BOX MONITOR

MODEL BM-185

OPERATING AND SERVICE MANUAL

Version 1.10.z

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TSA systems

BM-185

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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 BM-185. 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 Box Monitor, Model BM-185, is a box monitoring device, designed to screen small items of up to 50 pounds weight for radioactive contamination. It uses six plastic scintillation detectors, one each on the top, bottom, back, left and right sides of the chamber, plus one in the door.

Operation of the instrument is controlled from an integral terminal. All access is controlled by user-assigned password protection. An external printer with a standard Centronics interface can be connected to allow printing the background data.

The instrument performs a self-test and acquires a new background count each time it is powered up. It also monitors its own operation during normal use and indicates any failures. It runs continuously, updating backgrounds whenever no weight is detected inside the chamber. A new count is initiated every time a door open/door close sequence is detected.

The BM-185 operates on 120VAC 60Hz power. The internal power supply is protected by a line conditioner with a 4 ampere circuit breaker.

1.3. SPECIFICATIONS

Sensitivity:	See graph on next page "Minimum Detectable Activity Chart"
Detectors:	Six 12" x 12" x 1.5" (30 x 30 x 3.75cm) plastic scintillation detectors coupled to photo-multiplier tubes via prisms
Display:	Alphanumeric LCD, 2 lines x 40 characters, with backlight; red, amber, and green LEDs indicate status
Power Requirements:	115/230 Vac, 47 – 63 Hz, <500 VA
Scan Time:	1 to 1,000 seconds or minutes, user-programmable
Background Time:	11 to 1,000 seconds or minutes, user-programmable
Serviceability:	May be repaired to the board/subassembly level in the field
Dimensions:	
Overall:	43" h x 32" w x 28.5" d (108 x 80 x 71cm)
Internal Cavity:	12" high x 12" wide x 12" deep
Volume:	≈1 ft^3 (28 liters)
Unit Weight:	1,900lb (864kg) including casters
Sample Weight:	1 to 50 pounds (0.5 to 23kg)
Environmental:	
Temperature:	32 to 100˚ F (0 to 40˚C)
Humidity:	0 to 95% Relative Humidity (non-condensing)

INSERT

BM-185 Sensitivity Graph here

2. INSPECTION AND SET-UP

The following procedures should allow on-site personnel to correctly install and set up the BM-185 for normal operation. Follow the procedures in the order given. It is recommended that a copy of the Initial Installation Checklist (section 2.4.) be filled out after initial installation and whenever the BM-185 is put into service after prolonged storage.

Use the Configuration Tracking Sheet (Appendix D.) for maintenance and tracking instrument modifications.

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

2.1. INSPECTION

2.11 Incoming Inspection:
Immediately inspect the system for mechanical damage, scratches, dents, or other defects. It should be examined for evidence of concealed damage, as well as external disfigurement.

2.1.2. Damage Claims:
If the system 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 repair or replacement of the BM-185 as necessary.

2.1.3. Storage:
Care should always be taken to avoid subjecting the BM-185 to severe mechanical or electrical shock. The BM-185 should be stored in a dry location and in a temperature range of 0 to 60 degrees Celsius.

2.1.4. Shipping:

Before returning the BM-185 for any reason, notify TSA Systems of the difficulty encountered. Please be prepared to give the model and serial numbers of the equipment. TSA will furnish precise shipping instructions.

2.2. INSTALLATION

Connect the modular power cord to the power entry module on the rear of the BM-185 and plug it into a standard 115 volt 60 Hz AC receptacle. The power switch is located on the power entry module.

2.3. SET-UP AND PARAMETER ADJUSTMENT

This setup must be performed before putting the BM-185 into service. Make a copy of the Initial Installation Checklist (section 2.4.) and record the settings on the copy. This checklist may be helpful to refer to when troubleshooting the BM-185 in the event of a failure.

2.3.1. Discriminator Adjustments:

The discriminators (lower level and upper level) set the minimum and maximum energy levels at which the BM-185 will accept nuclear pulses to count. The adjustment range is from 0 to 2,000 keV. The adjustments are controlled by two 10 turn dials located inside the top cover of the BM-185. The approximate energy level in keV can be obtained by multiplying the knob settings by 200.

The exact value may vary slightly due to variations in the detectors and electronics.
For initial setup, a good starting point is:

LLD = 0.2 turns = 40.0 KeV
ULD = 10.0 turns = 2.0 MeV

NOTE:

The minimum LLD setting must be above 0 to prevent system "noise" from influencing the count.

Pressing the <Enter> key during normal operation will cause the BM-185 to prompt the user for a password before the set-up mode may be accessed. The set-up mode allows the user to access the set-up and diagnostic features of the BM-185. The following functions are available from the set-up mode:

SET-UP MODE FUNCTIONS		
F1: Show Count	F4: Scale Calibration	F7: Display Time
F2: Variance Analyzer	F5: Calibrate	F8: Exit to Operation
F3: Parameters	F6: Set Time	F9: Change Password

NOTE:

The password is set to "." when the BM-185 is shipped from the factory.

2.3.2. Show Counts [F1]:

Displays the counts/second for each detector and the total counts/second in the following format:

RIGHT	TOP	LEFT	
BOTTOM	BACK	DOOR	TOTAL

Press any key to exit the show counts mode.

2.3.3. Variance Analyzer [F2]:

The variance analyzer initiates a variance test. Each "pass" of the variance analyzer takes 15 seconds; the results are not valid until three passes have been completed.

The variance test checks the signal from each detector channel for Gaussian distribution. The variance should be 340.25 for each detector after three 15 second passes (the data is not valid until three passes have been completed).

NOTE:
If the reading is above 0.25 refer to the troubleshooting section to diagnose the problem.

Variance results are shown in the following format:

RIGHT	TOP	LEFT	
BOTTOM	BACK	DOOR	OVERALL

This test is helpful when setting the lower level discriminator. If the discriminator is set too low, power supply noise may be counted resulting in a variance near 1.0.

2.3.4. Setting Parameters [F3]:

This function allows the user to set the operating parameters for the BM-185.

There are no "artificial limits" placed on the numeric parameters; any number the computer can accept may be input. Numeric values are input directly from the numeric keypad and terminated with the <Enter> key. The remaining settings are selected from a list by pressing any numeric key to step through the list and <Enter> to accept the displayed value. Pressing the <Enter> key accepts the current value and steps to the next parameter.

Each parameter is explained in detail below:

2.3.4.1. Activity Alarm Limit:

Sets the level, above background, that will result in a radiation alarm for the activity alarm mode. The units depend on the setting in alarm units.

NOTE:

The BM-185 may indicate an alarm with slightly lower activity level than is input. This is necessary to ensure the confidence of detection.

2.3.4.2. Alarm type:

Activity, Specific Activity or Both

Activity alarms on the level set in "Activity Alarm Limit".

Specific activity alarms on the level set in "Specific Alarm Limit".

Both will allow an alarm if either of these limits is exceeded.

2.3.4.3. Alarm Units:

Sets the units for Activity Alarm Limit (section 2.3.4.1.). The possible selections are:

pCi, nCi, µCi or CPS.

2.3.4.4. Specific Activity Alarm Limit:

Sets the level, above background, that will result in a radiation alarm based on activity per unit weight. The units depend on the setting in specific activity units.

2.3.4.5. Specific Activity Units:

Sets the units for Specific Alarm Limit. The possible setting are pCi/gram, nCi/gram, µCi/gram, pCi/kg, nCi/kg, µCi/kg, pCi/lb, nCi/lb or µCi/lb.

2.3.4.6. Curie Calibration Source Activity:

Sets the size of the calibration in the units selected in curie range (next entry). This is the source that must be used for efficiency calibration (section 2.3.6.).

2.3.4.7. Curie Calibration Units (Range):

Selects the units for the calibration source in section 2.3.4.7. to pCi, nCi, µCi, DPS or DPM.

2.3.4.8. Automatic recount

Enables or disables automatic recount. With automatic recount enabled, the BM-185 will flash the alarm lamp, beep and initiate a second scan in the event of an alarm.

2.3.4.9. System Efficiency:

Allows the user to manually input an efficiency in percent. The efficiency calculation may also be performed automatically. Refer to section 2.3.6. Calibration.

2.3.4.10. Low Background Alarm Limit:

Sets the low background limit in counts per second per detector. There is no low background limit check on the total background count. This value is normally set to approximately 12 the normal background count of the detector with the lowest background.

2.3.4.11. High Background Alarm Limit:

Sets the high background limit in counts per second per detector. There is no high background limit check on the total background count. This value is normally set to approximately twice the normal background count of the detector with the highest background.

2.3.4.12. False Alarm Rate:

Sets the maximum acceptable false alarm rate. The numerator is fixed at 1, only the denominator is entered. Example: If 1 false alarm in 100 scans is tolerable, enter 100.

This value is only used in determining the detection limit (RDA). The less false alarms that can be tolerated, the higher the Reliable Detectable Activity will be.

2.3.4.13. Confidence of Detection:

Sets the confidence of detection (in sigma). The larger this value, the lower the chance of not alarming on the activity alarm value (2.3.4.1. and 2.3.4.3.).

For example: A setting of 1.3 results in a 90% confidence of detecting a source equal to the programmed alarm level; a setting of 3.1 results in a 99.9% confidence of detecting a source equal to the programmed alarm level.

This value is also used in determining the RDA. The higher this value, the higher the RDA will be.

NOTE:
The BM-185 may alarm on an item, but indicate less than alarm level activity. This is due to the statistical uncertainty of the measurement and is 100% normal. The probability of this occurring is directly related to the confidence level.

2.3.4.14. Weight Units:
Selects the units of weight that will be displayed. Units may be set to pounds, kilograms or grams. Internally the unit keeps all weights in grams and converts to the required units for display and alarm purposes.

2.3.4.15. Background Count Time:
Sets the time required in minutes or seconds (section 2.3.4.19.) to acquire an initial background for either standard or rolling background. In the fast background mode this entry has no effect on system operation.

2.3.4.16. Background Count Units:
Selects the units (minutes or seconds) to be used in conjunction with background count time (section 2.3.4.17.).

2.3.4.17. Background Method:
Selects rolling, standard or fast background method. The background display will be normalized to counts per second regardless of the background method.

Rolling Background:

The initial background will take the programmed background time to collect. The background count time is divided by 10, and the 10 most recent count periods are summed to make up the current background. After the initial background, the background will be automatically updated when the BM-185 is idle for background time/10.

Standard Background:

The initial background will take the programmed background time to collect. The background will be updated when the BM-185 is idle for this period of time.

Fast Background:

The initial background is complete when 10,000 background counts per detector have been acquired. When the BM-185 is left idle long enough to acquire an additional 10,000 counts, the background will be updated.

2.3.4.18. Printer:

Toggles the background printing off or on. When the printer is on, the date, time and current background count (in CPS) will be sent to the parallel printer port.

2.3.4.19. Calibration Due:

Sets the calibration cycle (in months). May be set to "0" to disable, or the number of months efficiency calibration is valid. Each time the BM-185 is calibrated (Section 2.3.6.) the calibration due date will be adjusted appropriately. The weight calibration does not update the calibration due date.

When the current date is later than the calibration due date both the efficiency and weight calibration factor will be set to 0. Both the efficiency and weight calibrations must be run before system operation will be allowed.

2.3.5. Calibrate Scale [F4]:

Performs a menu-driven, software calibration of the scale circuitry. The scale is first tared, then calibrated to a given weight (in grams). The last calibration weight entered is stored in non-volatile RAM, but the operator may input any weight up to 22,700 grams (50 lb.). The conversion factor used by the BM-185 is 454 grams per pound.

NOTE:

Scale calibration requires a calibration weight. Calibration weights may be acquired from the following manufacturer:

Cardinal Scale Mfg. Company
P.O. Box 151
Webb City, MO 64870
Phone: 417.673.4631
FAX: 417.673.5001

2.3.6. Calibrate [F5]:

Performs an automatic efficiency calibration. The routine will guide the operator through the calibration with prompts on the display.

The BM-185 will use the calibration source that was last entered in the set-up menu (section2.3.4.7. and section 2.3.4.8.). If a different source is to be used, exit the calibration routine and enter the proper calibration source in the set-up menu before proceeding.

The operator will be prompted to remove all sources from the chamber for a 60 second background count. The calibration may be aborted at this point by pressing the <Del> key.

Finally, the operator will be prompted to place the calibration source in the center of the chamber. The BM-185 will take another 60 second count with the source. The efficiency (in percent) will be automatically calculated and displayed. The efficiency for individual detectors and overall efficiency will be displayed. The BM-185 uses only the overall efficiency; the individual readings are displayed for reference only. The efficiencies will be displayed in the following format:

RIGHT	TOP	LEFT	
BOTTOM	BACK	DOOR	TOTAL

If the "Calibration Due" parameter is set "non-zero" the new calibration due date will be displayed after the efficiencies.

2.3.7. Set Time [F6]:
Allows the user to enter the current time and date.

2.3.8. Display Time [F7]:
Displays the current time and date settings.

2.3.9. Exit to Operation [F8]:
Returns to normal operation mode.

2.3.10. Change Password [F9 (2^{nd} then F1)]:
Prompts the user for a new password. A password may be any combination of up to ten keys (numeric or F keys only). The new password is stored in battery-backed non-volatile RAM.

WARNING:
Use caution when entering a new password. There is no verification!

2.4. INITIAL INSTALLATION CHECKLIST

Background:

__________ Counts

Test Source:

Isotope: __________ Activity; __________nCi

Serial No.: __________ Date of latest assay: __________

No. of Counts:

Right: __________ Top: __________ Left: __________

Bottom: _________ Back: __________ Door: __________

Total: __________

Efficiency:

Right: __________ Top: __________ Left: __________

Bottom: _________ Back: __________ Door: __________

Total: __________

Discriminator Settings:

LLD: ___________ ULD: __________

Set Up Parameters:

Alarm Limit: ___________
Alarm Type: ___________
Alarm Units: ___________
Specific Activity Alarm Limit: ___________
Specific Activity Units: ___________
Curie Range: ___________
Curie Calibration Factor: ___________
Auto Recount: ___________
System Efficiency: ___________
Low Alarm Limit: ___________
High Alarm Limit: ___________
False Alarm Rate: ___________
Confidence Factor: ___________
Weight Units: ___________
Background Count Time: ___________
Background Time Units: ___________
Background Method: ___________
Printer: ___________

Performed by: ______________________________ Date: __________

3. OPERATING INSTRUCTIONS

The BM-185 has been designed to be easy to operate. After the unit has been set-up, the operators require minimum training time.

3.1. CONTROLS AND INDICATORS

The BM-185 uses a terminal with a 40 character by 2 line alphanumeric display to provide system information.

The BM-185 is also equipped with three colored LEDs to indicate current operating status.

RED	Alarm
YELLOW	Acquiring Initial Background or Counting
GREEN	Ready

A speaker is also provided to annunciate certain conditions.

3.2. POWER UP AND SELF TESTS

When the BM-185 is powered up, it automatically executes a Power On Self Test (POST) on the following components:

System memory
Communications
Lamps
Counters (both weight and gamma)
Calibration required (either efficiency and/or weight)

If any of these tests fails, the BM-185 must be repaired (or calibrated) before operation. Certain fatal errors that could prevent operation of the terminal will also be reported via the LEDs. These LED codes are explained in the troubleshooting section of this manual.

The "Calibration Required" message is triggered if either calibration factor is "0".

NOTE:
If the "calibration required" failure is displayed, the second line of the display will indicate whether the [eff]iciency, [weight] or both calibrations are required. This message indicates that calibration is overdue or the non-volatile RAM/timekeeper has failed. It is advisable to check the clock/calendar and perform both calibrations to ensure proper operation.

Refer to sections 2.3.5. and 2.3.6. for instructions on calibrating weight and efficiency.

3.3. NORMAL OPERATION

After successful completion of the POST, the BM-185 will prompt the operator to verify that the chamber is empty and press the <Enter> key so the scale may be tared.

NOTE:
The scale should be tared periodically during operation.

The BM-185 will then automatically begin acquiring an initial background. The yellow LED will stay illuminated until the initial background is complete.

When the initial background is complete, the green LED will illuminate and the BM-185 is ready to scan items.

To initiate a scan, merely open the door and place the item to be scanned in the chamber. The BM-185 will first check the weight in the chamber. If the item weight is ≈500g (approximately 1.1 lb) the operator will be prompted for a scan time and factor.

Enter the count time. (minutes or seconds as programmed in the set-up menu)
Press enter.
Enter the transmission factor.
Press enter to start the scan.

The yellow LED will illuminate during the actual scan.

If the item is below alarm level(s), the BM-185 will chime and illuminate the green LED.

If the item is above alarm level, the BM-185 will illuminate the red LED and beep intermittently for approximately 10 seconds.

If automatic recount is enabled, the BM-185 will beep once and initiate a new count.

After the second count, the BM-185 will indicate clean or contaminated as above.

When the item is removed, the BM-185 will again check the weight in the chamber. If the weight is ≈500 g, another scan will start, otherwise the BM-185 will return to background update mode.

3.4. SCANNING LONG ITEMS

Pressing the F8 key initiates a scan without weight in the chamber. Long item scan uses the "Activity Alarm Limit" set in section 2.3.4.1. Since there will be no weight associated with the scan, the specific activity alarm cannot be used in this mode.

NOTE:
Turn the BM-185 off before removing the plugs for long item scans. Insert a 4 ½" tube carefully to void damaging the detectors. (The tube is not supplied with the BM-185) Turn the unit back on and wait for a new background.

3.5. PRINTING FEATURES

3.5.1. Print Background:
If the print mode is on and a printer is attached to the parallel printer port, the current date, time and background count will be printed each time the display is updated.

3.5.2. Print Parameters:
F10 [2nd then F2] will cause the BM-185 to print the current operating parameters. This will allow the operator to verify the operating parameters without having access to the password.

4. THEORY OF OPERATION

The BM-185 system is a self-contained small article monitor, controlled by a microprocessor, with an alpha-numeric terminal to monitor and control system operation. Operating parameters are set from the keyboard via a password protected set up menu.

The system continually monitors itself for fault conditions, and displays any errors on the terminal display. If the system detects a fault condition, it will not allow normal operation until the fault condition is corrected.

4.1. LOW VOLTAGE POWER SUPPLY

The power supply provides ±12 and + 5 VDC for all of the BM-185's electronics. This unit is purchased from Power One, Inc. and no schematics or detailed theory of operation is available.

4.2. CONTROLLER (CPU-902)

XC01 supplies a 4MHz clock to the ICs that make up the actual microprocessor (U1, U2, U4, and U5). U46 provides power-up reset and resets the computer if it is not properly executing the program. U6 is the PROM memory that contains the program; U7 and U8 provide transient memory. U7 provides battery backed non-volatile RAM and a clock/calendar.

U47A and U44 prescale the 4MHz clock before it is sent to the U5 and further divided for use by the SIO, audio tone generator, and system timing circuits.

U9 and U10 shift the voltage levels of the data to/from the serial ports.

U20 - U24 are general purpose counters. Each IC contains three 16 bit counters, which are normally used as radiation counters.

U25 - U27 are used to synchronize the counter inputs to the system clock before the pulses are sent to the general purpose counters. U35 - U38 selects either the synchronized pulses or a test count to the counter ICs (U20 - U24). The test counts are selected only during the power up self-tests.

U3, U13, and U14 latch output data to U11, U12, and U15 respectively. U11, U12, and U14 provide high current, open collector outputs for driving relays, lamps, or other relatively high current loads.

U34 is a general purpose analog to digital converter. U28 allows up to eight separate inputs to U28. The ADC may be used to monitor battery voltage, or other DC voltages as required by a particular application.

U47B supplies a square wave input to the audio amplifier (U45) for output to a loud speaker. VR1 and VR2 provide regulated +5 VDC and +12 VDC respectively. The CPU-902 uses +5 VDC for its logic and can support light external loads. The CPU does not use +12 VDC itself, but can provide ¸100 ma for external loads. U43 converts +5 VDC to -5 VDC for use by the RS-232 communications and LCD display.

The balance of the ICs on the CPU-902 board provide the required "glue logic" for address decoding etc..

4.3. DETECTOR ASSEMBLIES

The six radiation detectors consist of a 12" x 12" x 1.5" piece of plastic scintillation material coupled to a photo-multiplier tube via a prism. Each photon that is detected by the PMT produces an output pulse that is coupled to the SCA-452 board.

4.4 NUCLEAR PULSE AMPLIFIER (SCA-452)

Pulses from the scintillation detectors are routed from the dynode on each Photo-Multiplier tube through shielded BNC cables to the Controller module, and then into one of three inputs on one of the two SCA-452 amplifier boards. The cables from the door detector route through the door cable assembly on the top of the unit. Each pulse is amplified, and its shape normalized, by a "two operational amplifier" wave shaping circuit.

The output amplitude is then compared to the two voltages set by the Upper Level Discriminator potentiometer and Lower Level Discriminator potentiometer. (All of these circuits are also located within the Controller Module.)

Any pulses having an amplitude greater than the LLD and less than the ULD pass through the comparator circuits and trigger a one-shot pulse generator. A second one-shot stretches the output of the first one-shot to approximately 1.5 μsec. The 1.5 μsec pulses from all six detector amplifiers are sent to counters on the CPU-902 board.

The SCA-452 also supplies the 10.000 volt reference voltage to the discriminator controls.

4.5. HIGH VOLTAGE POWER SUPPLY (HHV-448)

High voltage to power the Photo-Multiplier tubes is furnished by the two HHV-448 High Voltage Power Supplies. These use the +12V input from the power supply to drive a discrete voltage multiplier diode/capacitor network, which boosts the output to approximately 1,000 Volts. HHV #1 supplies power to the Right, Left, and Top detectors, while HHV #2 powers the Bottom, Back, and Door.

4.6. SCALE AMPLIFIERS

Two Scale Amplifiers, each monitoring a load cell, are located in the upper electronics enclosure directly behind the CPU-902 and SCA-452 boards.

The load cells are strain gauges, utilizing a resistive bridge, across which +10 Volts from the amplifier card is applied. Changes in load produce a differential DC voltage output, which is amplified and buffered by a quad op amp (U1) differential amplifier circuit. Resistor R6 controls the DC offset, and R9 controls the gain.

The buffered output is applied to a Voltage-to-Frequency Converter. The two frequency signals (actually variable frequency pulse trains) are sent to the CPU-902 board where the pulses are counted to determine the weight in the chamber.

5. MAINTENANCE

Calibration of the scale amplifiers requires two customer supplied calibration weights. The software calibration has proven to adequately compensate for minor changes in the scale circuitry over time. The scales should be checked for accuracy each time the unit is calibrated. If the accuracy is within tolerance (± 0.5lb) the amplifiers are working properly and do not require hardware adjustment. For this reason the scale amplifier calibration is only covered in Troubleshooting (section 6.).

A Calibration Checklist (section 5.2.) is included at the end of this section. It is recommended that a copy of this be filled out whenever the BM-185 is put into service after tuning and recalibration.

5.1. CALIBRATION

5.1.1. HHV-448D:

Refer to "HHV448D Component Designator" Drawing 16 and "HHV-448D Schematic" Drawing 15 (Appendix F.)

WARNING:

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

The following tools are needed for this calibration procedure:

DVM
High voltage probe with a range of at least 10kVdc, input impedance 100MΩ

The High Voltage is adjusted using R1 on the HHV-448D board. The adjustments are accessible through two holes in the aluminum plate under the scale amplifiers.

Connect the high-voltage probe between the terminals marked "HV" (+) and "COM" (-) on the board. Adjust R1 on the board until the voltage reads 1050 ±50 volts DC. If the voltage will not reach this level or isn't stable within ±5 volts, the board must be replaced.

5.1.2. SCA-452B:

Refer to "SCA-452B Schematic" Drawing 13 & "SCA-452 Component " Drawing14. (Appendix F.)

The following tools are needed for this procedure:

DVM capable of reading in tenths of millivolts (.0001)
Oscilloscope with greater than 20 MHz
^{137}Cs source between 5 and 10 µCi
^{60}Co source between .5 and 5 µCi

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

Disconnect the inputs from the SCA board by removing the wires from J1, J2 and J3. Connect the DVM from the ground jumper X4 to R94 on the end closest to J6, then by adjusting R95 obtain a reading of 10.00 volts on the DVM. This is the reference voltage to the discriminator (only the reference voltage on SCA #1 is used in this application).

Leave the ground or common lead of the DVM on the ground jumper X4, and move the other lead to test point 2 (TP2) on the SCA board. By adjusting R14, obtain a reading on the DVM of -5.0 millivolts. Move the lead from test point 2 (TP2) to test point 4 (TP4) and adjust R43 to obtain a reading of -5.0 millivolts. Move the lead to (TP6) and adjust R77 for a reading of -5.0 millivolts. This adjusts the offset of the gain stages.

CAUTION:
Before proceeding make sure that the high voltage to the detectors is set to 1,050Vdc. See the HHV-448 tune-up procedure (section 5.1.1.) if necessary.

When you have verified the high voltage setting for both boards, reconnect the signal inputs to the SCA board. Attach the oscilloscope to the SCA-452B board and set as follows:

probe A to (TP2)
probe ground to X4
vertical deflection of 1 volt/division
horizontal sweep to 0.5 µseconds/division
positive edge triggering

The signal seen should resemble "Typical Pulse Profile." Drawing 21 (Appendix F.).

Place the source on the detector connected to channel 1. Follow the cabling if necessary to locate this detector. The pulse profile should now resemble "Pulse Profiles with Cesium" Drawing 21. (Appendix F.)

If not, adjust R7 on the SCA board to obtain a 3.3 volt ±0.3 volts pulse height. Move the probe to (TP4) and the source to the other detector, and adjust R37 for the same pulse height. Move the probe to (T6) and the source to the next detector, and adjust R68 for the same pulse height. The other adjustments are factory set and should not be attempted in the field.

Repeat section 5.1.2. for a second SCA-452B board.

After calibration is performed, remove source. Thereafter a variance test should be run to ensure that there are no problems with the detector channels. Refer to section 2.3.3. for details of the variance test.

5.2. CALIBRATION CHECK-LIST

High Voltage: HHV #1: __________ VDC HHV #2: __________ VDC

New Voltage Setting (if adjusted): ____________________

HHV #1: __________ VDC HHV #2: __________ VDC

Pulse Amplitude - Plastic Detectors:

Test Source: Isotope:__________ Activity: __________ µCi

Serial No.:________ Date of latest assay:__________

Peak Volts: Right: __________ Top: __________ Left: __________

Bottom: _________ Back: __________ Door: __________

Variance: Right: __________ Top: __________ Left: __________

Bottom: _________ Back: __________ Door: __________

Overall Efficiency: __________ %

Scales: Record measured weight for each test weight.

5 lb: __________ 25 lb: __________ 50 lb: __________

Performed by: _____________________________Date: ___________________

6. TROUBLESHOOTING

6.1. DIAGNOSTIC AIDS

The BM-185 is provided with diagnostic tools to assist in isolating certain problems that might otherwise be very difficult to troubleshoot.

6.1.1. Power-Up LED Codes:

When the BM-185 performs its POST, it reports the results to the terminal. As a back-up reporting method for fatal errors, the BM-185 will flash the following LEDs to indicate the following failures:

Red:

Red indicates a counter failure.

Red and yellow:

Red and yellow indicates a RAM test failure.

Red and green:

Red and green indicates the program could not properly open the communications link between the CPU board and the terminal.

Red, yellow and green:

Red, yellow and green indicates a failure in the communications hardware on the CPU board.

NOTE:

These are all considered fatal errors, and the BM-185 may not be used until they are corrected.

6.1.2. Variance Analyzer:

The variance analyzer mode is used to check whether the counts seen by the controller are actually from the proper distribution. If the distribution is normal, the resulting number will approach 0. Any significant deviation from the normal distribution will result in a larger number.

$\bar{R}$, the running value of "R", is displayed every 15 seconds. In an undisturbed background environment, the R values should be 0.25 or less, after three cycles.

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 15 seconds. Passing is any number lower than 0.25 after 3 passes (45 seconds). The results of each pass is displayed on the terminal and annunciated by audio tone. Variance results are shown in the following format:

RIGHT	TOP	LEFT	
BOTTOM	BACK	DOOR	TOTAL

6.1.3. Force Set-Up Mode:

Setting Dip Switch 1 to "open" before powering up the BM-185 will force the system into the set-up mode. This feature is provided to allow the user to access the set-up mode in the event that the system memory has been corrupted.

6.1.4. Tone On/Off:

Setting dip switch 2 to "open" before powering up the BM-185 will disable the speaker. The keyboard will provide audio feedback when a key is pressed.

6.1.5. Scale Diagnostics:

Setting Dip Switch 3 to "open" before powering up the BM-185 will put the system into a Scale Diagnostics mode. In this mode the raw counts (in CPS) from each of the scale amplifiers as well as the weight in the chamber (in grams) will be displayed.

6.1.6. Load Default Parameters:

Setting Dip Switch 8 to "open" before power up will load a set of default parameters. This feature is provided to allow recovery after replacing the non-volatile RAM chip, or a major malfunction that corrupts the data in the non-volatile RAM to the point that the BM-185 cannot be operated.

This also writes the appropriate codes to the EEPROM in the terminal and resets the password to ".".

NOTE:

Loading default parameters will destroy the efficiency and weight calibration factors.

6.2. FAULT ISOLATION

If the system fails to operate properly, note all anomalies, and try to determine if or how they are related. This will frequently help to isolate the problem, and reduce the time required to repair the system.

Always perform a thorough visual inspection of the suspect assemblies, looking for loose connectors, pinched and broken wires, burned components, and signs of overheating.

NOTE:

Always turn the power off when connecting or disconnecting components or cables.

After repairing the system, perform a calibration as outlined in Section 5.

6.3. SCALE AMPLIFIER SET-UP AND CALIBRATION

Refer to "Scale Amplifier Schematic" Drawing 17 and "Scale Amplifier Component Designator" Drawing 18 (Appendix F.) for scale amplifier identification and component locations.

The scale amplifier set-up and calibration steps are as follows:

1. Turn dip switch 3 on the CPU-902 board to "open" and turn the unit on. This will display the counts from the four load cell amplifiers.

NOTE:
Let the unit warm up for a minimum of fifteen minutes before performing a final scale calibration. This will allow the electronics and load cells to stabilize prior to calibration.

2. Connect a DVM between TP1(+) and TP4(-) on scale amplifier #1 (left side).

3. Adjust R6 (offset) for a reading of 0.050 ±0.010Vdc.

4. Repeat this procedure for scale amplifier #2 (right side).

5. Disconnect the DVM.

6. Adjust R9 (gain) for a reading of 500 ±50 CPS on the LCD display for each load cells.

7. Turn the unit off and switch dip-switch 3 on the CPU-902 board to the closed position.

8. Turn the unit back on and perform the Scale Calibration Procedure (section 2.3.5). of this manual.

9. Turn the unit off and switch dip-switch 3 on the CPU-902 board to the open position.

10. Test the scale with at least 3 calibration weights (10 lb., 25 lb., and 50 lb. recommended).

11. Turn the unit off and switch dip-switch 3 on the CPU-902 board to the closed position.

This completes the scale amplifier set-up and calibration.

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.

Manufactured by

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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

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

C.2. EFFICIENCY

$E = \dfrac{N}{37 * \text{activity}}$	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.

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

MODIFICATION:____

____

INSTALLED BY:____________________________________ DATE:___________

E. PARTS

E.1. RECOMMENDED SPARE PARTS

A complete list of spare parts is available by contacting TSA Systems, Ltd.

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 provided with the instrument)

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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F. DRAWINGS

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

For Assistance Call:

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