PORTAL MONITOR

MODEL PM-702B

OPERATING AND SERVICE MANUAL

TSA Systems, Ltd.

Nuclear Radiation Measurement Solutions

Doc. #5015 Rev. A
June, 2006

STANDARD WARRANTY FOR TSA SYSTEMS INSTRUMENTS

TSA Systems, Ltd., warrants this instrument to be free from defects in workmanship and materials for a period of twelve months from the date of shipment, provided that the equipment has been used in a proper manner and not subjected to abuse. At TSA's option, repairs or replacements will be made on in-warranty instruments without charge at the TSA factory. Warranty of sub-systems made by other manufacturers will be extended to TSA customers only to the extent of the manufacturer's liability to TSA. TSA reserves the right to modify the design of its product without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond the company's control, TSA does not assume any risks or liabilities associated with methods of installation or with installation results.

Every effort is made to keep the manuals up to date and accurate. However, because TSA Systems is constantly improving and upgrading the product line, TSA can make no guarantee as to the content of current manuals. No obligations are assumed for notice of change or future manufacture of these instruments.

Manufactured by

TSA Systems, Ltd.
14000 Mead Street
Longmont, Colorado USA 80504-9698
Phone: +1.970.535.9949
FAX: +1.970.535.3285

TABLE OF CONTENTS

CONFIGURATION TRACKING SHEET

TSA MODEL NUMBER:_______________ SERIAL NUMBER:_________________

SOFTWARE VERSION:_______________ DATE RECEIVED:_________________

OPTIONS AND ACCESSORIES:____

SYSTEM MODIFICATIONS

MODIFICATION: ____
____

INSTALLED BY:__________________________________ DATE: _________________

MODIFICATION: ____
____

INSTALLED BY:__________________________________ DATE: _________________

MODIFICATION: ____
____

INSTALLED BY:__________________________________ DATE: _________________

MODIFICATION: ____
____

INSTALLED BY:__________________________________ DATE: _________________

MODIFICATION: ____
____

INSTALLED BY:__________________________________ DATE: _________________

1.0INTRODUCTION

1.1. SCOPE AND PURPOSE OF MANUAL

This manual is designed to enable operating and service personnel to properly operate and care for the PM-702B. Since applications are necessarily site-specific, operation procedures are given in general terms. Service and repair are covered to the board level. Anything more complex than this requires that the instrument or assembly be returned to TSA.

1.2. GENERAL DESCRIPTION

The Personnel Portal Monitor, Model PM-702B, is a highly reliable system for the detection of radioactive isotopes. The PM-702B is used to monitor personnel. It can be set up quickly with a minimum of training.

When the portal is not occupied, the system will automatically monitor background radiation and periodically update a visual display on the controller. When a person enters the portal, the system begins fast count monitoring and will alarm if the count exceeds a predetermined alarm level. The system will also alarm if the background radiation level exceeds or falls below preset limits.

The system consists of two vertical pillars and an overhead cross-piece, which serves as an interconnect. The pillars are made of PVC cell core pipe to provide adequate strength and light weight. The system electronics are mounted on one of the vertical pillars, this pillar is considered to be the "master pillar" The pillar spacing is fixed at 32" to provide adequate clearance for wheelchairs. The PM-702B may be powered by six "D" sized alkaline cells which provide at least 24 hours of continuous operation; or from 100 - 240 Vac, 50 - 60 Hz power using the power supply included with the system.

Each pillar contains a radiation detector assembly and detector module. The system controller and occupancy detector are mounted on one of the vertical pillars.

1.3. SPECIFICATIONS

Detectors:
One 3" x 72" x 3" (7.5 x 180 x 7.5cm) organic plastic scintillator in each pillar, for a total detector volume of 1296in3 (21.2 liters) per system

Sensitivity:
1µCi of 137Cs

Power:
Six "D" size alkaline cells provide >24 hours of continuous operation, or 100 - 240V, 50 - 60Hz power at .7 amps.

Passage Time:
Normally 0.5 seconds on a walk-through basis

Serviceability:
Self-checking routines and easily performed tests simplify board level trouble shooting. The modular design allows quick and easy repair and maintenance.

Weight:
Approximately 200 lb (90kg) total

Dimensions:
Two, 6" diameter x 93" high pillars (15 x 236cm), with a 6" (15cm) diameter crossover which provides 33" (84cm) pillar spacing

2.0INSPECTION AND SET-UP

The following procedures should allow on-site personnel to correctly set up the PM-702B for normal operation. Follow the procedures in the order given. A Checklist is included at the end of Section 3. It is recommended that a copy of this be filled out after initial installation and whenever the PM-702B is put into service after prolonged storage.

2.1. INSPECTION

Immediately inspect the instrument for mechanical damage, scratches, dents or other defects. It should be examined for evidence of concealed as well as external damage.

2.1.1. DAMAGE CLAIMS

If the instrument is damaged in transit or fails to meet specifications upon receipt, notify the carrier and TSA Systems immediately. Shipping cartons, packing materials, waybills and other such documentation should be preserved for the carrier's inspection. TSA will assist in providing replacement or repair of the instrument if necessary.

2.1.2. STORAGE

If the instrument is to be stored for any length of time, disconnect power to the instrument and remove the batteries. Care should always be taken to avoid subjecting the instrument to severe mechanical or environmental shock. The instrument should be stored in a dry, temperature controlled location.

2.1.3. SHIPPING

Before returning the instrument for any reason, notify TSA Systems of the difficulty encountered, giving the model and serial numbers of the equipment. TSA will furnish specific shipping instructions.

2.2. SITE SELECTION AND PREPARATION

Select a smooth, level site with enough space to accommodate the system and provide access for the personnel to be scanned.

2.3. ASSEMBLING THE SYSTEM TO SCAN PEDESTRIANS

1. There will be two vertical pillars, a cross piece, and a foot plate.

2. Feed the two shorter RJ-45 cables through the crossover tube and out the small hole below the elbow.

3. Verify that the power switch is in the "Off" position. If the system is to be operated on batteries, install a fresh set of "D" cells at this time. Otherwise, make sure an ac power source is available.

4. Attach the vertical pillars to the foot plate. Orient the pillars so that the serial number labels are facing each other.

5. Connect the RJ-45 connectors to the mating connectors on the vertical pillars. The small hole below the elbow of the crosspiece should face the pillar with the controller.

6. Align the vertical pillars with the cross piece and slide the cross piece down onto the vertical pillars until it is firmly seated.

7. Connect the two RJ-45 cables to the connectors marked 1 and 2 on the controller.

8. If ac power is to be used, connect the power supply output to the corresponding connector on the TPM Controller, and plug the power supply into an ac outlet.

9. The system may be powered up, checked out, and programmed.

10. Attach the IR to the controller backplate using the supplied wing-nuts. The IR may be positioned to face straight across or 45 degrees down. This adjustment may be necessary to avoid triggering on people or vehicles outside the detection portal. Even with the IR pointing 45 degrees down it may not detect a very short person or an animal such as a dog. If this situation is encountered then the system controller may be manually put into constant occupancy by pressing the star (*) key on the keypad. To disable constant occupancy and return the unit to normal operation press the pound key (#) on the keypad.

3.0SET-UP AND PROGRAMMING

3.1. START-UP AND SELF TEST

Turn on the power switch located on the side of the PM-702B controller. The unit will reset and clear the system, then perform a Power On Self Test (POST) which takes approximately ten seconds. The tests are displayed on the screen as they are run, if any test fails, the system will be halted. The problem must be corrected before operation can commence.

The alarm will be turned on for about four seconds. If all the tests have been completed successfully the system will go into the BACKGROUND Mode. The initial background acquisition takes twenty seconds.

When the background is complete, system status will be displayed. The status screen consists of four lines:

GAMMA = nnnn (background or COUNT, in CPS)
READY (system status, READY, TAMPER, OCCUPIED)
OCC: (number of occupancies)
mm/dd/yy hh:mm (date and time)

The system is now ready for programming and set-up.

3.2. SET-UP

The PM-702B is fully calibrated at the factory. It is possible that these adjustments may be affected during shipment, so the calibration should be verified using the Field Calibration Procedures in Section 5.1.

The PM-702B controller is a variation of the SC-770, a general purpose controller that is used in several different systems. It has many user programmable parameters that can be used to optimize it for a wide variety of applications. Refer to Section 3.4 for details on programming the controller.

3.3. PASSWORD CONTROL

The zero (0) key on the keypad is used to enter the set-up mode from the operating screen. Before the menus can be accessed, the password must be input, followed by the pound (#) key. If the password in not entered correctly, the system will return to the operating screen.

NOTE: The password is set to "1234" and can not be changed.

3.4. PROGRAMMING THE SYSTEM

CAUTION
Always verify the calibration of the system before attempting to program the system.

All of the system parameters are controlled from the system controller which is mounted on the "#1" pillar. In order to access the PM-702B, the cover must be removed by removing the four screws in the corners of the clear cover.

The PM-702B has a twelve-key keypad on the front panel. Using this keypad, the operator can perform system set-up and diagnostic tests.

After the system has been powered up, and acquired its initial background, the set-up menu can be accessed. The parameters and diagnostic functions are protected by password access.

This section outlines the menus. A detailed description of the functions immediately follows. Pressing the number associated with the desired operation permits the operator to access that function. Pressing the zero key will display the next page of the current menu, where appropriate. Pressing the pound (#) key will return to the main menu from the sub menus, or return to normal operation if it is pressed at the main set-up menu.

When a parameter is with a "NEW =" prompt below it, a new value may be entered from the keypad. Pressing the asterisk (*) key clears the current operator entry, pressing the pound (#) key accepts the current value, or the new value that has been entered by the operator.

The set-up menu presents the operator with a choice of parameters or functions. Pressing the "one" key will present a menu of the available PARAMETERS. Pressing the "two" key will present a menu of the available FUNCTIONS.

3.4.1. PARAMETERS

To access PARAMETERS you will first have to press “0” followed by the password. The next screen gives you two options, 1. GAMMA and 2. COMM SET. Press 1 on the keypad. The next screen that comes up will give you 1. PARAMETERS and 2. FUNCTIONS. Press 1 to give you the following options:

1. HI/LO LEVELS: Background alarm levels
2. OCCUP HOLDIN: Number of 200ms intervals to hold in after occupancy
3. NSIGMA: N*sigma radiation alarm level
4. SET CLOCK: Time and date
5. BKG TIME: Number and position of detectors in the system
6. SHOW VERSION: Displays the firmware version
7. KEYPAD RESET: Changes from auto reset to manual reset
8. ADJ. DISCRIM Discriminator adjustment

3.4.1.1. HI/LO LEVELS: Sets the low and high background alarm levels, in CPS per detector. If the counts fall outside this window, the system will indicate a background fault, and not allow further operation until the problem is corrected. These levels should be set to alarm if the average background deviates too far from normal. These alarms are intended to flag a failure in the detector or electronics. The precise settings will vary with local conditions and requirements, but a good starting point is usually 50% of the average background (per detector) for the low and 150% of the average background (per detector) for the high.

3.4.1.2. OCCUP HOLDIN

Number of 200ms intervals to hold in after the occupancy signal indicates the system is vacant. This prevents the person from attenuating the background. The factory setting is 5 intervals (1,000 milliseconds), but the optimum setting may vary with local conditions.

3.4.1.3. NSIGMA

Sets N*sigma radiation alarm level. Where N is the number entered and sigma = 1 background in CPS. This formula determines the number of counts, above background, that will trigger a radiation alarm.

3.4.1.4. SET CLOCK

Sets the system time and date. The operator will be prompted to enter the hours (in 24-hour format), minutes, month, date, and year (last two digits only) from the keypad. When the pound (#) key is pressed after the last entry, the data are written to the internal clock/calendar.

3.4.1.5. BKG TIME

Sets the background counting time for the system. Press <1> to increment the time by 5 seconds, <7> to decrement the time by 5 seconds. Press <#> to accept the setting. Range is 20 - 120 seconds.
* If you have an area with large background fluctuations, you can increase the BKG Time to help average out those bkg spikes over a longer period of time (say ~1 minute).

3.4.1.6. SHOW VERSION

Displays the software version number, press any key to return to the setup menu.

3.4.1.7. KEYPAD RESET

When enabled, requires any alarm to be silenced by using the keypad.

3.4.1.8. ADJ. DISCRIM

Opens the menu to adjust the LLD and ULD. The discriminators set the energy levels at which the system will be accept counts. If the isotopes are unknown, leaving the discriminators set at the factory defaults of 0.068 and 5.040 volts is normally acceptable. When the system is shipped from the factory, the discriminators are set to accept energy in the approximate range of 22 keV to 1650 keV. The settings are necessarily site specific, and may require adjustment to meet local requirements. The relationship of discriminator voltage to energy level, in keV, is approximately 1 volt of discriminator level equals 330 keV. Using this formula, the factory settings equal:

LLD 0.068 volts = 22.4 keV
ULD 5.040 volts = 1,650 keV

This relationship is an approximation. In practice, the actual values will vary slightly. Always test the system with the isotope(s) of interest to ensure maximum sensitivity. Refer to the formula for signal to background ratio in Appendix A for details on optimizing the discriminator settings for specific isotopes.

NOTE: After changing the discriminator settings, always run a variance test to ensure that system noise is not affecting the count data.

Two methods of adjustment are provided:

1. Direct entry: Press the zero key from the "ADJUST ULD/LLD" menu. The operator will be prompted for a new LLD setting. Press the pound (#) key to accept the current setting. Three digits must be entered to change the value: volts, tenths of a volt and hundredths of a volt; press the pound (#) key to complete the operation.

NOTE: Since the Digital to Analog Converters (DACs) have limited resolution, manual entries will be rounded to nearest value the DACs can output.

2. Manual adjustment: At the "ADJUST ULD/LLD" menu, the discriminators may be adjusted one step at a time while observing the count from both detectors.

The following keys are used:
1 increments the LLD by one step (approximately 0.0098 volts)
7 decrements the LLD by one step
3 increments the ULD by one step (approximately 0.0196 volts)
9 decrements the ULD by one step

When the settings are satisfactory, press the pound (#) key to accept the settings.

Pressing the asterisk (*) key will load the default discriminator settings: LLD = 0.098 and ULD = 5.040.

3.4.2. FUNCTIONS

1. SHOW COUNT: Displays detector counts
2. VARIANCE: Performs variance test on all detectors
3. CLEAR G-CNTS: Clears the counter of recorded gamma alarms
4. F-ALARM TEST: Displays the number of alarm comparisons vs the number of alarms
5. SYSTEM ID: Assigns an identification number to the system
6. PROFILING: Turn ON or OFF an ASCII data string to the Ethernet and RS-232 outputs
7. CALIBRATION: Automatically adjusts each detector to achieve the proper CPS.
8. RESTORE CAL: Restores the factory calibration high voltage values.

3.4.2.1. SHOW COUNT

Displays detector counts, in CPS, updated once per second. All alarms are disabled in the show count mode. Press the pound (#) key to exit the show count mode.

3.4.2.2. VARIANCE

Performs a variance test on all detectors. The system runs 15-second variance passes. In the PM-702B system, TSA recommends running five 15-second passes. After five passes all variance readings should be less than 0.10. Refer to Appendix A for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test. Perform a variance test and a walk-through test with a source (see Section 4) before the unit is put into operation. For more information and recommended settings for different SNM types call TSA's engineering staff.

3.4.2.3. CLEAR G CNTS:

The SC-770 counts the number of occupancies and alarms since it was turned on. These numbers are displayed here. The counter may be cleared by pressing <1>, any other key exits this mode without clearing the counters.

3.4.2.4. F-ALARM TEST:
Displays the number of alarm comparisons that have been made and the number of alarms that were detected. These values are cleared when the system is turned off. The primary use for this feature is to test the number of nuisance alarms in a controlled environment.

3.4.2.5 SYSTEM ID:
Assigns an identification number to the system. This number is used to uniquely identify the system to a PC. This number must be used by the PC to establish a communications link. This range of this number is 1 - 32,767. This number is set to 1 when the system is shipped.

3.4.2.6 PROFILING:
The controller can be set to continuously output an ASCII data string to the Ethernet and RS-232 outputs. The display will show "ON" or "OFF". Pressing any key other than the <#> key toggles the setting. The <#> key accepts the current setting.

The strings look like this:

GB,XXXXXX,XXXXXX,XXXXXX,XXXXXX CRLF
Gamma background sent every 5 seconds. Counts are a 20 second rolling average normalized to a one second count.

GH,XXXXXX,XXXXXX,XXXXXX,XXXXXX CRLF
Gamma high background fault sent every 5 seconds for the duration of the fault condition.

GL,XXXXXX,XXXXXX,XXXXXX,XXXXXX CRLF
Gamma low background fault sent every 5 seconds for the duration of the fault condition.

GS,XXXXXX,XXXXXX,XXXXXX,XXXXXX CRLF
<u>TCP Ethernet output:</u> Raw gamma count information sent every 200msec while the system is occupied and not in an alarm condition.
<u>RS-232 Output</u>: Sent every second while the system is occupied and not in an alarm condition. The counts are a one second count averaged from the 200msec rolling count buffer.

GA,XXXXXX,XXXXXX,XXXXXX,XXXXXX CRLF
<u>TCP Ethernet output:</u> Raw gamma count information sent every 200msec while the system is occupied and in an alarm condition.
<u>RS-232 Output</u>: Sent every second while the system is occupied and in an alarm condition. The counts are a one second count averaged from the 200msec rolling count buffer.

TT,000000, 000000, 000000, 000000 CRLF
Tamper or power fail condition detected. This is sent once when the following conditions occur; ac power loss, charger output failure, or when the pillar doors are open. Fields are padded to 32 bytes.

TC, 111111,111111,111111,111111 CRLF
Tamper or power fail condition cleared. This is sent once when the following conditions occur; ac power returned, or when the pillar doors are closed. Fields are padded to 32 bytes.

GX,XXXXXX,000000,000000,000000 CRLF
System occupancy count since midnight each day. xxxxxx = 1 – 99,9999 occupancies. This message is sent with an incremented count every time the pillar clears the occupancy. This variable is automatically cleared on a power cycle and at midnight each day. Fields are padded for 32 bytes.

NOTE: PC Communications will not work (connect) when profiling is turned on.

3.4.2.7 CALIBRATION:

Required items: A Cs^{137} source with a depreciated value of 9uCi ± 1uCi

The first thing the TPM controller does is take "roll call" to identify/verify the addresses of the DM-757's. If the addresses haven't changed since the last time the unit was calibrated, it will continue with the calibration. If it senses a conflict, the TPM controller will instruct the pillars (DM-757's) to pick random addresses and will attempt to resolve the pillars. If communications fail after 3 attempts, the controller will tell the user which pillar failed and halt operation. If pillars are resolved successfully, calibration will continue.

After testing/resolving the pillars, the unit will flash both LED's and emit a short <beep>, then the user will be prompted:

PLACE SOURCE
ON PILLAR 1
PRESS ANY KEY

After user presses a key

CALIBRATING
PILLAR 1
COUNTS: X
HVDAC: X

COUNTS are one second count data from the pillar.

HVDAC is the DAC value being sent to the pillar to adjust the high voltage.

If the HVDAC value reaches 1000 and target counts haven't been achieved, the calibration will fail because the HV is getting dangerously high (for the PMT). The unit will flash both LED's, emit a short <beep> and the user will be presented with a message:

PILLAR 1
FAILED CALIBRATION
PRESS ANY KEY

After pressing any key, the user will be retuned to the menu. (No sense in continuing with the calibration at this point).

If the calibration completes successfully, the user will be prompted to place the source on pillar 2 and repeat the process for that pillar.

At the end of a successful calibration, the unit will flash both LED's, emit a short <beep> and the user will be presented with a message:

CALIBRATION
COMPLETED
PRESS ANY KEY

After user presses key:

PILLAR 1
HVDAC: X
PRESS ANY KEY

After user presses key the same info will be presented for pillar 2

Pressing any key at this point returns to menu.

3.4.2.8 RESET CAL:

This routine restores the factory calibration HVDAC value. When pillar is calibrated at TSA, the HVDAC value is stored in the DM-757 in the pillar. If a calibration fails, the user may attempt to recover by using the Reset Cal routine.

User is presented with:

RESET FACTORY
CALIBRATION
ON BOTH PILLARS
RESET: 1 ABORT: 3

If user presses 1:

The TPM controller sends a command to both pillars instructing the DM-757's to use the factory calibration HVDAC value and presents the user with:

FACTORY
CALIBRATION
RESTORED
PRESS ANY KEY

Pressing key returns to the menu

If the user chose to abort by pressing 2, he/she is presented with:

RESET ABORTED
PRESS ANY KEY

Pressing key at this point returns to menu

3.5. PC COMMUNICATION

A communications package is shipped with each system. The package requires an IBM/PC compatible computer running Microsoft Windows 98/ME or NT 4. The package allows the operator to examine the system parameters and download data from the nonvolatile RAM.

The system will continue to operate normally during PC communications; however communication will be suspended whenever the system is occupied.

WARNING
To ensure proper system operation, always close the communications program before disconnecting the RJ-45 cable.

3.6. INSTALLING THE SOFTWARE

The program files can be found on the CD ROM stored on the last page of this manual. To install the program, run "SETUP.EXE" on this disk. This will install the program on the host computer. The default directory is "\Program Files\Bicron\TPMCOM\, press the "Browse" button to install to a different directory.

3.7. TAB

After the installation is complete, the operator is given the option to run the program. Click on the "Tab" button to select the communications port to be used. Each time the program is run, the id number of the target system must be entered, then selected by clicking on the "Apply" button. **NOTE**: The id number entered into the PC, and the id number stored in the system must be identical. If they are not, communications can not be established.

3.8. PARAMETERS

The program will automatically read the parameters from the system and display them on the screen. The parameters can not be changed from the PC.

3.9. SHOW COUNT

Displays detector counts, in CPS, updated and averaged over the most recent 5 second data.

3.10. HISTORY

When the system is operating, certain data are written to its internal, non-volatile RAM. These data include:

Date and time stamp each time the system is powered up

The background is written each hour of operation, including date and time

Date and time stamp of each radiation alarm, including the detector counts and the background used in the radiation alarm calculations

These data can be downloaded to a disk file in a PC by clicking on the "History" tab. The operator will be given the option of downloading all records, or input the number desired. The system can store up to 3,017 records.

The operator must provide a file name, and optionally, an extension. If no extension is given, the program will use .LOG.

The data file is in ASCII text format, and will look something like this:

06/09/05 17:20:51 Power-up 0 0 0 0 0

06/09/05 17:21:51 Avg. Bkg. 1710 861 849 0 0

06/09/05 17:22:51 Avg. Bkg. 1989 998 991 0 0

06/09/05 17:24:52 Background 1997 1001 996 0 0

06/09/05 17:24:52 Rad Alarm 1951 981 970 0 0

15/09/05 19:37:59 Low Alarm 0 1257 8 0 0

After the download is complete, the operator will be prompted for a file name, and given the option to view a file at this time.

3.11. INITIAL INSTALLATION CHECKLIST

___ Incoming inspection performed by: ____

___ 90 - 250 Vac 47 - 63 Hz power supply available.
___ Pillars vertical and square to each other.
___ Pillars stabilized.
___ Cabling correctly installed.

___ System calibration: ___ unchanged ___ new values:
Pillar #1: LLD set to: _______________ ULD set to: _______________
Pillar #2: LLD set to: _______________ ULD set to: _______________
Parameter settings:
Number of Detectors set to: _______________
Low Alarm level set to: _______________
High Alarm level set to: _______________
Occupancy hold-in set to: _______________
Alarm Comparison Intervals set to: _______________
Alarm level (N*Sigma) set to: _______________
Algorithm: Sum____ Horizontal____ Vertical____ Single____

Background level (N*Sigma) set to: _______________
Background Time: _______________

___ Electronic calibration required - ___ SC-771 ___ GHA-472
___ System starts up and runs initial self-test without errors.
___ All modes operational.
___ Background mode in operation area; count = ______________

___ Variance test; variance detector 1: _______ 2: _______

___Test; list sources and sizes used: ____
____

Performed by:______________________________ Date: __________________

COMMENTS:____
____
____
____

4.0THEORY OF OPERATION

4.1. OVERVIEW

The portal monitor makes its decisions for radiation alarms in the following manner. A level for N*sigma is selected using the keypad. Whenever the occupancy detector senses that the monitor is occupied, the monitor starts making alarm comparisons based on the parameters that have been stored in the controller’s NVRAM (FAST COUNT mode).

When unoccupied, the portal monitor constantly updates the background count to reflect changes in the environment. The background is accumulated in 5-second increments, with the current background reading equal to the one-second average of the last four 5 second intervals. This updates the background completely every 20 seconds. When the unit is occupied, it ignores the current 5-second background interval, and goes into FAST COUNT mode.

The monitor collects its counts in 200 millisecond (0.2 sec.) intervals. For example, if the number of intervals is set to 5, the alarm comparison will be based on 1.0 second counts. This sum of counts is then compared to an alarm level which is normalized to that number of intervals.

The number of intervals should be selected based on an average walk speed of 1.5 meters/second while passing through the monitor. The summed count of the chosen number of intervals should reflect total occupancy time, and thus offer the maximum probability of detecting an alarm condition.

While the monitor is occupied, it makes an alarm comparison every 200 milliseconds, based on adding together the most recent n 200 millisecond intervals. The intervals are stored continuously, so that as soon as the monitor is occupied, it waits for the current interval to end, then adds up the selected number of intervals and makes an alarm comparison. This means that if the monitor is set to five intervals, it is effectively starting to monitor the passage 1 second before the monitor has been occupied. This is called "look back." The monitor will continue to make comparisons until the "occupancy hold-in" time has expired after the end of the occupancy. This is called "look after."

The "occupancy hold-in" forces the unit to continue to make alarm comparisons after the occupancy detector has cleared (look after). The amount of time selected for this parameter is based on the estimated speed of passage and pillar spacing.

4.2. MODES

4.2.1. SELF-TEST MODE

When the instrument is turned on, it performs a Power-On Self Test (POST). The POST performs the following tests:

RAM: Tests conventional memory, primarily the area used for the processor's stack
NVRAM: Tests the battery-backed, non-volatile memory used to store parameters
LAMPS: The audio annunciator and both LEDs are turned on for approximately 4 seconds.

If any of these tests fails, the controller will display a "FAIL" message. The system cannot be put into service until the problem is corrected.

After completing the POST, the system will enter the BACKGROUND mode and be ready to operate after the initial 20-second background is obtained.

4.2.2. BACKGROUND MODE

BACKGROUND mode is the default mode for routine operation. The system will automatically go to this mode after the initial self-test series. The display counts down from 19 to 0 during the first background collection period. During this initial countdown, no other functions are available, and occupancies are ignored. The unit then continuously takes 5-second background counts and adds the most recent 4 together to display the most recent 20-second average (20-second sliding background).

After the initial countdown, system status is displayed, and the system starts monitoring for occupancy. The background display will update every five seconds to show the current background being used for alarm calculations. While collecting background counts, the controller compares the latest count with the high and low background alarm levels once a second. If the background count is outside these limits, the unit will display DET X:LO/HI NNNN, where X is the detector number, and NNNN is the current background for that detector.

4.2.3. FAST COUNT MODE

Upon occupancy, the system automatically goes into fast count mode. While this mode does not take counts any faster, it does update the display more often - every second instead of every five seconds - and begins testing for alarm conditions every 0.2 seconds. The controller also stores a number of 0.2 second count intervals in RAM, so that it can "anticipate" occupancy and start alarm comparisons before the subject actually enters the pillar.

The system may be forced into the fast count mode by pressing the asterisk(*) key on the keypad. Pressing the pound (#) key returns the system to background mode.

Upon entering the fast count mode, the unit waits for the current interval to go to completion (0.2 seconds maximum), discards the oldest interval, adds the latest one, tests for alarm conditions, and begins another 0.2 second collection interval. This cycle continues during manual FAST COUNT, or during occupation and the "occupancy hold-in" period, which starts when the unit goes out of occupancy. If an alarm condition occurs, the PM-702B will hold the alarm on until 5 seconds after the alarm condition is cleared.

The radiation alarm level is calculated on the basis of variation from the background. The formula for N*Sigma may be found in the Appendix .

CAUTION
Do not leave unit in this forced state for normal operation.

4.2.4. VARIANCE ANALYZER MODE

In this mode, the unit takes 75 0.2 second background counts and performs a variance calculation on the data. A more detailed description of the variance test may be found in the Appendix.

4.3. COMPONENTS

1. The TPM Controller is installed on Pillar 1 of the two vertical pillars. It is made up of the following components:

1.1. The SC-771 board is the computer board for the system, and uses program software to run the unit and perform all functions. The SC-771 receives 12VDC from a dc to dc converter and uses another dc-dc converter to supply the ±5 Vdc required by its on-board circuitry.

The SC-771 board uses highly integrated components. If a failure occurs in the digital portion of the board, it must be replaced.

1.2. The GHA-472 board provides regulated dc high voltage to the voltage divider networks which are attached to the photo-multiplier tube on the detectors.

2. The DA372 Detector Assembly consists of a plastic scintillation detector coupled to a photo-multiplier tube through a plastic light pipe, plug-on base with voltage divider network and mounting hardware. The gamma ray is converted to photons (scintillation), which are then converted into a voltage pulse on the GHA-472 board.

3. The battery module consists of three battery holders which hold a total of six "D" size alkaline cells. The system can also be operated from a 100 - 240 volt, 50 - 60Hz ac outlet.

4. The Infrared detector is a passive type occupancy detector.

5. Alarm LED and buzzer - A red LED and piezo-electric buzzer are used to indicate a Radiation Alarm.

6. Ready LED - A green ready LED indicates the monitor is on and ready to scan.

5.0MAINTENANCE

Once initial installation has been completed, little maintenance is required. Periodic inspection is recommended to insure proper functioning. This should include (but is not limited to):

-visual inspection for loose wires, etc
-field calibration
-checking the settings of the control module
-running a variance test
-performing a walk-through test

A Performance Verification Checklist is included at the end of this section. It is recommended that a copy of this be filled out whenever the PM-702B is put into service after tuning and recalibration.

5.1. TPM Controller

The display contrast may change slightly with outside temperature variations. If the display is difficult to read, adjust the "R1" potentiometer on the SC-771 board. Refer to Drawings 6 and 10 for component locations.

5.2. VARIANCE ANALYZER MODE

After calibration is complete, a variance test should be performed. The variance analyzer will identify many problems such as noise or light leaks with both the detectors and associated electronics. Be sure to restrict all movement in the area while performing a variance test.

In the PM-702B system after five updates all variance readings should be less than 0.10. Refer to the Appendix for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test.

5.3. WALK THROUGH TEST

Due to the many different environments and materials being monitored, the walk through test will vary from site to site, although several general principles apply in all cases. Select an appropriate source, and instruct the test subject to walk at the normal speed for testing personnel, carrying the source alternately at belt level, at head level (under a hat), and at shoe or ankle level. Repeat the test several times and record the sources and sizes used.

5.4. PERFORMANCE VERIFICATION CHECKLIST

___ Repairs made (if any): list component and type of repair:

___ System calibration: _____ unchanged ______ new values:

LLD set to: _______________ ULD set to: _______________

Parameter settings:
Low Alarm set to: ______________

High Alarm set to: ______________

Occupancy hold-in set to: ______________

Alarm Comparison Interval set to: ______________

Sigma set to: ______________

___ Electronic calibration:

SC-771: ______ GHA-472: ______
___ System starts up and runs initial self-test without errors.
___ All modes operational
___ Background mode in operation area: count = _______________
___ Variance test; variance = 1: _______ 2: _______
___ Walk-through test; list test source serial number and activity:

Performed by: _____________________________ Date: ______________

COMMENTS:____
____
____
____
____
____
____
____
____

6.0TROUBLESHOOTING

This guide is designed so that on-site personnel can service the PM-702B and effect necessary minor repairs. It covers procedures and parts down to the board level. Any other problems should be referred to TSA's technical staff.

When a problem occurs, it is important to isolate the cause as much as possible. This is accomplished by a step by step procedure which checks each of the assemblies for proper function and works upwards through the system.

Begin with a physical inspection of the unit, then check the power supply and cabling. Examine the exterior of the enclosure for physical damage, faulty wiring, loose connections, etc. Open the enclosure and do the same inside, checking all wiring. If the physical inspection shows no obvious cause for the problem, proceed by checking the detectors, controllers, and other individual assemblies, as outlined in the following steps.

After repairs have been made, a field calibration must be performed. (See Section 3.4.2.7. Calibration.)

6.1. COMPONENT ACCESS

The TPM Controller is mounted on the "#1" vertical pillar (Drawing 1).

The IR occupancy detector is mounted on the controller on the "#1" pillar. To remove the occupancy detector, remove the two wing-nuts holding the mounting bracket to the controller back plate. Disconnect the connector, and the electronic assembly will be freed. Replace the electronic assembly and reverse the process to reassemble the detector.

The LEDs are installed on the mounting plate for the controller circuit board. Desolder the wires and remove the LED.

Install the replacement LED, and resolder the wires.

The pillars contain the detector assemblies, the detector module, and the high voltage module. Verify problems by substituting the detectors. Return the defective pillar to TSA for repair.

6.2. COMPONENT TROUBLESHOOTING

6.2.1. TPM CONTROLLER

The controller's function is to receive the detectors digital pulses for counting and processing. which are amplified and discriminated by the detector module.

Physically inspect the unit for harness wiring or connector problems. This procedure does not cover the replacement of wires or connectors. Such replacement should only be done by qualified service personnel. Questions concerning parts or wire type and availability may be addressed to TSA's technical staff.

If a problem is suspected in the controller, replace it with a known good assembly, either from spare parts or from another unit.

6.2.2. DETECTOR ASSEMBLIES

The detector assemblies have a detector module, high voltage module, and plastic scintillator detector mounted inside. This assembly is difficult to remove and then get reinserted into the PVC tube without damaging any of the parts. It is recommended that if a detector assembly is defective that it be returned to TSA for repair.

6.2.3. INFRARED DETECTOR

A green LED located on the top of the IR detector will illuminate on power up.

A yellow LED located on the top and back of the IR detector will illuminate when the detector senses an object.

7.0GLOSSARY

ADC: Analog to Digital Converter is an integrated circuit that converts an analog signal into a binary number than can be used by the microprocessor.

CPS: Counts Per Second

High Background Alarm/Fault: The condition that occurs if the counts exceed the programmed high background level. This condition prevents further operation until the problem is corrected. Normally set in CPS.

LCD: Liquid Crystal Display

LED: Light Emitting Diode

LLD: The Lower Level Discriminator provides an adjustable threshold that determines the lowest signal level that will be accepted as a nuclear pulse by the system's electronics. Some systems have both upper and lower level discriminators that can be used to set a discriminator window. The discriminator window can be used to effectively reduce the background counts, and increase system sensitivity to certain isotopes.

Low Background Alarm or Low Background Fault: The condition that occurs if the counts fall below the programmed low background level. This condition prevents further operation until the problem is corrected. Usually set in CPS.

POST: Power On Self Test

Rolling Background: This is the background accumulation method used in most of TSA's instruments. Background accumulation is done in ten separate buffers, each buffer representing 1/10 of the total background time. As each buffer is filled, the background is updated. This results in a background update at background time/10. Initial background accumulation requires the full background time.

Standard Background: Standard background requires the full background time for the initial background and updates.

ULD: The Upper Level Discriminator provides an adjustable threshold that determines the highest signal level that will be accepted as a nuclear pulse by the system's electronics. Some systems do not have an ULD. Also see LLD.

8.0PARTS LISTS

8.1. RECOMMENDED SPARE PARTS

The list of spare parts given here is based on the following assumptions. **One** - that the maximum downtime allowable is 2 hours. **Two** -that a technical background is not needed to perform the repairs.

Qty.	TSA Stock#	Description	Mfr.	Mfr's Part#
1	8233	Detector Assembly	TSA	8233
1	8753	SC-771 Circuit Board	TSA	8753
1	6668	Infrared Detector	Banner	QS30DQ
1	7491B	Power Supply, 7V	TSA	7491B

8.2 SPARE PARTS ORDERING INFORMATION

To facilitate the processing of spare parts orders the following information is required.

Product Number
Product Serial Number
TSA Stock number
Part description (from parts list)

When ordering programmed proms, the software version is required. This can be found on the prom label.

NOTE: Model number suffixes are generally not included in the text of the manual. However, the suffixes in the parts lists must be included on orders for spare parts.

FOR ASSISTANCE CALL:

TSA Systems, Ltd.
14000 Mead Street
Longmont, Colorado 80504-9698 USA
Phone: +1.970.535.9949
Fax: +1.970.535.3285
info@tsasystems.com

APPENDIX

The following formulas are used in various systems manufactured by TSA Systems, Ltd. They are provided to assist in verifying system operation and to give our customers a better understanding of how the systems operate. This is a general list, but most systems use some of these formulas.

ACTIVITY FROM COUNTS

$$\text{Activity} = \frac{N}{\text{Eff} * 37}$$

Where:
Activity = Activity in nCi
Eff = Decimal efficiency (i.e. 10% = 0.10)
N = Net counts per second (cps - background cps)
37 = bq per nCi

EFFICIENCY

$$E = \frac{N}{37 * \text{activity}}$$

where:
N = cps with source - background cps
activity = test source activity in nCi

N*Sigma Alarm Level

Used to calculate the alarm level on instruments using n*sigma alarm algorithm. Most systems that use n*sigma alarm levels operate in counts/second.

$$\text{Alarm Level} = \left(N * \sqrt{\text{bkg}} \right) + \text{bkg}$$

where:
bkg = Background counts
Sigma = $\sqrt{\text{bkg}}$
N = N*Sigma value

RELIABLE DETECTABLE ACTIVITY (RDA) FORMULA

This formula calculates the minimum activity, in disintegrations per minute that can be reliably detected under a given set of operational conditions.

$$F = \left[\frac{CON + \sqrt{CON^2 + 4\left(FA\sqrt{BKG} + BKG\right)}}{2} \right]^2$$

$$G = \frac{F - BKG}{CT}$$

$$RDA = \frac{2200 * G}{37 * E}$$

BKG = total background counts per count time
CON = confidence sigma
CT = count time in seconds
E = Decimal efficiency (i.e. 10% = 0.10)
F = false alarm level in cps
FA = false alarm sigma
G = intermediate variance
RDA = reliable detectable activity in DPM

SIGNAL TO BACKGROUND RATIO

The following formula is helpful in determining the optimum discriminator settings. Always perform a variance test at the final setting of the lower-level discriminator to ensure that system noise is not being introduced into the amplifier stage.

$$Q = \frac{S^2}{B}$$

where:
Q = Quality factor
S = Net signal (count with source - background)
B = Background count
Higher values of Q result in better sensitivity.

VARIANCE

The variance analyzer mode is used to check whether the counts seen by the controller are actually from the proper distribution. If the distribution approaches normal, the resulting number will approach 0. Any significant deviation from the normal distribution will result in a larger number. The two most common problems resulting in variance failure are light leaks in the detectors, and periodic noise in the electronics. Periodic noise will result in a number of about 1, a light leak will usually result in a number larger than 2. The number displayed during a variance test is the absolute value of the average of a number of these tests, with one test being performed every nn seconds. The data is valid after three iterations of nn seconds. The pass/fail criteria vary from unit to unit and are included in the variance section of the manual on most units.

$$\overline{C} = \frac{\sum C}{N}$$

$$S^2 = \frac{\sum (C - \overline{C})^2}{N - 1}$$

$$R = \frac{S^2 - \overline{C}}{\overline{C}}$$

where:
C = counts per sample time

$\overline{C}$ = mean counts
I = number of iterations
N = number of samples taken
R = sample variance modified to equal 0, rather than 1, for Gaussian distribution

$\overline{R}$ = mean variance, this term is referred to as variance in TSA's manuals
S2 = sample variance

9.0LIST OF DRAWINGS