GE Nuclear Energy

General Electric Company
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Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Robert C. Pierson, Director
Standardization and Non-Power Reactor Project Directorate

Subject: **Additional Tier 1 Design Certification Material for the GE ABWR Design, Stage 2 Submittal**

Reference: Letter, P. W. Marriott to Robert C. Pierson, "Tier 1 Design Certification Material for the GE ABWR Design, Stage 2 Submittal," Docket No. STN 52-001 dated April 6, 1992.

Enclosed are thirty-four (34) copies of the complete Section 3.7, Radiation Protection of the Stage 2 GE ABWR Tier 1 Design Certification Material. This submittal supplements the Tier 1 ABWR Design Certification Material transmitted earlier by the referenced letter, which contained Section 3.7 but without the figures designating radiation zones for the reactor building, control building, turbine building, and radwaste building..

Sincerely,

R C Stirn

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J. F. Quirk — GE

## 3.7 Radiation Protection

### Design Description

The ABWR design provides radiation protection features that will keep exposures for both plant personnel and the general public well below allowable limits. These low exposure conditions are achieved by an integrated approach that recognizes the contribution of both shielding provisions and ventilation system designs that control airborne contaminants. Monitoring of radiation levels is an integral part of the plant radiation protection strategy.

The plant design provides radiation shielding for rooms, corridors and operating areas commensurate with their occupancy requirements and thus maintains radiation exposures to plant personnel as low as reasonably achievable. Maintenance of plant components is achieved without significant radiation exposure from adjacent plant systems or equipment by use of shielded cubicles, labyrinth access and provisions for temporary shielding. Under accident conditions, plant shielding designs permit operators to perform required safety functions in vital areas of the plant. In addition to protection of operating personnel, the plant design provides radiation shielding which maintains radiation exposure to the general public as low as is reasonably achievable.

Plant ventilation systems insure that concentration of airborne radionuclides are maintained at levels consistent with personnel access requirements. In addition, airborne radioactivity monitoring is provided for those normally occupied areas of the plant in which there exists a significant potential for airborne contamination.

### Inspection, Test, Analyses and Acceptance Criteria

Tables 3.7a and 3.7b provide a definition of the inspections, tests, and/or analyses together with associated acceptance criteria which will be undertaken for the ABWR plant shielding, ventilation and airborne monitoring equipment.

## Table 3.7a: Plant Shielding Design

### Inspections, Tests, Analyses and Acceptance Criteria

| Certified Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 1. The plant design shall provide radiation shielding for rooms, corridors and operating areas commensurate with their occupancy requirements to maintain radiation exposures to plant personnel as low as reasonably achievable. | 1. An analysis of the expected radiation levels in each plant area will be performed to verify the adequacy of the shielding design. This analysis shall consider the following:<br><br>a. Confirmatory calculations shall consider all significant radiation sources (greater than 5% contribution) for an area. Radiation source strength in plant systems and components will be determined based upon an assumed source term of 100,000 μCurie/second offgas release rate (after 30 minutes decay), a 200 μCurie/gram-steam N-16 source term at the vessel exit nozzle, and a core inventory commensurate with a 4005 MWT equilibrium core at 51.6 kwatt/liter. All source terms shall be adjusted for radiological decay and buildup of activated corrosion and wear products.<br><br>b. Commonly accepted shielding codes, using nuclear properties derived from well known references (such as Vitamin C and ANSI/ANS-6.4) shall be used to model and evaluate plant radiation environments.<br>1) For non-complex geometries, point kernal shielding codes (such as QAD or GGG) shall be used.<br>2) For complex geometries, more sophisticated two or three dimensional transport codes (such as DORT or TORT) shall be used. | 1. Maximum expected radiation levels are well within (25% or less) of the radiation zone designation, for each plant area, as indicated in Figures 3.7.a through 3.7.cc. |

## Table 3.7a: Plant Shielding Design (Continued)

## Inspections, Tests, Analyses and Acceptance Criteria

| Certified Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| | 1. (Cont.)<br><br>c. In any calculation, a safety factor shall be applied based upon benchmark comparisons of the code and data collected from known and measured environments. | |
| 2. The plant design shall provide shielded cubicles, labyrinth access, and space for temporary shielding to allow for maintenance of plant components without significant radiation exposure from adjacent plant systems or equipment. | 2. Using the methods identified in (1) above, radiation levels present in areas where maintenance is performed shall be evaluated for the contribution from adjacent high radiation areas and equipment. | 2. Shielding design (with temporary shielding installed, where appropriate) is such that radiation from adjacent areas shall contribute no more than a small fraction (10% or less) of the radiation field intensity or less than 0.06mrem/hr whichever is larger, in plant areas where maintenance is performed. |
| 3. The plant radiation shielding design shall permit operators to perform required safety functions in vital areas of the plant (including access and egress of these areas) under accident conditions. | 3. An analysis of the expected high radiation levels in each area which will or may require occupancy to permit an operator to aid in the mitigation of or recovery from an accident (vital area) shall be performed to verify the adequacy of the plant shielding design. This analysis shall use calculational methods consistent with (1.b) above and a radiation source term (adjusted for radioactive decay) based on the following:<br><br>a. Liquid containing systems: 100% of the core equilibrium noble gas inventory, 50% of the core equilibrium halogen inventory and 1% of all others are assumed to be mixed in the reactor coolant and recirculation liquids recirculated by the residual heat removal system (RHR), the high | 3. Under accident conditions, radiation shielding design allows access, occupancy and egress of vital areas such that personnel radiation exposures do not exceed 5 rem to the whole body or its equivalent, for the duration of the accident (based on the required frequency of access to each vital area). For areas requiring continuous occupancy (such as the control room), local radiation hot spots shall not exceed 15 mrem/hr (averaged over 30 days). |

## Table 3.7a: Plant Shielding Design (Continued)

### Inspections, Tests, Analyses and Acceptance Criteria

| Certified Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| | 3. (Cont.)<br><br>pressure core flooder (HPCF), and the reactor core isolation cooling (RCIC) systems.<br><br>b. Gas containing systems: 100% of the core equilibrium noble gas inventory and 25% of the core equilibrium halogen activity are assumed to be mixed in the containment atmosphere. For vapor containing systems (such as the main steam lines) these core inventory fractions are assumed to be contained in the reactor coolant vapor space. | |
| 4. The plant design shall provide radiation shielding to maintain radiation exposure to the general public as low as is reasonably achievable. | 4. Using the methods identified in (1) above, the radiation dose to the maximally exposed member of the general public from direct and scattered shall be determined. | 4. The radiation dose to the maximally exposed member of the public is a small fraction (10% or less) of the dose limit to a member of the public listed in 40CFR190. |

## Table 3.7b: Ventilation And Airborne Monitoring

### Inspections, Tests, Analyses and Acceptance Criteria

| Certified Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 1. Plant design shall provide adequate containment of airborne radioactive materials and the ventilation system will ensure that concentrations of airborne radionuclides are maintained at levels consistent with personnel access requirements. | 1. Expected concentrations of airborne radioactive material shall be calculated by nuclide for normal plant operations, anticipated operational occurrences for each equipment cubicle, corridor, and operating area requiring personnel access. Calculations shall consider:<br><br>a. Design ventilation flow rates for each area,<br><br>b. Typical leakage characteristics for equipment located in each area, and<br><br>c. A radiation source term in each fluid system shall be determined based upon an assumed offgas rate of 100,000 Curie/second (30 minute decay) appropriately adjusted for radiological decay and buildup of activated corrosion and wear products. | 1. Calculation of radioactive airborne concentration shall demonstrate that:<br><br>a. For normally occupied rooms and areas of the plant (i.e. those areas requiring routine access to operate and maintain the plant) equilibrium concentrations of airborne nuclides will be a small fraction (10% or less) of the occupational concentration limits listed in 10 CFR 20 Appendix B.<br><br>b. For rooms that require infrequent access (such as for non-routine equipment maintenance), the ventilation system shall be capable of reducing radioactive airborne concentrations to (and maintaining them at) the occupational concentration limits listed in 10CFR20 Appendix B during the periods that occupancy is required.<br><br>c. For rooms that seldom require access (such as tank rooms), plant design shall provide sufficient containment and ventilation to ensure airborne contamination does not spread to other areas. |

## Table 3.7b: Ventilation And Airborne Monitoring (Continued)

### Inspections, Tests, Analyses and Acceptance Criteria

| Certified Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 2. Airborne radioactivity monitoring shall be provided for those normally occupied areas of the plant in which there exists as significant potential for airborne contamination (greater than 0.1 per year) | 2. An analysis shall be performed to identify the plant areas that require airborne radioactivity monitoring. | 2. Airborne radioactivity monitoring system shall:<br><br>a. Have the capability of detecting the time integrated change in concentrations of the most limiting particulate and iodine radionuclides in each area equivalent to the occupational concentration limits in 10CFR20, Appendix B for 10hours.<br><br>b. Provide a calibrated response, representatvie of the concentrations within the area (i.E. air sampling monitors in ventilation exhaust streams shall collect and isokinetic sample).<br><br>c. Provide local audible alarms (visual alarms in high noise areas) with variable alarm set points, and readout/ annunciation capability in the control room. |

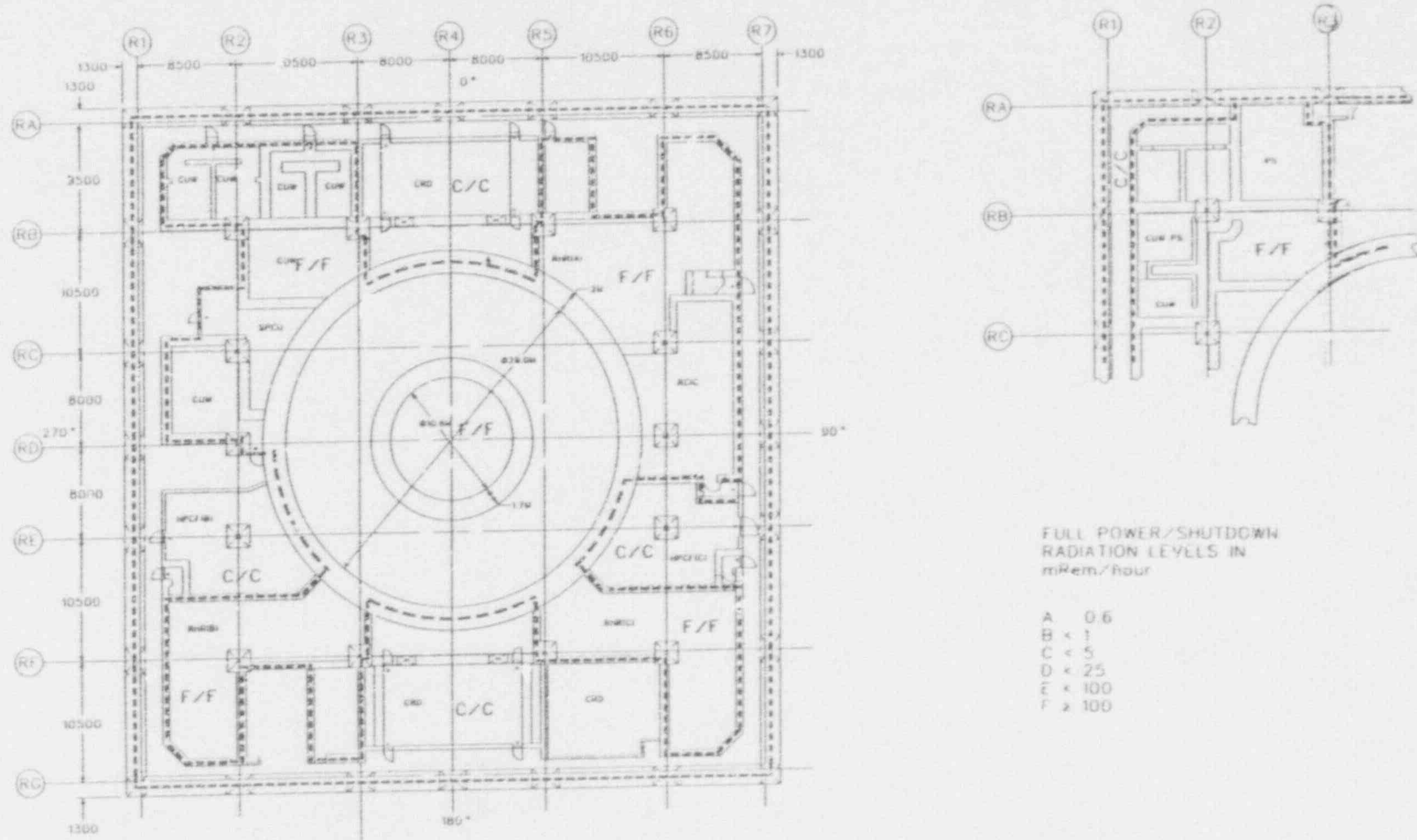



FIGURE 3.7c REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION -8200 (B3F)

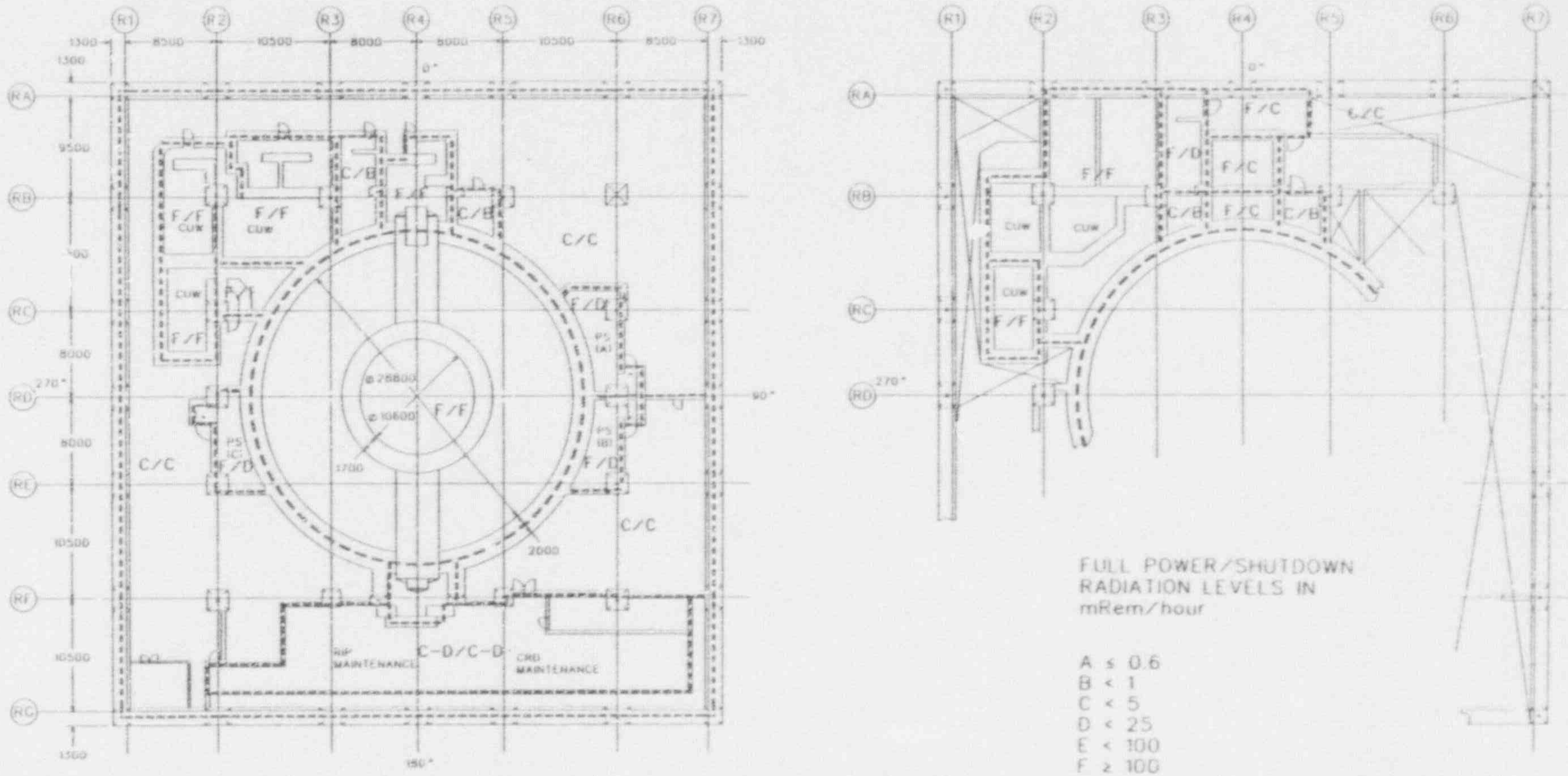
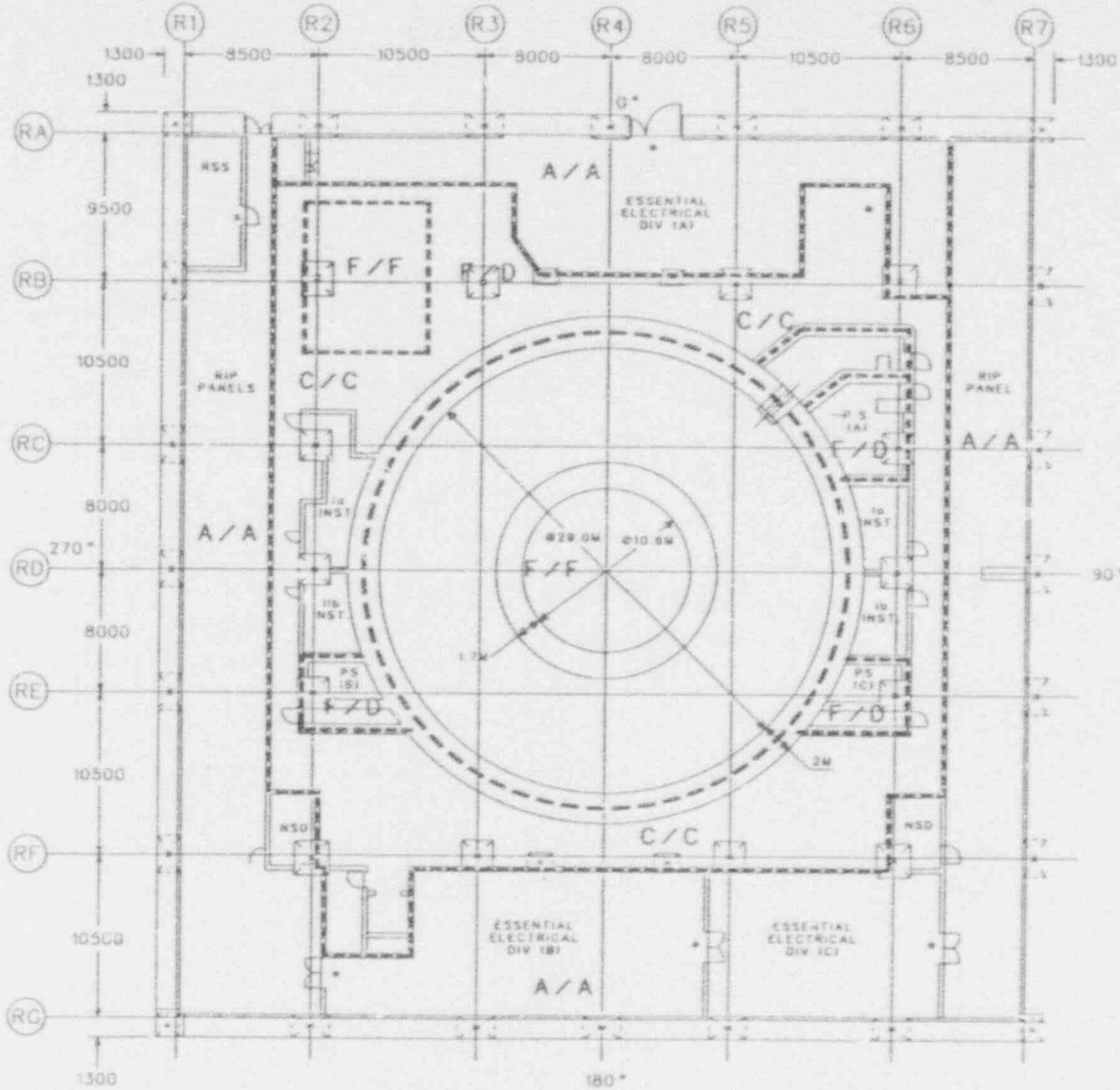


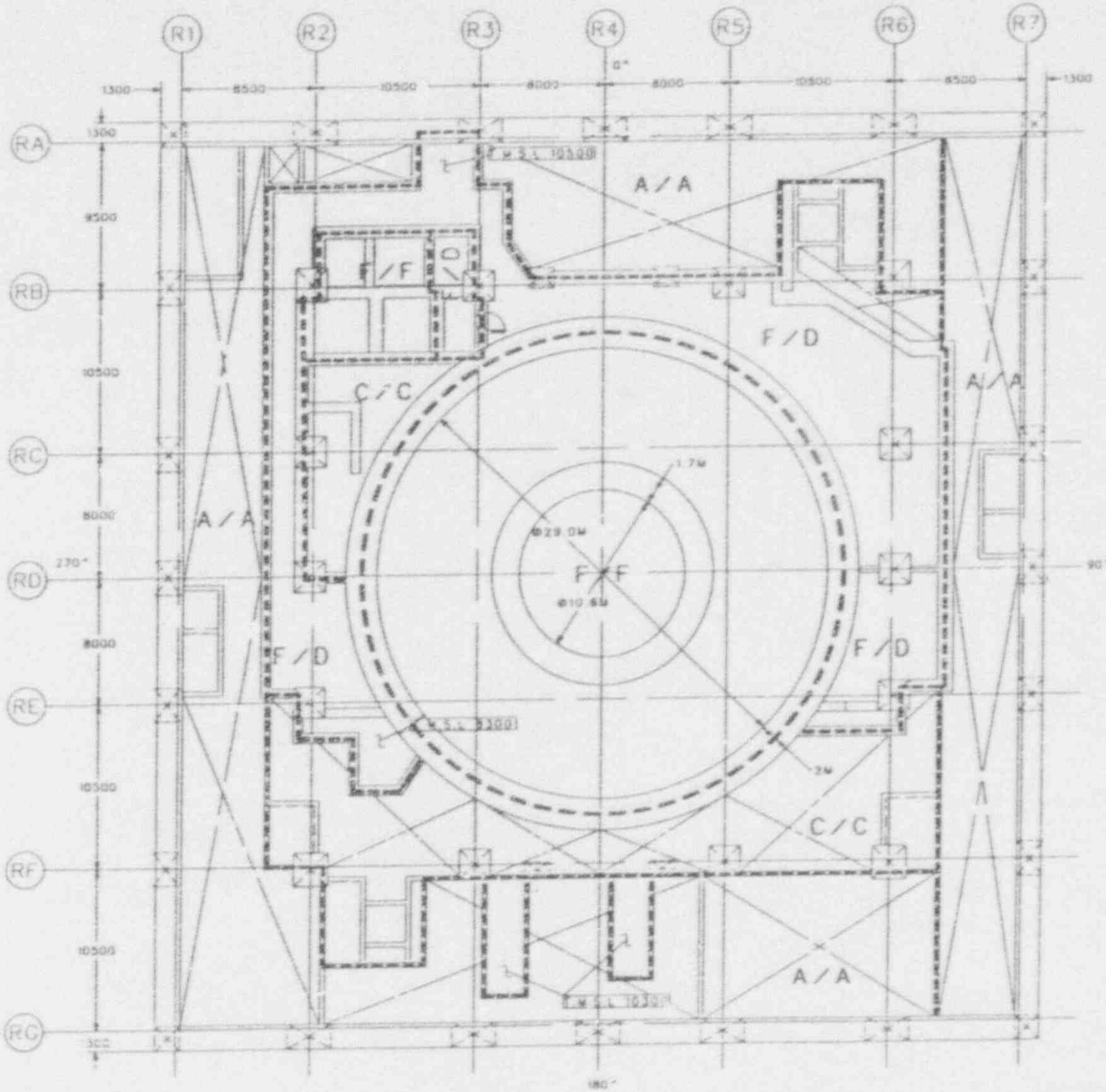

FIGURE 3.7b REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION -1700 (B2F)




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

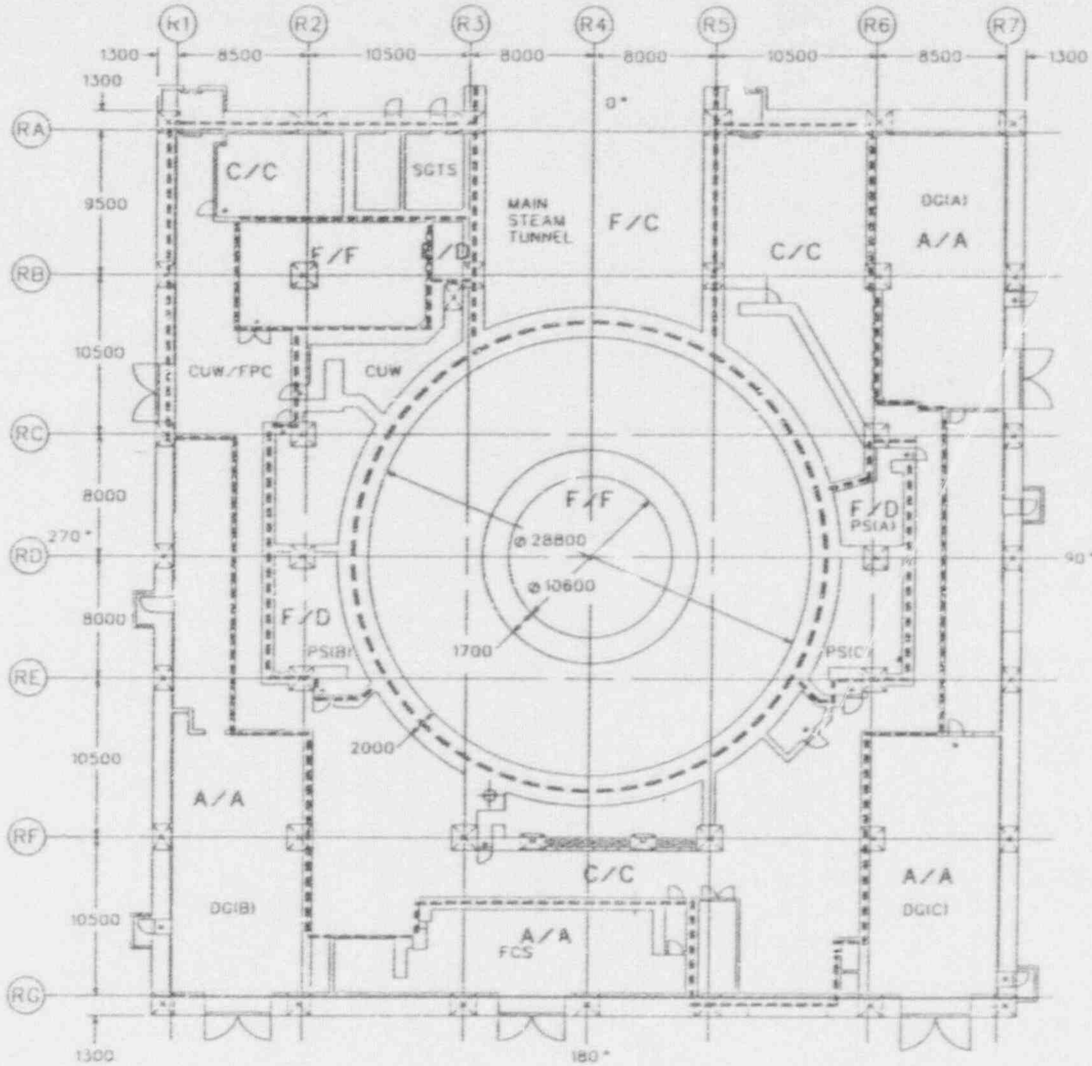
FIGURE 3.7c REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 4800 (B1F)




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

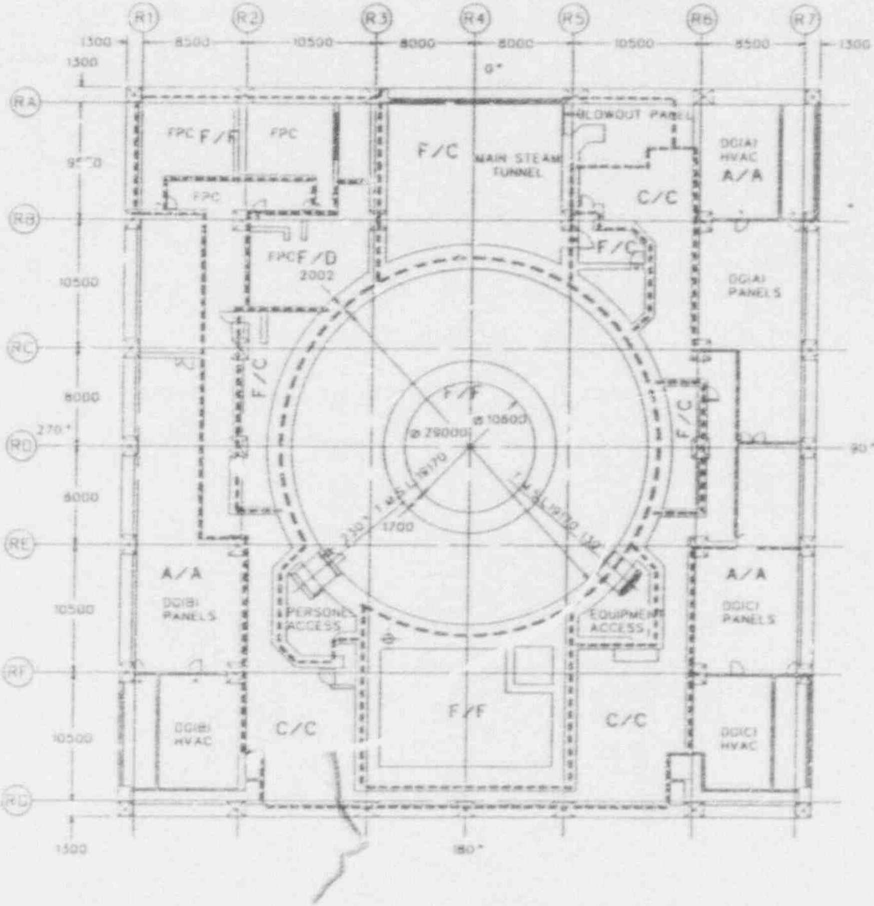
FIGURE 3.7d REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 8500 (B1F)

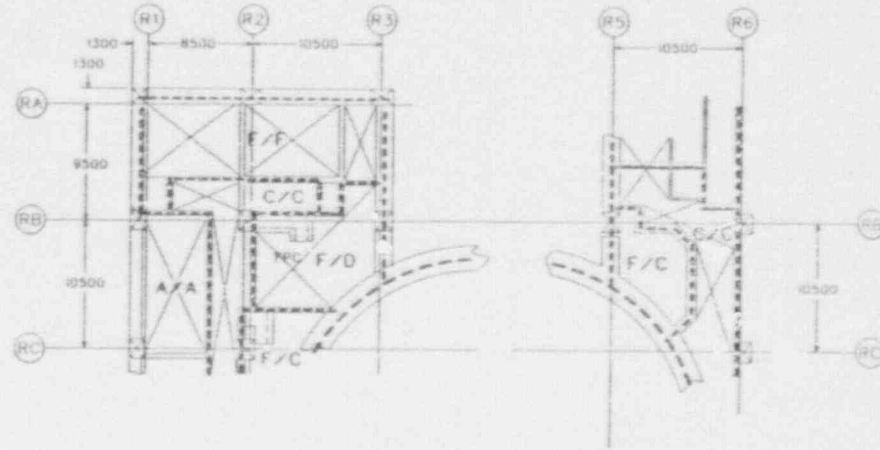



FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

FIGURE 3.7e REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 12300 (1F)

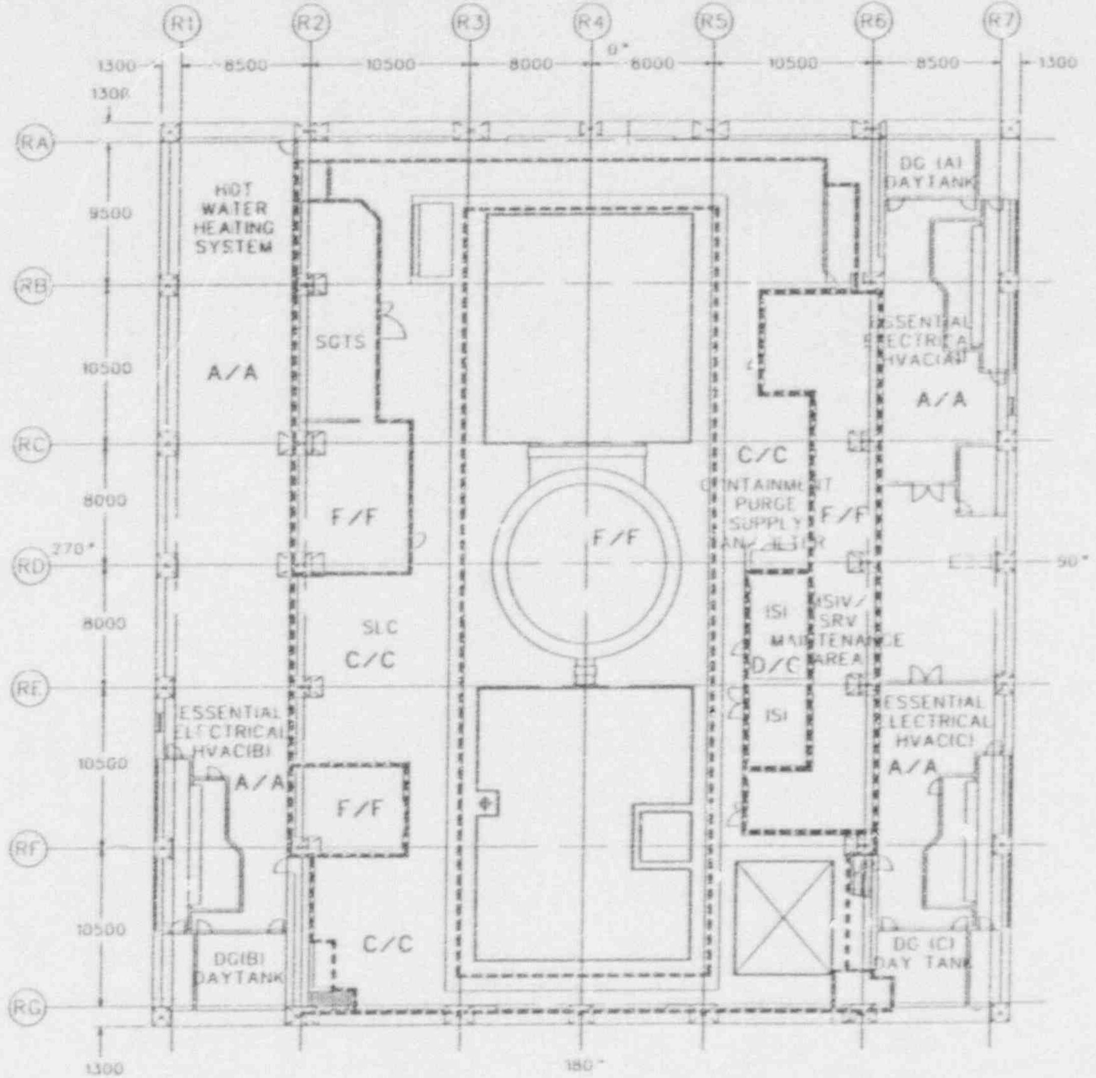



FULL POWER/SHUTDOWN RADIATION LEVELS IN mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

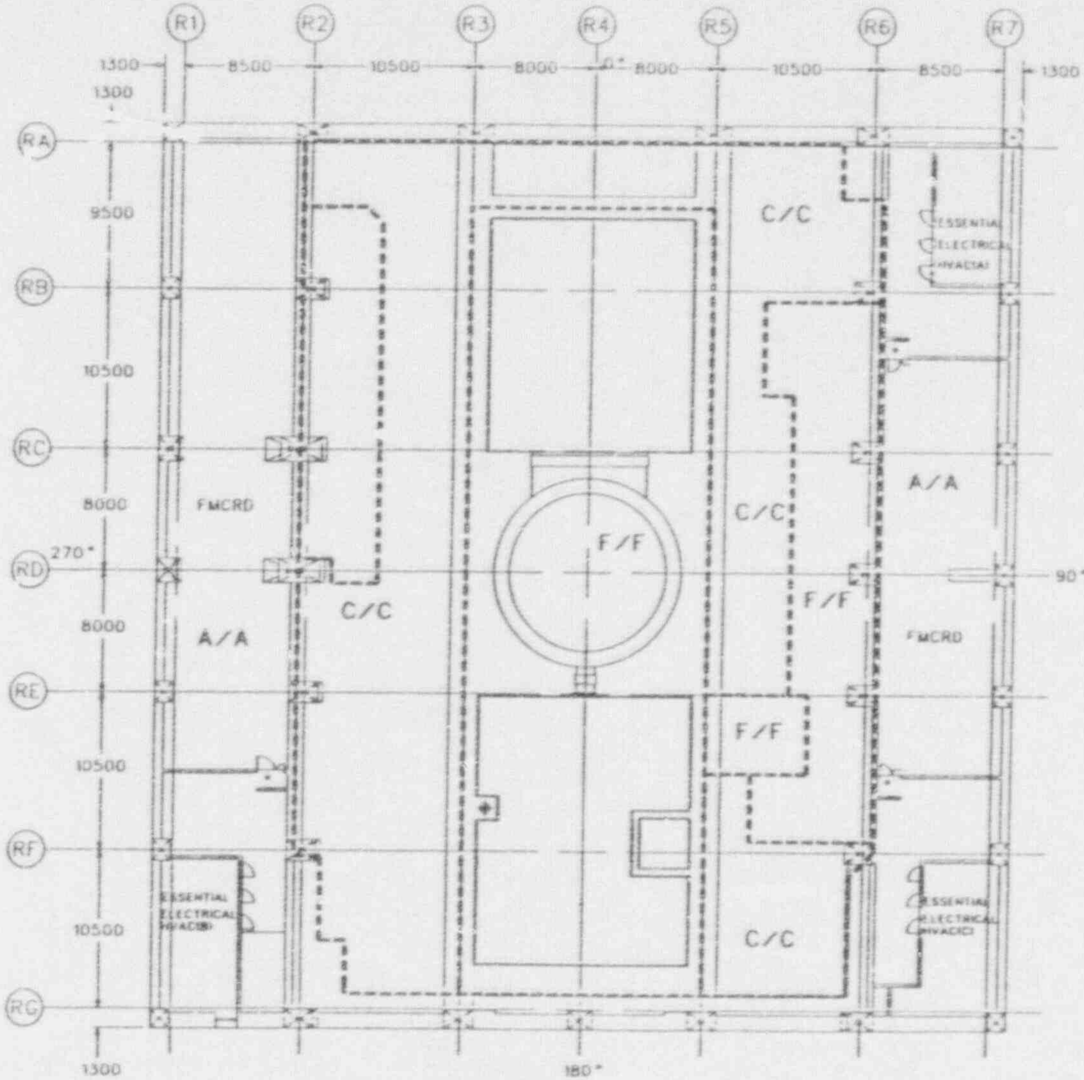
FIGURE 3.7t REACTOR BUILDING RADIATION ZONE MAP FOR FULL POWER AND SHUTDOWN OPERATIONS AT ELEVATION 18100 (2F)




FULL POWER/SHUTDOWN RADIATION LEVELS IN mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

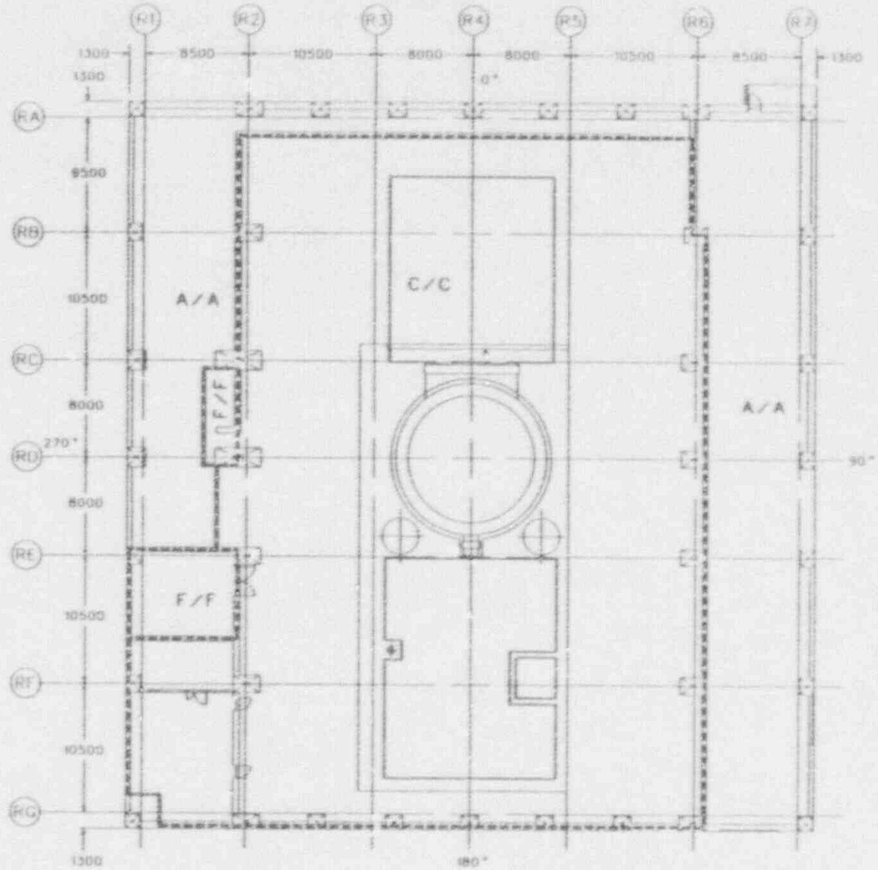
FIGURE 3.7g REACTOR BUILDING RADIATION ZONE MAP FOR FULL POWER AND SHUTDOWN OPERATIONS AT ELEVATION 23500 (B3F)




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ [illegible]

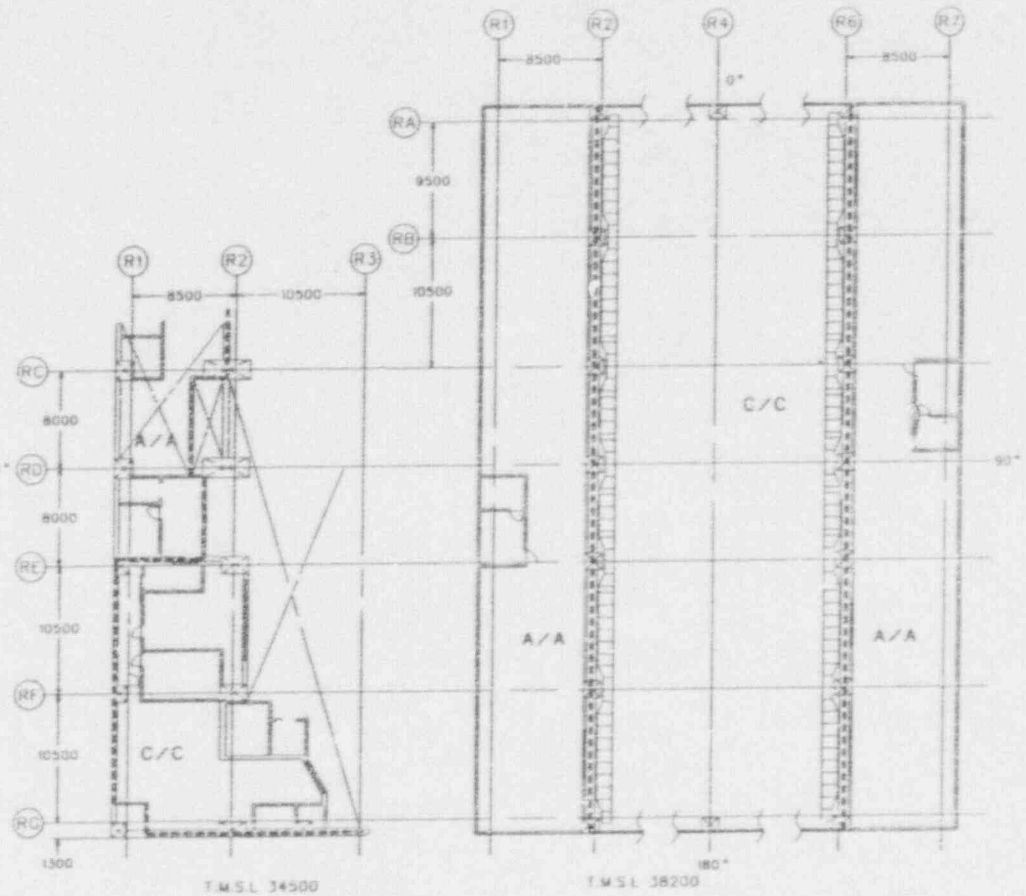
FIGURE 3.7h REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 27200 (4F)




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

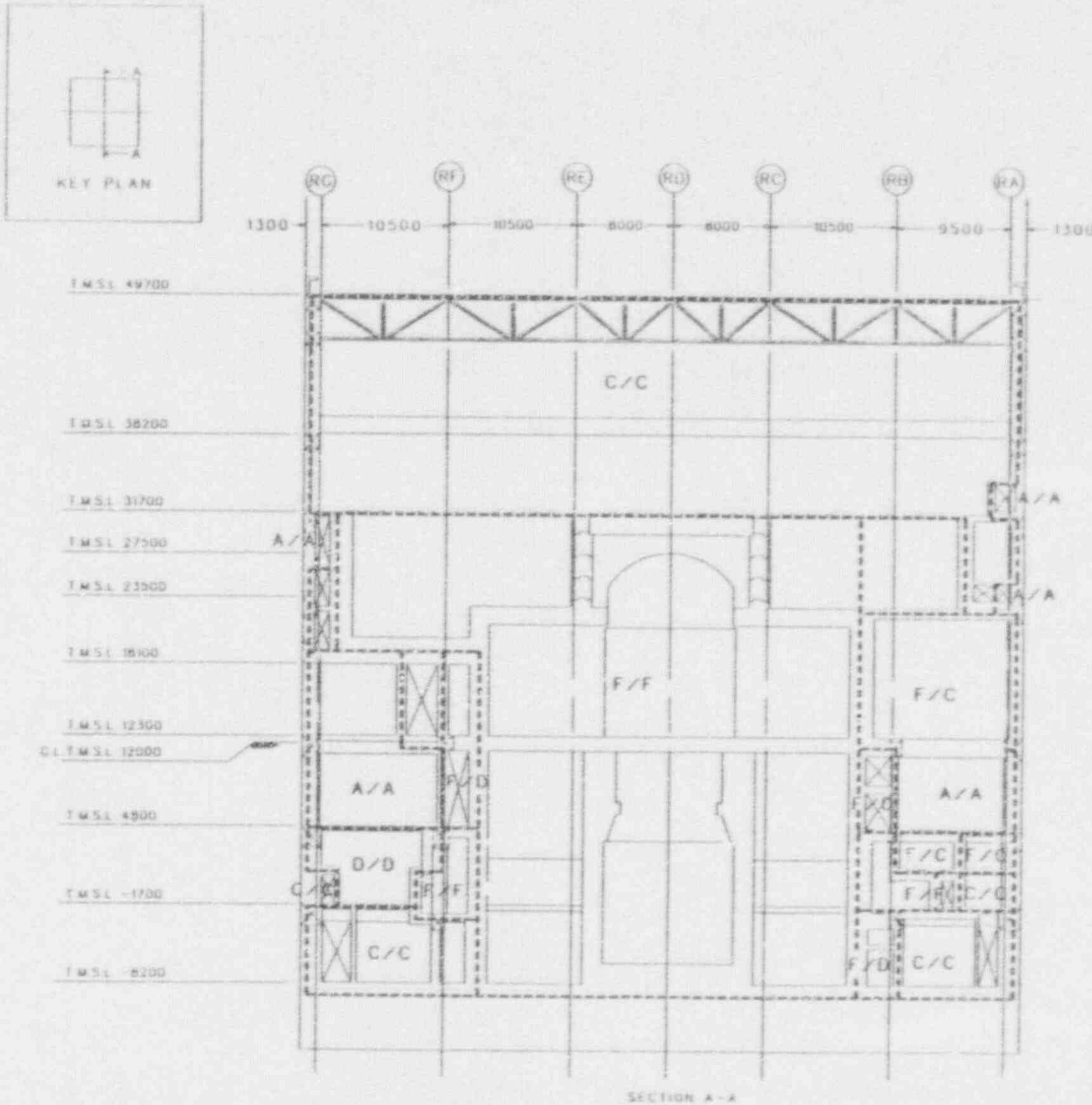
FIGURE 3.7i REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 31700 (4FM)




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

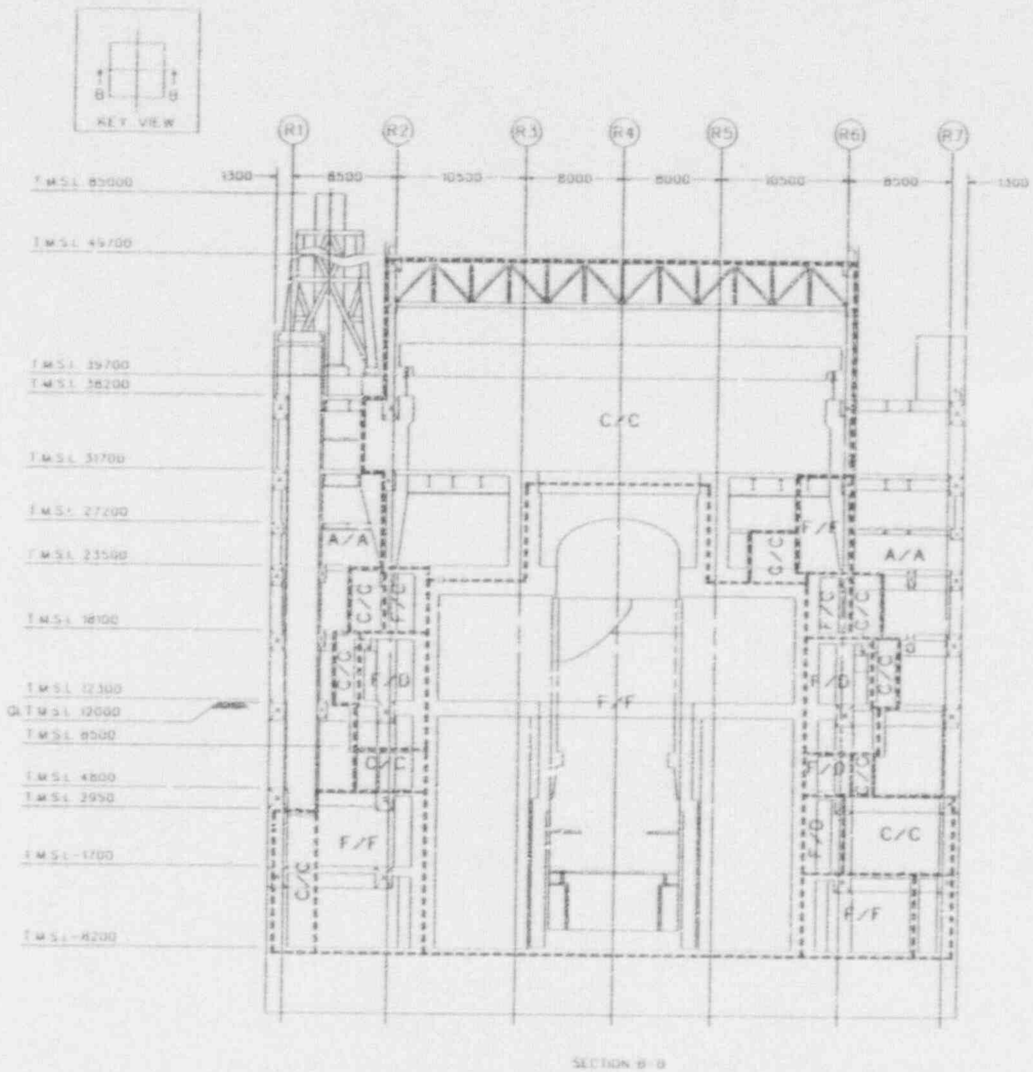
FIGURE 3.7j REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
AT ELEVATION 34500




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

FIGURE 3.7k REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
CROSS SECTION VIEW A-A




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mRem/hour

A ≤ 0.6
B < 1
C < 5
D < 25
E < 100
F ≥ 100

FIGURE 3.79 REACTOR BUILDING
RADIATION ZONE MAP FOR
FULL POWER AND SHUTDOWN OPERATIONS
CROSS SECTION VIEW B-B

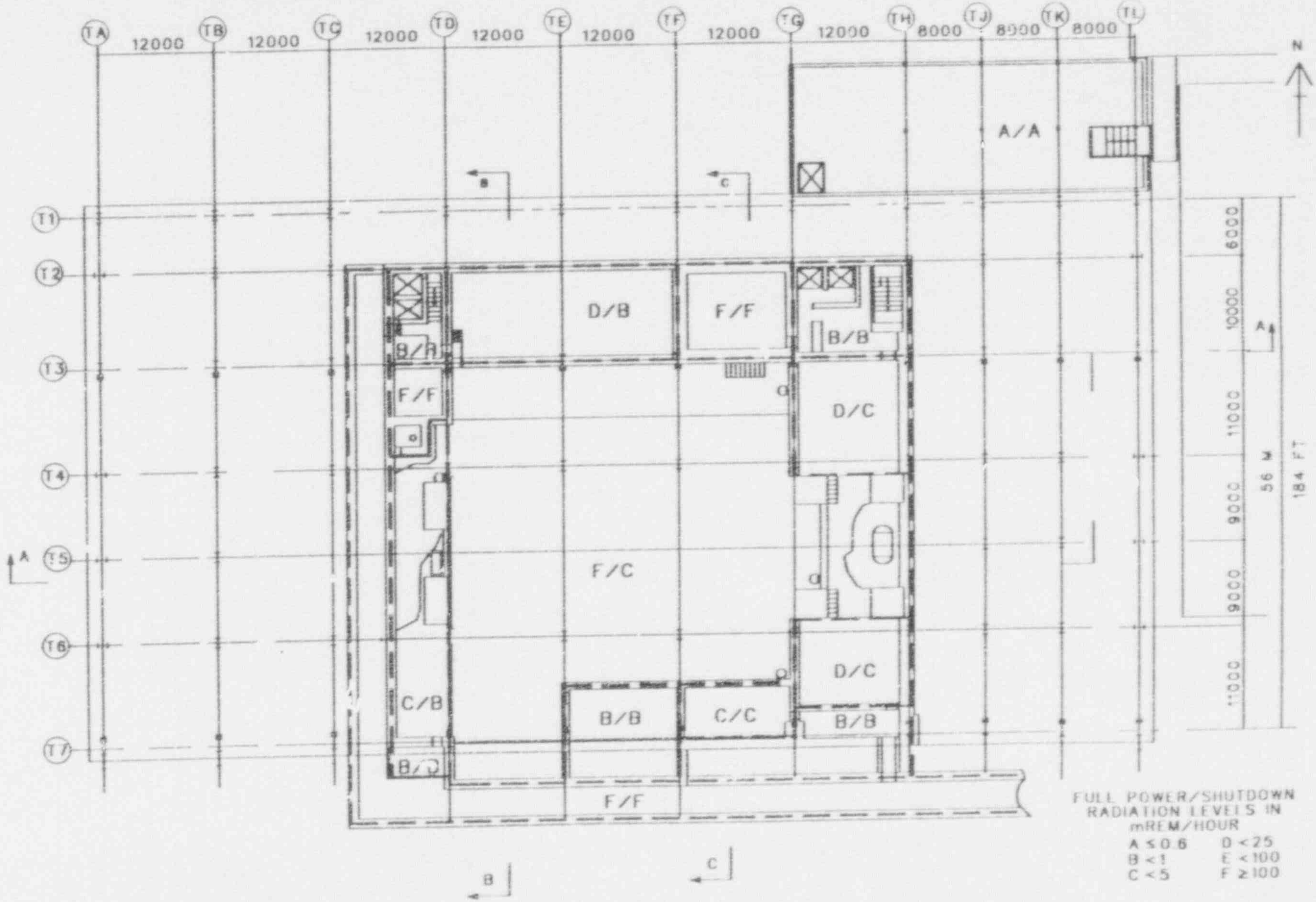



FIGURE 3.7m TURBINE BUILDING RADIATION ZONE AT ELEVATION 5.3M

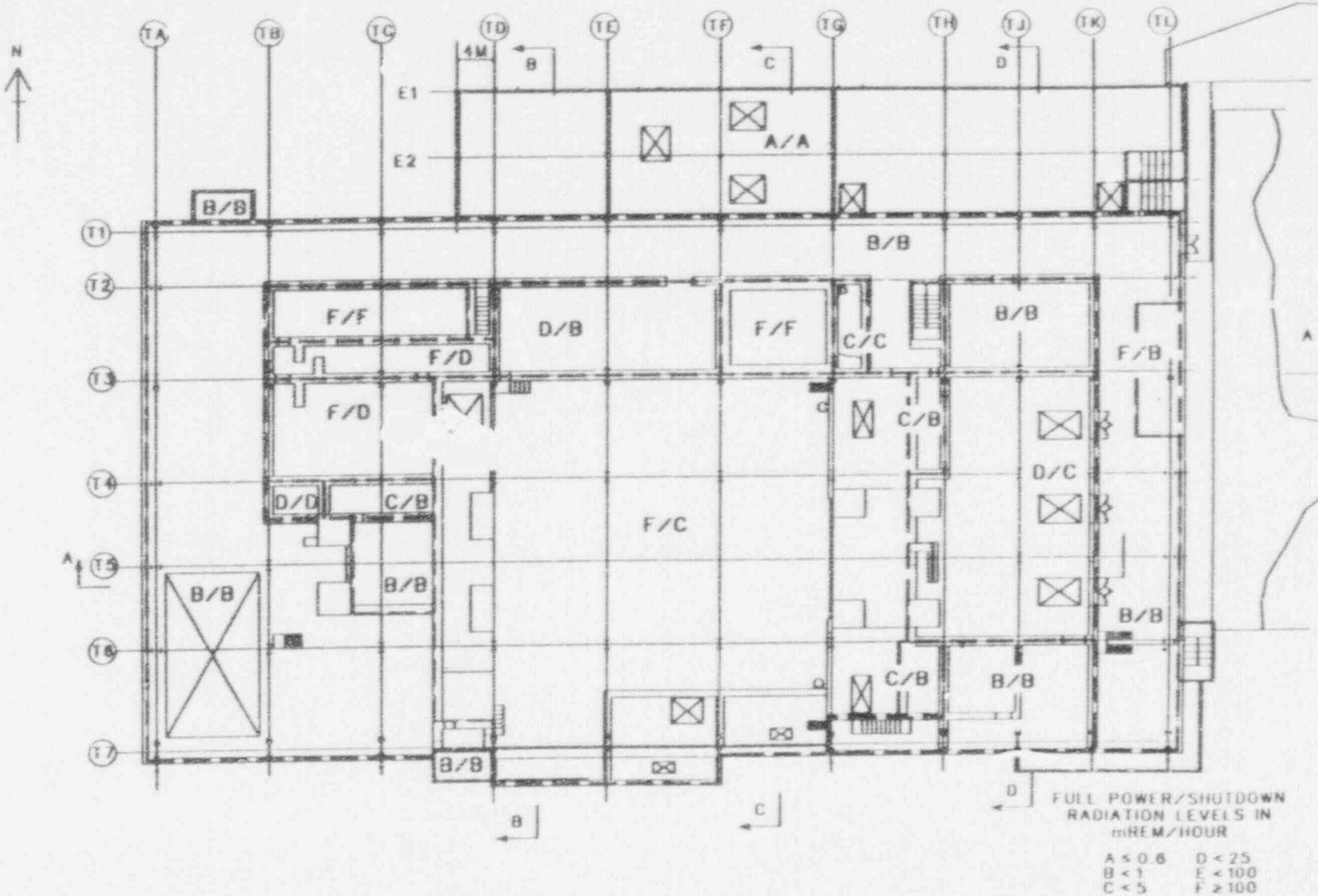



FIGURE 3.7n TURBINE BUILDING RADIATION ZONE AT ELEVATION TMSL 12.3M

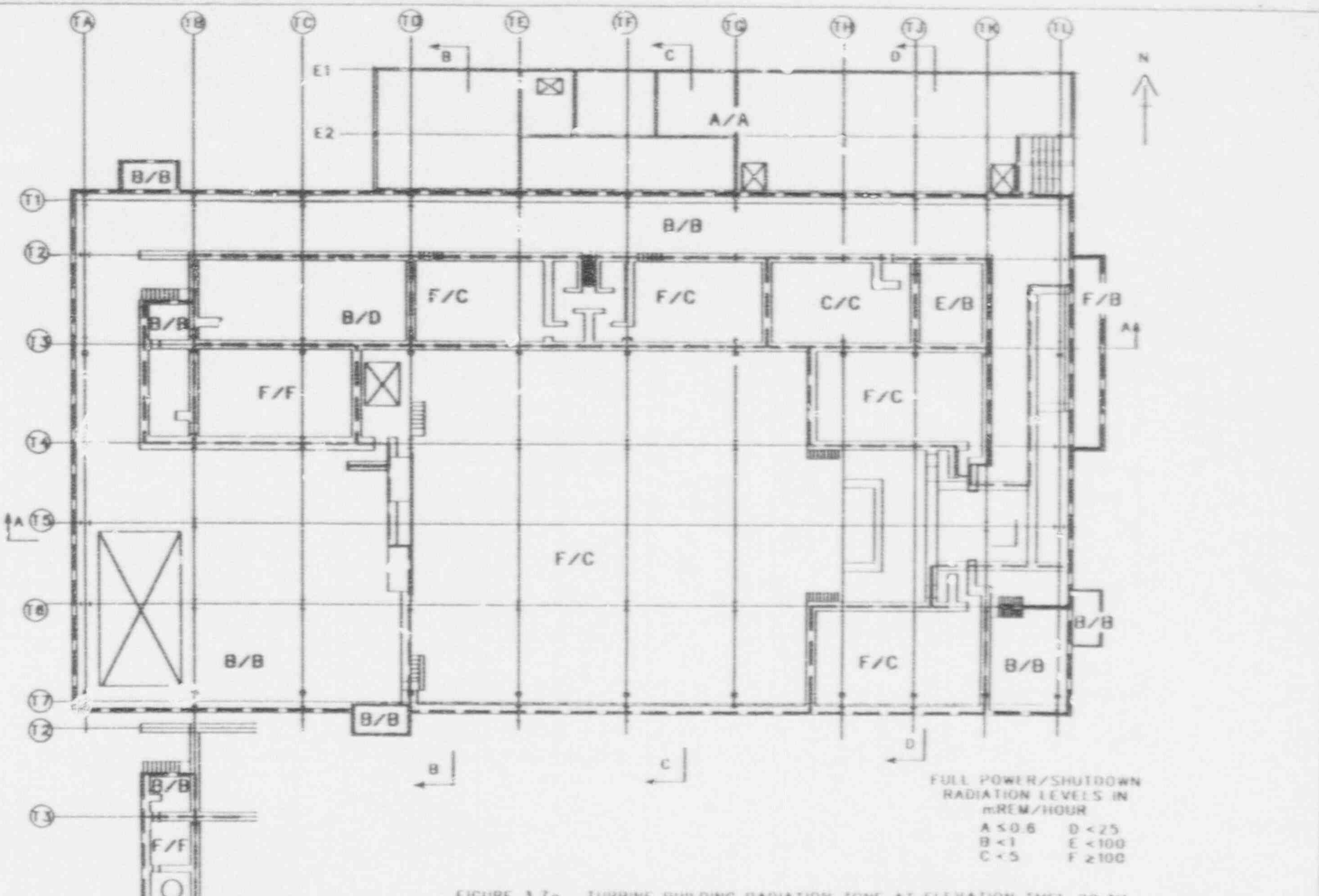
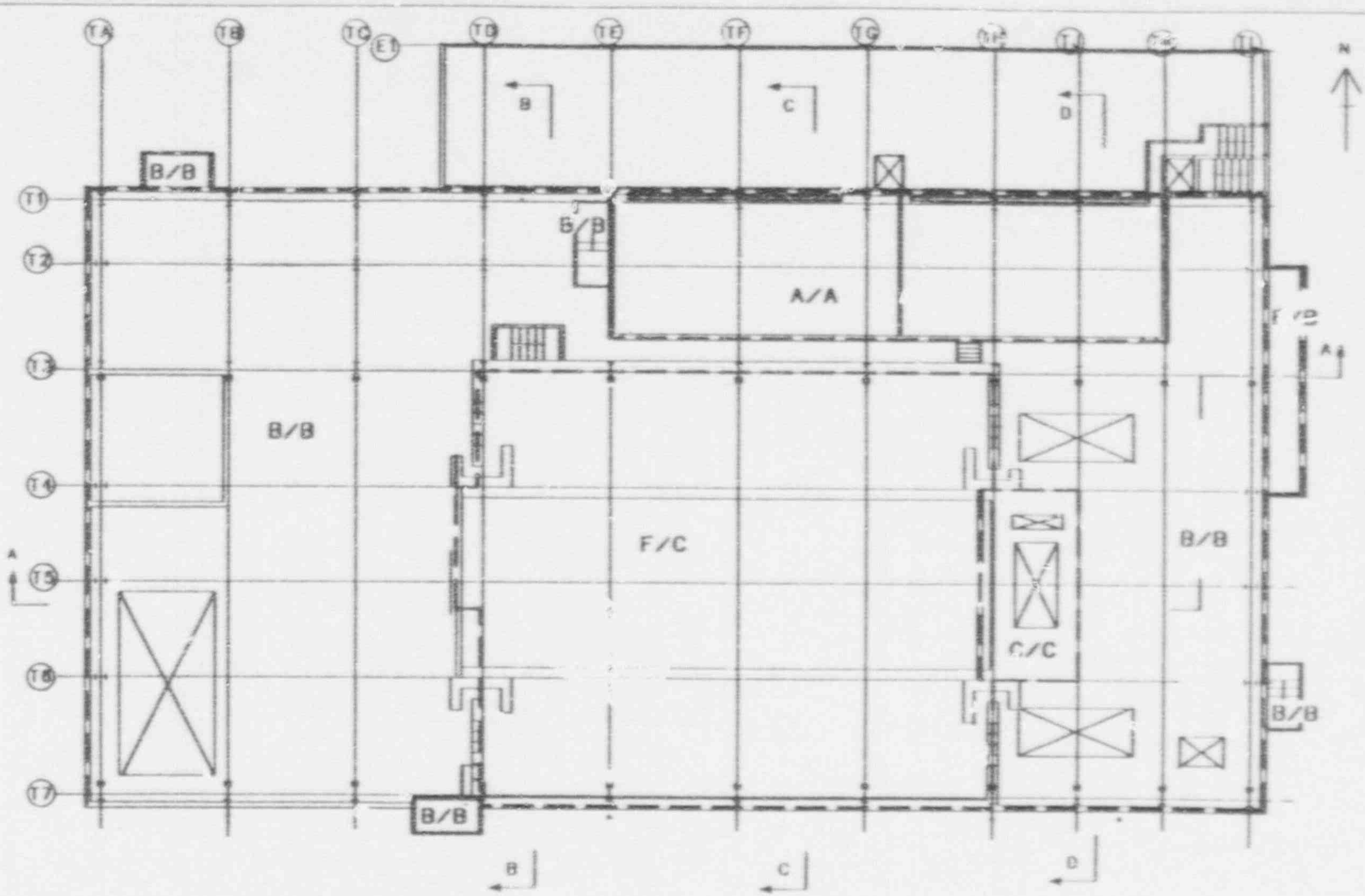



FIGURE 3.7o TURBINE BUILDING RADIATION ZONE AT ELEVATION TMSL 20.3M




FULL POWER/SHUTDOWN
RADIATION LEVELS IN
mREM/HOUR

| | |
|---|---|
| A ≤ 0.6 | D < 25 |
| B < 1 | E < 100 |
| C < 5 | F ≥ 100 |

FIGURE 3.7p TURBINE BUILDING RADIATION ZONE AT ELEVATION TMSL 30.3M

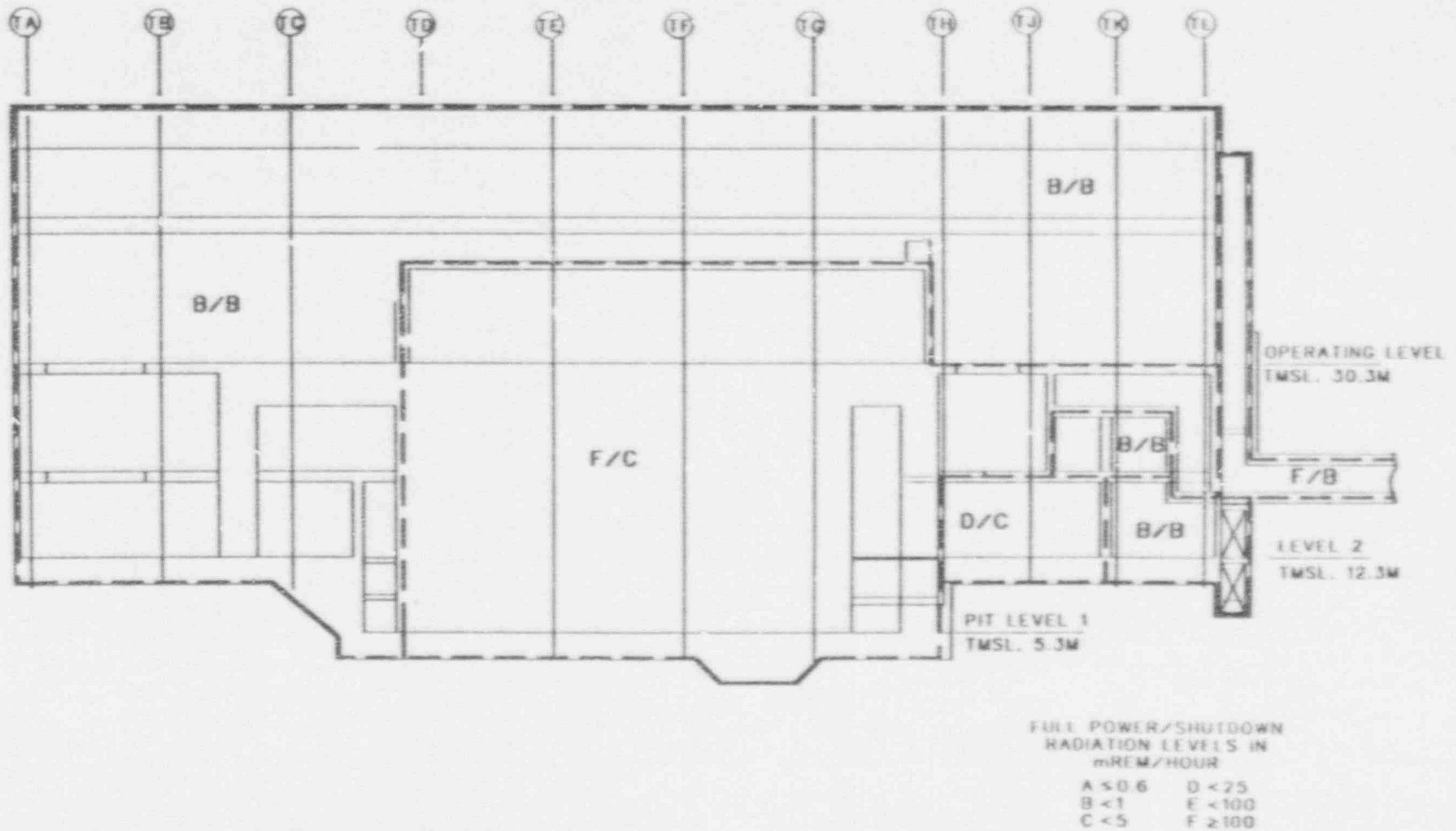



FIGURE 3.7Q TURBINE BUILDING RADIATION ZONE AT NORMAL OPERATION LONGITUDINAL SECTION AA

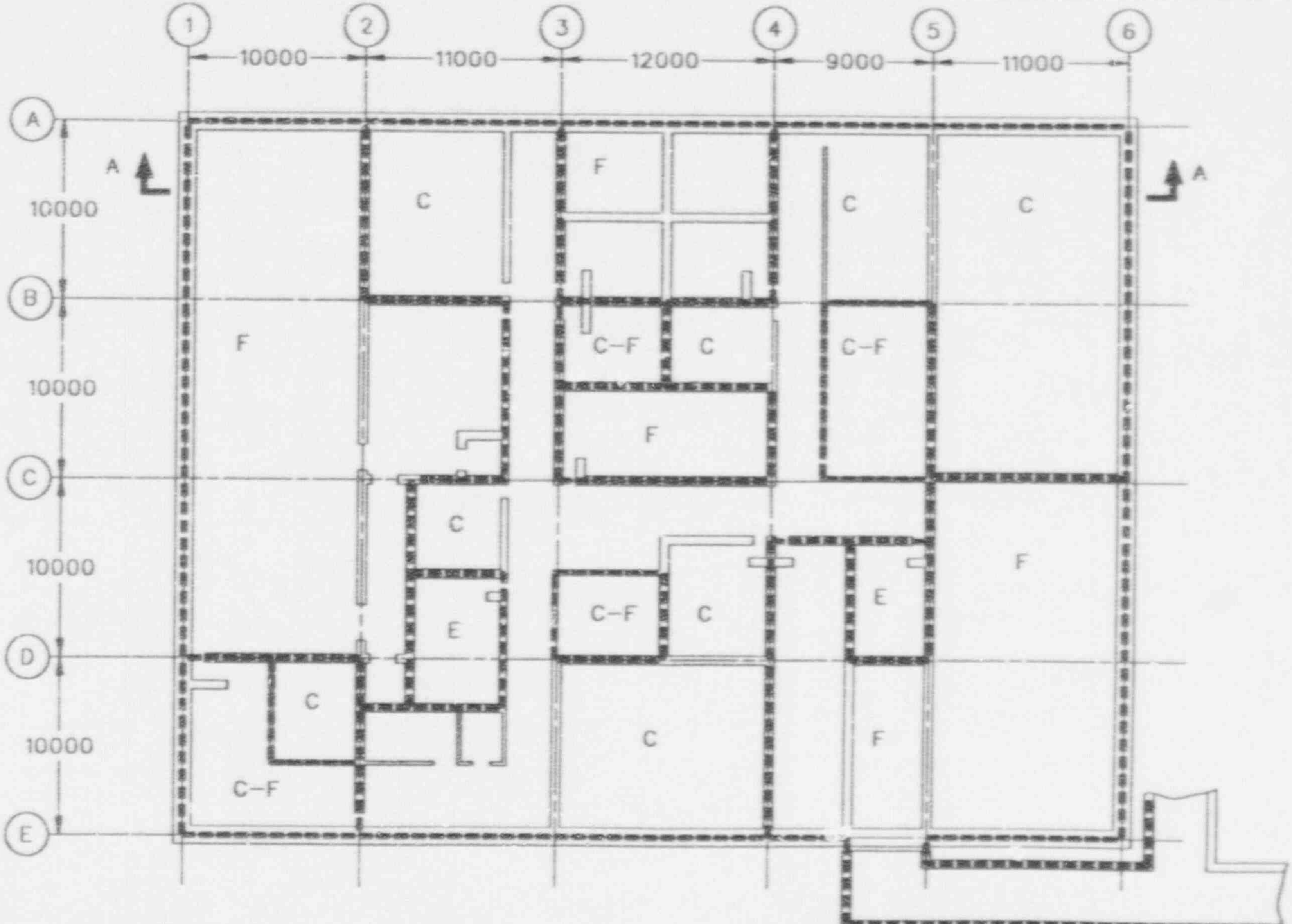



FIGURE 3.7r

RADWASTE BUILDING, RADIATION ZONE MAP, NORMAL OPERATION AT ELEVATION – 6500mm

A ≤ 0.6mrem/hr D < 25.0mrem/hr
B < 1.0mrem/hr E < 100mrem/hr
C < 5.0mrem/hr F ≥ 100mrem/hr

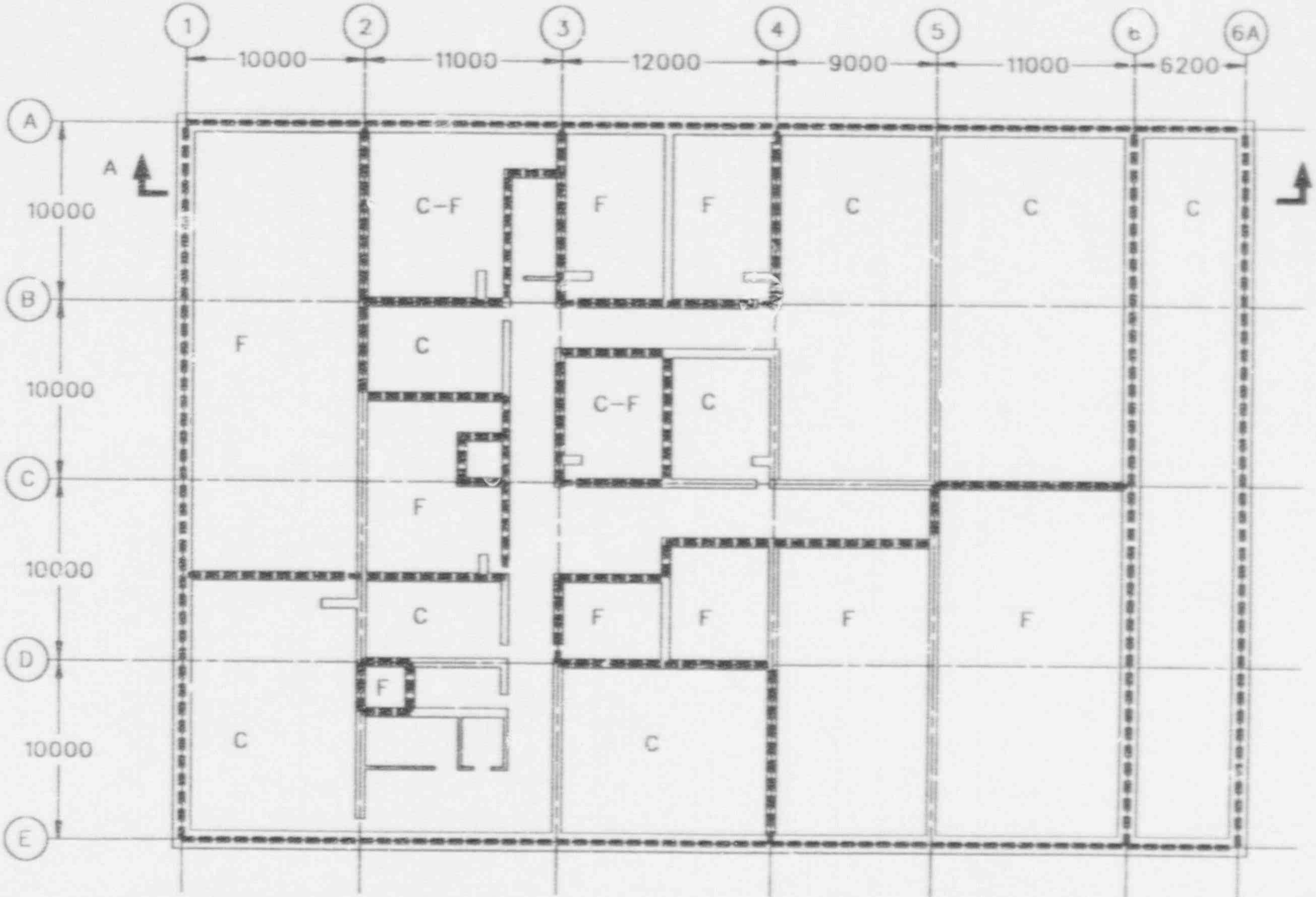



FIGURE 3.7s

RADWASTE BUILDING, RADIATION ZONE MAP,
NORMAL OPERATION AT ELEVATION – 200mm

A ≤ 0.6mrem/hr D < 25.0mrem/hr
B < 1.0mrem/hr E < 100mrem/hr
C < 5.0mrem/hr F ≥ 100mrem/hr

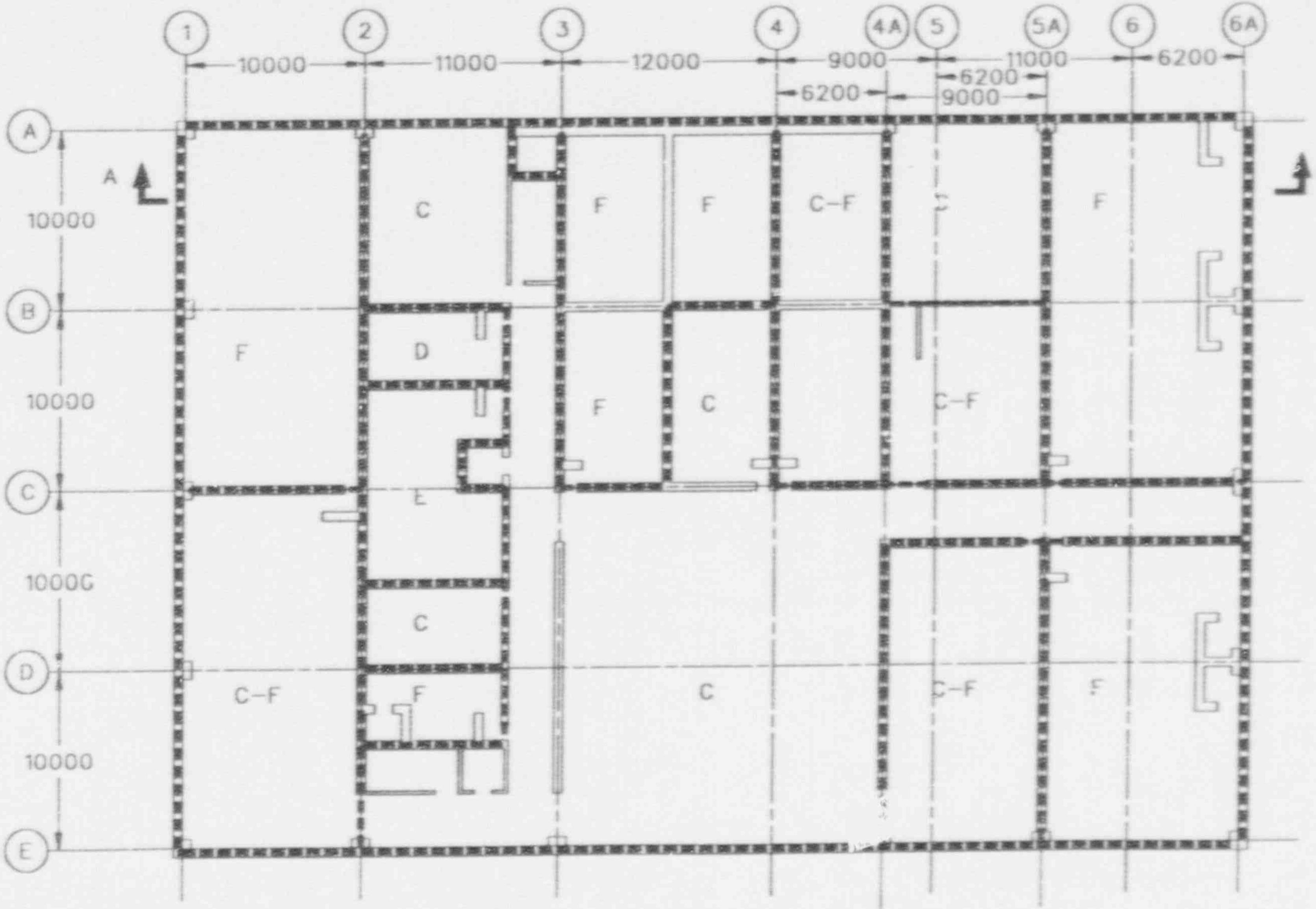



FIGURE 3.7t

RADWASTE BUILDING, RADIATION ZONE MAP,
NORMAL OPERATION AT ELEVATION 7300mm

A ≤ 0.6mrem/hr D < 25.0mrem/hr
B < 1.0mrem/hr E < 100mrem/hr
C < 5.0mrem/hr F ≥ 100mrem/hr

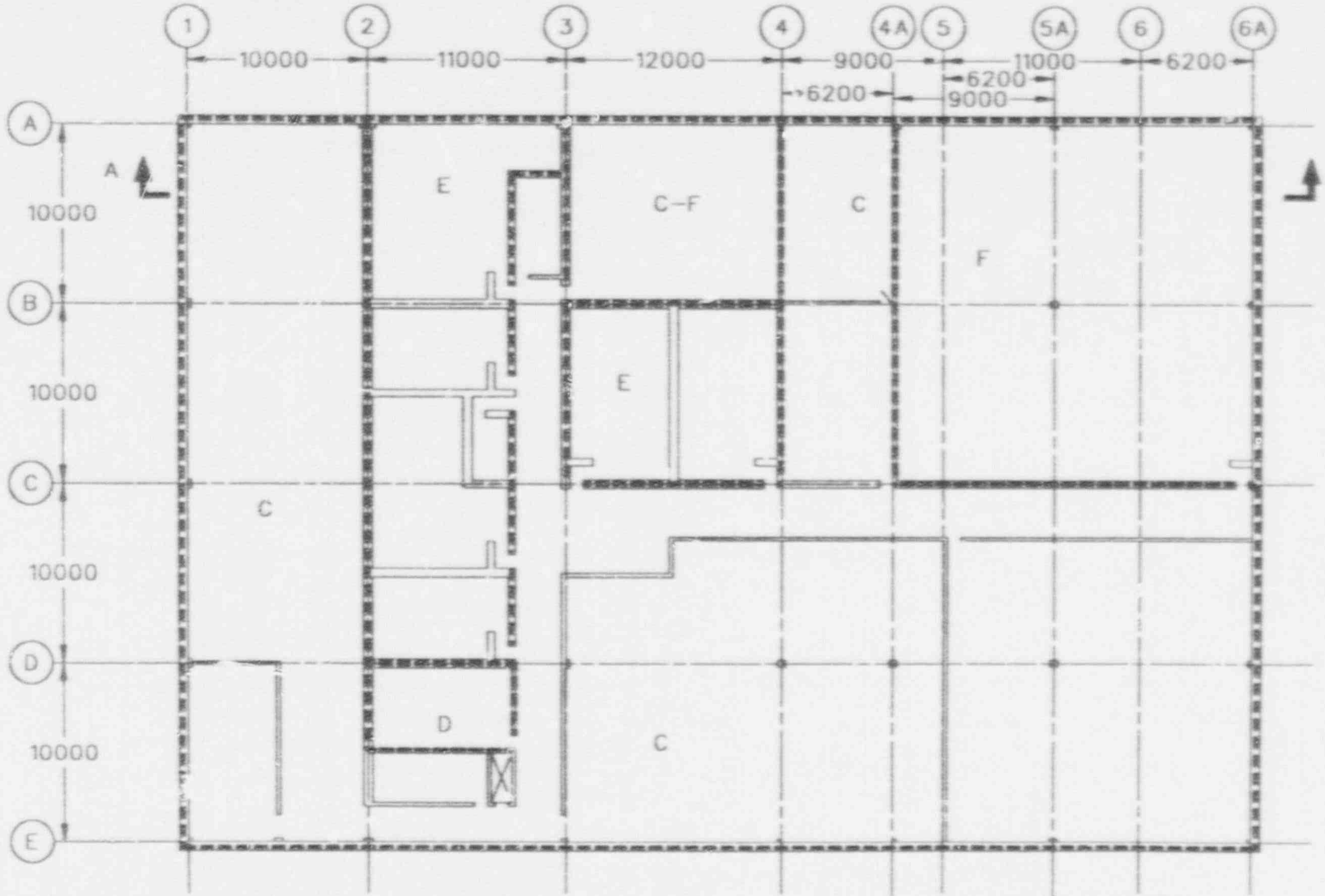



FIGURE 3.7u

RADWASTE BUILDING, RADIATION ZONE MAP,
NORMAL OPERATION AT ELEVATION 16000mm

A ≤ 0.6mrem/hr D < 25.0mrem/hr
B < 1.0mrem/hr E < 100mrem/hr
C < 5.0mrem/hr F ≥ 100mrem/hr

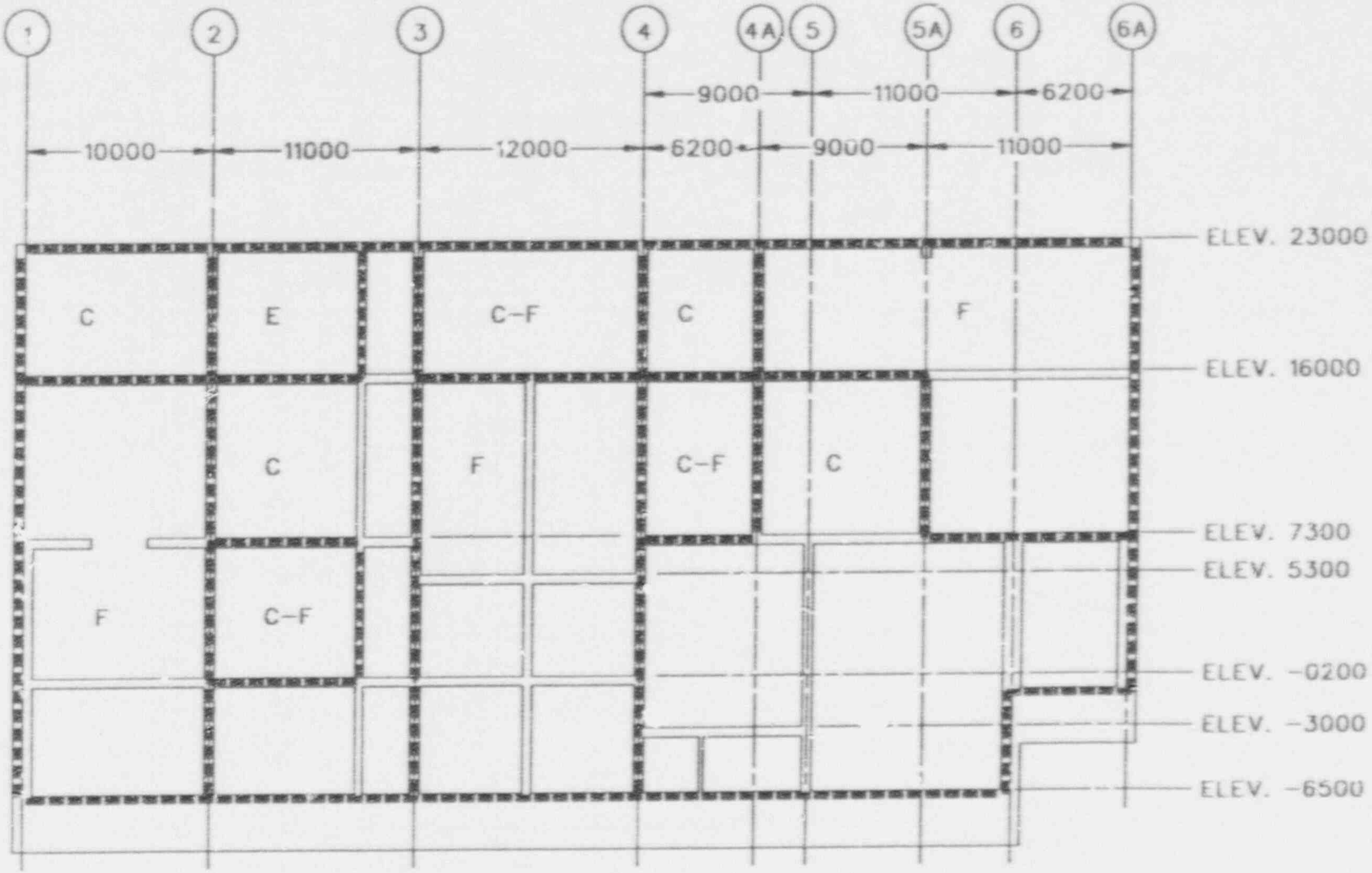
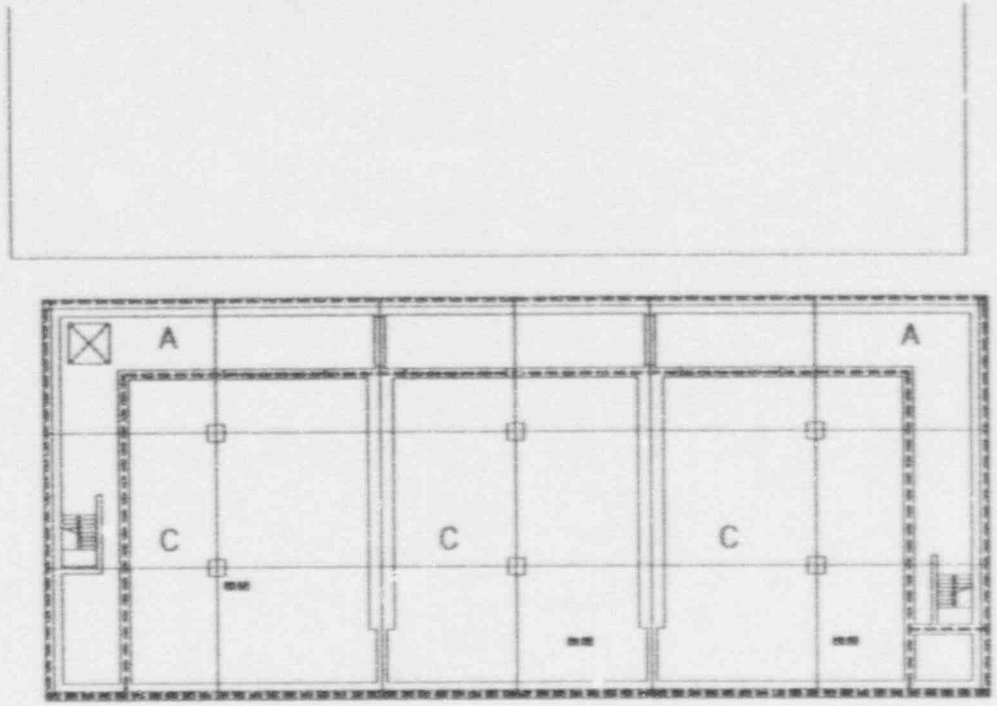



FIGURE 3.7v

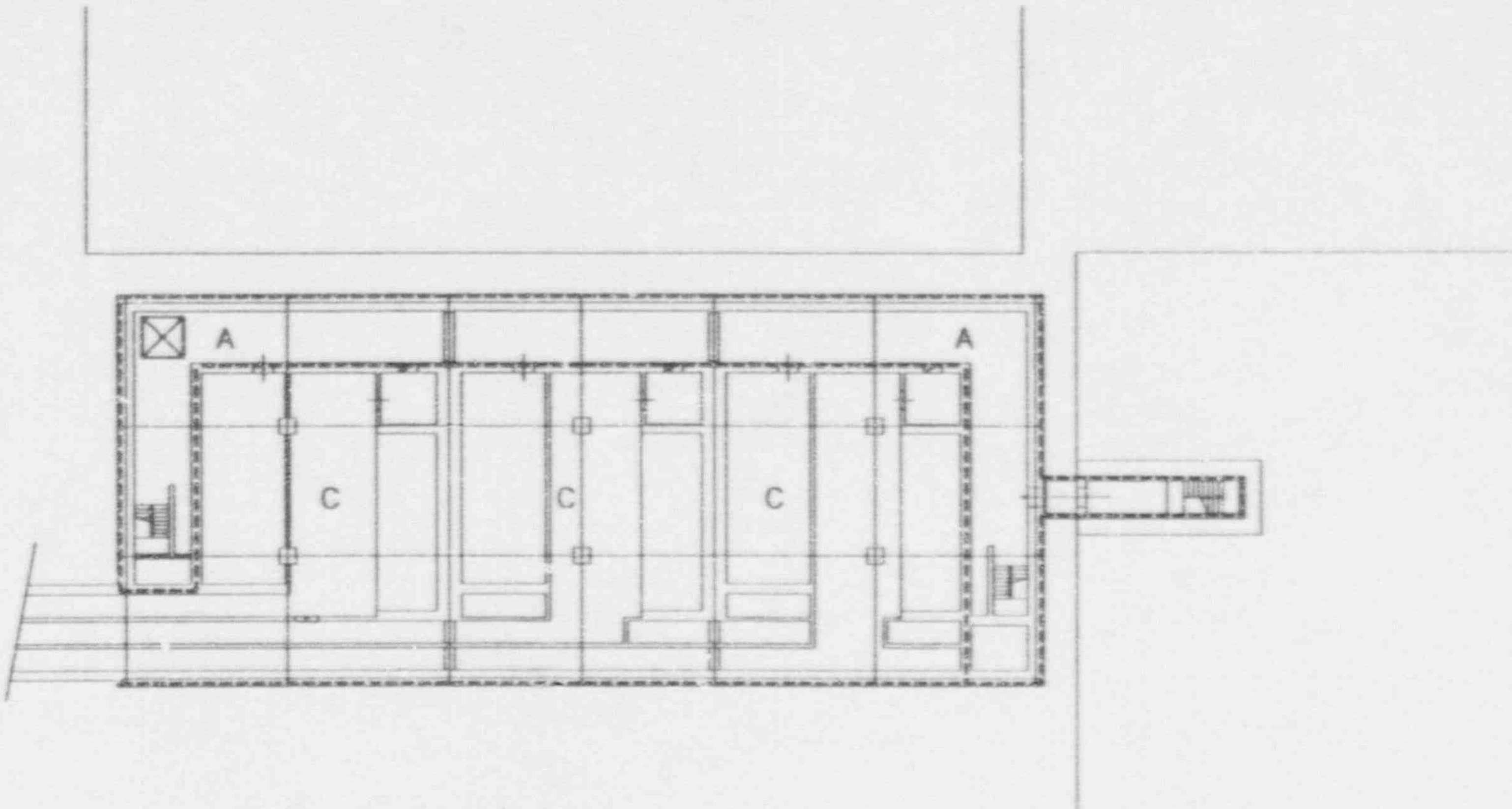
RADWASTE BUILDING, RADIATION ZONE MAP, NORMAL OPERATION AT CROSS SECTION A–A

A ≤ 0.6mrem/hr D < 25.0mrem/hr
B < 1.0mrem/hr E < 100mrem/hr
C < 5.0mrem/hr F ≥ 100mrem/hr



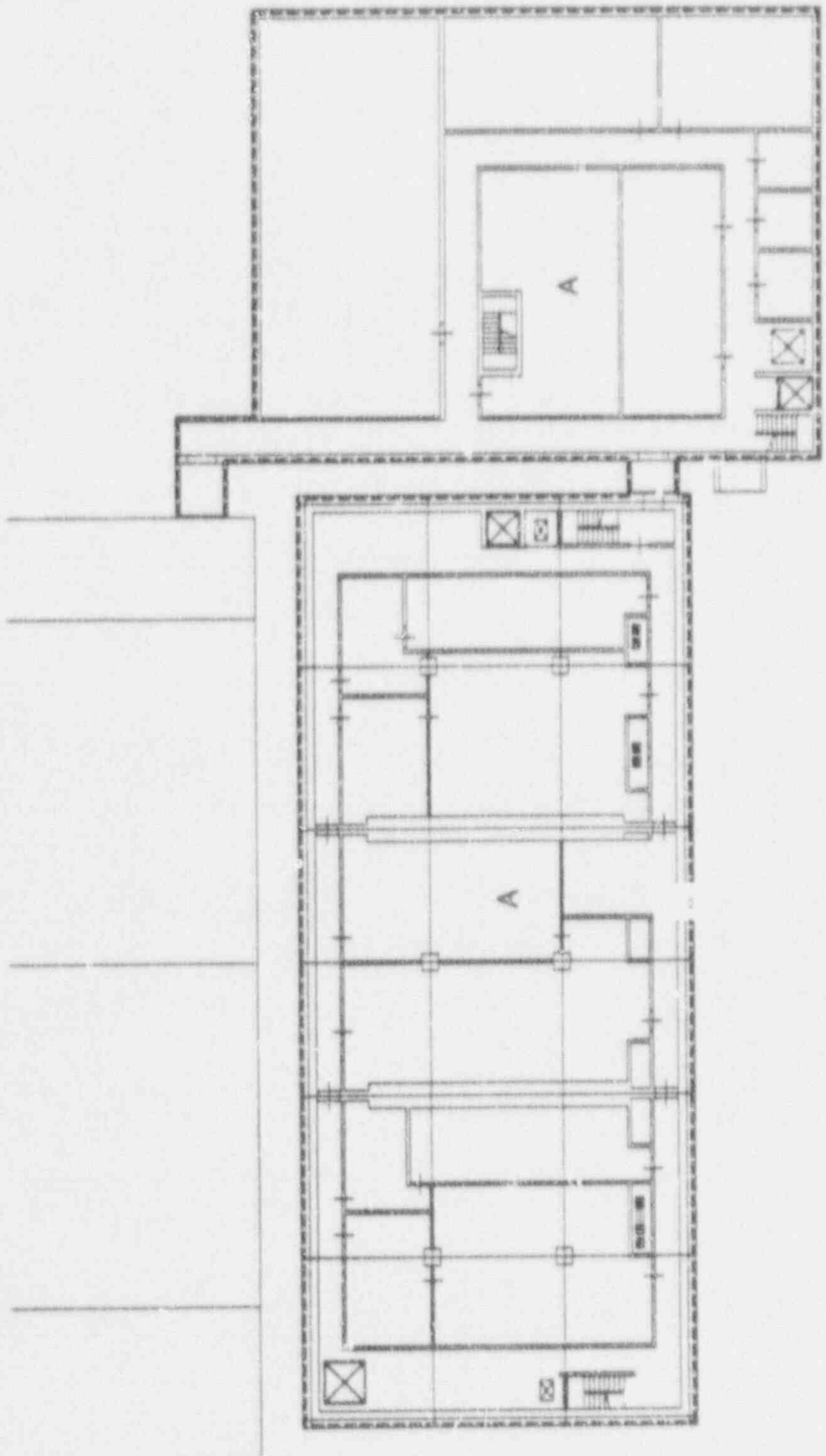

A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7w CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL - 8200MM



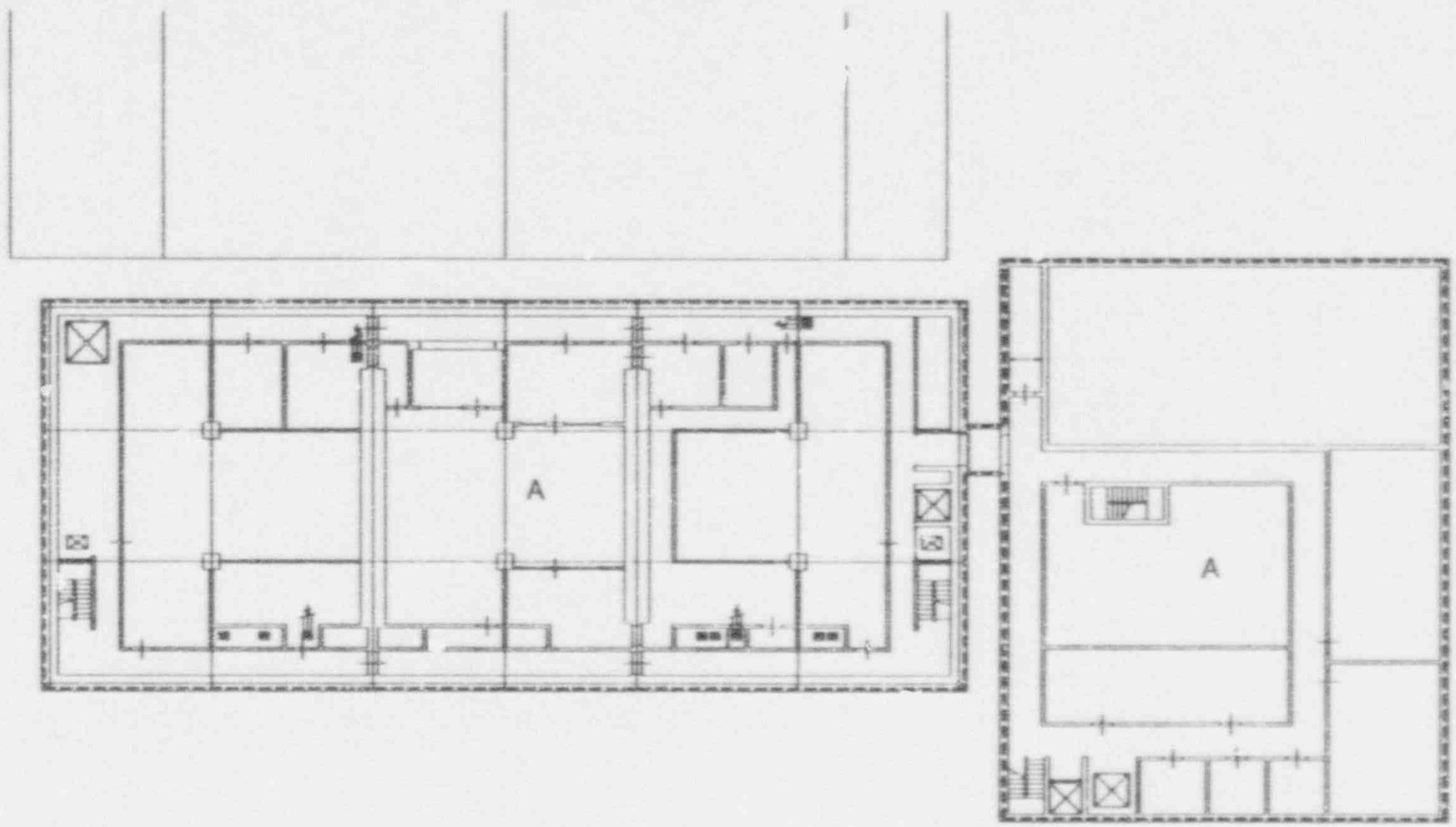

A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7x CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL – 2150MM



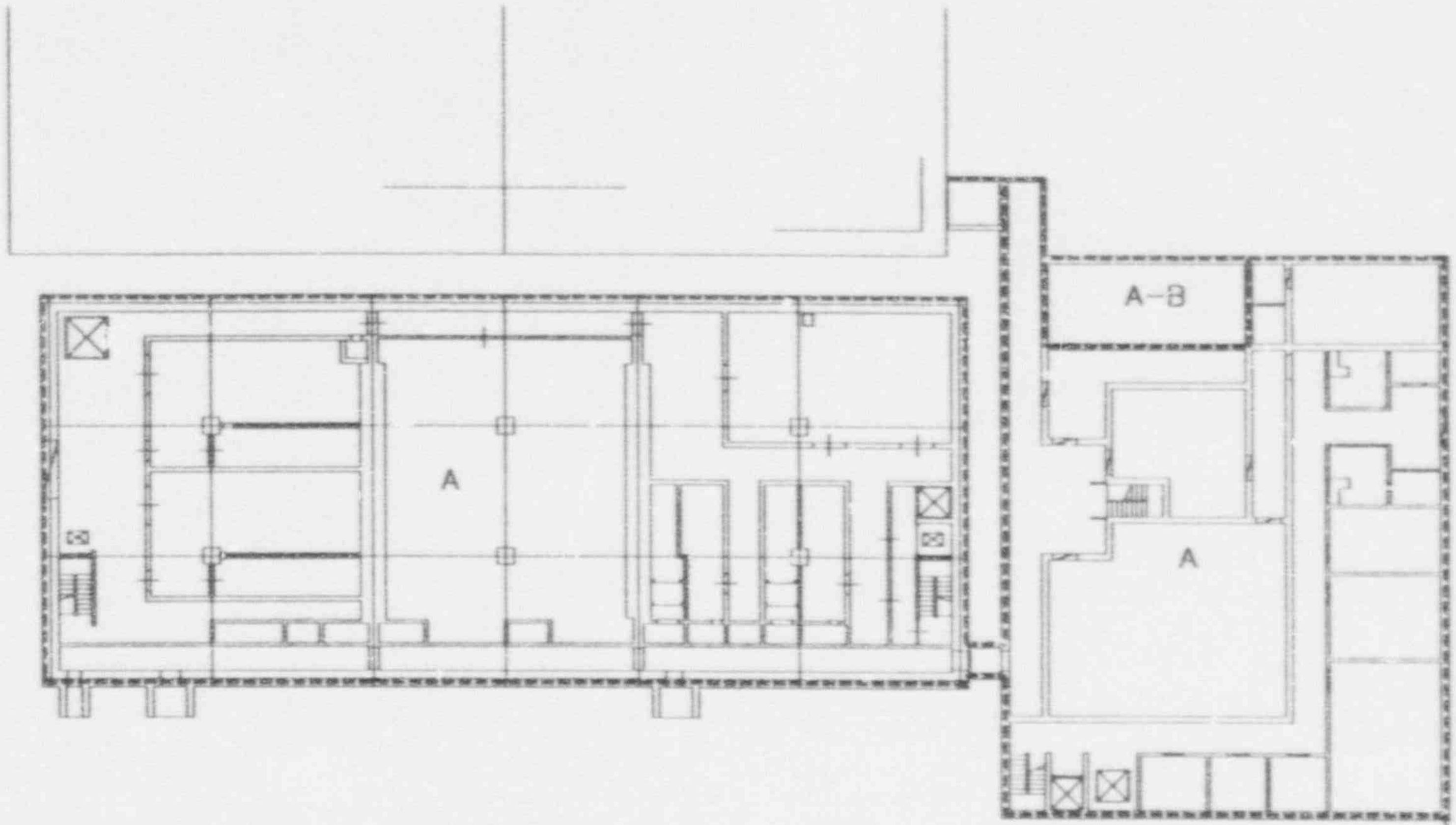

A ≤ 0.5 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7y CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL 3500MM



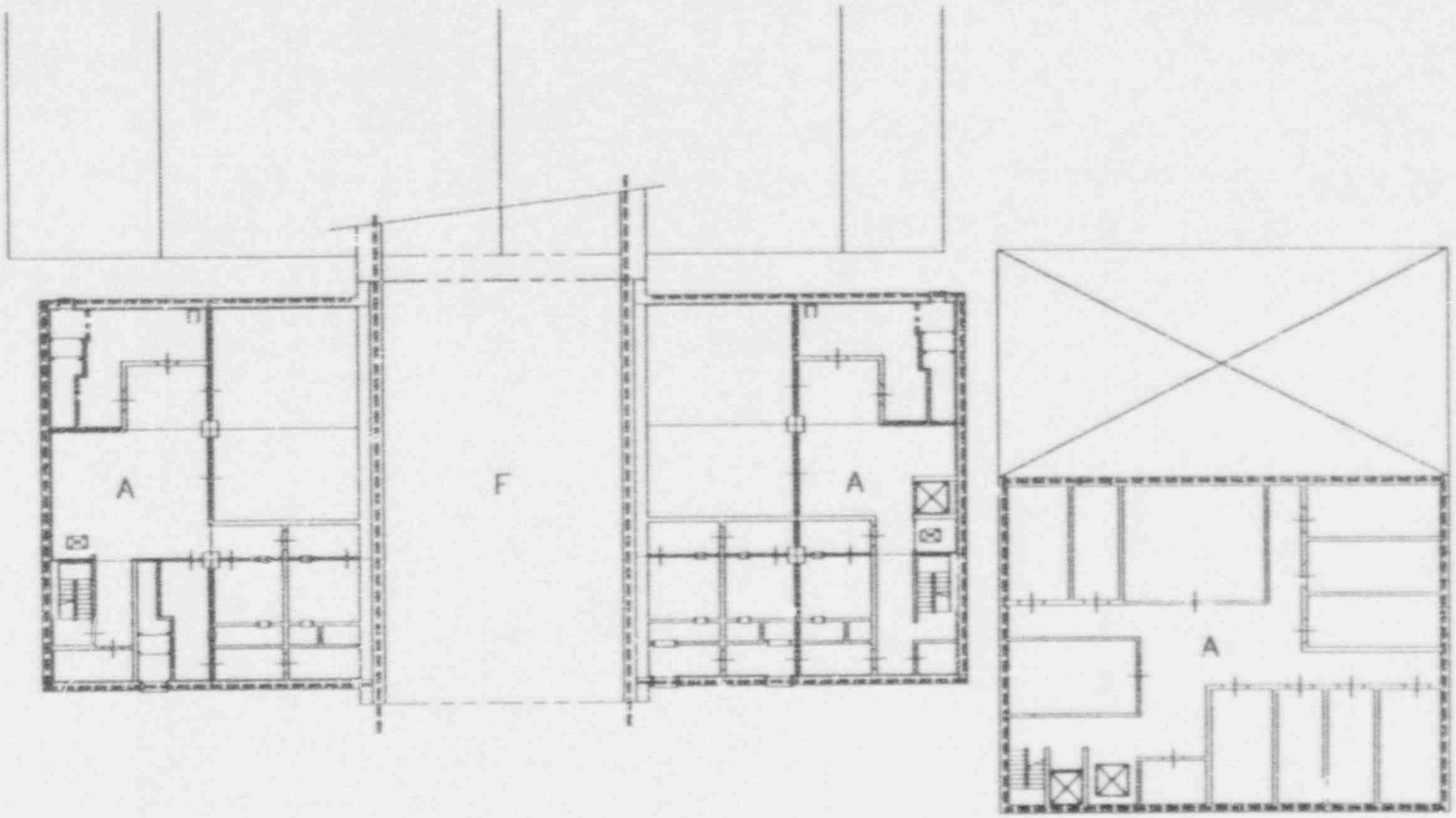

A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7z CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL 7900MM



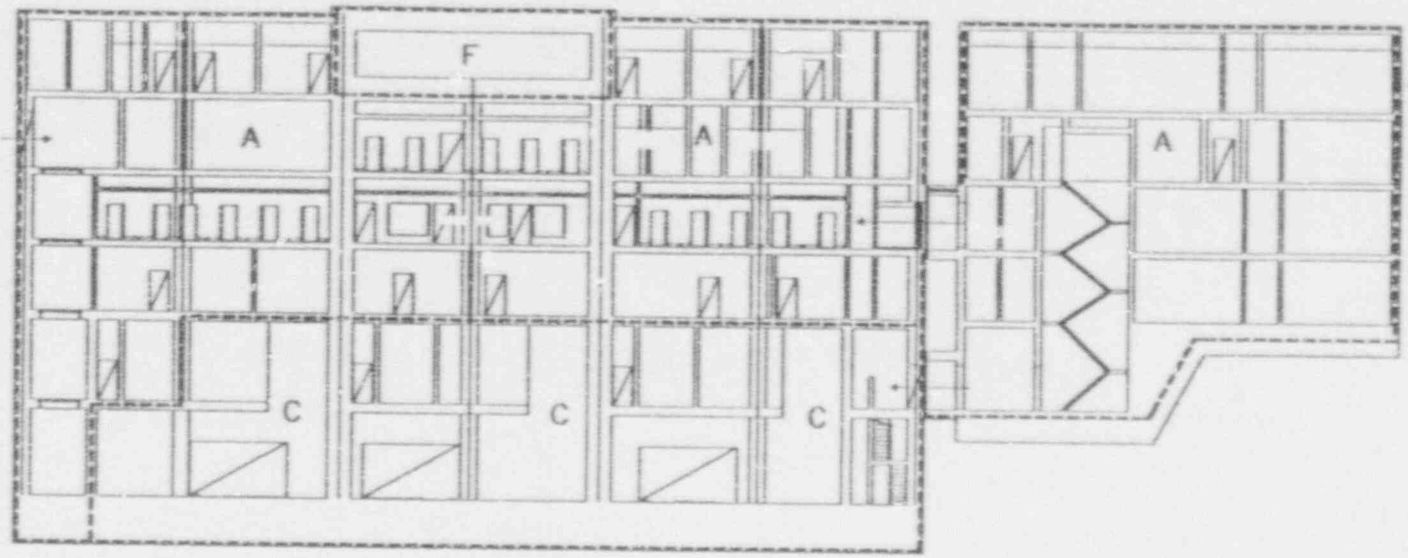

A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7aa CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL 12,300MM




A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7bb CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION AT FLOOR LEVEL TMSL 17,150MM




A ≤ 0.6 mREM/HOUR
B < 1.0 mREM/HOUR
C < 5.0 mREM/HOUR
D < 25.0 mREM/HOUR
E < 100.0 mREM/HOUR
F ≥ 100.0 mREM/HOUR

FIGURE 3.7cc CONTROL BUILDING RADIATION ZONE, NORMAL OPERATION, SIDE VIEW