PORTAL RADIATION MONITOR

MODEL PRM-470B

OPERATING AND SERVICE MANUAL

Version 1.01z

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TSA systems

PRM-470B

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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 PRM 470B. Since applications are necessarily site-specific, operation procedures are given in general terms. Service and repair are covered to the board or assembly level. Anything more complex than this requires that the instrument or assembly be returned to TSA.

1.2. GENERAL DESCRIPTION

The TSA Model PRM-470B Portable Radiation Monitor is a light-weight, portable, hand- held instrument designed to detect radioactive materials. The standard detector is a large plastic scintillator that is both gamma and neutron sensitive. A display backlight is supplied to permit use in low light conditions.

Uses for the PRM include Special Nuclear Material (SNM) searches at plant exits and material access areas, as well as contamination and background monitoring. The small size and light weight make it ideal for extended search time applications.

Upon power-up, the instrument goes through a self-test and warm-up period followed by an initial ten second background count. In background mode it continues to update background counts at ten second intervals; the display flashes the current background. In search mode, the current background is stored and the instrument makes alarm comparisons every 50 milliseconds. The display will show counts per second, divided by 1000, updated every second. If the detected radiation level exceeds the pre-programmed alarm level, an audio alarm is sounded.

The instruments covered by this manual have been modified to operate on a set of four AA size, alkaline batteries. The instrument will operate for approximately 24 hours on a fresh set of batteries.

The PRM-470B operates in two modes:

- Search mode - to locate radioactive material
- Background mode – to measure radiation intensity

Two rotary switches control sensitivity while in the search mode. The switches are located on the PRCB-474 PC board inside the instrument. The range of the sensitivity adjustment is 0.1 to 10.0 sigma.

There are two options for displaying the data:

- cps
- µsieverts

There are two rotary dip-switches located on the PRCB-001 board that control the display mode. If both switches are set to "0", the display is in cps.

NOTE:
The µsievert conversion is not compensated for energy. It is strictly a linear conversion of counts per µsievert.

1.3. SAFETY PRECAUTIONS

Cautions and warnings related to specific procedures are cited at appropriate places in this manual. A summary is given here.

WARNINGS:

Since the PRM-470B uses high voltage during operation, care must be taken during service procedures. Service should be done only by qualified personnel.

The electroluminescent backlight utilizes 400 volts ac for operation, and care must be taken to avoid accidental contact while servicing the instrument.

CAUTIONS:

The PRM-470B is water resistant, but will not withstand immersion in water.

The instrument should not be overcharged, as this will shorten the battery life. The instrument should not be constantly shallow charged refer to Maintenance Procedures (section 5.1.).

As with any sensitive electronic instrument, the PRM-470B should not be dropped or subjected to severe mechanical shock.

Damage to the copper coating inside the instrument can result in unacceptable RFI levels.

1.4. SPECIFICATIONS

Sensitivity:	Will detect 10g HEU or 1g ^{239}Pu when tested in accordance with ASTM Standard C 1237-93
Detector:	One, 3.5"h x 2.88"w x 1.25"d (8.8 x 7.2 x 3.1cm) plastic scintillator detector; provides 12.6 in^3 (206 cc) of detector volume
Alarm Levels:	Set by two internal rotary switches from 0.1 to 9.9 sigma
Alarm Indication:	Audible tone and LED
Count Time:	Search mode: 0.05 sec. count with .4 sec. moving average. Background time: 10 sec.
Display:	LCD, one line x 4 characters, with backlight
Power:	The internal NiCad battery pack provides more than 60 hours of continuous operation on a full charge.
Battery Charger:	The instrument is shipped with a universal input battery charger which operates on 90 – 250 Vac, 47 – 63 Hz. Recharge time is less than 16 hours. Optional 4 "AA" alkaline batteries will provide more than 24 hours of operation.
Conversion:	µsievert conversion: set by two internal rotary dip-switches; Range: 100 to 9900 cps/µsievert

Dimensions:	8"h x 5"w x 3"d (20 x 12.5 x 7.5cm)
Weight:	2.4 lb (1.1kg) with batteries
Environmental:	
Temperature:	32˚ to 100˚F (0˚ to 38˚C)
Humidity:	Up to 95% non-condensing

2. INSPECTION AND SETUP

The following procedures should allow on-site personnel to correctly inspect and set up the PRM-470B for normal operation. Follow the procedures in the order given. It is recommended that a copy of the Initial Set-Up Checklist (section 2.3.) be filled out after initial installation and whenever the PRM-470B is put into service after prolonged storage.

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

2.1. INSPECTION

2.1.1. Incoming 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.

2.1.2. 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.

2.1.3. Storage:
If the instrument is to be stored for any length of time, first 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 charged if necessary at least once a month. 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 constant location.

2.1.4. 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. SET-UP PROCEDURES

An Initial Setup Checklist is included at the end of this section (section 2.3.). It is recommended that a copy of this be filled out when the PRM-470B is first set-up, and whenever it is put into service after prolonged storage.

After initial inspection, charge the battery for several hours. Although the battery is fully charged before the instrument leaves the factory, some discharge is possible if the instrument has been in storage for any length of time.

After charging, turn the instrument on and test the controls, display and alarm According to the steps outlined in Power-Up and Self-Test (section 3.1.) in this manual. While the instrument comes from the factory tuned and calibrated, the calibration should be verified before putting the instrument into service.

2.2.1. Alarm Level:

To set the sigma level, open the instrument. Refer to Component Access (section 6.1.) and use a small slotted screwdriver to turn the two rotary switches marked "sigma" to the desired setting.

2.2.2. µsievert Conversion:

The cps/µsievert conversion is set in the same manner as the alarm level. Turn the two rotary dip-switches marked "k-factor" to the desired setting. This setting is multiplied by 100, so a setting of 19 would result in 1900 cps per µsievert.

NOTE:

Setting both k-factor switches to "0" will display cps.

The settings will appear on the display for approximately 3 seconds each during the warm-up period. They will be displayed in the following order:

- sigma
- cps/µsievert

After the settings are displayed, the instrument will initiate a 10 second countdown for the initial background.

2.3. INITIAL SETUP CHECKLIST

____ Initial inspection done

____ Battery charged

____ Initial self-tests show no error codes

____ Power switch operates correctly

____ Background in operating area = ______________________________

____ Mode change operates correctly

____ Sonalert works properly

____ Alarm test - source used: ___________________________________

____ Sensitivity (Sigma switch setting): ___________________________

____ μsievert conversion switch setting: ___________________________

Performed by: ____Date: _____________

3. OPERATING INSTRUCTIONS

3.1. POWER-UP AND SELF TEST

3.1.1. Power On:

For power-up, press and hold the power switch for 2 seconds. It is the dark blue area on the front panel marked "POWER". The instrument will sound a series of beeps to indicate that the power on signal has been latched.

3.1.2. Self Test:

The instrument will perform a display test, with all segments and decimal points "ON" for 2 seconds, accompanied by the audible alarm.

The instrument will then display the current settings for 3 seconds each.

If any of the power-up tests fails, an error code will be displayed. If no errors are present, the background countdown will be displayed.

3.1.3. Power Off:

Press and hold the power switch for 2 seconds to turn the instrument off. Power off will be acknowledged by displaying "----".

NOTE:

The instrument will not turn off until it has completed its power-up tests and displayed either an error code or the background countdown.

3.2. SEARCH MODE

After the initial 10 second background countdown, the instrument will automatically go into search mode. In this mode the display will be steady (not flashing) and will update the display every second.

There is an internal motion switch in the instrument that will automatically enable the search mode when the instrument is moved.

This feature can be enabled or disabled with jumper X1 on the PRCB-001 board.

To enable the motion switch, place the jumper between X1-1 and X1-2.
To disable the motion switch, place the jumper between X1-2 and X1-3.

When the motion switch is enabled, each time the instrument is moved, a 15 second timer is activated. The instrument will stay in search mode until the 15 second timer expires.

The instrument will produce an audio alarm from time to time in a search mode. When radioactive materials are present, it will alarm more rapidly. This is dependent on the intensity of the radiation and the sigma switch settings.

3.3. BACKGROUND MODE

The background mode is characterized by the display flashing once per second, and will update with a new background every 10 seconds. Pressing the mode switch and holding it until it is acknowledged with a "beep" toggles between search and background modes.

While in background mode the audio alarm is disabled and the display will continue to flash.

3.4. MODE CHANGE AND RESET

The instrument may be switched between search and background modes at any time by pressing and releasing the mode switch.

If the internal motion switch is enabled, the modes may be switched by setting the instrument on a stable platform like a table and waiting for the 15 second timer to expire.

To reset, the instrument must be power cycled. The instrument will go through another self-test and wait period. It will then display a new background count.

3.5. DISPLAY BACKLIGHT

The display backlight is turned on automatically at power-up. The display backlight will turn off again when the instrument enters the initial background countdown.

After the countdown starts, and at any other time while the instrument is operating, pressing the light switch will turn on the backlight for 30 seconds. Excessive use of the light will shorten the useful life of the battery by up to 50%.

3.6. LOW BATTERY DETECT

The PRM-470B is equipped with an automatic low battery detect circuit.

When the battery voltage drops to 5.2Vdc, all signal processing will stop, the display will show "LO", and the beeper will sound for five seconds.

The instrument will automatically power down at the end of the five seconds to avoid damage to the batteries. The PRM-470B will resume normal operation after replacing the batteries.

3.7. RECOMMENDED SETTINGS

There are two user adjustable parameters.

- n*sigma
- counts/µsieverts.

Both of these parameters are set using rotary dip-switches mounted on the main circuit board. When the instrument is shipped from the factory the switches are normally set for n*sigma = 3.0, and counts/µsieverts = 00.

The switches are read on power-up, so changing the switches while the instrument is operating will have no effect.

3.8. TYPICAL SEARCH PROCEDURES

The following search techniques are drawn from examples given in the Los Alamos National Laboratories User's Manual, "Hand-Held Search Monitor for Special Nuclear Materials", by Paul E. Fehlau (1984).

These techniques may serve as a general guide for search procedures. It is recommended to refer to your specific site regulations and Operating Procedures prior to search operation.

The efficiency of the search improves with close proximity to the article or person being searched, a thorough scan of all surfaces, and adequate time to allow the instrument to respond.

Personnel:

All articles in hand should be searched separately. The PRM should be held within 3 inches (7.5cm) of the person and moved slowly, from head to foot anteriorly and posteriorly.

Vehicles:

The engine should be off. All personnel are requested to leave the vehicle for an individual scan. All compartments (hood, trunk and glove box) should be opened and scanned with particular attention paid to possible areas of concealment, such as wheel wells, hub caps and relatively inaccessible areas.

If contamination or suspect material is located, follow site regulations.

As stated above, these search techniques are drawn from examples given in the Los Alamos National Laboratories User’s Manual, "Hand-Held Search Monitor for Special Nuclear Materials", by Paul E. Fehlau (1984). For more information, contact the Los Alamos National Laboratories staff directly.

4. THEORY OF OPERATION

The PRM-470B is designed to locate radioactive sources and measure intensity in the field. It uses low power CMOS electronics to provide over 60 hours of operation from the NiCad batteries. For emergency response or other applications where rechargeable batteries are not suitable, the PRM-470B features a self test during power-up, automatic background count and user determined alarm settings.

For wiring, and signal flow information, refer to "PRM-470B Internal, 3D View" Drawing 2 and "PRM-470B Wiring Diagram" Drawing 3 (Appendix F).

4.1. COMPONENTS AND SUBASSEMBLIES

4.1.1. Main Circuit Board, PRCB-001:

Refer to "PCRB-001 Control Board Schematic Diagram" Drawing 4 and "PCRB-001 Control Board Component Designator" Drawing 5 (Appendix F.).

The PRCB-001 microprocessor control board is the computer board for the system. Its program runs the PRM and processes the incoming signal from the detector assembly. The signal is analyzed with the resultant count rate output to the display. The board also accepts input from the various switches and outputs to the display and beeper.

4.1.2. High Voltage Power Supply, HHV-454:

Refer to "HHV-454 High Voltage Power Supply Schematic Diagram" Drawing 6 and "HHV-454 High Voltage Power Supply Component Designator" Drawing 7 (Appendix F.).

The HHV-454 high voltage power supply supplies regulated high voltage to the voltage divider assembly to power the PMT (photo-multiplier tube). This assembly is shielded to reduce RFI.

4.1.3. Detector Assembly:

The detector assembly converts gamma radiation into a voltage pulse. The voltage pulse is amplified on the PRCB-001 board so it can be counted and analyzed. The detector consists of organic plastic scintillation material, with a PMT coupled to it using optical adhesive. The whole assembly is wrapped in light tight materials.

4.1.4. Voltage Divider Assembly:

Refer to "PB-10M Voltage Divider Schematic Diagram" Drawing 8 and "PB-10M Voltage Divider Component Designator" Drawing 9 (Appendix F.).

The Voltage Divider Assembly is made up of the tube socket and voltage divider (resistors and capacitors). It divides the incoming high voltage for the dynodes in the PMT, and decouples the signal from the high voltage.

4.1.5. Batteries and Battery Charger:

The instrument operates on four, AA size, alkaline batteries. When the batteries have discharged to the point that they will no longer reliably operate the instrument, it will display "LO" and stop operating. Replace the batteries with a fresh set.

NOTE:

The alkaline batteries are not rechargeable. The charger jack has been disabled.

4.2. SELF TEST (SYSTEM RAM)

When the PRM is turned on it will automatically test the system RAM. Immediately after turning the instrument on, the display will show "8.8.8.8" and the beeper will sound. The beeper continues to sound for approximately two seconds while the instrument goes through the RAM test.

If the RAM test passes, the PRM-470B will display the current settings. If the RAM test fails, it will display "---1".

After the instrument has completed the RAM test it will display the current settings for approximately 3 seconds each. This delay also gives the high voltage time to stabilize.

The instrument will then count down from 10 seconds and will display a flashing background count followed by an automatic switch to "SEARCH" mode.

4.3. BACKGROUND MODE

The PRM may be returned to background mode by pressing and holding the mode switch until it is acknowledged with a beep. The display will flash in background mode, while the instrument constantly updates the background count to reflect changes in the environment. The background is accumulated in 10 second increments, with the current background displayed as the one second average.

4.4. SEARCH MODE

In search mode, the alarm threshold is determined by the Sigma switch setting. The instrument updates the display each second.

The instrument counts incoming pulses in 50 millisecond periods, and sums eight of these periods into a 400 millisecond moving average.

That is, the most recent 50 millisecond count is added to the moving sum and the oldest count discarded. This moving average sum is then compared to the alarm threshold.

If the moving average sum equals or exceeds this threshold, the audio alarm will sound momentarily. The audio alarm may also sound momentarily when the display is below the alarm threshold, since the display is updated every second, while the alarm comparisons are made every 50 milliseconds.

4.5. AUDIO ALARM

The audio alarm is a piezoelectric type. It is activated to signal the start of the self-test or an alarm condition.

The rate at which the audio tone repeats is dependent on intensity of the radiation field. The frequency is constant.

The alarm LED is also illuminated with the audio for use in high noise areas.

5. MAINTENANCE

5.1. MAINTENANCE PROCEDURES

The PRM-470B has been designed for continuous use up to 50 hours on a set of batteries. Once initial installation has been completed, little maintenance is required. Periodic inspection is recommended to insure proper functioning. It is recommended that a copy of the Calibration Checklist (section 5.3.) be filled out whenever the PRM-470B is put into service after repair or recalibration.

5.2. ELECTRONIC CALIBRATION PROCEDURE

The following is a list of the equipment required for the electronic calibration procedure. These steps should only be performed by qualified service personnel.

- Oscilloscope
- Tweaker or small slotted screwdriver
- Digital voltmeter
- 5-10µCi ^{137}Cs test source

5.2.1. Gain (HV) Adjustment:

Refer to "HHV-454 High Voltage Power Supply Schematic Diagram" Drawing 6 and "HHV-454 High Voltage Power Supply Component Designator" Drawing 7 (Appendix F.).

Place ^{137}Cs source on the detector. Adjust the high voltage pot which is found in the copper shielded H.V. board until a 3.2 volt pulse amplitude is obtained. Refer to "Typical Pulse Profile" Drawing 10 (Appendix F.).

5.2.2. LLD Adjustment:

Refer to "PCRB-001 Control Board Schematic Diagram" Drawing 4 and "PCRB-001 Control Board Component Designator" Drawing5 (Appendix F.).

Connect a digital volt meter between TP2 and ground. Adjust R18 to achieve a reading of 45 millivolts ±5 millivolts.

5.3. TUNE-UP AND CALIBRATION CHECKLIST

___ Tune-up procedure performed:

Sources used: ____

Background obtained: ____

___ Calibration procedure performed:

Source used: ____

Average background obtained: ____

Calibration performed by: _____________________________ Date: ___________

6. TROUBLESHOOTING

This guide is designed so that on-site personnel can service the PRM-470B 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 repairs are completed and the instrument returned to operation, a copy of the Performance Verification Checklist (section 5.4.) should be filled out and filed for future reference.

6.1. COMPONENT ACCESS

Refer to "PRM-470B Internal, 3D View" Drawing 2 (Appendix F.) for the following procedures.

6.1.1. PRCB-001 Board:

Refer to "PCRB-001 Control Board Schematic Diagram" Drawing 4 and "PCRB-001 Control board Component Designator" Drawing 5 (Appendix F.)

The PRCB-001 board is mounted on standoffs on the lid of the enclosure. To access the PRCB board, loosen the four screws securing the lid in place. The lid can now be removed to the limit of the wiring harness.

To take out the board, remove the two Molex connectors on the top of the board and the four phillips screws that secure the board to the standoffs. There is one additional connector on the underside of the board which must also be removed before the board will be completely free.

To replace the board, attach the connectors and place the board on the standoffs. Replace the four phillips screws to secure the board in place and re-attach the lid.

6.1.2. HHV-454:

Refer to "HHV-454 High Voltage Power Supply Schematic Diagram" Drawing 6 and "HHV-454 High Voltage Power Supply Component Designator" Drawing 7 (Appendix F.).

To access the HHV-454, open the enclosure by removing the four screws. Lift the lid off and set it to one side, being careful to avoid damaging the wiring harness. The High Voltage board can be seen in the bottom of the enclosure. It is connected to the detector assembly and lid by the wiring harness and covered with a RFI shield.

NOTE:

The RFI shield that covers the high voltage board is made up of a mylar layer covered with a copper tape layer. A ground wire is soldered onto the copper layer and connected to the Molex connector. The shield can be easily separated from the board.

Disconnect the Molex connectors from either end of the board. The board can then be removed.

To replace the board, slide the board back into the shield, and re-attach the connectors.

6.1.3. Voltage Divider Assembly:

Refer to "PB-10M Voltage Divider Schematic Diagram" Drawing 8 and "PB-10M Voltage Divider Component Designator" Drawing 9 (Appendix F.)

The voltage divider assembly is made up of a tube socket with attached components and the plastic cover. To access the assembly, open the enclosure by removing the slotted screws. The voltage divider assembly is visible, attached to the PMT. Remove the black electrical tape which secures the socket and cap to the PMT. The cables from the voltage divider go to the HHV-454 and to the PRCB-001 boards.

To replace the voltage divider assembly, plug it onto the tube and rewrap the area with electrical tape. Test carefully for light leaks.

NOTE:
It is essential that the voltage divider assembly is completely wrapped and that the tape covers the PMT to prevent light leaks.

Reconnect the two Molex connectors. Perform the Electronic Calibration Procedure. (5.2.)

6.1.4. Detector Assembly:
The detector assembly is made up of the PMT and the organic plastic detector. In either case, it is considered to be one unit and must be replaced as such. The detector is visible in the bottom of the enclosure when the top is removed.

To remove the assembly, lift the detector assembly out of the enclosure.

To replace the assembly, place the detector and the foam in the bottom of the enclosure.

6.1.5. Mechanical and Cabling Assembly:
The mechanical and cabling assembly is not considered field serviceable. If problems arise, the instrument should be returned to TSA for service.

6.2. TROUBLESHOOTING GUIDE

This guide is designed so that repairs can be made to the PRM by qualified service personnel and the instrument returned to service within a minimum time. It emphasizes board and assembly replacement.

General problems include inoperable switches, batteries that fail to charge, failed audio, broken wires, etc. Intermittent problems are often caused by loose or broken wires or loose connections.

Perform a physical inspection of the instrument, looking for faulty or broken wiring, foreign material, broken or damaged components, and loose connections.

Refer to the appropriate drawings (Appendix F.) for location of components as they are noted while using these procedures.

The following tools and equipment are needed for these procedures:

- Phillips screwdriver
- Slotted screwdriver
- Oscilloscope
- High voltage probe (>1,000 megohms)
- Nut-driver set
- DVM

6.2.1. Batteries and Charger:

If the instrument fails to operate properly, check the condition of the batteries. For example, if the instrument does not pass the self-test procedure, fails to count down, etc., the cause is often low battery charge. Check the condition of the batteries by measuring the voltage to confirm that it is 5.75 volts or greater. If the voltage is low, install a fresh set of alkaline batteries before continuing.

Do not go on to step 6.2.2. until the battery voltage is at least 5.75 volts.

NOTE:

Many apparent problems can be traced to a low battery condition, which can cause the instrument to behave erratically.

6.2.2. High Voltage:

If the problem persists with proper dc voltage present, check the high voltage board by connecting the high voltage probe to J2-1 on the HHV-454 board. The ground end of the probe may be connected to any convenient ground. The voltage should be at least 600 VDC. If it is not possible to adjust the level (R5 on the HHV 454 board), replace the board.

Do not go on to step 6.2.3. until the correct voltage range is present.

6.2.3. Detector:

Remove the three-pin Molex signal connector from the PRCB-001 board and attach an oscilloscope probe to it. The coax is the signal and the black #22 AWG wire is the ground.

Set the oscilloscope for negative edge triggering. The pulses should be negative and about 50 millivolts peak amplitude. If present, the detector assembly is working. If not, then either the detector or voltage divider assembly must be replaced.

It is recommended that the voltage divider be changed first.

Do not go onto step 6.2.4. until the pulses are present.

6.2.4. Amplifier:

Re-attach the signal wire and place a small ^{137}Cs source near the detector. Place an oscilloscope probe on TP1 on the PRCB-001. The pulses should be positive and approximately 3.2 volts in amplitude. If these pulses are present the input to the amplifier section of the computer board is working.

At this point there are correct pulses coming into the computer board from the detector assembly. Go through the Electronic Calibration Procedure (section 5.2.)

If any of the steps fail, then the computer board must be replaced.

6.2.5. Switches:

To test the front panel switches, remove the PRCB-001 board and test the switches using an ohmmeter. They should be normally open and less than 20 ohms to common when held down. The switches are an integral part of the front panel overlay and can not be replaced individually.

FRONT PANEL SWITCHES		
J5 pin		**Switch**
1		Mode
2		Light
3		Power
4		common

Disconnect J5 from the PRCB-001 board and test the switches at the pigtail.

The switches that adjust sigma and cps/µsievert may be tested by changing the setting and turning the unit on. The settings are displayed on power-up.

If the above steps do not isolate the problem and effect repair, contact TSA Systems Ltd. for engineering assistance.

6.3. PRCB-001 BOARD

This section is a cross reference for adjustments and test points on the PRCB-001 computer board.

Refer to "PCRB-001 Control Board Schematic Diagram" Drawing 4 and "PCRB-001 Control board Component Designator" Drawing 5 (Appendix F.) to identify the PRCB-001 component for the locations of the test points.

Refer to Parts (section Appendix E.1.) for information on parts ordering and replacement of the PRCB-001 board assembly.

Test points:

TP1: VCC test point (This should be 5.0 ±0.25Vdc.)
TP2: Ground
TP3: Counter input (This is the output of the LLD.)
TP4: Ground
TP5: Discriminator level (Pulses which do not cross this level are not counted by the PRM.)
TP6: Pulse amplitude test point (This is used when setting up the instrument.)
TP7: Five volt regulator output (This becomes VCC after L1.)

Potentiometers:

R2: Audio tone adjustment (This is factory adjusted for maximum volume.)
R18: Discriminator adjustment

APPENDIX

A. WARRANTY

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.

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B. GLOSSARY

ADC: Analog to Digital Converter, is an integrated circuit that converts an analog signal into a binary number that 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 a threshold, usually adjustable, 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. Also see ULD.

Low Background Alarm/Fault: The condition that occurs if the counts fall below the programmed high background level. This condition prevents further operation until the problem is corrected. Normally 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 represents 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 a threshold, usually adjustable, that determines the highest signal level that will be accepted as a nuclear pulse by the system's electronics. Also see LLD.

C. FORMULAS

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

C.1. ACTIVITY FROM COUNTS

$$\text{Activity} = \frac{N}{\text{Eff} * 37}$$	Where:	Activity = Activity in nCi
		Eff = Decimal efficiency (i.e. 10% = 0.1.)
		N = Net counts per second (cps – background cps)

C.2. EFFICIENCY

$$E = \frac{N}{37 * \text{activity}}$$	Where:	N = cps with source – background cps
		activity = test source activity in nCi

C.3. N*SIGMA ALARM LEVEL

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

$$\text{Alarm Level} = \left(N * \sqrt{\text{bkg}} \right) + \text{bkg}$$	Where:	bkg = Background counts
		Sigma = 1bkg
		N = N*Sigma value

C.4. 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.

$F = \left(\frac{CON + \sqrt{CON^2 + 4\left(FA\sqrt{BKG} + BKG\right)}}{2} \right)^2$		BKG = total background counts per count time
		CON = confidence sigma
		CT = count time in seconds
		E = system efficiency in percent
$G = \frac{F - BKG}{CT}$		F = false alarm level in cps
		FA = false alarm sigma
$RDA = \frac{2200 * G}{37 * E}$		G = intermediate variance
		RDA = reliable detectable activity in DPM

C.5. SIGNAL TO BACKGROUND RATIO

The following formula is helpful is 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
		B = Background count
Higher values of Q result in better sensitivity		

C.6. 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 varies from unit to unit and is included in the variance section of the manual on most units.

		R = the quality factor
$\overline{R} = \frac{R}{I}$		$S^2 = \text{variance} \frac{\sum \left(C - \overline{C}\right)^2}{N-1}$
		C = each of the individual counts
$\mathbf{R} = \frac{S^2 - \overline{C}}{\overline{C}}$	Where:	$\overline{C} = \text{the mean of the counts} = \frac{\sum C}{N}$
		N = number of counts taken
		$\overline{R}$ = mean variance
		I = number of iterations

D. 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:_______________

E. PARTS

E.1. RECOMMENDED SPARE PARTS

The following list of spare parts given here is based on the following assumptions:

One - the maximum downtime allowable is 2 hours.

Two - a technical background is not needed to perform the repairs.

Three - these spare parts are supporting from one to five systems.

NOTE:

If there are more than five systems, one set of spare parts should be maintained per five systems.

SPARE PARTS			
Qty	**Description**	**Mfr Name**	**Mfr Part #**
2	PRCB-001A Assembly	TSA	8670
2	HHV-454 PRM Assembly	TSA	8414
2	Voltage Divider Assembly, PB10	TSA	8661A
5	Battery Pack 1.4Ah	TSA	8110
4	Battery Charger	TSA	8140

E.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
970.535.9949
FAX: 970.535.3285

F. DRAWINGS

Please reference the drawings package provided with the instrument to view the following: