vii) Redundant fire dampers shall be provided to prevent fire and/or smoke propagation between the redundant safety related systems or their divisions through the ventilation ducts, with particular consideration given to measures to ensure high reliability of the dampers, including the source of power supplies and control, the quality assurance program for the equipment, and inspection and test procedures.

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

ix) No ignition sources shall be allowed in the battery rooms.

3) Other Connected Buildings

Other buildings shall be separated from the Reactor Auxiliary Building by 3-hour fire barriers or 6 m of open space to prevent the spread of fire, heat and smoke. Where spatial separation or a 3-hour barrier is impractical, two 1-hour fire barriers shall be used.

4) Turbine Building

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

ii) An appropriately designed smoke and heat ejection system shall be provided to minimize the possibility of building collapse due to structural failure, to avoid propagation of the fire to the reactor auxiliary building.

iii) The turbine generator shall be provided with a fire protection system such as a sprinkler or foam system.

iv) Oil filled outdoor transformers shall be located at least 15 m from the building, or the facing wall shall have a fire resistance of 2 hour.

v) Where necessary to maintain an essential safety related function, oil filled transformers shall be separated by fire walls or equivalent spatial separation.

vi) Large oil filled transformers (e.g., Station Service Transformer) shall be provided with dikes to contain any oil spillage or leakage. Oil filled transformers shall be provided with a deluge system.

s) The following separation requirements shall apply:

1) Since fire is a common cause event capable of affecting a number of systems in the plant, the requirements of 108-03650-SDG-004 "Separation of Systems and Components" shall be applied in establishing fire areas and fire barrier locations.

2) 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
  (2 m horizontally and vertically)
- long term cooling pump motors
  (2 m horizontally and vertically)
- feedwater pump motors
  (2 m horizontally and vertically).

The need for the above separation is to be confirmed via Fire Hazard Assessment. Each case shall be reviewed and suitable fire barriers may be required to protect the Safety System channels from the postulated fire.

3) Fire barriers required for the protection of Safety System channels shall be determined on assessment of the postulated fires. Some suitable barriers include solid bottom or enclosed cable trays (supplemented by an additional barrier where protection is not continuous), 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.

4) Redundant mechanical equipment of the Safety Systems which do not contain any appreciable combustible materials or fluids shall not require physical separation from each other for fire protection reasons.

5) Notwithstanding the above general rules, the fire hazards in areas containing safety related equipment shall be assessed, and detailed protection measures shall be based on such an assessment.

t) The following ventilation requirements shall apply:

1) The ductwork and structural supports required for proper operation of fire dampers shall be protected from gross failure during a fire. These dampers shall be closed automatically by fusible link mechanisms or by actuators.

2) The Main Control Room and the Secondary Control Area including any enclosed 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. However, if such is found to be credible, means shall be provided for rapid purging of air in these areas.

u) The following seismic qualification requirements shall apply:

1) Fire suppression systems protecting, or in the area of, seismically qualified equipment shall be qualified to the extent that they will not cause the protected equipment to fail or spuriously operate.

2) Fire detection systems in areas containing safety related equipment shall be seismically qualified (i.e., well supported to qualified structures, cables and detectors not located beneath non-qualified equipment).

3) Means to extinguish small fires in areas containing seismically qualified systems shall remain available after a DBE. 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 108-03650-SDG-002 [Reference 8] "Seismic Requirements").

4) 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 that can contain any possible leakage of the flammable liquids or gases.

v) Flammable or combustible liquids shall be handled and stored in accordance with the requirements of the National Building Code of Canada, National Fire Code of Canada and the IAEA Guide 50-SG-D2 (or its revised current form) requirements should be addressed, including the following requirements:

1) Self closing valves shall be used on dispensing valves and overflow prevention devices,

2) Venting devices to outside the building shall be provided to prevent spills and overpressure in the event of a fire,

3) Storage tank supports shall be designed to withstand fires without collapse.

w) The provision for fire exits shall be in accordance with the National Building Code of Canada and the IAEA Guide 50-SG-D2 (or its revised current form) requirements should be addressed, except for the following:

1) Minimum Number of Exits

The building code requirement of maximum floor area (200 m^2) with 2 exits need 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

The building code requirement of having a travel distance to an exit or at least one exit from any point in a service space need not be satisfied in the Reactor Building.

3) Self-closing Devices

The design of the Reactor Building air locks may not satisfy the requirement of having self-closing devices for a normally closed exit (i.e., door closes and latches automatically after use).

4) Door Release Hardware

The design of the Reactor Building air locks does not have to 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.

The above exceptions shall be reviewed for each case, and the life-safety provisions of the reactor building shall be reviewed as part of Preliminary Fire Hazard Assessment.

x) Fire fighting equipment needed to suppress a fire shall be located away from the immediate vicinity of the fire (e.g., hose stations, standpipes, extinguishers, protective equipment); this can be done by locating redundant equipment at another location.

4.5 Fire Hazards Assessment

The design requirements in the CSA Standard, IAEA Guide 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. This Fire Hazards Assessment may also be part of a Probabilistic Safety Assessment for fire events. The Fire Hazards 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 CSA Standard and the IAEA Guide. 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 and recorded in the fire hazards assessment.

b) Simple computer analysis or hand calculations shall be performed in areas of high fire loading to confirm the adequacy of the separation measures, including the fire separation rating or distance separation.

c) For defined fire barriers, the suitability of the standard time-temperature curve shall be confirmed, or a specific time-temperature curve shall be established, based on the quantity of combustibles in the area.

d) In crediting actions by plant operating personnel and fire fighting teams, the assessment shall identify the criteria used to justify the reliance on manual fire fighting, including the response time, manpower, accessibility of the area (temperature, radiant heat, toxic gases), visibility impairment, and the location of fire fighting equipment. In the event these specific data are not available, assumptions used in the assessment shall be documented.

e) For the turbine generator, the assessment shall consider the simultaneous failure of the hydrogen cooling system and lube oil system, as well as the potential for structural instability of the steel structural components of the turbine building.

f) The fire hazard assessment shall consider seismic event and any impact of non-seismically qualified system containing combustible gases and liquids.

5. DOCUMENTATION

The documents required to demonstrate an adequate fire protection program are identified in Appendix A. In the Fire Hazard Assessment document, the designer shall provide information on the definition of Design Basis Fires in a fire area.

6. REFERENCES

[1] Canadian Standards Association, “Fire Protection for CANDU Nuclear Power Plants”, CAN/CSA-N293-95, National Standard of Canada (approved February 1997)

[2] IAEA Safety Guides, “Fire Protection in Nuclear Power Plants”, Safety Series No. 50-SG-D2, 1979

[3] Safety Design Guide, “Separation of Systems and Components”, 108-03650-SDG-004

[4] International Organization for Standardization, ISO 834-1, “Fire-resistance tests-Elements of building construction, Part 1: General Requirements”, 1999

[5] CSA 22.2 No. 0.3, “Test Methods for Electrical Wires and Cables”

[6] ASTM E-119, “Fire Tests of Building Materials”

[7] The Institute of Electrical and Electronics Engineers, Inc., IEEE 383, “IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations”, 1974

[8] Safety Design Guide, “Seismic Requirements”, 108-03650-SDG-002

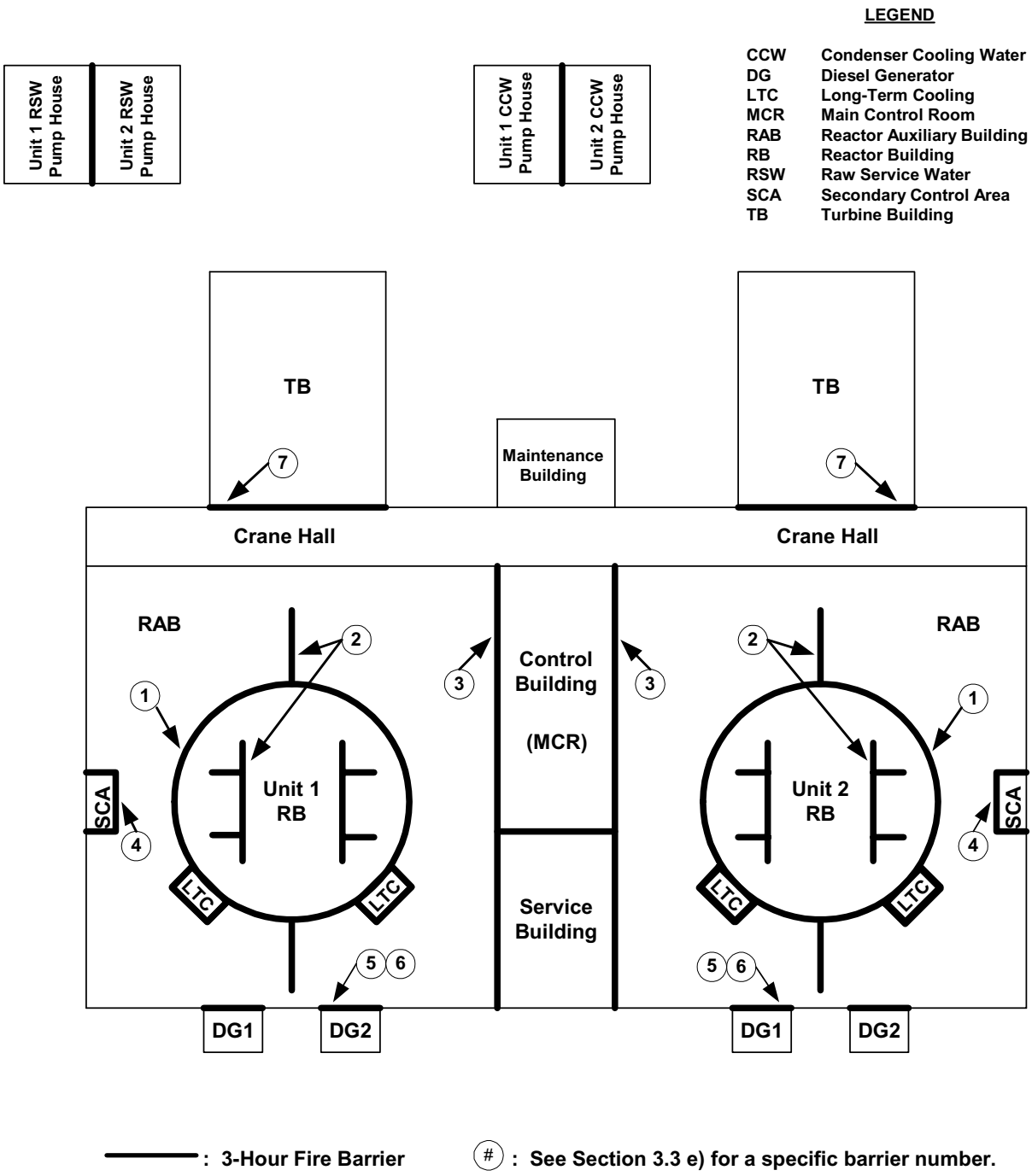

Figure 1 Major Fire Barrier Locations (Conceptual Schematic)

Appendix A

Fire Protection Program for Design

ACTIVITIES	DOCUMENTS INPUT	DOCUMENTS OUTPUT
(1) DEFINITION OF DESIGN REQUIREMENTS		
- To identify project specific requirements.	• CSA Standard N293 and IAEA Guide 50-SG-D2 (Revision 1) • Project-specific requirements	• Safety Design Guide SDG-005 (Fire Protection)
(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 Manual of fire protection systems • Procurement specifications • Suppliers' documentation • Safety Design Guide supplements
(4) DESIGN VERIFICATION		
- To demonstrate that design complies with all requirements.	• Relevant design documents • Design review records	• Final Fire Hazards Assessment report • Probabilistic Fire Hazards Assessment
(5) INPUT FOR OTHER STAGES		
- To pass assumptions, requirements and recommendations on.	• Fire protection design and assessment documents	• Guidelines for commissioning and plant operation included in Fire Hazard Assessment report and Design Manuals

Appendix B

List of Safety Design Guides

Identification	Title
108-03650-SDG-001	Safety Related Systems
108-03650-SDG-002	Seismic Requirements
108-03650-SDG-003	Environmental Qualification
108-03650-SDG-004	Separation of Systems and Components
108-03650-SDG-005	Fire Protection
108-03650-SDG-006	Containment
108-03650-SDG-007	Radiation Protection

Appendix C

Acronyms

AC	Alternating Current
ACR™*	Advanced CANDU Reactor™
AECL	Atomic Energy of Canada Limited
ALARA	As Low As Reasonably Achievable
ASDV	Atmospheric Steam Discharge Valves
ASI	AECL Subject Index
BOP	Balance Of Plant
CA	Control Absorber
CANDU®	Canadian Deuterium Uranium
CCP	Critical Channel Power
CCW	Condenser Cooling Water
CHF	Critical Heat Flux
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	The Canadian Standards Association
D_2O	Heavy Water
DBE	Design Basis Earthquake
DC	Direct Current
DCS	Distributed Control System
DEL	Derived Emission Limit
DG	Diesel Generator
EAB	Exclusion Area Boundary
ECCS	Emergency Core Cooling System
ECI	Emergency Core Injection
EDS	Electrical power Distribution System
HTS	Heat Transport System
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiation Protection
ISO	International Organization for Standardization
LCDA	Limited Core Damage Accident
LOCA	Loss Of Coolant Accident
LTC	Long Term Cooling

* ACR™ (Advanced CANDU Reactor™) is a trademark of Atomic Energy of Canada Limited (AECL).

® CANDU is a registered trademark of Atomic Energy of Canada Limited.

LWR	Light Water Reactor
MCR	Main Control Room
MOT	Main Output Transformer
MSIV	Main Steam Isolation Valves
MSSV	Main Steam Safety Valves
NEW	Nuclear Energy Worker
NSP	Nuclear Steam Plant
NSSS	Nuclear Steam Supply System
OM&A	Operation, Maintenance and Administration
PAM	Post Accident Management
PSA	Probabilistic Safety Assessment
PTR	Pressure Tube Reactor
PWR	Pressurized Water Reactor
RAB	Reactor Auxiliary Building
RB	Reactor Building
RCU	Reactivity Control Unit
RCW	Recirculated Cooling Water
RSW	Raw Service Water
RWS	Reserve Water System
SCA	Secondary Control Area
SDS 1	Shut Down System 1
SDS 2	Shut Down System 2
SEU	Slightly Enriched Uranium
SFC	Single Failure Criterion
SST	System Service Transformer
SU	Shutoff Unit
ULC	Underwriter's Laboratories Canada
UPS	Uninterrupted Power Supply
UST	Unit Service Transformer
ZCU	Zone Control Unit