PRM-470CGN

OPERATIONS MANUAL

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1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE OF STUDY GUIDE

This study guide is designed to enable operating and service personnel to properly test, operate, and care for the TSA Hand-held Gamma/Neutron monitors. 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

TSA's Hand-held monitors are highly reliable units for the detection of radioactive materials.

The PRM-470C is designed for both indoor and outdoor use but the unit is not water proof.

The PRM-470C has been designed to provide continuous use for 12 to 16 hours between charges. The charge time is only 4 hours. To charge the unit, turn off the unit and plug the charger into the side panel charger jack and the charger into an AC outlet.

Each hand-held unit contains one gamma detector and can also be outfitted with one ^{3}He tube for neutron measurement.

1.3 SPECIFICATIONS

Gamma Detector: One 3.4" x 2.7" x 1.3" (8.64 x 6.86 x 3.30cm) organic plastic scintillator.

Optional Neutron Detector: One 3/4" dia. X 5" length (1.9 X 12.7cm), 4ATM ^{3}He detector

Power:
4.8 volt, 2100 mAh NiMH battery charged by a 10 volt 800 mA charger

1.4 Serviceability:

Component level part replacement is not practical with this unit. A user can replace the battery pack or possibly a detector but it is recommended that the unit be returned to TSA for repair.

Weight:
Approximately 2.75lb

Dimensions:
7 7/8"h x 4 3/4"w x 3 5/8"d (20 x 12.07 x 9.21cm)

1.5 OPTIONAL COMPONENTS

1.5.1 Neutron Detector

The TSA Model PRM-470C Hand-held Monitor comes equipped with a gamma detector as standard equipment. An optional neutron detector can be added to give additional neutron sensitivity.

1.5.2 Headphones

Headphones may be used with the PRM-470C for areas that may be noisy or for situations where the fact that a unit is alarming is not information to be shared by other persons in the area. Headphones are a user supplied item.

2.0 PRODUCT CONDITIONS

The following steps should be followed to ensure that the PRM-470C is handled properly.

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.

2.2 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.

2.3 STORAGE

If the instrument is to be stored for any length of time, 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. 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.

2.4 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.

2.5 STANDARD WARRANTY FOR TSA SYSTEMS INSTRUMENTS

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

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

Manufactured by

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

3.0 SET-UP AND PROGRAMMING

To operate the monitor, press the POWER switch. The display will show TSA Systems Ltd. along with the model number and version number and the audible will sound. Next, the display counts down to zero until the monitor is ready for operation and displaying a new count. At this time the red and blue LEDs will go on and off (if the unit has both gamma and neutron detectors). Do not move the monitor until it has had an opportunity to acquire a background.

3.1 SET-UP

The monitor is fully calibrated at the factory. Since these adjustments may be affected during shipment, the calibration should be verified using the Electronic Alignment Procedures in Sections 7 & 8.

The PRM-470C has many user programmable parameters that can be used to optimize it for a wide variety of applications.

3.2 PROGRAMMING THE HAND-HELD

The TSA PC Communications Program is supplied on the CD that ships with the system documentation. The program requires an IBM/PC compatible computer running Microsoft Windows XP, 2000, NT4, 95, or 98. The program allows the operator to examine the system parameters and download data.

Step	Action
1	Install the Communication Application Software from the disk that comes with the unit
2	Use a standard RS232 cable or USB to serial converter cable to connect the PRM-470C to the computer
3	Find the Application on the computer by following this path: start→programs→TSA Systems→PRMCOM→PRMCOM
4	When the Application screen comes up you will need to move the cursor to the connect button and left click
5	After a few seconds the computer should connect and the previously stored parameters in the PRM-470C should be displayed
6	If a Data Plot is desired, the TX Data will need to be toggled from OFF to ON
7	If any parameter changes have been made, move the cursor to the SEND PARAMETERS button and left click
8	After a few seconds, data from the PRM-470C should be displayed in the RS232 Data Stream box
9	You can now select the Data Plots tab and view a graph of the data

3.3 DEFAULT PARAMETERS

The default parameters are as follows:

Sigma = 3 (Sigma)
Background Time = 5 (sec)
Motion Time = 30 (sec)
Gamma LLD = 0.06 (Volts)
Gamma ULD = 5.01
Neut LLD = 1.00
Neut ULD = 5.01
Neutron Alarm = 10 (CPS)
Low Gamma Alarm = 0 (CPS)
Restrict Setup = OFF
Count Mode = Find
Gamma Units = CPS
Alarm Pitch = 0
TX_Data = OFF

3.4 PARAMETER DETAILS

Sigma Changing this value will change the sensitivity of the unit. Alarms are calculated by taking the square root of the background and multiplying that value by the Sigma. The resulting value is the number of CPS above background to cause the unit to alarm. As the Sigma value is raised it will take more CPS above background to cause an alarm.

Background Time This value controls the amount of time the unit takes to count down and display a background. Increasing the time will help smooth the data and give a more accurate background count. In most cases the default setting of 5 should be the preferred setting.

Motion Time Adjusting this value changes the amount of time the unit must remain motionless until it switches to background mode. If the value is changed to 0 the unit won't sense motion. The unit will need to be manually put in search or find mode with the panel buttons.

Gamma LLD The Lower Level Discriminator (LLD) is the value for the lower energy window setting for the unit. Raising this value could cause some of the lower energy sources to be missed during a search. Lowering this value can cause false readings caused by noise. This value should be left at the default setting.

Gamma ULD The Upper Level Discriminator (ULD) is the value for the upper energy window setting for the unit. Lowering this value could cause some of the higher energy sources to be missed during a search. This value should be left at the default setting.

Neut LLD Sets the voltage of the neutron channel lower level discriminator

Neut ULD Sets the voltage of the neutron channel upper level discriminator

Neutron Alarm This value is the threshold for a neutron alarm in CPS. Increasing this value will mean that it will take more neutrons to cause the unit to alarm.

Low Gamma Alarm Gamma background CPS that fall below this value will cause a Gamma Low Fault message to be displayed on the unit.

Restrict Setup The default setting for this feature is off. This will allow any user to change the unit's parameters by using the front panel buttons. If you want to prevent parameters from being changed in the field, then the Restrict Setup should be turned ON.

Count Mode Displays the current or previously used search mode.

Gamma Units Changes how the data is being displayed. The selections are Counts per Second (CPS), MilliRem per Hour (mR/Hr), and MicroSieverts per Hour (uSv/Hr). The mR/Hr and uSv/Hr are not energy compensated. Values are estimated. This is not to be used as a survey instrument.

Alarm Pitch Adjusting this parameter causes the pitch of the SEARCH mode audible alarm to change. The FIND mode audible alarm is unaffected by this control. This feature can be useful to someone who has hearing difficulties for a particular range of tones.

TX Data Must be ON for the Application to display received count data and show plots of the data. Parameters can be viewed and changed without needing this ON. To conserve the battery, this feature should be turned OFF after you have finished observing the data or plots.

3.5 PROGRAMMING FROM THE FRONT PANEL

Front Panel switches (see photos on next page)

POWER - turns the unit on/off

MODE - Change mode from background to fast count. Hold down to enter menu. When in the menu, MODE acts as an ENTER button.

LIGHT - Turns the back-light on/off. When in the menu, LIGHT acts as an up arrow.

S/F - Search/Find - toggles fast count between search and find modes. When in the menu, S/F acts as a down arrow.

Internal motion switch - An internal motion switch senses when the unit is picked up or set down. If Motion Timeout is enabled (any value other than zero), the unit will enter background mode whenever the unit has set motionless for a user defined amount of time (see Motion Timeout below). If enabled, the unit will automatically change modes from background to search or find when the unit is picked up.

Menu - To enter the menu, press and hold MODE. "SETUP MODE" will be displayed along with a menu item. To change the value of a menu item, press MODE. "Adjust Value" will be displayed along with the current value of the menu item. Use the "LIGHT (up)" and "S/F (down)" buttons to increase or decrease the value. When the desired value is displayed, press MODE to accept. To view additional menu items, press the "S/F (down)" button to advance to the next item or press "LIGHT (up)" to return to the previous menu item. Below is a list of available menu items.

Front Panel

Side Panel

MENU ITEMS

ITEM	RANGE	DESCRIPTION
Sigma	1-100	Allows user to adjust the Sigma alarm threshold
Bkg Time	1-1000	Background time in seconds
Motion Timeout	0-3600	Adjusts how long the unit will remain in search or find mode before entering background mode if left motionless. Zero will disable motion timeout and the user will be required to change modes manually
Neu Alarm	1-10000	Adjusts the neutron alarm level in counts per second
Gamma LLD	0-5.00	Sets the voltage of the gamma channel lower level discriminator
Gamma ULD	0-5.00	Sets the voltage of the gamma channel upper level discriminator
Neut LLD	0-5.00	Sets the voltage of the neutron channel lower level discriminator
Neut ULD	0-5.00	Sets the voltage of the neutron channel upper level discriminator
Audio Adj	0-200	Sets the SEARCH mode alarm tone. The higher the number the higher the tone
Low Gamma	0-10000	Sets the low alarm fault value for the gamma channel
Units	CPS,mR/Hr,uSv/Hr	Sets the gamma channel display units (mR/Hr,uSv/Hr are not energy compensated. Values are estimated This is **not** to be used as a survey instrument)
CAL CPS/mR/Hr		Allows the user to calibrate the unit for CPS per mR/Hr. To perform the calibration, place the unit in a known mR/Hr field and adjust the K-factor with the "LIGHT (up" and "S/F (down)" buttons until the mR/Hr display matches the known field
TX DATA	ON/OFF	Turns RS-232 one second blind broadcast of count data on/off IMPORTANT: Turn off to increase battery life
EXIT		Exit the menu and return to operation

If these parameters are changed, the changes should be documented and retained for future reference.

3.6 FIELD ELECTRONIC ALIGNMENT PROCEDURES

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

Tools and equipment

Since the electronic alignment procedures require specialized tools and knowledge, only qualified technical personnel should work on these instruments.

- Oscilloscope with greater than 20 Meg. Band width
- Tweaker or small slotted screwdriver
- Digital voltmeter with a resolution of 0.1 millivolts
- High voltage probe with a range of 10,000 Vdc and Zin ≥100MΩ
- 5-10uCi ^{137}Cs test source

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

Gamma

1. Use the scope to set the high voltage for a first stage gain of 1.5 volt with the ^{137}Cs (GHA TP1 and R10 upper board). (Reference drawings 3 and 10)
2. Adjust the second stage gain for 4.0V with the ^{137}Cs (GHA TP2 and R17 upper board). (Reference drawings 3 and 10)

Neutron

1. Max out the second stage gain. (GHA TP2 and R17 lower board). (Reference drawings 3 and 10)
2. Set the high voltage for 1375 volts (GHA TP1 and R10 lower board). (Reference drawings 3 and 10)

4.0 OPERATIONAL TEST

Due to the many different environments and materials being monitored, the operational test will vary from site to site, although several general principles apply in all cases.

1. Select an appropriate source, and instruct the user to approach the source with the PRM-470C in the SEARCH or FIND mode.
2. Record the distance at which the unit alarms.
3. Repeat the test several times and record the sources and sizes used.

4.1 GAMMA and NEUTRON MAINTENANCE

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 unit
- performing a test using sources

4.2 COMPONENT ACCESS

Battery : To remove, disconnect the in line connector between the printed circuit board and the battery and lift it out. To reinstall the battery, reverse the above.

The **gamma detector assembly** can be removed by disconnecting the cabling and removing the brackets 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 **neutron detector assembly** can be removed by disconnecting the cabling and removing the brackets that secure them in place. Handle these with care to avoid damage. To replace, set the detector in place and fasten the Velcro straps, and connect the cabling.

5.0 GLOSSARY

CPS or cps: Counts Per Second

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.

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.

6.0 PARTS LISTS

6.1 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)

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

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

6.2 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.	Stock #	Description
1	6471	NiMH 4 cell battery pack
1	6471D	NiMH charger w/ 3 pin DIN connector
1	8673A	PRCB-472A
1	8674A	GHA-472
1	8677E	PRM-470 Detector (gamma)
1	6690B	HE-3 Neutron Detector

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

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

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

EFFICIENCY

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

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

N*Sigma Alarm Level

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

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

where:
bkg = Background counts
Sigma = 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

SIGNAL TO BACKGROUND RATIO

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

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

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

VARIANCE

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

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

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

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

where:
C = counts per sample time

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

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

LIST OF DRAWINGS