50-289

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 2, 1998

LICENSEE: GPU Nuclear Corporation

FACILITY: Three Mile Island Unit No. 1 (TMI-1)

SUBJECT: MEETING SUMMARY

On December 12, 1997, GPU Nuclear Corporation (GPU or the licensee) representatives met with members of the NRC staff to discuss the licensee's Control Room Habitability evaluation related to control room operator thyroid dose from fission product releases during a postulated design basis accident at TMI-1. The meeting was requested by the staff in a September 24, 1997, letter to the licensee. The letter acknowledged that by previous agreement with the NRC staff, as documented in an August 14, 1986 letter and supplemental Safety Evaluation Report, the licensee was only required to address whole body and beta skin doses in its response to NUREG-0737 Item III.D.3.4, Control Room Habitability. Consideration of thyroid doses from iodine releases was to be deferred until a source term reevaluation effort by the staff was completed. As the staff has yet to complete its implementation plan on the use of revised accident source terms for operating plants, the licensee was requested to provide the results of its evaluation of the thyroid doses within six months of the September 24, 1997, letter. The purpose of the December 12 meeting was for the staff to review the licensee's progress and gain a better understanding of the design and operation of the TMI-1 control building ventilation system (CBVS). Also in attendance as an observer was a representative from Nucleonics Week.

The licensee provided the staff with a discussion of the CBVS layout and control room building arrangement. The licensee also provided details of the CBVS design features, automatic initiation features and potential failure modes. The licensee also provided operational details of the system and assumptions being made in the thyroid dose calculation including modeling techniques used, X/Q values assumed, and accidents considered. The licensee indicated it was still on schedule for a March 24, 1998, submittal.

The licensee broached the concept of using a total effective dose equivalent (TEDE) for the thyroid in lieu of the thyroid dose limit, but the staff indicated that it may be premature to consider that argument in Regulatory space and that current regulatory requirements would need to be addressed such

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as are contained in General Design Criterion (GDC) 19. The staff also commented on the licensee's proposed use of probabilistic risk assessment consideration, indicating that such considerations were not normally credited in design basis accident analyses. The licensee also discussed use of the new source term limit and credit for offsite power restoration and restoration of the non-class 1E auxiliary building ventilation system, but the staff indicated that these were not normally given credit on the front end analysis. The licensee indicated it used NUREG-1228 for iodine reduction factors and plate out assumptions and used the same assumptions as in its Chapter 14 FSAR accident analysis. The staff acknowledged that there may be conservatism in the licensee's single failure assumptions described in its analysis.

Enclosure 1 is a list of attendees; and Enclosure 2 contains the licensee's slides.

Original signed by
Timothy G. Colburn, Senior Project Manager
Project Directorate I-3
Division of Reactor Projects I/II
Office of Nuclear Reactor Regulation

Docket No. 50-289
Enclosures: 1. List of Attendees
2. Slides
cc w/enclosures: See next page

HARD COPY	E-MAIL
Docket File	SCollins/FMiraglia (SJC1/FJM)
PUBLIC	RZimmerman (RPZ)
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December 12, 1997

MEETING WITH GPU NUCLEAR CORPORATION

CONTROL ROOM HABITABILITY STUDY

ATTENDEES

Name	Affiliation
T. Colburn	NRC/NRR/DRPE/PD1-3
B. Buckley	NRC/NRR/DRPE
J. Lee	NRC/NRR/DRPM/PERB
C. Miller	NRC/NRR/DRPM/PERB
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B. Parfitt	TMI/Radiological Engineering
T. Y. Byoun	GPU Nuclear/Nuclear Fuels
P. Bennett	TMI/HVAC System Engineer
J. Fornicola	GPU Nuclear/Director Nuclear Safety Assessment
K. Woodard	PLG Consulting
A. Irani	GPU Nuclear/Safety Analysis
C. Hartman	GPU Nuclear/System Engineering TMI
D. Distel	GPU Nuclear/Licensing
B. Williamson	Nucleonics Week

Enclosure 1

GPU NUCLEAR CORPORATION

CONTROL ROOM HABITABILITY STUDY

DECEMBER 12, 1997

HANDOUT MATERIAL USED AT THE MEETING

Enclosure 2

GPU NUCLEAR/NRC MEETING
December 12, 1997

TMI-1 CONTROL ROOM HABITABILITY EVALUATION

I. Control Building Envelope (CBE) and
Control Building Ventilation System (CBVS)

- Site Building Layout
- CBE Arrangement
- CBVS Arrangement

II. Control Building Ventilation System

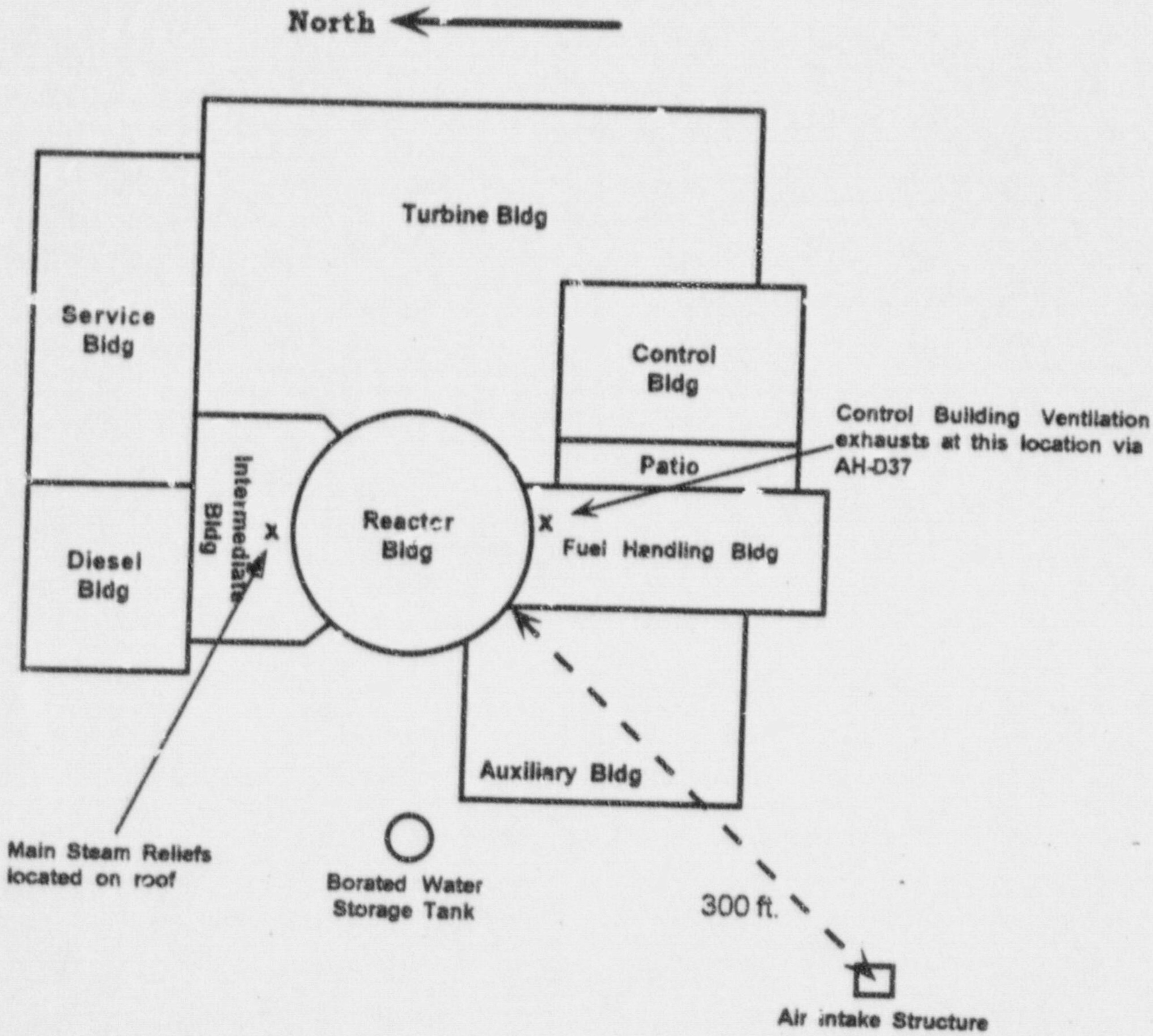
- Design Features
- System Diagram
- Potential Failure Modes

III. Control Room Evaluation Analysis

- Modeling TMI-1 Control Room Doses
- X/Q Values for Control Room Habitability Analysis
- Accidents Considered
- TEDE Dose Criteria

IV. Control Room Habitability Submittal

CONTROL BUILDING ENVELOPE (CBE) & CONTROL BUILDING VENTILATION SYSTEM (CBVS)



PARTIAL SITE PLAN FOR TMI-1

CONTROL BUILDING VENTILATION ZONES

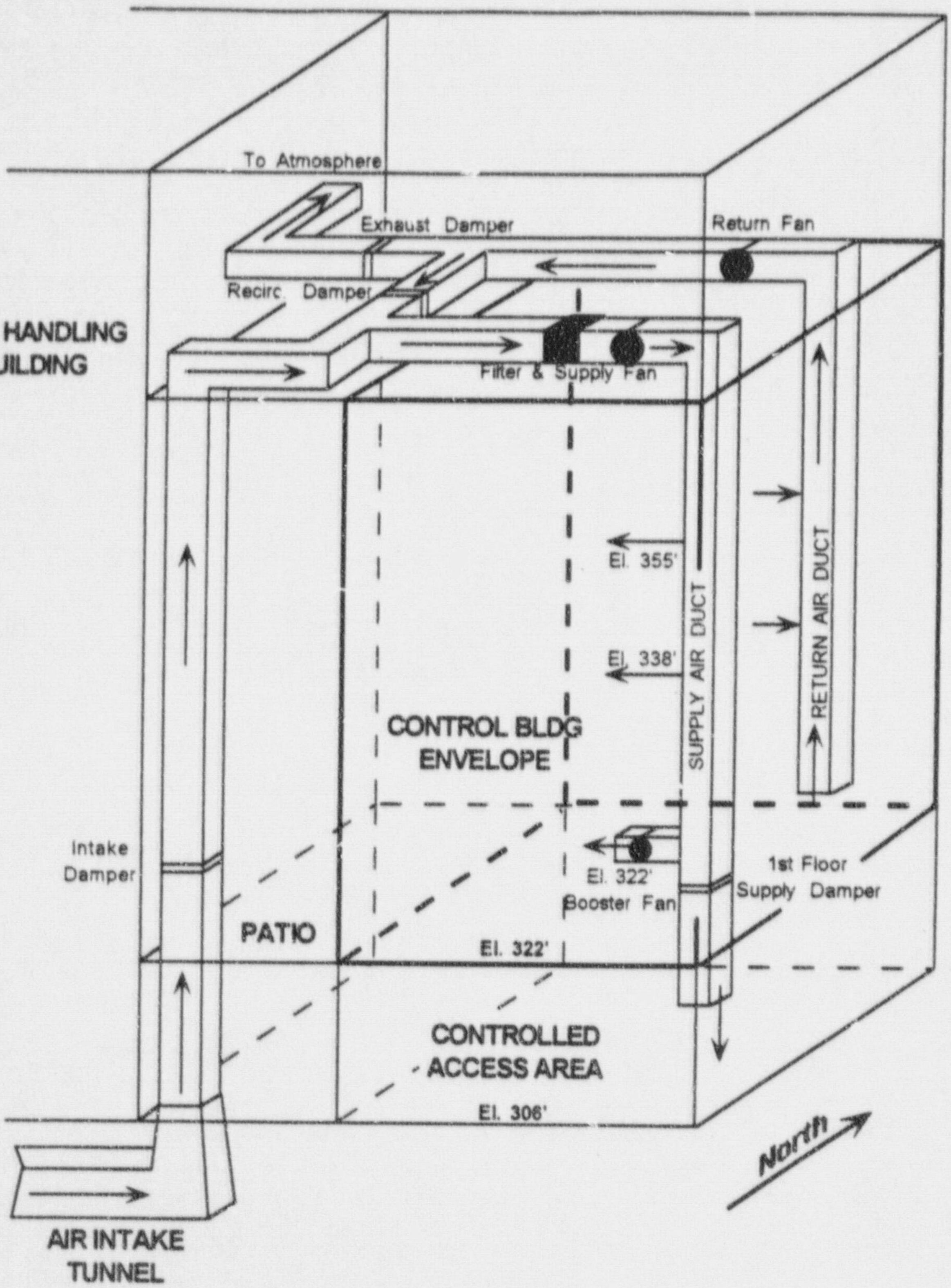
Definitions:

Control Room (CR) – Elevation 355' of Control Building excluding stairwell and Control Building Hallway (Patio).

Control Building Envelope (CBE) – Elevations 355' (CR), 338' and 322' of the Control Building, excluding stairwell and Control Building Hallway (Patio).

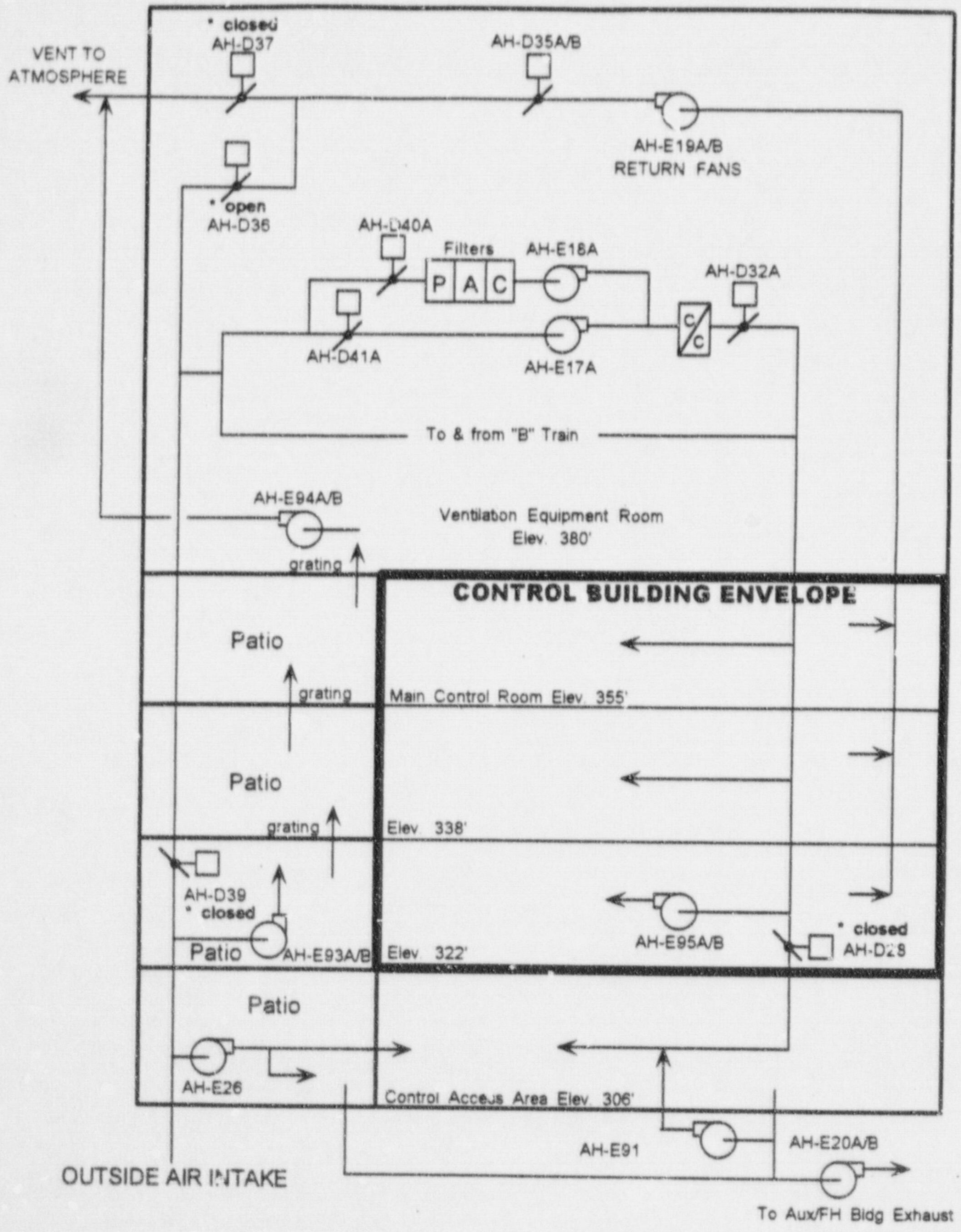
Control Building Hallway (Patio) – Adjacent to west wall of Control Building Envelope, and elevation 380' of the Control Building.

Controlled Access Area (CAA) – Elevation 306' of the Control Building, excluding the Hot Tool room area.



SIMPLIFIED VIEW OF CONTROL BUILDING

(*) Emergency Position



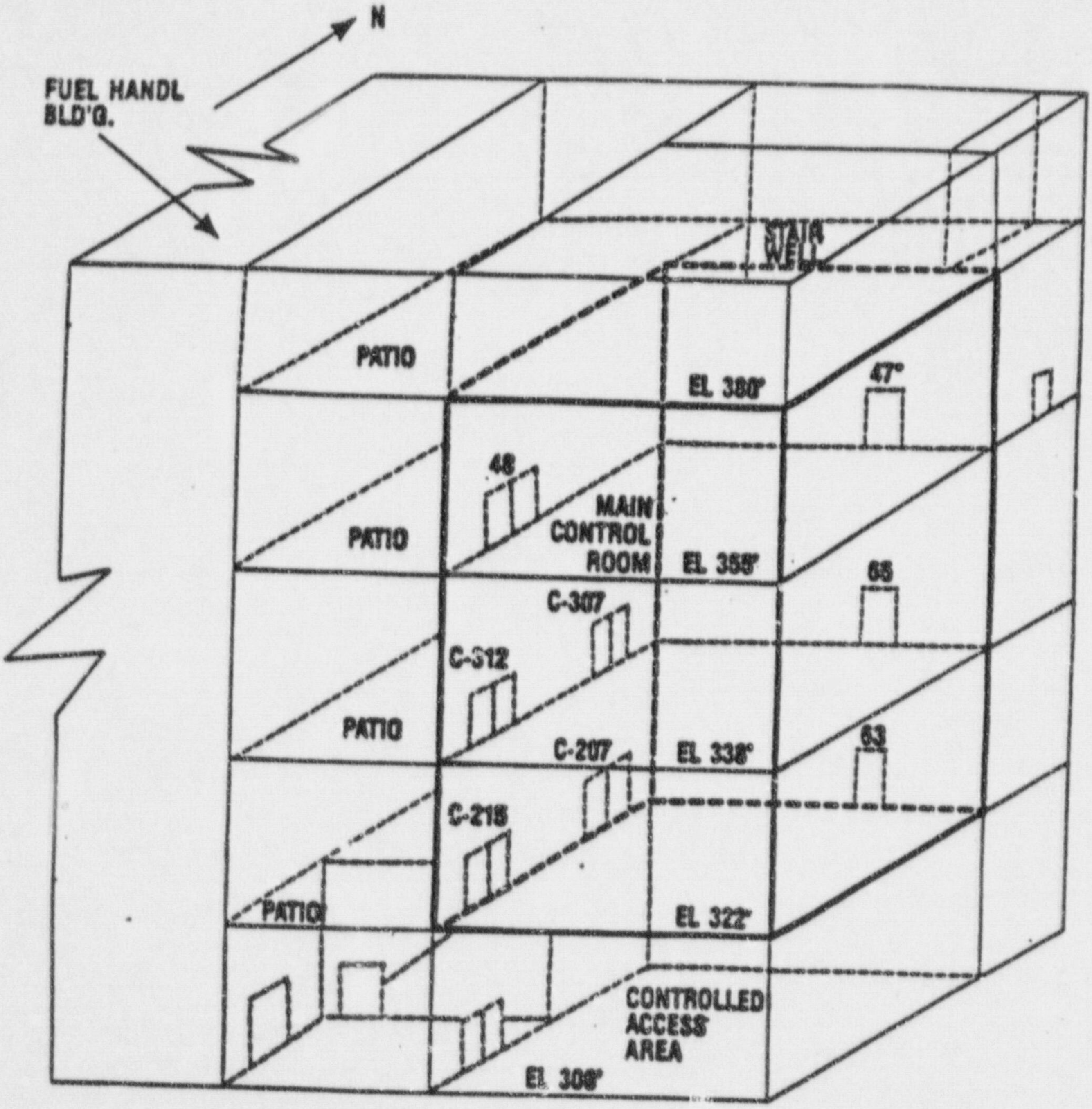
TMI-1 CONTROL BUILDING VENTILATION SYSTEM

CONTROL BUILDING VENTILATION SYSTEM

CONTROL BUILDING & VENT. SYS. FEATURES

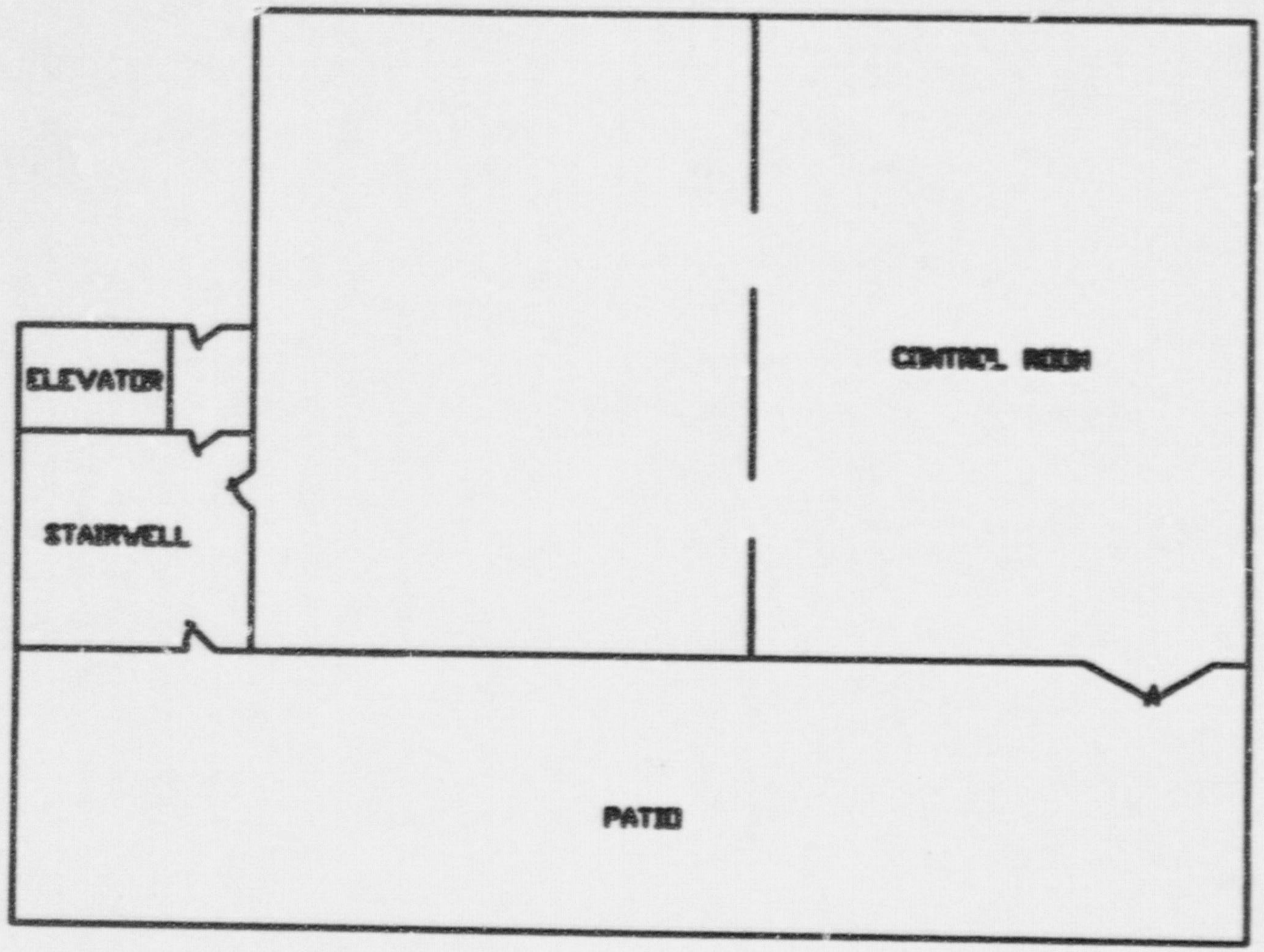
- Control Building Separate Concrete Structure – Protection from Direct Streaming
- Penetrations Between Floors Sealed - Minimizes Transfer Air
- Ventilation Ductwork – Welded Construction
- Redundant Emergency Powered Fans with Filter Banks
- Redundant Emergency Powered Control Air System for Dampers & Controls
- Diverse Initiation Features for Control Building Ventilation System Emergency Mode of Operation
- Positive Pressure Maintained in Control Room As Demonstrated By Test for Various Failures
- Procedural Action to Maintain Pressurized Envelope by Admission of Outside Air
- Breathing Apparatus and Potassium Iodide Available
- Single Doors Between CBE and Patio Area
- Positive Pressure Not Maintained in Lower Elevations During Various Failures

CONTROL BUILDING

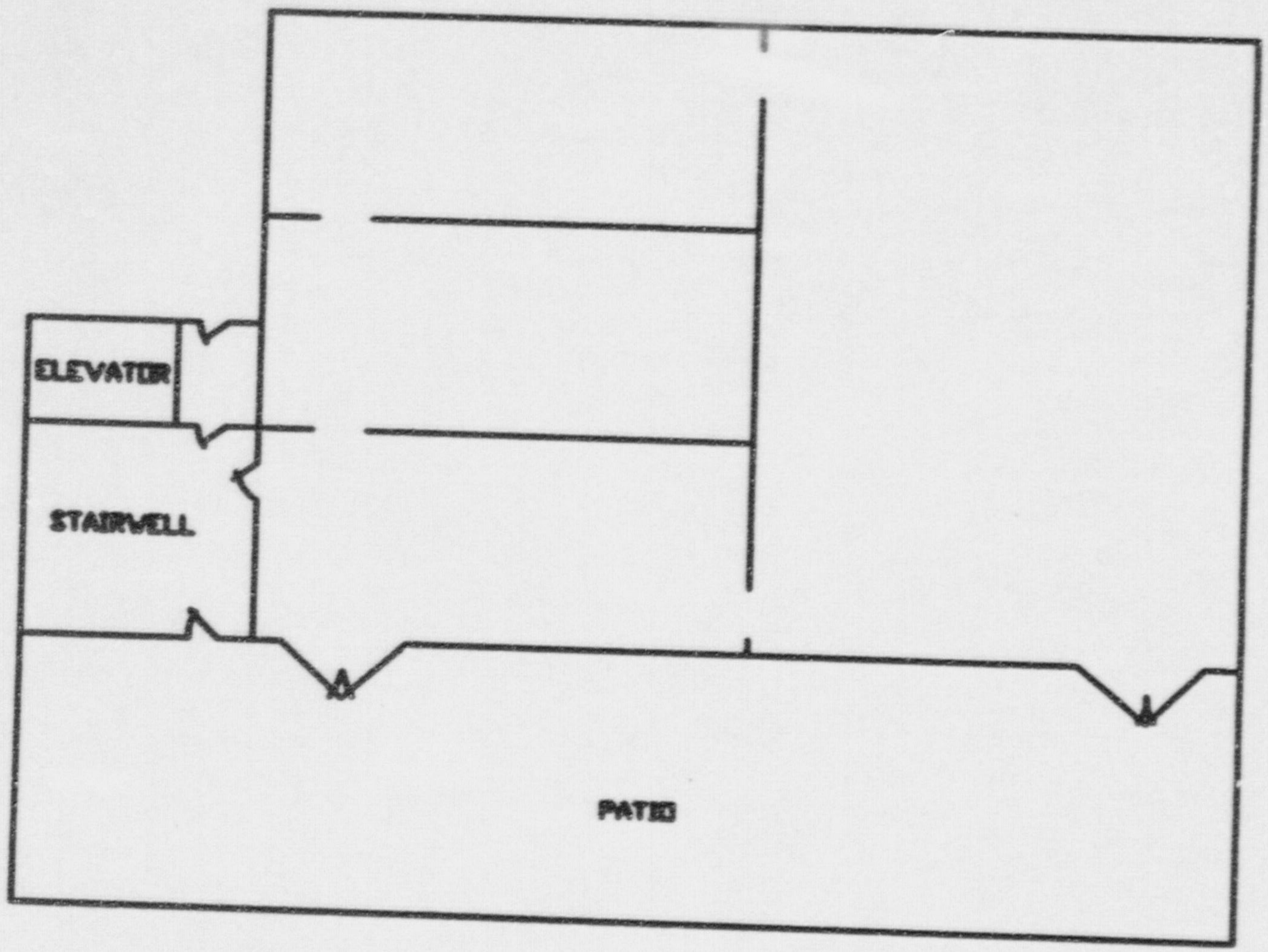


LEGEND

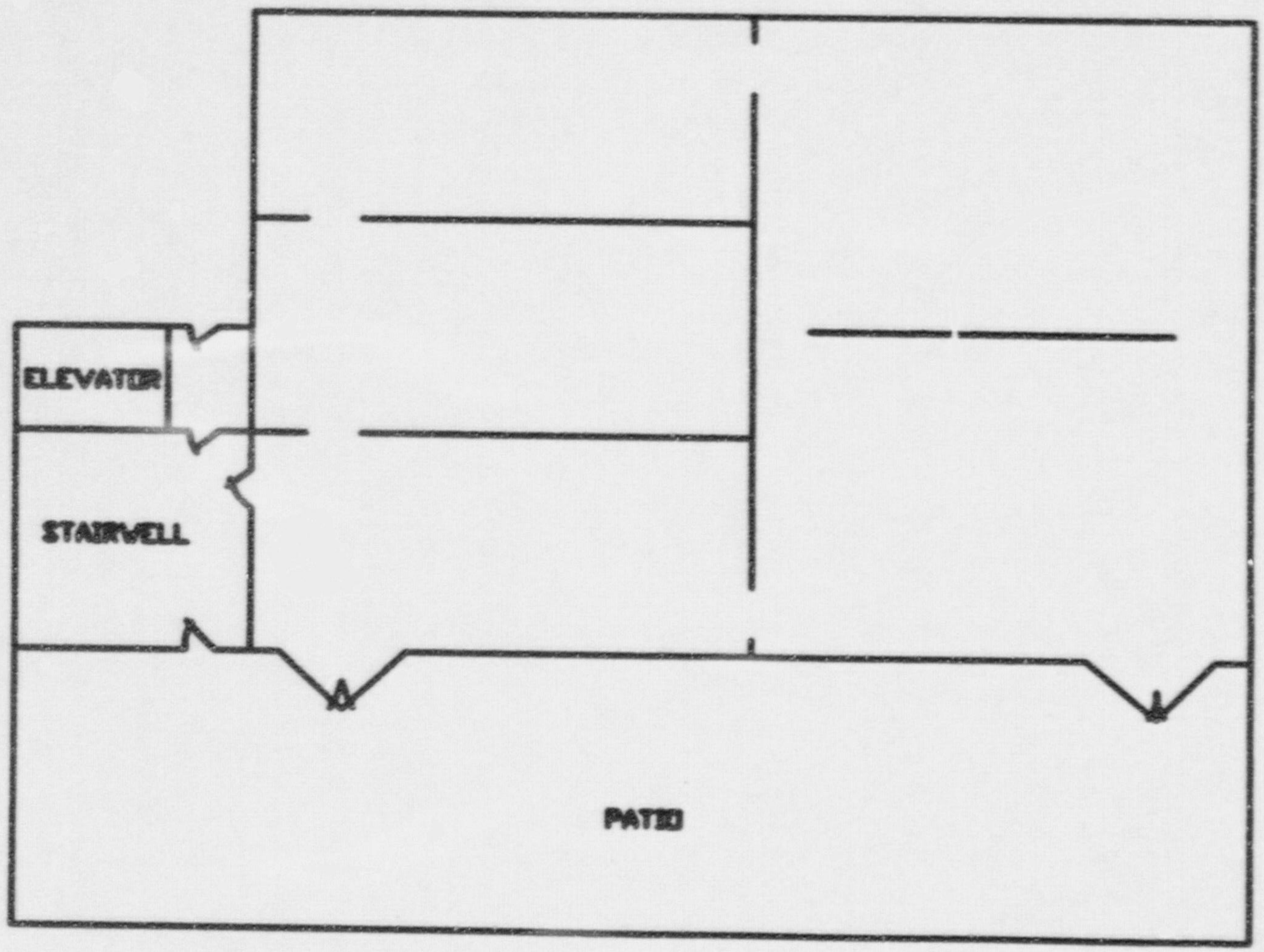
* INDICATES DOOR NUMBER
— CONTROL BLD'G ENVELOPE



CONTROL BUILDING ELEV. 355'

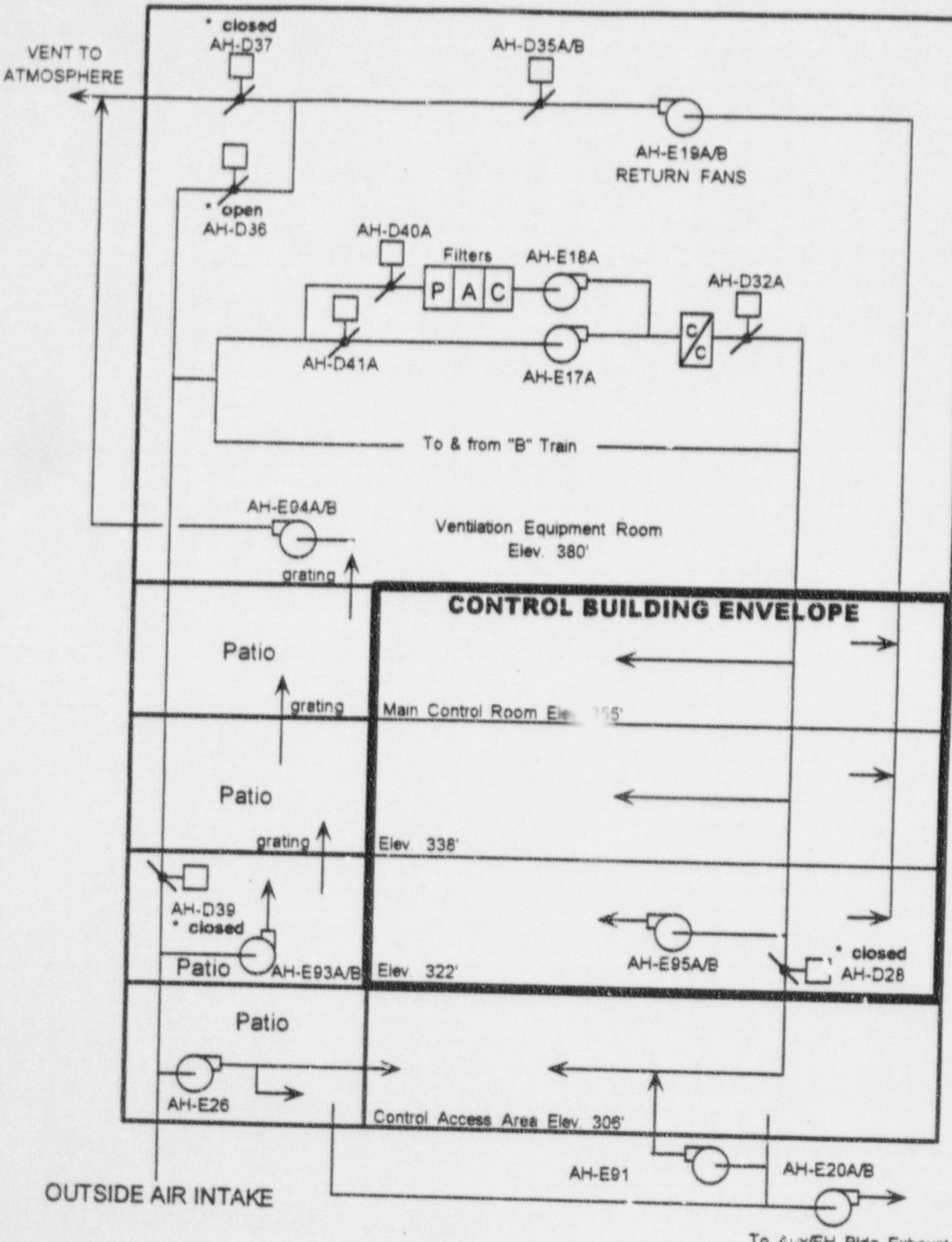


CONTROL BUILDING ELEV. 338'



CONTROL BUILDING ELEV. 322'

(*) Emergency Position



TMI-1 CONTROL BUILDING VENTILATION SYSTEM

PATHWAYS ANALYSIS
(CONSISTENT WITH PREVIOUS HABITABILITY ANALYSIS)

External (Atmospheric Transport)

Damper 28 Failure (Open)

- Positive Pressure All Elevations of CBE
- No Internal Paths Modeled
- ESF Leakage Assumed External
- X/Q 's Determined for Yard Intake (300' from containment)

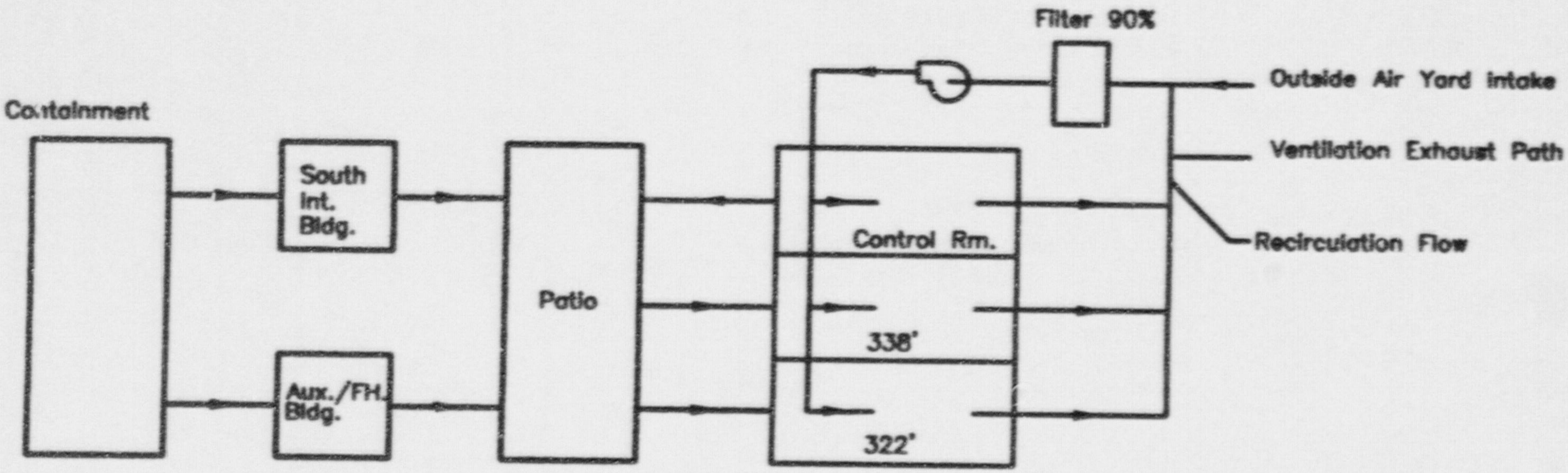
Gradual Position Switch Failure (AH-D-39 & AH-D-37 Closed, AH-D-36 Open)

- Positive Pressure Control Room
- Two Intake Pathways (Yard Intake & Vent. Exhaust Leakage)
- ESF Leakage included
- Two conditions of X/Q's
- No internal transport assumed

Internal Transport

- Gradual Position Switch Failure (AH-D-39 & AH-D-37 Closed, AH-D-36 Open)
- Two credible pathways developed (South Int. Bldg. & Aux/FH Bldg
- No External Contribution Assumed
- Non – emergency powered ventilation systems off
- Transport by Diffusion
- Infiltration to CBE based on previous DP test & analysis

PATHWAYS


Containment
South Int. Bldg.
Aux./FH. Bldg.
Patio
Control Rm.
338'
322'
Filter 90%
Outside Air Yard intake
Ventilation Exhaust Path
Recirculation Flow

CONTROL ROOM EVALUATION ANALYSIS

MODELING TMI CONTROL ROOM DOSES

- Use PLG's MCD (Multi-Compartment Dose) computer program.
- Assumes well mixed isotopic concentration in each volume.
- Dynamic model using 1-minute time scale.
- Accounts for varying isotopic input to, and transfer from, each volume.
- Doses are accumulated for up to 30 days in each volume.

MCD PROCESSING

- Reads input source term comprised of 13 noble gas and 5 iodine isotopes.
- Computes concentration in each room including effects of radioactive decay.
- Concentrations and doses are printed for each volume as a function of time.
- Dilution between the containment surface and leakage into a compartment is accounted for.

MCD METHODOLOGY

- A differential equation is set up for each compartment volume.

- These equations are solved simultaneously for concentration every minute using a numerical algorithm referred to as the Runge-Kutta method.

- The removal mechanisms for radioactive material include air flow, isotopic decay, and filtration of iodines.

FLOW CONDITIONS

- Model includes ventilation air flow rates in the supply and return ducts.

- Iodine filtration with 90% efficiency is assumed for initial makeup as well as during recirculation.

- Each volume can be modeled to leak in to any other volume(s) as required by the particular scenario.

- Single failures in fan motors or dampers can be modeled to determine effect on doses.

EXTERNAL DOSE MODEL

- **External dose is adjusted using a finite volume correction factor such that the walls, floor, and ceiling limit the receptor dose. The reduction factor (F_c) applied to the external dose is of the form:**

$$F_C = (1 - e^{-\mu R}) - (\mu - \mu_a) R e^{-\mu R}$$

where: μ and μ_a are attenuation factors for air and R is the radius of a hemisphere with volume equivalent to that of the Control Room

TMI-1 χ/Q-Values for Control Room Habitability Analysis

METHODOLOGY:

- In accordance with the **Murphy & Campe** Guidelines
- **Source-Receptor configuration** ⇒ Diffused Source and Point Receptor
- **Meteorological Data** ⇒ 1996 Joint Frequency Data
- **Effective χ/Q-Values:**

$$\chi/Q = 1 / [U \{\pi\sigma_y \sigma_z + a / (K + 2)\}] * D * S * O$$

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

Long-term adjustment factors included are:

(1) Wind Direction Factors (D)
(2) Wind Speed Factors (S)
(3) Occupancy Factors (O)

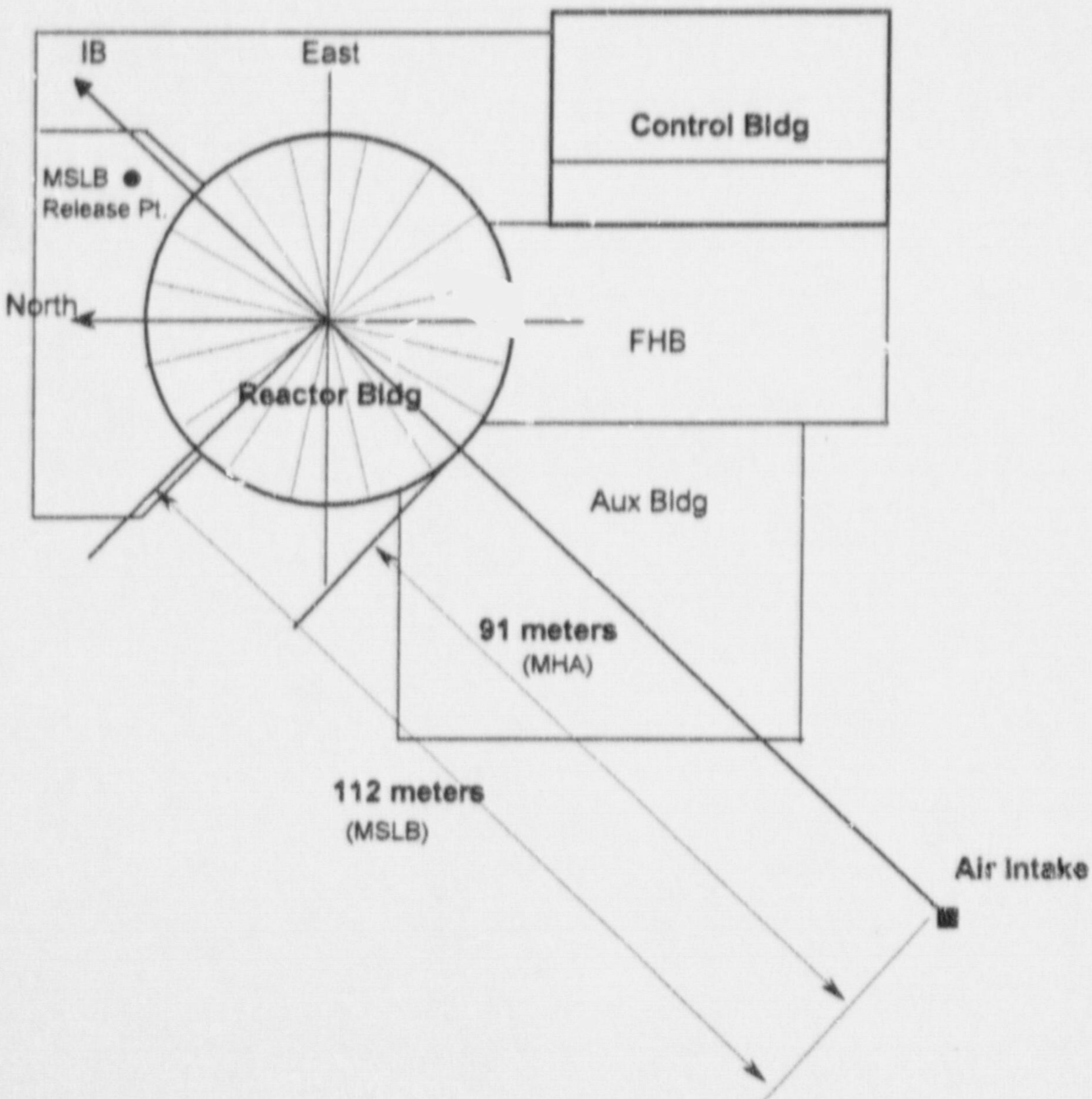
(Nomenclatures to be referred to the 13th Air Clearing Conference Proceedings)

KEY DATA:

- MHA Source-Receptor Distance (s^{MHA}) = 300 ft ⇒ **91 meters**
- MSLB Source-Receptor Distance (s^{MSLB}) = 370 ft ⇒ **112 meters**
- Reactor Containment Diameter (d) = 140 ft ⇒ **42 meters**
- Containment Projected Area (a) = **1985 m^2**
- 5% Wind Speed (U) = **0.67 m/sec** (1.5 mph= 4.94%)

TMI-1 Control Room Habitability x/Q Analysis

(Source-Receptor Configuration)



Maximum Hypothetical Accident

Reactor Building Leakage Assumptions

- 2568 MWt Core Inventory
- Increased by 10% for conservatism
- TID-14844 release
- Containment leak rate
  - 0.1% /day for first 24 hours
  - 0.05%/day for remaining 29 days
- Two compartment containment model
  - 67.1% sprayed
  - 32.9% unsprayed
  - 100,000 cfm flow between volumes

Maximum Hypothetical Accident
Reactor Building Leakage Assumptions

- Spray Removal Coefficients based on one spray pump operation

Elemental	7.39 hr^{-1}
Particulate	3.03 hr^{-1}
Organic	0.0072 hr^{-1}

- Decontamination Factors

Elemental	100
Particulate	100
Organic	1.04

Maximum Hypothetical Accident

ES Leakage to the Auxiliary Building

- Total leak rate to the Auxiliary Building is 18 gph
- 50% of core iodine inventory in water being recirculated - 0.0477 Ci/ml DEI
- 1.25% of coolant flashes to steam for the first two hours of the accident - no partitioning
- Remaining coolant released as liquid - partition factor of 0.009

Maximum Hypothetical Accident
ES Leakage to the Auxiliary Building

- 50% of airborne iodine plates out in Auxiliary Building prior to release
- No credit taken for filtration by the Auxiliary Building ventilation system
- No credit taken for decay during hold up in the Auxiliary Building

Maximum Hypothetical Accident
ES Leakage to the BWST

- Leak rates to the BWST are:

0-1 hr	3 gpm
1-24 hrs	1.6 gpm
1-30 days	0.5 gpm

- 50% of core iodine inventory in water being recirculated - 0.0477 Ci/ml DEI
- Partition factor of 0.009 between liquid and gas spaces of tank
- Release rate from the tank equal to air displaced by water leaking in
- No credit taken for plateout in the tank

Main Steam Line Break

- RCS Dose Equivalent Iodine prior to accident is 1 uCi/g

- When accident occurs, iodine release rates from the fuel rods increase by a factor of 500

- The total primary-to-secondary leakage during the duration of the accident is 9960 gallons (hot)

- Reduction factors in the secondary side:

  0.5 for the first 10 minutes

  0.25 after 10 minutes

Dose Equivalent Iodine-131 Released

Maximum Hypothetical Accident

9000 Curies

Main Steam Line Break

1070 Curies

GDC 19 Acceptable Dose

- The requirement of General Design Criterion (GDC) 19 in Appendix A of 10CFR50 states:
  - "A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation **exposure in excess of 5 Rem whole body, or its equivalent to any part of the body, for the duration of the accident."**

GDC 19 Acceptable Dose

- Key words - or its equivalent to any part of the body -- 5 Rem Total Effective Dose Equivalent (TEDE).

- TEDE, CEDE, and DDE are defined in 10CFR50.2 (Amended 12/96).

- The Standard Review Plan (NUREG 0800) in Section 6.4.II.c states that the system design is acceptable if the requirements of GDC 19 are met.

GDC 19 Acceptable Dose

- SRP interprets the acceptable dose of GDC 19 as 5 Rem whole body gamma, 30 Rem to the thyroid, and 30 Rem to the skin.
- Consistent with the annual dose limits specified by ICRP 2 – 10CFR20 at the time.
- When the SRP was written, there were no NRC regulations describing methods for the determination of "5 Rem whole body or, or its equivalent to any part of the body".

GDC 19 Acceptable Dose

- January 1, 1994, - a new revision to 10CFR20 was required to be used by licensee's for radiation protection - based on ICRP 26

- New 10CFR20 requires (and provides a method for) licensee's to sum the external whole body dose with the internal whole body equivalent dose to other parts of the body as the method for controlling occupational radiation exposure.

GDC 19 Acceptable Dose

- The criteria for habitability specified in GDC 19 is solely based on operators not receiving more than 5 Rem TEDE dose during the accident.

- There is no need for a separate thyroid dose limit. It is automatically accounted for in TEDE concept.

- Control room operators during an accident receive occupational dose. Current regulations for measuring occupational dose conform to the language in GDC 19.

- Calculation of TEDE occupational dose can be performed for any source term assumed.

CONTROL ROOM HABITABILITY SUBMITTAL

- Submittal to NRC by March 24, 1998
- Description of CBE and CBVS
- Description of Analytical Model
- Basis for X/Q Values Utilized (ARCON96)
- Accidents Analyzed - MHA Bounding (LOCA)
- Comparison of Results with GDC-19 TEDE Limits
- Discuss Compensating Factors
  - New Accident Source Terms
  - More Realistic X/Q Models
  - Credit for Offsite Power Restoration to Aux. and FHB Ventilation System.
  - Scenario Based on PRA Insights