VEHICLE PORTAL MONITOR

MODEL VM-250

OPERATING AND SERVICE MANUAL

Version 2.40

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systems ltd.

How to use this manual

Configuration tracking sheet:	Record of system configuration, modifications, upgrades etc.
Standard Warranty	
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Section 6:	Calibration and periodic maintenance instructions.
Section 7:	Troubleshooting guide and diagnostic tools.
Glossary:	Definition of terms
Formulas:	List of mathematical formulas that are used in TSA systems.
Drawings:	Drawings and schematic diagrams for the system.
Parts Lists:	Detailed parts lists by subassembly. Includes the manufacturer's part numbers and instructions for ordering spare parts.

CONFIGURATION TRACKING SHEET

TSA MODEL NUMBER:________________ SERIAL NUMBER:__________________

SOFTWARE VERSION:________________ DATE RECEIVED:__________________

OPTIONS AND ACCESSORIES:____

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SYSTEM MODIFICATIONS

MODIFICATION:____

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INSTALLED BY:_____________________________________ DATE:___________

MODIFICATION:____

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INSTALLED BY:_____________________________________ DATE:___________

MODIFICATION:____

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INSTALLED BY:_____________________________________ DATE:___________

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INSTALLED BY:_____________________________________ DATE:___________

MODIFICATION:____

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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

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VEHICLE PORTAL MONITOR, MODEL VM-250
TABLE OF CONTENTS

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1. INTRODUCTION

1.1. SCOPE AND PURPOSE OF MANUAL

This manual is designed to enable operating and service personnel to properly operate and care for the VM-250. 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 TSA Vehicle Portal Monitor, Model VM-250, is a highly reliable system for the radiometric protection of special nuclear material (SNM). The VM-250 is suitable for indoor or outdoor installation. The VM-250 is offered in two versions, a 96" pillar for cars and light trucks and a 120" pillar for monitoring large trucks.

When the portal is not occupied, the system will automatically monitor background radiation and periodically update a visual display on the controller. When a vehicle 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 VM-250 is equipped with tamper switches and loss of power indicators. These conditions may be monitored with a TSA model AM-255 alarm monitor.

The Portal Monitor system consists of two pillars which contain the subsystem modules. The pillars may be spaced up to 17 feet apart. The VM-250 is powered by a battery on a charger, which will provide at least 12 hours continuous service in case of a power failure. The system may be set up in any location where a 90 - 250 Vac 47 - 63 Hz power source is available. Typical locations might be entrances and exits to access areas, or between different access areas where SNM is not routinely transferred between zones.

Each pillar contains two radiation detector assemblies. The "master" pillar also has a portal monitor controller (SC-755), a battery and charger, load disconnect, infrared occupancy detector, alarm lights and buzzer. The "slave pillar" contains single channel

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analyzer (model SCA-725) and an infrared occupancy detector.

The pillars use lead shadow shielding on the rear and sides of the detectors to reduce the background radiation and increase the ability of the system to detect SNM passing through the portal.

User-supplied conduits must be used to provide power, signal, and optionally alarm outputs to external equipment. AC power to the master pillar, and interface signals between the pillars are required. If the system is equipped with heaters, ac power must also be supplied to the heaters in the slave pillar. The ac power and interface signals may be run in the same conduit, if local code permits it.

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1.3. SPECIFICATIONS

Detectors:	Two 6" x 30" x 1.5" (15 x 79 x 3.8cm) organic plastic scintillators in each pillar
Sensitivity:	Exceeds Los Alamos specification #7229 for SNM. For details refer to Los Alamos Publication number LA-10912-MS, dated March 1987, "An Applications Guide to Vehicle SNM Monitors".
Power:	12 V 12.5 amp hour sealed, rechargeable lead-acid battery charged by 90 - 250 Vac line power
Passage Time:	Normally 3 seconds on a drive through basis
Serviceability:	Portal: Each detector and controller is accessible for testing and maintenance Portal Monitor Controller: Self-checking routines and easily performed tests simplify board level trouble shooting. The modular design allows quick and easy repair and maintenance.
Weight:	(operating weight of complete monitor) approximately 300 lb/pillar
Dimensions: (each pillar)	Eight foot system; 10" x 10" x 8’ (25 x 25 x 244cm) Ten foot system: 10" x 10" x 10’ (25 x 25 x 305cm)

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1.4. OPTIONAL COMPONENTS

1.4.1. Alarm Monitor Model AM-255

The TSA Model AM-255 Alarm Monitor is a self-contained unit designed for use with TSA's personnel and vehicle portal monitors. The AM-255 provides both remote audible and remote visual alarm indication for radiation level, high and low background, and tamper conditions. In addition, output relays are provided to integrate the AM-255 into existing alarm systems.

One AM-255 will support two pillar systems.

1.4.2. Occupancy Detectors

Any occupancy detector which uses an normally open relay closure may be wired in parallel with the existing occupancy detector. Check with TSA's technical staff for further details.

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2. INSTALLATION

The following procedures should allow on-site personnel to correctly install and set up the VM-250 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 VM-250 is put into service after prolonged storage.

If necessary, consult TSA Systems for assistance in case of unusual site conditions or requirements.

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 and store any batteries separately in a cool place. If batteries are to be stored for any length of time, they should be inspected, and, if necessary, fully charged at least once a month. The detector cabinets may be laid flat on their backs, but should not be stacked. 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 site with enough space to accommodate the detector cabinets. The pillars will need to have an adequate base or some means of stabilization to insure that they remain stationary after alignment. In addition, the system requires 90 - 250 Vac 47 - 63 Hz site power supply.

2.3. DETECTOR CABINET INSTALLATION (Drawing 1)

The Portal Monitor is shipped completely assembled for ease of handling and to minimize shipping damage.

Place the two pillars upright, facing each other at the required spacing, at the desired location.

The pillars should be securely anchored to a cement slab using anchors. In extremely windy locations guy wires may be required.

2.4. ELECTRICAL INSTALLATION

CAUTION: *AC power, signals, and alarm outputs are run through a user-supplied conduit. This conduit must be watertight if the system is to be installed outdoors. The conduits are typically installed under the roadway.*

Once the pillars are in place the unit must be wired for ac power. AC power, alarms, and communication output (for remote monitoring, if desired) are brought into each pillar through user-supplied conduits. These conduits may be brought into the pillar at any convenient location (normally near the bottom of the pillar), but should not be placed in such a way as to interfere with the opening of the door.

2.4.1. Wire the 90 - 250 Vac line to the AC J-box in the master pillar (15 amps @ 90 - 250 Vac). All wiring should be done in compliance with local electrical codes.

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2.4.2. Pillar to pillar interconnections: The pillar interconnections must be connected from the DLT-001 in the master pillar to the DLT-001 in the slave pillar.

Master	Slave	Signal	Color
5	17	signal 4-	yellow/black
6	18	signal 4+	yellow
7	19	signal 3-	orange/black
8	20	signal 3+	orange
15	3	SDO-	brown/black
16	4	SDO+	brown
17	5	SK-	violet/black
18	6	SK+	violet
19	7	DO-	blue/black
20	8	DO+	blue
23	25	tamper	red
27	27	+12Vdc	red (AWG12)
28	28	ground	black (AWG12)

The balance of the wires are either connected within the respective pillar, or not used.

2.4.3. Check that the ON/OFF switch on the Load Disconnect is in the OFF position, and connect the battery in the master pillar by connecting the battery cable to the in-line connector from the load disconnect.

NOTE: *If it is necessary to access the alarm outputs for remote alarms, they are located on terminal strip 2 in the master pillar. The remote tamper alarm should be connected to DLT-001 J4-24. TS2-7,8 are common points.*

<u>Terminal Strip 2</u>

Pin	Signal	Color
1	Radiation Alarm	Brown
3	High Background Alarm	Red
5	Low Background Alarm	White
7&8	Common	green, blue, and orange

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2.4.4. Check that the ON/OFF switch on the Load Disconnect is in the OFF position, and connect the battery in the master pillar by connecting the battery cable to the in-line connector from the load disconnect.

All of the other cables are factory installed. This completes the internal wiring of the VM-250. At this point the green LED on the Load Disconnect should turn on when the switch is in the ON position. The SC-755 should turn on when the switch on the side is turned ON.

2.5. Start-Up and Self Test

Turn on the power switch located on the Load Disconnect. The unit will reset and clear the system, then perform a Power On Self Test (POST) which take 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.

Towards the end of the test series, the alarms 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:

BKG = nnnn (background or COUNT, in cps)
OK (system status, OK, TAMPER, OCCUPIED)
BATT: nn.nn (battery voltage)
mm/dd/yy hh:mm (date and time)

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

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3. SET-UP AND PROGRAMMING

3.1. SET-UP

The VM-250 is fully calibrated at the factory. Since these adjustments may be affected during shipment, the calibration should be verified using the Field Calibration Procedures in section 6.

The SC-755 is 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 for details on programming the SC-755.

3.2. PASSWORD CONTROL

The zero 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 an 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.*

3.3. 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 SC-755 controller located in the master pillar. In order to access the SC-755, the door must be opened using the keys supplied with the system to release the latches, and swing the door open. The SC-755 is located approximately in the center of the pillar.

The SC-755 has a telephone style, 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

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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.

3.3.1. PARAMETERS

1. HI/LO LEVELS: Background alarm levels
2. INTERVALS: Number of 200ms intervals per comparison
3. OCCUP HOLDIN: Number of 200ms intervals to hold in after occupancy
4. NSIGMA: N*sigma radiation alarm level
5. DET. ONLINE: Number and position of detectors in the system

3.3.1.1. 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 for the low and 150% of the average background for the high.

3.3.1.2. INTERVALS: Intervals actually controls two functions:

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1. The number of 200 ms intervals to "look back" after the system detects occupancy.
2. The number of 200 ms intervals that are used for each alarm comparison.

This feature ensures that the front of the approaching vehicle is scanned, and prevents it from affecting the background. The factory setting is 5 intervals (one second), but the optimum setting may vary with local conditions.

3.3.1.3. OCCUP HOLDIN: Number of 200ms intervals to hold in after the occupancy signal indicates the system is vacant. This feature ensures that the rear of the departing vehicle is scanned, and prevents it from affecting the background. The factory setting is 10 intervals (two seconds), but the optimum setting may vary with local conditions.

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

3.3.1.5. DET. ONLINE: Number and position of detectors in the system. The SC-755 will support up to four detector inputs. If less than four detectors are installed in a system, the unused inputs must be disabled to allow proper system operation. The detectors on line will normally display "1234". To disable an individual detector, type a zero in its position. For example: typing "1034", would disable detector number 2, the detectors on line would display 1_34. To enable all four detector inputs (the normal setting for a VM-250 system) enter "1234", the detectors on line will display "1234".

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3.3.2. FUNCTIONS

1. SHOW COUNT: Displays detector counts
2. DSCR. ADJUST: Discriminator adjustment
3. VARIANCE: Performs variance test on all detectors
4. SET CLOCK: Sets system time and date
5. BAUD RATE: Sets baud rate for RS-232 communications

3.3.2.1.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.

3.3.2.2. DSCR. ADJUST: 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 0.098 and 5.040 volts is normally acceptable.

When the system is shipped from the factory, the SCA gains are normally set to accept energy in the approximate range of 40 keV to 1.6 MeV. This window may be changed using the discriminators. 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 0.098 volts = 32 keV
ULD 5.040 volts = 1663 keV

For SNM applications, setting the LLD at 0.069 (approximately 22 keV) and the ULD at 0.455 (approximately 144 keV) will provide maximum sensitivity and minimize nuisance alarms.

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.

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The master and slave discriminators are set independently to permit maximum flexibility in programming the system. In most cases the settings will be the same for both pillars.

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. Enter the new value, the first digit entered is volts, the second digit entered is tenths of a volt, etc., and press the pound (#) key, or simply press the pound (#) key to accept the current setting. *Note: Since the DACs have limited resolution, manual entries will be rounded to nearest value the DACs can output.* Once the pound (#) key has been pressed, the ULD menu will be presented. Use the same method to set the ULD. This sets the discriminator levels for the master pillar. After the discriminators in the master pillar have been set, the menu heading will change to "REMOTE ULD/LLD".

Repeat the above process to set the discriminators for the slave pillars.

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 and access the menu for the slave pillar. The display will change from "ADJUST ULD/LLD" to "REMOTE ADJUST" to indicate that the discriminators in the slave pillar are ready to be adjusted.

Repeat the process for the slave pillar.

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Pressing the asterisk (*) key at either the master or slave screen will load the default discriminator settings: LLD = 0.098 and ULD = 5.040.

3.3.2.3. VARIANCE: Performs a variance test on all detectors. The SC-755 runs 15 second variance passes. In the VM-250 system, TSA recommends running five, 15 second passes. After five passes all variance readings should be less than 0.15. Refer to appendix A for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test.

NOTE: *The variance for a detector that is disabled will be 99.00.*

3.3.2.4. 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 is written to the internal clock/calendar.

3.3.2.5. BAUD RATE: Sets baud rate for RS-232 communications. Valid entries are: 1200, 2400, 4800, an 9600 bps. The other communications parameters are: no parity, eight bit data, and one stop bit.

Perform a variance test, and a drive-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.

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3.3.3. ADVANCED

1. ALGORITHM
2. BKG TIME
3. SHOW VERSION
4. CLEAR CNTS
5. F-ALARM TEST
6. BKG.NSIGMA
7. SYSTEM ID

3.3.3.1. ALGORITHM: Permits the operator to select which detectors will be included in the alarm calculations. This allows the operator to optimize system operation for the local conditions. When this mode is selected, the selections will be presented on the display one at a time. Pressing any key, except the <#> will toggle the calculation on and off. To accept the current setting, press the <#> key to step to the next selection. The available selections are:

SUM:	Tests the sum of all detectors in the system (usually four)
HORIZontal:	Tests the sum of the two top detectors and two bottom detectors
VERTical:	Tests the sum of the upper and lower detectors in each pillar
SINGLE:	Tests each detector individually

3.3.3.2. BKG TIME: Sets the initial background 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.

3.3.3.3. SHOW VERSION: Displays the version of the installed software.

3.3.3.4. CLEAR CNTS: The SC-755 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.

3.3.3.5. F-ALARM TEST: Provides a convenient means to test false alarms versus occupancies. Enter <1> to select the number of trials. The range is 1 to 32,000, or 0 for continuous testing. Enter <2> to exit this mode without testing.

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The false alarm routine takes a 30 second background, 60 seconds of occupancies. Each occupancy is for three seconds, after twenty occupancies, the system acquires a new background. The number of occupancies and number of alarms are displayed as the data is collected.

The display looks like this:

F-ALARM TEST
TRIALS= nnnnnn
ALARMS= nnnnnn
MODE= BKG, OCC, DONE

When MODE=DONE, press a <#> to exit the routine and erase the numbers.

Pressing the <#> key while the test is in progress will terminate the test. Pressing the <#> key a second time will exit the test mode and reset the system.

3.3.3.6. BKG.NSIGMA: Sets a sigma value for a "throw-through alarm". This alarm runs continuously in the background mode to ensure that a source is not thrown through the monitor without occupancy being sensed. Throw-through alarm comparisons are performed every 200 ms during background mode. The range is from 0.0 to 99.9. Setting the value to 0.0 will disable this feature. A very high false alarm rate can occur if this value is set to low. Test the unit after enabling this feature.

3.3.3.7. SYSTEM ID: Assigns an identification number to the system. This number is used to uniquely identify the system to one or more PC’s. This number must be used by the PC to establish a communications link. This range of this number i 1 - 32,767.

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3.4. 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:
Master: LLD set to: ________________ ULD set to: ________________
Slave: 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-755 ___ HHV-448
___ Electronic calibration required - ___ SCA-725 ___ HHV-448
___ 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: ________ 3: ________ 4: ________
___ Drive-through test; list sources and sizes used:
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Performed by:_______________________________ Date: ___________________

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4. PC COMMUNICATIONS

A communications package is shipped with each system. The package requires an IBM/PC compatible computer running Microsoft Windows 95/98 or NT 4. The package allows the operator to examine the system parameters and download data from the non-volatile 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 RS-232 cable.*

4.1. INSTALLING THE SOFTWARE

The program files can be found on the CDROM 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\TSA Systems ltd\, press the "Browse" button to install to a different directory.

4.2. 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.*

4.3. 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.

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4.4. ALARM DATA

Data for the most recent six alarms, including 15 minutes of background data prior to the alarm is stored and may be viewed graphically. As the cursor is moved along the horizontal axis, current counts for all detectors are shown in the windows below the graph. Any of the detector data may be temporarily removed from the graphical view by clicking on the check boxes on the left side of the display.

4.5. SHOW COUNT

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

4.6. HISTORY

When the system is operating, certain data is written to its internal, non-volatile RAM. This data includes:

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

This 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.

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

```
06/09/95 17:20:51  Power-up          0      0       0       0        0
06/09/95 17:21:51  Avg. Bkg.      3515    861     849     873      932
06/09/95 17:22:51  Avg. Bkg.      4086    998     991    1024     1073
06/09/95 17:20:47  Tamper            0      0       0       0        0
06/09/95 17:24:52  Background        0   1001     996    1028     1059
06/09/95 17:24:52  Rad Alarm      4283    981     970    1095     1237
15/09/95 19:37:59  Low Alarm      1265   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.

5. THEORY OF OPERATION

5.1. 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 a 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 background time. This updates the background completely every selected background time (20-120) 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 second) 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 monitoring speed of 5 mph passing through the monitor. The summed count of the chosen number of intervals should reflect the time a given point on the vehicle will be in the detection zone, resulting in 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.

5.2. MODES

5.2.1. 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, and downloadable data
LAMPS:	The audio annunciator and both lamps are turned on for approximately 4 seconds.

If any of these tests fails, the SC-755 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.

5.2.2. 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 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 set together to display the current average background count.

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 SC-755 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

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DET X:LO/HI NNNN, where X is the detector number, and NNNN is the current background for that detector. It will also light the amber fault light on the control pillar, and the appropriate alarm lamp on a remote alarm console, if one is included in the system.

5.2.3. 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 "anticipates" occupancy by storing the number of 0.2 second intervals stored in NVRAM.

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 VM-250 will hold the alarm on until 5 seconds after the alarm condition is cleared.

Select a site with enough space to accommodate t 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 VM-250 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 appendix A.

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

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5.2.4. 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 appendix A.

5.3. COMPONENTS

5.3.1. The **SC-755** is installed in the master pillar. It is made up of the following components:

5.3.1.1. The **SC-755** board is the computer board for the system, and uses program software to run the unit and perform all functions. It also contains two SCA channels that amplify and digitize the signal from the detectors in the master pillar.

The SC-755 receives battery voltage and uses a dc-dc converter to supply the ±5 Vdc required by its on board circuitry.

The digital portion of the SC-755 board uses highly integrated components. If a failure occurs in the digital portion of the board, it must be replaced.

The analog/SCA portion of the board uses a dual operational amplifier and a dual comparator to perform the SCA function. One SCA output is counted in U10, and the other is counted in U5.

Discriminator adjustment is accomplished using a four-channel DAC (U8). The DAC output is set by the SC-755 each time the system is powered up, and whenever a new discriminator setting is entered.

5.3.1.2. The **HHV-448** high voltage power supply board provides regulated dc high voltage to the voltage divider networks (PB-4.7m) which are attached to the photo-multiplier tube on the detector.

5.3.1.3. The **GPRB-756** accepts the background (low and high), and radiation alarm signals from the SC-755 and switches the appropriate relay contacts. The relay outputs are not used by the VM-250, but may be used by an AM-255, or interfaced to the customer’s security systems.

5.3.1.4. The **DLT-001** is a Differential Line Transmitter/receiver to permit noise immune data transfer between the two pillars. The discriminator control signals are transmitted to the slave pillar, and the SCA outputs are received from the slave pillar.
There is also a provision to convert an RS-232 signal to RS-422 compatible levels. The DLT-001 has two DB-9 connectors, one male for DCE equipment, and one female for DTE equipment. TD, RD, CTS, and RTS signals are converted to differential RS-422 levels. The SC-755 may be connected to the male port, if RS-422 communications are required.

5.3.1.5. The **ISR-213A** contains an opto-isolator to receive the pulses from the slave pillar’s SCA-725. The pulses are transmitted between the pillars in current mode to minimize the impact of noise over the relatively long lines between the two pillars. The opto-isolator outputs are sent to a Schmitt-trigger to sharpen the edges before being sent to the counters on the SC-755 board.

This board also has a voltage inverter to provide VEE (contrast voltage) to the LCD module.

NOTE: *The opto-isolators are not used on systems which were shipped after July 1, 1998. These systems utilize the DLT-001 for the inter-pillar interface. On the later systems, the opto-isolator (U2) must be removed, and jumped from pins 2 to 7 and 3 to 6.*

5.3.2. The **SCA-725** is installed in the remote pillar. It is made up of the following components:

5.3.2.1. The **DLT-001** is identical to the one in the master pillar. They are connected differently to properly accommodate the pillar to pillar interface.

5.3.2.2. The **SCA-456** single-channel analyzer board. This is a four-channel, amplifier/SCA board. In this application, only two channels (1 and 3 are used. The analog/SCA portion of the board uses a dual operational amplifier and a dual comparator to perform the SCA function. The SCA-456 has a dc-dc converter much like the one on the SC-755 to convert battery voltage to the ±5 Vdc required by its components.

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The SCA output is sent to U3, where the digital pulses are timed using the 4MHz clock oscillator. The outputs of U3 are passed on to U4, which drives an opto-isolator in the master pillar.

Discriminator adjustment is accomplished using a four-channel, serial input, DAC (U5). The DAC output is set by the SC-755 each time the system is powered up, and whenever a new discriminator setting is entered.

5.3.2.3. The **HHV-448** is the same as in the SC-755.

5.3.3. The **DA631 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 signal network and mounting hardware. The gamma ray is converted to photons (scintillation), which are then amplified by the photo-multiplier tube and turned into a voltage pulse by the PB-4.7m.

5.3.4. The battery module consists of a 12 amp/hr 12 volt sealed lead-acid battery, and a constant voltage charger.

5.3.5. The LD-260 Load Disconnect controls the power to the system and shows the status of the power with a pair of LEDs. The amber LED indicates that ac power is present, the green LED indicates that the battery status is OK, and the system power is turned on. The toggle switch is used to manually turn the system power on and off. While turned on, the load disconnect monitors the battery voltage level. If the battery voltage drops below 10.5 Vdc the load disconnect will turn off the system power. When the battery voltage rises to 12.5 Vdc the load disconnect will automatically reconnect the power to the system. Anytime there is a loss of ac power to the system, K2 will deenergize.

5.3.6. The Infrared detector is a passive continuous curtain type detector. It utilizes the zone detection system, with a sensitivity of 0.5 ft/sec to 7.5 ft/sec, and a temperature differential as low as 2 degrees C (manufacturer’s specifications).

5.3.7. Alarm lights and buzzer - A red strobe light and piezo-electric buzzer are used to indicate a Radiation Alarm. Both operate on 12 Vdc. A steady Amber light is used to indicate a High or Low Alarm.

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5.3.8. Optional Alarm Monitor - If an alarm monitor, such as the TSA Systems AM-255, is being used in the system, it will indicate radiation, high and low alarms, but will not give a readout of radiation level.

The tamper alarm is a signal that either the door of the pillar has been opened, or the load disconnect senses a low dc power condition. When a tamper alarm condition exists, it is indicated only on a remote alarm monitor; that is at a security station, and not at the site of the monitor. This signal is generated by one of the pillar tamper switches, or the load disconnect.

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6. MAINTENANCE

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 drive-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 VM-250 is put into service after tuning and recalibration.

6.1. FIELD CALIBRATION PROCEDURES

WARNING: *This procedure involves high voltage and should only be performed by qualified personnel!*

Since the calibration procedures require specialized tools and knowledge, only qualified technical personnel should work on these instruments. TSA's technical staff is always ready to answer any questions. The following tools are needed for this procedure:

DVM with a resolution of 0.1 millivolts (.0001 volts)
High voltage probe with a range of 10,000 Vdc and Zin ?100 MÛ
Oscilloscope with greater than 20 Meg. band width
5 to 10 µCi ^{137}Cs source

NOTE: *Other mono-energetic sources may be used. Call TSA for full details.*

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6.1.1. SC-755 (MASTER PILLAR)

All of the calibration adjustments in the master pillar are located in the SC-755 enclosure. To gain access for calibration, release the latches on the pillar door and swing the door open. The SC-755 is located in the center of the pillar. Loosen the four screws located in the corners of the enclosure, the screws are held captive in the lid. Gently pull the lid away from the bottom of the enclosure and swing the lid down to expose the electronics.

The board in the lid is the SC-755 board. This board contains the amplifiers and digital electronics.

The base contains three boards, the GPRB-756, the ISR-213A, and the HHV-448, refer to drawing 7 to identify the boards. The only board that requires adjustment is the HHV-448.

The display contrast may change slightly with outside temperature variations. If the display is difficult to read, adjust R2 on the ISR-213A board. Refer to drawings 7, 12, and 13 for component locations.

6.1.1.1. LOW VOLTAGE CHECKS

This step verifies that the low voltage circuitry is operating properly before performing the actual calibration.

Using the DVM, verify that the following dc voltages are present before performing a calibration. All readings are referenced to ground, there are numerous ground test points on the board.

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Test point	Voltage	Description
????????????????????????		
TP7	?12.6 volts	Switched battery
TP8	+5 ±0.1 volts VCC	
TP9	-3 to -5 volts	negative rail
J3-2	Channel 1 LLD setting ±0.015 volts	
J3-3	Channel 1 ULD setting ±0.030 volts	
J3-4	Channel 2 LLD setting ±0.015 volts	
J3-5	Channel 2 ULD setting ±0.030 volts	

Do not proceed with calibration until these voltages are within tolerance.

6.1.1.2. CALIBRATING THE HHV-448

The high voltage is calibrated to ensure that the peak pulse amplitude at the output of the first amplifier stage is at least 0.75 volts. This setting will provide the best overall performance of the system. If the high voltage is too low, the signal to noise ratio will suffer.

While following this procedure refer to Drawings 19 Schematic and 20 Component Designator. The High Voltage is adjusted using R1 on the HHV-448 board.

Attach the oscilloscope to the SC-755 board and set as follows: channel 1 probe to TP1 and probe ground to ground. Set the vertical deflection to 1 volt/division, horizontal sweep speed to 0.5 µseconds/division and positive edge triggering. The signal seen should resemble drawing 26 "typical pulse profile". **NOTE**: *The drawing should be used only to represent pulse shape, not pulse amplitude for this step.* Adjust the trigger level and intensity on the oscilloscope for the best display. Place the source on the lower detector.

Adjust R1 on the HHV-448 board achieve a peak pulse amplitude of 0.75 ±0.05 volts. Move the oscilloscope probe to TP4. If the peak pulse amplitude at TP4 is >0.75 volts, the high voltage calibration is complete. If the peak pulse amplitude is <0.75 volts, adjust R1 to achieve a peak pulse amplitude of 0.75 ±0.05 volts.

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Use the high voltage probe to verify that the high voltage is <1,500Vdc, and is stable ±5Vdc.

6.1.1.3. CALIBRATING THE SC-755 (use Drawings 7 & 8)

Attach the oscilloscope to the SC-755 board and set as follows: channel 1 probe to TP5 and probe ground to ground. Set the vertical deflection to 1 volt/division, horizontal sweep speed to 0.5 μseconds/division and positive edge triggering. The signal seen should resemble drawing 26 "typical pulse profile". Adjust the trigger level and intensity on the oscilloscope for the best display. Place the source on the lower detector. Adjust R1 on the SC-755 board to obtain a 2.0 ±0.1 volts pulse amplitude. Now move the probe to TP6 and the source to the upper detector. Adjust R16 for the same pulse amplitude.

6.1.2. SCA-725 (SLAVE PILLAR)

All of the calibration adjustments in the slave pillar are located in the SCA-725 enclosure. To gain access for calibration, release the latches on the pillar door and swing the door open. The SCA-725 is located in the center of the pillar. Loosen the four screws located in the corners of the enclosure, the screws are held captive in the lid. Gently pull the lid away from the bottom of the enclosure and swing the lid down to expose the electronics. Refer to drawing 16 for circuit board locations.

The board in the lid is the SCA-456 board. This board contains the amplifiers and SCA electronics. The SCA-456 will support up to four amplifier/SCA channels. In the VM-250, only two channels are required, channels A and C are used. The component designations are identical except for the channel suffix (A or C in this instance). When referring to the schematic diagram, substitute the appropriate suffix letter for the channel being tested.

The base contains the HHV-448 board.

6.1.2.1. LOW VOLTAGE CHECKS

This step verifies that the low voltage circuitry is operating properly before performing the actual calibration. Refer to drawings 17 & 18 for test point locations.

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Using the DVM, verify that the following dc voltages are present before performing a calibration. All readings are referenced to ground, there are numerous ground test points on the board.

Test point	Voltage	Description
?????????????????????????		
TP9	?12.6 volts	Switched battery
TP8	+5 ±0.1 volts	VCC
TP7	-3 to -5 volts	negative rail
TP10	5.00 ±0.01 volts	Discriminator reference voltage
TP3A	LLD setting ±0.015 volts	
TP5A	ULD setting ±0.030 volts	

Do not proceed with calibration until these voltages are within tolerance.

6.1.2.2. CALIBRATING THE HHV-448

While following this procedure refer to Drawings 19 Schematic and 20 Component Designator. The High Voltage is adjusted using R1 on the HHV-448 board.

Attach the oscilloscope to the SCA-456 board and set as follows: channel 1 probe to TP1A and probe ground to ground. Set the vertical deflection to 1 volt/division, horizontal sweep speed to 0.5 μseconds/division and positive edge triggering. The signal seen should resemble drawing 26 "typical pulse profile". **NOTE**: *The drawing should be used only to represent pulse shape, not pulse amplitude for this step.* Adjust the trigger level and intensity on the oscilloscope for the best display. Place the source on the lower detector.

Adjust R1 on the HHV-448 board achieve a peak pulse amplitude of 0.75 ±0.05 volts. Move the oscilloscope probe to TP1C. If the peak pulse amplitude at TP1C is >0.75 volts, the high voltage calibration is complete. If the peak pulse amplitude is <0.75 volts, adjust R1 to achieve a peak pulse amplitude of 0.75 ±0.05 volts.

Use the high voltage probe to verify that the high voltage is <1,500Vdc, and is stable ±5Vdc.

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6.1.2.3. CALIBRATING THE SCA-725 (use Drawings 14, 15 & 16)

Attach the oscilloscope to the SCA-456 board and set as follows: channel 1 probe to TP4A and probe ground to ground. Set the vertical deflection to 1 volt/division, horizontal sweep speed to 0.5 µseconds/division and positive edge triggering. The signal seen should resemble drawing 26 "typical pulse profile". Adjust the trigger level and intensity on the oscilloscope for the best display. Place the source on the lower detector. Adjust R5A on the SC-725 board to obtain a 2.0 ±0.1 volts pulse amplitude. Now move the probe to TP4C and the source to the upper detector. Adjust R5C for the same pulse amplitude.

6.2. VARIANCE ANALYZER MODE

After calibration is complete, a variance test should be performed. The variance analyzer will identify many problems with both the detectors and associated electronics.

In the VM-250 system, TSA recommends running five, 15 second passes. After five passes all variance readings should be less than 0.15. Refer to appendix A for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test.

NOTE: *The variance for a detector that is disabled will be 99.00.*

6.3. DRIVE THROUGH TEST

Due to the many different environments and materials being monitored, the drive through test will vary from site to site, although several general principles apply in all cases. Select an appropriate source, and instruct the driver to drive at the normal speed used for monitoring vehicles. Repeat the test several times and record the sources and sizes used.

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6.4. PERFORMANCE VERIFICATION CHECKLIST

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

___ System calibration: _____ unchanged ______ new values:

Master LLD set to: _______________
Master ULD set to: _______________
Slave LLD set to: _______________
Slave ULD set to: _______________

Parameter settings:
Number of Detectors set to: _______________
Low Alarm set to: _______________
High Alarm set to: _______________
Occupancy hold-in set to: _______________
Alarm Comparison Interval set to: _______________
Sigma set to: _______________
Algorithm set to: Sum____ Horizontal____ Vertical____ Single____
Background level (N*Sigma) set to: _______________
Background Time set to: _______________

___ Electronic calibration:
Master Pillar: _____ SC-755 ______ HHV-448
Slave Pillar: _____ SCA-456 ______ HHV-448
___ System starts up and runs initial self-test without errors.
___ All modes operational
___ Background mode in operation area; count = _______________
___ Variance test; variance = 1: _______ 2: _______ 3: _______ 4: _______
___ Drive-through test; list sources and sizes used:
____

Performed by: ______________________________ Date: ______________

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6.5. 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	6479	Battery Pack 12 Vdc	GATES	0840-0114
1	8451	Load Disconnect LD-260	TSA	
1	8200A	Detector Assembly	TSA	8200A
1	9453A	SC-755 Assembly	TSA	9453
1	9451A	SCA-725	TSA	9451A
1	6692	Infrared Detector	TSA	6692
1	7817	Tamper Switch	UNIMAX	2TMT15-4
1	8141	Chargers, 12V	TSA	8141
1	8661	Dynodes, PB-4.7m	TSA	8661
1	7355A	Light Bulbs For Amber Light	TSA	7355A
1	7350	Red Strobe Light	WHEELOCK	WHIT12/P81478-002
1	8160	DLT-001	TSA	8160

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7. TROUBLESHOOTING

This guide is designed so that on-site personnel can service the VM-250 and effect necessary minor repairs. It covers procedures and parts down to the board level. Any other problems should be referred to factory authorized service personnel. Unauthorized repair voids warranty.

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 cabinets for physical damage, faulty wiring, loose connections, etc. Open the cabinets and do the same inside, checking all wiring carefully.

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 6. Field Calibration Procedures.)

7.1. COMPONENT ACCESS

Battery : To remove, disconnect cable #10 from the battery, and lift it out. To reinstall the battery, reverse the above.

Load Disconnect : The load disconnect may be removed by disconnecting cables #9 and #10, and removing it from the battery bracket, where it is secured with velcro straps.

To reinstall the load disconnect attach it to the velcro on the battery bracket and connect cables #9 and #10.

Battery charger : is mounted to the backplate next to the battery. Disconnect cable #10, unplug the AC line cord from the AC j-box and take the battery charger out, by removing the four mounting screws.

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To reinstall the battery charger, reverse the above steps.

The **detector assemblies** can be removed by disconnecting the cabling and unfastening the velcro straps that secure them in place. Handle these with care to avoid damage which could cause light leaks. To replace, set the detector in place and fasten the velcro straps, and connect the cabling.

The **SC-755 and SCA-725** are mounted in the middle portion of their respective pillars (Drawings 3 & 4). Four phillips screws hold each module onto the back plate of the pillar. To remove the module, remove the four screws inside the corners of the enclosure and disconnect the cables going to the unit. To replace this module, connect the cables and replace the four screws.

The **IR occupancy detectors** are mounted on the pillar doors. To remove, disconnect the three wires from the detector and loosen the IR bracket. Refer to drawing 2 for connections and wire colors.

To reinstall, replace the IR detector in the bracket and tighten the two screws. Connect the wires to the as shown in drawing 2.

The **lights and Sonalert** are secured to the pillar doors by screws. To remove, disconnect the wires from terminal strip #2 and remove the screws.

To reinstall, replace the light or Sonalert, replace the screws, and connect the wires to terminal strip #2, drawing 2. Be sure to use silicone caulking liberally to ensure water-tight integrity of the pillar.

7.2. POWER DISTRIBUTION

If the unit is totally inoperative, verify that the unit is receiving power throughout the system. Use drawing 3 for the following procedures.

Open the door to the master pillar and disconnect the battery charger plug from the J-box. Measure the AC voltage at the J-box with a DVM, VOM or other AC tester. If the 90 - 250 Vac is not present, the site power must be checked, and restored if missing. Do not

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go on to the next step until the 90 - 250 Vac is present at the J-box.

The battery charger is the only assembly that uses the 90 - 250 Vac directly. To test the battery charger, remove the white connector from the load disconnect and measure the voltage on pins 1 and 3 of the connector (pin 1 is + and pin 3 is ground). The voltage should be 13.5 Vdc.

If the voltage is low or not present, the battery charger must be replaced.

To check the 12 volt power system, check the battery voltage with cable #10 from the load disconnect removed (should be at least 12.5 Vdc). Reconnect cable #10, and check that the switch on the load disconnect is in the ON position and the green LED is on.

If the battery voltage is low (less than 12.5 Vdc), and the charger is working, try to recharge the battery. If the battery will not charge it must be replaced.

NOTE: *Battery voltage must be at least 12.5 Vdc for load disconnect to operate.*

The load disconnect will not turn on if there is a short in the system. To test for this condition remove cable #10 from the load disconnect to TS1. If the green LED comes on, there is a short in the system. See drawings 2 & 3 for more details.

All low voltage power (12 Vdc) for the pillar is controlled by the load disconnect. The solid-state relay in the LD-260 switches the battery voltage to the system. When the LD-260 is turned on, it supplies a logic low to the "coil" of the solid-state relay. This closes the relay and supplies battery voltage to DLT-001-29 through a 3 amp cartridge fuse. From there it is distributed to the controllers, IR detectors, lights and Sonalert. By checking for the presence of 12 Vdc at the various points it is possible to eliminate the power cabling and connections as the source of problems. If a point does not have the proper voltage then the cables between that point and DLT-001 should be checked for "open" conditions and replaced if faulty.

TEST POINT		**CABLE TESTED**
A)	DLT-001-29 (+12) DLT-001-30 (Ground)	LD-260 to DLT-001

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In this step the wires to the IR detectors and lights are tested. The recommended action to be taken if the test fails is given in brackets [ ].

Remove the top cover from the IR detector and measure pin 2 for +12 volts and pin 4 for ground [Replace wires to the IR detector].

Test the wiring that brings power to the lights and Sonalert. The lights and Sonalert are at a constant 12 volt dc potential, and the ground is switched through the SC-750 Alarm relays. Disconnect Cable #7; take a jumper wire and connect one end to TS #4-7 and touch the other end to TS #4-1, 3, and 5 in turn. When TS #4-1 is touched the red light and the Sonalert should come on. When TS #4-3, and 5 are touched, the amber light should come on but not the Sonalert. This also tests the lights and Sonalert for proper operation [Cable #8 and/or the wiring from TS #4 to the lights and Sonalert - replace cable and/or wiring].

The above steps test for "open cables". The procedure for "shorted cables" is much the same. If a short is suspected in a cable, IR detector, light or controller, use the following procedure.

Disconnect all the power cables (see above steps) except for cable #10 from the load disconnect to TS #1. Attach a DVM or VOM to TS #1-8,10, making sure to observe correct polarity, and start re-connecting the power cables one at a time, while observing the voltage on the meter. If the meter indicates low or no voltage, the cable just connected is shorted. If the cable goes to a controller or IR detector, it may be the assembly that is bad. To check, disconnect the cable in question from the assembly at the assembly end and repeat the test. This will isolate the problem to either the cable or the assembly. [As in the preceding steps, replace the bad cable or assembly.]

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7.3. INDIVIDUAL ASSEMBLIES

This section deals with the individual assemblies and how to repair them. As stated at the start of this section the steps only go to board level.

In the master pillar the detector signals are fed into the SC-755 controller, where they are processed.

If an alarm condition is found, the SC-755 activates the lights and Sonalert. The SC-755 receives occupancy input through the IR detectors. This section will follow the Flow Diagram as much as possible.

7.3.1. DETECTOR ASSEMBLIES

When the steps call for disconnecting or re-connecting cables, the unit should be turned off, and when the step is completed, it should be turned back on to check the results of that test.

NOTE: *The signal cable is the one with the BNC connectors, and the high voltage cable is the one with the MHV connectors, which are the larger of the two.*

Using a DVM with a high-voltage probe, verify the high voltage at the MHV connectors on the SC-755. Disconnect the MHV connectors from both units and measure the high voltage from the center conductor (+) to ground (-). The voltage should be between 600 and 1,500Vdc, and stable within ±5 Vdc. Record the voltage, and adjust R1 on the HHV-448 board. Adjust R1 on the HHV-448 board to at least 50 volts above and 50 volts below the recorded voltage to ensure that the regulator is operating properly. If this voltage is out of spec, and/or will not adjust over this range, replace the defective HHV-448 board before continuing with this procedure.

Verify the signal outputs from the detectors using an oscilloscope. Set the oscilloscope to 50 millivolts/division vertical gain, the time base to 1 millisecond/division and trigger to negative slope. Use the existing BNC cable to connect the detector output to the oscilloscope input (the BNC cable may be extended using a BNC to BNC adaptor to connect a second cable if necessary). The oscilloscope should display negative pulses ranging from 50 to 700 millivolts in amplitude. Repeat this test for all detectors.

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NOTE: *if the pulses are not present for any detector, check the trigger level and intensity on the scope.*

If the pulses are not present, substitute the voltage divider assembly with a known working assembly, or replace the entire detector assembly. The system must be recalibrated after any components are replaced.

7.3.2. SC-755 CONTROLLER

The controller's function is to receive the detector signals, which are amplified and discriminated by the analog section and sent to the digital section for counting and processing. The controller provides high voltage to the detector assemblies from the HHV-448 board.

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 Engineering staff.

If a problem is suspected in the SC-755/SCA-725 unit, replace it with a known good assembly, either from spare parts or from another unit. However, remember that the replacement unit will have to be calibrated.

7.3.2.1. INFRARED DETECTOR

To check the IR detector on the master pillar, turn the unit on, connect a DVM to TS #2-6,8 and verify +5Vdc "NO" condition when un-occupied and a 0Vdc "NC" condition when the pillar is occupied. Perform the same test in the other pillar. This test assumes that the wires running from the IR detector to the terminal strip are good.

If the IR detector is found to be good, but the system will still not occupy, the occupancy line in cables #8 and 5 should be checked for "opens" or "shorts."

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GLOSSARY

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 or 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.

ULDS: 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.

APPENDIX A

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

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

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

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

where:

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

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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 = 1bkg
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

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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.

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VARIANCE

The variance analyzer mode is used to check whether the counts seen by the controller are actually ffrom 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 varies from unit to unit and is included in the variance section of the manual on most units.

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

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

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

$$\overline{R} = \frac{R}{I}$$

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 refered to as variance in TSA’s manuals

S2 = sample variance

8. PARTS LISTS

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:

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Phone# (303) 651-6147
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9. LIST OF DRAWINGS