Safety Analysis Report

for the

Penn State Breazeale Reactor

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The Pennsylvania State University
University Park, PA 16802

September 21, 1992

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By:

Marcus H. Voth (Director)
Terry L. Flinchbaugh (Editor)
Penn State Radiation Science and Engineering Center
Department of Nuclear Engineering
The Pennsylvania State University
University Park, PA 16802

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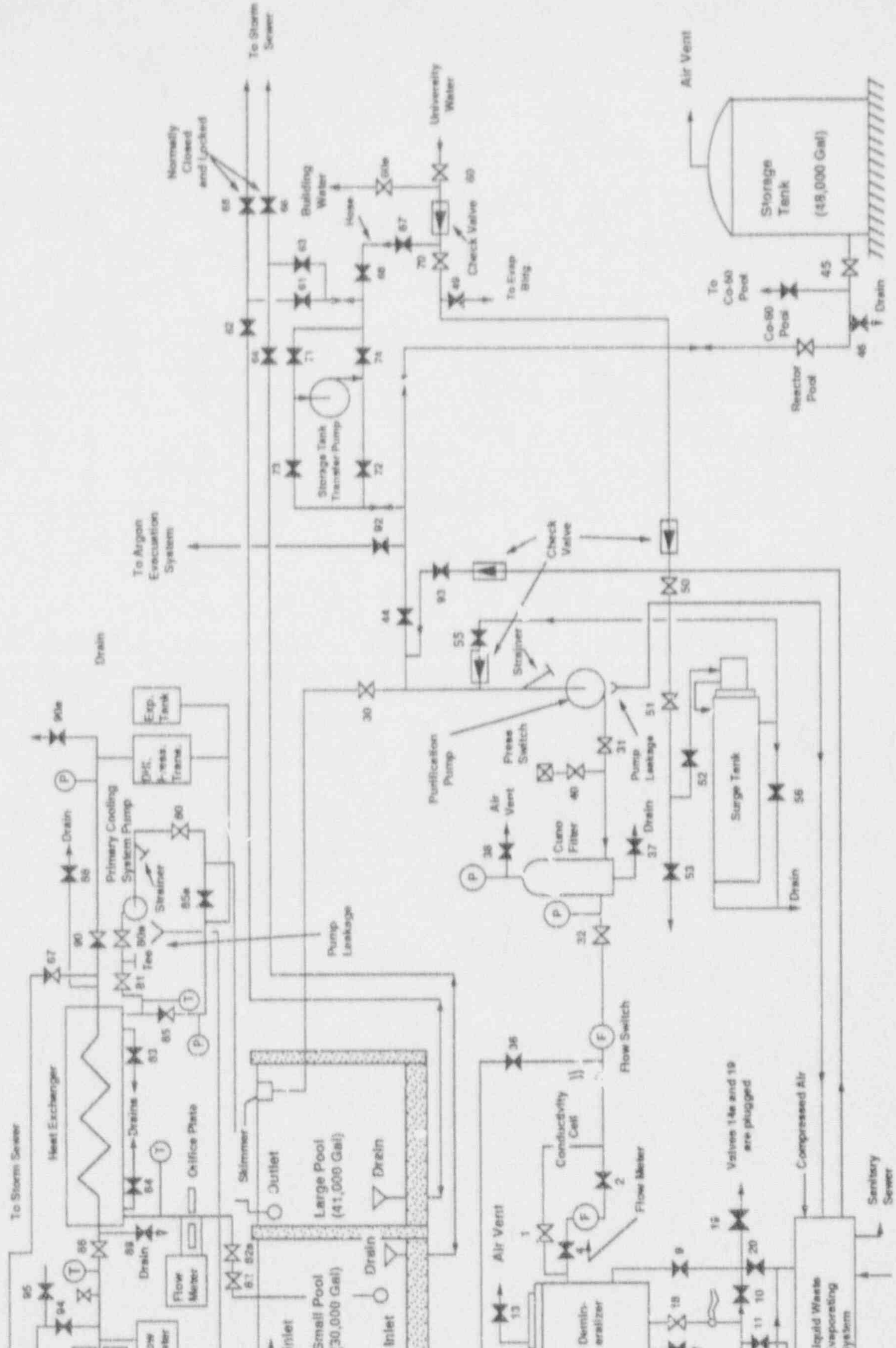

Figure 4-1 The PSBR Water Handling System

Figure 4-2 (This Figure is Deleted)

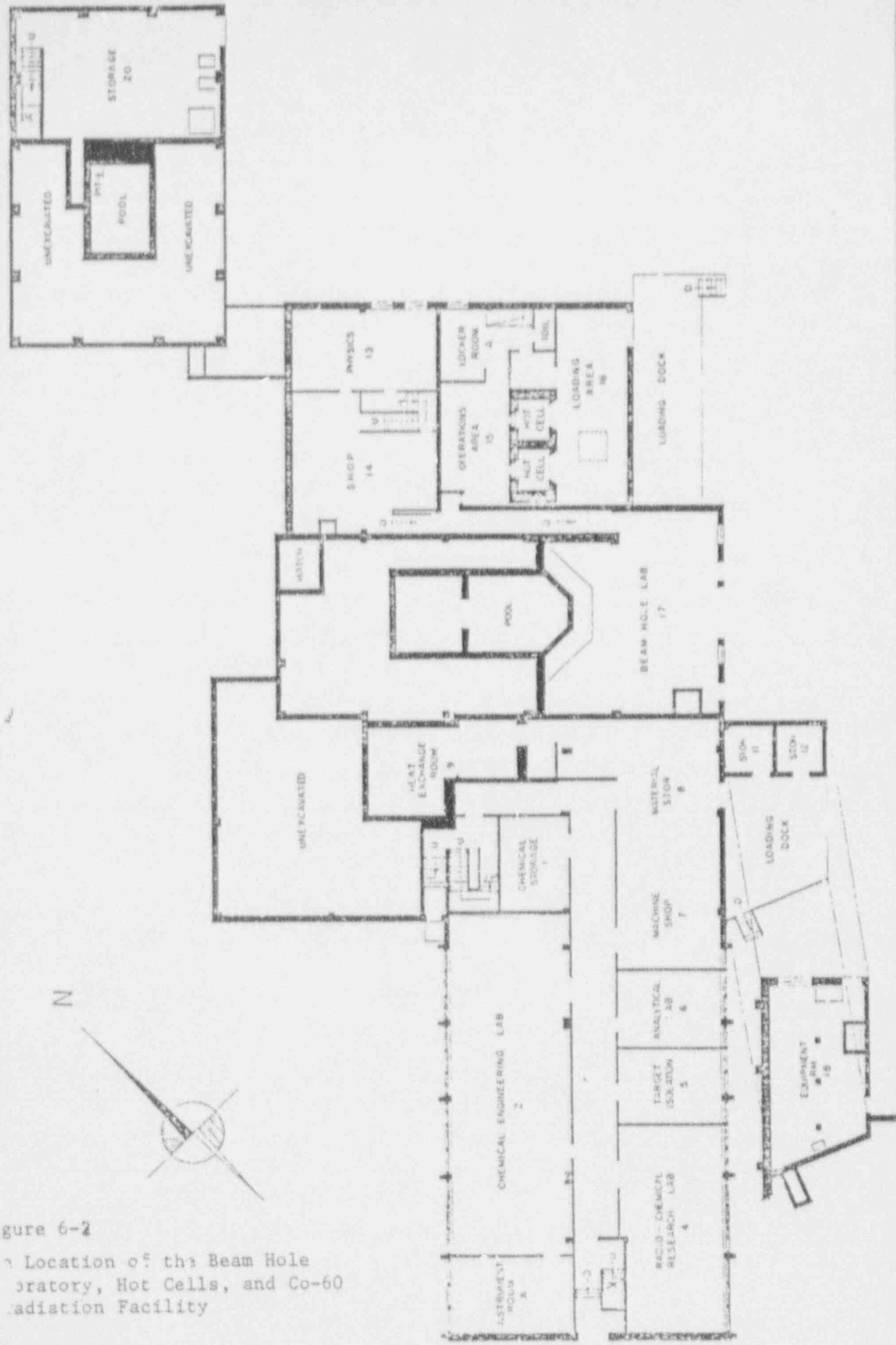

Figure 6-2

Location of the Beam Hole
oratory, Hot Cells, and Co-60
adiation Facility

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readout in the reactor control room. A TV camera is located in the BHL which can view the beam port area in use. A remote TV receiver is located in the control room. Two remote manual scram buttons are located on the east and south walls of the BHL. A beam gate open alarm circuit is activated when any of the beam port doors is open. Opening the beam gate or the outside entry door (normally bolted and locked from the inside) to the beam area will give a sonalert alarm in the BHL and a beam gate open alarm to the Protection, Control and monitoring System (PCMS).

B. D_2O Thermal Column

The D_2O thermal column in use at the PSBR is constructed of 6061-T6 aluminum and the tank section measures 34" in diameter and is 27" long. Although it is movable, its normal position is adjacent to beam port #4 (see Figures 6-1 and 6-3). The air filled flux trap that is built into the D_2O tank is 9" long and 10" in diameter. The air filled flux trap creates an 18" thickness of D_20 between the reactor core and the trap, which provides an optimum flux for the rabbit thimble and beam port #4.

Since mechanical interference prohibits the D_20 tank from contacting the beam port, an aluminum air filled extension is bolted to the beam port flange (see Figure 6-3) to remove pool water from the path of the neutron beam.

To protect the pool wall directly behind the thermal column from neutron and gamma radiation, a boral shield is fitted to the beam port end of the D_2O tank. A second boral shield on the reactor end of the D_2O tank keeps the scattered neutron interactions with the reactor instrumentation detectors to a minimum. Additional gamma shielding is provided for the pool wall by positioning a 2' x 2' x 1" lead shield around beam port #4.

C. Central Thimble

The central thimble, located in the radial center of the core, provides space for the irradiation of samples at the point of maximum neutron flux. The thimble is an aluminum tube 1.5" O.D. and 1.33" I.D. It extends from

Radiation High from one of the following:

- East Bay Monitor.
- West Bay Monitor.
- East Air Monitor.
- West Air Monitor.
- Neutron Beam Lab Monitor.
- Co-60 Lab Monitor.

- Emergency Evacuation Button.
- Remote Pushbutton (1 of 4).
- Reactor Bay Truck Door Open.
- Both East and West Facility Exhaust Fans Off.
- Interlock Validation Failure.
- Rod Velocity Signal Failure.
- Rod Motor Overspeed.
- Square Wave Termination Request.

To allow testing of the RSS logic, a testing bypass is provided for the DCC-X SCRAMs as specified for the stepback function (see above).

(c) Reactor Interlocks

All of the operational interlock logic in the RSS is validated by DCC-X. DCC-X monitors all of the inputs and outputs of the hardware logic and performs the identical logic in software. If a validation failure is detected, a SCRAM is requested.

The DCC-X control logic is designed to avoid signal outputs that are in violation with the RSS interlocks.

(d) Facilities Systems Support

The following functions are performed for control and monitoring of various systems in the reactor facility:

(i) Emergency Evacuation

An emergency evacuation is initiated on high radiation or manually from a switch on the console. Following initiation these listed actions occur:

- evacuation horn is energized.
- emergency exhaust system is turned on.
- alarm light on console is lighted.
- alarm is sent to police services.
- facility exhaust system is secured.

(ii) Reactor Operation Inhibit:

Reactor operation is inhibited by initiating a reactor stepback when an inhibit condition exists. The inhibit conditions cover the following situations:

- keyswitch is off.
- a radiation hazard from the neutron beam ports exists.
- both east and west bay or air radiation trips are defeated.
- pool temperature is high.
- reactor bay truck door is open.

(iii) Manual Controls:

Manual control of the following devices is provided:

- east and west facility exhaust fans.
- N-16 diffusion pump.
- neutron beam lab CCTV camera and monitor.
- rabbit system controls.

(iv) Operating History Records:

The following parameters are continually updated:

- integrated power.
- total time that the reactor was critical.
- total operating time (i.e. time that the keyswitch was in the operate position).

(v) Police Services Notification:

The following operational conditions will initiate a signal of notification to Penn State University Police Services:

- evacuation initiate.
- reactor pool level #1 low.
- reactor pool level #2 low.
- reactor pool level high.
- intrusion alarm.
- intrusion tamper alarm.
- UPS-1 low battery.
- waste tank level high.
- Co 60 pool level low.
- west air radiation high.
- east air radiation high.
- beam lab radiation high
- Co 60 bay radiation high
- west bay radiation high
- east bay radiation high
- hot cell fire
- DCC-X computer down.

display driver command list for display of the pulse. This task exists only on DCC-X and thus its internal variables cannot be accessed on DCC-Z.

In the *PROTROL* operating environment, tasks have the following attributes:

- independent scheduling frequency.
- definable scheduling priority relative to other tasks.
- independent module of code with controlled interfaces to other tasks.
- critical/non-critical attribute to determine whether or not failure will drop the watchdog.

The principles used for the task structure outlined above, are as follows:

[1] The independent safety system support functions are separated into different tasks from control system functions.

[2] Hardware I/O operations for safety support and control functions are performed independently in the associated task. This means that common I/O signals related to safety are not read from the hardware in one task and then passed to the other task in software (even though this would reduce CPU loading).

[3] Functions that do not have a high execution frequency requirement are placed into separate slower tasks so that CPU loading is not made unnecessarily high. For this reason there are both fast and slow safety support tasks (SSF & SSS) and control tasks (RRS & FAC).

[4] Related functions are grouped into common tasks to minimize task interfaces (even though they may have varying execution frequency requirements).

[5] Functions related to control of the operator interface are implemented in non-block language tasks allowing use of conditionally executed code. For example, dynamic portions of CRT displays are updated only when needed (i.e. a change has occurred). Much of the code must execute only when a key is pressed. This minimizes CPU loading without peak loading concerns since the operator cannot physically generate requests fast enough to cause a high peak load. The operator interface has been slowed down to provide additional assurance.

[6] Special purpose functions where the block language is mostly unusable, are implemented in non-block language tasks (e.g. PULS).

The design details of the various application software tasks as they apply to DCC-X and DCC-Z are provided in the design manual (reference [15]).

K. Control Room

K.1. General Description

The console assembly is located in the control room. All of the equipment described above is located in the console assembly with the exception of the FC and GIC Detector Assemblies, the in core fuel temperature TCs, the Wide Range Amplifier and the field sensors. A window is provided between the control room and the reactor bay such that an operator seated at the console can observe personnel movement in the reactor bay. A CCTV system is also provided in the control room so that the operator can observe personnel movement in the beam hole laboratory.

Three internal communication systems and a commercial telephone are available to the reactor operator in the control room. The internal communication systems allow: 1) two way conversation with anyone on the reactor bridge and the experimenters using the pneumatic transfer systems at any of the sending stations; 2) two way conversation between offices and offices within the building; and 3) the use of a page system that has speakers in all parts of the building.

A window between the control room and a public corridor allows visitors to conveniently view the reactor controls; it allows Police Services to observe any unusual indications on their inspection tours; and it allows the reactor staff to observe instrumentation from outside the reactor bay.

K.2. Monitor Indications in the Control Room

Table 7-1 lists the monitors and type of detectors, their ranges and alert and alarm settings for the major radiation monitors that provide inputs to the PCMS. All except the air east and air west monitors have readout modules located in an instrumentation pedestal as shown in Figure 7-8. For the monitors in the pedestal (except the Reactor Bridge West High) an alert results in an amber warning light on the monitor and a status and an alarm message is issued by the PCMS; an alarm results in a red alarm light on the monitor and a status alarm, an alarm message and an evacuation initiation is

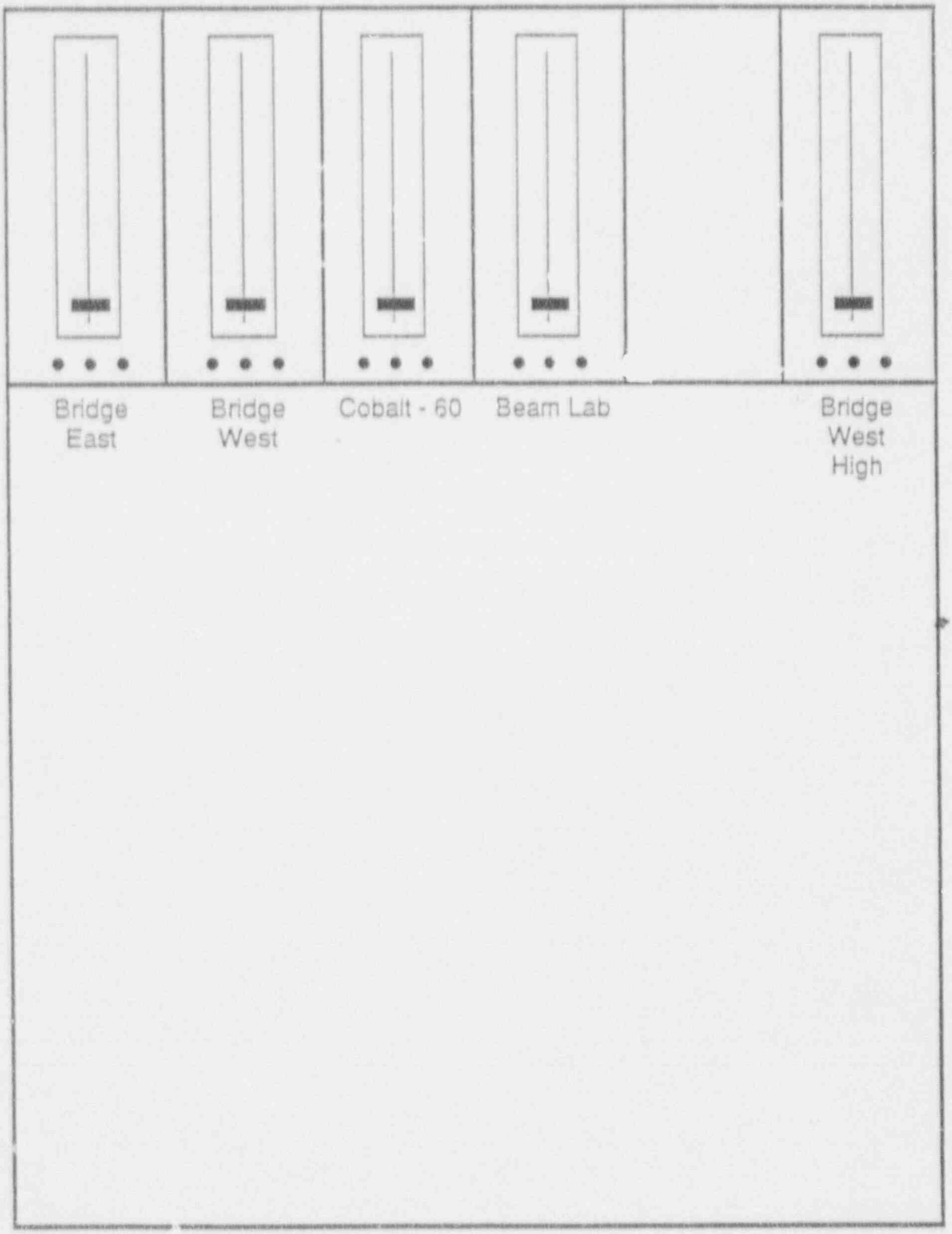

Figure 7-8 Instrumentation Pedestal

Table 7-1

Contrc Room *Alarmed Radiation Monitors

Monitor	Detector	Range	Setting**
Reactor Bridge East	G-M Tube	0.1 to 10^4 mR/hr	Alert: 15 mR/hr Alarm: 30 mR/hr
Reactor Bridge West	G-M Tube	0.1 to 10^4 mR/hr	Alert: 50 mR/hr Alarm: 200 mR/hr
Reactor Bridge West High	Ionization	1.0 to 10^4 R/hr	No alarm
Reactor Bay Air East	Thin End G-M Tube	10 to 10^5 c/m	Alert: 6000 c/m Alarm: 10000 c/m
Reactor Bay Air West	Thin End G-M Tube	10 to 10^5 c/m	Alert: 6000 c/m Alarm: 10000 c/m
Co-60 Bay	G-M Tube	0.1 to 10^4 mR/hr	Alarm: 6 mR/hr
Beam Laboratory	G-M Tube	0.1 to 10^4 mR/hr	Alarm: 6 mR/hr

*An analog output from the monitors is an input to the FCMS. When that signal exceeds the setpoint a status alarm is issued, an alarm message is issued and an Evacuation is initiated (see section 7.5.1.2.e.).

**Setting is determined internally and established by PSBR procedure.

issued by the PCMS. The air east and air west monitors have their own local bells and flashing red light alarms that can be observed by the control room operator. A current radiation reading can be read on bar or trend graphs on the PCMS for all the monitors listed in Table 7-1. Police DO bar trends indicate the status of console alarm conditions to Police Services.

L. Minimum Safety SCRAMS and Interlocks

Tables 2a and 2b in the Technical Specifications section list the minimum safety circuits and the minimum operational interlocks for the PSBR.

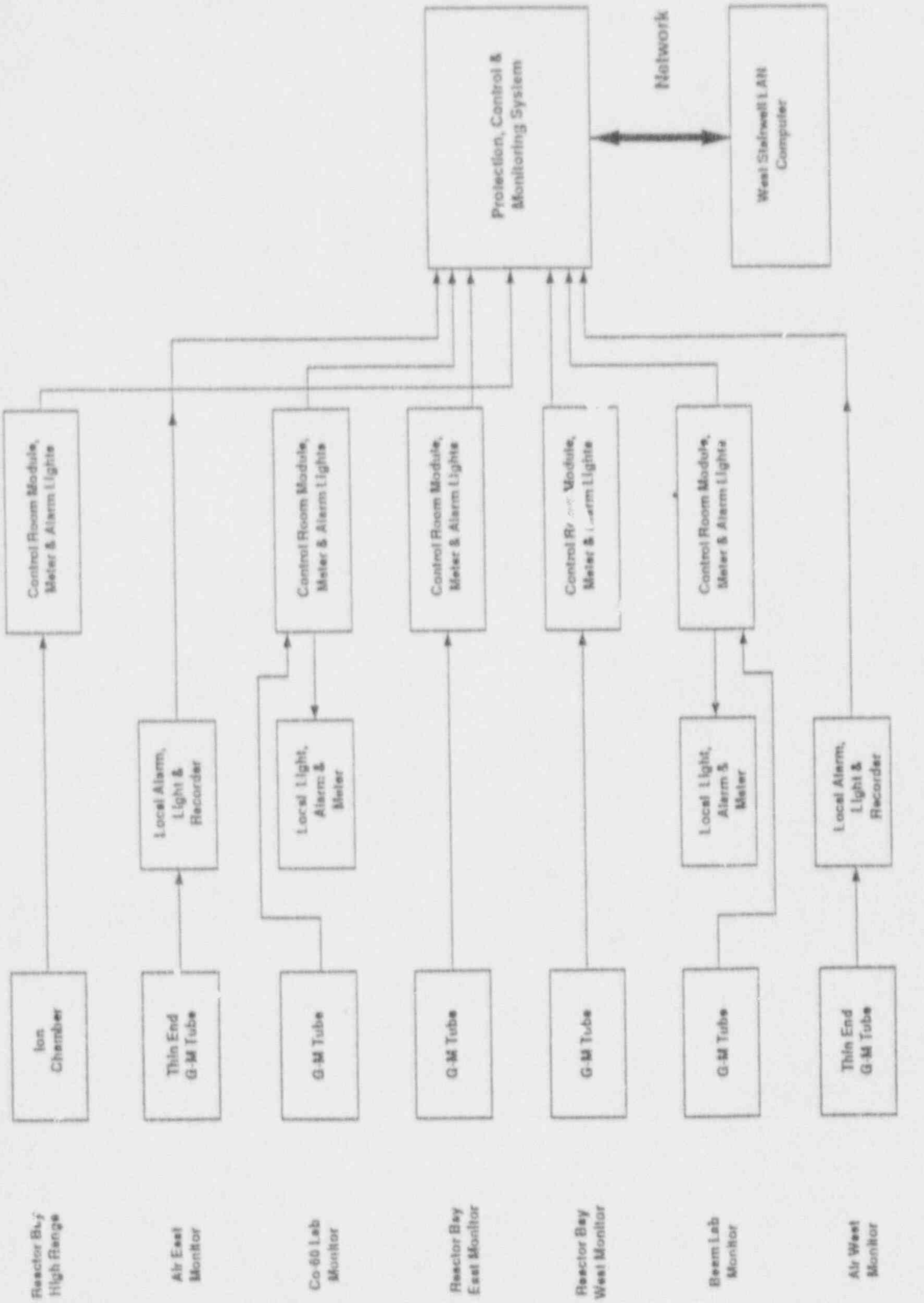

Figure 7-9 Radiation Monitoring System