CONTROL ROOM HABITABILITY STUDY

FOR

QUAD CITIES UNITS 1 AND 2

COMMONWEALTH EDISON COMPANY

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Ann Arbor, Michigan

Partial Report
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CONTROL ROOM HABITABILITY STUDY

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1.0 INTRODUCTION

A study is being conducted of the Quad Cities Units 1 and 2 control room habitability during toxic gas releases, radioactive gas releases, and direct radiation resulting from design basis accidents (DBAs). The study includes a survey of potential onsite and offsite sources of toxic chemical hazards which could jeopardize control room habitability, along with an analysis of control room doses resulting from a DBA loss-of-coolant accident (LOCA). The study is intended to satisfy the requirements for control room habitability as provided in Item III.D.3.4 of NUREG 0737, Clarification of TMI Action Plan Requirements. A copy of NUREG 0737, Item III.D.3.4 is provided as Appendix A.

The following report summarizes the results of the study. This report is only a partial submittal. The analysis of the radiological calculations, and the recommended design modifications that address those results, are complete and are included in Sections 4 and 5. A response to the "Request for Information Required for Control Room Habitability Evaluation," as contained in Attachment 1 to Item III.D.3.4 of NUREG 0737, is provided as Appendix B. However, the survey of potential onsite and offsite sources of toxic chemicals is an ongoing effort. Preliminary information is provided in Section 3. Final results of the toxic chemical survey, and any recommended design modifications that address those results, will be provided as a revision to this report at a later date.

2.0 EXISTING DESIGN

The Quad Cities Units 1 and 2 control room is located in the control building at elevation 623'. The existing HVAC system which supplies conditioned air to the control room is located in the service building at elevation 623'. This system also provides conditioned air to the computer room (elevation 595'), auxiliary electric equipment room (elevation 595'), cable spreading room (elevation 609'), HVAC equipment room, and miscellaneous areas. The HVAC system operates continuously to maintain 75F in the control room for personnel comfort and safety and equipment reliability. FSAR Subsection 10.10.4 provides further details on the control building HVAC system.

3.0 TOXIC CHEMICAL SURVEY

A survey for potentially toxic chemicals stored or transported onsite, or within a 5-mile radius offsite, of Quad Cities Units 1 and 2 is being conducted in accordance with the criteria outlined in NUREG 0737, Item III.D.3.4. Information is being requested from each industrial facility, business, and farm regarding toxic chemical storage or transport by truck, rail, barge, or pipeline. Information is also being requested from the railroad and pipeline companies operating lines in this area. Available data on regional truck and barge traffic are also being compiled.

The toxic chemical survey is an ongoing effort. The final results of the survey will be provided at a later date, pending receipt of responses to our requests for information.

4.0 RADIOLOGICAL ANALYSIS

General Design Criterion 19, Standard Review Plan (SRP) 6.4, and NUREG 0737, Item III.D.3.4 require that adequate radiation protection exist to permit control room access and occupancy for the duration of a design basis accident (DBA). The radiological analysis, provided in Appendix D, considered the loss-of-coolant accident (LOCA) as the worst-case DBA and assumed main steam isolation valve (MSIV) leakage at technical specification limits. Although several natural mechanisms exist to reduce or delay radioactive release to the environment, as discussed in Appendix D, credit was taken only for iodine plateout on surfaces of the steam lines and condenser and radioactive decay prior to release. The analysis also assumed that the control building HVAC system was designed with the proposed modifications discussed in Section 5.3. A detailed discussion of the methodology and assumptions of the analysis, as well as the conservatism of the approach, is included in Appendix D.

The following results are 30-day integrated doses in the control room based on the intake of unfiltered outside air for 8 hours following the LOCA, and filtered outside air thereafter. The dose guidelines provided in SRP 6.4, Acceptance Criterion 8 are also provided for comparison purposes. The thyroid and skin doses consist of contributions from airborne radioactivity inside the control room. The whole-body dose consists of contributions from airborne radioactivity inside and outside the control room, as well as direct shine from activity within the reactor building above the refueling floor.

TOTAL CONTROL ROOM DOSES (Rem)

	Thyroid	Skin	Whole-Body
Quad Cities Units 1 and 2	9.66	1.78	0.165
SRP 6.4, Guidelines for Control Room	30	30	5

As evidenced by these results, the control building HVAC system, with the design modifications discussed in Section 5.3, meets the radiological protection requirements of General Design Criterion 19 and SRP 6.4.

5.0 PROPOSED HVAC DESIGN MODIFICATIONS

5.1 OVERVIEW

The following section presents proposed modifications to the existing control room HVAC system to meet the intent of NUREG 0737, Item III.D.3.4 and SRP 6.4, and to satisfy the requirements of General Design Criterion 19 regarding control room habitability following a radiological DBA. These modifications include the addition of a redundant system (train B) consisting of an air handling unit (AHU), return air fan, chiller, pump, and associated piping, ducts, dampers, and appurtenances, and an air filtration unit (AFU) common to both air handling systems.

The following discussion includes only the design changes required to address radiological accident requirements. Any design changes required to address toxic chemical requirements will be provided upon completion of the toxic chemical survey. Refer to Section 3.0 for further information.

5.2 EMERGENCY ZONE

SRP 6.4 defines the boundaries for a control room emergency zone. Within this zone, the plant operators are adequately protected against the effects of accidental radiological gas releases. This zone also allows the control room to be maintained as the center from which emergency teams can safely operate in a design basis radiological release.

To satisfy this requirement, the following areas are included in the emergency zone.

a. Main control room, which includes all critical documents and reference files

b. Cable spreading room

c. Auxiliary electrical equipment room

d. Computer room

e. New HVAC equipment room, which houses the new train B system

Areas outside the emergency zone, which are normally serviced by the existing AHU system (train A), shall be isolated in emergency conditions. Support rooms such as the kitchen, offices, and washrooms are accessible to operators with the aid of breathing equipment. The existing HVAC equipment room is also not included in the emergency zone.

5.3 PROPOSED MODIFICATIONS

The proposed HVAC system design modifications are described below. Figure 1 provides a schematic of the proposed system.

a. Existing supply AHU train A, return air fan A, and all related ductwork will be utilized.

b. New supply AHU train B will be located in a new HVAC equipment room. AHU train B will be sized to supply the emergency zone as discussed in Section 5.2. Ducts from new AHU train B will be connected to the corresponding ducts of the existing air handling system. A suggested possible arrangement is outlined in Figure 1.

c. New return air fan B will return air to new supply AHU train B. New AHU train B will also have outside air of 2,500 cfm.

d. A new AFU, sized to accommodate 1,600 cfm, will be located in the new HVAC equipment room. This unit will consist of a prefilter, electric heating coils, high-efficiency particulate air (HEPA) filter, charcoal filters, HEPA filter, and two full-capacity fans. The AFU will be in compliance with Regulatory Guide 1.52.

e. A new 100%-capacity chilled water system for train B will be installed in the new HVAC equipment room.

f. Bubbletight and low-leakage dampers will be used as shown in Figure 1.

5.4 MODIFIED SYSTEM OPERATION

For normal conditions, the AHU train A system will operate as discussed in Section 2.0.

For emergency conditions, as determined by radiation monitors in the reactor building ventilation manifold, system operation will be as follows. The bubbletight isolation dampers will automatically isolate the normal outside air intake to the AHUs and all ventilation zones which are not mentioned in Section 5.2 above.

Within 8 hours, the outside air damper to the new AFU will be remote manually opened and an AFU fan will begin supplying filtered air to one AHU train. The return air fan will route the return air to the associated AHU train. Barring component failures in the operating AHU train, the system will continue to operate in this manner for the duration of the emergency.

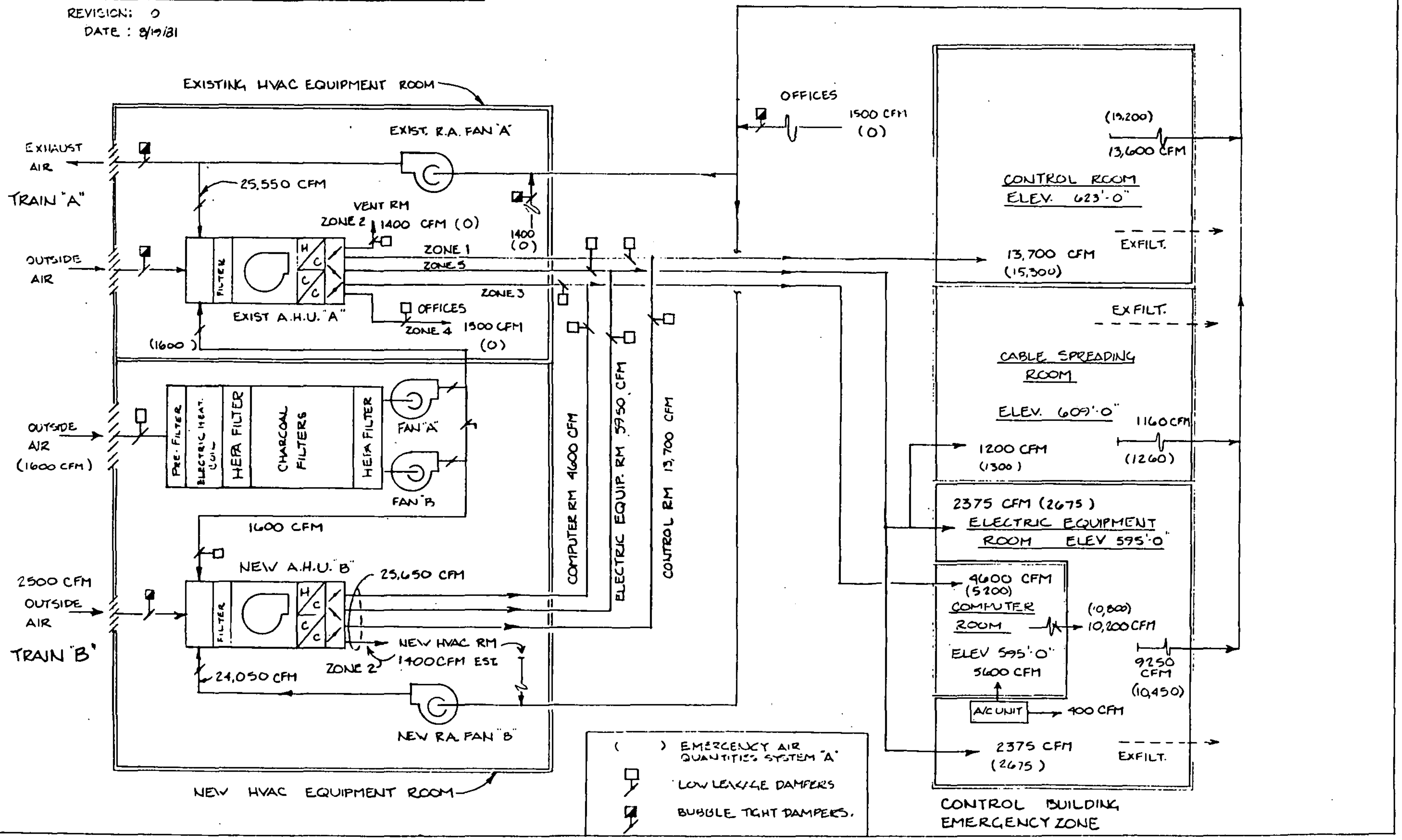
On failure of airflow in the operating AHU train system, that train is automatically isolated and the redundant train is energized. Outside air will be supplied to the redundant AHU train by an AFU fan in this operating mode. The return air fan will route the return air to the associated AHU.

6.0 RECOMMENDATIONS

Based on the results of the radiological analysis, it is recommended that the control building HVAC system design incorporate the modifications discussed in Section 5.3.

FIGURE 1
QUAD CITIES
CONTROL RM HVAC SCHEMATIC

REVISION: 0
DATE: 8/19/81



APPENDIX A

NUREG 0737, ITEM III.D.3.4

CONTROL ROOM HABITABILITY REQUIREMENTS

III.D.3.4 CONTROL-ROOM HABITABILITY REQUIREMENTS

Position

In accordance with Task Action Plan item III.D.3.4 and control room habitability, licensees shall assure that control room operators will be adequately protected against the effects of accidental release of toxic and radioactive gases and that the nuclear power plant can be safely operated or shut down under design basis accident conditions (Criterion 19, "Control Room," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50).

Changes to Previous Requirements and Guidance

There are no changes to the previous requirements.

Clarification

(1) All licensees must make a submittal to the NRC regardless of whether or not they met the criteria of the referenced Standard Review Plans (SRP) sections. The new clarification specifies that licensees that meet the criteria of the SRPs should provide the basis for their conclusion that SRP 6.4 requirements are met. Licensees may establish this basis by referencing past submittals to the NRC and/or providing new or additional information to supplement past submittals.

(2) All licensees with control rooms that meet the criteria of the following sections of the Standard Review Plan:

2.2.1-2.2.2	Identification of Potential Hazards in Site Vicinity
2.2.3	Evaluation of Potential Accidents;
6.4	Habitability Systems

shall report their findings regarding the specific SRP sections as explained below. The following documents should be used for guidance:

(a) Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of Regulatory Power Plant Control Room During a Postulated Hazardous Chemical Release";

(b) Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accident Chlorine Release"; and,

(c) K. G. Murphy and K. M. Campe, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Design Criterion 19," 13th AEC Air Cleaning Conference, August 1974.

Licensees shall submit the results of their findings as well as the basis for those findings by January 1, 1981. In providing the basis for the habitability finding, licensees may reference their past submittals. Licensees should, however, ensure that these submittals reflect the current facility design and that the information requested in Attachment 1 is provided.

(3) All licensees with control rooms that do not meet the criteria of the above-listed references, Standard Review Plans, Regulatory Guides, and other references.

These licensees shall perform the necessary evaluations and identify appropriate modifications.

Each licensee submittal shall include the results of the analyses of control room concentrations from postulated accidental release of toxic gases and control room operator radiation exposures from airborne radioactive material and direct radiation resulting from design-basis accidents. The toxic gas accident analysis should be performed for all potential hazardous chemical releases occurring either on the site or within 5 miles of the plant-site boundary. Regulatory Guide 1.78 lists the chemicals most commonly encountered in the evaluation of control room habitability but is not all inclusive.

The design-basis-accident (DBA) radiation source term should be for the loss-of-coolant accident LOCA containment leakage and engineered safety feature (ESF) leakage contribution outside containment as described in Appendix A and B of Standard Review Plan Chapter 15.6.5. In addition, boiling-water reactor (BWR) facility evaluations should add any leakage from the main steam isolation valves (MSIV) (i. e., valve-stem leakage, valve seat leakage, main steam isolation valve leakage control system release) to the containment leakage and ESF leakage following a LOCA. This should not be construed as altering the staff recommendations in Section D of Regulatory Guide 1.96 (Rev. 2) regarding MSIV leakage-control systems. Other DBAs should be reviewed to determine whether they might constitute a more-severe control-room hazard than the LOCA.

In addition to the accident-analysis results, which should either identify the possible need for control-room modifications or provide assurance that the habitability systems will operate under all postulated conditions to permit the control-room operators to remain in the control room to take appropriate actions required by General Design Criterion 19, the licensee should submit sufficient information needed for an independent evaluation of the adequacy of the habitability systems. Attachment 1 lists the information that should be provided along with the licensee's evaluation.

Applicability

This requirement applies to all operating reactors and operating license applicants.

Implementation

Licensees shall submit their responses to this request on or before January 1, 1981. Applicants for operating licenses shall submit their responses prior to issuance of a full-power license. Modifications needed for compliance with the control-room habitability requirements specified in this letter should be identified, and a schedule for completion of the modifications should be provided. Implementation of such modifications should be started without awaiting the results of the staff review. Additional needed modifications, if any, identified by the staff during its review will be specified to licensees

Type of Review

A postimplementation review will be performed.

Documentation Required

By January 1, 1981 licensees shall provide the information described in Attachment 1. Applicants for an operating license shall submit their responses prior to full-power licensing.

Technical Specification Changes Required

Changes to technical specifications will be required.

References

NUREG-0660, Item III.D.3.4.

Letter from D. G. Eisenhut, NRC, to All Operating Reactor Licensees, dated May 7, 1980.

III.D.3.4, ATTACHMENT 1, INFORMATION REQUIRED FOR CONTROL-ROOM HABITABILITY EVALUATION

(1) Control-room mode of operation, i.e., pressurization and filter recirculation for radiological accident isolation or chlorine release

(2) Control-room characteristics

   (a) air volume control room

   (b) control-room emergency zone (control room, critical files, kitchen, washroom, computer room, etc.)

   (c) control-room ventilation system schematic with normal and emergency air-flow rates

   (d) infiltration leakage rate

   (e) high efficiency particulate air (HEPA) filter and charcoal adsorber efficiencies

   (f) closest distance between containment and air intake

   (g) layout of control room, air intakes, containment building, and chlorine, or other chemical storage facility with dimensions

   (h) control-room shielding including radiation streaming from penetrations, doors, ducts, stairways, etc.

   (i) automatic isolation capability-damper closing time, damper leakage and area

   (j) chlorine detectors or toxic gas (local or remote)

   (k) self-contained breathing apparatus availability (number)

   (l) bottled air supply (hours supply)

   (m) emergency food and potable water supply (how many days and how many people)

   (n) control-room personnel capacity (normal and emergency)

   (o) potassium iodide drug supply

(3) Onsite storage of chlorine and other hazardous chemicals

   (a) total amount and size of container

   (b) closest distance from control-room air intake

(4) Offsite manufacturing, storage, or transportation facilities of hazardous chemicals

   (a) identify facilities within a 5-mile radius;

   (b) distance from control room

   (c) quantity of hazardous chemicals in one container

   (d) frequency of hazardous chemical transportation traffic (truck, rail, and barge)

(5) Technical specifications (refer to standard technical specifications)

   (a) chlorine detection system

   (b) control-room emergency filtration system including the capability to maintain the control-room pressurization at 1/8-in. water gauge, verification of isolation by test signals and damper closure times, and filter testing requirements.

APPENDIX B

NRC-REQUESTED INFORMATION REQUIRED

FOR

CONTROL ROOM HABITABILITY EVALUATION

The following list of responses corresponds directly to the items requested by Attachment 1 to NUREG 0737, Item III.D.3.4. The responses reflect the modified control building HVAC system design as discussed in Section 5.3 of this report.

Please note that the toxic chemical survey is an ongoing effort. Upon completion of the survey, the appropriate responses below will be revised to include the requested information.

Item	Response
1	Upon detection of high airborne radioactivity in the reactor building ventilation manifold, the control building HVAC system will enter the emergency mode of operation. In this mode, normal makeup and selected return air ducting are automatically isolated. Within 8 hours, the control room emergency zone is pressurized by once-through makeup air passing through an emergency filter unit. The control building HVAC system emergency mode of operation for a toxic chemical release will be provided following receipt and evaluation of the requested information.
2	Control Room Characteristics a. Control room air volume: The air volume of the control room emergency zone is approximately 184,000 cubic feet, including 58,000 cubic feet for the main control room. b. Control room emergency zone: The control room emergency zone includes the main control room, cable spreading room, computer room, auxiliary electrical equipment room, and the new HVAC equipment room. c. Control room ventilation system schematic: Figure 1 of this report provides a proposed ventilation system schematic for the control room emergency zone indicating normal and emergency airflows. d. Infiltration leakage rate: Infiltration leakage into the control room is negligible because the control room will be maintained at a positive pressure with respect to adjacent rooms during both normal and emergency conditions. For emergency conditions, makeup air will be limited to a maximum of 2,000 scfm. Backflow infiltration is assumed to be 10 scfm.

Item	Response
e.	HEPA filter and charcoal adsorber efficiencies: The HEPA filters in the emergency filtration train are rated at 99.97% efficiency in removing particulates of 0.3-micron size and larger. The charcoal filters in the emergency filtration train are rated at 99% efficiency for removal of elemental and organic iodine.
f.	Closest distance between containment and air intake: The control building HVAC system intake (elevation 633') is located approximately 232 feet from the closest wall of the secondary containment building. Additionally, the standby gas treatment system (SGTS) vent stack is located approximately 520 feet laterally and 272 feet above the HVAC system intake.
g.	Layout: A layout drawing showing the relative location of the control room, HVAC system intake, turbine building, SGTS vent stack, and the containment is shown in attached Figure B-1.
h.	Control room shielding: The control room design consists of poured-in-place reinforced concrete with 6-inch floor and ceiling slabs and 18- to 27-inch walls. The radiation streaming effect in the control room is considered negligible during normal operation and provides a 30-day integrated whole-body dose of 57 mRem post-LOCA. Refer to FSAR Section 12.3 for further details.
i.	Automatic isolation capability, damper information: Isolation of the normal makeup air intake takes approximately 20 seconds. (The isolation time is tentative pending the results of the toxic chemical survey.) The makeup air intake and exhaust dampers will be bubble-tight with an area of 25 square feet each and a leakage factor of zero. Office zone 10" x 10" duct and HVAC equipment room zone 18" x 10" duct will be isolated with bubbletight dampers with a leakage factor of zero for the return air, and a low leakage type damper for the supply air.
j.	Chlorine or toxic gas detectors: Response to be provided upon receipt of the requested information.
k, l.	Self-contained breathing apparatus availability and bottled air supply: Five self-contained breathing apparatus are available in the control room, each with a 20-minute air supply. A manifolded bottled air system is also available. The system is capable of supplying air to five people for 6 hours.

Item	Response

m. Emergency food and potable water supply: The control room does not presently contain food provisions. Adequate water is available.

n. Control room personnel capacity: During normal operation, the control room will contain four people. In emergency conditions, the personnel capacity will be limited to five people by the bottled air system capabilities.

o. Potassium iodide supply: A supply of 1,000 130-milligram doses of potassium iodide is available in the control room.

3 Onsite Storage of Chlorine and Other Hazardous Chemicals

Response to be provided upon receipt of the requested information.

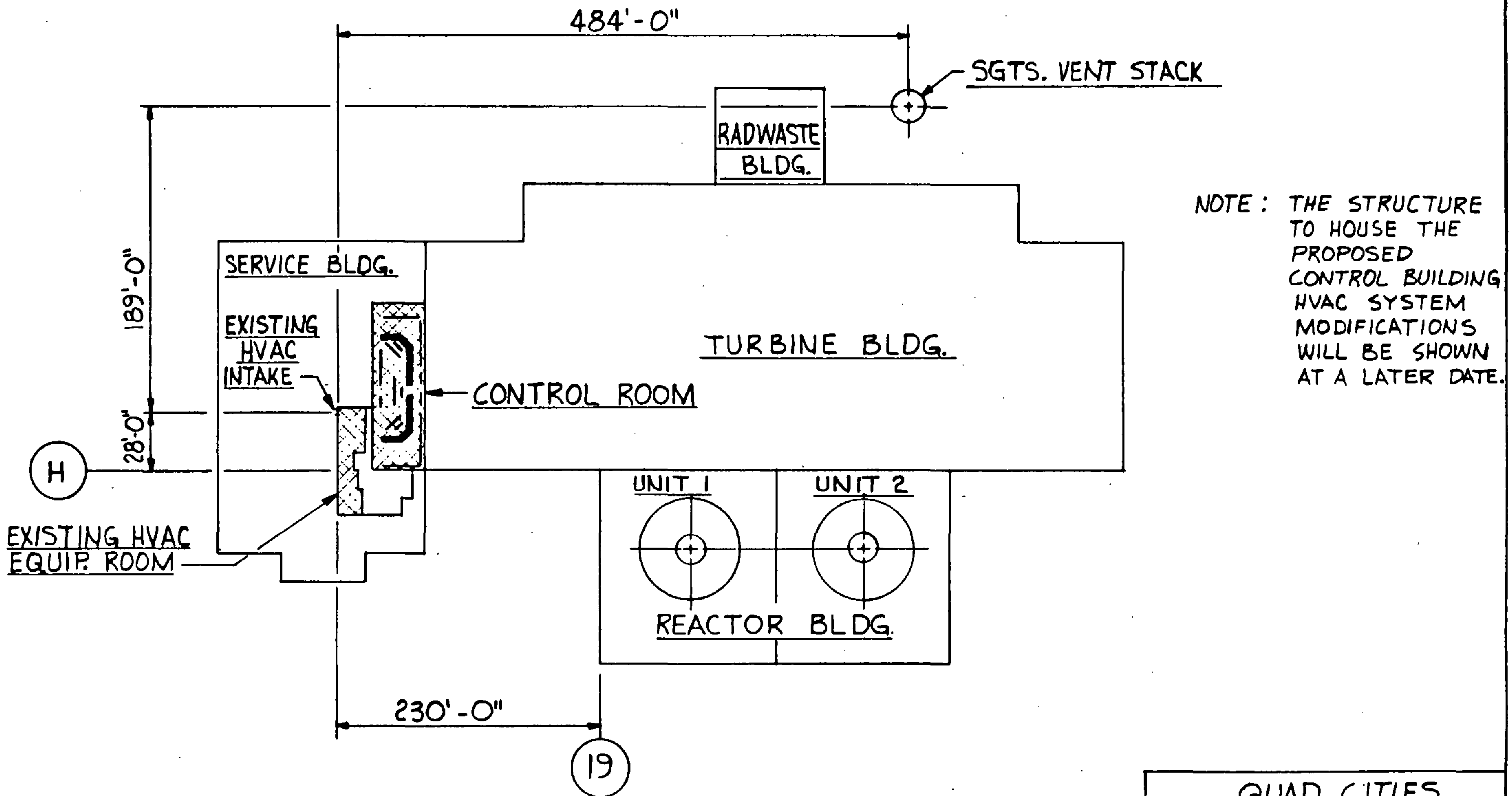
4 Offsite Manufacturing, Storage, or Transportation Facilities of Hazardous Chemicals

Response to be provided upon receipt of the requested information.

5 Technical Specifications

a. Chlorine detection system: Because no chlorine detection system exists at the present time, no technical specification has been written for it. Based on the results of the toxic chemical survey, the technical specifications will be reviewed and revised, as necessary.

b. Control room emergency filtration system: Because no control room emergency filtration system exists at the present time, no technical specification has been written for it. The technical specifications will be reviewed and revised, as necessary, to address the proposed modifications.



QUAD CITIES
CONTROL ROOM HABITABILITY
GENERAL PLANT LAYOUT
FIGURE B-1
NOT TO SCALE

APPENDIX C

SUMMARY OF OFFSITE TOXIC CHEMICAL SURVEY

(The toxic chemical survey is an ongoing effort. Information for this appendix will be provided at a later date.)

APPENDIX D

RADIOLOGICAL ANALYSIS

FOR

CONTROL ROOM HABITABILITY

FOLLOWING A DBA-LOCA

A. INTRODUCTION

The following analysis was performed in accordance with the guidance of NUREG 0737, Item III.D.3.4 to determine compliance with the radiological requirements of General Design Criterion 19 and Standard Review Plan (SRP) 6.4. The loss-of-coolant accident (LOCA) was considered in the analysis to be the radiological design basis accident (DBA). Furthermore, main steam isolation valve (MSIV) leakage at the technical specification limit was assumed for the analysis.

The results of this analysis are considered conservative. Several natural mechanisms will reduce or delay the radioactivity prior to release to the environment. However, credit was taken only for iodine plateout on surfaces of the steam lines and condenser and radioactive decay prior to release. These mechanisms are discussed in Section E.

B. METHODOLOGY

The guidelines given in SRP 6.4 (Reference 1) and Regulatory Guide 1.3 (Reference 2) have been used with the exception of the X/Q for the control room and plateout of iodines during transportation within pipes. Realistically, the components of main steam lines and the turbine-condenser complex, though nonsafety grade, would remain intact following a DBA-LOCA. Therefore, plateout of iodines on surfaces of main steam lines and the turbine-condenser complex is expected. Atmospheric dispersion factors are based on the Halitsky Methodology from Meteorology and Atomic Energy 1968, as discussed in Section D.

C. ASSUMPTIONS AND BASES

Regulatory Guide 1.3 has been used to determine activity levels in the containment following a DBA-LOCA. Activity releases are based on a containment leakage rate of 0.5% per day. Table D-1 lists the assumptions and parameters used in the analysis and dose point locations. The majority of the containment leakage will be collected in the reactor building and exhausted to the atmosphere through the 99% efficient SGTS filters as an elevated release from the main stack. However, there are certain release pathways from the containment which will bypass the SGTS filters. The bypass leakage has been quantified by assuming that all MSIVs leak at the technical specification limit of 11.5 scfh per main steam line. Based on this assumption, a total leakage for all steam lines together would be 46 scfh (0.7667 scfm).

Radioactivity leaking past the isolation valves could be released through the outboard MSIV stems into the steam tunnel, or continue down the steam lines to the stop valves and into the turbine-condenser complex. Leakage into the steam tunnel is exhausted by the SGTS filtration system, thus eliminating it as a bypass pathway. Leakage down the steam lines is subject to plateout and delay within the lines. Reference 3, Section 5.1.2 discusses iodine removal rates which can be applied to calculate plateout on the piping and turbine condenser surfaces. Elemental and particulate iodine decontamination factors of over 100 can be calculated for small travel distances and large travel times down the steam lines, considering the small volumes of leakage which leak past the valves.

The credit for plateout and holdup within steam lines and the turbine-condenser complex has been taken by dividing them into three different volumes. The first volume consists of steam lines between the inboard and outboard isolation valves, the second volume consists of steam lines between the outboard isolation valves and the turbine stop valves, and the third volume includes the steam lines after the turbine stop valves and the turbine-condenser volume complex. Conservatively, failure of an inboard isolation valve in one main steam line has been considered. The activity leaking from the primary containment travels through, and mixes well within, each volume prior to release to the environment from the turbine-condenser complex. The removal rate for iodine due to plateout within each volume is based on the estimated surface area and the methodology given in Reference 3, Section 5.1.2. These removal rates are only applied to elemental and particulate iodines. The removal of organic iodine through plateout is not considered. It was assumed that the bypass leakage is collected in the steam line turbine-condenser volume complex from which it will leak at 1% of the turbine-condenser volume per day. This leak rate is consistent with the assumptions used for the control rod drop accident in SRP 15.4.9 (Reference 4). This assumption is conservative, because the volumetric leakage out of the condenser would be approximately the same as the inleakage and the 1% leak rate per day out of the turbine-condenser volume is higher than the leak rate into the steam lines from the drywell. Furthermore, the bypass leakage will be cooling and condensing as it travels down the lines.

Leakage within the turbine building would be exhausted by the heating, ventilating, and air conditioning (HVAC) system if it were working. Additional plateout on ductwork, fans, and unit coolers would further minimize the iodine releases. Should the HVAC system not be working, then any bypass leakage would tend to collect in the building and be subject to additional decay and plateout. Leakage from the turbine building into the control room is minimized by the separate HVAC systems and by maintaining the interconnecting doors in their normally closed positions.

The control room pressurization system ensures that leakage is from the protected area towards the other parts of the building, further minimizing the possibility of contaminating the protected areas. A positive pressure is maintained in the main control room by introducing 1,600 cfm of outside air through a 99% efficient filtration system.

The activity which enters the main control room may be the result of bypass leakage, standby gas treatment system (SGTS) exhaust in the outside air, or both, depending on wind direction. Because of the locations of these sources with respect to the control room HVAC intake, it is possible for the intake to be exposed to activity from both sources at the same time. Because the SGTS exhaust is elevated, the concentrations from this source at the intake will be less than those due to bypass leakage. This analysis conservatively assumes that the activity concentration at the intake is due to concurrent bypass leakage and stack releases for the duration of the event.

D. ATMOSPHERIC DISPERSION FACTOR (X/Q)

The following discussion is an explanation of the reasons for the use of the Halitsky X/Q methodology and a value of $K_c = 2$, instead of the Murphy methodology (Reference 5) which SRP 6.4 suggests as an interim position.

Historically, the preliminary work on building wake X/Q's was based on a series of wind tunnel tests by J. Halitsky, et al. Halitsky summarized these results in Meteorology and Atomic Energy in 1968 (Reference 6). In 1974, K. Murphy and K. Campe of the NRC published their paper based on a survey of existing data. This X/Q methodology, which presented equations without derivation or justification, was adopted as the interim methodology in SRP 6.4 in 1975. Since then, a series of actual building wake X/Q measurements have been conducted at Rancho-Seco (Reference 7) and several other papers have been published documenting the results of additional wind tunnel tests.

In Reference 5, Murphy suggested the following equation for the calculation of X/Q

$$X/Q = K_c/AU$$

where

$K_c = K + 2$

$K = 3/(S/d)^{1.4}$

A = Cross-sectional area of the building

U = Wind speed

This formulation was derived from the Halitsky data in Figure 37 of Reference 5 from Murphy's paper. The Halitsky data were from wind tunnel tests on a model of the EBR-II rounded (PWR type) containment and the validity of the data was limited to $0.5<s/d<3$ (Reference 6, Section 5.5.5.2). The origin and reason for the +2 in K + 2 is not known. All other formulations use K only, and for the situation where K is less than 1, the use of K + 2 imposes an unrealistic limit on the X/Q.

For the Quad Cities plant, the building complex is composed of square-edged buildings and not a round-topped cylindrical containment as was used in the Halitsky experiments. For an HVAC intake located near the south wall of the control room at elevation 633'-0", the intake will be subject to a building wake caused by a combination of the reactor building and the turbine building for any bypass leakage escaping from the turbine building. There will be no reactor building bypass leakage because the building is kept at a negative pressure by the SGTS which exhausts from the main stack.

Because the Murphy methodology could not be applied, a survey of the literature was undertaken. It was found that the Halitsky wind tunnel test data (Reference 6, Section 5.5.5) conservatively overestimated K_c values "by factors of up to possibly 10." Given this conservatism, it was felt that the use of a reasonable K_c value from the Halitsky data on square-edged buildings should be acceptable. A review of Figure 5.27 from M&AE (Reference 6) resulted in K_c values in the 0.5 to 2 range. A value of $K_c = 2$ was chosen to get a X/Q for the control room. A building cross-sectional area of 1,550 m^2 was conservatively used. This corresponds to a projected area of one reactor building above grade. The use of a 1,550 m^2 area is very conservative because both the reactor buildings are adjacent to each other and the combined projected area would be larger than the value used. Information from other sources, as indicated below, has also shown that this should be a conservative value.

1. In a paper by D.H. Walker (Reference 8), control room X/Q's were experimentally determined for floating power plants in wind tunnel tests. Different intake and exhaust combinations were considered. Using the data for intake 6 and stack A exhaust (Reference 8), X/Q values of 1.77×10^{-5} and 2.24×10^{-5} were found after adjusting the wind speed from 1.5 m/sec to 1 m/sec. These values are approximately two order-of-magnitudes lower than the conservatively calculated value for Quad Cities.

2. In a wind tunnel test by P.N. Hatcher (Reference 9), a model industrial complex was used to test dispersions due to a wake. Data obtained from these tests show that K_c has a value less than 1, and decreases as the test points are moved closer to the structure. In a study to determine optimum stack heights, R.N. Meroney and B.T. Yang (Reference 10) show that for short stacks (6/5 of building height), K_c reaches a value of approximately 0.2 and decreases closer to the building. They concluded that the Halitsky methodology was "overly conservative." These recent experimental tests show that $K_c = 2$ used to determine the X/Q for Quad Cities is a conservative estimate by at least a factor of 2 and possibly by 10 or more.

3. Field tests were made on the Rancho-Seco facility (Reference 7), and X/Q values were obtained. The data indicate that the use of $K_c = 2$ is conservative.

It was concluded that sufficient data and field tests exist to give a reasonable assurance that the chosen X/Q is a conservative one, over and above the conservatism implied by using the fifth percentile wind speed and wind direction factors. Based on the above discussion, the following equation is used in the calculation of X/Q values.

$$X/Q = 2/AU$$

E. MECHANISMS FOR REDUCING IODINE RELEASES

The following mechanisms could result in significant quantities of iodine being removed before they are released to the environment. However, numerical credit for the plateout mechanisms is the only credit taken in the calculation of radiological consequences.

1. DRYWELL SPRAYS, SUPPRESSION POOL TO AIR PARTITIONING, AND CONDENSATION EFFECTS

Though manually operated, the drywell sprays will reduce the iodine source term if actuated. Even without the spray system, condensation will occur in the drywell and wetwell.

The iodines in the air and suppression pool are expected to reach equilibrium due to this phenomenon. Because the iodines have a preference to stay in water due to the equilibrium partition factor of over 400 established by the physical conditions in the containment, the iodines available for release by air leakage will be reduced significantly. In addition, recent investigations after TMI (NSAC-14, Workshop on Iodine Releases in Reactor Accidents) have indicated that the iodine release assumption may be excessively conservative. Most of the iodine may be released as cesium iodide instead of elemental iodine. The cesium iodide has a much higher solubility and ability to plateout than elemental iodine.

2. PLATEOUT

Although there is an implied factor of 2 iodine plateout in Regulatory Guide 1.3 source term, experimental evidence and the experience at TMI indicates that significantly larger plateout factors are common. The plateout removal constant used in this analysis is based on the lowest deposition velocity quoted in Reference 3. The other data quoted in Reference 7 indicate that the deposition velocities could be higher by a factor of 4, which would tend to increase the plateout.

3. REMOVAL THROUGH VALVES AND LEAKAGE HOLES

Because the bypass leakage paths are through minute holes in valves and valve seats, the leakage will be subjected to filtration effects. Larger particulates could tend to plug the leak paths (Reference 11).

4. CONDENSATE WITHIN PIPES

Condensation will occur within the pipes when the pipes cool down to ambient temperature. This could result in removal of iodines and particulates from the gas phase.

F. <u>RESULTS</u>

The calculated radiation doses are given in Table D-2 and are found to be within the guidelines of General Design Criterion 19 and SRP 6.4.

REFERENCES

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TABLE D-1

LOSS-OF-COOLANT ACCIDENT
PARAMETERS TABULATED FOR POSTULATED ACCIDENT ANALYSES

		Design Basis Assumptions	
I.	Data and Assumptions Used to Estimate Radioactive Source from Postulated Accidents		
	A. Power level, MWt	2,527	
	B. Burnup	NA	
	C. Fission products released from fuel (fuel damaged)	100%	
	D. Iodine fractions		
	Organic	0.04	
	Elemental	0.91	
	Particulate	0.05	
II.	Data and Assumptions Used to Estimate Activity Released		
	A. Primary containment leak rate, %/day	0.5	
	B. Volume of primary containment, cu ft	1.58E+5	
	C. Secondary containment release rate, %/day	100	
	D. Leak rate through MSIV, scfh	11.5	
	E. Number of main steam lines	4	
	F. Leak rate from turbine condenser complex, %/day	1.0	
	G. Volume and surface area (all four steam lines)	Ft^3	Ft^2
	Between inboard and outboard MSIV	176	470
	Outboard and turbine stop valves	761	1,693
	Turbine condenser complex	1.7×10^5	6.5×10^5
	H. Deposition velocity for iodines, cm/sec		
	Particulate	0.012	
	Elemental	0.012	
	Organic	0.0	
	I. Valve movement times	(See Note)	
	J. SGTS adsorption and filtration efficiencies, %		
	Organic iodines	99	
	Elemental iodine	99	
	Particulate iodine	99	

Table D-1 (continued)

	Design Basis Assumptions	
III. Dispersion Data, sec/m^3		
A. CR building wake X/Q for time intervals of	Bypass Leak	SGTS (Stack)
0 to 2 hours	1.29E-3	7.0E-4*
2 to 8 hours	1.29E-3	6.45E-6
8 to 24 hours	7.61E-4	3.81E-6
1 to 4 days	4.84E-4	2.42E-6
4 to 30 days	2.13E-4	1.07E-6

*0 to 2 hour fumigation conditions assumed according to Regulatory Guide 1.3

IV. Data for Control Room	
A. Volume of control room, ft^3	5.83E+4
B. Filtered intake, cfm	1,600
C. Efficiency of charcoal adsorber, %	99
D. Efficiency of HEPA, %	99.9
E. Unfiltered inleakage, cfm	10
F. Recirculation flowrate	0.0
G. Occupancy factors:	
0 to 1 day	1.0
1 to 4 days	0.6
4 to 30 days	0.4

Note: The MSIV movement times are not applicable to the analysis because the valves will close before any significant fuel failures occur. The control room HVAC intake valve movement times are not applicable because the calculated doses assume an unfiltered outside air intake of 1,600 cfm for the first 8 hours post-LOCA.

TABLE D-2

DBA-LOCA RADIOLOGICAL CONSEQUENCES

CONTROL ROOM	Doses (Rem) Thyroid	Skin	Whole-Body
1. Bypass Leakage			
a. Activity inside control room	2.97	4.77E-1	1.52E-2
b. Plume shine	--	--	2.03E-3
c. Direct shine	--	--	5.70E-2
2. Stack Release			
a. Activity inside control room	6.69	1.30	7.96E-2
b. Plume shine	--	--	1.10E-2
TOTAL CONTROL ROOM DOSES	9.66	1.78	1.65E-1

Note: The values provided above represent 30-day integrated doses. The doses are calculated assuming an unfiltered outside air intake of 1,600 cfm for the first 8 hours post-LOCA. At 8 hours, the control room operators are assumed to remote manually activate the charcoal filtration unit.