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DESCRIPTION OF FACILITY CONTAMINATION ALARM SYSTEM INSTALLED IN THE PHYSICAL EXAMINATION HOT CELLS, BUILDING 3025

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1. ABSTRACT

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A Facility Contamination Alarm System was installed in the hot cell section of Building 3025 to continuously and automatically monitor air contamination (by three beta-gamma air monitors) in the entire facility.

These instruments and other components in the network provide health physics monitoring information, sound local alarms when abnormal conditions occur, and indicate these conditions on a central panel board in the operating area.

Operating personnel are first given warning when air-borne contamination is detected by a constant air monitor or a mobile air monitor reaches a preset caution level. A second warning is given when the high-level set point is reached.

The building evacuation system operates automatically when two or more air monitors detect a high level of air contamination.

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2. INTRODUCTION

The Physical Examination Hot Cells in Building 3025 is one of 17 facilities at Oak Ridge National Laboratory being equipped with networks of radiation and air monitoring instruments connected to a central control panel in the building and to the Laboratory Emergency Control Center.¹ A facility contamination system was installed in the building to continuously and automatically determine the radioactive contamination condition of the entire facility and to report this information to a central control panel within the building. Should the air activity in two isolated portions of the building exceed preset values, an audible alarm in the building will be actuated, warning lights outside the building will flash, and an alarm signal will be transmitted to the Emergency Control Center, Building 2500.

3. DESCRIPTION

3.1 System

Air is monitored for beta-gamma-emitting particles by three constant air monitors located in three separate parts of the building (Table 1).

Table 1. Contamination Monitors Installed in Building 3025

Location	Monitor Number
Facility Contamination Monitors ^a	
Second Floor, North	1 ^b
Second Floor, South	2 ^b
Mezzanine	3 ^c

^aCoincidence of any two high-level alarms in the group causes automatic evacuation.

^bORNL Model Q-1740B Mobile Air Monitor.

^cORNL Model Q-2240B-4 Constant Air Monitor.

¹D. J. Knowles et al., Instrumentation and Controls Div. Ann. Progr. Rept. Sept. 1, 1963, ORNL-3578, pp. 37-40.

Most of the required air monitoring instrumentation had been installed previously as personnel protection instrumentation with local audible and visible alarms. These instruments are used in the facility contamination alarm system without altering their local health physics functions by connecting to auxiliary contacts within the instrument or by adding auxiliary alarm devices to the equipment. Each instrument is connected to an individual indicator module on the monitoring panel in the operating area. By means of three colored lamps, which normally give a dim light, an indicator module indicates the condition of the instrument to which it is connected; that is, a white lamp burns at full intensity if the instrument becomes inoperative, an amber lamp burns at full intensity if the caution-alarm level is reached and a red lamp burns at full intensity if the high-alarm level is reached (Table 2). Any change in the intensity of any lamp in the indicator module is accompanied by a buzzer signal.

Table 2. Central Control Panel Alarm Indications for Air Monitors

Instrument Condition	Lamp Intensities		
	Red	Amber	White
Normal Operation	Dim	Dim	Dim
Caution Level ^a	Dim	Bright	Dim
High Level ^b	Bright	Bright	Dim
Instrument Inoperative	Dim	Dim	Bright
Instrument Removed ^c	Bright	Bright	Bright

^aCaution level is 1000 counts/min for a model Q-2240 beta-gamma air monitor, and 2000 counts/min for a model Q-1740 air monitor.

^bHigh level is 4000 counts/min for a model Q-2240 air monitor, and 10,000 counts/min for a model Q-1740 air monitor.

^cLamp intensities remain until a maintenance connection is made giving "inoperative" indication.

The high-level alarm outputs of the three constant air monitors are connected to a coincidence module. If a coincidence module receives a high-level alarm signal from any two or more constant air monitors, the building evacuation system is actuated.

Fig. 1. Central Panel Board for the Facility Contamination Alarm System in the Physical Examination Hot Cells, Building 3025.

Fig. 2. Mobile Air Monitor, ORNL Model Q-1740.

Fig. 3. Beta Gamma Constant Air Monitor, ORNL Model Q-2240.

3.2 Components

3.2.1 Panel Board

The central panel board for the entire system is located in the operating area (Fig. 1). It consists of a 12-module rack, a central control chassis, and a dc power supply. The 12-module rack contains an indicating module for each instrument, a coincidence module for the contamination alarm system, a buzzer module, and a manual evacuation module.

The racks and modules are made of anodized aluminum. The modules have anodized Metalphoto front panels. A Metalphoto text strip is provided at the top of the rack for instrument identification. The central control chassis contains manual switches, timers, relays, and monitoring equipment which are parts of the system but not built in modular form.

3.2.2 Air Monitors

Two types of air monitors are used in the system: an older model, the Mobile Air Monitor, ORNL model Q-1740 (Fig. 2); and its successor, the Beta-Gamma Constant Air Monitor, ORNL model Q-2240 (Fig. 3).

Mobile Air Monitor. -- This monitor consists of an aspirating system, a paper filter, a halogen-type Geiger-Mueller tube detector, a logarithmic count-rate meter, and visible and audible alarms. Any background radiation within the range of the instrument can be suppressed, and from one to five decades may be selected for display on a strip-chart recorder. This scale arrangement allows the instrument to accumulate air-contamination data while operating in areas where the background count is high.

A Model H, Leeds & Northrup Speedomax recorder with upscale, downscale, and set-point alarms indicates high radiation, instrument failure, and above-tolerance contamination, respectively. The local alarm circuit is so arranged that, if the air contamination increases to a point above the set point, an amber local annunciator light is actuated to indicate tolerance level. At very high radiation conditions, an alarm bell and a red annunciator light are actuated simultaneously. The local annunciator lights are mounted on top of the instrument cabinet so that operation of the monitor can be observed from any position in the immediate area. A time-delay relay prevents remote alarms from operating until the instrument has warmed up after being turned on.

Beta-Gamma Constant Air Monitor. -- This monitor consists of an aspirating system, a paper-tape filter, a halogen-type Geiger-Mueller tube detector, a linear count-rate meter, a recorder, and visible and audible alarms. Air is drawn through

the filter at 3 cfm (controlled manually) by a Roots blower. A sample of dust particles in the air is collected on the paper-tape filter. The sample tape is advanced automatically every 24 hours. The tape may be advanced manually at any time by the operator.

The detector counts the sample as it is being collected. The count-rate meter is a linear duty-cycle type utilizing a single range and having a high-voltage supply as an integral part. The normal range is 0 to 5000 counts/min, and ranges of 0 to 250, 0 to 1000, 0 to 10,000, and 0 to 25,000 counts/min at full scale may be obtained by relocating two jumper wires under the chassis. The input voltage sensitivity of the rate meter is 200 mv. The over-all accuracy of the rate meter, including the effect of long-term drift, is within 5%. The corona-regulated high-voltage supply is nominally 900 v with ± 150 -v adjustment. The maximum load current is 20 μ a.

The rate meter has adjustable high-level and caution alarms and puts out a 1-ma full-scale signal to drive an integrally mounted Rustak recorder. The caution alarm is adjustable over the range of approximately 2 to 59%, and the high-level alarm is adjustable from the caution-alarm set point to full scale. The caution alarm is an electronic circuit which employs a dual triode and plate relay with potentiometer adjustment. The relay is energized below the trip point and is de-energized by current transfer from one triode to the other by a diode that couples the cathode circuits. Hysteresis is approximately 4% of full scale. The high-level trip is accomplished by the high contact on a contact-making meter. The associated high-level relay is de-energized below the set point. When the set point is reached, the meter contacts and relay are locked in; these are released by depressing the reset pushbutton. A low-level pointer on the panel meter has no contacts and is used only as a visible indicator. The pointer should be set at the level corresponding to the caution-alarm set point.

The instrument has an alarm panel with four lights, a bell, and a buzzer. When the caution set point is reached, an amber lamp is lighted and the buzzer is energized. There is no switch to silence the buzzer, and the operator is expected to advance the tape when this point is reached. When the high-level trip point is reached, a red lamp is lighted and the bell rings. The bell can be silenced by a toggle switch, and when this is done, an amber neon indicator is lighted.

When the filter tape breaks, a red neon indicator is energized and the caution circuit is energized through a flasher. The amber neon bulb burns continuously, and the caution light and the buzzer come on intermittently. If a tape breaks and, at the same time, the caution alarm sounds, the tape-break neon light, the caution light, and the buzzer will be on continuously. A test pushbutton permits checking the alarm panel by simultaneously simulating tape break and high-level alarm signals.

The instrument and alarms operate as follows:

1. An accessory meter-relay (Q-2311B-4) chassis, mounted inside the cabinet at the rear and connected to the count rate meter of the constant air monitor, will cause the white light on the central panel to burn brightly and indicate that the instrument is not operating properly whenever the meter pointer drops to zero (indicating no signal from the instrument) or when ac power is lost. After power is restored and a 60-sec delay, this alarm clears itself. During the 60-sec delay, local caution- and high-level alarms do not sound since they are locked out.

The mobile air monitor (Q-1740) is equipped with an accessory chassis containing three relays. The accessory chassis signals the "inoperative" condition at the central panel whenever the mobile air monitor recorder goes to zero or the monitor ac supply has been interrupted. To reduce the danger of false alarms due to warm-up transients, a time delay relay prevents caution- and high-level alarms for 60 sec after the instrument is turned on.

2. At the caution-alarm-level set points on a model Q-2240 or Q-1740 air monitor, an electronic alarm circuit will cause a yellow lamp in the control room to burn brightly and a buzzer will sound. With an ORNL model Q-2240 air monitor, a buzzer will sound at the instrument and an amber lamp will be brightly lit. With an ORNL model Q-1740 air monitor, a bell will ring intermittently at the instrument and an amber light will be brightly lit. Caution level alarms are reset automatically at the instrument when the filter is changed.

3. At the high-alarm level the panel meter relay on the Q-2240 monitor causes the red lamp on the control panel to burn brightly and the buzzer to sound. The bell on the ORNL model Q-2240 monitor will sound and a red lamp on the instrument will light. The bell on the model Q-1740 instrument will change from an intermittent to a steady ringing and a red light will become lit. These alarms are reset when the filter tape is advanced or changed or by pressing the manual reset button on the monitor.

3.2.3 Indicator Module

The indicator module, ORNL model Q-2563-1 (Fig. 4), consists of three independent transistorized channels, each operating an indicator lamp and providing a dc-voltage shift signal for alarm or control purposes and a voltage pulse signal for operating the buzzer module. The three lamps and a pushbutton are on the front panel. Each module is 35.8 mm wide, 120 mm high, and 125.8 mm deep. All connections are made at the rear edge of the plug-in module.

When the instrument connected to an indicator module is operating normally, all lamps on that module are dim (Table 2). When the module receives a signal that

Fig. 4. Indicator Module, ORNL Model Q-2563-1.

the instrument is operating abnormally or that the caution level or the high-level alarm values have been exceeded, the lamps burn at full intensity: white for inoperative instrument, yellow for caution level, and red for high level. A signal is also generated by the module that causes the buzzer to sound. The white lamp indication will remain until the condition causing the alarm is cleared, at which time the lamp will return to the dim condition. The red and amber lights will remain bright until they are manually reset by means of a pushbutton on the indicator module. If the indicator module is reset when the alarm or abnormal condition still exists, the lamps will momentarily become dim when the reset button is depressed, and then will become bright and the buzzer will sound again when the reset button is released.

All ORNL Q-2563 series indicator modules have identical circuits and can be interchanged or replaced without alteration. Some of these units have been modified by omitting parts, and these have suffix numbers other than -1.

3.2.4 Coincidence Module

The coincidence module, ORNL model Q-2563-2 (Fig. 5), consists of one transistorized circuit which accepts a dc-shift signal from as many as six indicator modules. The circuit can be adjusted by internal jumper connections to operate a relay for alarm or control purposes on any combination of one to six input signals. The coincidence module at Building 3025 is arranged to operate the relay when there is a coincidence of any two high-level alarms. The module is 35.8 mm wide, 120 mm high, and 125.8 mm deep. All connections are made on printed strip connections at the rear edge of the plug-in module.

Fig. 5. Coincidence Module, ORNL Model Q-2563-2.

When two or more of the indicator modules receive high-level alarm signals, the coincidence module will actuate the building warning and evacuation equipment and will transmit a signal to the Emergency Control Center, Building 2500.

A red lamp on the coincidence module indicates that an abnormal condition has been detected. When the indicator modules showing an abnormal condition are reset manually, the coincidence module will also be reset.

All coincidence modules are identical and can be interchanged or replaced without alteration, except for an internal jumper connection which determines the number of coincidental input signals required for an output signal.

3.2.5 Buzzer Module

The buzzer module, ORNL model Q-2563-4 (Fig. 6), consists of a transistorized trigger circuit that operates a silicon controlled rectifier to actuate a buzzer when a voltage shift pulse is received from an indicator module. The buzzer module is the same size as all other modules and is interchangeable with other buzzer modules.

The buzzer module gives an audible notice that an indicator module has received any one of three input signals. The buzzer module, which serves all indicator modules, is reset by a pushbutton on its front panel.

After being reset, the buzzer will sound again whenever an input signal is received by one of the indicator modules. For example, a change in radiation from a normal condition to a "caution alarm level" at some location will start the buzzer. After it is reset, a change to "high alarm level" or to "inoperative instrument" will start the buzzer again.

3.2.6 Air Whistle and Beacon Lights

Air Whistle. -- When a coincidence module has been energized by two or more air monitors, an air whistle is actuated by a nitrogen gas bottle to notify the building occupants to leave the building. The air whistle, a "Clarion Whistle" by Westinghouse Air Brake Company, will operate for about 4 min on a 100-psi gas supply from a gas bottle.

The nitrogen is supplied through a control box which contains a pressure regulating valve, pressure switches which monitor bottle and regulated pressures, and a solenoid valve that is opened by an electrical signal from the coincidence module. Two standard high pressure gas bottles filled with oil-pumped nitrogen to a pressure of approximately 1800 psi are connected to a manifold through isolating valves to the control box. Normally the valves are set so that while one bottle is supplying the

Fig. 6. Buzzer Module, ORNL Model Q-2563-4.

system, the second bottle is valved off as a standby supply. The valve arrangement permits replacement of an empty bottle without disturbing the operational status of the whistle.

The whistle operates when a voltage is momentarily applied to the solenoid valve in the control box; the solenoid valve will remain open until it is closed manually by pressing the mushroom head of the valve stem inward.

The normal gas pressures for proper operation of the whistles are not less than 1000 psig tank pressure and 80 to 120 psig line pressure to the solenoid valve. Abnormal pressures are indicated by a red lamp (labeled "horn trouble") on the central control panel board. A dim lamp indicates normal pressures, and a bright lamp indicates abnormal pressures. The gages will indicate whether the tank pressure or the line pressure is abnormal.

Beacon Lights. -- Federal Sign and Signal Corp., model 27S-110-v beacons with magenta colored lens are installed at the corners of the building to warn personnel outside that the building has been evacuated. These beacons are actuated by a signal from a coincidence module, and they are automatically stopped when the coincidence module has returned to a normal condition.

Control Switches. -- A key-operated switch, labeled "normal-disable," on the central control panel board may be used to disconnect the air whistle and beacons during maintenance or abnormal operation periods. Since the Emergency Control Center receives an alarm signal when the switch is moved to the "disable" position, the Control Center should be notified before the switch is set at this position. They may be contacted by telephone by calling extension 3-6646.

A large red pushbutton on the central control panel (Fig. 7), labeled "manual evacuate," actuates the air whistle and beacons and transmits an alarm signal to the Emergency Control Center (if the Center has not already received an alarm), regardless of the position of the "normal-disable" switch. If the manual evacuation pushbutton has been used, it must be reset by pressing the "reset" pushbutton on the module to restore the system to the normal condition.

3.2.7 Power Supplies

The main power for the system is 120 v, 60 cycle, and is supplied from the building emergency power bus to the 24-v dc power supply and the monitoring instruments. The system power supply is rack-mounted on the central alarm panel.

The 24-v dc power supply is a regulated saturating core stabilized voltage unit. Green "power on" lamps on the control chassis and on the power supply panel will be brightly lighted to indicate that the power supplies are operating.

Fig. 7. Manual-Evacuate Module, ORNL Model Q-2563-16.

3.3 Drawings

3.3.1 Instrument Department Drawings

The Facility Contamination Alarm System in Building 3025 is described in the following ORNL Instrumentation and Controls Division drawings:

1. Q-2373-1 through -6	Instrumentation location and wiring diagrams.
2. Q-2563-1 through -4 and -16	Plug-In modules.
3. Q-2240-1 through -23	Constant air monitor.
4. Q-2311B-4	Constant air monitor instrument trouble box.
5. Q-1740A-1 through -20	Mobile air monitor.
6. Q-2312-7 and -8	Mobile air monitor instrument failure box.

3.3.2 Prepared by the General Engineering and Construction Division

1. E-20350-ED-001	Radiation warning and communications, Bldg. 3025 electrical plan and details.

4. CHECKOUT AND OPERATING PROCEDURES

Although the central alarm panel board serves as an aid in operating the facilities in the building, its primary purpose is to provide automatic contamination alarms required by radiation safety and control regulations. An "inoperative instrument" alarm and two levels of radiation alarms from each of the fixed-installation monitoring instruments in the facility are indicated on the central alarm panel. High-level alarm signals from these instruments actuate the evacuation alarm when the alarm limit is reached on two or more air monitors.

To utilize the indications efficiently, the instruments should be reset, the alarm signals should be cleared, and burned out lamps, horn pressure alarms, and other abnormalities should be corrected promptly. An alarm signal can be cleared by performing the following steps:

1. Press the reset button on the buzzer module. This permits the audible alarm to be sounded again if another alarm is actuated before the first alarm can be cleared.
2. Check conditions at the instrument and reset the instrument if required (air-monitor filter change or air monitor high-level alarm). The air-monitor "caution" and "instrument inoperative" alarms are self-resetting when the radiation level or trouble causing the alarm is removed.
3. Reset the module on the central alarm panel by pressing the button at the bottom of the module.

Whenever the local evacuation alarm is sounded in the facility, an alarm signal is indicated and sounded in the Emergency Control Center, Building 2500.

A procedure for checking the instruments and their indicators for proper operation and a sheet for recording the test results are given on the following pages.

FACILITY RADIATION AND CONTAMINATION ALARM SYSTEM CHECK SHEET

MONTHLY ☐
 QUARTERLY ☐
 ANNUAL ☐

BLDG: 3025
 CHECKED BY: _____
 DATE: _____

CONTAMINATION		INOP.	RADIATION				REMARKS
MONITOR	LOCATION	AC OFF	METER	CAUTION	HIGH	EVAC.	
β - γ CONTAMINATION							
CAM 1	2nd Floor North						
CAM 2	2nd Floor South						
CAM 3	Mezzanine						
Coincidence modules checked using station _____ with all other modules.							

* Manual evacuation checked ☐

* Building containment checked ☐

BEACON*	LOCATION	ON	ROTATING	HORN	LOCATION	ALARM LIGHTS		CYL. PRESS. (PSIG)	
						LOW CYL.	HIGH CYL.	LOW HORN*	HIGH HORN*
1	Bldg. Corner SW			1	2nd Floor South				
2	Bldg. Corner NW								
3	Bldg. Corner NE								
4	Bldg. Corner SE								

ALARMS AT BLDG. 2500—KEY SWITCH DISABLED: Contamination _____ Buzzer _____.

* Quarterly and annual checks only.

FACILITY CONTAMINATION ALARM SYSTEM CHECK-OUT PROCEDURE

Date _____

Building 3025

Test	Purpose and Procedure	Correct Operation
1. Preliminary	Prepare to test system.	
a. Disable evacuation portion of system	<ol style="list-style-type: none"> 1. Contact Emergency Control Center (phone 3-6646) and notify dispatcher of coming alarm. 2. Obtain clearance from building supervisor and have test announced on public address system. 3. Turn key switch to "Disable" and close valves on N₂ tanks for whistle. 	Disconnects evacuation whistle and beacon lights. Gives evacuation alarm signal at Emergency Control Center.
b. Check panel lamps	Examine all panel lamps.	All lamps are dim.
2. Facility Beta-Gamma Contamination System	Test all monitors individually (see checkout sheets for locations).	
a. "Inoperative" alarm	<ol style="list-style-type: none"> 1. Unplug instrument. 2. Plug in instrument. 	<p>Buzzer sounds and white lamp glows brightly. Buzzer can be reset, but lamp cannot be reset.</p> <p>After 1-min delay, white lamp will reset.</p>
b. "Caution" alarm	<ol style="list-style-type: none"> 1. Increase gamma count rate with source to caution-alarm level. 2. Remove source until the count rate is below caution level. 	<p>Buzzer sounds and yellow lamp glows brightly. Buzzer can be reset, but lamp cannot be reset.</p> <p>Yellow lamp can be reset.</p>
c. "High-Level" alarm	<ol style="list-style-type: none"> 1. Increase count rate with source to high-alarm level. 2. Remove source; reset instrument. 	<p>Buzzer sounds and yellow and red lamps glow brightly. Buzzer can be reset, but neither lamp can be reset.</p> <p>Yellow and red lamps can be reset.</p>
d. Return system to normal	Turn key switch to "Normal"	Permits beacon lights and Emergency Control Center indicator to operate on alarm condition. Emergency Control Center alarm will reset.
3. Evacuation System	Check all features of evacuation system for correct operation.	A coincidence of two high-level alarms from Facility Contamination System should operate the evacuation horn, magenta lights outside building should flash, and Building 2500 should receive correct alarm light. Key-switch lock-out of horn and lights, and gas tank pressure switch should also be tested.
a. Check for control output from coincidence alarm	<ol style="list-style-type: none"> 1. Turn key switch to "Disable" after contacting Emergency Control Center. 2. Check evacuation module for contamination alarm system. <ol style="list-style-type: none"> a. Increase radiation at one air monitor to high-alarm level. b. Increase radiation at second air monitor in same system to high-alarm level. c. Remove radiation sources. d. Different pairs of instruments should be used each time this test is made. 	<p>Check Emergency Control Center. A contamination alarm should be noted there.</p> <p>A coincidence of two high-level alarms from Facility Contamination System should operate the "Evacuation" module. Red lamp on the Evacuation module should be bright.</p> <p>Red and yellow lamps on this module become bright and buzzer sounds. Reset buzzer.</p> <p>Red and yellow lamps become bright on second module and buzzer sounds. Red lamp in evacuation module becomes bright. Reset buzzer.</p> <p>Alarm lamps and buzzer may be reset. Evacuation alarm should reset automatically when either alarm is cleared.</p>
b. Check evacuation alarm equipment	<ol style="list-style-type: none"> 1. Close valve on all horn N₂ supply tanks (if not previously done in Part I). 2. Plug in horn trouble test box at horn control box. 3. Move key switch from "Disable" to "Normal." 	Alarm light at Emergency Control Center clears.

FACILITY CONTAMINATION ALARM SYSTEM CHECK-OUT PROCEDURE (Continued)

Test	Purpose and Procedure	Correct Operation
	4. Set two coincident "High-Level" alarms on the Facility Contamination System.	Buzzer, channel alarms, and coincidence alarm noted on central panel. Horns sound a short blast, alarm should indicate at Emergency Control Center, and flashing lights outside building should start. Horn trouble light at central panel becomes bright. Low-line pressure and low-tank pressure lights show on test box.
	5. Reduce radiation levels to normal and reset alarm modules.	All modules clear, Emergency Control Center alarm clears, and flashing beacons stop.
	6. Reset horn solenoid valves manually; open tank valves until low-pressure alarms on test box clear.	Gas cylinder pressure gauges should show at least 1000 psi on tank side of regulator and between 80 and 100 psi on horn side. Neither high-pressure nor low-pressure alarms show on test box. Horn trouble light becomes dim. All alarms in all locations should be clear.
	7. Test high-pressure alarm by raising pressure regulator setting in horn box to more than 110 psi.	Horn trouble light should be on. High-pressure alarm is indicated by test box.
	8. Close valves on tanks and push manual evacuation button.	Same as step 4, except no buzzer, no channel alarms, and a contamination (amber) light appears on the central panel at the Emergency Control Center.
	9. Reset manual evacuation button and repeat step 6.	End of test.
c. Conclude test	Return all controls and instruments to normal condition.	<p><u>Check List</u></p> <ol style="list-style-type: none"> 1. Key switch is in "normal" position. 2. No alarm light on central panel of Emergency Control Center. 3. One gas tank at horn should have valves open, one should have valves closed. Regulators should be adjusted to 100 psi. Minimum pressure of 1000 psi on both tanks. 4. Notify Emergency Control Center and building personnel of end of test period.

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