

FLUKE®

Biomedical

Model 90100

TRACKER™ System

Operators Manual

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Section 1

General Information

1.1 Introduction

The Model 90100 TRACKER is a radiation measurement system intended for use in quality assurance programs for high-energy accelerators and Co₆₀ machines. While its ease of operation makes it ideal for daily checks of beam constancy, symmetry, and flatness, its portability makes it a good choice for field service engineers and consulting physicists. The two main components of the system are the Model 35360A TRACKER Display, and the Model 35300A Detector, see Figure 1-1.



Figure 1-1. Model 35360A TRACKER Display and Model 35300A Detector

The 35360A TRACKER Display contains a five-channel electrometer capable of producing measurements of both dose and dose rate. A microcontroller performs air density corrections and displays the measurement results on the 4 line by 20 character vacuum fluorescent display (VFD) directly in the user's choice of radiological units. An integrated rechargeable battery and a 300 V electronic bias supply greatly simplify maintenance of the system. Another important feature built into the 35360A TRACKER Display includes the capability for fully remote and automated operation via an RS-232 computer interface (software is not included).

The 35300A Detector contains an array of four orthogonally placed ion chambers on 10 cm radii from a fifth isocentrally located ion chamber. The five ion chambers are of a vented, circular, parallel-plate configuration and are fully guarded for low leakage. An overlay label on the outside of the 35300A Detector marks the ion chamber locations for alignment with a therapy source light field system. The 35300A Detector connects to the 35360A TRACKER Display through a lightweight interface cable. This

cable is of a design that provides a high degree of flexibility and allows it to flatten to fit under a treatment room entrance door.

Included with each 90100 TRACKER System is an MS-DOS based Customization program that provides a means of performing field customization and calibrations. Some of the items that may be field customized include the measurement display units, temperature and pressure units, the ion chamber calibration factors, and the number of minutes to power down. This program may also be used to generate a printed report containing all of the customization and calibration settings.

A number of optional accessories including a carrying case for storage and transport, build-up plates of various thickness/materials, and a build-up retaining hardware kit are available also.

1.2 Features

- Measurement values from peripheral ion chambers may be displayed in either absolute dose measurement units or as a percentage of the center ion chamber's measurement value.
- A wide AC Line Input Range of 100 to 240 VAC and the use of an IEC 320/C13 style receptacle provide worldwide operation by use of the proper line cord.
- The levels of the internal 300 V electronic bias supply and the rechargeable battery supply are continuously monitored. Annunciators appear on the display if an abnormal bias voltage or low battery voltage level is detected.
- All front panel settings are automatically stored at power down and restored at power up eliminating the need to reconfigure the front panel settings upon each use.
- Dose measurement values may be displayed in units of roentgens, rads, sieverts, grays, or monitor units. Dose rate measurement values may be displayed in units of roentgens/min, rads/min, sieverts/min, grays/min, or monitor units/min.
- Front panel gain settings allow the user to easily match displayed measurement values to the linear accelerator's monitor readout or to a precision calibration.
- Precision five-channel electrometer provides $\pm 0.003\%$ linearity and a long-term stability of better than 0.25% of reading per year.
- The system may be operated from either AC line power source or from its internal battery. The batteries will be charged during use from AC line power.
- A high performance rechargeable battery system provides 8 hours of continuous operation from a 3-hour charge. A low battery annunciator indicates when 30 minutes or less of operation remains.

1.3 Before You Start - Safety Precautions

This product is designed for quality assurance testing of therapeutic radiation treatment machines. It is not for machine calibration nor is it intended as a substitute for a precision dosimeter system (Farmer-type Probe and Electrometer with official calibration). Its use should be restricted to the monitoring of constancy of output, flatness, and symmetry. It is the responsibility of the user to establish the correct procedure of uses including the initial configuration of the device, (via the Customization program included). Quality assurance testing should be done by qualified personnel under the supervision of a trained medical physicist. The Model 90100 TRACKER System should be used only by people who are:

- aware of and understand the limitations of the device as they relate to the measurement of radiation output;
- knowledgeable about safety procedures observed when working with radiation sources, such as therapy radiation machines;
- aware of safety precautions required to avoid possible injury when using electrical/electronic equipment.

Please take the time to read this manual carefully before operating this instrument.

1.4 Safety Terms

The following terms are used in this manual.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

1.5 Manual Addenda

Any improvements or changes concerning the instrument or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

1.6 Specifications

1.6.1 Model 35300A Detector

Source Modes and Energies

Photons: 300 keV to 25 MeV, with suitable build-up material

Electrons: 2 MeV to 25 MeV, with suitable build-up material

Recommended Operation Conditions

Source Distance: 100 cm
Collimated Field Size: 25 × 25 cm
Source Dose Rate Range: 50 to 500 rads/min

Nominal Ion Chamber Characteristics

Wall and Window Material: Continental Polymers ACRYCAL-CP or equivalent
Window Area Density: 600 mg/sq cm (0.51 cm acrylic plastic)
Window Transmission: 95% for 662 keV photons; for electrons, transmission through window occurs above 1.5 MeV.
Sensitivity: 3.52 R/nC at 22°C and 760 mm Hg
Active Volume: 0.93 cc ±5%
Active Diameter: 1.162 cm
Active Cross-Sectional Area: 1.06 sq cm
Collector-to-Bias Separation: 0.44 cm
Ion Transit Time: 0.418 ms @ bias voltage of 300V
Collection Efficiency: >99% at 500 rads/min pulsed; >99.9% at 500 rads/min continuous
Leakage: Less than 0.5 pA over the full operating temperature range

Ion Chamber Factory Calibration

Method: Each of the 5 ion chambers within the detector array is calibrated by comparison with a reference standard ion chamber in a Co₆₀ beam. The comparison is performed in free air and results in an R/nC Calibration Factor for each of the five ion chambers.
Comparison Standard: 0.6 cc NE Farmer Probe with 3 MeV buildup cap.
Uncertainty: 2.5% using IEC/NIST guidelines.

Mechanical Specifications

Detector Configuration: The detector array consists of four orthogonally placed ion chambers on 10 cm radii from a fifth centrally located ion chamber.
Dimensions: 33.7 cm wide x 43.8 cm deep x 2.2 cm high (13.25 in. x 17.25 in. x 0.875 in.). Depth dimension assumes handle is fully extended; height dimension assumes no accessory pegs or build-up added.
Weight: 4 kg (8.8 lbs)

1.6.2 Model 35360A TRACKER Display

Measurements Mode

The measurement mode is user-selected from the front panel prior to the start of the exposure.

Dose (rad): Electrometer is operated in integrating mode with capacitive feedback.

Dose Rate (rad/min): Electrometer is operated in non-integrating mode with resistive feedback.

Display Mode

The display mode is user-selected from the front panel and may be selected before, during, or following the exposure.

Absolute: All five ion chamber measurement values are displayed in absolute dose measurement units (typically rads or rad/min) as defined by the dose measurement unit's description.

Percent-of-Center: Only the center ion chamber measurement value is displayed in absolute dose measurement units (typically rad or rad/min) as defined by the dose measurement unit's description.

Four peripheral ion chamber measurement values (top, bottom, left, and right) are displayed as a percentage of the center ion chamber measurement value.

Electrometer / A-D Converter

Nominal Full Scale Output: 3 volts.

A/D Converter Resolution: 16 bits unipolar.

Nominal Full Scale and Sensitivity in Electrical Units:

A-D Dose Full Scale	A-D Dose Sensitivity	A-D Rate Full Scale	A-D Rate Sensitivity
1000.0 nC ± 2%	0.015 nC/count	1000.0 nC/min ± 2%	0.015 (nC/min)/count

An overrange indication will be displayed when the input current or charge have exceeded the full-scale values. The full-scale value of any unit is guaranteed not to differ from nominal values by more than ± 2%.

Long Term Stability: Expected to be less than 0.25% of reading per year.

Non-linearity: Less than ± 0.4% of range.

Display Resolution: 0.003% of range (4-3/4 digits) for both dose and dose rate. Display resolution is limited by the following relationship for all display units;

$1 \text{ A-D Count} \leq 1 \text{ Display Count} < 10 \text{ A-D Counts}$.

This relationship insures that the resolution of the measurement display values is as high as possible without exceeding the inherent resolving capability of the

A-D converter.

Gain Temperature Stability: Less than ± 0.4% of reading over operating range of 10°C to 35°C.

Measurement Noise: Charge and Current measurement noise are less than ± 1 count at the display exclusive of source noise effects. Typical effects from a Co_{60} source are on the order of ± 0.2 rad/min at 100 rad/min. Source noise effects during dose rate measurements on a linear accelerator may be excessive.

Measurement Accuracy: Fluke Biomedical factory calibration will provide a basic Charge (Current) measurement accuracy of ±1% of reading ± 0.3 nC (± 0.3 nC /min) exclusive of long-term drift and temperature effects. Similar results may be obtained in the field using a suitable calibration source such as the Keithley Instruments, Inc. Model 263 Calibrator/Source and the included Customization software.

Current Leakage: Less than 1 pA (typically 1 rad in 5 minutes)

Zero Offset Voltage: Factory trimmed to 0 counts at the display.

Offset Temperature Drift: The zero offset voltage will drift less than ± 1 count at the display over the operating range of 10°C to 35°C.

High Performance Battery Charger

Battery Type and Capacity: 6V (3 cell) Lead Acid (5 AH) provide 8 hours of continuous operation.

Recharge Time: Fast recharge time on the order of 2 - 3 hours even during operation.

Battery Life Span: On the order of 8-10 years due to multiple level charging circuit (2000 charge/discharge cycles typically).

Low Battery Annunciator: Displayed when 30 minutes or less of operation remains.

Environment

Operating: 0°C to 35°C, up to 70% relative humidity.

Storage: -25°C to +65°C.

Mechanical

Dimensions: 21.6 cm wide x 8.9 cm high x 26 cm deep (10 in. x 9.4 in. x 4 in.)

Weight: 5 kg (11 lbs.)

1.6.3 Interface Cable - Detector to Display

Part Number: 37783-X where X denotes cable length in meters.

Standard Length: 15 m and 30 m.

Maximum Total Length: 60 m (197 ft.).

Ion Chamber Signal Cable Type: Five channels of RG-174 low noise coaxial.

Leakage: Less than 0.5 pA over the full operating temperature range.

Connector Type: Display interface end has five AMP male coaxial connectors and three AMP male single conductor connectors housed in a single DB-37 type housing. Detector interface end has a five AMP female coaxial connectors and three AMP female single conductor connectors housed in a single DB-37 type housing. Multiple cables may be interconnected to form other lengths.

Minimum Conduit Diameter: 7.6 cm (3 in.) without disassembly. Cable may be run through smaller opening by using special tool for disassembly. Consult factory for further details.

Weight: 2.25 kg (5 lbs.) at 15 m (weight is approximately proportional to cable length for other lengths).

** Specifications subject to change without notice.*

1.7 Unpacking and Inspection

The 90100 TRACKER System was carefully inspected before shipment. Upon receiving the 90100 TRACKER System, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage that might have occurred during shipment. Report any damage to the shipping agent at once. Retain the original packing material in case reshipment becomes necessary. The items in Figure 1-3 are included with every 90100 TRACKER System.

Standard System Contents

- Model 35360A TRACKER Display
- Model 35300A Detector
- 15 m Detector to Display Interface Cable (37783-15)
- AC Line Cord
- Customization Software Kit (37827): Contains disk, cable, and adapters.

Optional Equipment

- System Carrying Case (37780): Dimensions are 41.9 cm wide x 45.2 cm long x 22.2 cm deep (16.50 in. x 17.75 in. x 8.75 in.). Empty weight is 0.9 kg (2 lbs.).
- Cable (37783-30): 30 m Detector to Display Interface Cable
- Build-Up Kit (37825): Contains 10 pieces of 0.44 cm acrylic part number 37051-1. Kits containing other quantities of plates, plate materials, and plate thicknesses are available.
- Pegs and Retainer Kit (37825): Contains eight each, pegs and retainers for attach build-up plates to detector.

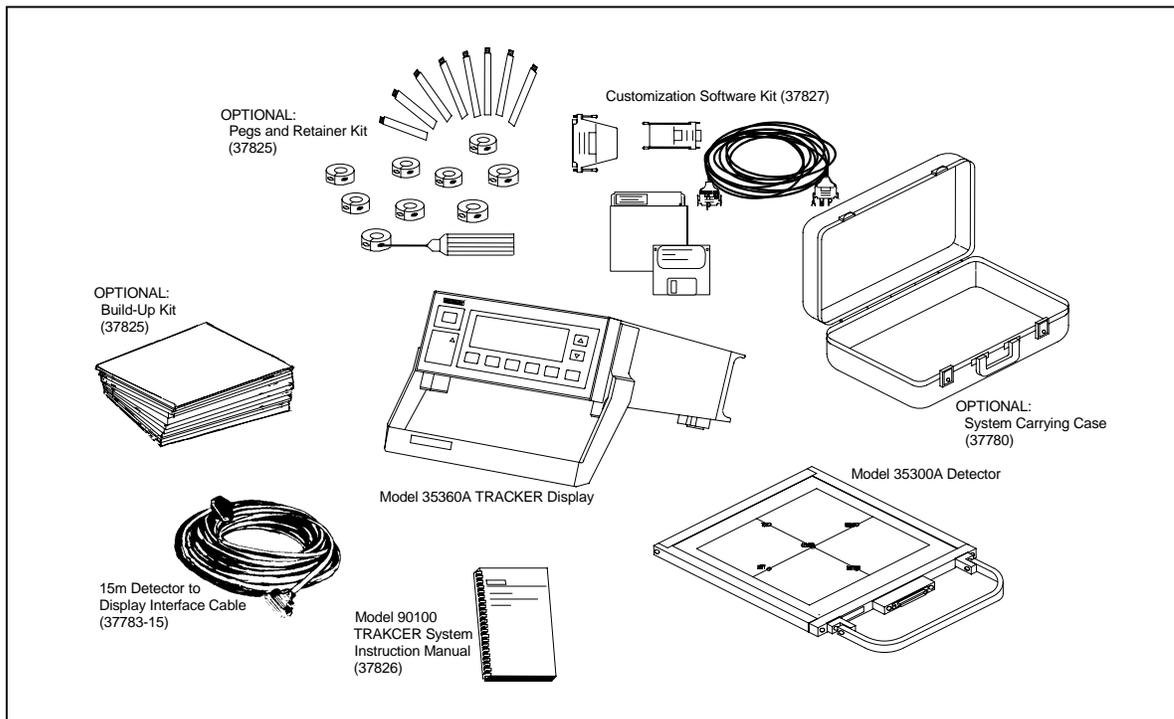


Figure 1-3. Model 90100 TRACKER System Parts and Accessories

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Section 2 Operation

2.1 Introduction

This section contains set-up and connection procedures for the Model 90100 TRACKER System in order to measure therapy beam characteristics.

If you want to use build-up to simulate tissue, you can put plates of either "solid water" or acrylic (optional accessories) securely on one or both sides of the Model 35300A Detector. Build-up pegs and retainer rings for securing the plates to the 35300A Detector are optional with the 90100 TRACKER System. See Appendix A for additional information.

It is recommended that the user customize his Model 35360A TRACKER Display prior to its first use as a quality assurance tool. This customization may involve selecting the desired display units, display units conversion factor, temperature units, and pressure units. Procedures for carrying out the customization is covered in Section 5.

2.2 Rear Panel Familiarization

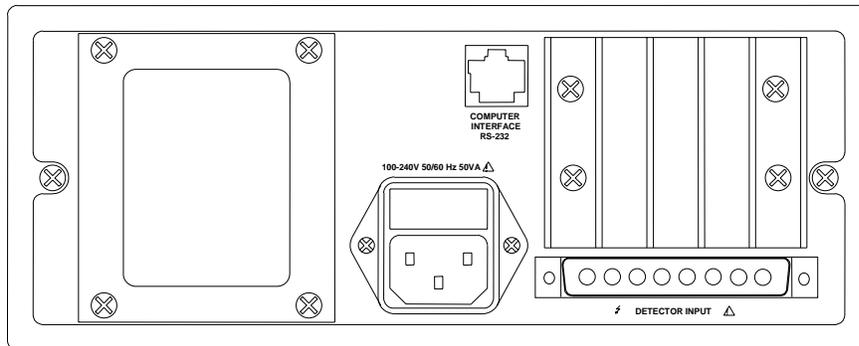


Figure 2-1. Model 35360A TRACKER Display Rear Panel

2.2.1 Powering the System

The Model 35360A TRACKER Display may be operated from either line or battery power. The line receptacle at the rear panel of the Model 35360A TRACKER Display mates with a 3-wire line cord to provide a connection to line voltage (high, neutral and earth ground).

WARNING

When powering the 35360A TRACKER Display from an AC line, always use a 3-wire grounding type line cord such as the one supplied with the 90100 TRACKER System. In addition, only connect the 35360A TRACKER Display to an AC power outlet employing a third wire safety ground. Failure to ground the Model 35360A TRACKER Display may result in personal injury or death in the event of a short circuit or malfunction.

The 35360A TRACKER Display operates on battery power for eight hours after a full charge. The 35360A TRACKER Display can be recharged quickly, usually in two to three hours, even during instrument operation. A low battery annunciator is displayed when 30 minutes or less of operation remains. When the battery pack is fully discharged, the instrument automatically shuts off and will not operate until AC line power is connected.

The Model 35360A TRACKER Display operates from line voltage ranging from 100 to 240 VAC without operator switching. An IEC 320/C13 style receptacle provides worldwide operation by simply changing line cords.

2.2.2 Detector Input

The Model 35360A TRACKER Display connects to the Model 35300A Detector through an interface cable. The cable connects to an 8-pin D connector on the back of the 35360A TRACKER Display housing (see Figure 2-1).

Before you attach the 35300A Detector to the 35360A TRACKER Display, you must perform the following procedure (refer to Figure 2-2 and Figure 2-3).

1. Turn the 35360A TRACKER Display OFF.

WARNING

Always turn the Model 35360A TRACKER Display's power off prior to connecting or disconnecting the interface cable. Failure to do so may result in an electrical shock.

2. Firmly press the 8-pin D connectors at either end of the interface cable into the 35360A TRACKER Display and the 35300A Detector, see Figure 2-2 and Figure 2-3.

CAUTION

This interface cable has different mating pins for both the 35300A Detector and 35360A TRACKER

Display. Be sure to use the correct end of the cable.

3. Secure the cable at each end by twisting the thumbscrews in a clockwise direction until tight.

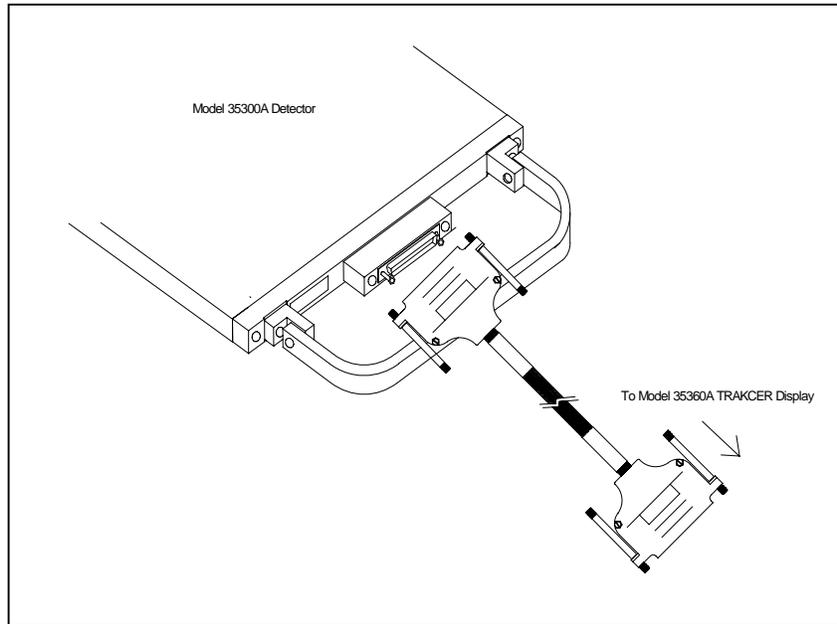


Figure 2-2. Connecting the Interface Cable to the Model 35360A TRACKER Display

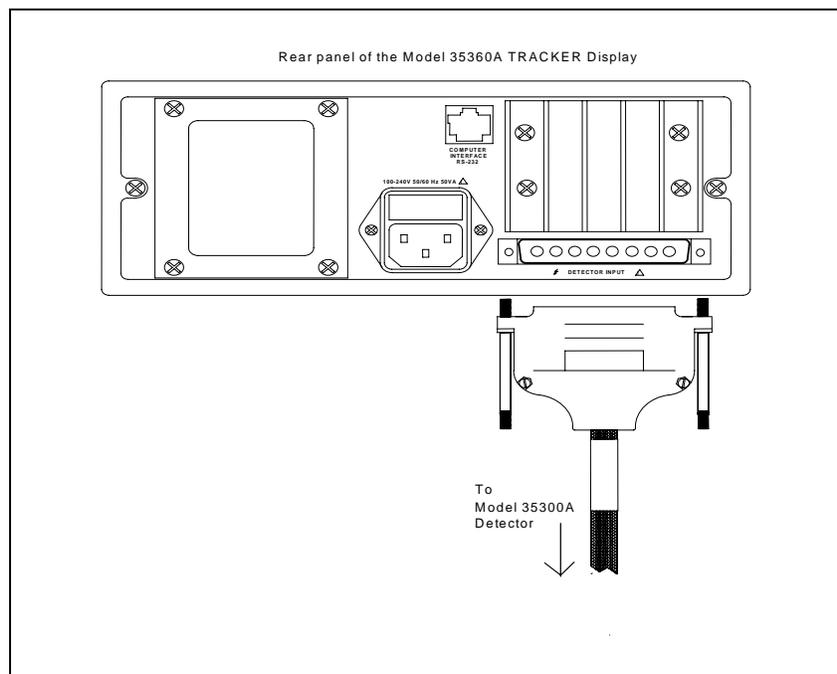


Figure 2-3. Connecting the Interface Cable to the Model 35300A Detector

4. Power can now be applied to the system. Wait for the Test/Detector screen shown below before pressing any keys.



Reverse the above procedure to disconnect the interface cable from the 35300A Detector.

WARNING

Always turn the Model 35360A TRACKER Display's power off prior to connecting or disconnecting the interface cable. Failure to do so may result in an electrical shock.

2.2.3 RS-232 Computer Interface (RJ-45 Style)

The RS-232 Computer Interface provides a means for computer controlled factory test and calibration. It is also used in conjunction with the Customization program during the user customization process.

2.3 Positioning the Model 35300A Detector in the Beam

Proper and consistent positioning of the 35300A Detector is necessary for reliable measurement results. The 35300A Detector has a printed overlay on both of its flat surfaces to indicate the location of the five detectors inside the assembly. The overlays also include a black cross-hair to aid in centering the device in the treatment beam.

The 35300A Detector should be placed so that the center detector will be in the center of the treatment beam. For a gantry angle of 0 degrees, place the 35300A Detector on the treatment table with the axis label face up, and the connector facing away from the gantry. The "TOP" chamber should be the one nearest the gantry. This placement is shown in Figure 2-4.

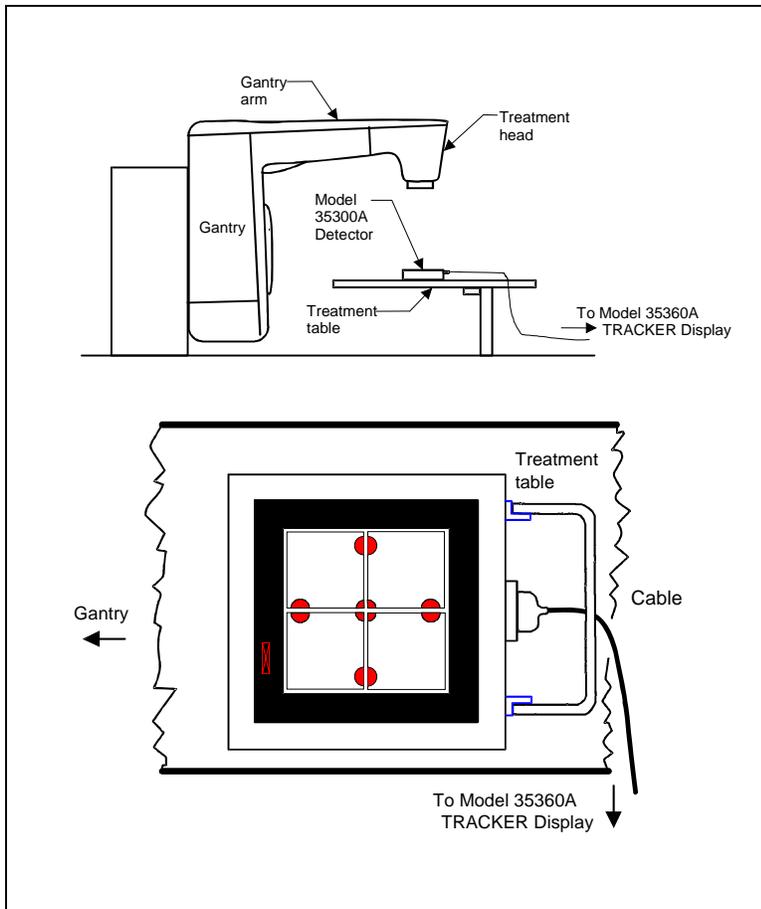


Figure 2-4. Setup for 0-Degree Gantry Angle (NOTE: Build-up not shown for clarity)

For those who have purchased the optional Build-Up Peg and Retainer Kit, gantry angles other than 0 degrees may be used. For gantry angles of 90 or 270 degrees, place the 35300A Detector on its side so the label faces the head. Orient the connector away from the gantry. This placement is shown in Figure 2-5.

WARNING

Operating the 35300A Detector on edge without build-up pegs constitutes a tip-over hazard and could result in personal injury.

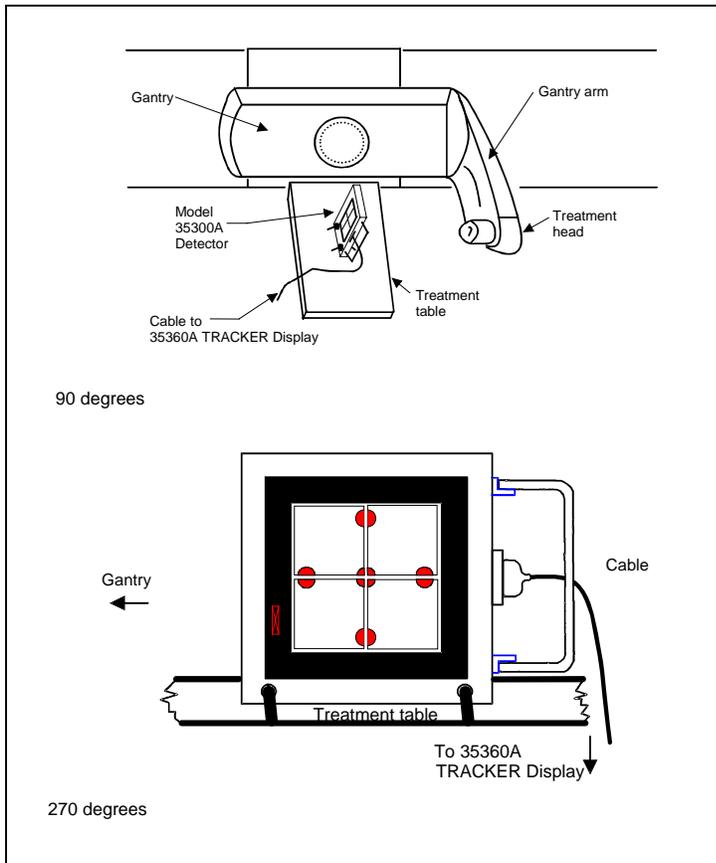


Figure 2-5. Setup for 90- and 270-Degree Angles (NOTE: Build-up not shown for clarity)

2.4 Operation Instructions

This section contains detailed instructions on the front panel operation of the Model 35360A TRACKER Display. The 35360A TRACKER Display front panel keys and display are explained. Please note that the display examples shown here correspond to a particular customization set-up. Other customization set-ups will produce different results.

2.4.1 Front Panel Controls

Figure 2-6 shows the front panel of the 35360A TRACKER Display. The front panel consists of control buttons and a display. The following paragraphs describe the operation of each control button and the corresponding display screens.

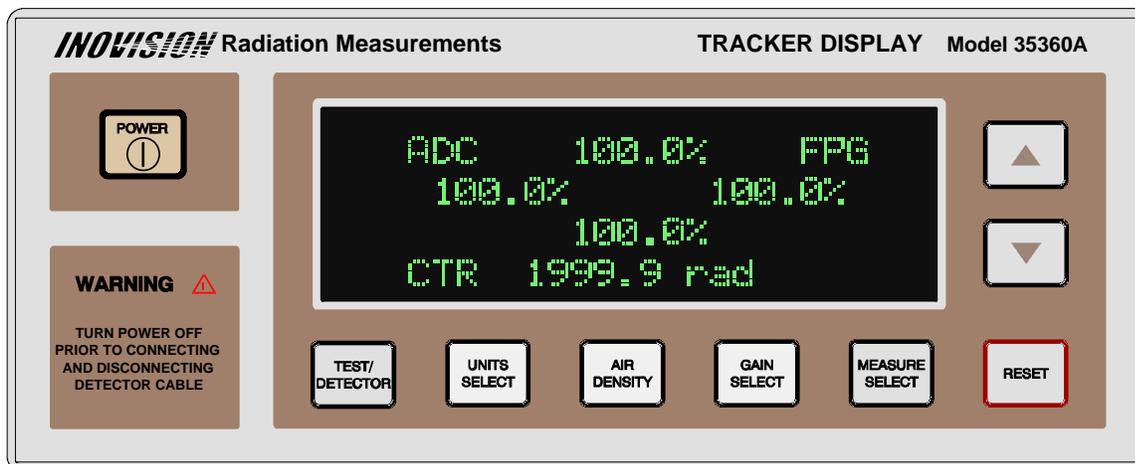


Figure 2-6. The Model 35360A TRACKER Display Front Panel

Power

The POWER button toggles the system power on or off.

Test/Detector

The TEST/DETECTOR button displays and sequences the Test/Detector screens.

Units Select

The UNITS SELECT button displays the Units Select screen. Subsequent presses toggle the measurement units between dose and dose rate units.

Air Density

The AIR DENSITY button displays the Air Density screen. Subsequent presses advance the cursor through the temperature, pressure, and Air Density Correction Factor (ADCF) fields.

Gain Select

The GAIN SELECT button displays the Gain Select screen. Holding the GAIN SELECT key for three seconds toggles the 35360A TRACKER Display between the Gain Setting and Normal Operation modes. In the Gain Setting Mode, pressing the GAIN SELECT button advances the cursor through the Front Panel Gain Factor (FPGF) fields.

Measure Select

The MEASURE SELECT button displays the Measurement screen. Subsequent presses toggle the display mode between absolute and percentage presentations.

Reset

The RESET button zeroes all measurement readings when dose units are selected. This button displays the Measurement screen if it is not already displayed.

Up

The UP button function depends on the displayed screen. It increments the temperature, pressure, or a front panel gain. It toggles the state of the air density correction annunciator or the front panel gain annunciator. For the Test/Detector screen or the Measurement screen, it displays the previously displayed screen.

Down

The DOWN button function depends on the displayed screen. It decrements the temperature, pressure, or a front panel gain. It toggles the state of the air density correction annunciator or the front panel gain annunciator. For the Test/Detector screen or the Measurement screen, it displays the next screen.

2.4.2 Powering Up the Model 35360A TRACKER Display

Pressing the POWER button turns on the instrument. Initially, it runs self-tests, restores the temperature, pressure, air density correction factor, front panel gain factors and measurement units to their previous values, and waits for the bias supply to stabilize.

NOTE

When attempting to turn the instrument on, firmly press the power ON/OFF button and hold for approximately one second. Always allow several seconds between retries.

During this self-test period, the 35360A TRACKER Display displays a sequence of screens on its VFD. The first screen to appear after pressing the POWER ON/OFF button is the Pixel Test screen shown in Figure 2-7.

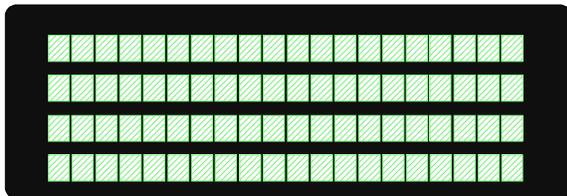


Figure 2-7. *The Pixel Test Screen*

This screen will remain visible for approximately two seconds and be followed by the General Information Test Screen shown in Figure 2-8. After an additional two seconds, the display will change to the Bias and Battery Voltage Test Screen shown in Figure 2-10. As soon as this screen is displayed, the 35360A TRACKER Display is fully operational and ready to respond to further panel key presses.

2.4.3 Powering Down the Model 35360A TRACKER Display

Pressing the POWER ON/OFF button turns the instrument off. As part of the power down sequence, the 35360A TRACKER Display saves all of its front panel settings and is thus able to restore these settings during the next power up sequence.

2.4.4 Using the TEST/DETECTOR Button

Press the TEST/DETECTOR button to display the first Test/Detector screen, see Figure 2-8. Use the TEST/DETECTOR, UP, and DOWN buttons to cycle through the three Test/Detector screens. These screens contain information about the instrument's calibration date, firmware revision date, serial number, ion chamber calibration factors, current operating state, and an optional text line. The optional text line, shown in Figure 2-10, can be customized using the Customization software.

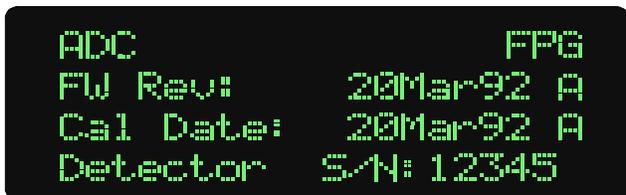


Figure 2-8. *Test/Detector Screen 1 - General Information*

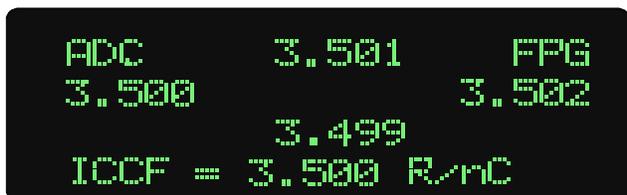


Figure 2-9. Test/Detector Screen 2 - Ion Chamber Calibration Factors



Figure 2-10. Test/Detector Screen 3 - Bias and Battery Voltages Plus an Option Text Line

In Figure 2-10, the battery current, "+0.1 A", is displayed to the right of the battery voltage, "6.8 V". A positive current value of up to 2.5 amperes indicates that the battery is being charged from the AC line. As the battery approaches full charge, this current will decrease to near zero. A negative current value will be shown when the instrument is operated from battery power, and indicates the actual current consumption of the instrument.

The battery voltage number displayed is the terminal voltage of the battery. During a charging cycle, the voltage can be anywhere from 5.5 volts to 8.5 volts. After the battery reaches its full charge, the charging circuit switches to trickle charge mode with a corresponding terminal voltage of approximately 7 volts. The unit will remain in this trickle charge mode as long as the instrument is attached to an AC line. When the instrument is operated with battery power, the voltage will read between 6.5 volts (battery fully charged) and 5.4 volts (low battery shutdown voltage).

2.4.5 Using the UNITS SELECT Button

Pressing the UNITS SELECT button displays the Units Select screen, see Figure 2-11. The "►" cursor points to the currently selected measurement unit. Press the UNITS SELECT button to toggle the "►" cursor between the dose and dose rate measurement units.



Figure 2-11. The Units Select Screen with Dose Measurement Units Selected

The Display Units Conversion Factor (DUCF) is displayed at the bottom of the Units Select screen. The 35360A TRACKER Display uses the DUCF to convert from the detector calibration units to the display units selected during the customization process (see Section 5).

2.4.6 Using the AIR DENSITY Button

Pressing the AIR DENSITY button displays the Air Density screen, see Figures 2-12 and 2-13. This screen contains the temperature value, pressure value, and Air Density Correction Factor (ADCF). Press the AIR DENSITY button to advance the "▶" cursor to the next field. To change the value or state of an item at the "▶" cursor, use the UP and DOWN arrows. The 35360A TRACKER Display displays the Air Density Correction (ADC) annunciator in the upper left-hand corner of most screens if the air density correction is enabled, see Figure2-12.



Figure 2-12. The Air Density Screen With Air Density Corrections Enabled

To disable the air density correction, advance the "▶" cursor to the ADC annunciator at the upper left of the VFD. With the "▶" cursor at this position, pressing the UP and DOWN keys will toggle the air density correction on and off.



Figure 2-13. The Air Density Screen With Air Density Corrections Disabled

2.4.7 Using the GAIN SELECT Button (Normal Mode)

Pressing the GAIN SELECT button displays the Gain Select screen, see Figures 2-14 and 2-15. This screen displays the five Front Panel Gain Factors (FPGF) and the Front Panel Gain annunciator "FPG". The "▶" cursor points to the FPG annunciator.

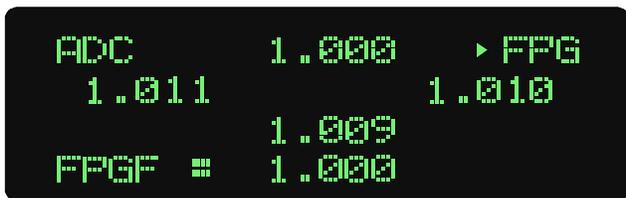


Figure 2-14. The Gain Select Screen With the Front Panel Gain Enabled



Figure 2-15. The Gain Select Screen With the Front Panel Gain Disabled

NOTE

The FPGF for the center ion chamber is displayed on the bottom line of the VFD.

Use the UP and DOWN buttons to toggle the FPG annunciator on or off. The FPG annunciator in the upper right-hand corner of the display signifies that FPG corrections are enabled, see Figure 2-15. When the FPG annunciator appears, the 35360A TRACKER Display multiplies each ion chamber's exposure value by its FPGF before displaying the reading. See section 2.4.10 for information on how to set the front panel gain factors.

2.4.8 Using the MEASURE SELECT Button (Normal Mode)

Press the MEASURE SELECT to display the Measurement screen. The 35360A TRACKER Display can present the measurement data in an absolute form, or as a percentage of the center ion chamber. While the Measurement screen is displayed, press the MEASURE SELECT button to toggle the display mode between the percentage-of-center and absolute presentations.

2.4.8.1 Absolute Measurements

Figure 2-15 shows the ion chamber layout for the Measurement screen in the absolute display mode. The 35360A TRACKER Display displays the four outside ion chamber readings in a diamond pattern above the center channel. All five readings are in the selected units ("rads" in this case).

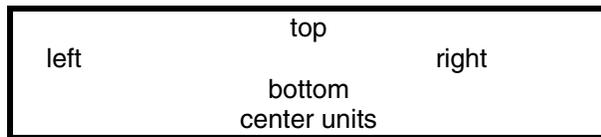


Figure 2-16. Measurement Screen Showing the Ion Chamber Layout

NOTE

The measurement value corresponding to the central ion chamber is always displayed on the bottom line of the VFD.



Figure 2-17. An Absolute Dose Measurement With Air Density Corrections and the Front Panel Gain Factors Enabled



Figure 2-18. An Absolute Rate Measurement With Air Density Corrections and the Front Panel Gain Factors Disabled

Prior to making a dose measurement, press the RESET button to zero all ion chamber readings. Pressing this button has no affect when performing dose rate measurements.

2.4.8.2 Percent-of-Center Measurements

The Percent-of-Center Measurement screen displays the central ion chamber's reading in absolute measurement units and the four peripheral ion chamber's readings as a percentage of the center ion chamber's reading.

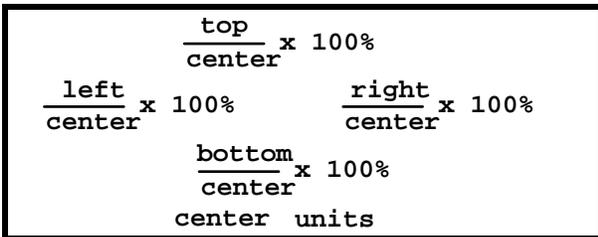


Figure 2-19. A Percentage Measurement Showing How the Ratios are Calculated

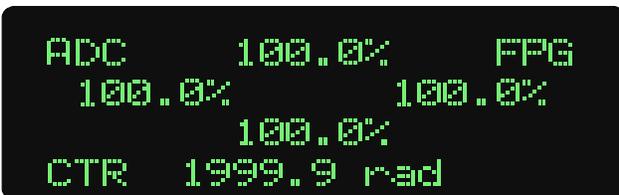


Figure 2-20. A Percentage Dose Measurement With Air Density Corrections and the Front Panel Gain Factors Enabled



Figure 2-21. A percentage rate measurement with both air density corrections and the front panel gain factor disabled

NOTE

Pressing the RESET button while performing a dose measurement causes all percentages to immediately change to "UNDER". This is normal operation (see section 2.4.8.3 for more information).

2.4.8.3 Underranging and Overranging Conditions

The 35360A TRACKER Display displays an underrange indicator when a preset threshold has not yet been reached, and an overrange indicator when the electrometer's maximum limit has been exceeded (see Figures 2-22 and 2-23).

An underrange occurs in the percent-of-center measurement mode when the central exposure is too small to precisely calculate percentages.



Figure 2-22. Underranging the Electrometer



Figure 2-23. Overranging the Top and Night Channels of the Electrometer

Table 2-1 summarizes the underrange and overrange conditions and results.

Table 2-1. Underrange and Overrange Conditions

Measurement Mode	Condition	Chamber Reading
Absolute	Overrange a chamber	OVER for chamber
Percent-of-Center	Exposure at center chamber too small to calculate percentages	UNDER for all peripheral chambers
Percent-of-Center	A peripheral chamber overranges while center chamber is within range limit	OVER for peripheral chamber
Percent-of-Center	Center chamber overranges	OVER for all chambers

2.4.9 Battery and Bias Annunciators

As already discussed, the 35360A TRACKER Display continuously monitors the ion chamber bias and battery voltages. If either one of these values is outside the specified range, the 35360A TRACKER displays an annunciator to indicate the error. Table 2-2 specifies these annunciators.

Table 2-2. Bias and Battery Annunciators

Condition	Annunciator
Low Bias voltage	LoBias
High Bias voltage	HiBias
Low Battery voltage	LoBat

Figure 2-24 illustrates the locations of the annunciators on the VFD. The High Bias annunciator would appear in place of the Low Bias annunciator should this condition be detected.

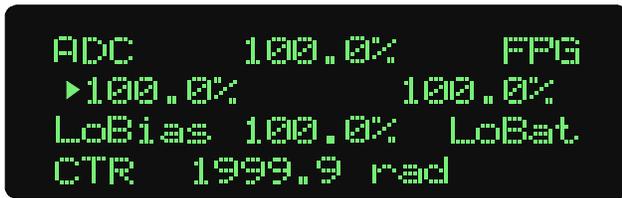


Figure 2-24. Positions of the Battery and Bias Annunciators

See Section 4 for information on how to deal with the LoBat, HiBias, and LoBias conditions.

2.4.10 Gain Setting Mode

The 35360A TRACKER Display uses several variables to determine an exposure's value: the electrometer reading in Coulombs and Coulombs/min, the Display Units Conversion Factor (DUCF), an Ion Chamber Calibration Factor (ICCF), the Air Density Correction Factor (ADCF), and a Front Panel Gain Factor (FPGF). The FPGF's provide a means of adjusting the measurement readings from the front panel of the 35360A TRACKER Display.

The 35360A TRACKER Display must be in the Gain Setting Mode before an FPGF can be changed. To enter or exit the Gain Setting Mode, press and hold the GAIN SELECT button for approximately three seconds. Entry into the Gain Setting Mode is indicated by a movement of the "▶" cursor from the FPG annunciator to one of the five FPGF values as shown in Figure 2-25.

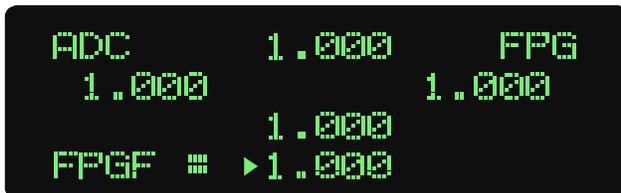


Figure 2-25. The Gain Select Screen in the Gain Setting Mode

NOTE

The FPGF's are automatically enabled upon entering the Gain Setting Mode. They cannot be disabled while the instrument is in this mode.

Subsequent presses of the GAIN SELECT button advance the "▶" cursor through the FPGF's. Press the UP or DOWN button to increase or decrease an FPGF.

While in the Gain Setting Mode, all of the screens may be viewed and the measurement system will function as it does in the Normal Mode. The FPGF's may be set either from the Gain Select screen, or from one of the Measurement screens. Pressing the MEASURE SELECT button cycles the VFD through a sequence consisting of the Absolute Measurement Screen, the Percent-of-Center Measurement Screen, and back to the Gain Select Screen.

2.4.10.1 Changing Front Panel Gain Factor's From the Measurement Screen

The five FPGF's may be set by adjusting the measurement readings to achieve a set of desired values. Press the MEASURE SELECT button until the desired Measurement screen is displayed. Press the GAIN SELECT button to advance the "►" cursor among the five measurement values. Next use the UP and DOWN buttons to adjust the selected measurement value.

When the measurement values are displayed in the absolute form, see Figure 2-26, pressing the UP or DOWN arrow increments or decrements the selected chamber's FPGF. For example, increasing the left dose value by 2% will increase the left FPGF by 2%.



Figure 2-26. An Absolute Dose Measurement With the Center Ion Chamber Selected for FPGF Modification

When the measurement values are displayed in the percent-of-center form, see Figure 2-27, and the "►" cursor is pointing at one of the percentage values, pressing the UP or DOWN arrow will increment or decrement the selected chamber's FPGF. For example, increasing the left percentage value by 2% will increase the left FPGF by 2%.

When the measurement values are displayed in the percent-of-center form and the "►" cursor points to the center ion chamber's absolute measurement value, pressing the UP or DOWN arrow increments or decrements **all five** of the FPGF's. This causes the FPGF of the center channel to increase, while allowing the four peripheral ratios to remain unchanged. For example, increasing the center chamber's absolute dose value by 2% will increase all five of the FPGF's by 2%.

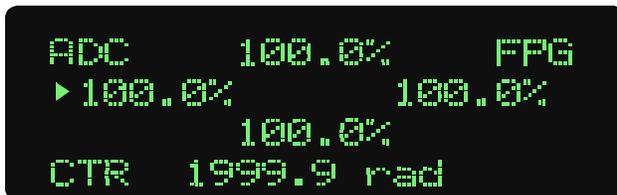


Figure 2-27. A Percentage Dose Measurement With the Left Ion Chamber Selected for FPGF Modification

2.4.10.3 Saving the FPGF Changes

To save any changes made to the FPGF's, press and hold the GAIN SELECT button for approximately three seconds. These settings become permanent and will be used when the 35360A TRACKER Display displays the FPG annunciator.

2.4.10.4 Aborting the FPGF Changes

To abort any changes made to the FPGF's, turn off the instrument while in the Gain Setting Mode. This causes the 35360A TRACKER Display to discard the new FPGF settings and use the values previously stored.

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Section 3

Theory of Operation

3.1 Introduction

The Model 90100 TRACKER System is a radiation measurement system intended for use in quality assurance programs for high-energy accelerators and Co_{60} . The two main components of the system are the Model 35300A Detector and the Model 35360A TRACKER Display. This section describes the basic theory of operation of these devices. For more information regarding radiation dosimetry and ion chamber measurement theory, the reader should refer to one of the standard radiology physics texts.

The section begins with a simplified hardware block diagram of the Model 35360A Display accompanied by a short description of the most important blocks. Next follows a short description of the Model 35300A Detector and a discussion of air density corrections. The section concludes with a description of the system's basic operating parameters and equations.

3.2 Overall Functional Description of the Model 35360A TRACKER Display

The 35360A TRACKER Display contains a five-channel electrometer capable of producing measurements of dose and dose rate. Its 4 line by 20 character vacuum fluorescent display (VFD) can display the measurement results directly in the user's choice of radiological units. These readings may include air density corrections if desired. An integrated rechargeable battery and a 300 V electronic bias supply greatly simplify maintenance of the system. The 35360A TRACKER Display includes an RS-232 serial communication port that allows complete computer control of the measurement system. This communications port, in conjunction with internal non-volatile memory, also provides a means of customization and calibration of the 35360A TRACKER Display.

Figure 3-1 is a simplified hardware function block diagram for the 35360A TRACKER Display. While the most important interblock connections have been shown, many interconnections have been omitted in order to maintain clarity. Three external connections are illustrated. These are the AC Line, the RS-232 Computer Interface, and the Detector Input.

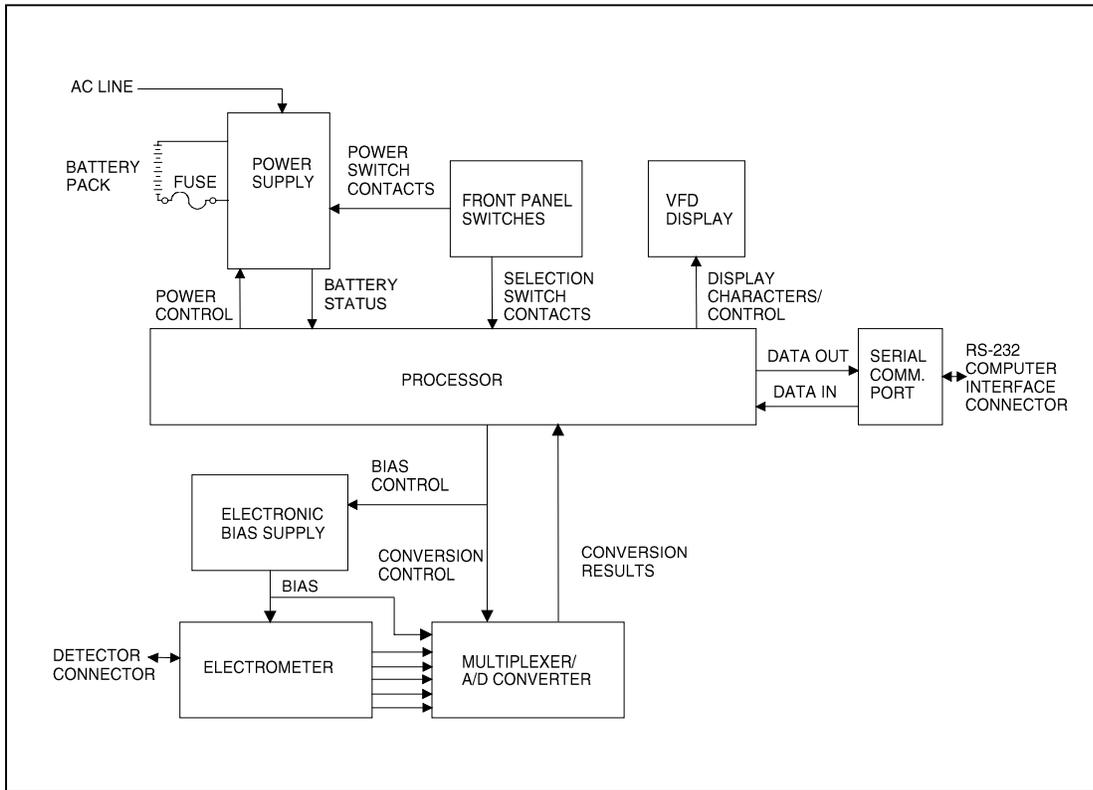


Figure 3-1. Hardware Block Diagram of the Model 35360A TRACKER Display

3.2.1 Power Supply

The Power Supply converts AC line power in the range of 100 to 240 VAC, or 6 VDC from the internal rechargeable battery pack, to the various DC voltage levels that are used to power all of the other blocks of the system. These interconnections have been omitted from the diagram for clarity. The Power Supply also includes a high performance charger for the internal Battery Pack. This Battery Pack will normally provide a continuous operational life of approximately 8 hours on one charge. The batteries may be charged in about 2 to 3 hours and charging will take place even when the instrument is in use. When the batteries have reached their fully charged level, the charger automatically enters a trickle charge mode. During trickle charging, the user need not be concerned about over charging the batteries. This mode will maintain the Battery Pack at its fully charged condition indefinitely.

When operating from batteries, an automatic turn off feature may be used to power down the unit after a user-defined period of inactivity. A low battery annunciator is displayed when less than 30 minutes of the useful battery life remains, and an automatic power down will occur when the Battery Pack is completely exhausted. All front panel settings are automatically stored at power down and restored at power up. Thus, the need to reconfigure the front panel settings upon each use has been eliminated.

Although the Power Supply is under the control of the microcontroller during normal operation through the Power Control connection shown, it is forced to turn on when the operator presses the front panel Power On/Off button. The BATTERY STATUS connection between the Power Supply and the Processor blocks provides the means by which the microcontroller can monitor the battery voltage and thus detect low and exhausted batteries. This voltage is automatically displayed during the power up sequence and may be viewed at any time on one of the test screens.

3.2.2 300-VOLT Electronic Bias Supply

The 300 volt ionization potential is generated internally by an electronic bias supply circuit. The supply eliminates the need for the 35360A TRACKER Display to contain high voltage batteries. As explained below, the ion chamber collector and guard are maintained at the same potential as the chassis of the 35360A TRACKER Display, and the ion chamber bias plates are negatively biased at 300 VDC. A readout of the bias potential is facilitated by a divided bias signal generated within the bias supply block and connected to the A-D converter.

The output of the electronic bias supply is highly regulated and filtered. In addition, the output energy and current have been limited should the operator make direct contact. Since the bias voltage at the detector input connector is automatically discharged at power down, the operator should always turn the instrument off before attempting to make or break a connection involving the detector interface cable. During operation, the Bias Supply output level is continuously measured and verified. Any abnormal level will be indicated by an annunciator on the VFD.

3.2.3 Front Panel Switches

The nine front panel switches are of the momentary contact type, and are continuously monitored by the microcontroller for detection of contact closure. At the detection of any contact closure, the microcontroller scans the switch set to determine which key has been pressed, and then takes the appropriate action. The dedicated function of each key is described in Section 2.

3.2.4 Processor

The Processor block is based on the Motorola 68HC11 microcontroller and includes 256 KBytes of factory programmed memory (EPROM) containing all of the executable code (firmware). The revision date associated with this code is displayed during the power up sequence on the VFD. Also contained within the Processor block is 32 KBytes of RAM memory which is used to hold all volatile variables (those whose values are lost when the instrument is powered down).

A 512 byte block of nonvolatile memory (EEPROM) has also been provided. A portion of the EEPROM is automatically reprogrammed during each power down sequence to hold all of the user's front panel selections. Thus the units, front panel gain, temperature, and pressure settings in effect at power down can be automatically restored at the next power up. The EEPROM is also used to hold all of the internal electrical calibration factors for the unit, as well as all of the customization selections installed by the user over the RS-232 via the Customization program.

Besides its role as a controller of the other hardware blocks, the Processor Block performs several computational functions. It applies a number of correction factors to the displayed dose and dose rate values including the air density correction factor, the ion chamber calibration factor, the display units conversion factor, and the front panel gain settings. It also performs the ratio calculations necessary to display the percentage-of-center measurement values for the peripheral ion chambers.

3.2.5 VFD Display

All display functions are handled by a 4 line by 20 character alpha-numeric VFD module. The module is under the direct control of the microcontroller and is capable of displaying all of the user's front panel selections as well as the numerical measurement results along with their appropriate units. Other informational items including the battery and bias voltage, calibration date, and ion chamber calibration factors may be displayed. The VFD has a distinct advantage over other display technologies, such as LCD, in that it provides good visibility, and a wide viewing angle in all lighting conditions.

3.2.6 Serial Communications Port

A computer interface has been provided in the form of a DCE configured RS-232 port. This port is configured for operation at 9600 baud and uses a standard Xon/Xoff handshaking protocol. The associated RJ-45 type connector is located on the 35360A TRACKER Display's rear panel. This interface provides the means for production testing and calibration, field customization by the user, and fully programmable operation using appropriate software.

3.2.7 Electrometer

This block contains a fully guarded, five channel, single range, dual measurement mode electrometer. It is capable of providing both dose and dose rate measurements from the five detector channels. The connection to the electrometer's inputs is made through five coaxial inserts in a D-style receptacle located on the 35360A TRACKER Display's rear panel. Also located within this connector are three single conductor outputs for safety ground, signal ground, and ion chamber bias.

The measurement mode is user-selected from the front panel prior to the start of the exposure. In the dose mode, the electrometer is operated in integrating mode with capacitive feedback. Prior to each exposure the user must manually reset the electrometer to zero by pressing the front panel "RESET" button. During dose rate measurements, the electrometer is operated in a non-integrating mode with resistive feedback.

3.2.8 Multiplexer and A/D Converter

This block consists of an six channel analog multiplexer and 16 bit A/D Converter which operates under the direct control of the microcontroller. Its main function is to convert the five analog voltage signals produced by the Electrometer Block into digital signals for use by the microcontroller. It is also used to measure the output of the 300 Volt Electronic Bias Supply. Although the 16 bit A/D Converter operates in a unipolar mode, its zero measurement point is offset slightly below the zero output level of the electrometer. This configuration provides optimal matching between the A/D's input span and electrometer's 3 Volt full scale output swing. It also provides the ability to read the small negative voltages which might result from electrometer leakage and offset drift.

A second 8-bit A/D Converter (actually located within the microcontroller) is used for measuring non-critical internal parameters such as the battery voltage and current.

Full scale electrometer and A/D Converter values in electrical units are given in Table 3-1. The corresponding values in radiological units are given in Table 3-2.

Table 3-1. Nominal Full Scale and Sensitivity in Electrical Units

Dose Full Scale	Dose Sensitivity	Rate Full Scale	Rate Sensitivity
1000.0 nC	0.1 nC	1000.0 nC/min	0.1 nC/min

Table 3-2. Nominal Dose and Rate Display Ranges in Radiological Units

Dose Full Scale	Dose Sensitivity	Rate Full Scale	Rate Sensitivity
3,520 R	0.1 R	3,520 R/min	0.1 R/min
3,093 rad	0.1 rad	3,093 rad/min	0.1 rad/min
30.93 Gy	1 mGy	30.93 Gy/min	1 mGy/min
30.93 Sv	1 mSv	30.93 Sv/min	1 mSv/min

Above values assume nominal electrical and radiological sensitivity, air density correction and front panel gain factors set to unity, and nominal value for the Display Units Conversion Factors. The following unity conversion factors were used; 3.52 R/nC, 0.879 rad/R, 0.00879 Gy/R, and 0.00879 Sv/R. The sensitivity values have been selected so the display resolution will not exceed the resolving capability of the A-D converter.

3.3 Model 35300A Ion Chamber Detectors

The Model 35300A Detector contains an array of four orthogonal placed ion chambers on 10 cm radii from a fifth centrally located ion chamber. The five ion chambers are of a vented, circular, parallel-plate configuration and are fully guarded for low leakage. The 35300A Detector connects to the 35360A TRACKER Display through a light weight interface cable.

Each of the 35300A Detector's five ion chambers may be depicted as containers of air, whose inside surfaces (bias plates) have been given a conductive coating. Located centrally in the air volume is a plastic disc (collector) which also has a conductive coating. The collector is electrically insulated from the bias plates and connected to the electrometer input through the 37783-15 detector interface cable.

Photons or electrons from the linear accelerator or Co_{60} source pass through and are absorbed into the chamber's materials and internal air volume. Absorption may also take place in external build-up materials when they are present. The primary absorption takes place in the chamber's windows and build-up materials when the incident photons or primary electrons interact with the atoms of these materials. When absorption occurs, high speed electrons are emitted from the interacting atoms. The high speed electrons spray into the ion chamber's air volume and produce many ionization tracks consisting of lower velocity electrons and "air" ions. The 300 V bias voltage separates the secondary electron cloud from the cloud of positive ions before recombination can occur. The sweeping of the electron cloud onto the ion chamber's collector produces a charge (or current) whose magnitude may be measured by the electrometer.

3.4 Air Density Corrections

For any vented ion chamber, the measurement of exposure (in roentgens) depends upon the mass of air from which the ionization charge is collected. The ion chamber calibration factors (ICCF's) supplied by Fluke Biomedical expresses this sensitivity in terms of R/nC. These ICCF's are specified for a temperature of 22 °C and a pressure of 760 millimeters of mercury (mm Hg). Since the 90100 TRACKER System may be used under ambient conditions which significantly differ from these, the corresponding changes in the sensitivity of the ion chamber must be accounted for. The air density correction factor (ADCF) has been defined as follows:

$$ADCF = (760 \text{ mm Hg} / P) * (T / 295.15 \text{ K})$$

where the pressure "P" is expressed in mm Hg and the temperature "T" is in Kelvin.

When the user has customized the 35360A TRACKER Display to use other temperature and pressure units, the corresponding values entered by the user at the instrument's front panel are automatically converted to mm Hg and K before use in the above equation. The equations used for these conversions are listed in the following table.

Pressure	Temperature
mm Hg = inch Hg * 25.4	K = (5/9) * (°F -32) - 273.15
mm Hg = 760 * (54,041 - feet ASL) / (54,041 + feet ASL)	K = °C + 273.15
mm Hg = 760 * (16,472 - meters ASL) / (16,472 + meters ASL)	
mm Hg = mB * 0.75006	
mm Hg = hPa * 0.75006	

3.5 Basic Operating Equations

This section lists the basic operating equations used within the 35360A TRACKER Display to produce its dose and dose rate measurement values for display on the VFD. These equations are expressed in terms of a set of basic operating quantities which are described in Table 3-3.

3.5.1 Charge

Although charge is not a value which can be displayed directly by the 35360A TRACKER Display, it is an intermediate result upon which the dose value directly depends.

$$Q [\text{nC}] = (\text{ADC} [\text{counts}] - \text{ADZ} [\text{counts}]) \times \text{QG} [\text{nC/count}]$$

3.5.2 Current

Although current is not a value which can be displayed directly by the 35360A TRACKER Display, it is an intermediate result upon which the dose rate value directly depends.

$$I [\text{nC/Min}] = (\text{ADC} [\text{counts}] - \text{ADZ} [\text{counts}]) \times \text{IG} [(\text{nC/Min})/\text{count}]$$

3.5.3 Absolute Dose

$$\text{AbsoluteDoseDisplay}[\text{DisplayUnits}] = \frac{Q [\text{nC}] \times \text{ICCF} [\text{Ion Chamber Cal Units/nC}]}{\times \text{DUCF} [\text{Display Units/Ion Chamber Cal Units}] \times \text{ADCF} \times \text{FPGF}}$$

3.5.4 Absolute Dose Rate

$$\text{Absolute Rate Display} [\text{Display Units/Min}] = \frac{I [\text{nC/Min}] \times \text{ICCF} [\text{Ion Chamber Cal Units/nC}]}{\times \text{DUCF} [\text{Display Units/Ion Chamber Cal Units}] \times \text{ADCF} \times \text{FPGF}}$$

3.5.5 Percent-of-Center

$$\text{Percentage Display for Perhiperal Channel} [\%] = 100 [\%] \times \frac{\text{Absolute Rate Display for Perhiperal Channel}}{\text{Absolute Rate Display for Center Channel}}$$

3.6 Basic Operating Quantities

Table 3-3. Basic Operation Quantities

Quantity	Description	Units	Comments
I	Current	nC/Min	Electrical current delivered to readout in response to radiation incident upon detector.
Q	Charge	nC	Electrical charge delivered to readout in response to radiation incident upon detector.
ADC	A-D Counts	Counts	Electrometer output level returned by A-D Converter during dose or dose rate measurement.
ADZ	A-D Zero	Counts	Electrometer output level returned by A-D Converter while operating in the dose rate measurement mode and in the absence of radiation. A-D Zero levels are field programmable via Customization Software.
QG	Charge Gain	nC / Count	Overall electrical charge gain of the electrometer / A-D combination when measuring in the dose mode. Charge gain values are field programmable via Customization Software.
IG	Current Gain	(nC/Min) / Count	Overall electrical current gain of the electrometer and A-D combination when measuring in the dose rate mode. Current gain values are field programmable via Customization Software.
ICCF	Ion Chamber Calibration Factor	Ion Chamber Calibration Units / nC	Specific R/nC values are supplied by factory for each of the five ion chamber channels. Values are field programmable via Customization Software.
DUCF	Display Units Conversion Factor	Display Units / Radiation Calibration Units	Factory default of 0.879 rad/R is supplied. Value is field programmable via Customization Software.
ADCF	Air Density Correction Factor	None	Calculated by instrument and depends on front panel Temperature and Pressure settings.
FPGF	Front Panel Gain Factor	None	User specified via front panel gain setting.

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Section 4 Maintenance & Service

WARNING

The Model 35360A TRACKER Display and 35300A Detector contain no internal operator serviceable parts. Disassembly of either unit could result in electrical shock.

Always turn the 35360A TRACKER Display's power off prior to connecting or disconnecting the interface cable. Failure to do so may result in an electrical shock.

When powering the 35360A TRACKER Display from an AC line, always use a 3-wire grounding type line cord such as the one supplied with the 90100 TRACKER System. In addition, only connect the 35360A TRACKER Display to an AC power outlet employing a third wire safety ground.

4.1 Introduction

This section outlines steps that the operator may take to identify and correct problems. It also gives instructions on how to order replacement parts or arrange for service if necessary.

For the purposes of troubleshooting, the system consists of three major components: detector, display, and an interface cable. Even though these major components contain no internal operator serviceable parts, a number of problems can be dealt with by the operator in the field environment.

4.2 Troubleshooting

This system contains a number of troubleshooting procedures that may be executed by the user in the field. Each procedure is illustrated in the form of a flow chart and is directed toward resolving the specific symptom listed in the first block of the chart.

Problem	Figure
The 35360A TRACKER Display's VFD does not illuminate when POWER key is pressed.	See Figure 4-1.
Low Battery annunciator is displayed on the 35360A TRACKER Display's VFD.	See Figure 4-2.
Bias error annunciator is displayed on the 35360A TRACKER Display's VFD	See Figure 4-3.
One or more dose measurement value(s) exhibits a drift rate of greater than two counts per minute in the absence of radiation.	See Figure 4-4.
One or more dose rate measurement values does not return to within one count of zero in the absence of radiation.	See Figure 4-5.

35360A TRACKER Display will not turn on (display will not light)

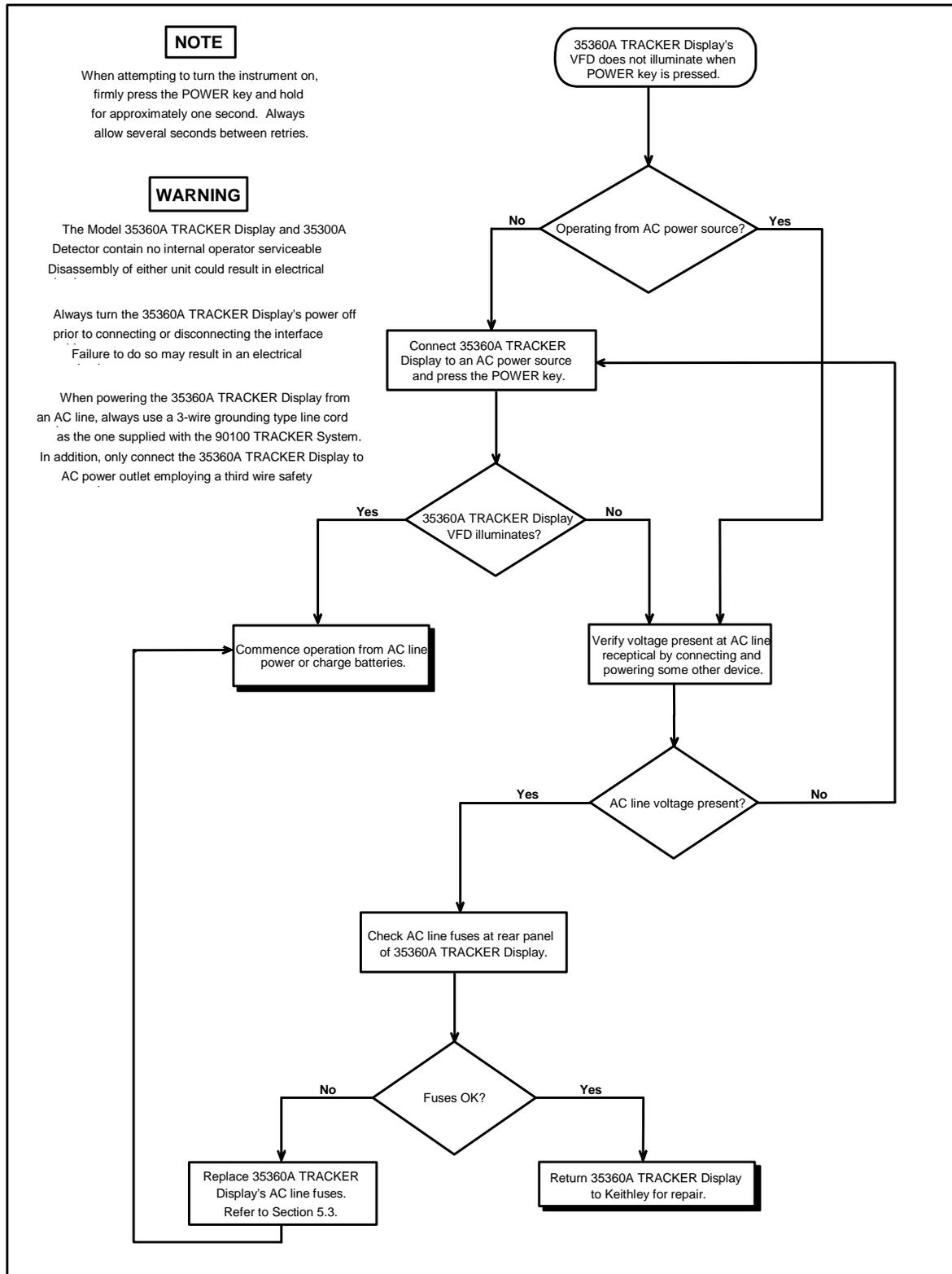


Figure 4-1. No Display Flowchart

Low Battery Indication at the Display

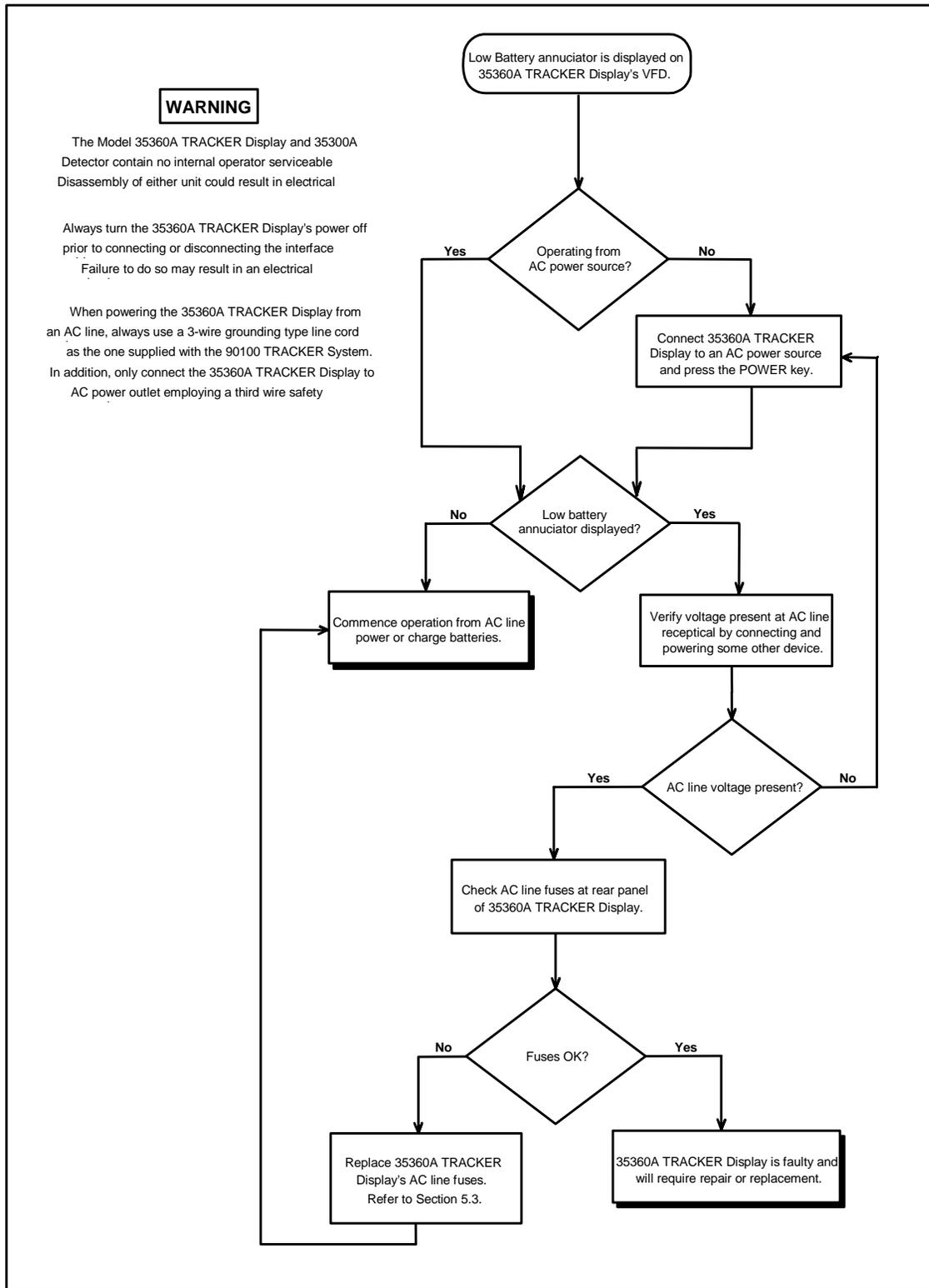


Figure 4-2 Low Battery Flowchart

Bias Error (LoBias or HiBias) Indication at the Display

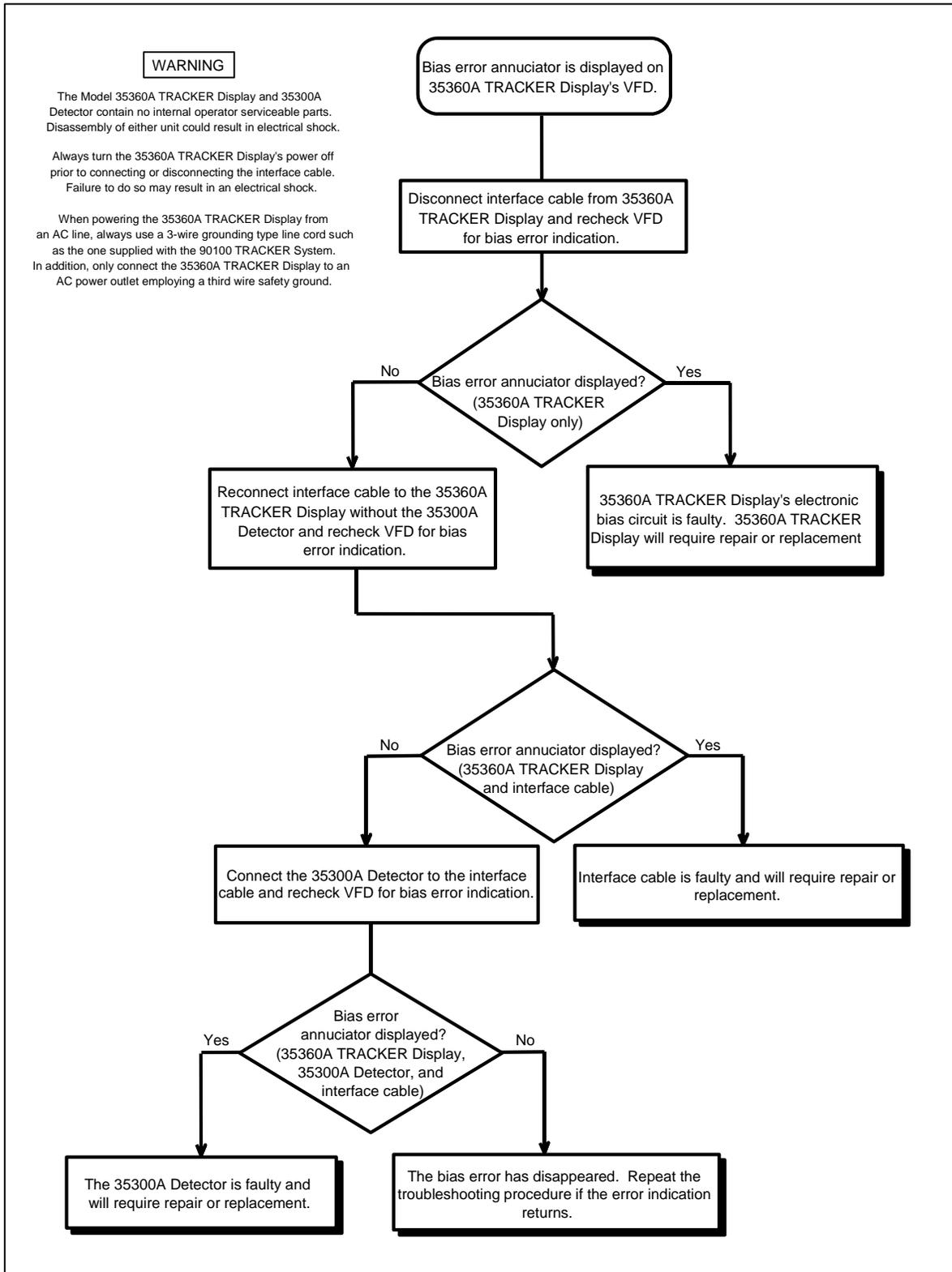


Figure 4-3. Bias Error Flowchart

Dose Measurement Value Drifts Prior to (or following) the Exposure

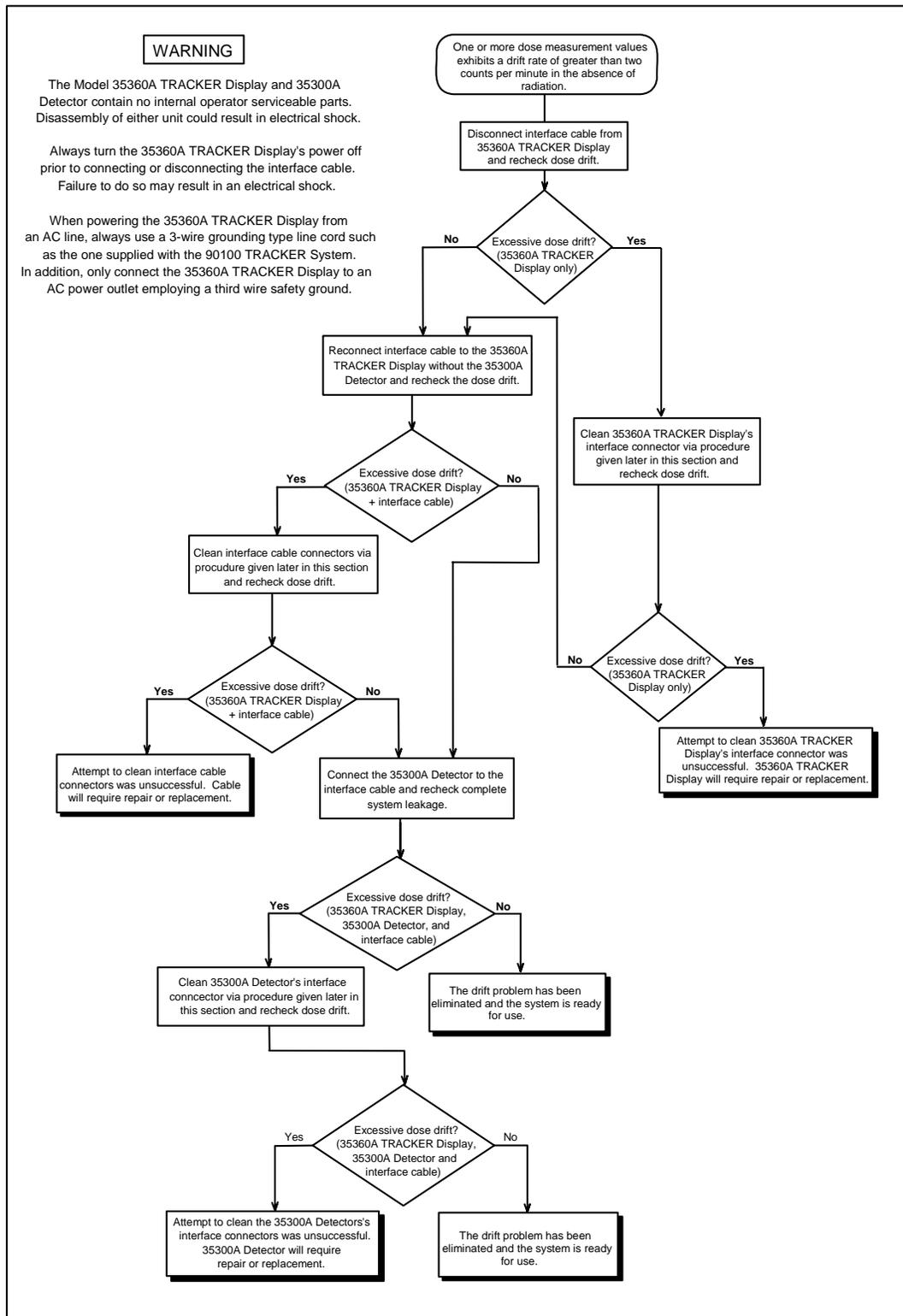


Figure 4-4. Leakage Flowchart

Dose Rate Measurement Value Does Not Return to Zero in the Absence of a Radiation Beam

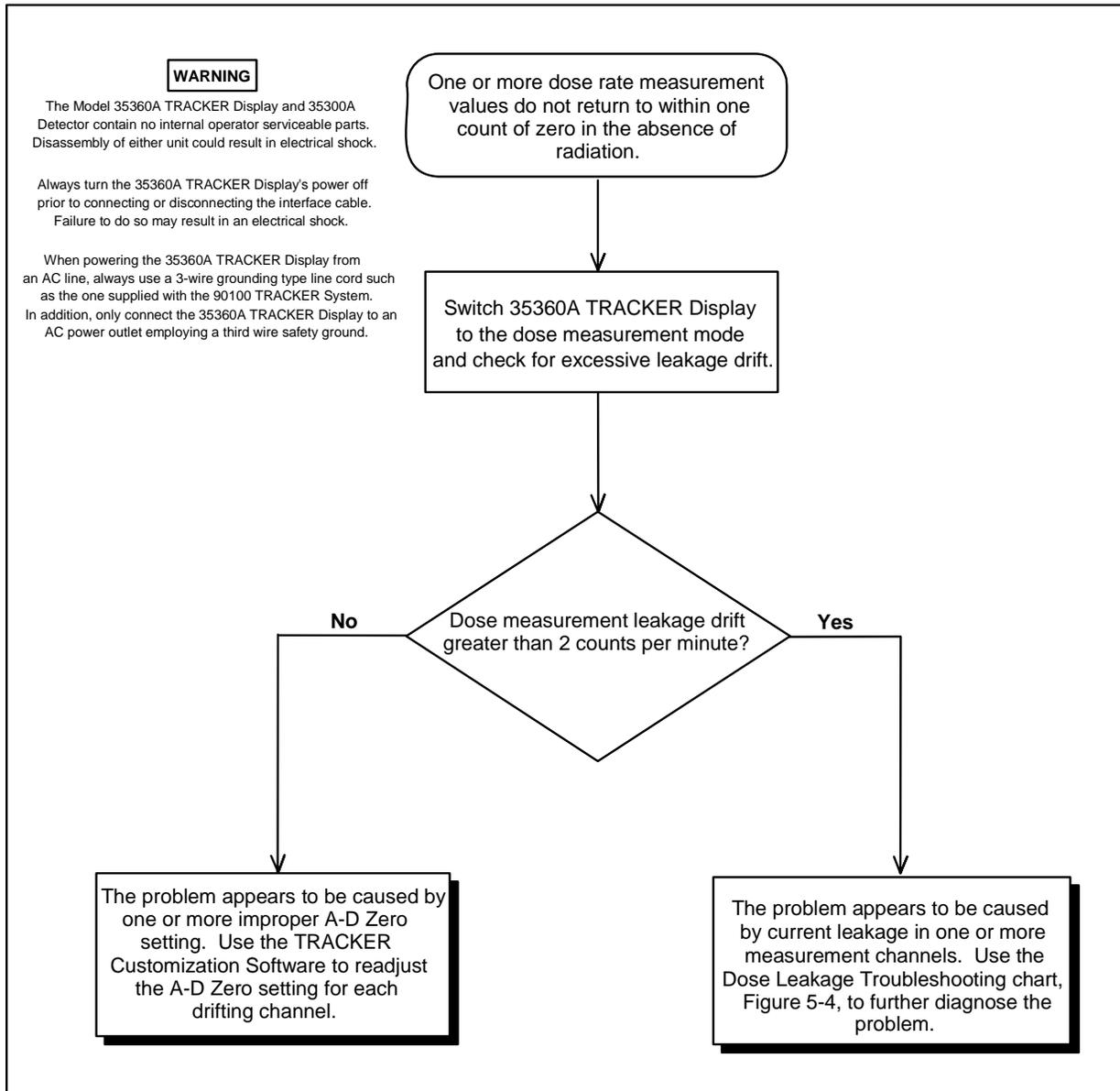


Figure 5-5 Dose Rate Measurement Zero Problem Flowchart

4.3 Line Fuse Replacement

WARNING

Disconnect the 35360A TRACKER Display from other equipment along with the AC line power and turn off power before continuing with this section.

1. Position the instrument on its display face.

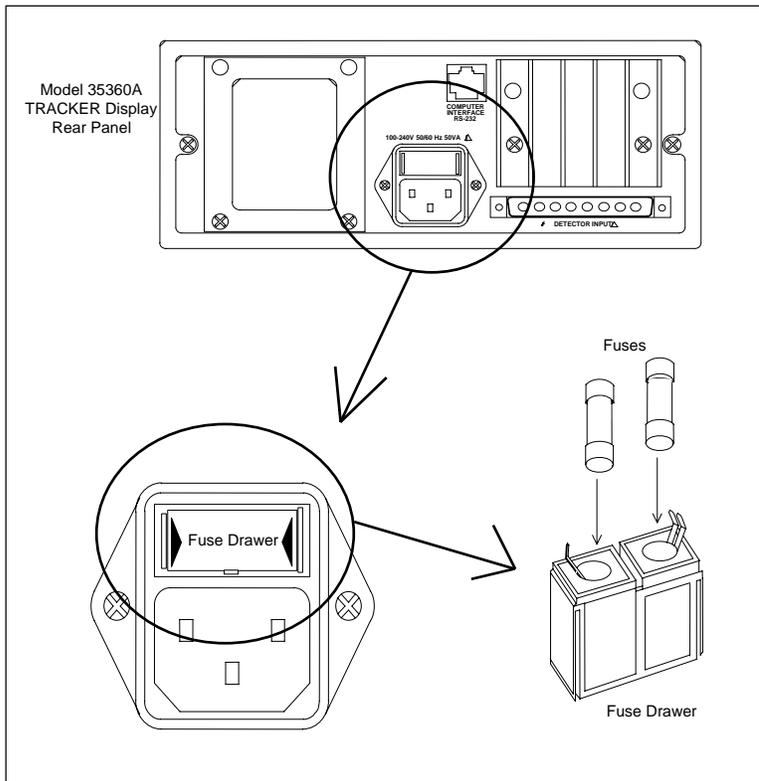


Figure 4-6. Model 35360A TRACKER Display Fuse Replacement

2. Remove the fuse drawer. With your fingernails, squeeze together the two ends of the fuse drawer and pull it out of its slot.
3. Replace the fuses with IEC 127 type FST5X20, 0.63 A, 250 V time-lag fuses.

WARNING

Use only the recommended fuse type. The use of a higher current rating than specified above may cause damage to the instrument, which will void any or all warranties currently in effect.

4. Place the fuse drawer back into its slot. Press on the fuse drawer firmly until it snaps back into place. Both sides of the fuse drawer should snap into place.

NOTE

If fuses continue to blow - return instrument for repair.

4.4 Interface Connector Cleaning

WARNING

Always turn the 35360A TRACKER Display's power off prior to cleaning the interface connectors. Failure to do so may result in an electrical shock.

The presence of dust or lint at the interface connectors can produce leakage currents which may have a detrimental affect upon the accuracy of radiation measurements.

The ends of the interface cable typically pick up dust and lint as the cable touches the floor during packing and unpacking. Dirt may later be transferred to the interface connectors located on the 35300A Detector or on the 35360A TRACKER Display during mating with the interface cable.

In some cases, the offending foreign matter may be removed by gently blowing across the connector with dry air. Air containing moisture or other contaminants should be avoided. A suitable source of dry air is available where camera accessories are sold. They are intended for use in cleaning fine and delicate camera equipment.

If this cleaning method fails to produce satisfactory results, then service by Fluke Biomedical will be required.

A procedure for troubleshooting excessive leakage is given earlier in this section.

4.5 Cleaning the Instrument

To clean the exterior of the instrument, follow these steps:

1. Turn off the instrument and disconnect all input connectors.
2. Place the cap on the detector connector.
3. Moisten a soft cleaning cloth with a solution of three parts water and one part liquid dishwashing detergent.

WARNING

Do not soak the cloth in the solution; you must not let the solution drip inside the instrument.

4. Use the moistened cloth to wipe the instrument's exterior cover.
5. Let the instrument dry completely before using.

4.6 Replaceable Parts Information

Fluke Biomedical maintains a complete inventory of all normal replaceable parts (see Table 4-1). To place an order, or to obtain information concerning replaceable parts, contact Fluke Biomedical at 440.498.2564, or Fax 440.542.3682.

Table 4-1. Replaceable Parts List

Description	Part Number
Therapy Beam Evaluator	35300A
Readout	35360A
System Carrying Case	37780
Fuse	38476
AC Line Cord (USA)	CO-19
AC Line Cord (Europe CEE 7/7)	86512060
AC Line Cord (UK & Ireland)	86583000
AC Line Cord (Denmark)	86536041
AC Line Cord (Italy)	86531031
AC Line Cord (Switzerland)	86515050
15 m Interface Cable	37783-15
30 m Interface Cable	37783-30
Customization Kit	37827
DB-9 Female Wiring	37616
7 Ft. RJ-45 Cable (L-COM)	105-260
Customization Software Disk	38330
Build-Up Plate	37051
Pegs and Retainer Kit	37825
Pegs	37081
Retainers	37082
Hex-key Wrench	LN-964
Fuse Drawer	018-304

4.7 Recalibration & Repair Information / Technical Assistance

If your instrument needs recalibration or repair, we request that you consult Fluke Biomedical at 440.498.2564, or Fax 440.542.3682.

More information concerning the operation, application, or service of your instrument may be obtained from the applications engineer at the previously listed numbers.

Section 5 Customization

5.1 Introduction

From the factory, the Model 35360A TRACKER Display arrives with valid settings allowing you to make measurements immediately. Should the need arise to change or modify any of the Items described below, the Customization software provides a friendly environment for customizing the 35360A TRACKER Display to meet your needs. The Customization software allows you to modify the power down interval, temperature and pressure units, an optional message, serial number of the detector you are using with the 35360A TRACKER Display, units of calibration for the detector, and the 35360A TRACKER Display's units and units conversion. Additionally, the electrometer gains and zeros, and the ion chamber calibration factors may be changed.

The basic features of the Customization software are its ease of use, an on-line help facility, printer support, and of course full customization capability for the 35360A TRACKER Display.

The Customization software has the following requirements:

- IBM Personal Computer or compatible
- EGA or VGA display
- one floppy drive (5¼ or 3½ inch)
- DOS version 3.0 or higher
- 512k memory
- one serial port (COM1: or COM2:)

If you want to produce a record of the customized items, you must also have a printer and printer port (LPT1:).

CAUTION

Do not use this software until you are fully familiar with both the setup and operation of the Model 90100 TRACKER System. A complete understanding of the Basic Operating Equations Quantities as contained in Sections 3.5 and 3.6 of this manual is an important prerequisite for adjusting the electrometer gains and offsets.

5.2 Make a Working Disk

Before using the Customization software, we recommend that a working disk be made. To make a working disk, simply copy all of the files from the disk to a blank, formatted disk. Store the original in a safe place.

CAUTION

Always operate the Model 90100 TRACKER System from an AC line power source during the customization/calibration process to eliminate the possibility that the 35360A TRACKER Display will automatically shut off prematurely.

5.3 Connection to the Computer

To prepare the 35360A TRACKER Display for customizing, insert the RS-232 cable into the instrument. Connect the other end of the RS-232 cable to the computer's serial port. Personal computers have serial ports that are either 9 or 25-pin. Determine which you have and use the appropriate adapter included with your 35360A TRACKER Display. Use COM1 if it is available, otherwise use COM2. Turn on the 35360A TRACKER Display. Wait approximately five seconds after turning on the instrument before starting the Customization software. Place the working disk into the floppy drive. If you wish to operate the Customization software from the hard drive, copy all of the files from the working disk to a directory on the hard drive.

5.4 Starting the Customization Software

1. If you are operating from a floppy drive, log onto the drive by typing the drive letter followed by a colon and press Enter (e.g., for drive A, type a: and Enter).
2. Start the Customization software by typing CUSTOM. If you connected the instrument to COM2 on your personal computer, type CUSTOM /2.

We recommend that you print a copy of the customization report as your first step in the customization process. This report will contain all of the customization/calibration values and thus serve as a guide for returning to the original settings should an operator keyboard error occur during the process. Additionally, print a copy of the customization report as the final step in the customization process. Use this final report to verify the new customization/calibration parameter values and then save it in a safe place for future reference.

5.5 Screen Formats

The customization software contains two different screens: Display Customization Items (Figure 5-1) and Display Calibration Items (Figure 5-2).

At the bottom of both screens, the Customization software displays the active keys and a short definition for each key.

On the Display Customization screen, the serial number of the 35360A TRACKER Display, the firmware's version, and the current date appear. The date of the last calibration appears in the bottom box. This date changes to the current date if you make a change to any item.

Finally, in the upper right corner, the status indicator for the RS-232 connection appears. For normal operation, the status indicator should be two blocks connected by a line (◐——◑). If the connection is severed, the status indicator will indicate so.

F1 Help (On-Line Help for using the Customization software)

Press F1 to view the On-Line Help for the Customization software. The text includes help on editing and printing.

F2 Edit (Item Editing)

To edit any Item, place the cursor on it and press F2. The Customization software enters Edit mode. The Item is blanked and a blinking cursor appears to show the position of the next character. Enter text or a value from the keyboard. For Items that require a choice, use the up and down arrow keys or the space bar to change the Item.

To exit Edit mode with the changes made to the Item, press Enter. After you press Enter, the Customization software downloads the new information to the 35360A TRACKER Display. In this manner, the Customization screens always reflect the information in the instrument. When the download finishes, the Customization software displays the text, value, or choice it received back from the instrument. If the returned information does not match the information sent down, an error message appears indicating a mismatch. The Customization program retains the original text or value if this error occurs.

To enter large or small values, use scientific notation. The accepted format for this type of entry is x.xxxE+xxx. For example, 1.234E+001 would be equivalent to 12.34; 1.234E-001 would be equivalent to .1234. It is not necessary to specify all three exponent digits. The program accepts an entry of "1e9" to represent 1,000,000,000.

To exit Edit mode without change to the Item, press Escape. The Item will appear in the Selection area as it did before you entered Edit mode.

F6 Print (Report Printing)

Press F6 to print a report of the customization and calibration items (both screens). The report is one page.

F10 Exit

Press F10 to exit the Customization software. When the confirmation box appears, press "Y" to exit, press "N" to return to the Selection mode.

PgDn (Navigation)

Press the Page Down key to move between the Display Customization Items and the Display Calibration Items screens.

5.6 Definitions

This section describes all of the Items that may be customized with the Customization software. It is split into two sections matching the two screens.

CUSTOMIZATION ITEMS

Power Down Interval

The power down interval is used to specify the number of minutes the 35360A TRACKER Display remains powered during periods of inactivity. If the 35360A TRACKER Display senses no operator input in the form of a key press, exposure, or RS-232 command for the duration of the power down interval, it will turn itself off. This interval must be in the range of 5 to 255 minutes. An entry of zero will disable the automatic power down feature.

Temperature Units

This Item provides a selection of temperature scales for use on the 35360A TRACKER Display's Air Density screen. The choices are: Celsius, Fahrenheit, and Kelvin.

Pressure Units

This Item provides a selection of pressure scales for use on the 35360A TRACKER Display's Air Density screen. The choices are: millimeters of mercury (Hg), inches of mercury, feet from sea level, meters from sea level, millibars, and hectoPascals.

Optional Message

Text entered for this Item will appear on the bottom line of the 35360A TRACKER Display's Test screen. The Item is limited to a maximum of 20 characters.

Ion Chamber Calibration Units (ICCU)

The Ion Chamber Calibration Units Item defines the units in which the ion chambers in the 35300A Detector were calibrated. The default is roentgens per nanocoulomb.

This means that the Ion Chamber Calibration Factor (ICCF) given on the Display Calibration Items screen **MUST** be in units of R/nC. Choices for units are roentgens per nanocoulomb, grays per nanocoulomb, sieverts per nanocoulomb, and rads per nanocoulomb.

Display Units

The Display Units Item defines the units in which measurements will be displayed on the 35360A TRACKER Display screen. The choices are roentgens, grays, sieverts, rads, and monitor units. The default is rads.

Display Units Conversion Factor (DUCF)

The 35360A TRACKER Display uses the Display Units Conversion Factor (DUCF) Item to convert the output of the ion chambers (in units defined by the Ion Chamber Calibration Units) to the units required for display (defined by Display Units).

IMPORTANT

You must set the Display Units Conversion Factor correctly and accurately to convert the ion chamber output to displayed units. The default is 0.879 rads/R.

The 35360A TRACKER Display supports four units of radiation. To convert between these units, use Table 5-1. This table was developed from accepted definitions of radiation units. While Table 5-1 shows sieverts and grays as equivalent, we acknowledge that other factors may contribute to this conversion. Additionally, the instrument allows you to display readings in monitor units. Because monitor units are not defined in terms of radiation units, and monitor units could vary from machine to machine, we suggest that you develop your own conversion factor from the Ion Chamber Calibration Units to monitor units.

Table 5-1. A Guideline to Converting Between Units

To Convert:	To:	Multiply By:
roentgen (R)	gray (Gy)	.00879
roentgen (R)	sievert (Sv)	.00879
roentgen (R)	rad	0.879
gray (Gy)	roentgen (R)	113.77
gray (Gy)	sievert (Sv)	1
gray (Gy)	rad	100
sievert (Sv)	roentgen (R)	113.77
sievert (Sv)	gray (Gy)	1
sievert (Sv)	rad	100
rad	roentgen (R)	1.1377
rad	gray (Gy)	.01
rad	sievert (Sv)	.01

DISPLAY CALIBRATION ITEMS

Charge Gain (QG)

The 35360A TRACKER Display uses the Charge Gain to convert the number from the analog-to-digital converter to charge. The Charge Gain must be in units of nanocoulombs per count.

Current Gain, Current Zero (IG and ADZ)

The 35360A TRACKER Display uses the Current Gain and Current Zero to convert the number from the analog-to-digital converter to current. The Current Gain must be in units of nanocoulombs per minute, and the Current Zero must be in units of counts.

Ion Chamber Calibration Factor (ICCF)

The 35360A TRACKER Display uses the Ion Chamber Calibration Factor to convert charge from the 35300A TRACKER Detector ion chambers to radiation units. The factory calibrates the 35300A TRACKER Detector in units of roentgens per nanocoulomb. The accuracy of the calibration factor is $\pm 2.5\%$.

5.7 Setting the Electrometer Gains and Offsets

To set the electrometer gains, you must have a Keithley Instruments, Inc. Model 263 Calibrator/Source or equivalent. The current required for calibration procedure below must be 15 nanoamperes $\pm 0.07\%$; the charge required for calibration procedure below must be 950 nanocoulombs $\pm 0.5\%$. The Electrometer Offsets must be specified before the Electrometer Gains.

ELECTROMETER OFFSET (ADZ)

The procedure for setting the electrometer offsets for current and charge is the same. For every electrometer channel, repeat this procedure once. Turn the instrument off and disconnect the interface cable if it is connected.

WARNING

Always turn the Model 35360A TRACKER Display's power off prior to connecting or disconnecting the interface cable. Failure to do so may result in an electrical shock.

Turn on the instrument. Place the 35360A TRACKER Display in rate mode. Turn off the Front Panel Gain Factor (FPGF) and the Air Density Correction Factor (ADCF).

1. Reset the instrument. Note the dose rate offset value for the channel under adjustment displayed on the VFD. Also note the old ADZ value for the channel under adjustment on the Display Calibration Items screen. Calculate a new ADZ value using the following equation:

$$ADZ_{New} = ADZ_{Old} + (\text{Dose Rate Offset}) / (\text{Current Gain} \times \text{ICCF} \times \text{DUCF})$$

2. Add the value calculated in Step 1 to the original ADZ. Enter this value into the Display Calibration Items screen of the Customization software. Be sure to enter it in the correct column and row. For example, if you are setting the charge offset for the Top chamber, enter the calculated value in the first column and second row.
3. Repeat Steps 1 and 2 if the value displayed on the 35360A TRACKER Display is not zero.

ELECTROMETER GAINS

The procedure for setting the electrometer gains differs for current and charge. For every electrometer channel, repeat the gain setting procedure for current and charge. Turn off the Front Panel Gain Factors and the Air Density Correction Factor. This procedure requires a special cable. Consult the factory for details.

Electrometer Current Gain (IG)

1. Apply 15 nanoamperes (900 nC/min) to the input of an electrometer channel.
2. Check the measurement on the 35360A TRACKER Display's Front Panel. Calculate the new Current Gain factor using the equation below.

$$\text{New Current Gain} = \text{Old Current Gain} \frac{900 \times \text{ICCF} \times \text{DUCF}}{\text{Measurement}}$$

where Measurement is the value on the 35360A TRACKER Display, and ICCF and DUCF are defined on page 60 and page 59 respectively.

3. Enter the value calculated in Step 2 into the Display Calibration Items screen of the Customization software. Be sure to enter it in the correct column and row. For example, if you are setting the current gain for the Right chamber, enter the value calculated in Step 1 in the fourth column and third row.

Electrometer Charge Gains (QG)

1. Reset the instrument and apply 950 nanocoulombs to the input of an electrometer channel.
2. Check the measurement on the 35360A TRACKER Display's Front Panel. Calculate the new Charge Gain factor using the equation below.

$$\text{New Charge Gain} = \text{Old Charge Gain} \frac{950 \times \text{ICCF} \times \text{DUCF}}{\text{Measurement}}$$

where Measurement is the value on the 35360A TRACKER Display, and ICCF and DUCF are defined on page 60 and page 59 respectively.

Enter the value calculated in Step 2 into the Display Calibration Items screen of the Customization software. Be sure to enter it in the correct column and row. For example, if you are setting the charge gain for the Center chamber, enter the value calculated in Step 1 in the third column and first row.

If you wish to use the Front Panel Gain Factor and the Air Density Correction Factor, be sure to enable them after the calibration is finished.

5.8 Usage Examples

CHANGING THE POWER DOWN INTERVAL

1. Place the cursor on the Power Down Interval Item.
2. Press F2. The field clears.
3. Enter 10 and press Enter.
4. The software indicates that it is downloading. When the Item reappears, the download was successful. The number that appears is the value returned from the 35360A TRACKER Display.

CHANGING THE PRESSURE UNITS

1. Place the cursor on the Pressure Units Item.
2. Press F2. The function key area indicates the keys used to make a choice.
3. Press the spacebar or use the up and down arrow keys to change the units.
4. Select millibars and press Escape. The original units remain and the Customization software returns to Selection mode.
5. Repeat steps 2 and 3. Select millibars and press Enter.
6. The software indicates that it is downloading. When the Item reappears, the download was successful.

CHANGING THE DISPLAY UNITS CONVERSION FACTOR

CAUTION

This example changes the current value of a factory-set conversion factor. Make a note of the value **BEFORE** changing it so that it may be set to this value at the end of the example.

1. Place the cursor on the Display Units Conversion Factor Item.
2. Press F2. The field clears.
3. Enter 0.765 and press Enter.
4. The software indicates that it is downloading. When the Item reappears, the download was successful. The number that appears is the value returned from the 35360A TRACKER Display.
5. Press F2.
6. Enter the original value and press Enter.
7. The software restores the original value in the instrument.

CHANGING THE ION CHAMBER CALIBRATION FACTOR UNITS

CAUTION

This example changes the current value of a factory-set calibration factor. Make a note of the value **BEFORE** changing it so that it may be set to this value at the end of the example.

1. Press the Page Down key until the Display Calibration Items screen appears.
2. Move the cursor to the Ion Chamber Calibration Factor for the Center chamber.
3. **IMPORTANT:** Make a note of the current value.
4. Press F2. The field clears.
5. Enter 1.234 and press Enter.
6. The software indicates that it is downloading. When the Item reappears, the download was successful. The number that appears is the value returned from the 35360A TRACKER Display.
7. Press F2.
8. Enter the original value and press Enter.
9. The software restores the original value in the instrument.

CHANGING THE CURRENT GAIN

CAUTION

This example changes the current value of a factory set current gain. Make a note of the value **BEFORE** changing it so that it may be set to this value at the end of the example.

1. Press the Page Down key until the Display Calibration Items screen appears.
2. Move the cursor to the Current Gain for the Top chamber.
3. **IMPORTANT:** Make a note of the current value.
4. Press F2. The field clears.
5. Enter 1e100 and press Enter.
6. The software indicates that it is downloading. Because the value, 1e100, is not a valid value for the Current Gain, the software indicates a mismatch error. Press any key to clear the error. Note that the instrument returned a value but not the one that was entered.
7. Enter the original value and press Enter.
8. The software restores the original value in the instrument.

5.9 Errors

During program operations, errors may appear. The error messages are grouped into input errors, a hardware error, and communication errors.

INPUT ERRORS

Input errors may appear while changing Item values. When these errors occur, press any key to clear the error and enter a different value. After clearing the error, you may press Escape to end editing. The input errors are:

- Value must be greater than zero
- Must specify at least one digit
- Value must be less than 999.99

HARDWARE ERROR

A hardware error occurs when the program cannot perform a required hardware operation. The only hardware error is a printer error. If the Customization software cannot send information to the printer, the following message appears.

Printer Error

Press any key to clear the error. Correct the problem causing the error (for example, out of paper or the printer is not on-line), and try printing again.

COMMUNICATION ERRORS

These errors indicate that the communications between the computer and the instrument is faulty. Generally, the icon in the upper right corner indicates the status of the RS-232 connection. The following errors indicate problems during actual communication. Press any key to clear the error.

Dosimeter is not connected

If the RS-232 connection becomes severed during communication, this error appears. Re-connect the line and try the download again.

Upload/Download mismatch

If the information received from the 35360A does not match that sent by the Customization software, this error appears. Generally, the downloaded information was out of the boundary given for the specific Item. The Customization software retains the ORIGINAL text or value.

Finally, the Customization software checks the RS-232 connection at the beginning of the program. If it detects that no instrument is connected, the program ends and an error message occurs. Check the cable for breaks and confirm that the connections are solid. The program defaults to COM1: for the communications port. If that port is in use, specify COM2: by placing /2 on the command line:

custom /2

Also, make sure that the instrument has been on for at least five seconds.

Appendix A Using Build-Up

A.1 Build-Up, Peg, and Retainer Kit Options

If you want to use build-up to simulate tissue, you can put plates of either "solid water" or acrylic (optional accessories) securely on one or both sides of the Model 35300A Detector. Build-up pegs and retainer rings for securing the acrylic plates to the 35300A Detector are also available as optional accessories (see Figure A-1). The build-up pegs (a set of eight) screw into threaded holes in the 35300A Detector, (four build-up pegs can be installed on each side of the 35300A Detector). The retainer rings are held in position with set screws that are turned with a hex wrench also included with the Model 90100 TRACKER System.

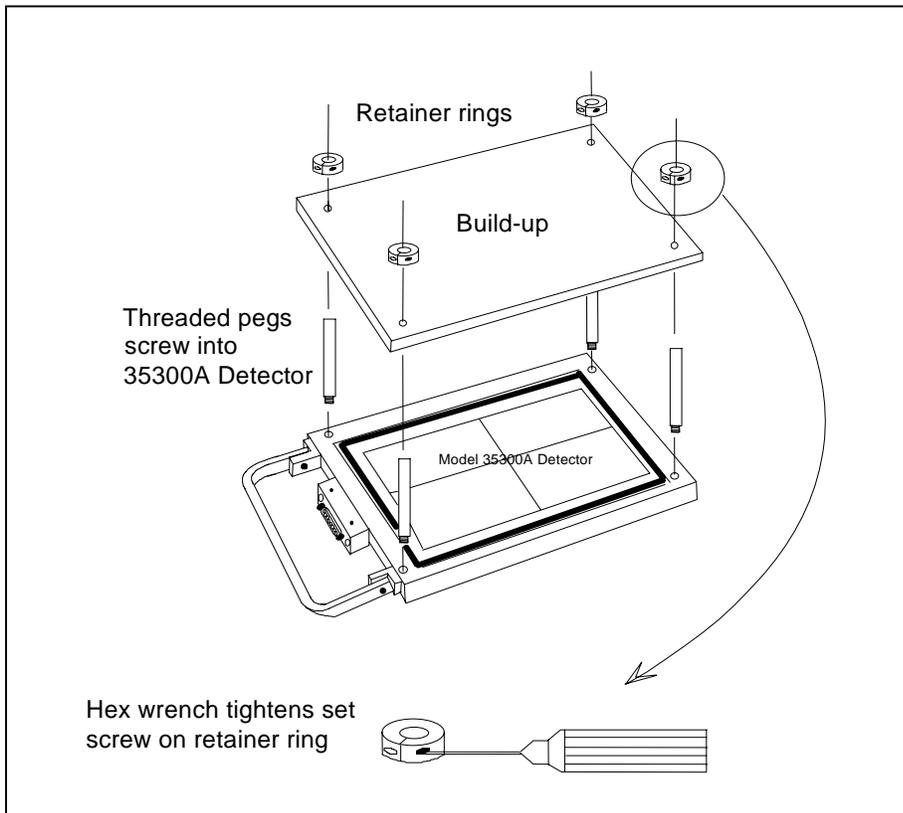


Figure A-1. Installation of Pegs, Build-up and Retainer Rings

Recommended build-up for photons is given in Table A-1; recommended build-up for electrons is given in Table A-2. Table A-2 takes into account the 0.56 cm water-equivalent inherent in the 35300A Detector. Cobalt-60 radiation does not require any added build-up.

Table A-1. Recommended Amount of Build-up to Use With the Model 35300A Detector to Attain Photons d_{max} for Linear Accelerators

Nominal Accelerator Potential, MeV	Number of build-up plates (37051C-1)	"Solid Water" thickness (cm)
2	0	0
3	1	0.5
4	2	0.5
5	2	1.0
6	3	1.0
7	3	1.5
8	3	1.5
9	4	1.5
10	4	2.0
11	4	2.0
12	4	2.0
13	5	2.0
14	5	2.5
15	5	2.5
16	6	2.5
17	6	3.0
18	6	3.0
19	6	3.0
20	7	3.0
21	7	3.5
22	7	3.5
23	7	3.5
24	8	4.0
25	8	4.0

Table A-2. Recommended Amount of Build-up to Use With the Model 35300A Detector to Attain Electrons d_{max} for Linear Accelerators. 37051C-1 Plates are 0.44 cm Each

Nominal Accelerator Potential, MeV	Number of build-up plates (37051C-1)	"Solid Water" thickness (cm)
2	1	0.5
3	1	0.5
4	1	0.5
5	2	1.0
6	2	1.0
7	3	1.5
8	3	1.5
9	4	2.0
10	5	2.0
11	5	2.5
12	6	3.0
13	6	3.0
14	7	3.5
15	7	3.5
16	8	4.0
17	8	4.0
18	9	4.5
19	10	4.5
20	10	5.0
21	11	5.5
22	11	5.5
23	12	6.0
24	12	6.0
25	13	6.0

The amount of underside build-up to be used depends on how closely you wish to approximate the back-scattering of a water bath or other test set-up. Generally, several inches are used: about eight 37051C-1 plates (or about 4.0 cm of "Solid Water") regardless of the incident energy shown in the tables.

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