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DESCRIPTION OF FACILITY RADIATION AND CONTAMINATION ALARM SYSTEMS INSTALLED IN THE INTERMEDIATE AND HIGH LEVEL WASTE EVAPORATOR BUILDING (BLDG. 2531)

C. C. Hall

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ORNL-TM-4317

Contract No. W-7405-eng-26

INSTRUMENTATION AND CONTROLS DIVISION

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C. C. Hall

NOVEMBER 1973

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OAK RIDGE NATIONAL LABORATORY
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ABSTRACT

A Facility Radiation and Contamination Monitoring System was installed in the Intermediate and High Level Waste Evaporator Building, Building 2531, to continuously monitor airborne beta-gamma contamination, beta-gamma background radiation, and steam condensate beta-gamma and gamma radiation. The monitoring instruments and their associated system components provide health physics information, sound local alarms when abnormal conditions occur, and indicate the abnormal condition on a central panel in the operating area.

Beta-gamma air monitoring instruments actuate the building containment system when a predetermined level of airborne contamination is reached or when any one of the air monitors becomes inoperative.

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1. INTRODUCTION

The Intermediate and High Level Waste Evaporator Building (Building 2531) is one of many facilities at ORNL equipped with networks of radiation and airborne contamination monitoring instruments connected to a centrally located alarm and control panel. Should the airborne contamination level exceed preset values in certain areas of the facility, alarms will be sounded, the building containment system will be operated, and an alarm will be transmitted to the Waste Disposal Control Center (Building 3105).

2. DESCRIPTION

2.1 System

Radiation and contamination levels are monitored throughout the building. Air is monitored for airborne radioactive particles by three beta-gamma constant air monitors. Background levels of beta-gamma radiation are monitored in the operating area. Process steam condensate is monitored for beta-gamma radiation. Steam condensate discharged from the facility is monitored for gamma radiation. These monitor locations are shown in Fig. 1.

None of the health physics functions originally designed into the constant air monitors were altered. Each instrument is an independent unit and retains all of its local alarm functions. The beta-gamma constant air monitor sounds a buzzer to indicate a caution alarm at 1000 counts/min and sounds a bell to indicate a high-level alarm at 4000 counts/min. Beta-gamma background and steam condensate monitors are panel mounted count-rate meters, located in the operating area, and the detectors are halogen-quenched Geiger-Mueller (G-M) tubes. The count-rate meters have ranges of 250, 1000, 2500, 10,000, 25,000, and 50,000 counts/min.

Audible and visible alarms are provided by a contact-making meter that has an adjustable pointer which can be set to any point within the meter range. In addition, each instrument is connected to an individual indicator lamp assembly at the central alarm panel in the operating area. Colored lamps on the module indicate the condition of the instrument to which they are connected.

Relay modules at the central alarm panel operate the building containment system when a high-level or an inoperative alarm is received from any air monitor or when a manual containment button is pushed. The lamp indication for each alarm condition is tabulated in Table 1.

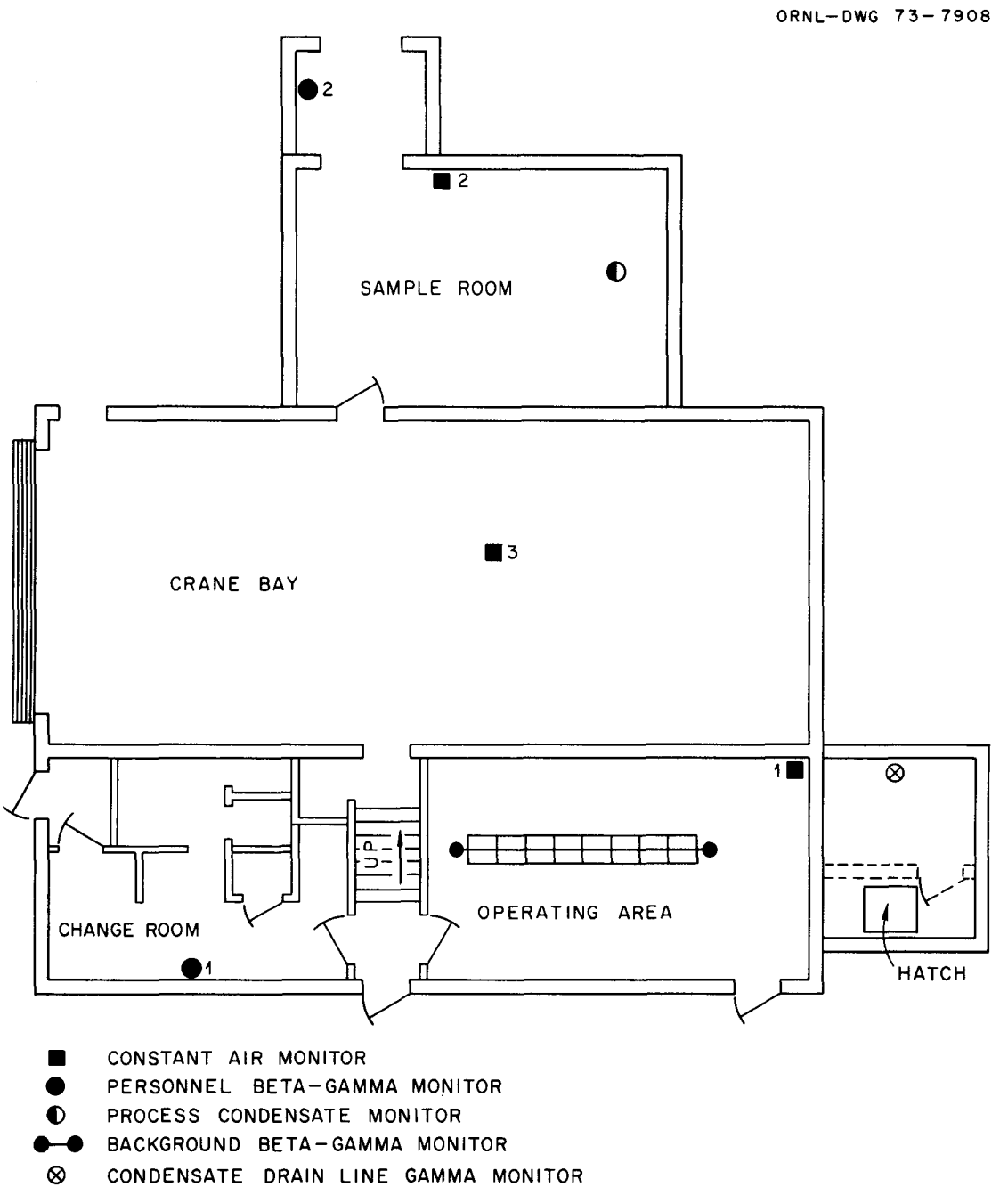


Fig. 1. Location of facility radiation monitoring instruments in building 2531.

Table 1. Central alarm panel alarm indications for radiation monitoring instruments

Instrument Condition	Lamp Intensities		
	Red	Amber	White
Normal	Dim	Dim	Dim
Caution level[a]	Dim	Bright	Dim
High level	Bright	Bright	Dim
Instrument inoperative	Dim	Dim	Bright
Instrument removed	Bright	Bright	Bright

[a]Caution level for beta-gamma air monitors is 1000 counts/min.

[b]High level for beta-gamma air monitors is 4000 counts/min.

2.2 Components

2.2.1 Air Monitors

The beta-gamma constant air monitor, ORNL model Q-2240 (Fig. 2), has an aspirating system, a paper-tape filter, a radiation detector, a linear count-rate meter, a recorder, and visible and audible alarms.

Air is drawn through a section of filter tape by a Roots blower. The flow rate is manually adjusted to 3 cfm. Airborne particulate matter is collected on the filter tape and continuously monitored for beta-gamma activity. Beta-gamma activity is monitored by a halogen-quenched G-M tube. The filter tape is advanced automatically every 24 hr, but it can be advanced manually at any time.

The count-rate meter (CRM) is a linear duty-cycle type utilizing a single range and has a high voltage power supply as an integral part. The normal range of the model Q-2240 beta-gamma CRM is 0 to 5000 counts/min. The CRM input voltage sensitivity is 200 mV, and the overall accuracy of the CRM, including the effect of long-term drift, is within 5%. The corona-regulated, high voltage power-supply output is 900 V nominal and is adjustable to ± 150 V of the nominal value. The maximum load current is 20 uA.

Fig. 2. Beta-gamma constant air monitor, ORNL model Q-2240.

The CRM has adjustable caution and high-level alarm set points. The caution alarm set point is adjustable between 2% and 64% of the meter scale. The caution alarm is an electronic circuit that has a dual triode and plate relay with a potentiometer adjustment. The relay is energized below the trip point and is deenergized by current transfer from one triode to the other by a diode that couples the cathode circuits. The low-level pointer on the CRM panel meter has no contacts and is used only as a visible indicator. This pointer is adjusted to correspond to the caution alarm set point. The high-level alarm is actuated by the high contact-making pointer on the CRM panel meter. When the high-level alarm set point is reached, the meter contacts and relay are latched in; they can be released only by depressing the reset button on the meter panel. The CRM circuit provides a 0- to 1-mA output signal to drive a Rustrak recorder which is an integral part of the CRM.

There are connectors on the rear of the CRM chassis for connection to remote caution and high-level alarms. There is another connector that provides a 0- to 1-mA output signal for operating an instrument-inoperative panel. A time-delay relay in the CRM circuit shorts the caution and high-level alarm circuits for approximately 60 sec after ac power is applied to the circuit. This prevents false caution and high-level alarms during instrument warm-up.

An alarm panel with four lights, a bell, and a buzzer is furnished with the air monitors. When the caution alarm set point is reached, the amber light is turned on and the buzzer is energized. The buzzer cannot be silenced on the beta-gamma air monitor until the radiation level decreases below the caution level set point or the filter tape is manually advanced. When the high-level set point is reached, the red lamp is turned on and the bell rings. The bell can be silenced by a toggle switch, but the red light remains on until the radiation level decreases below the set point and the count-rate meter is manually reset. A filter-tape-break alarm neon bulb is turned on and the caution alarm circuit is energized through a flasher. The neon bulb burns continuously, and the caution light and buzzer are operated intermittently. A pushbutton is located on the alarm panel and may be operated to test the audible and visible alarm circuits.

A Q-2311C-4 instrument-inoperative panel (Fig 3) inside the air monitor cabinet has contacts that operate a remote alarm to indicate that the instrument is inoperative, such as when a G-M tube or the count-rate meter has failed, the instrument has been unplugged, or there is an ac-power outage.

Fig. 3. Constant air monitor, "inoperative instrument" alarm, ORNL model Q-2311C-4.

2.2.2 Background Monitor

The beta-gamma background monitor consists of a Q-2313-8 count rate meter, a Q-2311C-4 inoperative panel, and two G-M tubes connected in parallel. The count-rate meter is a linear, duty-cycle type with ranges of 0-250, 0-1000, 0-2500, 0-10,000, and 0-25,000 counts/min full scale. The count-rate meter has a high-voltage power supply which has a nominal output of 900 V and can be adjusted to ± 150 V of the nominal value.

A high-level alarm is activated by a contact-making pointer on the CRM panel meter. The pointer may be set to any point on the meter scale. When the high-level alarm set point is reached, the meter contacts and relay are latched in and can be released only by depressing a reset button on the CRM panel. A high-level is indicated at the count rate meter by a red lamp. A connector at the rear of the CRM chassis provides an output alarm signal for operating a remote high-level alarm.

The G-M tubes are halogen quenched, thin wall (stainless steel, wall thickness 30 mg/cm^2), and operate at 900 V dc nominal. The cathode diameter is 5/8 in., and the active length is 3-1/2 in.

2.2.3 Process Condensate Radiation Monitor

The process condensate radiation monitor consists of a Q-2313-1 count-rate meter, a Q-2311C-4 inoperative panel, a lead shield, a Q-1907-13 detector assembly, and a condensate sample pump.

Steam condensate from waste evaporation is collected in a 150 gal tank in Cell 2; a sample of the condensate is continuously pumped from the tank through the beta-gamma detector assembly at 3 gal/min and monitored for beta-gamma radiation. When the radiation level in the condensate sample reaches a predetermined value, a high-level alarm signal from the monitor operates condensate drain valve RSV-A5, which stops the flow of steam condensate from the tank.

The Q-2313-1 count-rate meter is essentially the same as the Q-2313-8 count-rate meter described in Sect. 2.2.2, except a tube in the CRM input was replaced with a transistorized, impedance-matching module so that the detector assembly could be placed at a remote location from the count-rate meter. The count-rate meter has a 0-50,000 count/min range in addition to the ranges listed for the Q-2313-8 CRM (Sect. 2.2.2).

The detector assembly monitors ~ 1800 ml of water and can be easily disassembled for decontamination. The G-M tube is halogen-quenched,

with a stainless steel wall thickness of 30 mg/cm^2. The cathode diameter is 5/8 in., and the active length is 3-1/2 in.

2.2.4 Steam Condensate Drain Line Monitor

The steam condensate drain line monitor consists of a Q-2313-1 count-rate meter and detector, a Q-2311C-4 inoperative panel, and a flow rate monitor. Steam condensate is monitored for gamma radiation as it flows through a drain pipe to the ORNL liquid process waste system. The flow rate is monitored (at ORNL manhole No. 243) by a V-notch weir, bubbler tube, and flow recorder. The flow rate and radiation level signals are telemetered to the Waste Disposal Control Center (Bldg. 3105) where they are recorded on multipoint recorders. When the radiation level reaches a predetermined value, a high-level alarm signal from the monitor operates a block valve (SCBV) in the steam condensate drain line and a solenoid valve CSV-A2 which controls shutoff valve HCV-337 on the 35 psi process steam condensate line.

The count-rate meter is described in Sect. 2.2.3. The detector is a halogen-quenched, thin window (30 mg/cm^2 stainless steel), G-M tube and operates at 900 V dc nominal.

2.2.5 Central Alarm and Control Panel

The central alarm and control panel is located on panel MB-7 in the operating area (Fig. 4). The system consists of three count-rate meters with inoperative alarm panels, one 12-module rack, and a dc power supply. The module rack contains one indicating module for each monitoring instrument, a coincidence module for each group of instruments in a coincidence group, a dc failure alarm module, a manual containment module, and an audible alarm module.

The alarm indicating modules are grouped together (Fig. 5). Modules 1-1 through 1-3 receive alarm signals from three beta-gamma constant air monitors. A high-level or an inoperative alarm from either of the three air monitors will operate the "contain" module (module 1-4), which in turn, operates the building containment system and annunciator A2-6. Module 1-5 receives caution and inoperative alarm signals from the beta gamma background monitor in the control room. Module 1-6 receives high-level and inoperative alarm signals from the steam-condensate drain line radiation monitor and operates alarm module 1-7 when a high-level alarm is received. Module 1-7 then operates valve CSV A2 and SCBV. Module 1-8 receives high-level and inoperative alarm signals from the

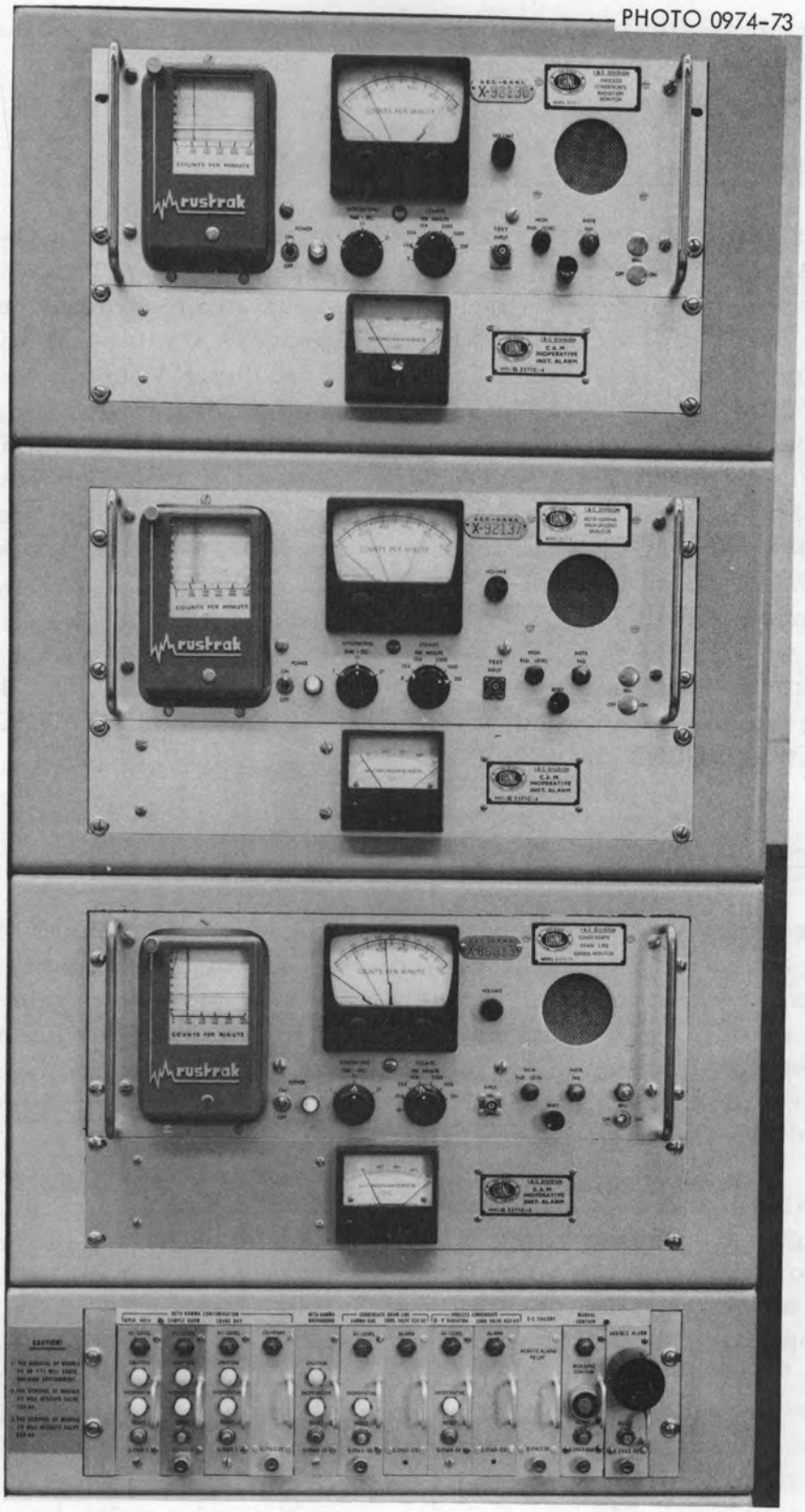
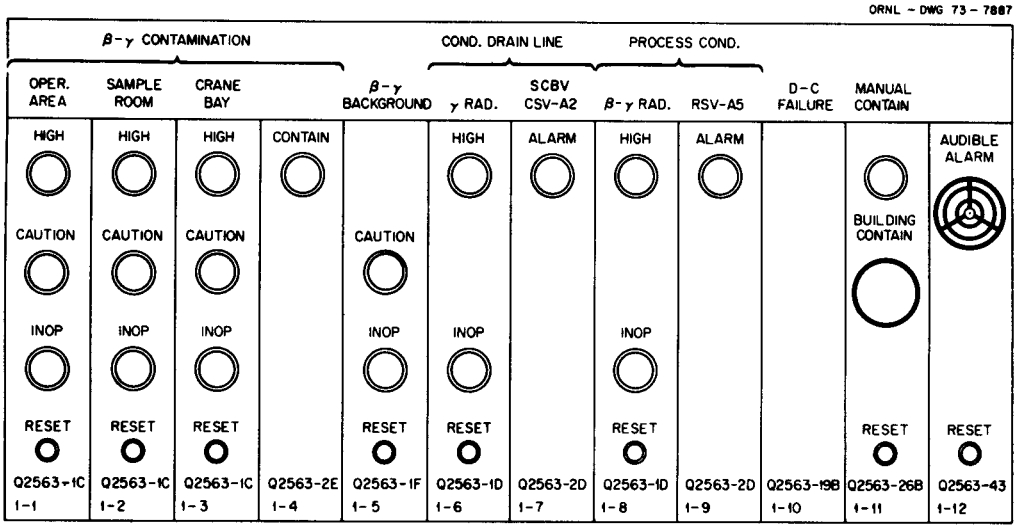


Fig. 4. Central alarm and control panel.



BUILDING 2531 ALARM PANEL

Position	Type		Function
1-1 to 1-3	Q2563-1C	3-Input Indicator Alarm Module	Accepts alarm signals from constant air monitors (beta-gamma). Alarm output on high, caution or inoperative.
1-4	Q2563-2E	6-Input Relay Module	Accepts alarm output from modules 1-1, 1-2, 1-3 on high or inoperative Actuates containment and annunciator A2-6 on 1 high or inoperative signal.
1-12	Q2563-4D	Buzzer Module	Accepts alarm signal from 1-1, 1-2, 1-3, 1-6, 1-7, 1-8. Buzzer sounds on each successive alarm. Silence buzzer by reset button on unit.
1-9	Q2563-2D	6-Input Relay Module	Accepts high level signal from 1-8. Actuates process condensate drain valve RSV-A5 and annunciator A3-2.
1-11	Q2563-16A Q2563-26B	Manual Contain Module	Actuates "containment" relay when large button is pushed. Reset by reset button on unit.
1-6, 1-8	Q2563-1D	2-Input Indicator Alarm Module	Accepts alarm signals from steam condensate drain line and PCR gamma monitors. Alarm output on high or inoperative signals.
1-10	Q2563-19-B	Remote Alarm Relay Module	Operates Annunciator A2-6 when alarm panel d-c power supply fails
1-5	Q2563-1F	2-Input Indicator Alarm Module	Accepts alarm signals from operating area background monitors. Alarms on caution or inoperative signals
1-7	Q2563-2D	6-Input Relay Module	Accepts high level signal from 1-6 and actuates steam shutoff valve CSV-A2 and steam condensate block valve (SCBV).

Fig. 5. Central alarm panel modules.

process condensate radiation monitor and operates module 1-9. Module 1-9 then operates steam condensate valve RSV-A5 and annunciator A3-2. Module 1-10 operates annunciator A2-6 when the dc power supply becomes inoperative. Module 1-11 is a facility containment module which is manually operated to actuate the building containment system. Module 1-12 is an audible alarm module and is operated when an alarm signal is received by any of the alarm indicating modules.

Alarm contacts in annunciator A2-6 operate a remote alarm in the Emergency Control Center (Building 3105) when the containment system is automatically operated or when there is a dc power failure.

2.3 Drawings

The Facility Radiation and Contamination Alarm System for Building 2531 is described in the following Instrumentation and Controls Division drawings:

1.	Q-2576-9, -10, -13, -23, and -30 through -36.	Instrument Location and Wiring Diagram
2.	Q-2563-1, -2, -13, -19 -26, -41, and -43.	Plug In Modules
3.	Q-2340, Q-2118, Q-2786, Q-2787.	Beta-Gamma Constant Air Monitor
4.	Q-2311C-4	Constant Air Monitor Inoperative Panel
5.	Q-2563-36	Constant Air Monitor, Typical Installation
6.	Q-2313-1, -8	Count Rate Meter Circuits
7.	Q-2191A-1 through -6	Count Rate Meter
8.	Q-1907-13 and -15	Water Monitor Detector and Shield.

3. CHECKOUT AND OPERATING PROCEDURES

The primary purpose of the central alarm panel is to provide automatic radiation and contamination alarms required by radiation safety and control

regulations. The alarm panel also serves as an aid to facility operating personnel, since it continuously monitors each instrument and indicates abnormalties, visibly by brightly illuminated lamps and audibly by an audible alarm. "Inoperative," "caution-level," and "high-level" alarms are indicated on the central alarm panel for each constant air monitor. "Inoperative" and "high-level" alarms are indicated for the steam condensate monitors, and a "caution" alarm is indicated for the operating area background monitor. These alarm signals actuate other systems, which are described in detail in Sect. 2.2.5.

To utilize the alarm indications efficiently, the instruments should be reset and the alarm signals cleared promptly. An alarm signal can be cleared by performing the following steps:

1. Press the reset button on the audible alarm module. This permits the audible alarm to be sounded again if another alarm signal is received before the first signal is cleared.

2. Check conditions at the instrument and reset the instrument if required. It may be necessary to advance the filter tape on the constant air monitors before the instrument can be reset. The air monitor "caution" alarm is self-resetting when the condition causing the alarm is corrected.

3. Reset the module on the central alarm panel by pressing the module reset button.

When the facility containment system is automatically actuated, an alarm signal is transmitted to the Waste Disposal Control Center (Building 3105) over telephone lines.

FACILITY RADIATION AND CONTAMINATION
ALARM SYSTEM CHECKOUT PROCEDURE

TEST	PURPOSE AND PROCEDURE	CORRECT OPERATION
1. Preliminary	Prepare to test system	
	1. Notify the operator in the Waste Disposal Control Center (Bldg. 3105) that the system is about to be checked.	
	2. Examine all panel lamps.	All module lamps are dim.
2. Facility Beta-Gamma Contamination Monitoring System.	Test all monitors individually (see check out sheets for locations).	
a. "Inoperative" Alarm	1. Unplug instrument	Audible alarm sounds and white lamp glows brightly. Red lamp on "contain" module glows brightly and building containment system is operated. Audible alarm can be reset, but lamps cannot be reset.
	2. Plug in instrument.	After 1 min delay, white lamp can be reset. Red lamp on "contain" module resets automatically when white lamp is reset.
	3. Disconnect cable between count-rate meter and G-M tube.	"Inoperative" panel meter goes slowly to zero; audible alarm sounds and white lamp glows brightly. Red lamp on "contain" module glows brightly. Audible alarm can be reset, but lamps cannot be reset.
	4. Connect cable between count-rate meter and G-M tube.	"Inoperative" panel meter goes upscale. White lamp can be reset. Red lamp on "contain" module resets automatically when white lamp is reset.
b. "Caution" Alarm	1. Increase count-rate with a source to "caution" alarm set point.	Audible alarm sounds, and amber lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	2. Remove source until the count-rate is below the "caution" alarm set point.	Amber lamp resets automatically.
c. "High-Level" Alarm	1. Increase the count-rate with a source to the "high-level" alarm set point.	Audible alarm sounds, and amber and red lamps glow brightly. Red lamp on "contain" module glows brightly. Audible alarm can be reset, but lamps cannot be reset.
	2. Remove source and reset instrument.	Red lamp can be reset; amber lamp resets automatically. Red lamp on "contain" module resets automatically when "high-level" lamp is reset.
	3. Reset building containment system.	Building is no longer in containment.
NOTE:	All three beta-gamma constant air monitors should be checked before the building containment system is reset.	
3. Beta-Gamma Background Monitor		
a. "Inoperative" Alarm	1. Unplug instrument.	Audible alarm sounds and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	2. Plug in instrument.	After 1 min delay, white lamp resets automatically.
	3. Disconnect cable between the count-rate meter and G-M tubes.	"Inoperative" panel meter goes slowly to zero; audible alarm sounds and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.

FACILITY RADIATION AND CONTAMINATION
ALARM SYSTEM CHECKOUT PROCEDURE (Continued)

TEST	PURPOSE AND PROCEDURE	CORRECT OPERATION
	4. Connect cable between count-rate meter and G-M tubes.	"Inoperative" panel meter goes upscale and white lamp resets automatically.
	5. Increase the count-rate to the "caution" set point by placing a source near one of the G-M tubes.	Audible alarm sounds and amber lamp glows brightly. Audible alarm can be reset, but amber lamp cannot be reset.
	6. Remove source; reset instrument	Amber lamp can be reset.
	7. Repeat steps 3.a.5 and 3.a.6, placing the source near the second G-M tube.	
4. Steam Condensate Drain Line Gamma Monitor		
a. "Inoperative" Alarm.	1. Unplug instrument.	Audible alarm sounds, and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	2. Plug in instrument.	After 1 min delay, white lamp resets automatically.
	3. Disconnect cable between the count-rate meter and G-M tube.	"Inoperative" panel meter goes slowly to zero; audible alarm sounds and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	4. Connect cable between count-rate meter and G-M tube.	"Inoperative" panel meter goes upscale, and white lamp resets automatically.
b. High-Level Alarm	1. Increase the count-rate with a source to the "high-level" alarm set point.	Audible alarm sounds, and red lamp glows brightly. Red lamp on control module glows brightly, and valve CSV-A2 and the steam condensate block valve (SCBV) are operated. Audible alarm can be reset, but lamp cannot be reset.
	2. Remove source and reset instrument.	Red lamp can be reset. Red lamp on control module resets automatically when "high-level" lamp is reset. Valves CSV-A2 and SCBV return to normal position.
5. Process Steam Condensate Beta-Gamma Monitor		
a. "Inoperative" Alarm.	1. Unplug instrument.	Audible alarm sounds, and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	2. Plug in instrument.	After 1 min delay, white lamp resets automatically.
	3. Disconnect cable between count-rate meter and G-M tube.	"Inoperative" panel meter goes slowly to zero; audible alarm sounds and white lamp glows brightly. Audible alarm can be reset, but lamp cannot be reset.
	4. Connect cable between count-rate meter and G-M tube.	"Inoperative" panel meter goes upscale, and white lamp resets automatically.
b. High-Level Alarm	1. Increase the count rate with a source to the "high-level" alarm set point.	Audible alarm sounds, and red lamp glows brightly. Red lamp on control module glows brightly, and valve RSV-A5 is operated. Audible alarm can be reset, but lamps cannot be reset.
	2. Remove source and reset instrument.	Red lamp can be reset. Red lamp on control module resets automatically when "high-level" lamp is reset. Valve CSV-A5 returns to normal position.

FACILITY RADIATION AND CONTAMINATION
ALARM SYSTEM CHECKOUT PROCEDURE (Concluded)

TEST	PURPOSE AND PROCEDURE	CORRECT OPERATION
6. D-C Power Failure Alarm	1. Disconnect 24-V dc power supply from alarm panel.	All lamps on the central alarm panel are out. Annunciators (A2-6 in Bldg. 2531 and 71 in Bldg. 3105) are operated. Annunciators can be acknowledged but not reset.
	2. Connect 24-V dc power supply to alarm panel.	All lamps glow dim. Annunciators can be reset.
7. Manual Containment Control	1. Press red button on manual containment module.	Red lamp on containment module glows brightly. Building containment system is operated.
	2. Reset containment module.	Red lamp on containment module glows dim. Building containment system can be reset.
8. Conclude Test	1. Check alarm panel.	All alarm lamps are reset and glowing dim. Building containment system is reset.
	2. Notify operations personnel in the Waste Disposal Control Center that the check out is complete.	

FACILITY RADIATION AND CONTAMINATION ALARM SYSTEM
BUILDING CONTAINMENT CHECK SHEET

BLDG: 2531
CHECKED BY: _____
DATE: _____

MONITOR	LOCATION	RADIATION CAUTION	RADIATION HIGH	RADIATION INOP.	CONTAIN. HIGH	CND.VALVE INOP.	ALARM	ANN.	REMARKS
BETA-GAMMA CONTAMINATION									
CAM 1	Operating Area						X	X	
CAM 2	Sample Room						X	X	
CAM 3	Crane Bay						X	X	
STEAM CONDENSATE RADIATION									
CRM 1	Drain Line Gamma	X			X	X			
CRM 2	PCR Gamma	X			X	X			
BETA-GAMMA BACKGROUND									
CRM 3	Operating Area		X		X	X	X	X	

DC FAILURE MODULE CHECKED ☐

MANUAL CONTAINMENT CHECKED ☐

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