

TNT 12000

X-Ray Test Tools

Users Manual

Warranty and Product Support

Fluke Biomedical, Radiation Management Services* products are warranted against defects in material and workmanship.

- Instruments: Warranted for one year from date of shipment. The warranty for instruments that require calibration may be extended each year by the GCL Extended Warranty Program.
- Phantoms: Warranted for 6 months from date of shipment. The warranty excludes disposable phantoms.
- CLEAR-Pb[®]: Warranted for 6 months from date of shipment against defects in material and workmanship.
- Software: Warranted for 90 days that it will perform substantially in accordance with its documentation.
- Consumables: Not covered under warranty.

During the warranty period, Fluke Biomedical will, at its discretion, either repair or replace the component or product that proves to be defective upon the company's examination. Repairs are limited to those components pertaining to functionality and not cosmetic appearance.

The limited warranty becomes void if the product is disassembled, modified or repaired by an unauthorized person or facility, or if the product's functionality is impaired by damage, abuse or failure to use and maintain the instrument according to the manufacturer's instructions.

To exercise this warranty, the owner must write or call a Fluke Biomedical customer service representative to receive a Service Return Authorization (SRA). The owner must send the product, transportation prepaid, to a specified service facility. Repairs will then be made, and the product will be returned to the owner with transportation (normal, service) prepaid. Repaired or replaced products are warranted for the balance of the warranty period. For products not covered by warranty, the part repaired has a warranty of 90 days.

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Disclaimer

Please Note: If an instrument is intended for the detection and measurement of ionizing radiation, it should be used only by persons who have been trained in the appropriate safety procedures to be followed in the presence of radiation and the proper interpretation of the instrument's readings. Instruction and precautions contained in the manuals must be read before use and strictly followed. Failure to follow these instructions and precautions may result in inaccurate readings and/or user hazard. Battery and other preoperational checks should be performed prior to each use to assure that the instrument is functioning properly.

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Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

Technical Support

For application support or answers to technical questions, either email radtechsupport@flukebiomedical.com or call 1-800- 850-4608 or 1-440-498-2560. Technical support is also available at <http://www.flukebiomedical.com/techsupport>.

Claims

Our routine method of shipment is via common carrier, FOB origin. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim. If the instrument is delivered in good physical condition but does not operate within specifications, or if there are any other problems not caused by shipping damage, please contact Fluke Biomedical or your local sales representative.

Standard Terms and Conditions

Refunds and Credits

Please note that only serialized products and their accessory items (i.e., products and items bearing a distinct serial number tag) are eligible for partial refund and/or credit. Nonserialized parts and accessory items (e.g., cables, carrying cases, auxiliary modules, etc.) are not eligible for return or refund. Only products returned within 90 days from the date of original purchase are eligible for refund/credit. In order to receive a partial refund/credit of a product purchase price on a serialized product, the product must not have been damaged by the customer or by the carrier chosen by the customer to return the goods, and the product must be returned complete (meaning with all manuals, cables, accessories, etc.) and in “as new” and resalable condition. Products not returned within 90 days of purchase, or products which are not in “as new” and resalable condition, are not eligible for credit return and will be returned to the customer. The Return Procedure (see below) must be followed to assure prompt refund/credit.

Restocking Charges

Products returned within 30 days of original purchase are subject to a minimum restocking fee of 25 %. Products returned in excess of 30 days after purchase, but prior to 90 days, are subject to management approval. Additional charges for damage and/or missing parts and accessories will be applied to all returns.

Return Procedure

All items being returned (including all warranty-claim shipments) must be sent freight-prepaid to our factory location. When you return an instrument to Fluke Biomedical, we recommend using United Parcel Service, Federal Express, or Air Parcel Post. We also recommend that you insure your shipment for its actual replacement cost. Fluke Biomedical will not be responsible for lost shipments or instruments that are received in damaged condition due to improper packaging or handling.

Use the original carton and packaging material for shipment. If they are not available, we recommend the following guide for repackaging:

- Use a double-walled carton of sufficient strength for the weight being shipped.
- Use heavy paper or cardboard to protect all instrument surfaces. Use nonabrasive material around all projecting parts.
- Use at least four inches of tightly packed, industry-approved, shock-absorbent material around the instrument.

Returns for partial refund/credit:

Every product returned for refund/credit must be accompanied by a Return Material Authorization (RMA) number, obtained from our Customer Support Group at 1-800-850-4608 or 1-440-498-2564 or email orders@flukebiomedical.com.

Repair and calibration:

To find the nearest service center, go to www.flukebiomedical.com/service, or

In the U.S.A.:

Cleveland Calibration Lab
Tel: 1-800-850-4606 ext. 2564
Email: globalcal@flukebiomedical.com

Everett Calibration Lab
Tel: 1-888-993-5853
Email: service.status@fluke.com

In Europe:

Eindhoven Calibration Lab
Tel: +31-402-675300
Email: ServiceDesk@fluke.com

Certification

This instrument was thoroughly tested and inspected. It was found to meet Fluke Biomedical's manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Institute of Standards and Technology (NIST). Devices for which there are no NIST calibration standards are measured against in-house performance standards using accepted test procedures.

WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. Fluke Biomedical will not be responsible for any injuries sustained due to unauthorized equipment modifications.

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Manufacturing Location

The TNT 12000 X-Ray Test device is manufactured in Cleveland, Ohio by Fluke Biomedical, 6045 Cochran Rd., Cleveland, OH, U.S.A.

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Chapter 1

Introduction

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Introduction

The Fluke Biomedical TNT 12000 X-ray Test Tools (the TNT 12000) are used to calibrate and service diagnostic X-ray imaging systems.

The TNT 12000 X-ray Test Tools has these parts:

- TNT 12000WD X-ray Detector option (the X-ray Detector). The X-ray Detector contains an array of solid-state sensors and filters that measure kV, Dose, Half-Value Layer (HVL), and exposure time.
- TNT 12000 DoseMate option (the Dosimeter Detector). With its related ion chambers, the Dosimeter Detector measures dose and rate on all X-ray modalities: radiographic, mammographic, dental, cine, fluoroscopic, and CT.
- TNT 12000 mAs option (the mAs Detector) to measure X-ray tube current over time. Use the mAs Detector on radiographic (or Dental or Mammography) and fluoroscopic X-ray imaging modalities. The mAs option is installed in the X-ray or Dosimeter Detectors.
- TNT 12000 Display (the Display). The Display contains a 320 x 240 color LCD, four navigation buttons, an ENTER button, and a power button. The display controls test-system functions and shows all system measurements.
- TNT 12000/DoseMate/mAs CD that contains an Excel Add-in to control the test system and import all measurements.
- AC Power Adapter used to charge the rechargeable batteries in the X-ray Detector, Dosimeter Detector, mAs Detector, and the Display.

The TNT 12000 options communicate between the detectors and the display or computer through a wireless (ZigBee) or wired (USB) connection.

Unpacking and Inspection

The TNT 12000 is shipped in a container designed to prevent damage during shipment. Examine the components for damage, and immediately report any damage to the shipper. Keep the damaged shipping container and packing material for inspection by the carrier.

Note

The shipping container contains foam inserts to prevent damage during shipment. Keep these and the container for future shipment.

When you unpack the TNT 12000, compare the parts to the packing list. If you ordered the mAs option, make sure it is installed in a Detector by looking for an mAs input jack on a Detector. See the Familiarization section later in this chapter. Report any shortage to the place of purchase.

Storage

To store the TNT 12000, put it in its carrying case. Keep it in an environment free of corrosive material and within the storage temperature and operating humidity ranges shown in the specifications. Also prevent vibration and shock to the system.

General Safety Considerations

In this manual, a **Warning** identifies conditions and actions that pose hazards to the user. A **Caution** identifies conditions and actions that may damage the test equipment or the equipment under test.

Symbols used on the test system or in this manual are explained in Table 1-1.

To ensure safe operation of the Test System, fully observe all instructions and warnings contained in this manual.

Warning

To avoid possible electrical shock or personal injury, follow these guidelines:

- **Use the TNT 12000 only in the manner specified by the manufacturer.**
- **Do not use the product if it operates abnormally.**
- **Use only the ac adapter provided with the system.**
- **Ensure that the external power source is properly rated for the system.**

Caution









To avoid damage to the TNT 12000 or adverse affects on its performance, follow these guidelines:

- **Allow only qualified technical personnel to service the system.**
- **Do not expose the system to temperature extremes. Ambient temperatures should remain between 0 °C and 35 °C. System performance may be adversely affected if temperatures fluctuate above or below this range.**
- **Clean the TNT 12000 by gently wiping down with a clean, lint-free cloth dampened with a mild detergent solution. Do not immerse the unit in liquid.**

Symbols

Table 1-1 describes the symbols associated with the TNT 12000.

Table 1-1. Symbols

Symbol	Description	Symbol	Description
	Hazardous voltage		Conforms to European Union directives
	Important information, refer to manual		Conforms to relevant Australian EMC requirements
	Complies with RoHS directives		Complies with Part 15 of the FCC rules
	Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.		This product contains a Lithium-ion battery. Do not mix with solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler per local regulations. Contact your authorized Fluke Service Center for recycling information.

RF Certification

The TNT 12000 contains radio transceivers that are used for wireless communication between the Display and the Detectors. The transceivers operate in the 2.4 GHz frequency band with a maximum transmitting power of 1 mW. The transceivers have been tested and certified for use in various areas worldwide.

United States

The transceivers used in the TNT 12000 have been approved for use in the United States by FCC Part 15 certification, FCC ID: OUR-XBEE. The following statement accompanies the device:

“Contains FCC ID: OUR-XBEE”

The enclosed device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Re-orient or relocate the receiving antenna, increase the separation between the equipment and receiver, connect equipment and receiver to outlets on different circuits, or consult the dealer or an experienced radio/television technician for help.

Warning

To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Canada

The transceiver used in the TNT 12000 has been certified for use in Canada, IC certification number IC: 4214A-XBEE.

Europe

The transceiver used in the TNT 12000 conforms to European Union EMC Directive 2004/108/EC, ETSI EN 301 489-1 and EN 301 489-17; and R&TTE Directive 1999/5/EC, ETSI EN300 328.

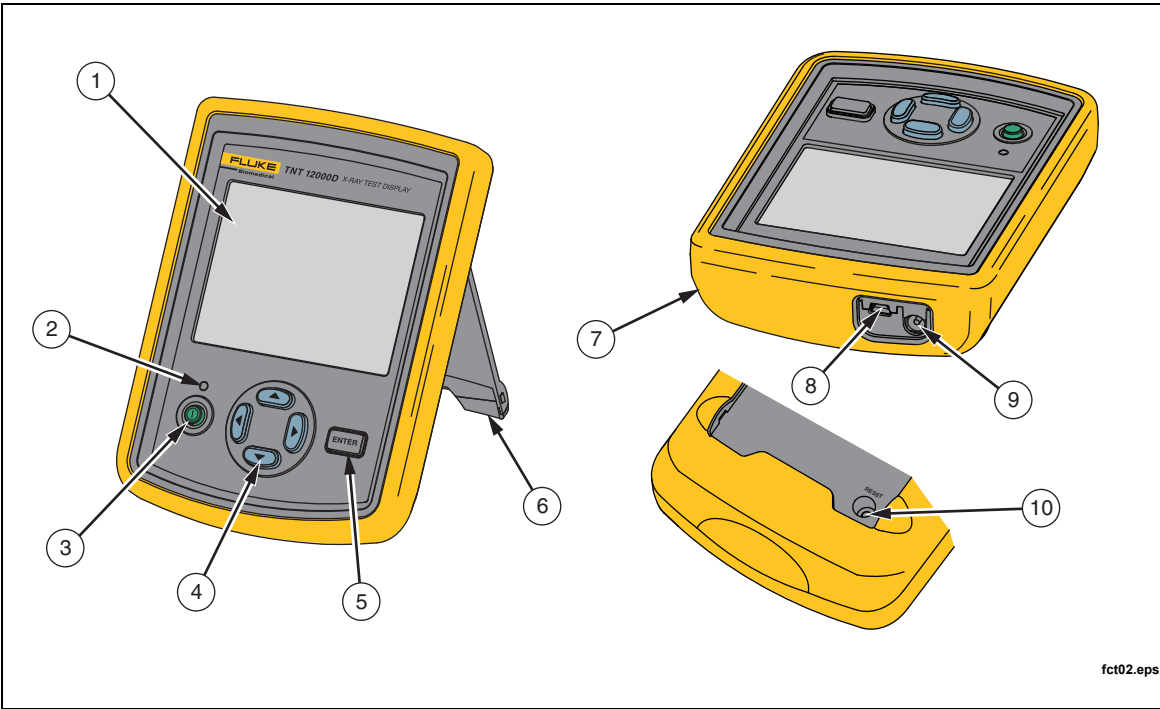
Japan

Japan ID: 005NYCA0378

Familiarization

To use the TNT 12000, you must first connect the Display to the X-ray Detector or Dosimeter Detector. Tables 1-2 through 1-4 shows the controls, indicators, and connectors of the Display and Detectors.

Table 1-2. Display Components

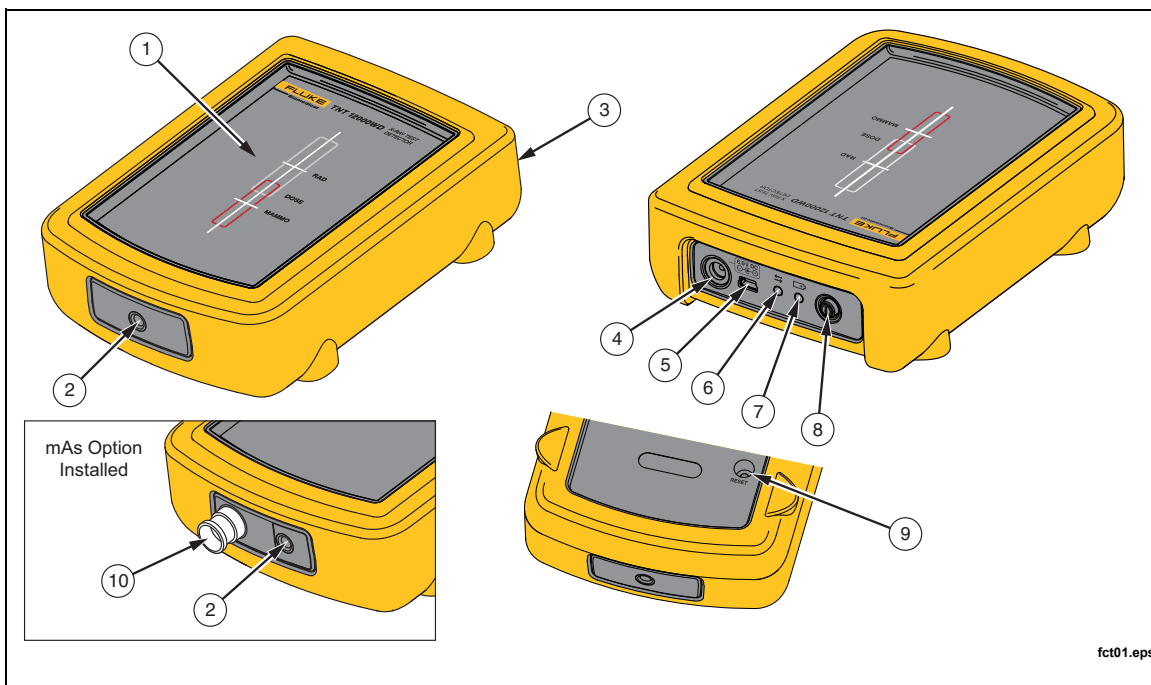


Item	Name	Description
①	LCD Panel	320X240 color display
②	Battery-status Indicator	Tri color LED indicating the battery status of the display. Refer to the Battery Charging section for more details.
③	On/Off Switch	Powers the display On/Off
④	Navigational Keys: Left, Right, Up, and Down keys	Moves the cursor through the menu options on the display screen in various directions. Note: The cursor movement is circular
⑤	Enter key	Selects the menu option on the display screen
⑥	Stand	Display support stand
⑦	Holster	Protective cover for the display
⑧	USB Connector	To connect the detector or a Computer via USB cable
⑨	AC adapter connector	Connects the ac adapter
⑩	Reset switch	Resets the display

Note

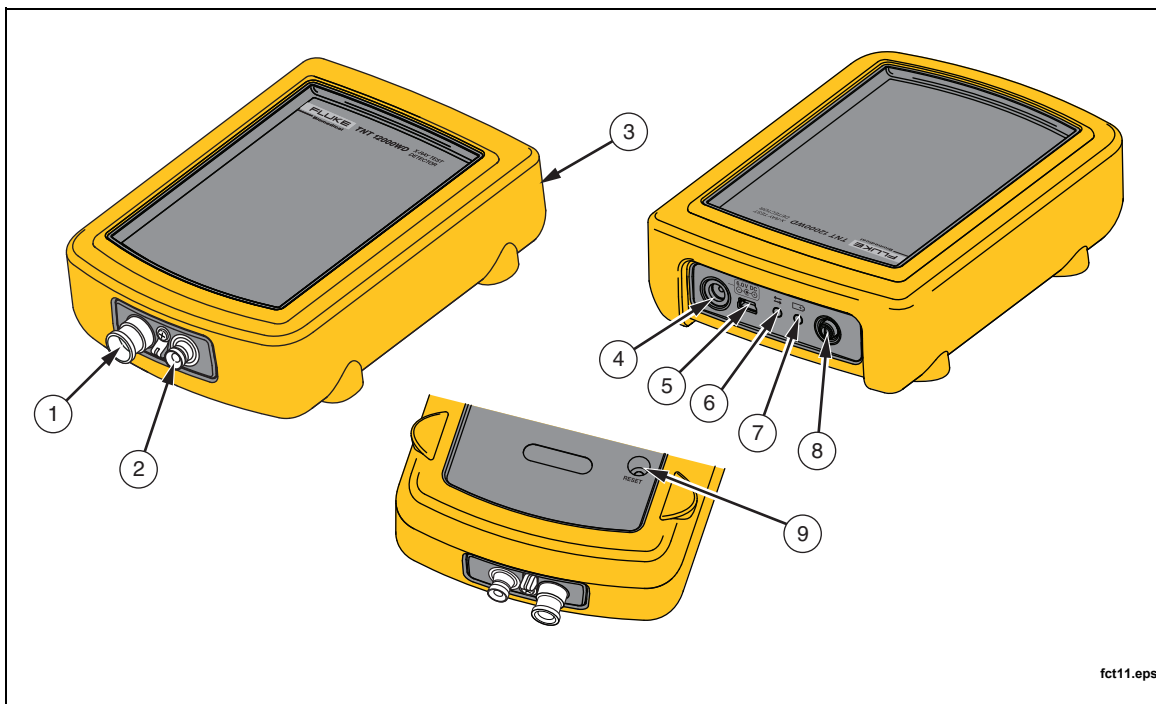
A short beep sounds for a valid key press, and a long beep sounds for an invalid key press.

Table 1-3. X-ray Detector Components



Item	Name	Description
①	Exposure Surface	The surface to be exposed to x-ray radiation
②	Threaded Insert	Secures the detector to a test stand, such as a camera tripod
③	Holster	Protective cover for the display
④	AC adapter connector	Connects the ac adapter
⑤	USB Connector	To connect the detector or a Computer via USB cable
⑥	Communication status LED	Indicates the communication status (see the Display to Detector Communications section in Chapter 1)
⑦	Battery-status Indicator	Tri color LED indicating the battery status of the display. Refer to the Battery Charging section for more details.
⑧	On/Off Switch	Powers the Detector On/Off
⑨	Reset switch	Resets the Detector
⑩	mAs input jack (when mAs option is installed)	Male coaxial BNC jack for connection to the mA/mAs interface cable <div style="text-align: center;"> ⚠ Caution To avoid damage to the Detector, never connect to generator mA/mAs taps without the TNT 12000 mAs shunt. </div>

Table 1-4. Dose Detector Components



fct11.eps

Item	Name	Description
①	mAs input jack (when mAs option is installed)	Male coaxial BNC jack for connection to the mA/mAs interface cable ⚠ Caution To avoid damage to the Detector, never connect to generator mA/mAs taps without the TNT 12000 mAs shunt.
②	Ion Chamber Connector	Triaxial input connection for the Ion Chamber.
③	Holster	Protective cover for Dosimeter
④	AC adapter connector	Connects the ac adapter
⑤	USB Connector	To connect the Detector or a computer via USB cable
⑥	Communications Status Indicator	Indicates the communication status (see the Display to Detector Communications section in Chapter 1)
⑦	Battery-status Indicator	Tri color LED indicating the battery status of the display. Refer to the Battery Charging section for more details.
⑧	On/Off Switch	Powers the Detector On and Off.
⑨	Reset switch	Resets the Dose Detector

How to Charge the Battery

Charging the internal batteries of the detectors and display from mains power can be done in three different configurations as shown in Figure 1-1.

⚠ Caution

To prevent damage to the TNT 12000, do not leave batteries unused for an extended period of time. When a battery has not been used for six months, check the charge status and charge if necessary.

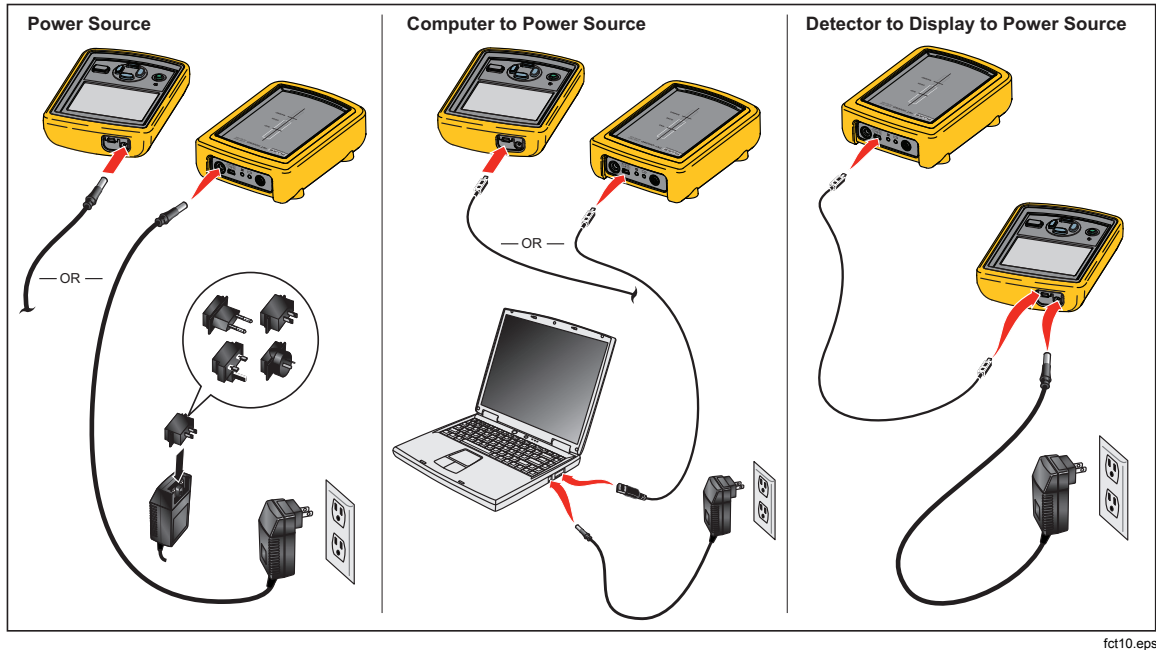


Figure 1-1. Charging Methods

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To charge a Detector or the Display directly from mains power, connect the ac-power adapter directly to the ac adapter connector on a Detector or the Display. To charge a Detector and the Display simultaneously, connect the ac adapter to the ac adapter connection on the Display and then, using the Mini-B to Type-A USB cable, connect the Detector to the Display.

Note

See the markings on the ends of the cable to identify the Mini-A and Mini-B ends.

A Detector or Display battery can also be charged through a USB connector on a PC. Connect the Display or Detector to a PC USB port using the Mini-A to Type-A USB cable.

Both Detectors and the Display have a battery-status indicator to indicate the condition of the internal battery. The indicator is a tri-color LED that shows the level of charge on the internal battery. Table 1-5 explains the battery-status indicator levels.

Table 1-5. Battery Status Indicator

Color	Description
Blue	Battery is fully charged.
Green	Battery is charging.
Off	Unit is not connected to a charging power source and is operating on battery power.
Yellow	Battery is approximately 20 % charged.
Red	Battery has 10 % charge and will turn off in two minutes.

Accessories

Items shown in Table 1-6 are standard accessories provided with the TNT 12000. Some accessories are only associated with specific options. Items in Table 1-7 are optional.

Contact your Fluke Biomedical representative to purchase the accessories shown below.

Table 1-6. Accessories

Accessory	Fluke Biomedical Part No
Cable, Type A to Mini B USB	3346027
Cable, Mini A to Mini B USB	3346030
ZigBee Dongle	3341333
AC Power Adapter	3548014
Multi-Prong Adapter	3549414
CD, TNT 12000/DoseMate/mAs	3586667
Ansur Demo CD	2795488
DoseMate Option	
Carrying Case, DoseMate/mAs	3586528
Test Stand, DoseMate	3586537
HVL Filter Set	3264115
Adapter Stem	3264091
Tirax Cable, Male to Male, BNC, 1.82 m (6 ft)	3586644
mAs Option	
mA Cable Assembly, BNC (male to female)	1918780
mA Shunt Assembly	3586555
Alligator Clip, Banana Plug (Red)	1942964
Alligator Clip, Banana Plug (Black)	1942920
Connector, BNC (F) to Binding Posts	1938315
Connector, BNC (F) to Double Banana Plug	1633042

Table 1-7. Optional Accessories

Accessory	Fluke Biomedical Part No
Ansurs Plug In, TNT 12000	3337356
Optional Accessories for the DoseMate Option	
Diagnostic Ionization Chamber, 150cc, Model 96020C	2549992
Diagnostic Ionization Chamber, 15cc, Model 96035B	2550024
CT Ion Chamber, 3cc, Model 500-100	2549734
CT Ion Chamber, 10cc, Model 500-200	2549741
Triax Cable, Male to Male, BNC, 6.1 m (20 ft)	3265786
Optional Accessories for the mAs Option	
Non-Invasive mA/mAs Clamp	3586746
mA Cable Assembly, BNC, 6.1 m (20 ft) (male to female)	2118136

Specifications

Physical

Display Screen 320X240 Color LCD

Size

Display 15.24 cm X 11.43 cm X 4.45 cm (6 in X 4.5 in X 1.75 in)

Detector 15.24 cm X 11.43 cm X 4.45 cm (6 in X 4.5 in X 1.75 in)

Weight

Display 347 g (0.93 lb)

X-ray Detector w/o mAs 560 g (1.5 lb)

X-ray Detector with mAs 560 g (1.5 lb)

DoseMate w/o mAs 392 g (1.05 lb)

DoseMate with mAs 392 g (1.05 lb)

Electrical

Battery

Battery Type Lithium-Ion, 3.7 V, 4000 mAh

Battery Charging time Approx. 5 hr

Battery Discharge time Approx. 8 hr

Battery Cutoff Voltage 3.0 V

AC Adapter

Input Voltage 100 V ac to 240 V ac

Input Frequency 50/60 Hz

Input Current 0.5 A (rms)

Output Voltage +6 V dc

Output Current 2500 mA (max.)

Environmental

Operating Temperature.....	0 °C to 35 °C (32 °F to 95 °F)
Storage Temperature.....	-35 °C to 50 °C (-31 °F to +122 °F)
Operating Humidity.....	20 % to 80 % RH (Non Condensing)
Wireless Range.....	30 m (100 ft)

X-ray Specifications

kVp

Units.....	kVp Average (Average of peaks during a specified interval) kVp Max (Highest peak during a specified interval) PPV (Peak Practical Voltage)
------------	--

Ranges

Radio/Fluoro/Dental Modes (W,Al)	40 kV–150 kV
--	--------------

Mammo Mode

Mo/Mo.....	22 kV–35 kV
Rh/Rh.....	25 kV– 49 kV
Mo/Rh	22 kV–40 kV
Mo/Al.....	22 kV– 49 kV
Rh/Al	25 kV–49 kV
W/Rh.....	22 kV–39 kV
W/Ag.....	22 kV–39 kV

Resolution:	0.1 kV
-------------------	--------

Accuracy (including calibration uncertainty)

Radio/Fluoro/Dental Modes	±2 % or ±1 kV, whichever is greater
Mammo Mode	±2 % or ±0.7 kV, whichever is greater
Reproducibility	±1 % (standard deviation % of 5 readings)

Filtration Correction Range

Radio/Fluoro/Dental Modes	1–10 mm Al or equivalent
Mammo Mode	0–0.4 mm Al or equivalent added filtration (0–0.2 mm Al below 25 kV)

Dose/Exposure

Units.....	Roentgens (R) Grays (Gy)
Range	0.5 mR–999 R 5 mGy–999 Gy
Resolution	1 µR 0.01 µGy
Accuracy	±5 %
Reproducibility	±0.5 % (standard deviation % of five readings)
Filtration Correction Range	
Radio/Fluoro/Dental Modes	10 mm Al or equivalent
Mammo Mode	0–0.4 mm Al or equivalent added filtration (0– 0.2 mm Al below 25 kV)
kV Correction Ranges	
Radio/Fluoro/Dental Modes	40 kV–150 kV
Mammo Mode: Mo/Mo	22 kV–35 kV

Dose/Exposure Rate

Units.....	Roentgens per hour, minute, second, pulse (R/hr, R/min, R/sec, R/Pulse) Grays per hour, minute, second, pulse (Gy/hr, Gy/min, Gy/sec, Gy/Pulse)
Range	8 mR/s–10 R/s 70 µGy/s–100 mGy/s 130 µR/Pulse–160 mR/Pulse (@ 60 PPS) 12 µGy/Pulse–1.4 mGy/Pulse (@ 60 PPS)
Resolution	1 µR/s 0.01 µGy/s 0.02 µR/Pulse (@ 60 PPS) 0.2 nGy/Pulse (@ 60 PPS)
Accuracy	±5 %

Filtration Correction Range	
Radio/Fluro/Dental Modes	1-10 mm Al or equivalent
Mammo Mode	0-0.4 mm Al or equivalent added filtration (0-0.2 mmAl below 25 kV)
kV Correction Range	
Radio/Fluro/Dental Modes	40 kV-150 kV
Mammo Mode: Mo/Mo	22 kV-35 kV

Exposure Time-Radiographic Modes

Range @ stated accuracy	
Milliseconds	10-9999 ms
Pulses	1-999 pulses
Resolution	
Milliseconds	0.1 ms
Pulses	1 pulse
Accuracy	
Milliseconds	1 % or 0.5 ms
Pulses	±1 pulse
Reproducibility	
Milliseconds	1 % or 0.5 ms
Pulses	±1 pulse

Elapsed Time-Fluoro Modes

Range	10-9999 seconds
Resolution	0.1 second
Accuracy	1 % or 0.5 second

Average Pulse Rate – Pulsed Fluoro

Range	1-999 pps (pulses per second)
Resolution	1 pps
Accuracy	1 pps

Average Pulse Width – Pulsed Fluoro

Range	10-999 ms
Resolution	0.1 ms
Accuracy	1% or 0.5 ms

HVL (Half Value Layer)

Range	
Radio/Fluro/Dental Modes	1.2-10 mm Al (equivalent)
Mammo Mode	0.2-0.6 mm Al (equivalent)
Resolution	
Radio/Fluro/Dental Modes	0.1 mm Al (equivalent)
Mammo Mode	0.01 mm Al (equivalent)
Accuracy	
Radio/Fluro/Dental Modes	±10 % or 0.2 mm Al (equivalent)
Mammo Mode: Mo/Mo	± 5 % or 0.05 mm Al (equivalent)

mAs Specifications**Accuracy**

With Invasive Shunt	±2 % of rdg ±2 digits
With Non-Invasive Shunt	±3 % ±3 mA
Invasive mA/mAs Range.....	
0.00 – 99.99 mA/mAs	
100.0 – 999.9 mA/mAs	
1000 – 1999 mA/mAs	
Non-Invasive mA/mAs Ranges	
0 – 999.9 mA/mAs	
1000 – 3999 mA/mAs	
Trigger Levels	
Invasive Shunt	3 mA
Non-Invasive Shunt	6 mA
Input Jack.....	Male Coaxial BNC
mA/mAs Interface Cable	152.4 cm (60 in) BNC Male – Female, 50 Ohm cable with strain relief

Adapters..... BNC Female to Binding Posts, BNC Female to Banana Plug
Test Leads 91.4 cm (36 in) safety set with finger guards on probes and shrouded banana plugs

Invasive Shunt

Shunt Impedance..... 1 Ohm
Sensitivity..... 1 mV per mA
Shunt Signal Input Limit..... 1 A for 30 seconds (Limit set by power dissipation rating of shunt resistors. Maximum common mode voltage is 500 V).
Input/Output 4 mm Binding posts, 4 mm Banana Plugs
Size 4.45 cm x 3.66 cm x 1.75 cm (1.75 in x 1.44 in x 0.69 in)
Weight..... 45 g (0.1 lb)

Non-Invasive Clamp

Range 0 – 4 Amps
Sensitivity..... 100 mV/A
Power Source 2 x 1.5 V AA UM3 Batteries
Current Consumption..... 10 mA
Operating Condition -10 °C to +50 °C at 85 % max. RH

DoseMate Specifications

Accuracy ±1 % of rdg ±2 of range resolution steps (see DoseMate Measurement Ranges) over the range of 18 to 28 °C and ±2 of reading ±2 range resolution steps over the full operating temperature range of 0 to 35 °C. This accuracy is exclusive of all ion chamber effects. A 3 % NIST traceable calibration is provided with each system.
Bias Voltage..... 300 V. The bias voltage is removed from the triaxial input connector at instrument turnoff.
Ion Chamber Input Triaxial-BNC input connector, collector and guard positive-biased relative to ion chamber body/dosimeter chassis.
Ion Chamber Cable..... 1.8 m (6 ft), Triaxial Male to Male cable
Test Stand..... Machined stainless steel upright tool with baseplate, ion chamber holder, and tray for HVL filters, which includes the ion chamber stem.
HVL Filter Set..... Set of nine aluminum filters for half-value layer measurements: one 2 mm, two 1 mm, two 0.5 mm, three 0.1 mm, and one 0.2 mm.
Temperature Accuracy..... ±2 °C (3.6 °F)
Pressure Accuracy..... ±5 mm Hg

Note

The measured temperature is the internal temperature of the DoseMate, which may not be the same temperature as the Ion Chamber that is in use. Adequate time must be allowed for the DoseMate and Ion Chamber to reach thermal equilibrium before automatic temperature sensing is used.

Measurement Ranges

Values for ion chambers are calculated using nominal sensitivities: 15 cc: 2.4 x 108 R/C, 150 CC: 2.4 x 107 R/C.

15 cc Ion Chamber

Units	Effective Range ^[1]	Threshold	Resolution Step Size
R	100 µ to 20	60 µ	1 µ
R/s	100 µ to 20	60 µ	1 µ
R/min	5 m to 1200	3.6 m	50 µ
R/hr	100 m to 72 k	216 m	1 m
R/frame ^[2]	2 µ to 333 m	1 µ	0.02 µ
Gy	1 µ to 0.2	0.52 µ	0.01 µ
Gy/s	1 µ to 0.2	0.52 µ	0.01 µ
Gy/min	50 µ to 12	31.5 µ	0.5 µ
Gy/hr	1 m to 720	1.89 m	0.01 m
Gy/frame ^[2]	0.02 µ to 333 m	0.008 µ	0.2 n
[1] IEC 61674 effective range at 1 % resolution steps.			
[2] At 60 frames/s (1 to 120 frames/selectable).			

150 cc Ion Chamber

Units	Effective Range ^[1]	Threshold	Resolution Step Size
R	10 μ to 2	6 μ	0.1 μ
R/s	10 μ to 2	6 μ	0.1 μ
R/min	0.5 m to 120	0.36 m	5 μ
R/hr	10 m to 7.2 k	21.6 m	0.1 m
R/frame ^[2]	0.2 μ to 33 m	0.1 μ	0.002 μ
Gy	0.1 μ to 0.02	0.052 μ	0.001 μ
Gy/s	0.1 μ to 0.02	0.052 μ	0.001 μ
Gy/min	5 μ to 1.2	3.15 μ	0.05 μ
Gy/hr	0.1 m to 72	0.189 m	0.001 m
Gy/frame ^[2]	0.002 μ to 0.33 m	0.8 n	0.02 n
[1] IEC 61674 effective range at 1 % resolution steps.			
[2] At 60 frames/s (1 to 120 frames/selectable).			

150 cc Low Rate Ion Chamber

Units	Effective Range ^[1]	Threshold	Resolution Step Size
R/s	2 μ to 2 ^[3]	NA	0.1 μ
R/min	0.1 m to 120 ^[3]	NA	5 μ
R/hr	2 m to 7.2 k ^[3]	NA	0.1 m
R/frame ^[2]	0.04 μ to 33 m ^[3]	NA	0.002 μ
Gy/s	0.02 μ to 0.02 ^[3]	NA	0.001 μ
Gy/min	1 μ to 1.2 ^[3]	NA	0.05 μ
Gy/hr	0.02 m to 72 ^[3]	NA	0.001 m
Gy/frame ^[2]	0.4 n to 0.33 m ^[3]	NA	0.02 n
[1] IEC 61674 effective range at 1 % resolution steps.			
[2] At 60 frames/s (1 to 120 frames/selectable).			
[3] Low Rate effective range at 5 % resolution steps.			

Electrical Units

Units	Effective Range ^[1]	Threshold	Resolution Step Size
C	1 p to 100 n	0.5 pC	0.01 p
A	1 p to 100 n	250 fA	0.01 p
[1] IEC 61674 effective range at 1 % resolution steps.			

Chapter 2

Operation

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Introduction

This chapter gives instructions on how to connect, setup, and use the TNT 12000 to calibrate and service X-ray equipment. It is assumed the reader already read Chapter 1 and understands the Test Tool components.

Safety Information

In this manual, a **Warning** identifies conditions and actions that pose hazards to the user.

A **Caution** identifies conditions and actions that may damage the TNT 12000 or the equipment under test.

Warnings

To prevent electric shock:

Use the TNT 12000 as specified in this manual or the protection provided might be impaired .

Inspect the test leads for damaged insulation or exposed metal. Check the test leads for continuity. Replace damaged test leads before using the TNT 12000.

Turn the X-ray generator power off before connecting or disconnecting the TNT 12000.

Caution

To prevent damage to the TNT 12000, Do not apply more than 500 V, between the input and earth ground.

How to Set Up the System

The Display controls the detectors and must be set to communicate with a Detector before you can make a measurement. When connected, all measured values are shown in the Display.

The subsequent setup step is to prepare the Detector for a measurement. For X-ray Detector measurements, put the Detector in the X-ray beam. For the Dosimeter, an ion chamber is connected to the Dosimeter and put in the X-ray beam.

When an mAs Detector is installed in the X-ray Detector or Dosimeter Detector, you connect the X-ray detector to the X-ray generator. You do this with test leads connected to an mAs test point or a non-invasive mAs clamp.

Display to Detector Communications

Communication between the Display and a Detector is through a wireless (ZigBee) or wired (USB) connection. All Test Tool components communicate in these two ways.



The X-ray Detector and Dosimeter Detector have a communication status indicator to indicate the condition of communications to the Display. See Table 2-1.

Table 2-1. Communication Status Indicator

LED Activity	Communication Status
On	Detector is connected to the Display/computer
Off	Detector is not connected
Blinking	Detector is scanning for the Display/computer

How to Setup a Wireless Connection

To connect the Display to the Detector through a wireless connection:

1. Push  on the Detector.
2. Push  on the Display.

Go to the Communications Settings section to complete the communication setup.

How to Setup a USB Connection

To connect the display to a Detector through a USB connection:

1. Connect the ends of the Mini-A to Mini-B USB cable to the USB port of the Display and the Detector as shown in Figure 2-1.

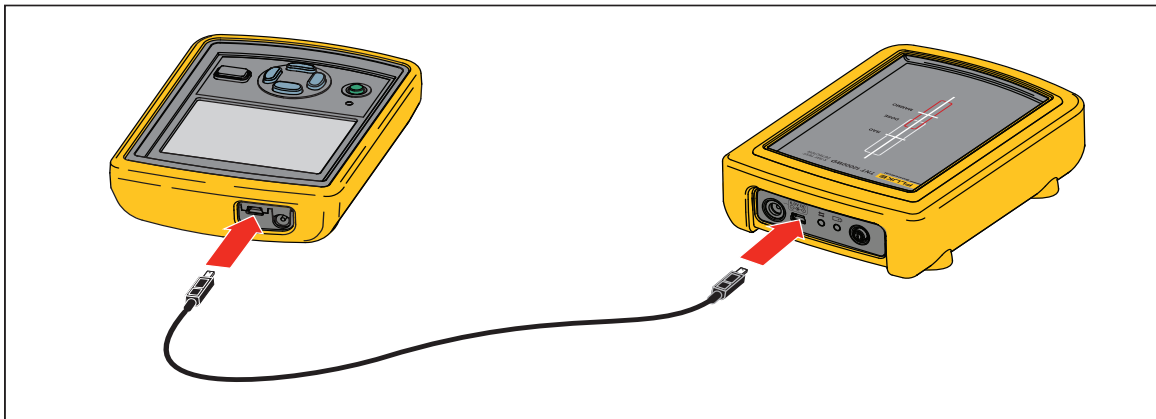




Figure 2-1. Wired (USB) Connection

fct04.eps

2. Push  on the Detector.
3. Push  on the Display.

Go to the Communications Settings section to complete the communication setup.

Multiple Detector Connections

A maximum of two Detectors can operate with the Display at one time. The X-ray or Dosimeter Detector can operate with the mAs Detector at the same time. The X-ray Detector and Dosimeter Detector can not operate with the Display at the same time.

You can make the connections through a combination of USB and/or wireless connections. With the Display and Detectors turned on, set the combination pair through the **CONNECTION** screen in the Communication Settings section.

Communication Settings

When power is applied to the Display, the system does a self-test while a message shows in the Display. After the self-test, the software and hardware versions show in the Display.

If the Display senses no Detectors, a **No Detector Found** screen shows in the Display. If it senses only one Detector, the communication settings are complete. For the subsequent step, go to the manual section for the sensed Detector. If it senses more than one Detector (within rf range and/or connected by wire), the connection screen (see Figure 2-2) shows in the Display.

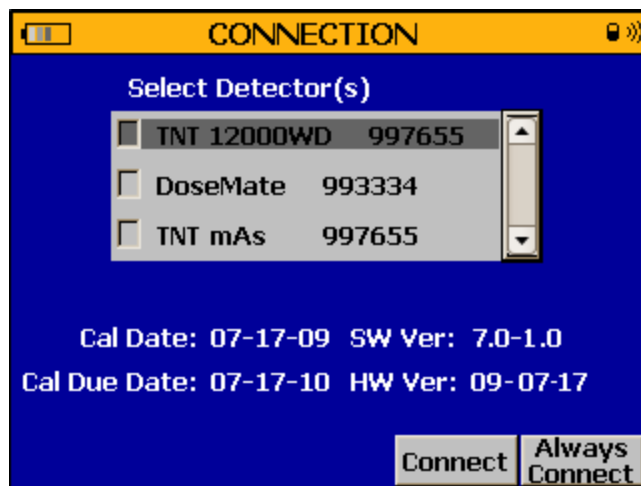


Figure 2-2. Connection Screen

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1. Use or to scroll through the list of detectors.
When you scroll through the detectors, or appears in upper-right corner of the screen if a connection exists between the Display and the highlighted Detector. Calibration date, calibration due date, software version, and hardware version for the highlighted Detector shows below the Detector list.
2. With a Detector highlighted, push or to highlight the **Connect** or **Always Connect** button.
3. To make a Detector selection, use or to highlight the Detector and push **ENTER**.

The TNT 12000 automatically goes to the setup or measurement screen for the connected Detector. For the subsequent step, go to the manual section for the connected Detector.

To connect to a second Detector, highlight the **Setup** button and push **ENTER** in the **MEASUREMENT** screen. Navigate to the **CONNECTION** screen shown in Figure 2-2 to make a second selection.

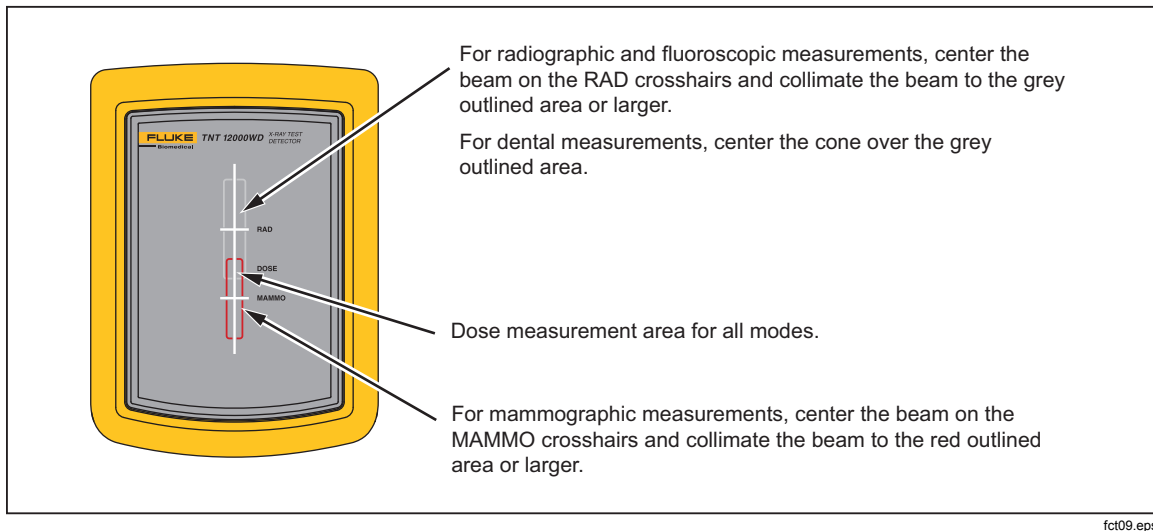
How to Use the X-ray Detector (TNT 12000WD)

The four operation modes of the X-ray Detector are:

- Radio Mode – used to make measurements on radiographic X-ray machines. Radio mode measures kVp Average, kVp Maximum, kV PPV, Dose, Average Dose Rate, Exposure Time, and HVL at the same time from one exposure.
- Mammo Mode – used to make measurements on mammographic X-ray generators. Mammo mode measures kVp Average, kVp Maximum, kV PPV, Dose, Average Dose Rate, Exposure Time, and HVL at the same time from one exposure.
- Fluoro Mode – used to make measurements on fluoroscopic X-ray generators. Fluoro mode can make Continuous fluoro and Pulsed fluoro measurements. Fluoro Mode measures kVp Average, kVp Maximum, kV PPV, Dose Rate, Accumulated Dose, Elapsed Time, Pulse Rate (for Pulsed Fluoro only), Pulse Width (for Pulsed Fluoro only), and HVL.
- Dental Mode – used to make measurements on Dental X-ray generators. Dental mode measures kVp Average, kVp Maximum, kV PPV, Dose, Average Dose Rate, Exposure Time, and HVL at the same time from one exposure.

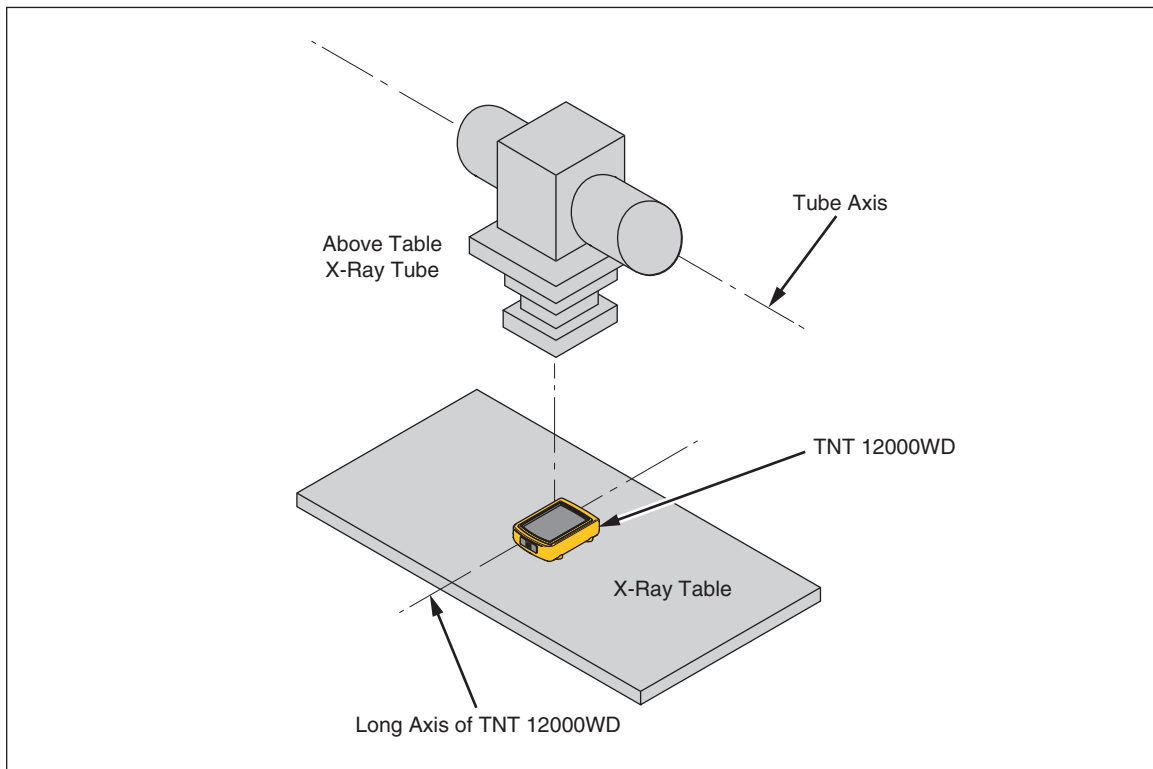
How to Position the X-ray Detector

To make measurements, the X-ray Detector must be put into the X-ray beam. The marks on the face of the Detector help align it in the X-ray beam. See Figure 2-3 for a description of how to use the marks for an accurate measurement. The distance from the top surface of the X-ray Detector to the solid state detectors is 0.230 inches or 5.84 mm.



Detector Placement with Above Table X-ray Source

For X-ray machines that have the X-ray source above the table, align the Detector face up, in the middle of the beam, with the long axis of the Detector perpendicular to the axis of the X-ray tube. See Figure 2-4.



Note

Set the Detector so all of the active area of the Detector is exposed to the X-ray beam. A 22-inch distance from the focal point to the Detector is suggested.

Detector Placement with Below Table X-ray Source

For X-ray machines that have the X-ray source below the table, align the Detector face down, in the middle of the beam, with the long axis of the Detector perpendicular to the axis of the X-ray tube. See Figure 2-5.

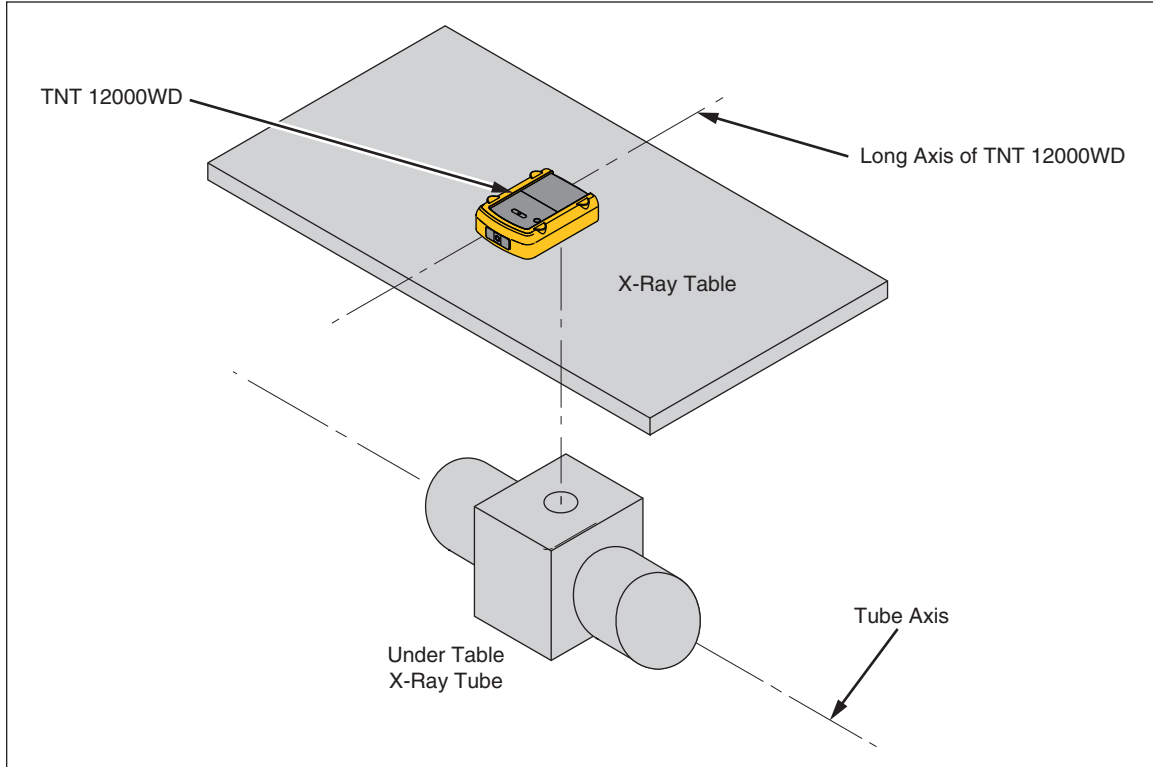


Figure 2-5. X-ray Detector Setup for Below Table X-ray Source

How to Measure X-ray Parameters

Connect and set up the X-ray Detector for a measurement. See the How to Setup the System section above for connection and set up instructions. The **MEASUREMENT** screen in Figure 2-6 shows in the Display.

Note

If the mAs Detector is already connected, an mAs Measurement Option screen can show in the display. Go to the How to Use the mAs Detector manual section to set the mAs measurement options. When done, come back to this section to continue the X-ray measurement.

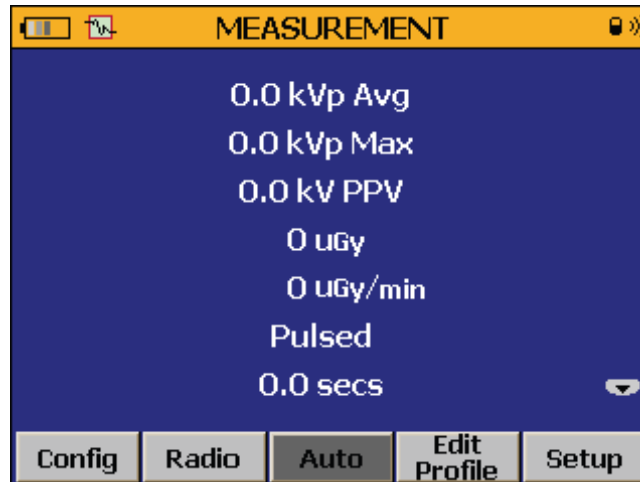


Figure 2-6. X-ray Detector Measurement Screen

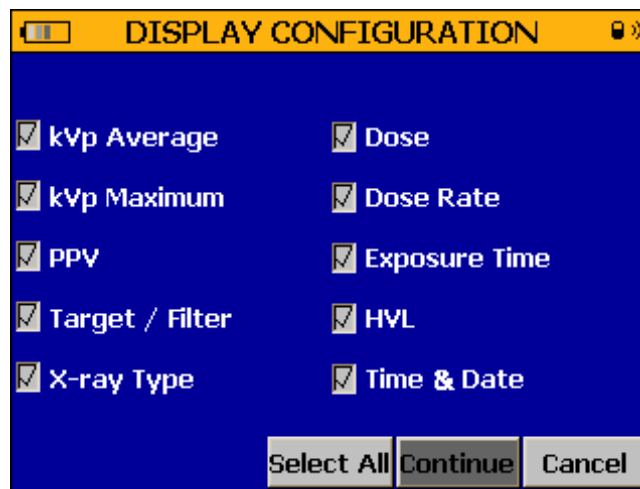
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The buttons at the bottom of the **MEASUREMENT** screen are used to set the measurement mode, the measurements to show in the Display, the measurement profile, the measurement parameters, and set system options. The ▾ in the Display shows there is a second screen of information. Highlight the icon and push **(ENTER)** to reveal the next screen of information.

X-ray Display Configuration

To set the X-ray measurement parameters that show in the **MEASUREMENT** screen:

1. In the **MEASUREMENT** screen, use **⬅** or **➡** to highlight the **Config** button.
2. Push **(ENTER)** to open the **DISPLAY CONFIGURATION** screen.



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3. Use **⬆**, **⬇**, **⬅**, and **➡** to highlight one of the parameters and push **(ENTER)** to toggle the check box between checked and unchecked.
4. When you complete the measurement selections, highlight the **Continue** button and push **(ENTER)** to save the configuration and return to the **MEASUREMENT** screen.

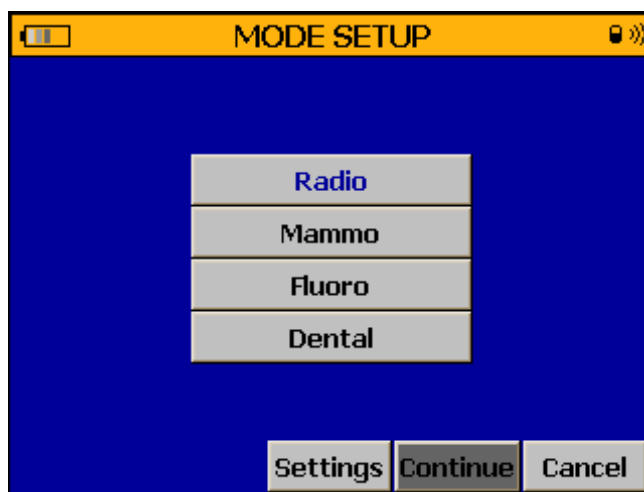
Note

The sequence of values in the Measurement screen is set by the parameters you set with a check in the Display Configuration screen.

Measurement Mode Setup

To set the X-ray measurement mode:

1. In the **MEASUREMENT** screen, use \leftarrow or \rightarrow to highlight the 2nd button from the left. The name on this button shows the measurement mode selection. In Figure 2-6, the button is named **Radio** which shows the Detector is set to the Radio Measurement mode. The **MODE SETUP** screen in Figure 2-7 shows in the Display.



fct209.png

Figure 2-7. Mode Setup Screen

2. Use \uparrow or \downarrow to highlight one of the measurement mode buttons and push **ENTER**. The color of the button name changes to blue.
3. Use \uparrow or \downarrow to highlight the **Continue** button and push **ENTER** to set the measurement mode and return to the **MEASUREMENT** screen. The name on the middle button changed to the name of the new measurement mode.

Note

*Before the measurement mode is set, move the highlight to the **Cancel** button and push **ENTER** to cancel the measurement mode change.*

Highlight the **Settings** button in this screen to change the parameters for the measurement mode. See the How to Change Profile Parameters section.

Measurement Mode Profile Parameters

Each measurement mode has a number of parameters that can be changed and set into the Detector. These parameters are used to setup the Detector for the X-ray exposure and set the units of measure. These parameters together make a special Detector profile. Table 2-2 shows the settable profile parameters.

Table 2-2. Settable Profile Parameters

Parameter	Description
Dose Units	Sets the Dose unit between Roentgen (R) or Gray (Gy) . ^[3]
Time Units (Radio, mammo, dental only)	Sets time unit to milliseconds (msec) or pulses.
Dose Rate Units (Fluoro only)	Sets the dose Rate units to second, minute, hour, or pulse. ^[3]
% kV ^[2] (Radio, mammo, dental only)	Sets %kV to 0%, 75%, 80%, or 90%. ^[1]

Table 2-2. Settable Profile Parameters (cont.)

Parameter	Description
Fluoro Type ^[2] (Fluoro only)	Sets the Fluoro type to continuous (CONT) or pulsed.
Target/Filter	Sets the Target/Filter option.
Delay ^[2] (Radio, mammo, dental only)	Sets a delay (0 to 999 milliseconds) to postpone the start of data analysis in order to skip over waveform anomalies that can occur at the beginning of an exposure. See the How to Enter a Delay section.
Include Delay ^[2] (Radio, mammo, dental only)	Set this option when waveform anomalies, such as leading edge overshoots are to be excluded from kV measurement but included in exposure time measurement. Deselect this option when waveform anomalies, such as filament preheat pulses are to be excluded from kV and exposure time measurement.
<p>[1] If 0% is selected, the Detector measures radiographic exposure time from the moment x-rays are detected until they are no longer detected. Otherwise, the Detector measures exposure time between the 75 %, 80 %, 90 % points on the kV waveform respectively.</p> <p>[2] Parameter is not user settable in Auto profile.</p> <p>[3] In the TNT 12000 PTB version, only Gy (Gray) is available.</p>	

Not all parameters are available in all four measurement modes. Dose Rate Units and Fluoro Type are only available when the Detector is set for the Fluoro measurement mode. Time Units, %kV, and Delay are not available in Fluoro mode. All parameters can be set manually or some of the parameters can be set automatically.

There are three standard profiles for each measurement mode: Manual, Auto, and Default. These 12 profiles are kept in memory. Each profile is defined by the values set for each parameter contained in the set. The value of each parameter in the Manual and Auto profiles can be changed and put in memory. The default profiles are factory defaults and can not be changed.

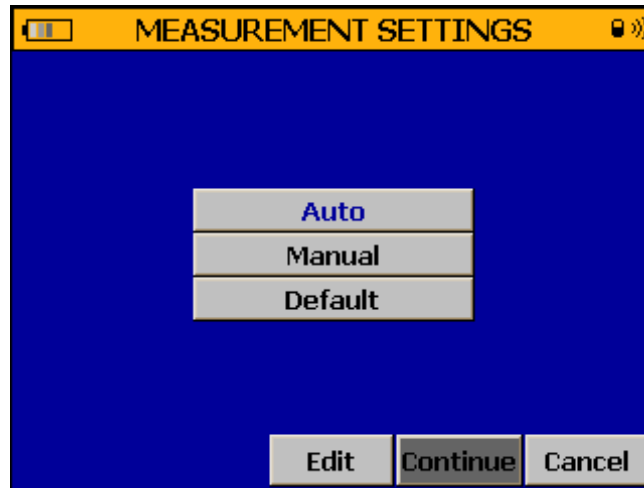
You can make a maximum of five user-defined profiles for each measurement mode. These 15 user-defined profiles add to the standard 12 profiles.

How to Set a Detector Profile

To set measurement parameters in the X-ray Detector, a profile is recalled from memory and used to setup the Detector.

To set the X-ray Detector measurement mode parameters:

1. Highlight the **Settings** button in the **MODE SETUP** screen or the middle button in the **MEASUREMENT** screen. The name on the middle button shows the measurement profile selection.
2. Push **(ENTER)** to open the **MEASUREMENT SETTINGS** screen.



ftc210.png

3. The button with blue lettering identifies the profile selection. To change the profile, use or to highlight a profile button and push **ENTER**.
4. To set the profile into the Detector, use or to highlight the **Continue** button and push **ENTER**. The parameter values in the profile selection are set into the Detector and the **MEASUREMENT** screen shows in the Display.

To see or change a profile parameter set, highlight the **Edit** button and push **ENTER**. Go to the How to Change Profile Parameters section for instructions to change parameters.

To abort the profile change, use or to highlight the **Cancel** button and push **ENTER**. The Detector parameters do not change and the **MEASUREMENT** screen shows in the Display.

Auto Profiles

There is one Auto profile for each of the measurement modes. When an Auto profile is set into the Detector, some of the measurement parameters are set automatically. The Detector uses automatic waveform analysis to find some of the parameter values. Parameters that are not user settable in the Auto profile are identified in Table 2-2.

When Auto profile is set in to the Detector, shows in the top-left corner of the **MEASUREMENT** screen. See TNT 12000WD kV, Exposure, and Exposure Time measurements in Appendix E.

Note

When the FLUORO SETTING: AUTO profile is set in the Detector, a progress bar shows during the first three seconds of the exposure. In these three seconds, the Detector examines the data to identify the fluoro machine type and set the applicable fluoro profile parameters.

Default Profiles

Each measurement mode has a factory default parameter set or profile. You can not change the parameters in the four default profiles. Table 2-3 shows the default value for each measurement mode parameter.

Table 2-3. Default Parameter Values for Each Measurement Mode

Parameter	Measurement Mode			
	Radio	Mammo	Fluoro	Dental
Dose Units	R (Roentgen)	R (Roentgen)	R (Roentgen)	R (Roentgen)
Time Units	msec (milliseconds)	msec (milliseconds)	NA	msec (milliseconds)
Dose Rate Units	NA	NA	R/min	NA
% kV	90 %	90 %	NA	0 %
Fluoro Type	NA	NA	CONT (continuous)	NA
Target/Filter	W/AI	Mo/Mo	W/AI	W/AI
Delay	0 msec	0 msec	NA	0 msec

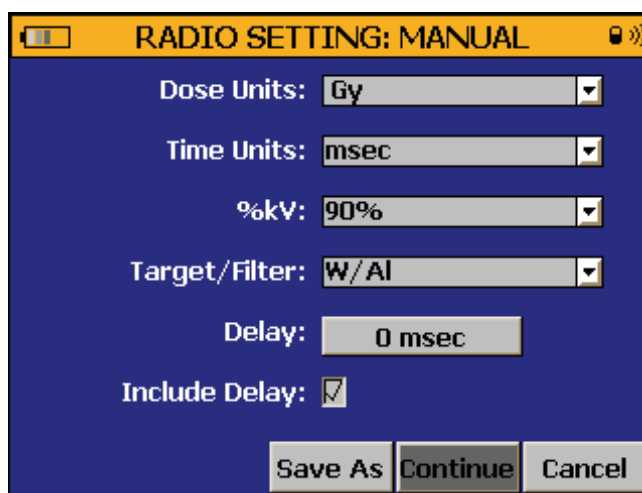
How to Change Profile Parameters

The four manual profiles, four auto profiles, and all user-defined profiles contain parameters that can be changed. After parameters are changed and then used to set the Detector, those changes redefine the profile in memory.

To change the parameters in a profile:

1. Highlight the **Settings** button in the **MODE SETUP** screen or the **Edit Profile** button in the **MEASUREMENT** screen.
2. Push **(ENTER)**.

The **SETTING** screen shows in the Display.



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Note

The manual settings screen for the Radio mode is shown in the above example. The banner text shows the mode selection (RADIO, MAMMO, FLUORO, or DENTAL) and the profile (AUTO, MANUAL, DEFAULT or user-defined). See Table 2-2 for the parameters that are available for each measurement mode.

3. Use **▲** or **▼** to highlight the parameter you want to change and push **(ENTER)** to open the drop-down list.
4. Use **▲** or **▼** to highlight a value in the list and push **(ENTER)** to set the parameter to

the highlighted value.

5. Use  or  to highlight the **Continue** button and push **ENTER** to set the parameters into the Detector.

Note

The parameter values set at this point redefines the profile selection.

The **MEASUREMENT** screen shows in the Display. The name on the middle button in the bottom of the screen shows the profile (Auto, Manual, Default, or user-defined label) to which the Detector is set.











To cancel parameter changes before the changes are set, highlight the **Cancel** button and push **ENTER**.

The **Save As** button only shows in the **MANUAL** settings screen and makes a user-defined profile. When the profile is a user-defined profile, the **Save As** button is replaced with a **Save** button. The **Save** button allows you to change the name of a user-defined profile. See the How to Make a User-Defined Profile section for more on user-defined profiles.



How to Make a User-Defined Profile

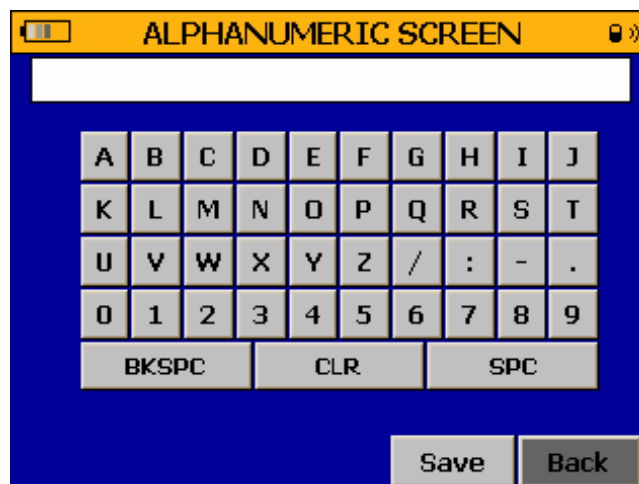
User-defined profiles, or parameter sets, are specified through the **Manual** setting screen.

To make a user-defined profile:

1. Select a measurement mode in the **MODE SETUP** screen.
2. Use  or  to highlight the **Settings** button and push **ENTER** to open the **MEASUREMENT SETTINGS** screen.
3. Use  or  to highlight the **Manual** button and push **ENTER**.
4. Use  or  to highlight the **Edit** button and push **ENTER**.
5. Use  or  to highlight the parameter you want to change and push **ENTER** to open the drop-down list.
6. Use  or  to highlight a value in the list and push **ENTER** to set the parameter to the highlighted value.

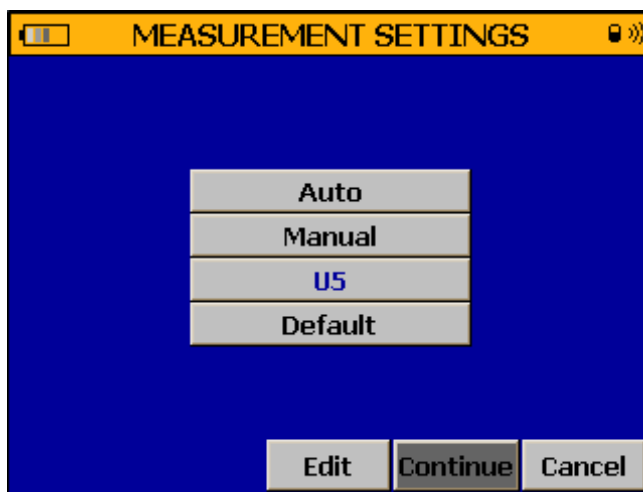
Repeat steps 5 and 6 for each parameter that needs to be changed.

7. Use  or  to highlight the **Save As** button and push **ENTER** to show the **ALPHANUMERIC SCREEN** in the Display.



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8. Use \uparrow , \downarrow , \leftarrow , and \rightarrow to highlight a character and push **ENTER** to construct a name that identifies the user-defined profile. You can have a maximum of 8 characters in the name.
9. Use \uparrow or \downarrow to highlight the **Save** button and push **ENTER**. The profile is saved with the name and the Detector is set to the user-defined profile. The **MEASUREMENT SETTINGS** screen shows in the Display with the new user-defined button added.



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Note

The example above shows a user-defined profile button labeled U5.

To change the name of a user-defined profile from the **MEASUREMENT SETTINGS** screen:

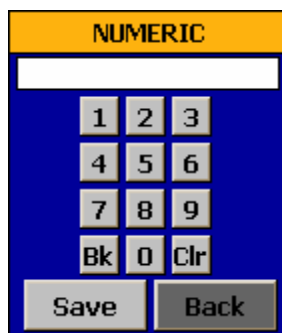
1. Use \uparrow or \downarrow to highlight the user-defined profile button you want to change the name of and push **ENTER**.
2. Use \uparrow or \downarrow to highlight the **Edit** button and push **ENTER**.
3. Use \leftarrow or \rightarrow to highlight the **Save** button and push **ENTER** to open the **ALPHANUMERIC** screen.
4. Use \uparrow , \downarrow , \leftarrow , and \rightarrow to highlight a character and push **ENTER** to construct a new name for the user-defined profile. You can have a maximum of 8 characters in the name.
5. Use \uparrow or \downarrow to highlight the **Save** button and push **ENTER**. The profile is put in memory with the name and the Detector is set to the user-defined profile. The **MEASUREMENT** screen shows in the Display with the user-defined button renamed.

To delete a user-defined profile from the **MEASUREMENT SETTINGS** screen:

1. Use \uparrow or \downarrow to highlight the user-defined profile button you want to delete and push **ENTER**.
2. Use \uparrow or \downarrow to highlight the **Edit** button and push **ENTER**.
3. Use \leftarrow or \rightarrow to highlight the **Delete** button and push **ENTER**. The profile is removed from memory and the **MEASUREMENT** screen shows in the display.

How to Enter a Delay

When the Delay button is selected in the settings screen, the numeric entry screen shows in the Display.



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To enter a delay time:

1. Use , , , and to highlight a number button and push **ENTER** to add the number to the entry.
2. Highlight **Save** and push **ENTER** to enter the delay value.

Highlight the **Back** button and push **ENTER** to discard the entered value and return to the last settings screen.

How to Use the Dosimeter Detector (TNT 12000 DoseMate)

The Dosimeter Detector measures ionizing radiation outputs of diagnostic X-ray systems. You must connect an ion chamber to the Detector and put the ion chamber in the X-ray beam for a Dosimeter measurement.

Note

A list of optional Dosimeter ion chambers are shown in the Optional Accessories table in Chapter 1.

Preparation for a Dosimeter measurement involves:

1. Choose an ion chamber that best fits the measurement sensitivity requirements.
2. Put the ion chamber in the X-ray beam.
3. Connect the ion chamber to the Dosimeter Detector.
4. Power on the Detector.
5. Define the ion chamber parameters in the TNT 12000.
6. Expose the ion chamber to X-rays.

Warning

To prevent electric shock and damage to the ion chamber, power off the Dosimeter Detector before you connect or disconnect the ion chamber and triaxial cable. Although current limited, the center pin and inner shield operate at 300 V above the outer shell.

Each ion chamber must have a definition in the TNT 12000. The Detector holds a maximum of nine ion chamber definitions, each with a maximum of ten calibration factors.

If at power up, no ion chamber is defined, highlight the **Cancel** button at the **IC NOTIFICATION** screen and push **ENTER**. Or if an ion chamber definition is already set,

highlight the **IC** button in the **MEASUREMENT** screen and push **(ENTER)**. Go to the Ion Chamber Selection and Setup section to set **No Ion Chamber** in the **ION CHAMBER SETUP** screen.

Ion Chamber Selection and Setup

Choose an ion chamber for the measurement sensitivity requirements, X-ray beam dimensions, beam-accessing port dimensions, and/or special function performance (e.g. CT probe). After you pick an ion chamber, the subsequent step is to find a chamber definition in the TNT 12000. If the definition is not found, make one.

Ion Chamber Connection and Placement

Warning

To prevent electric shock and damage to the ion chamber, power off the Dosimeter Detector before you connect or disconnect the ion chamber and triaxial cable. Although current limited, the center pin and inner shield shell operates at 300 V above the outer shell. High voltage is internally discharged within a few seconds when the Detector is turned off.

Caution

To prevent damage to the ion chamber, do not connect a BNC type cable to the ion chamber input connector.

Note

Keep the Dosimeter Detector out of the radiation field. Only the ion chamber must be exposed to the radiation.

To connect an ion chamber to the Dosimeter Detector:

1. Remove the dust cover from the ion chamber input connector.
2. Connect one end of the Triaxial ion chamber cable to the ion chamber connector as shown in Figure 2-8.

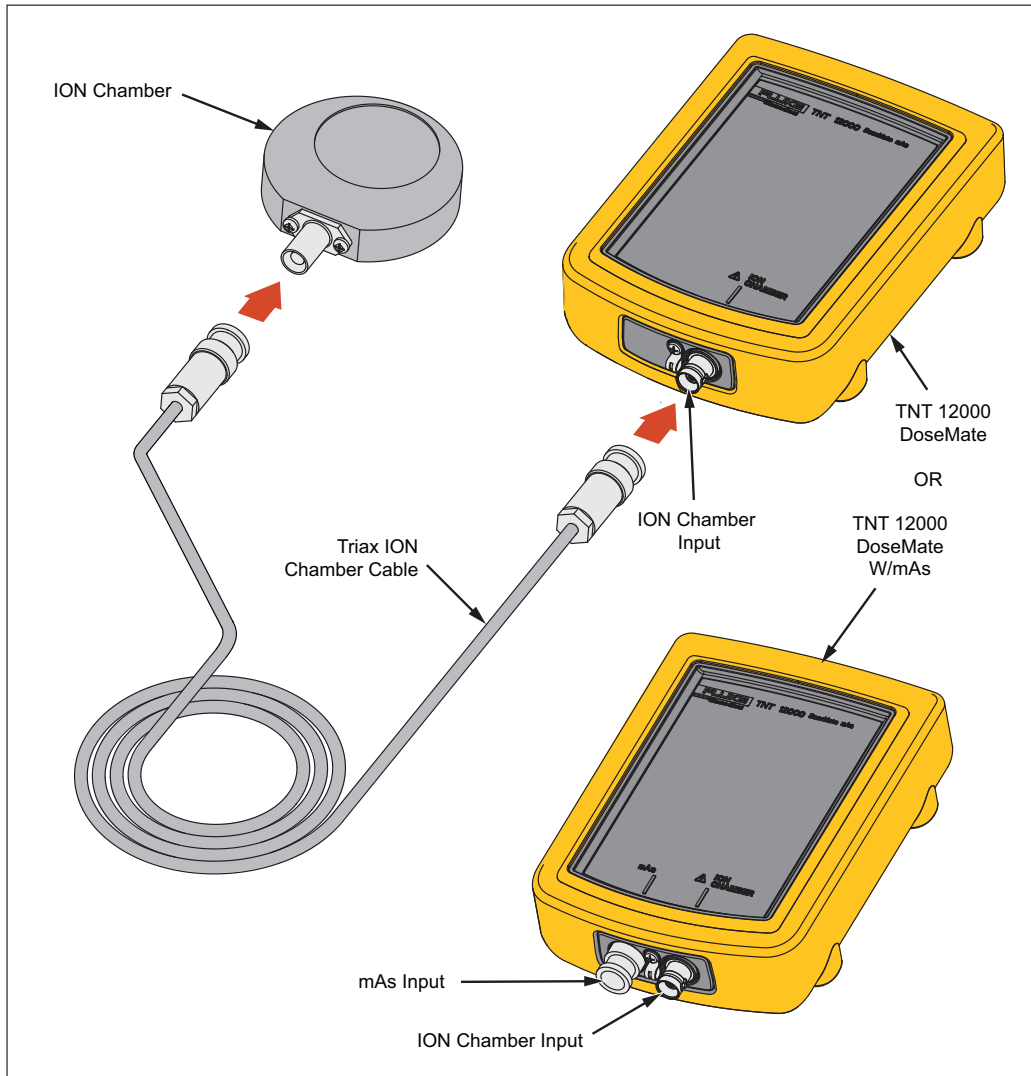


Figure 2-8. Ion Chamber Connection to Dosimeter

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3. Connect the other end of the cable to the ion chamber input connector on the Dosimeter Detector.

Note

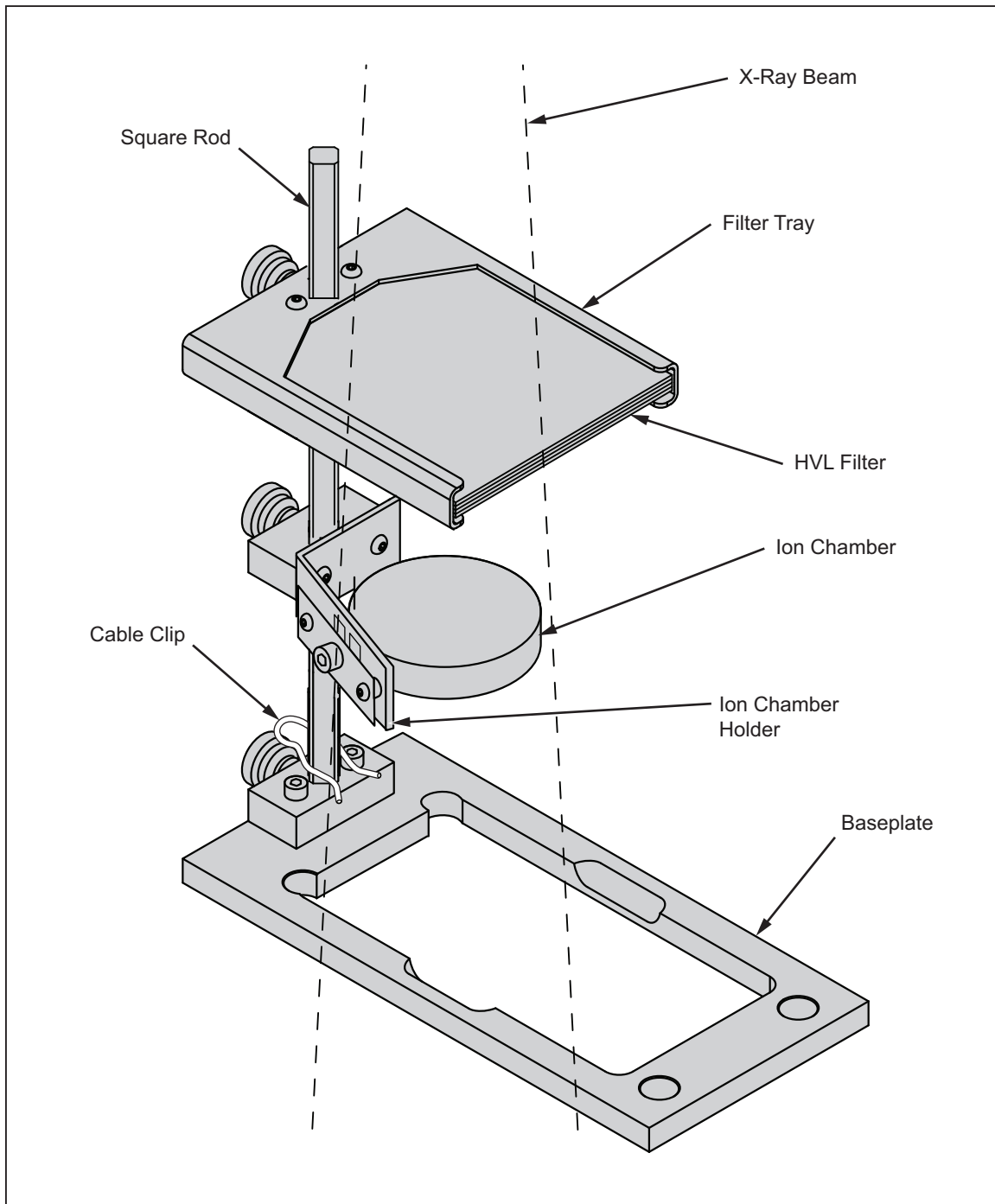
For ion chamber protection, put the dust cover on the ion chamber connector when the ion chamber is not connected to the Detector.

Put the ion chamber in the X-ray beam. Be sure the Detector and Display are not in the radiation beam before the Dosimeter Detector and Display are turned on. A test stand and adapter stem are included with the Dosimeter Detector. The sections that follow demonstrate how the test stand helps hold the ion chamber in the X-ray beam.

How to Place the Ion Chamber for Over-Table X-ray Sources

When the X-ray source is above the table, use the test stand to hold the ion chamber in the X-ray beam.

To install the ion chamber on the test stand, see Figure 2-9 and do the steps that follow:



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Figure 2-9. Test Stand Configuration for Over-Table Tubes

1. Put the square rod into the test-stand baseplate and tighten the baseplate thumbscrew.
2. Put the ion chamber bracket on the square rod. Move it along the rod until the top of the bracket aligns with the scribe mark in the middle of the rod. Tighten the chamber bracket thumbscrew.
3. Put the HVL filter tray on the rod. Move it along the rod until the top of the tray aligns with the top scribe mark on the rod. Tighten the HVL filter thumbscrew.
4. Attach the ion chamber to the bracket.

5. Attach the triaxial cable to the chamber.
6. Use the cable clips to attach the cable down the rod.

⚠ Caution

To prevent damage to the test equipment, attach the cable near the bottom of the test stand. Make sure that the cable is not in the X-ray beam between the tube and the ion chamber.

7. Put the test stand in the middle of the X-ray beam.
8. Attach the loose end of the triaxial cable to the input connector of the Dosimeter Detector.

Note

To do an HVL test, put the HVL filters in the test stand filter tray.

How to Place the Ion Chamber for Under-Table X-ray Sources

To attach the ion chamber to the test stand, see Figure 2-10 and do the steps that follow:

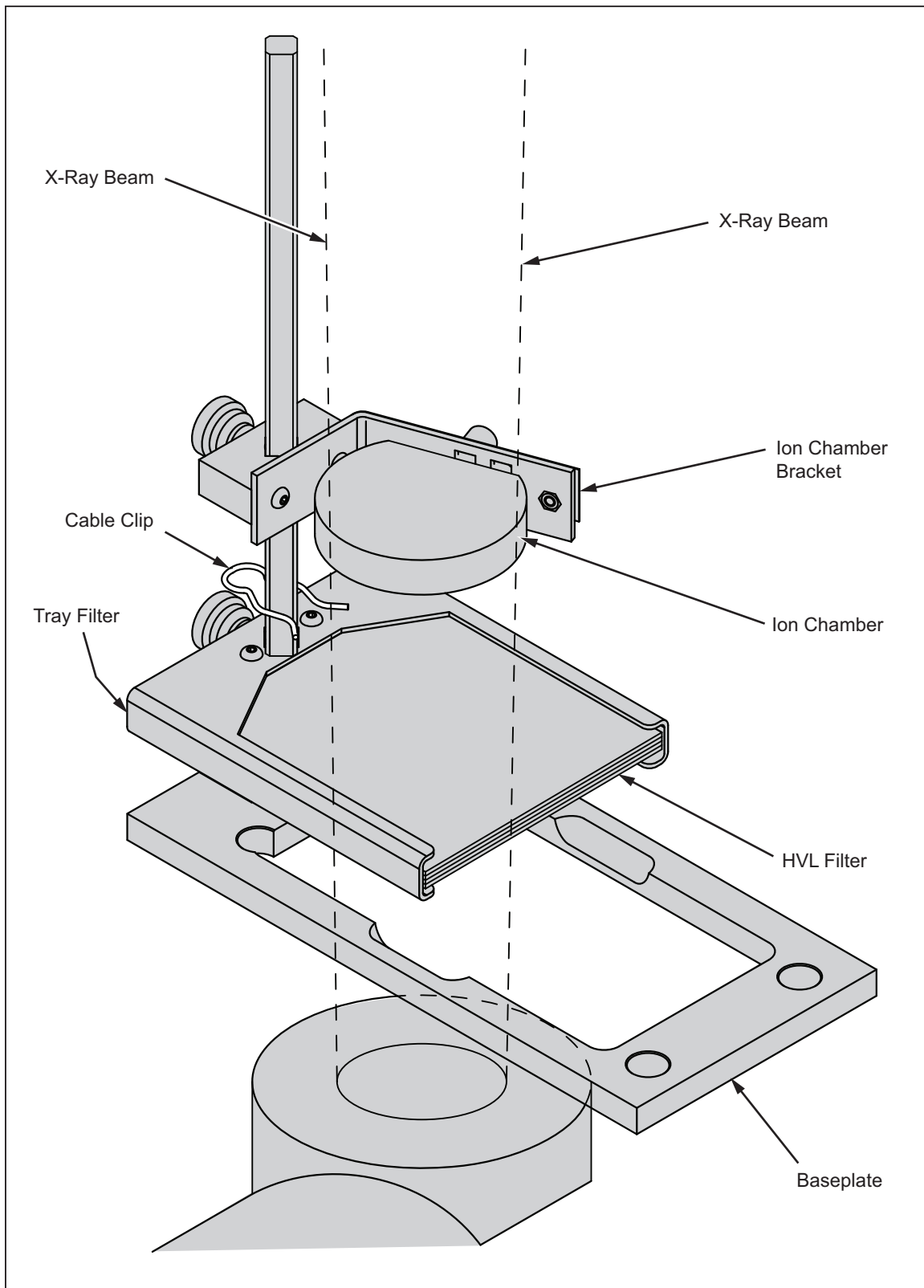


Figure 2-10. Test Stand Configuration for Under-Table X-ray Tube

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1. Move the HVL filter tray up the rod until the top scribe mark aligns with the top of the filter tray. Tighten the thumbscrew.
2. Move the ion chamber holder up the rod until the top of the holder aligns with the middle scribe mark. Tighten the thumbscrew.
3. Loosen the thumbscrew that holds the test stand rod to the base.
4. Hold the test stand rod and lift it away from the base. Turn the rod upside down and re-attach it to the base and tighten the thumbscrew.
5. Attach the ion chamber to its holder.
6. Attach the triaxial cable to the ion chamber.
7. Use the cable clips to attach the cable down the rod.

 Caution

To prevent damage to the test equipment, attach the cable near the bottom of the test stand. Make sure that the cable is not in the X-ray beam between the tube and the ion chamber.

8. Put the test stand in the middle of the X-ray beam.
9. Attach the loose end of the triaxial cable to the input connector of the Dosimeter Detector.

Note

To do an HVL test, put the HVL filters in the test stand filter tray.

How to Place the Ion Chamber for Horizontal X-ray Beams

To setup the ion chamber on the test stand, see Figure 2-11 and do the steps that follow.

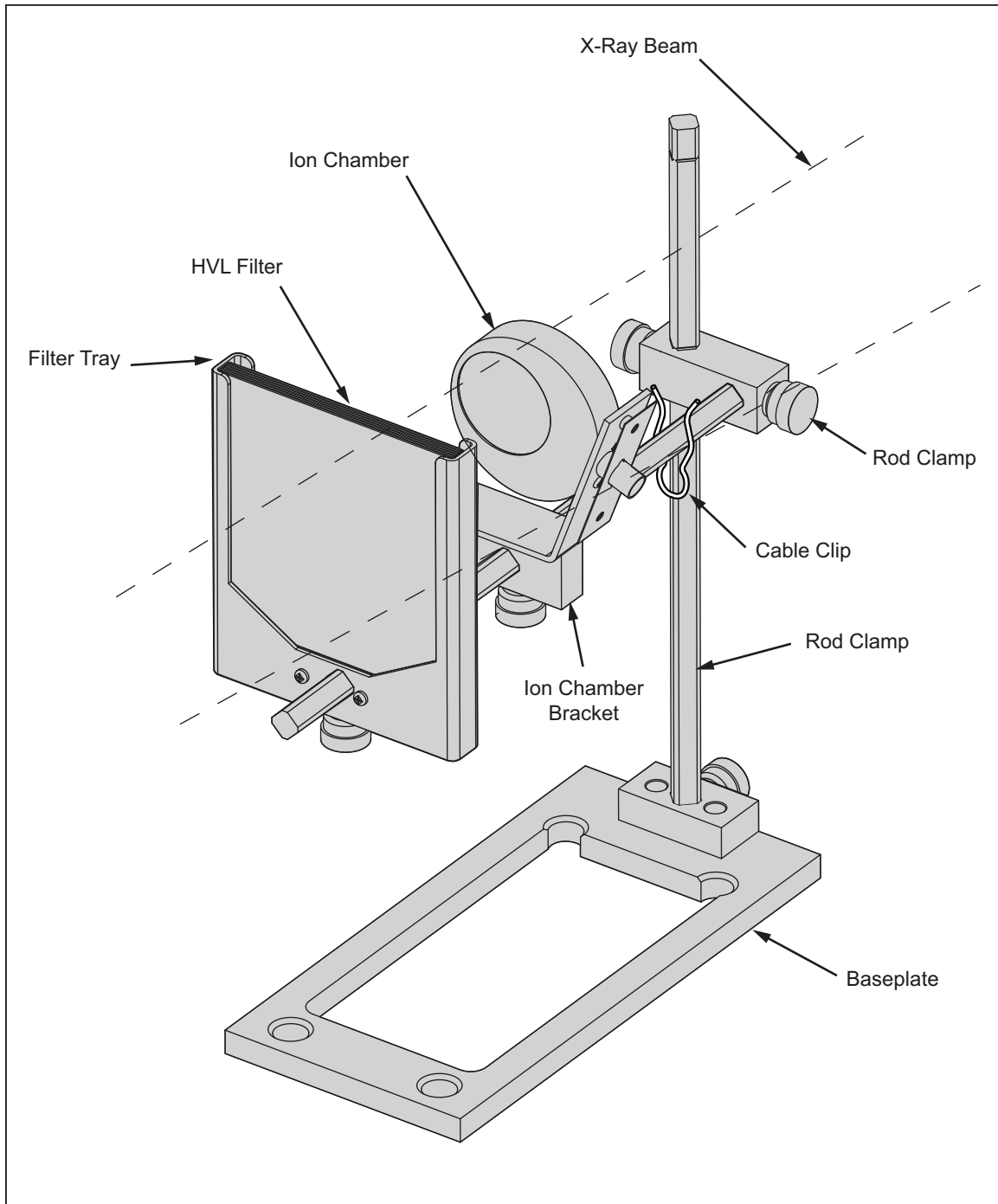


Figure 2-11. Test Stand Configuration for Horizontal Tube

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1. Put the short square rod into the baseplate and tighten the thumbscrew.
2. Put the rod clamp on the short square rod and move it to approximately the middle of the rod. Tighten the rod clamp thumbscrew to the short rod.
3. Put the long square rod into the remaining rod clamp hole and tighten the rod clamp thumbscrew. This makes a horizontal square rod.

4. Put the ion chamber bracket on the horizontal rod. Move it along the rod until the top of the bracket aligns with the scribe mark in the middle of the rod. Tighten the chamber bracket thumbscrew.
5. Put the HVL filter tray on the horizontal rod. Move it along the rod until the top of the tray aligns with the top scribe mark on the rod. Tighten the HVL filter thumbscrew.
6. Attach the ion chamber to the bracket.
7. Attach the triaxial cable to the chamber.
8. Use the cable clips to attach the cable down the rod..

⚠ Caution

To prevent damage to the test equipment, attach the cable near the bottom of the test stand. Make sure that the cable is not in the X-ray beam between the tube and the ion chamber.

How to Place the Ion Chamber in Limited Access Situations

Use the plastic cable stem to accurately put the ion chamber in image-intensifier housings or other hard to access situations. The plastic cable stem attaches to the triaxial-cable connector nearest the ion chamber. This adds **five inches** of position control.

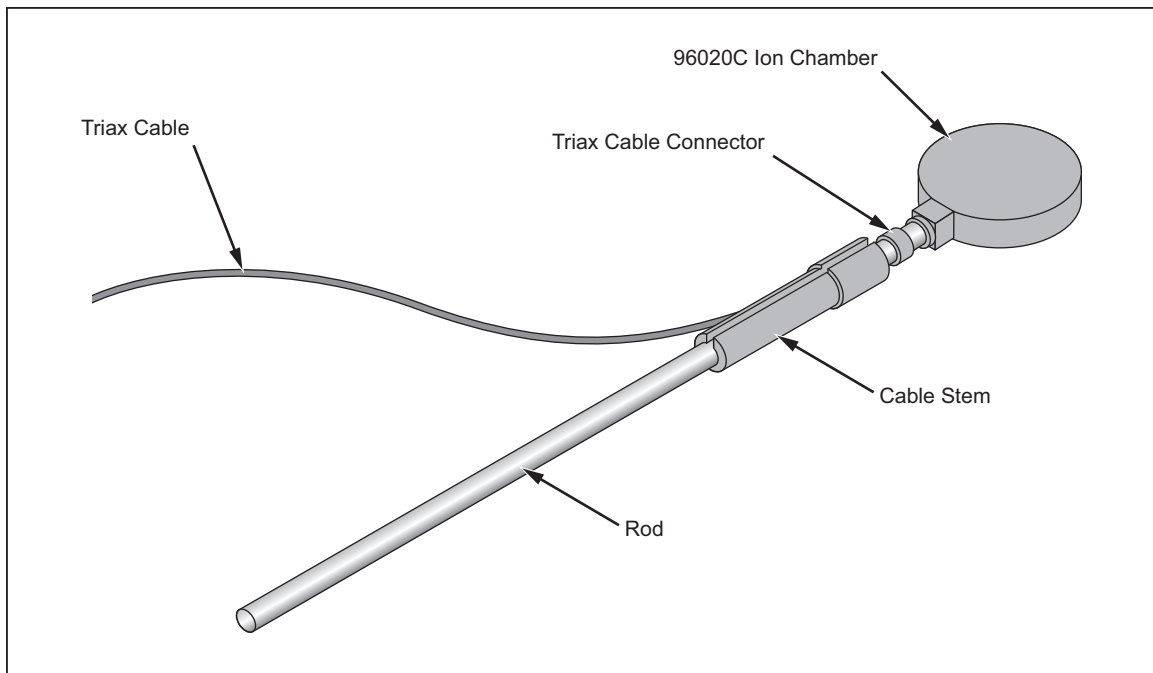


Figure 2-12. Ion Chamber Cable Stem

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If more distance is necessary, attach the cable stem to the threaded end of the vertical rod, as Figure 2-12 shows. This adds **15 inches** of rigid control.

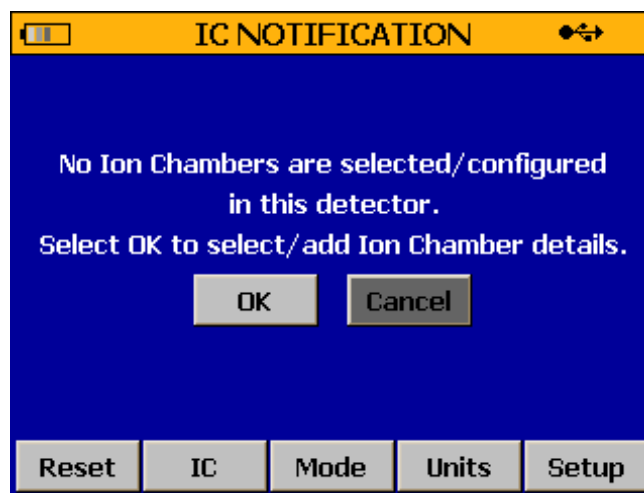
How to Make a Dosimeter Measurement

After the ion chamber is connected to the Detector, push **Ⓢ** on the Detector and Display.

Note

If the mAs Detector is already connected, an mAs Measurement Option screen can show in the display. Go to the How to Use the mAs Detector manual section to set the mAs measurement options. When done, come back to this section to continue the Dosimeter measurement.

Once connected to the Dosimeter Detector, the system checks if an ion chamber is set for the measurement. If set, the **MEASUREMENT** screen in Figure 2-15 shows in the Display. If an ion chamber is not set, then the **IC NOTIFICATION** screen shown in Figure 2-13 shows in the Display. Go to the Ion Chamber Setup section if an ion chamber is necessary for the measurement.



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Figure 2-13. Ion Chamber Notification Screen

Select **OK** and push **ENTER** to select or configure an ion chamber. If you select Cancel, Dose and Dose Rate are set to C and A, and you cannot change the measurement units.

Ion Chamber Setup

Open the ion chamber setup screen opened from the **IC NOTIFICATION** screen or the Dosimeter **MEASUREMENT** screen.

To setup the TNT 12000 for an ion chamber:

1. Use **⬅** or **➡** to highlight **OK** in the **IC NOTIFICATION** screen or the **IC** button in the Dosimeter **MEASUREMENT** screen.
2. Push **ENTER** to open the **ION CHAMBER SETUP** screen shown in Figure 2-14.



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Figure 2-14. Ion Chamber Setup Screen

If **No Ion Chamber** is highlighted in the **ION CHAMBER SETUP** screen, use to highlight **New** and push **ENTER**. Go to the How to Add an Ion Chamber Definition or Cal Factor section to add an ion chamber.

If an ion chamber definition is in the Detector:

3. Use and to highlight the desired ion chamber in the left frame of the screen.
4. Use to move the highlight to the right frame of the screen.

If there are no Cal Factors for the Ion Chamber, then highlight **New** and push **ENTER**. See the How to Add an Ion Chamber Definition or Cal Factor section to make a cal factor.

If there is a Cal factor, then:

5. Use and to highlight the desired calibration factor and push **ENTER**.
6. Use or to highlight the **Continue** button and push **ENTER**.

If Air Density Correction Factor (ADCF) is set to off or if it is on and the Temperature/Pressure is configured for Internal Temperature/Pressure Compensation then the Dosimeter Measurements screen shows on the Display. Go to the Dosimeter Measurements section to continue the measurement procedure.

Dosimeter Measurements

When the Display and Dosimeter Detector are connected and the ion chamber parameters are set, the **MEASUREMENT** screen shows in the Display.

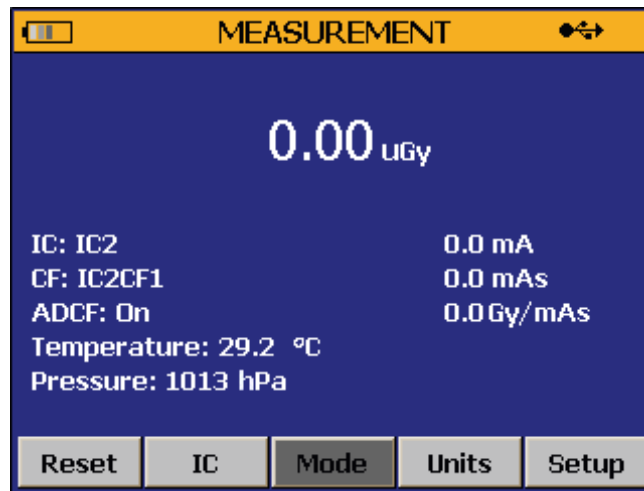


Figure 2-15. Dosimeter Measurement Screen

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Note

Average mA, mAs, and Dose/mA are only shown when the mAs Detector is connected to the Display.

With the ion chamber set in the X-ray beam, make an exposure. The Display and Dosimeter Detector beep when an exposure is sensed and the Display is updated with the measured values.

The procedure for all subsequent measurements depends whether the Automatic Reset feature is turned on or not. See the Measurement Mode Selection section to set this feature. If **Automatic Reset** is on, make an exposure and the Detector resets itself. If **Automatic Reset** is off:

1. Use **▶** or **◀** to highlight the **Reset** button and push **ENTER**.
2. When the reset message is removed from the display, make an exposure.

The **MEASUREMENT** screen is refreshed with new values after the exposure.

Note

When the mode is set to Dose Rate, the display refreshes at one second intervals. See the Measurement Mode Selection section to set the mode.

How to Add an Ion Chamber Definition or Cal Factor

You can add a maximum of nine ion chamber definitions to the Detector from the Dosimeter **MEASUREMENT** screen, or the **ION CHAMBER SETUP** screen. Each ion chamber can have a maximum of 10 cal factors.

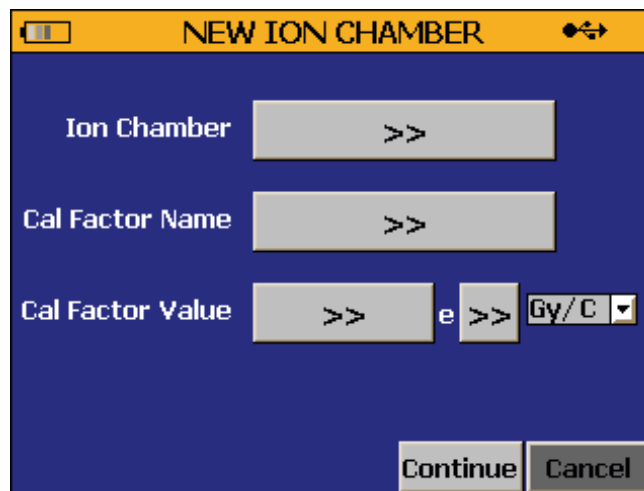
To add an ion chamber definition:

1. Use **▶** or **◀** to highlight the **IC** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **ION CHAMBER SETUP** screen shows in the Display.



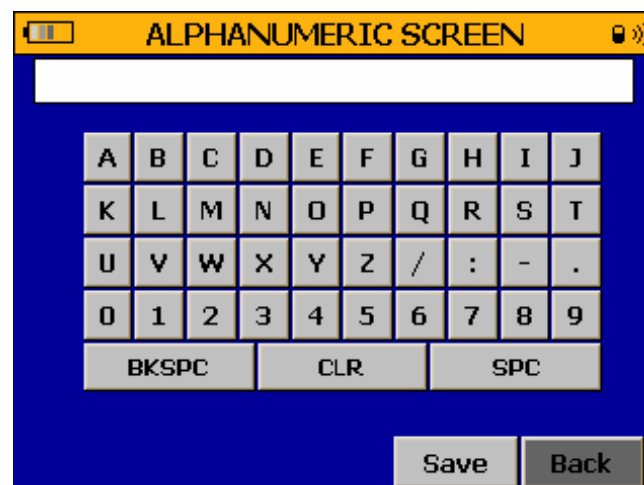
fct241.png

2. Use \uparrow or \downarrow to highlight **New** in the ion chamber list and push **(ENTER)**. The **NEW ION CHAMBER** screen shows in the Display.



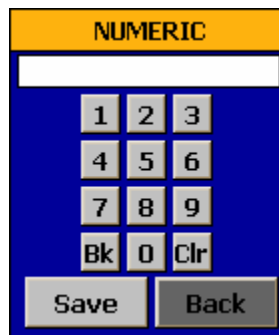
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3. Use \uparrow or \downarrow to highlight the **>>** button next to the **Ion Chamber** label and push **(ENTER)**. The **ALPHANUMERIC SCREEN** shows in the Display.



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4. Use \uparrow , \downarrow , \rightarrow , and \leftarrow to highlight a character and push **ENTER** to construct a name that identifies the ion chamber definition. You can have a maximum of 15 characters in the name.
5. Use \uparrow or \downarrow to highlight the **Save** button and push **ENTER**. The ion chamber definition name is put in memory and the Display shows the **ION CHAMBER SETUP** screen.
6. Use \uparrow or \downarrow to highlight the **>>** button next to the **Cal Factor Name** label and push **ENTER**. The **ALPHANUMERIC SCREEN** shows in the Display.
7. Use \uparrow , \downarrow , \rightarrow , and \leftarrow to highlight a character and push **ENTER** to construct a name that identifies the cal factor. You can have a maximum of 15 characters in the name.
8. Use \uparrow or \downarrow to highlight the **Save** button and push **ENTER**. The cal factor name is put in memory and the Display shows the **ION CHAMBER SETUP** screen.
9. Use \uparrow or \downarrow to highlight the **>>** button next to the **Cal Factor Value** label and push **ENTER**. The **NUMERIC** screen shows in the Display.



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10. Use \rightarrow , \leftarrow , \uparrow , and \downarrow to highlight a number button and push **ENTER** to add the number to the entry. You can have a maximum of seven digits in the range of -9.999999 to +9.999999.
11. Use \rightarrow or \leftarrow to highlight the **Save** button and push **ENTER**. The cal factor value is put in memory and the Display shows the **ION CHAMBER SETUP** screen.
12. Use \rightarrow or \leftarrow to highlight **<<** button next to the **e** label to enter an exponent for the cal factor.
13. Use \rightarrow , \leftarrow , \uparrow , and \downarrow to highlight a number button and push **ENTER** to add the number to the entry. You can have a maximum of two digits in the range of -20 to +20 for an exponent.
14. Use \rightarrow or \leftarrow to highlight the **Save** button and push **ENTER**. The cal factor value is put in memory and the Display shows the **ION CHAMBER SETUP** screen.
15. Use \rightarrow or \leftarrow to highlight the dropdown list and push **ENTER**.
16. Use \uparrow or \downarrow to highlight one of the cal factor units and push **ENTER**. Table 2-4 shows the available cal factor units.

Table 2-4. Cal Factor Units

Cal Factor Units	Description
R/C	Roentgens per Coulomb
R/nC	Roentgens per nano Coulomb
Gy/C	Grays per Coulomb
Gy/nC	Grays per nano Coulomb

Note

This unit definition is independent of the units set for Dose or Dose rate.

17. Use \leftarrow or \rightarrow to highlight the **Continue** button and push **ENTER**. The Display shows the **ION CHAMBER SETUP** screen.

How to Edit an Ion Chamber Definition or Cal Factor

To edit an ion chamber definition:

1. Use \leftarrow or \rightarrow to highlight the **IC** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **ION CHAMBER SETUP** screen shows in the Display.
2. Use \uparrow or \downarrow to highlight one of the ion chamber definition names and push **ENTER**.
3. Use \uparrow or \downarrow to highlight the **Edit** button and push **ENTER**. The **EDIT ION CHAMBER** screen shows in the Display.

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4. Use \leftarrow , \rightarrow , \uparrow , and \downarrow to highlight the button next to the value you want to edit and push **ENTER**. In the case of the dropdown list, highlight the dropdown box and push **ENTER**.

See the How to Add an Ion Chamber Definition or Cal Factor section for the steps on how to set each value.

5. When the values are set, use \uparrow or \downarrow to highlight the **Cancel** button and push **ENTER**.

How to Delete an Ion Chamber Definition or Cal Factor

To delete an ion chamber definition:

1. Use **▶** or **◀** to highlight the **IC** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **ION CHAMBER SETUP** screen shows in the Display.
2. Use **▲** or **▼** to highlight one of the ion chamber definition names and push **ENTER**.
3. Use **▲** or **▼** to highlight the **Delete** button and push **ENTER**. The **DELETE IC/CF** screen shows in the Display.



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4. Use **▶** or **◀** to highlight the **Delete IC** button and push **ENTER**.

Use **▶** or **◀** to highlight the **Cancel** button and push **ENTER** if you want to cancel the delete operation.

To delete a cal factor:

1. Use **▶** or **◀** to highlight the **IC** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **ION CHAMBER SETUP** screen shows in the Display.
2. Use **▲** or **▼** to highlight one of the ion chamber definition names.
3. Use **▶** to move to the cal factor list.
4. Use **▲** or **▼** to highlight one of the ion chamber cal factor names and push **ENTER**. The **DELETE IC/CF** screen shows in the Display.
5. Use **▶** or **◀** to highlight the **Delete CF** button and push **ENTER**.

Note

If the deleted cal factor is the only cal factor for an ion chamber, then the ion chamber is also deleted.




Measurement Mode Selection

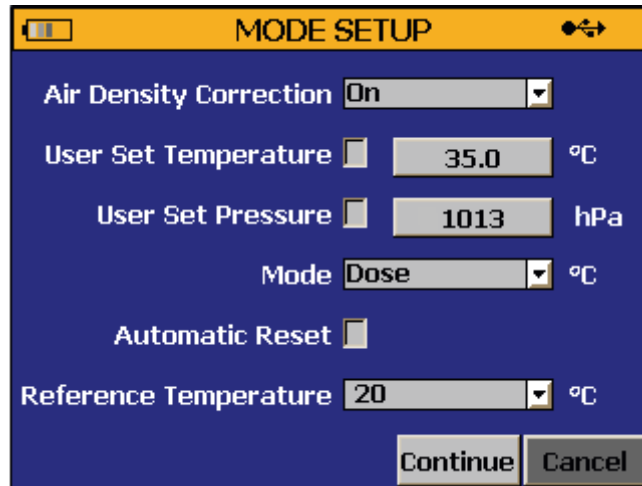
The Dosimeter has three measurement modes. Table 2-5 shows the modes and their definition.

Table 2-5. Dosimeter Measurement Modes










Measurement Mode	Definition
Dose	<p>Automatic drift and offset compensation, and automatic post-exposure display hold are done in this mode.</p> <p>The display updates at the end of each exposure. Only the Dose value shows along with the mAs measurements^[1] in the Measurement Screen.</p> <p>When Automatic Reset is enabled, at the end of an exposure, the measurement is held on the display and the meter is reset automatically. The exposure start and end detection are based on the exposure rate level crossing a 0.25 pA threshold. You can reset the exposure measurement anytime, by selecting Reset in the measurement screen.</p> <p>When the Automatic Reset option is disabled, exposure start detection is based on the exposure rate level crossing a 0.25pA threshold but the exposure measurement is only reset by selecting Reset in the measurement screen.</p>
Dose Rate	<p>Automatic offset compensation and nonlinear digital filtering are performed in this mode. Auto ranging provides five decades of sensitivity ranges.</p> <p>The measurement range covers a span from low-level image intensifier inputs to unattenuated direct beams.</p> <p>Note: The display of the mAs values remain unaffected (if the mAs detector is selected for measurement).</p> <p>Differentiation between exposure on and off condition is based on 0.25 pA threshold.</p>
Low Rate	<p>This mode is only for making very low dose rate measurements. Nonlinear digital filtering and auto ranging provide five decades of sensitivity ranges. In this mode, automatic current offset and drift compensation is disabled. As a result, the system leakage (includes dosimeter, cable and ion chamber) must be compensated for. This option should only be used with ion chambers suitable for very low dose rate measurements.</p> <p>In the Measurement Screen, only the Dose Rate will be displayed along with the mAs readings^[1] and the display updates once per second.</p> <p>Note: The display of the mAs values remain unaffected (if the mAs detector is selected for measurement).</p>
[1] mAs units are only shown if the mAs Detector is setup for measurements.	

To set the Dosimeter mode:






1. Use  or  to highlight the **Mode** button in the Dosimeter **MEASUREMENT** screen and push . The **MODE SETUP** screen shows in the Display.



fct250.png

2. Use  or  to highlight the **Mode** dropdown box and push .
3. Use  or  to highlight one of the three modes and push .
4. Use  or  to highlight the **Continue** button and push . The mode is set and the **MEASUREMENT** screen shows in the Display.




To set Automatic Reset:

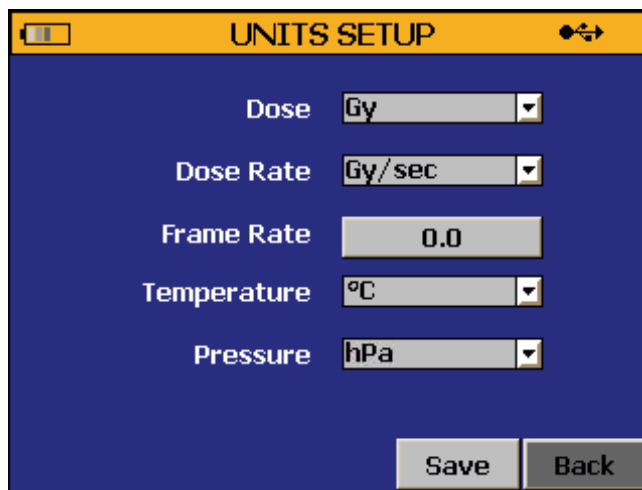
1. Use , , , and  to highlight the checkbox next to the **Automatic Reset** label.
2. Push  to toggle the checkbox.

In automatic reset, the last calculated value is held in the Display until a subsequent above-threshold exposure occurs, a function changes, or a power down. When exposures occur at less than one-second intervals, the Detector measures them as one exposure.

How to Set Units of Measurement

The Dosimeter measures radiation in **Roentgens (R)** and Grays (Gy). Current measurement units are coulombs and amperes. To set the units of measure:



1. Use  or  to highlight the **Units** button in the Dosimeter **MEASUREMENT** screen and push . The **UNITS SETUP** screen shows in the Display.



fct251.png

2. Use  or  to highlight the **Dose** dropdown box and push .

The available dose units are **Roentgens (R)**, Grays (Gy), and Coulombs (C).

3. Use  or  to highlight one of the dose units and push **ENTER**.

Note

The TNT 12000 DoseMate PTB version only measures dose in Grays and Coulombs.



4. Use  or  to highlight the **Dose Rate** dropdown box and push **ENTER**. Table 2-6 shows the dose rate values.

Table 2-6. Dose Rate Values

Dose Setting	Available Dose Rates	Description
Grays (Gy)	Gy/sec	Grays per second
	Gy/min	Grays per minute
	Gy/hr	Grays per hour
	Gy/pulse	Grays per pulse
Coulombs (C)	A	Amperes

Note

*If **No Ion Chamber** is set, dose unit is set to C and the dose rate is set to A. These units can not be changed.*

5. Use  or  to highlight one of the dose rates and push **ENTER**.

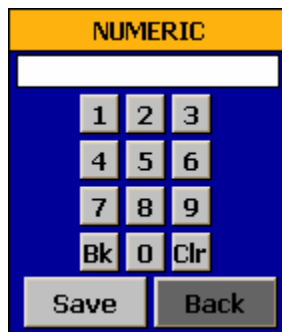
Note

The TNT 12000 PTB version only has dose rates of Gy/sec, Gy/min, Gy/hr, and Gy/pulse when dose unit is set to Gray. Amperes is only available when dose unit is set to Coulombs.







6. Use  or  to highlight the **Frame Rate** button and push **ENTER**. The **NUMERIC** screen shows in the Display.

Note

*The Frame Rate button is only active when dose rate is set to **R/pulse** or **Gy/Pulse**.*









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7. Use , , , and  to highlight a number button and push **ENTER** to add the number to the entry. Use a number between 1 and 120 with a step size of 0.1.
8. Use  or  to highlight the **Save** button and push **ENTER**.

9. Use  or  to highlight the **Temperature** dropdown box and push **ENTER**.



Note

If ADCF is off, the temperature option is disabled.

10. Use  or  to highlight °C, °F, or K and push **ENTER**.
11. Use  or  to highlight the **Pressure** dropdown box and push **ENTER**.
12. Use  or  to highlight inHg, mmHg, mbar, hPa, feet, or meters and push **ENTER**.

Note



If ADCF is off, the pressure option is disabled.

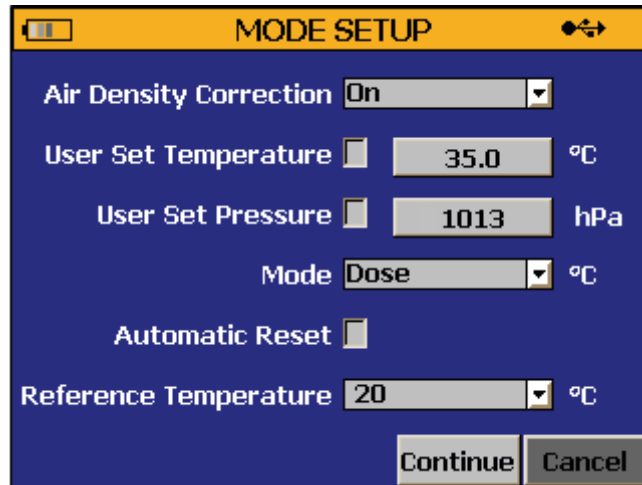
13. Use  or  to highlight the **Save** button and push **ENTER** to save the units selections.

Air Density Correction





When Air Density Correction is set to on, the Dosimeter corrects dose and dose rate measurements based on temperature and barometric pressure. Temperature and pressure values can be set externally through the Display or internally by the Dosimeter temperature and pressure sensors.

To turn the Air Density Correction Factor (ADCF) on or off:

1. Use  or  to highlight the **Mode** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **MODE SETUP** screen shows in the Display.
































fct250.png

2. Use  or  to highlight the **Air Density Correction** dropdown box and push **ENTER**.
3. Use  or  to highlight **On** or **Off** and push **ENTER**.

To set **Temperature**, **Pressure**, and **Reference Temperature** in the **MODE SETUP** screen, **Air Density Correction** must be set to **On**. If set to **Off**, all three controls are disabled in the **MODE SETUP** screen.

External Temperature/Pressure Compensation Mode

It is assumed that air density correction is set to **On** in the steps that follow.

1. Use , , , and  to highlight the checkbox next to the **User Set Temperature** label and push  to toggle the checkbox. When the box is checked, the button to the right of the checkbox is enabled. When this checkbox is not checked, internal temperature compensation is activated.
2. Use  to highlight the temperature button and push  to change the temperature value. The **NUMERIC** screen shows in the Display.
3. Use , , , and  to highlight a number and push  to add the number to the entry.
4. When the temperature value is set, highlight the **Save** button and push  to set the temperature compensation value.
5. Use , , , and  to highlight the checkbox next to the **User Set Pressure** label and push  to toggle the checkbox. When the box is checked, the button to the right of the checkbox is enabled. When this checkbox is not checked, internal pressure compensation is activated.
6. Use , , , and  to highlight the Reference Temperature dropdown box and push .
7. Use  or  to highlight 20 or 22 and push . The ion chamber is calibrated at this reference temperature. See the Ion Chamber Specifications for the highlighted chamber in Appendix A, B, C, or D.
8. Use  or  to highlight the **Continue** button and push . The mode is set and the **MEASUREMENT** screen shows in the Display.

Internal Temperature/Pressure Compensation Mode

When the Dosimeter is set for internal temperature compensation, the temperature value is set by an internal sensor. This temperature can be different than the temperature of the ion chamber connected to the Detector. The Detector and the ion chamber must be the same temperature as the environment before a measurement.

The Dosimeter internal temperature approximately 30 minutes after it is turned on is typically 10 to 15 °C above ambient temperature. At standard conditions of 22 °C and 760 mm Hg, a change of 1 °C ~ 0.36 % change in ADC. Fluke Biomedical recommends the internal temperature sensor only be used to measure temperature after the Detector is turned on and the Dosimeter and ion chamber are the same temperature as the environment. Then set this temperature into the Detector manually.



Note

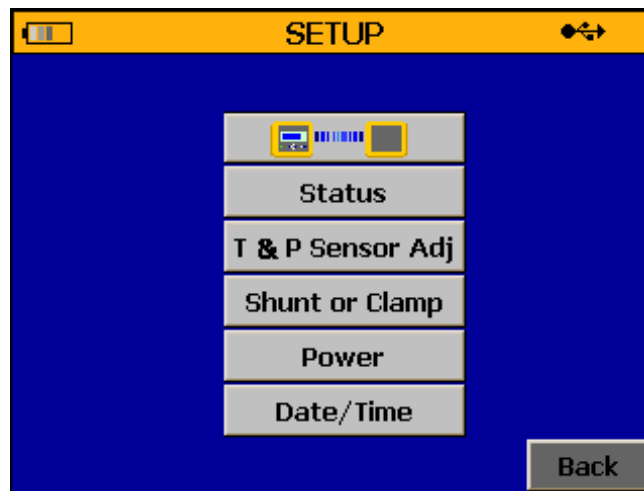
With its internal temperature compensation, the internal pressure sensor works in all conditions.

How to Adjust the Internal Temperature/Pressure Sensor

The Dosimeter Detector lets you override the internal measured values through an offset value, or a specified temperature or pressure entry. Before you override the temperature and pressure values, let the Detector equalize for a minimum of one hour. Use only calibrated thermometers and barometers to set the temperature and pressure.

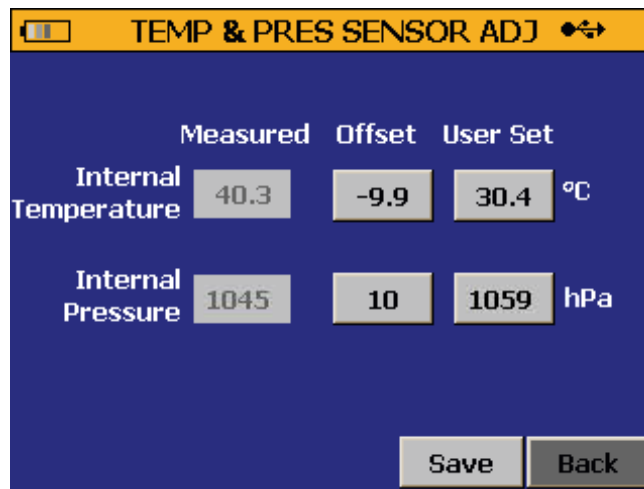
To override the temperature and/or pressure values:

Use  or  to highlight the **Setup** button in the Dosimeter **MEASUREMENT** screen and push **ENTER**. The **SETUP** screen shows in the Display.





fct254.png

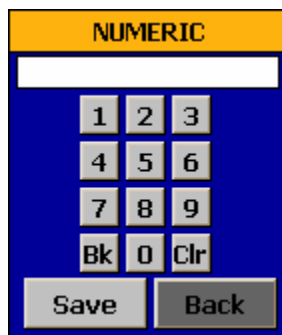
Use  or  to highlight the **T & P Sensor Adj** button and push **ENTER**. The **TEMP & PRES SENSOR ADJ** screen shows in the Display.



fct253.png

You can override the temperature and pressure values with an offset value or a user set value. To set an offset temperature value:

1. Use  or  to highlight the button to the right of the **Internal Temperature** label and under the **Offset** label.
2. Push **ENTER** to open the **NUMERIC** screen.



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3. Use , , , and to highlight a number button and push **ENTER** to add the number to the entry. Use a number between 1 and 10 for an offset.

Note

The unit of measurement for Temperature is °C and pressure is mmHg. This is different than the units set in the Unit Setup screen.

4. Use or to highlight the **Save** button and push **ENTER**. The offset value is automatically summed with the measured value and the user set button shows the new value.

Use the same steps to set an offset pressure value.

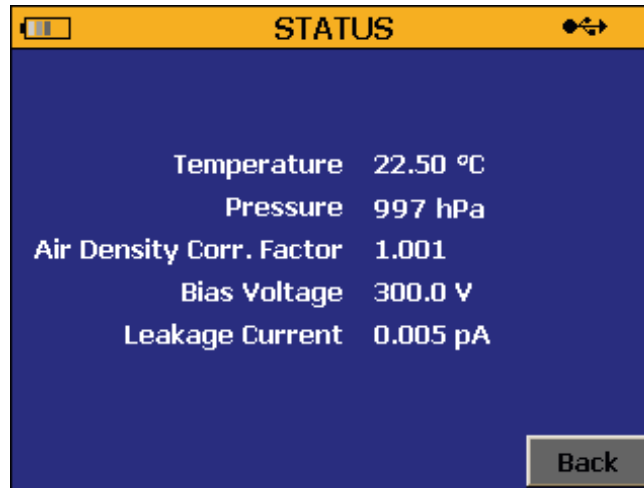
To set a user set temperature value:

1. Use or to highlight the button to the right of the **Internal Temperature** label and under the **User Set** label.
2. Push **ENTER** to open the **NUMERIC** screen.
3. Use , , , and to highlight a number button and push **ENTER** to add the number to the entry. Use a number in the range between the measured value – 10 and the measured value + 10.
4. Use or to highlight the **Save** button and push **ENTER**. The user set value is automatically summed with the measured value and the user set button shows the new value.

Dosimeter Status

To examine the status of the Dosimeter Detector:

1. Use or to highlight the **Setup** button in the **MEASUREMENT** screen and push **ENTER**.
2. Use or to highlight the **Status** button and push **ENTER**. The **STATUS** screen shows in the Display.

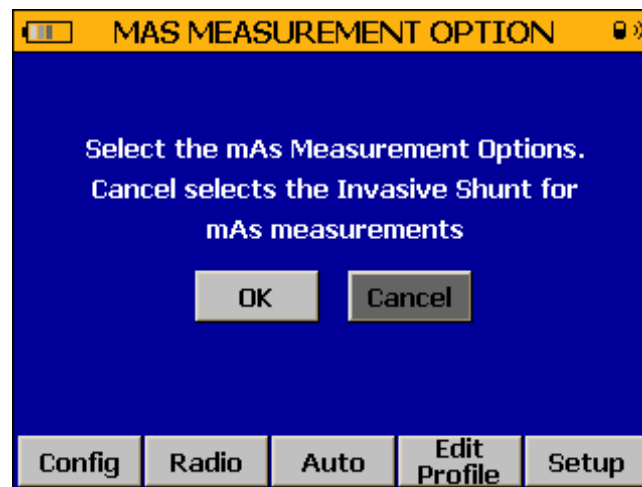


fct255.png

The temperature and pressure values are internal sensor measurements. The bias voltage and leakage current are values measured in the ion chamber. If these values are more than the measurement limits, **High** or **Low** shows as the value.

How to Use the mAs Detector (TNT 12000 mAs)

When the mAs Detector selection is made from the connection screen, the **MAS MEASUREMENT OPTION** screen shows if the mAs input type is not set. See Figure 2-16.



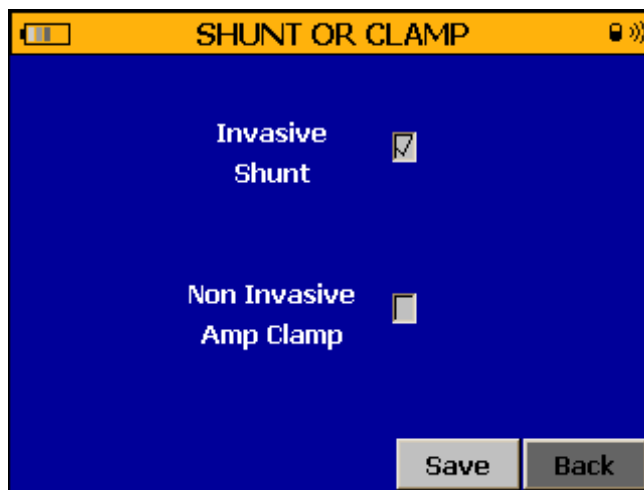
fct15.bmp

Figure 2-16. mAs Measurement Option Screen

If the input type is set, the **MEASUREMENT** screen shows in the Display. See the How to Measure mAs section below.

To set the input measurement option to shunt, highlight the **Cancel** button and push **ENTER**. The current shunt is the default selection.

To set the input measurement option to clamp, highlight **OK** and push **ENTER**. The **SHUNT OR CLAMP** screen shows in the Display. See Figure 2-17.



fct207.png

Figure 2-17. Shunt or Clamp Screen

Use \uparrow or \downarrow to highlight the **Invasive Shunt** or **Non Invasive Amp Clamp** checkbox. Push **ENTER** to toggle the checkbox. Use \leftarrow or \rightarrow to highlight the **Save** button and push **ENTER** to set the input measurement option.

How to Connect to the X-ray Tube for mAs Measurements

⚠ Caution

To prevent damage to the Detector and/or X-ray equipment, do not connect to the generator mA/mAs taps without the TNT 12000 mAs shunt.

An mAs measurement is the X-ray tube current multiplied times the exposure time. The mAs Detector auto ranges through three ranges. There are also two X-ray tube current measurement methods. A current shunt is put into the X-ray tube current path or a current clamp is put around the X-ray tube anode cable. Table 2-7 shows the three ranges with the two measurement methods.

Table 2-7. mAs Current Ranges

Measurement Method	Ranges
Invasive Shunt	0 – 99.99 mA/mAs
	100.0 – 999.9 mA/mAs
	1000 – 1999 mA/mAs
Non-Invasive Clamp	0 – 99.99 mA/mAs
	100.0 – 999.9 mA/mAs
	1000 - 3999 mA/mAs

Shunt Connections

You must put the mAs shunt in series with the actual current path of the x-ray tube. This is usually the ground line of the high-voltage transformer of the X-ray tube. You can put the shunt in series with the rectified tube current (dc path), through dc input jacks. A different procedure is to use ac input jacks in series with the transformer downstream of the rectifier (ac path).

It is necessary that all the tube current go through the mAs shunt to make an accurate measurement. If different or parallel current path of x-ray tube current bypasses the shunt, the measurement will be incorrect.

Do not use resistors, varistors, bypass, or distributed capacitors in parallel with the shunt. The effect of these components can cause measurement errors. Before you put the mAs shunt in the current path, examine the X-ray tube current circuit. Make sure that the shunt is connected so these components do not have an unwanted effect on the measurement. Varistors, which have limiting voltages more than 10 Volts, will probably not change the measurement.

The mAs adapters shipped with the TNT 12000 adapt the shunt to different X-ray tube mA/mAs connections. Some X-ray generators have standard 1.9 cm (0.75") spaced banana jacks or binding posts to monitor X-ray tube current. After you remove the shorting plug, the TNT 12000 shunt is connected to these jacks for mAs measurements. As Figure 2-18 shows, the BNC Female to Banana Plug adapter connects the shunt to the mAs input through the mA/mAs interface cable.

Warning

To prevent electric shock or personal injury, follow these guidelines:

- **Observe extreme caution when power is applied to the shunt.**
- **Use this Analyzer only in the manner specified by the manufacturer or the protection provided may be impaired.**
- **Follow all safety precautions called for in the X-ray generator documentation.**
- **Use extreme caution when working with voltages above 30 V.**
- **Inspect the test leads for damaged insulation or exposed metal. Check the test leads for continuity. Replace damaged test leads before you use the TNT 12000.**
- **Do not touch the test leads or the Detector while power is applied to the circuit under test.**
- **Turn the X-ray generator off before connecting or disconnecting the TNT 12000.**

Caution

To prevent damage to the TNT 12000 or equipment under test, do not exceed 500 V peak between the input and earth ground.

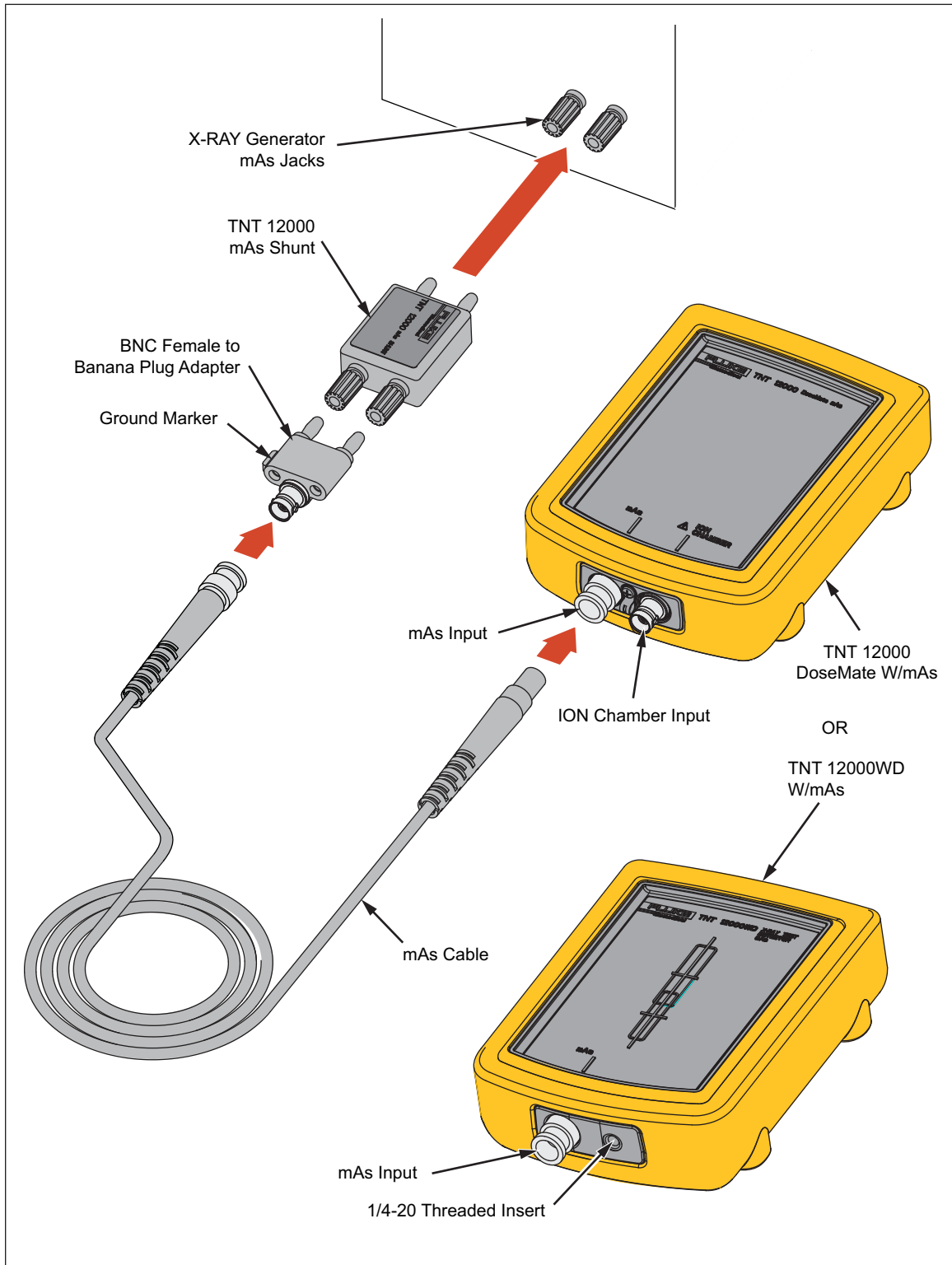


Figure 2-18. Direct mAs Shunt Connection to Current Jacks

fct22.eps

For X-ray devices that do not have a banana jack or binding post connection, test leads are supplied for the connection. As Figure 2-19 shows, the BNC Female to Binding Posts adapter connects the shunt to the mAs input through the mA/mAs interface cable.

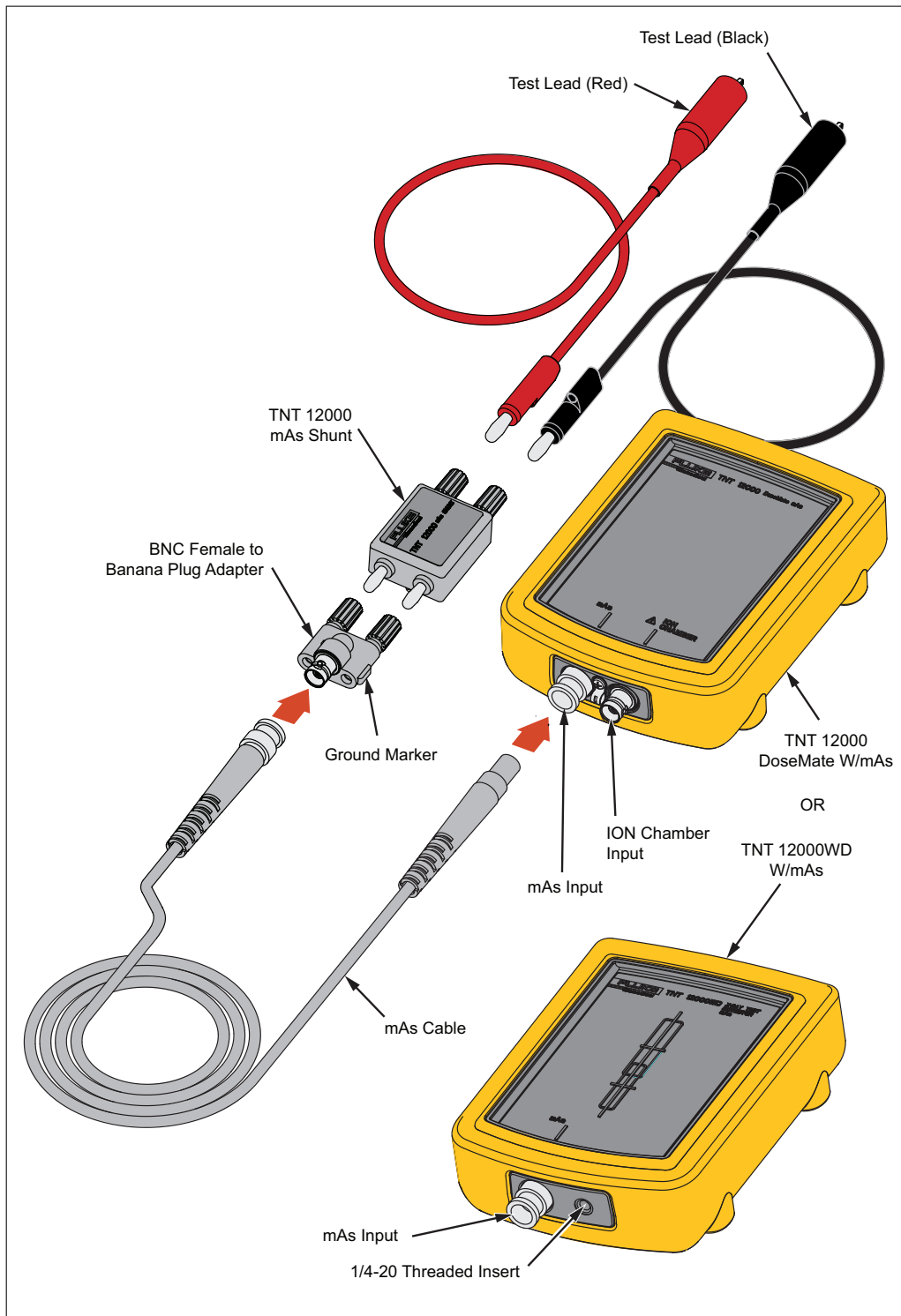


Figure 2-19. mAs Test Leads Connection

fct23.eps

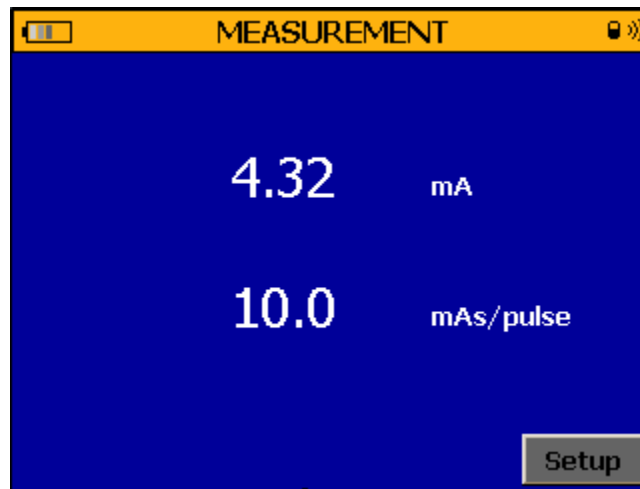
Clamp Connections

Some dental X-ray heads do not have an access to the tube current. Some X-ray circuits are contained inside the X-ray head. Other systems measure current as a voltage across an internal resistor. The mAs shunt can not be used on these X-ray systems. For these cases, use a non-invasive current clamp. To make an mA or mAs measurement:

1. Put the clamp around the anode cable where it exits the X-ray tube. Make sure the jaws are completely closed around the cable. For correct polarity, make sure the arrow on the moveable jaw of the clamp points in the direction of current flow in the cable.
2. Connect the clamp to the mAs input connector with the BNC female to banana plug and the mA/mAs interface cable.
3. Turn on the clamp and set to the 4A range.
4. Zero the clamp before the measurement.
5. Make an exposure.
6. Read the current in the Display.

How to Measure mAs

After the mAs measurement options are set, the **MEASUREMENT** screen in Figure 2-20 shows in the display.



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Figure 2-20. mAs Measurement Screen

After the mAs is connected to the X-ray tube, the **MEASUREMENT** screen is refreshed with the new measurements after each exposure.

Setup Options

The setup options for the TNT 12000 lets you connect Detectors to the Display, set the power settings, and set the date and time clock. When the **Setup** button is highlighted and **(ENTER)** is pushed, the **SETUP** screen in Figure 2-21 shows in the Display.

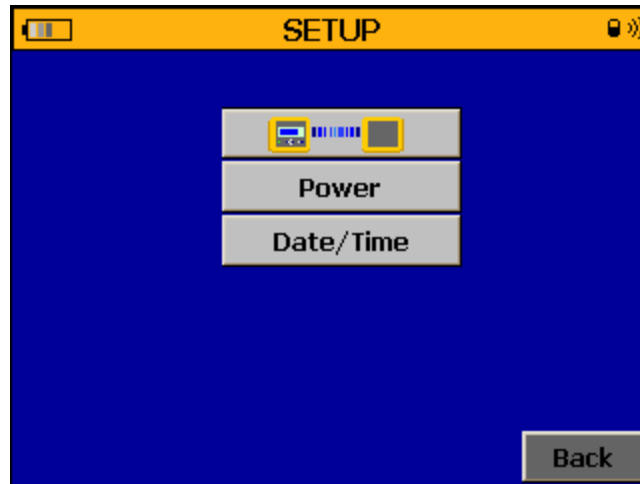


Figure 2-21. Setup Screen

fct13.bmp

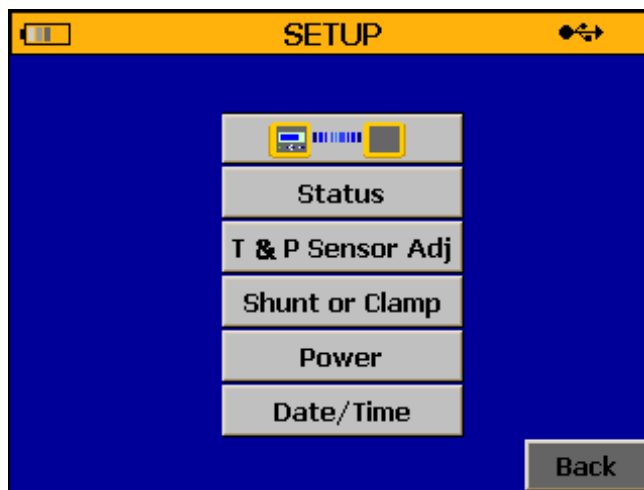
If the mAs Detector is connected to the Display, a setup button for a **Shunt or Clamp** is added as shown in Figure 2-22. See the How to Use the mAs Detector section to use the clamp or shunt for this measurement.



Figure 2-22. Setup Screen from mAs Measurement

fct18.bmp

If the DoseMate Detector is connected to the Display, a setup button for **T & P Sensor Adj** and **Status** are added as shown in Figure 2-23. See the How to Use the Dosimeter Detector section for information on these two selections.



fct254.png

Figure 2-23. Setup Screen with mAs and DoseMater Detectors Connected

Use and to highlight a button and push **(ENTER)** to move to a setup option.

Connection Option

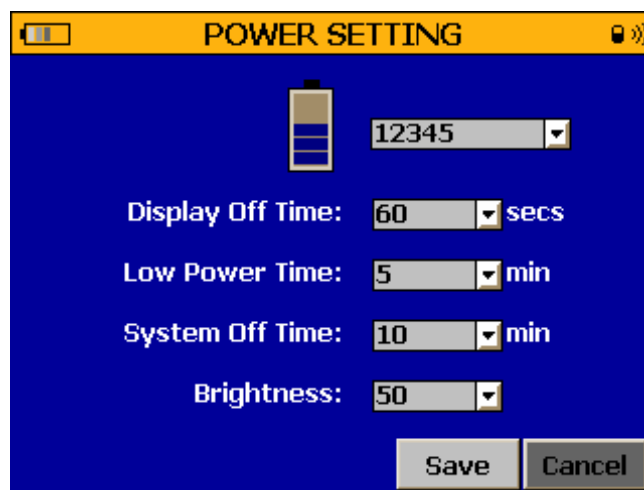
Instructions for using the Connection () setup are in the Communications Settings section above.

How to Set Power Settings

To increase battery life, a display off time, low power time, system off time, and Display brightness is user settable. You can read the charge level of the battery in each Detector from the Power Setting screen as well.

To set a power parameter or see a Detector battery charge level:

Use or to highlight the **Power** button in the **SETUP** screen and push **(ENTER)** to open the **POWER SETTING** screen shown in Figure 2-24.







fct14.bmp

Figure 2-24. Power Setting Screen

When all the power settings are set, use or to highlight the **Save** button and push **(ENTER)** to return to the **SETUP** screen.

Detector Battery Charge Level





The Detector Battery Status Indicator shows the level of charge in the battery of the connected Detectors. To examine the battery charge level of a detector:

1. Use the  or  to highlight the Detector drop-down list and push **ENTER**.
2. Use the  or  to highlight the serial number of a Detector and push **ENTER**.

The battery indicator shows the level of charge in the battery of the Detector.

Display Off Time

To set a time (5 to 99 seconds) from the last measurement or button push to backlight off:

1. Use the  or  to highlight the Display Off Time drop-down list.
2. Push **ENTER**.
3. Use the  or  to highlight the number of seconds.
4. Push **ENTER**.

Low Power Time

The TNT 12000 circuitry goes to a low-power mode if there are no measurements or key pushes for the time period set for Low Power Time. In low power mode, measurements are disabled and the screen in Figure 2-25 shows in the Display.

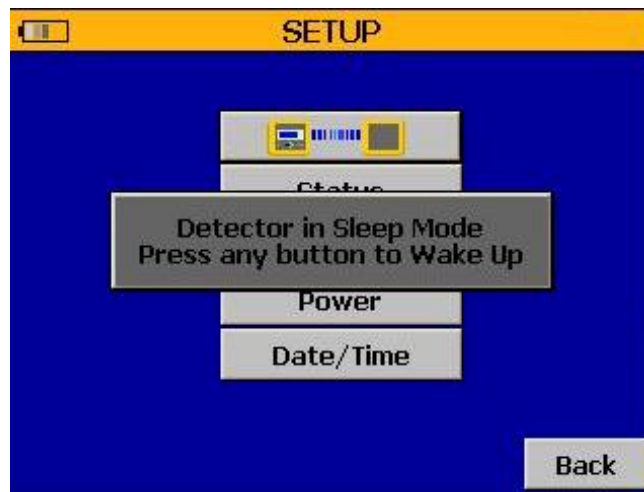






Figure 2-25. Sleep Mode Display

ftc261.png





To set a Low Power Off Time:

1. Use the  or  to highlight the **Low Power Time** drop-down list.
2. Push **ENTER**.
3. Use the  or  to highlight the number of minutes (2 to 9 minutes or None). The none setting disables Low Power Time and the system never goes into Low Power mode.
4. Push **ENTER**.

When a Display button is pushed, the system will return to normal power.

System Off Time





The system shuts down if there are no measurements or key pushes for the time period set for System Off Time. To set a System Off Time:

1. Use the  or  to highlight the **System Off Time** drop-down list.
2. Push **ENTER**.
3. Use the  or  to highlight the number of minutes (2 to 9 minutes or None). The none setting disables System Off Time and the system never shuts down.
4. Push **ENTER**.

Push  to restart the system.

Brightness

To set the brightness of the Display:

1. Use the  or  to highlight the **Brightness** drop-down list and push **ENTER**.
2. Use the  or  to highlight a number (0 to 99) and push **ENTER**.
3. Push **ENTER**.

How to Set the Date and Time

The **SET DATE/TIME** screen in Figure 2-26 allows you to set the Date and Time.

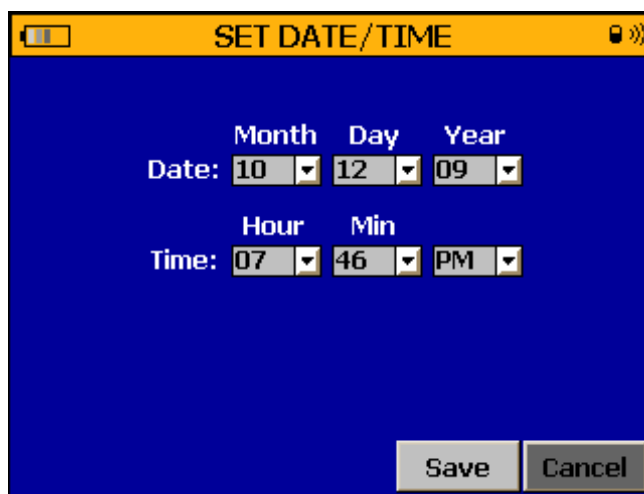










Figure 2-26. Date and Time Setting Screen

ftc204.png

To set the Date:

1. Use the  or  to highlight the **Month**, **Day**, or **Year** drop-down list and push **ENTER**.
2. Use the  or  to highlight the number for the Month, Day, or Year and push **ENTER**.

To set the Time:

1. Use the  or  to highlight the **Hour**, **Min**, or AM/PM drop-down list and push **ENTER**.
2. Use the  or  to highlight the number for the Hour or Min, or AM or PM and push **ENTER**.

When a date and/or time is set, highlight the **Save** button and push **ENTER** to save the new settings.

Chapter 3

Microsoft Excel Add-In Software

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Introduction

The Microsoft Excel Add-In Software (hereafter the Add-In) emulates the TNT 12000 Display. You can set Detector parameters and collect measurement data through the PC to Detector connection. Waveform download is an added function that is not available through the Display. The kV data measured by the Detector is downloaded to the Add-In and placed in a worksheet. The data points are then plotted using the Microsoft Excel graph feature.

System Requirements

The Add-In must be loaded onto a PC with the following hardware and software:

- Microsoft Windows 2000, Windows XP, or Windows Vista operating system.
- Microsoft Excel 2000 or higher
- One USB port
- CD-ROM disk drive

Communication between the PC and a Detector is through a wireless (ZigBee) or wired (USB) connection.

How to Install the Add-In

Installation involves installing the Excel Add-In software and a Vendor Class driver.

How to Install the Excel Add-In Software

To install the Excel Add-In software:

1. Start the PC.
2. Put the TNT 12000 X-ray Test Tools CD in the CD-ROM drive. The installation starts automatically. If not, browse to the CD-ROM and double-click on launch.exe to start the installation.
3. After the CD-ROM program starts, click on the “Install Excel Add-In” button.
4. When the InstallShield Wizard screen shown in Figure 3-1 shows, click on **Next**.



Figure 3-1. InstallShield Wizard

fct301.bmp

5. When the **Ready to Install** screen shows, click **Install**.
6. When the InstallShield Wizard Completed screen shows, click **Finish**.

How to Install the TNT 12000 Vendor Class Driver

1. Start the PC.
2. Put the TNT 12000 X-ray Test Tools CD in the CD-ROM drive.
3. Connect a Detector to the PC through the USB cable (Type-A to Mini-B) and turn on the Detector. See Figure 3-2. The Found New Hardware Wizard shows in the PC display.

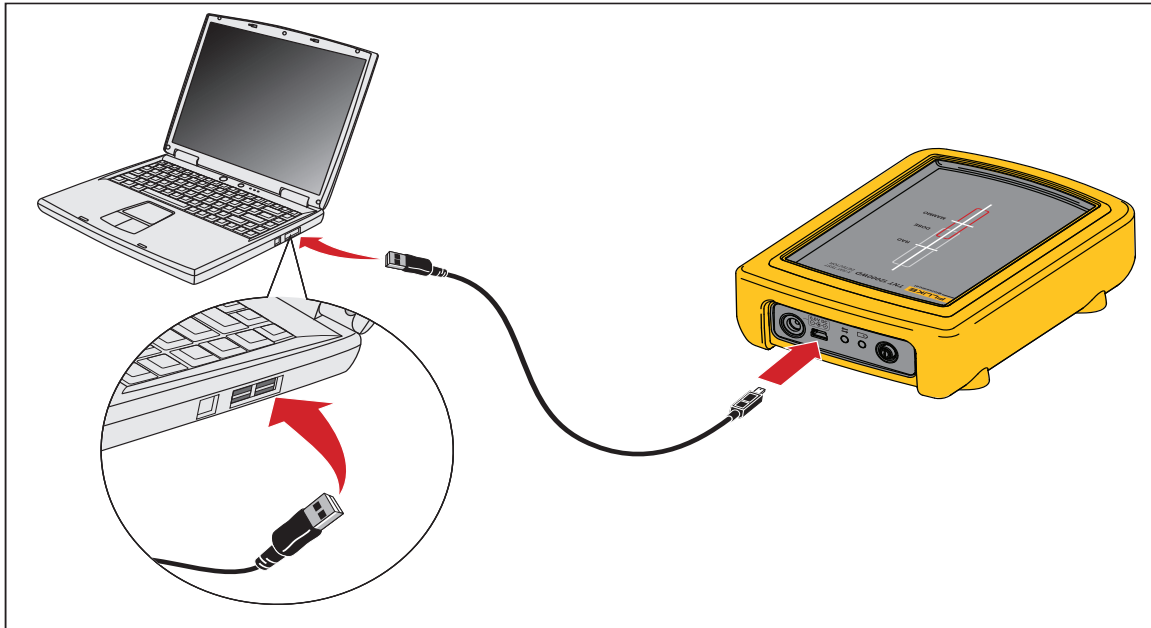


Figure 3-2. USB Connection between PC and Detector

fct07.eps

4. Select **Install from a list or specific location (Advanced)** option and click **Next**. The **Found New Hardware Wizard** window shown in Figure 3-3 shows in the PC display.

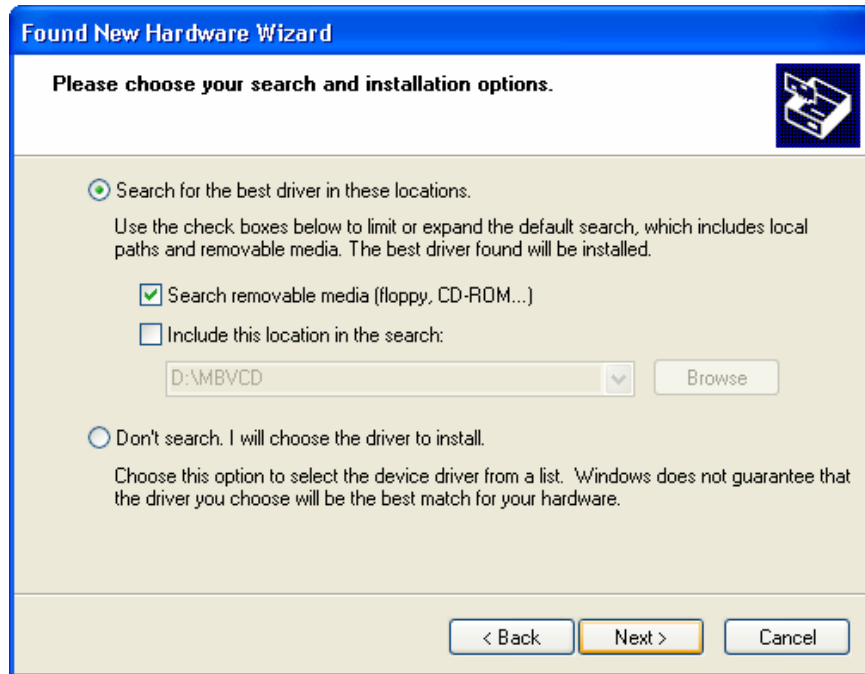


Figure 3-3. Found New Hardware Wizard Window

fct307.bmp

5. Check the **Search for the best driver in these locations** option.
6. Check the **Search removable media (floppy, CD-ROM...)** option.
7. Click **Next**.
8. When the **Hardware Installation** message shows, click **Continue Anyway**.
9. Click **Finish** to complete the installation

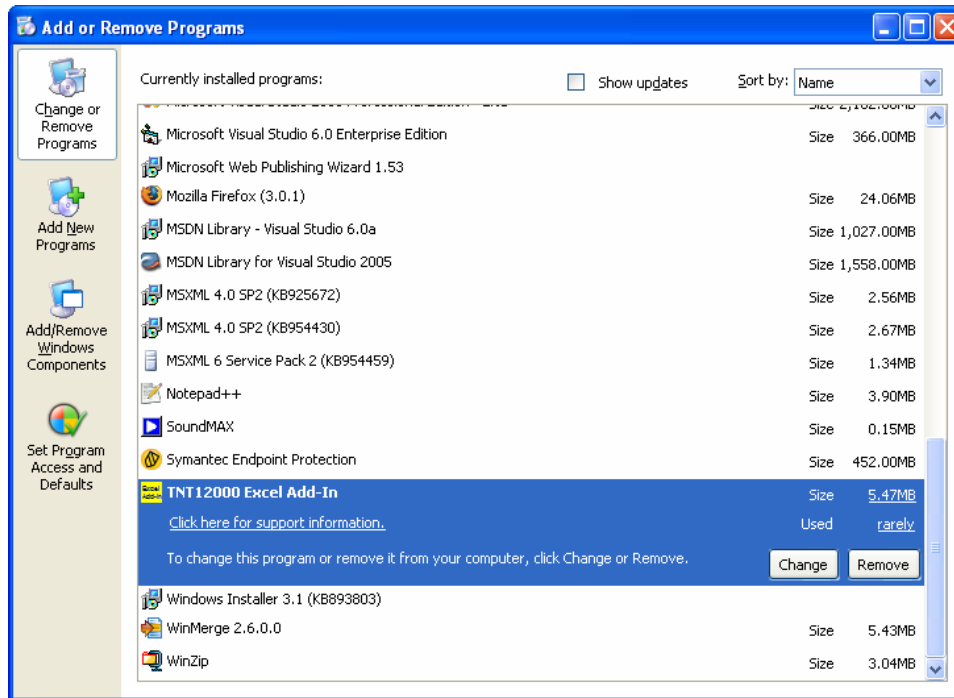
How to Uninstall the Add-In

To remove the Add-In from a PC you must uninstall the Excel Add-In software and the Vendor Class driver.

How to Uninstall the Excel Add-In Software

To uninstall the Excel Add-In software:

1. Start the PC.
2. Click **Start** on the task bar.
3. Click on **Settings: Control Panel**.
4. Double-click on the **Add or Remove Programs** icon to open the Add or Remove Programs dialog window.



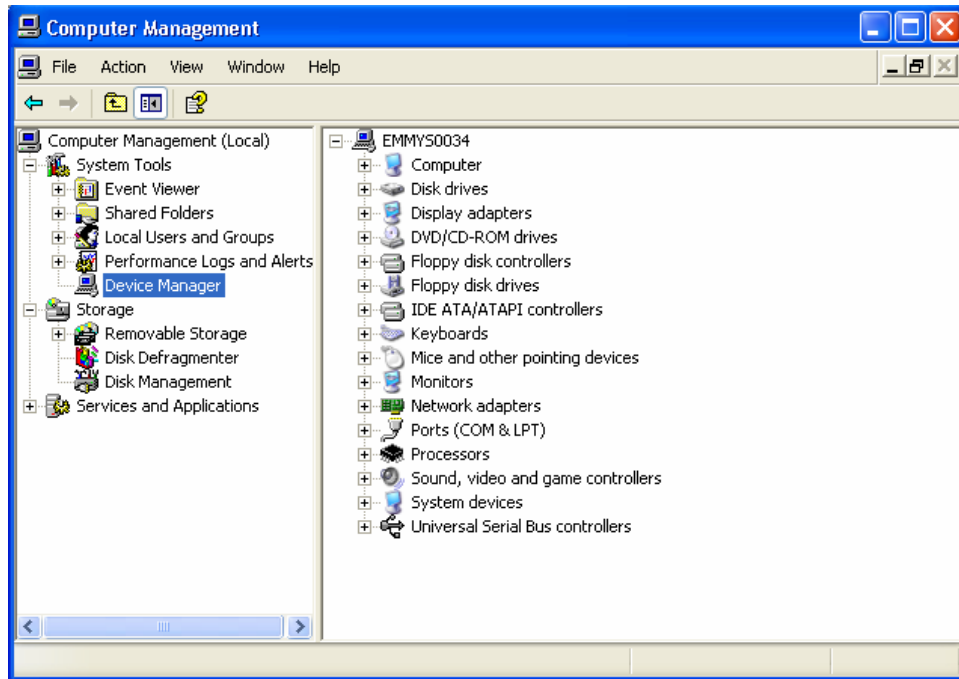
fct304.bmp

Figure 3-4. Add or Remove Programs Dialog

5. Scroll to and select the **TNT 12000 Excel Add-In** program.
6. Click **Yes** in the confirmation window to uninstall the software.

How to Uninstall the TNT 12000 Vendor Class Driver

1. Start the PC.
2. Connect a Detector to the PC through the Mini-B to Type-A USB cable.
3. Push Ⓢ on the Detector.
4. Right-click the **My Computer** icon and select **Manage**.
5. Select **Device Manager** on the left side of the window as shown in Figure 3-5.



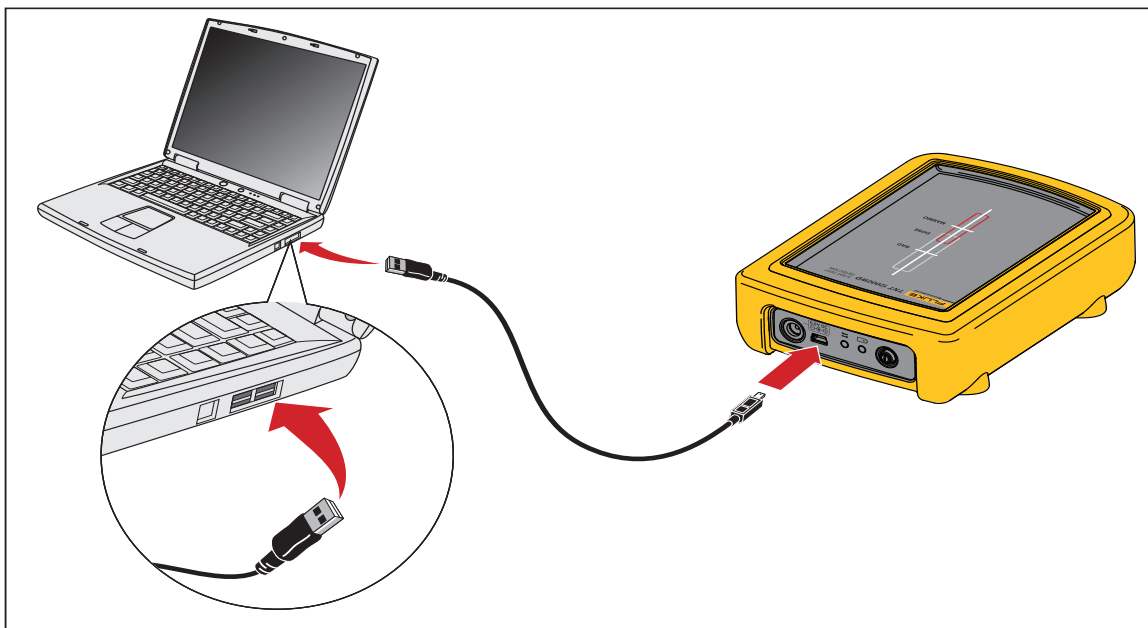
fct310.bmp

Figure 3-5. Computer Management Windows

6. Click **+** adjacent to **Universal Serial Bus controllers**.
7. Right-click **TNT 12000 Device** and select **Uninstall**.
8. Click on the **OK** button in the Confirm Device Removal dialog box.

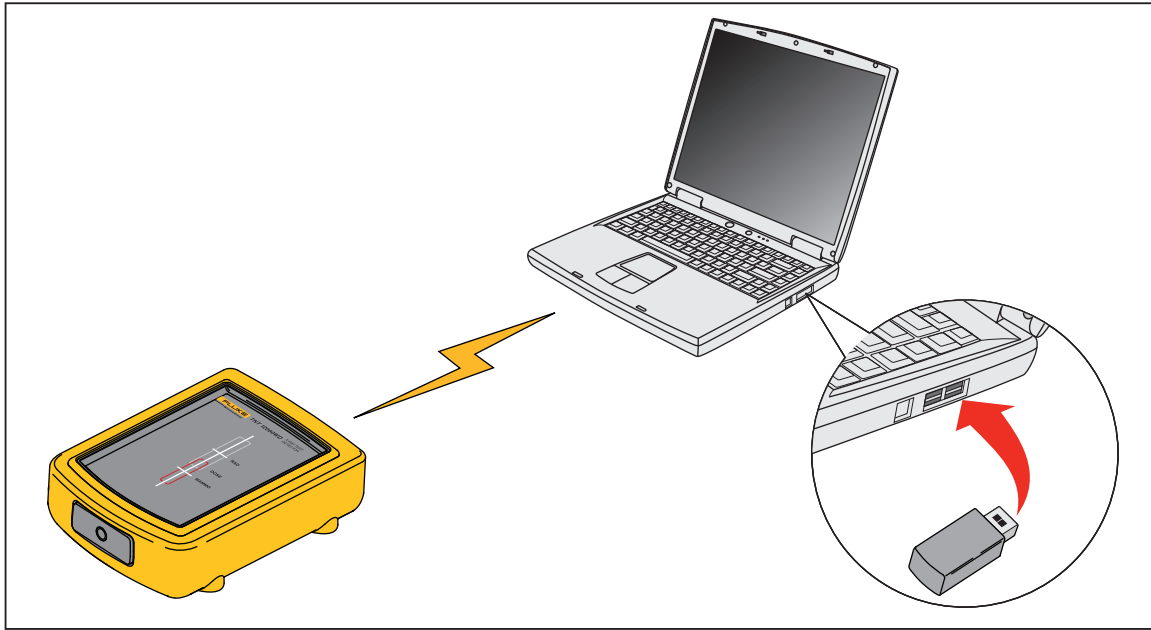
Communication between a PC and Detector

To operate the TNT 12000 from a PC, there must be communication through a wireless or wired connection. Figure 3-6 shows a wired connection with a USB cable. Figure 3-7 shows a wireless connection with a wireless dongle plugged into a USB port of the PC.



fct07.eps

Figure 3-6. USB Connection between PC and Detector



fct03.eps

Figure 3-7. Wireless Connection Between PC and Detector

How Initialize the TNT 12000 Add-In Software

To initialize the TNT 12000 Add-In software:

1. Start the PC.
2. Click **Start** on the task bar.
3. Click **Programs**.
4. Click on **TNT 12000 Excel Add-In** to open the TNT 12000 Excel Add-In.

Note

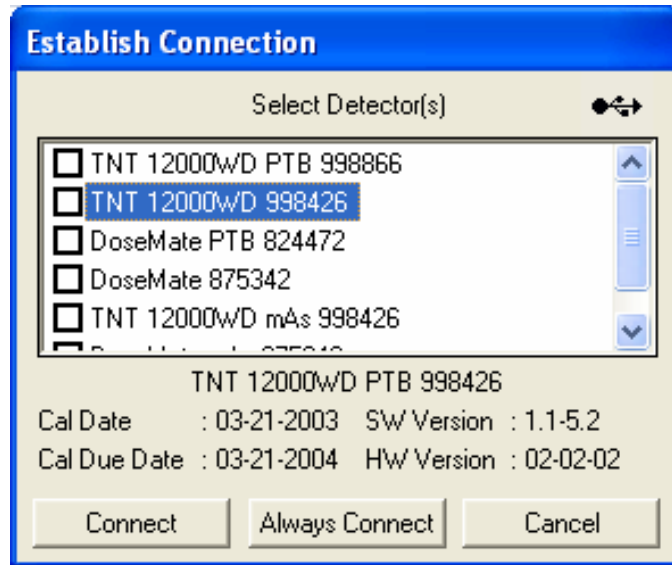
*A different launch procedure is to double-click the **TNT 12000 Excel Add-In** shortcut icon on the desktop.*

TNT 12000 shows in the menu at the top of the screen and the TNT 12000 control toolbars shows.

Note



Macros must be enabled in Excel before you can use the TNT 12000 Excel Add-In. Excel offers macro virus protection as an option. Refer to the Excel documentation for more about how to enable macros.

5. Click **Connect** option in the toolbar to open the **Establish Connection** window shown in Figure 3-8.



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Figure 3-8. Detector Connection Window

When you scroll through the detectors,  or  appears in upper-right corner of the screen if a connection exists between the Display and the highlighted Detector. Calibration date, calibration due date, software version, and hardware version for the highlighted Detector shows below the Detector list.

6. Make a Detector selection from the list.
A maximum of two Detectors can operate with the Display at one time. The X-ray or Dosimeter Detector can operate with the mAs Detector at the same time. The X-ray Detector and Dosimeter Detector can not operate with the Display at the same time.
7. Click **Connect** or **Always Connect** to connect the PC with the Detector.
8. Make a worksheet selection and put the cursor on the cell where the data is to be put. The measurement data is automatically put into the active worksheet cell after the measurement.

Note

To learn more on how to use the PC Excel Add-In, refer to the TNT 12000 Excel Add-In Software Help. It is available in the TNT 12000 drop-down menu or the toolbar.

TNT 12000WD Toolbar Options

Figures 3-9 and 3-10 shows the TNT 12000WD drop-down menu and toolbar. See the toolbar option descriptions in Table 3-1.

Note

In Microsoft Excel 2007, click the Add-Ins tab in the toolbar to show the TNT 12000 menu and toolbar.

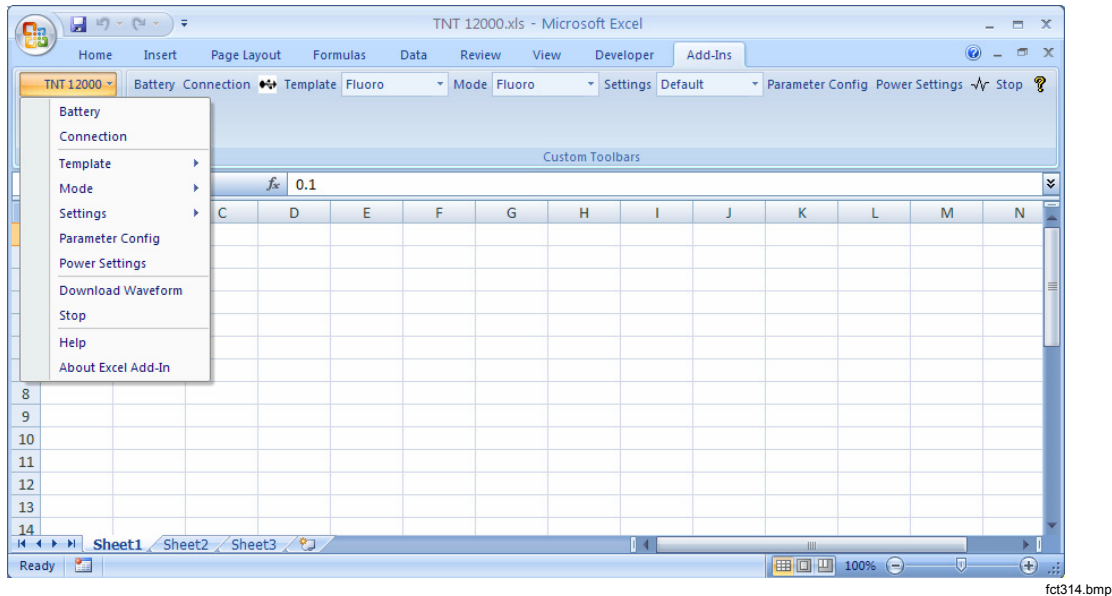



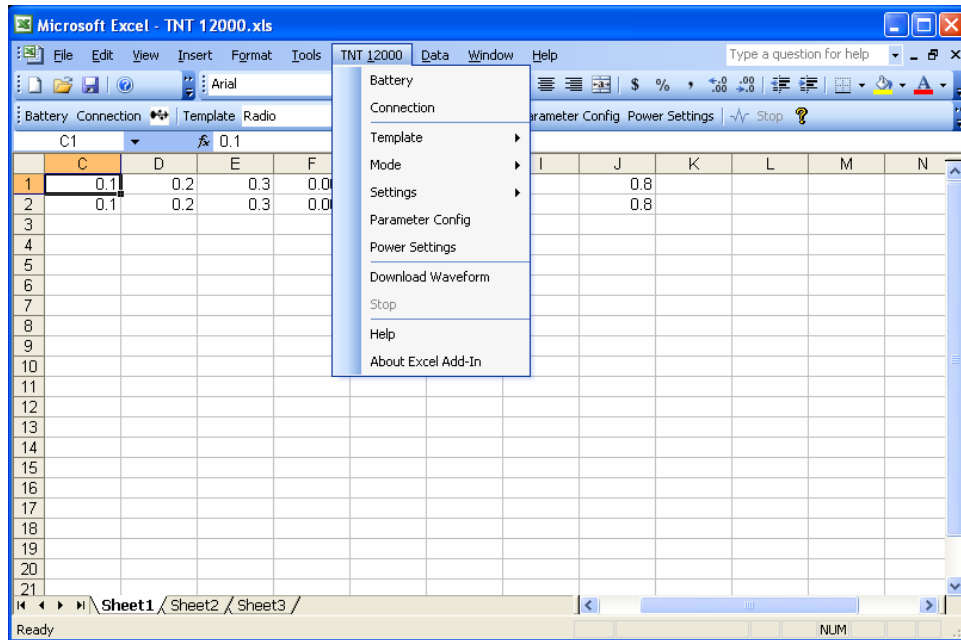
Figure 3-9. TNT 12000WD Excel Add-In Menu and Toolbar (Excel 2007)

Table 3-1. TNT 12000WD Excel Add-In Menu and Toolbar Options

Option	Description
Battery	Shows the battery status of the connected Detector
Connection	Looks for available Detectors.
Template	Used to set the Fluoro, Radio, or Mammo template.
Mode	Used to set the measurement mode to Fluoro, Radio, Mammo, or Dental.
Settings	Used to set the measurement mode profile to Auto, Manual, User defined, or Default.
Parameter Configuration	Sets the measured parameters to show and sets the order for each measurement mode in the Excel add-in.
Power Settings	Used to set the system low power mode time and system shutdown time.
 Download Waveform	Downloads the kV waveform. (This option is only enabled after an exposure is made and is disabled when the TNT 12000WD is making a measurement.
Stop	Keeps the measurement data of the exposure. (During Fluoroscopic measurement only)
Help	Shows the TNT 12000 Excel Add-In help file.
About Excel Add-In	Shows the TNT 12000 Excel Add-In version, serial number, firmware version, hardware version, and calibration date of the connected Detector. (Available only in TNT 12000 menu)

Note

In Microsoft Excel 2003, click TNT 12000 tab in the toolbar to show the TNT 12000 Menu.



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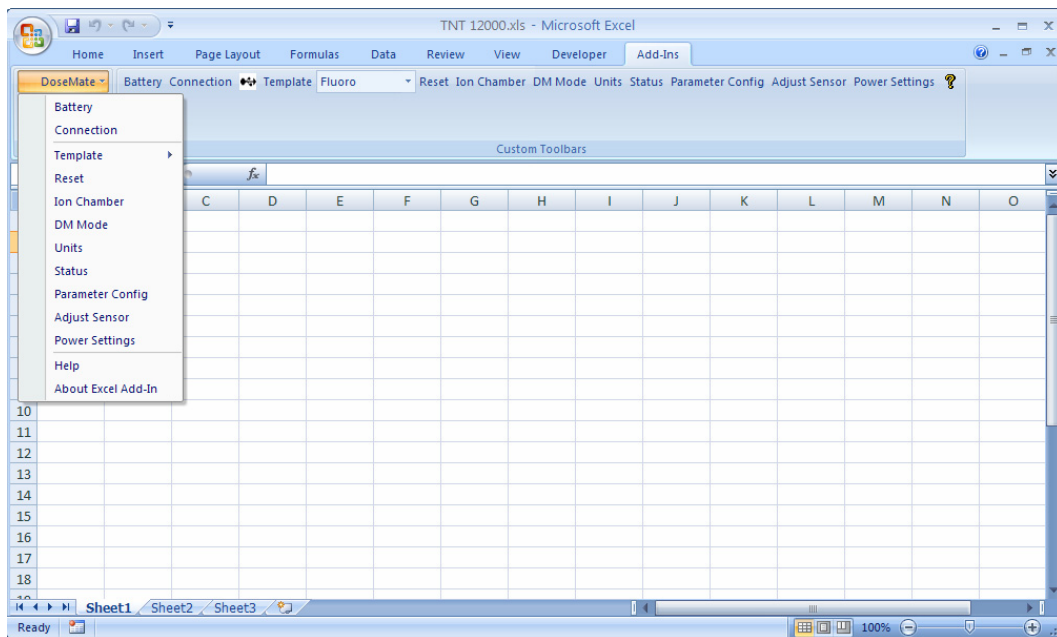
Figure 3-10. TNT 12000WD Excel Add-In Menu and Toolbar (Excel 2003)

DoseMate Toolbar Options

Figures 3-11 and 3-12 show the DoseMate drop-down menu and toolbar. See the toolbar option descriptions in Table 3-2.

Note

In Microsoft Excel 2007, click Add-Ins tab in the toolbar to show the DoseMate menu and toolbar.



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Figure 3-11. DoseMate Excel Add-In Menu and Toolbar (Excel 2007)

Table 3-2. DoseMate Excel Add-In Menu and Toolbar Options

Option	Description
Battery	Shows the battery status of the connected Detector
Connection	Looks for available Detectors.
Template	Used to set the Fluoro, Radio, or Mammo template.
Reset	Used to manually reset the Detector for a new exposure.
Ion Chamber	Opens the ION CHAMBER SETUP window. All the ion chambers available, along with cal factor names, are shown in the window. There are options to select, add, edit, and delete ion chambers and calibration factors.
DM Mode	Opens the Mode window. Here you can: Set Air Density Correction ON/OFF. Set Temperature/Pressure compensation to internal or external. Enter temperature and/or pressure values for external temperature/pressure mode. Select the dose mode. Auto reset.
Units	Opens the UNIT SETUP window where you can make a units of measurement selection for dose, dose rate, temperature, pressure, and enter frame rate value.
Status	Opens the STATUS dialog box where temperature, pressure, air density correction factor, bias voltage, and leakage current of the ion chamber are shown.
Parameter configuration	Sets the measured parameters to show and sets the order for each measurement mode in the Excel add-in.
Adjust sensor	The T&P screen opens if the ADCF option is on, and either temperature or pressure is set to internal compensation. Active only if an ion chamber is configured on the Detector and it is set in the Detector for the measurement.
Power settings	Used to set the system low power mode time and system shutdown time.
Help	Shows the TNT 12000 Excel Add-In help file.
About Excel Add-In	Shows the TNT 12000 Excel Add-In version, serial number, firmware version, hardware version, and calibration date of the connected Detector. (Available only in TNT 12000 menu)

Note

In Microsoft Excel 2003, click DoseMate tab in the toolbar to show the DoseMate Menu.

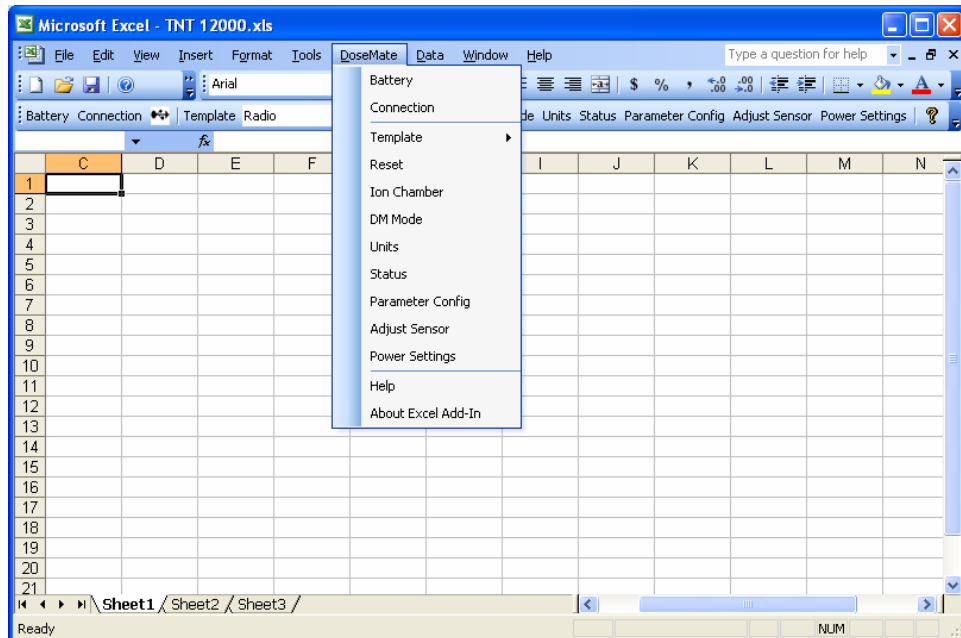


Figure 3-12. DoseMate Excel Add-In Menu and Toolbar (Excel 2003)

fct318.bmp

mAs Toolbar Options

Figures 3-13 and 3-14 show the mAs drop-down menu and toolbar. See the toolbar option descriptions in Table 3-3.

Note

In Microsoft Excel 2007, click Add-Ins tab in the toolbar to show the mAs menu and toolbar.

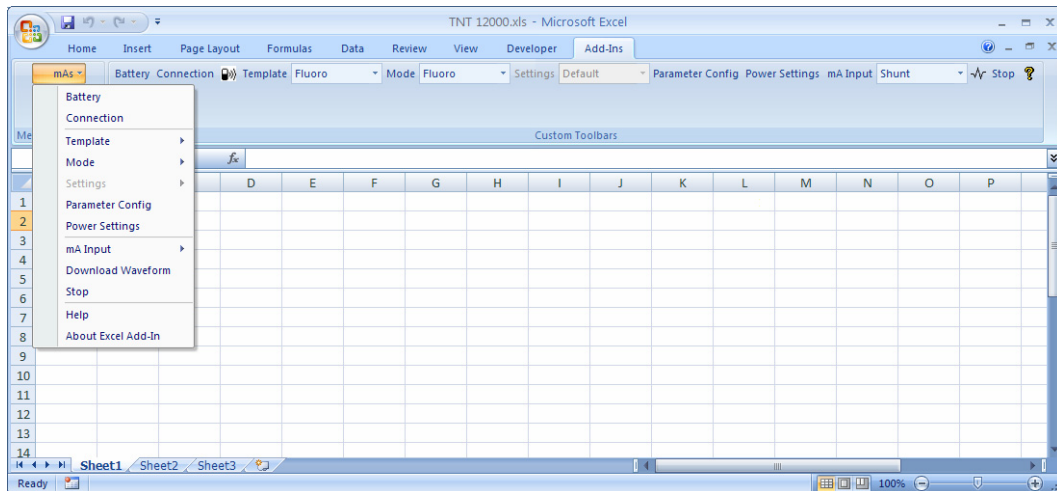



Figure 3-13. mAs Excel Add-In Menu and Toolbar (Excel 2007)

fct316.bmp

Table 3-3. mAs Excel Add-In Menu and Toolbar Options

Option	Description
Battery	Shows the battery status of the connected Detector
Connection	Looks for available Detectors.
Template	Used to set the Fluoro, Radio, or Mammo template.
Mode	Used to set the measurement mode to Fluoro, Radio, Mammo, or Dental.
Settings	Disabled in mAs.
Parameter Configuration	Sets the measured parameters to show and sets the order for each measurement mode in the Excel add-in.
Power Settings	Used to set the system low power mode time and system shutdown time.
mA Input	Used to set the mAs measurement input mode between shunt and clamp.
 Download Waveform	Only enabled after an exposure and is disabled while a mAs measurement is in progress. Downloads the kV waveform.
Stop	Keeps the measurement data of the exposure. (During Fluoroscopic measurement only)
Help	Shows the TNT 12000 Excel Add-In help file.
About Excel Add-In	Shows the TNT 12000 Excel Add-In version, serial number, firmware version, hardware version, and calibration date of the connected Detector. (Available only in TNT 12000 menu)

Note

In Microsoft Excel 2003, click mAs tab in the toolbar to show the mAs Menu.

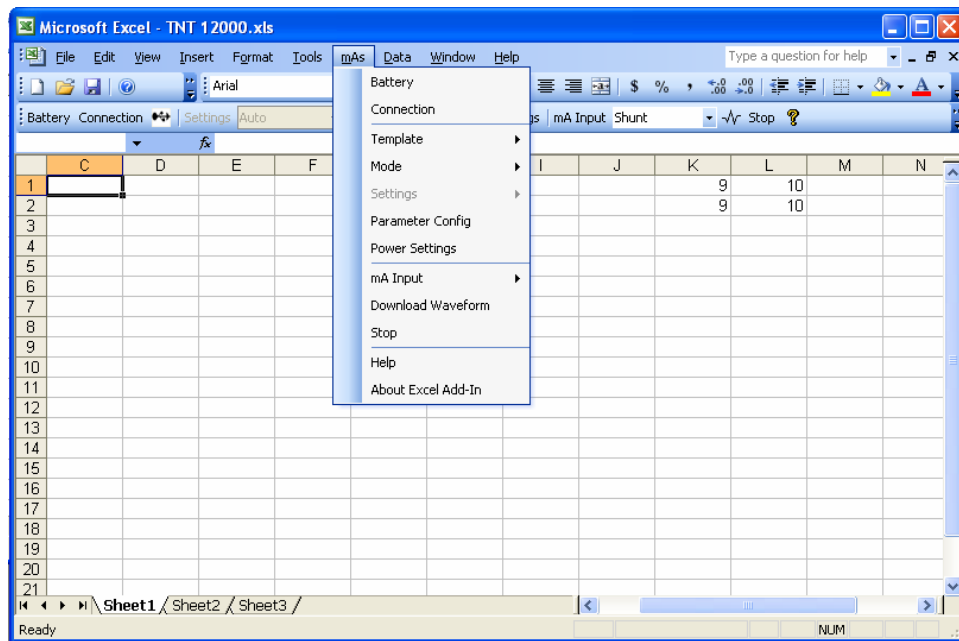


Figure 3-14. mAs Excel Add-In Menu and Toolbar (Excel 2003)

fct319.bmp

Chapter 4
Maintenance

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Shipping.....	4-4

Introduction

The TNT 12000 is a calibrated instrument. Fluke Biomedical recommends a calibration period of one year. To help make sure the TNT 12000 stay in calibration, prevent mechanical abuse during operation and storage.

Caution

To prevent damage to the TNT 12000, always operate the TNT 12000 in the specified operation temperature range and humidity in the specifications.

Ion Chamber Care

When the ion chamber is not connected to a cable, put the dust cap on the connector.

The dust cap helps keep contaminants out of the connector, decrease damage to the connector, and assures a long service life without electrical leakage.

Install the dust cap on the Dosimeter Detector input connector when it is not connected to an ion chamber.

Cleaning

Clean the TNT 12000 external surfaces with a damp cloth and weak detergent.

Caution

To prevent damage to the TNT 12000 or an unwanted effect on performance, do not apply liquids as a spray or put in liquids. The unit is not waterproof.

Firmware Upgrade


The Display and Detectors contain firmware that is upgradeable. New firmware is available through the Fluke Biomedical web site. After new firmware is downloaded from the web site to your PC, the Display or Detector is connected to the PC to receive the new firmware.

Note

The Excel Add-In and TNT 12000 Vendor Class Driver must be installed to do a firmware upgrade.

Go to www.FlukeBiomedical.com and download the upgrade file to your PC.

Detector

1. Double-click the downloaded executable file for the Detector.
2. When the **Device Validation** window shows, connect the Detector to the PC through the Mini-B to Type-A USB cable.
3. Push  on the Detector.
4. When the upgrade button on the **Device Validation** window is activated, click the **Upgrade** button.
5. While the firmware downloads to the Detector, a progress bar in a **Device Upgrade** window shows in the PC display. LEDs on the Detector blink while data moves to the Detector.

Note

Do not click on the close button in the upper-right hand corner of the Device Upgrade window during the download. This will abort the download.

6. When the **Device Upgrade** window in the PC display shows the upgrade is successful, click on the **Exit** button. The Detector starts automatically after the download.

Display

1. Double-click the downloaded executable file for the Display.
2. When the **Device Validation** window shows, connect the Display to the PC through the Mini-B to Type-A USB cable.
3. Push Ⓢ on the Display.
4. When the upgrade button on the **Device Validation** window is activated, click the **Upgrade** button.
5. While the firmware downloads to the Display, a progress bar in a **Device Upgrade** window shows in the PC display. LEDs on the Display blink while data moves to the Display.

Note

Do not click on the close button in the upper-right hand corner of the Device Upgrade window during the download. This will abort the download.

6. When the **Device Upgrade** window in the PC display shows the upgrade is successful, click on the **Exit** button. The Display starts automatically after the download.

Service and Calibration

If repair or calibration becomes necessary, send the TNT 12000 to the factory or nearest service center. Always contact the Fluke Biomedical Service Center for a Return Authorization Number before you pack the TNT 12000 for shipment.

Packing

When you return the TNT 12000 to the factory or service center, provide the following information.

- Serial numbers
- Specific steps that reproduce the problem
- Daytime phone number
- Your name / company
- FAX number, if available

Carefully put the TNT 12000 in the shipping container supplied by Fluke Biomedical. If the container the TNT 12000 came in is not available, refer to the Return Procedure at the front of this manual. You can get a replacement shipping container from Fluke Biomedical through their web site.

Note

Failure to pack the TNT 12000 properly could void the warranty.

Shipping

Before shipping the TNT 12000:

1. Place the Return Authorization Number in a prominent place on the outside of the box. Always refer to the number in any correspondence with Fluke Biomedical.
2. Enclose your return address and Return Authorization Number.
3. Insure the shipment for full retail value.
4. Ship to the nearest Fluke Biomedical Service Center.

Appendix A

Model 96020C Ion Chamber

Introduction

The Model 96020C parallel-plate ion chamber is optimized for low-level intensity measurements. The chamber has a flat energy response suitable for both attenuated and unattenuated diagnostic beam qualities. Complete physical, electrical, and energy response specifications are given in this appendix.

Physical Specifications

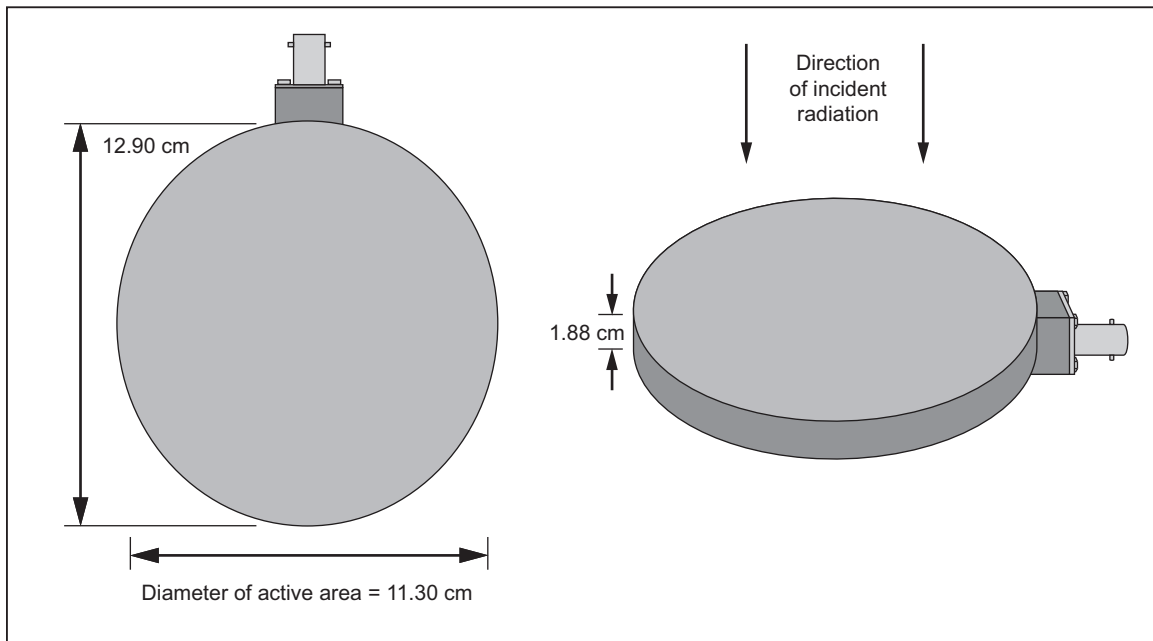


Figure A-1. Model 96020C Ion Chamber Dimensions

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Description	Vented, parallel-plate air ionization chamber
Overall Dimensions	12.90 \pm 0.03 cm diameter by 1.88 \pm 0.01 cm thick
Nominal Volume	150cc, 11.30 cm diameter by 1.50 cm thick active volume
Wall Material	Composite graphite-filled thermoplastic
Window Material	0.76 mm thick, graphite-coated polycarbonate (lexan). A 3.5 by 4 cm piece of 0.0025 cm thick aluminum is attached to the back of the window to improve the energy response.

Window Density	91 mg/ cm ²
Active Window Area	100 cm ² , centered within the chamber body
Connector	Side-mounted triaxial two-lug BNC connector
Collector Plate	Centrally mounted collector is a 0.8 mm thick graphite-coated acrylic plate, 10.80 cm in diameter. Thirty-five, 6.4 mm diameter holes are drilled through the plate. A 2.16 x 2.85 cm guard region is electrically isolated from the collector area.
Foam Supports	Two, 1.30 x 1.30 x 0.94 cm pieces of Styrofoam DB are used to support the collector plate and provide mechanical stability.

Electrical Specifications

Sheet Resistivity	All areas sprayed with graphite conductive coating measure less than 6 k/square but greater than 3 k_/square.
Leakage Current	With 300 volt bias in effect and 0.1 volt potential imposed between the guard and collector, at 20 °C and 50 % relative humidity, the leakage current is < 10 fA within 60 seconds of applying the voltage. The leakage under the above bias conditions is < 100 fA within 60 seconds of applying the voltage over both the full operating temperature range of 8 – 38 °C and for 20 – 80 % relative humidity, but only for conditions in which the absolute humidity is _ 20 g/m ³ (the equivalent R.H. is 75 % at 25 °C, 60 % at 30 °C, and 50 % at 35 °C).

Radiological Specifications

Energy Range	30 to 150 kVp
Nominal Sensitivity	H60: 2.08 x 10 ⁷ R/C (1.82 x 10 ⁵ Gy/C) at 22 °C and 1013 hPa DV70: 2.12 x 10 ⁷ R/C (1.86 x 10 ⁵ Gy/C) at 20 °C and 1013 hPa DH70: 2.07 x 10 ⁷ R/C (1.81 x 10 ⁵ Gy/C) at 20 °C and 1013 hPa Multiply values by 0.00876 to convert from R to Gy.
Sensitivity Range	Sensitivity range is ±5 % of nominal
Reference Point	The reference point of measurement for the chamber is 1.05 cm directly below the center of the top of the entrance window. This corresponds to the center of the active region.
Incident Beam Direction	A small sticker with the word "FOCUS" is secured to the top, entrance window of the chamber. The reference direction of incident radiation is perpendicular to this surface.
Angular Dependence	The ion chamber response to radiation incidence variations up to ± 5° of normal is within ± 1 % of the response to incident radiation striking perpendicular to the entrance window surface.
Ion Transit Time	Maximum of 1.0 ms in the center of the chamber at STP with a bias voltage of 300 volts.
Collection Efficiency	The collection efficiency for both continuous intensity and 120 Hz half wave rectified intensity is theoretically calculated using Boag's equations. An ionization potential of 300 V is used in both cases. An effective plate separation distance of 0.8 cm was determined experimentally and used to generate the curves in Figure A-2.

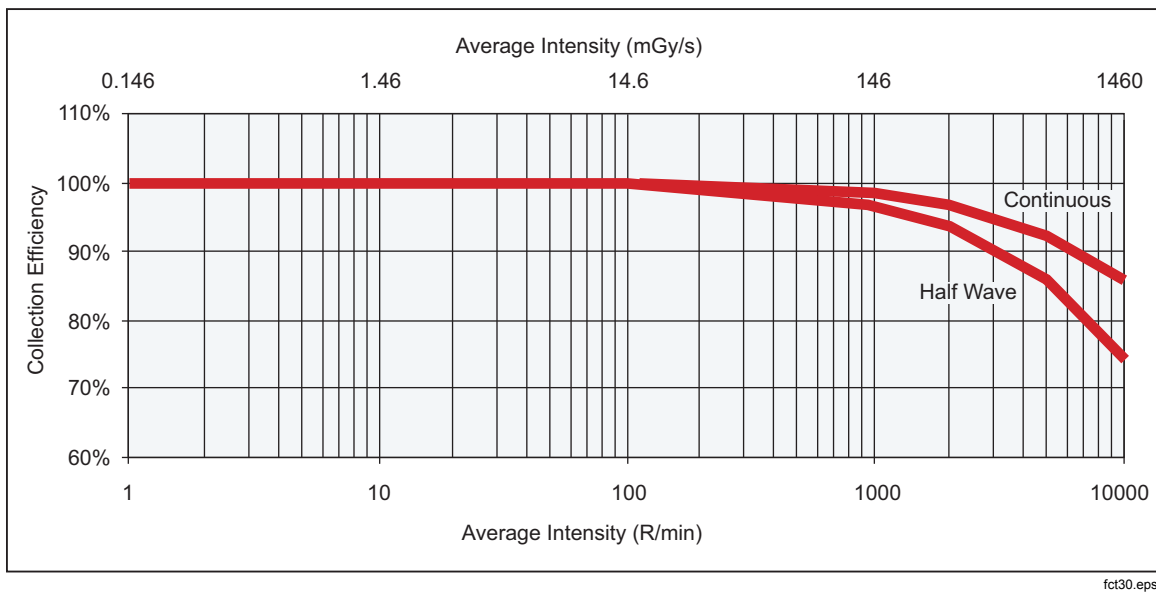


Figure A-2. Collection Efficiency of the Model 96020C Ion Chamber

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Air Density Correction To perform air density corrections when using a calibration factor with a reference temperature of 22 °C, multiply the ion current by the following correction factor, F:

$$F = (273.15 + T) / (295.15 \times P)$$

Where T is the actual temperature in °C and P is the pressure expressed as a fraction of a standard atmosphere (1013 hPa). For chambers with a calibration factor normalized to 20 °C, the denominator is 293.15 x P.

Calibration and Verification

Calibration or calibration verification is performed by comparison of each 96020C ion chamber with a reference chamber calibrated at either the National Institute of Standards and Technology (NIST) or PTB.

Specifications for all PTB equivalent beam qualities are given in Table A-1 and Table A-2 in the energy correction factor section.

Standard Calibration

The standard calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of H60 (NIST defined as 60 kVp, first HVL of 6.0 mm Al, homogeneity coefficient of 94). The calibration factor is normalized to 22 °C and 1013 hPa of atmospheric pressure.

European Calibration Option

This calibration option replaces the standard calibration for units sold in Europe, or when specifically requested by a customer. This calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DH70 (PTB defined as 70 kVp, first HVL of 6.77 mm Al). The calibration factor is normalized to 20 °C and 1013 hPa of atmospheric pressure.

PTB Calibration Option

This calibration option replaces the standard calibration when PTB requirements must be met, or when specifically requested by a customer. This option includes calibration at both of the beam qualities listed below. Calibration factors are normalized to 20 °C and 1013 hPa of atmospheric pressure.

Unattenuated beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DV70 (PTB defined as 70 kVp and first HVL of 2.45 mm Al).
Attenuated beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DH70 (PTB defined as 70 kVp and first HVL of 6.77 mm Al).

Other Calibration Options

Optional calibration points are the Fluke Biomedical, Radiation Management Services equivalent of L100, M50, S75, DV30, DV40, DV50, DV60, DV80, DV90, DV100, DV120, DV150, DH40, DH50, DH60, DH80, DH90, DH100, DH120, and DH150. Calibration factors at these points may be normalized to either 20 °C or 22 °C, as specified by the customer.

Calibration Accuracy

NIST traceable	NIST traceable reference chambers are accurate to within ± 1 % at each beam quality. Matching between the reference and unknown chamber is accurate to ± 1 %. Thus, NIST traceable calibrations are accurate to within ± 2 %.
PTB traceable	PTB traceable reference chambers are accurate to within ± 1.5 % at each beam quality. Matching between the reference and unknown chamber is accurate to ± 1 %. Thus, PTB traceable calibrations are accurate to within ± 2.5 %.

Calibration Verification

NIST traceable	For NIST traceable calibrations, a chamber will be reported to be outside of its calibration accuracy specification when a new calibration value differs from the old calibration value by more than ± 4 %. This includes the ± 2 % accuracy specification plus ± 1 % for the verification reference plus ± 1 % for the verification match.
PTB traceable	For PTB traceable calibrations, a chamber will be reported to be outside of its calibration accuracy specification when a new calibration value differs from the old calibration value by more than ± 5 %. This includes the ± 2.5 % accuracy specification plus ± 1.5 % for the verification reference plus ± 1 % for the verification match.

Energy Correction Factors

Attenuated Beam (Behind the Phantom)

The energy correction factors for the 96020C are determined for the attenuated diagnostic beam using the PTB defined DN series of beam qualities given in Table A-1.

Table A-1. Specifications for PTB Defined Attenuated Beam Qualities

PTB Denomination	kVp	Added Filtration in mm Al	First HVL in mm Al	First HVL in mm Cu
DN40	40	6.5	2.2	0.07
DN50	50	12.5	3.4	0.123
DN60	60	18.5	5.0	0.207
DN70	70	23.5	6.2	0.289
DN80	80	29.5	7.8	0.403
DN90	90	32.5	9.0	0.501
DN100	100	36.5	10.1	0.609
DN120	120	42.5	12.0	0.839
DN150	150	52.5	14.1	1.245

Typical energy correction factor curves are obtained by dividing the calibration factor at each beam quality by the calibration factor at a reference point and plotting the result versus first HVL. The first HVL at H60 is chosen as the reference point for chambers receiving the standard calibration while the first HVL at DH70 is chosen for chambers receiving the PTB calibration option. DH70 is a new calibration point defined by PTB with a first HVL of 6.77, which falls between DN70 and DN80 in the table above. The correction factor charts normalized to these two points are shown in Figure A-3 and Figure A-4.

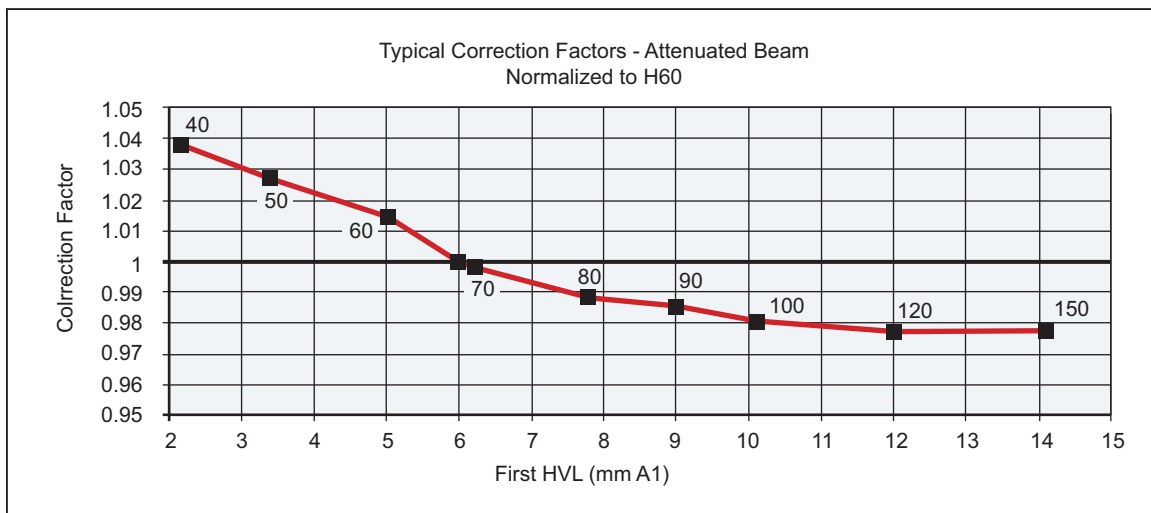


Figure A-3. Energy Correction Factors for Model 96020C in Attenuated Beam Normalized to H60

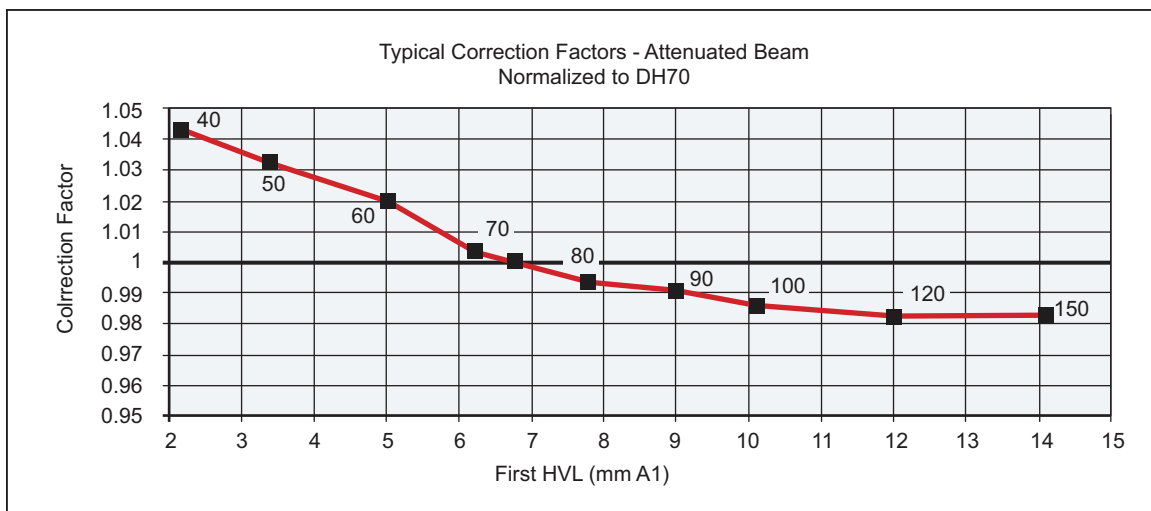


Figure A-4. Energy Correction Factors for Model 96020C in Attenuated Beam Normalized to DH70

All 96020C ion chambers must have an actual correction factor within $\pm 1.5\%$ of the value shown in the curves at any point.

The energy correction factors are multiplicative, such that multiplying the measured ion chamber output at any beam quality by the appropriate value from the curve will correct readings not made at the calibration factor beam quality.

The numerical value shown beside each point is the kVp value of that point in the DN series of beam qualities. Users making measurements in an attenuated beam with characteristics similar to the PTB DN series may use these values to easily obtain the appropriate correction factor. For a more precise correction factor value, or when making

measurements in an attenuated beam not similar to a DN series point, the user may calculate the actual first HVL and locate the proper correction value on the curve.

Unattenuated Beam (In Front of the Phantom)

The energy correction factors for the 96020C are determined for the unattenuated diagnostic beam using the PTB defined DV series of beam qualities given in Table A-2.

Table A-2. Specifications for PTB Defined Unattenuated Beam Qualities

PTB Denomination	kVp	Added Filtration in mm Al	First HVL in mm Al	First HVL in mm Cu
DN40	40	2.5	1.05	0.031
DN50	50	2.5	1.42	0.045
DN60	60	2.5	1.82	0.059
DN70	70	2.5	2.45	0.081
DN80	80	2.5	3.10	0.112
DN90	90	2.5	3.60	0.126
DN100	100	2.5	4.30	0.165
DN120	120	2.5	5.40	0.231
DN150	150	2.5	1.05	0.031

Typical energy correction factor curves are obtained by dividing the calibration factor at each beam quality by the calibration factor at a reference point and plotting the result versus first HVL.

The typical correction factor curves for the unattenuated beam are shown below normalized to L100 in Figure A-5 and DV70 in Figure A-6.

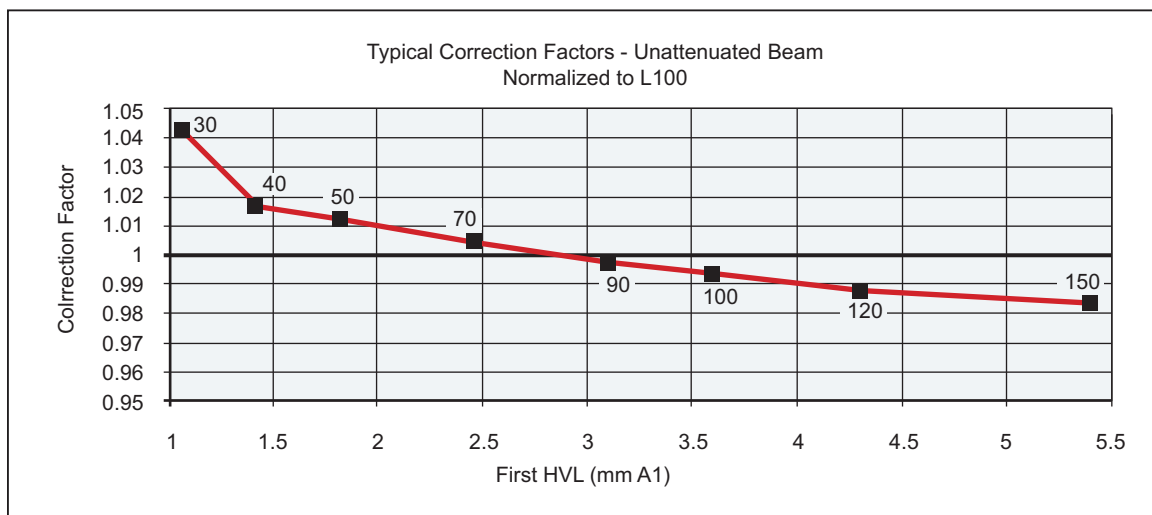


Figure A-5. Energy Correction Factors for Model 96020C in Unattenuated Beam Normalized to L100

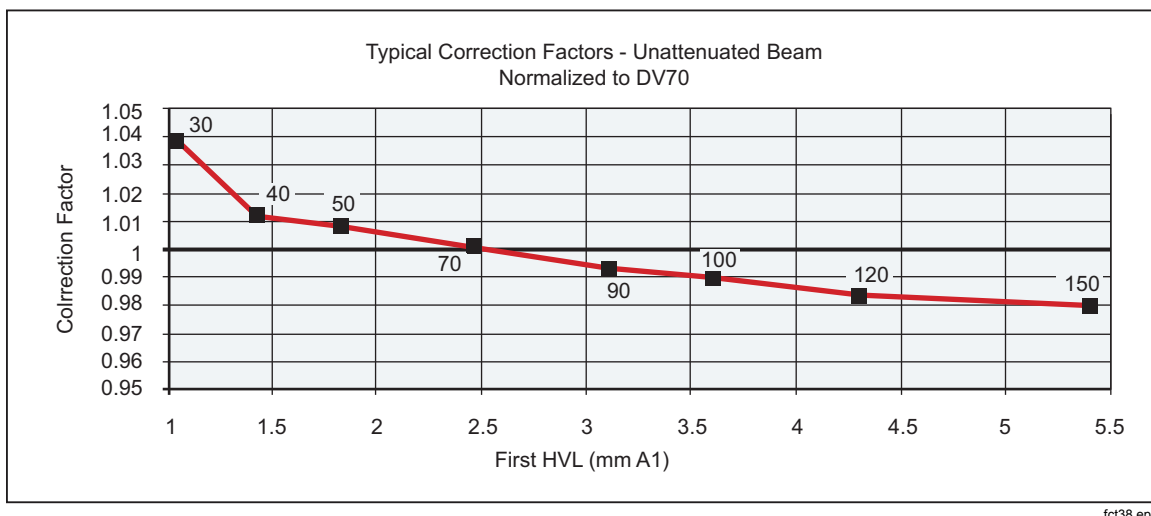


Figure A-6. Energy Correction Factors for Model 96020C in Unattenuated Beam Normalized to DV70

All 96020C ion chambers must have an actual correction factor within $\pm 1.5\%$ of the value shown in the curves at any point. Users receiving the standard calibration must request a calibration factor at either L100 or DV70 to use the correction factors in these curves.

The numerical value shown beside each point is the kVp value of that point in the DV series of beam qualities. Users making measurements in an unattenuated beam may use these values to easily obtain the appropriate correction factor. For a more precise correction factor value, the user may calculate the actual first HVL and locate the proper correction value on the curve.

Note

Introduction of material, other than free air, behind the Ion Chamber will cause its response to change due to backscatter.

Appendix B

Model 96035B Ion Chamber

Introduction

The Model 96035B dual entrance window parallel-plate ion chamber has a flat response suitable for both diagnostic radiography and mammography. One entrance window is provided for diagnostic measurements and one for mammographic measurements. The fully guarded, centrally located collector plate provides excellent collection efficiency. This appendix provides complete physical, electrical, and energy response specifications.

Physical Specifications

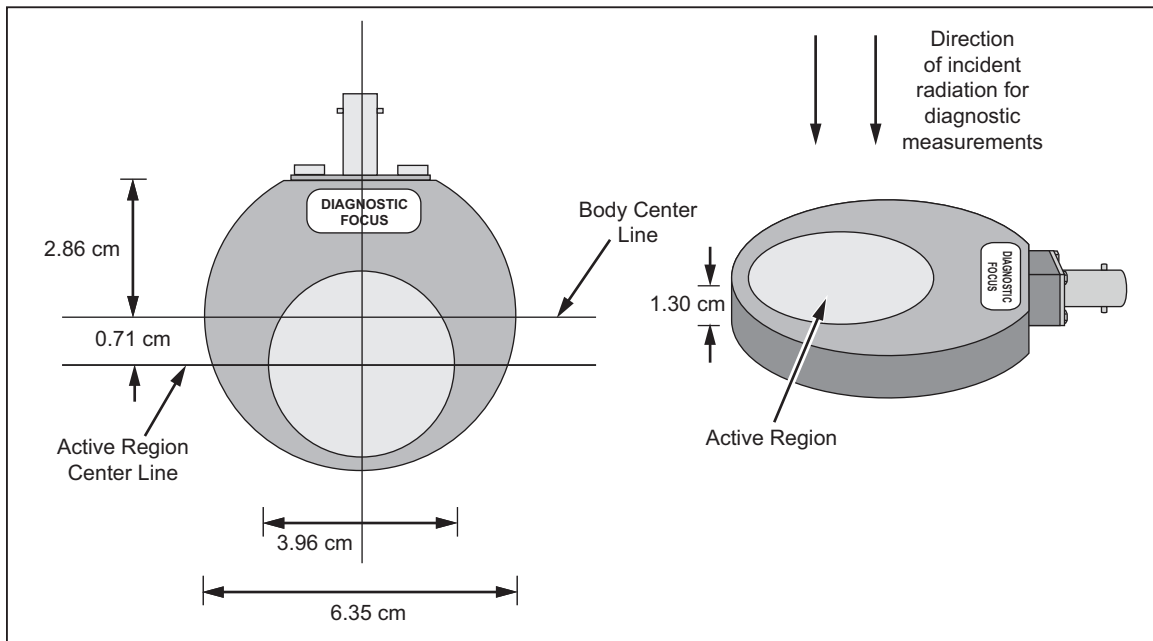


Figure B-1. Model 96035B Ion Chamber Dimensions

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Description	Vented volume, parallel-plate air ionization chamber
Overall Dimensions	6.35 ±0.04 cm diameter by 1.30 ±0.01 cm thick
Nominal Volume	15 cc, 3.96 cm diameter by 1.22 cm thick active volume
Wall Material	Graphite-coated acrylic

Window Material	0.25 mm thick, graphite-coated polycarbonate (lexan). A 1.5 by 1.6 cm piece of 0.0025 cm thick aluminum is attached to the back of the window with the diagnostic sticker to improve the energy response for diagnostic measurements.
Window Density	32 mg/cm ²
Active Window Area	12.32 cm ² , centered within the chamber body
Connector	Side-mounted triaxial two-lug BNC connector
Collector Plate	Centrally mounted collector is a 0.25 mm thick graphite-coated acrylic plate, 3.18 cm in diameter. A 1.27 x 0.89 cm guard region is electrically isolated from the collector area.

Electrical Specifications

Sheet Resistivity	All areas sprayed with graphite conductive coating measure less than 6 k/square but greater than 3 k/square.
Leakage Current	With 300 volt bias in effect and 0.1 volt potential imposed between the guard and collector, at 20 °C and 50% relative humidity, the leakage current is < 10 fA within 60 seconds of applying the voltage. The leakage under the above bias conditions is < 100 fA within 60 seconds of applying the voltage over both the full operating temperature range of 8 – 38 °C and for 20 – 80 % relative humidity, but only for conditions in which the absolute humidity is $\geq 20 \text{ g/m}^3$ (the equivalent R.H. is 75 % at 25 °C, 60 % at 30 °C, and 50 % at 35 °C).

Radiological Specifications

Energy Range	30 to 150 kVp for diagnostic measurements; 20 to 50 kVp for mammographic measurements.
Nominal Sensitivity	
L100	2.00 x 10 ⁸ R/C (1.75 x 10 ⁶ Gy/C) at 22 °C and 1013 hPa
MV30	2.21 x 10 ⁸ R/C (1.94 x 10 ⁶ Gy/C) at 22 °C and 1013 hPa
DV70	2.01 x 10 ⁸ R/C (1.76 x 10 ⁶ Gy/C) at 20 °C and 1013 hPa
DH70	1.89 x 10 ⁸ R/C (1.66 x 10 ⁶ Gy/C) at 20 °C and 1013 hPa
MH30	2.16 x 10 ⁸ R/C (1.89 x 10 ⁶ Gy/C) at 20 °C and 1013 hPa
	L100, DV70, and DN70 nominal sensitivities apply to the diagnostic side of the chamber, while MV30 and MH30 apply to the mammographic side. Multiply values by 0.00876 to convert from R to Gy.
Sensitivity Range	Sensitivity range is ± 8 % of nominal
Reference Point	The reference point is located 6.5 cm directly below the center of the either active window region. This corresponds to the center of the active volume.
Incident Beam Direction	For diagnostic measurements, the reference direction of incident radiation is perpendicular to the entrance window with the "DIAGNOSTIC FOCUS" sticker attached, and with this window facing the x-ray source. For mammographic measurements, the reference direction of incident radiation is perpendicular to the entrance window with the "MAMMOGRAPHY FOCUS" sticker attached, and with this window facing the x-ray source.
Angular Dependence	The ion chamber response to radiation incidence variations up to $\pm 8^\circ$ of normal is within ± 1 % of the response to incident radiation striking perpendicular to the entrance window surface.
Collection Efficiency	The collection efficiency for both continuous intensity and 120 Hz half wave rectified intensity is theoretically calculated using Boag's equations. An ionization potential of 300 V is used in both cases. An effective plate separation distance of 0.73 cm was determined experimentally and used to generate the curves shown in Figure B-2.

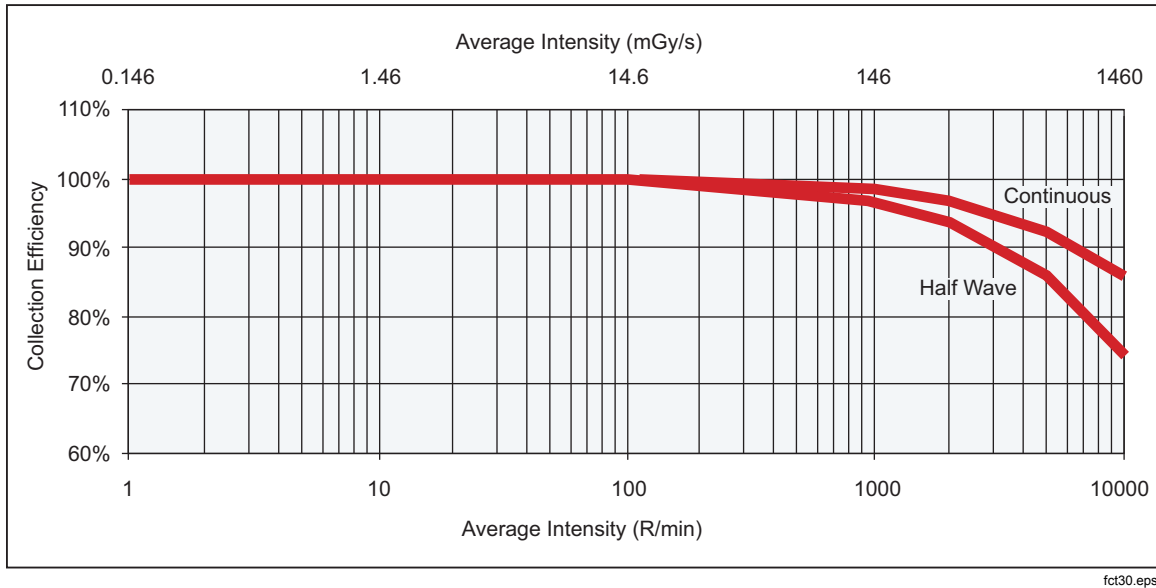


Figure B-2. Collection Efficiency of Model 96035C Ion Chamber

Ion Transit Time Maximum of 0.67 ms in the center of the chamber at STP with a bias voltage of 300 volts.

Air Density Correction To perform air density corrections when using a calibration factor with a reference temperature of 22 °C, multiply the ion current by the following correction factor, F:

$$F = (273.15 + T) / (295.15 \times P)$$

Where T is the temperature in ° C and P is the pressure expressed as a fraction of a standard atmosphere (1013 hPa). For chambers with a calibration factor normalized to 20 °C, the denominator is 293.15 x P.

Calibration and Verification

Calibration or calibration verification is performed by comparison of each 96035B ion chamber with a reference chamber calibrated at either the National Institute of Standards and Technology (NIST) or PTB.

Specifications for all PTB equivalent beam qualities are given in the tables in the energy correction factor section.

Standard Calibration

The standard calibration is performed at one diagnostic and one mammographic beam quality as given below. Calibration factors are normalized to 22 °C and 1013 hPa of atmospheric pressure.

Diagnostic Unattenuated beam: Calibration is performed at the Fluke Biomedical, Radiation

Management Services equivalent of L100 (NIST defined as 100 kVp, first HVL of 2.8 mm Al, homogeneity coefficient of 59).

Mammographic beam: Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of MoMo28 (NIST defined as 28 kVp, first HVL of 0.332 mm Al, homogeneity coefficient of 74.3).

European Calibration Option

This calibration option replaces the standard calibration for units sold in Europe, or when specifically requested by a customer. This option includes one diagnostic and one mammographic beam quality, as given below. Calibration factors are normalized to 20 °C and 1013 hPa of atmospheric pressure.

Diagnostic Unattenuated beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DV70 (PTB defined as 70 kVp, first HVL of 2.45 mm Al).
Mammographic beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of MV30 (PTB defined as 30 kVp, first HVL of 0.337 mm Al).

PTB Calibration Option

This calibration option replaces the standard calibration when PTB requirements must be met, or when specifically requested by a customer. This option includes two diagnostic points and one mammographic point as given below. Calibration factors are normalized to 20 °C and 1013 hPa of atmospheric pressure.

Diagnostic Unattenuated beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DV70 (PTB defined as 70 kVp, first HVL of 2.45 mm Al).
Diagnostic Attenuated beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of DH70 (PTB defined as 70 kVp, first HVL of 6.77 mm Al).
Mammographic Beam	Calibration is performed at the Fluke Biomedical, Radiation Management Services equivalent of MH30 (PTB defined as 30 kVp, first HVL of 0.67 mm Al).

Other Calibration Options

Optional calibration points are the Fluke Biomedical, Radiation Management Services equivalent of M50, S75, H60, MoMo35, DV30, DV40, DV50, DV60, DV80, DV90, DV100, DV120, DV150, DH40, DH50, DH60, DH80, DH90, DH100, DH120, and DH150. Calibration factors at these points may be normalized to either 20 °C or 22 °C, as specified by the customer.

Calibration Accuracy

NIST Traceable	NIST traceable reference chambers are accurate to within ± 1 % at each beam quality. Matching between the reference and unknown chamber is accurate to ± 1 %. Thus, NIST traceable calibrations are accurate to within ± 2 %.
PTB traceable	PTB traceable reference chambers are accurate to within ± 1.5 % at each beam quality. Matching between the reference and unknown chamber is accurate to ± 1 %. Thus, PTB traceable calibrations are accurate to within ± 2.5 %.

Calibration Verification

NIST traceable	For NIST traceable calibrations, a chamber will be reported to be outside of its calibration accuracy specification when a new calibration value differs from the old calibration value by more than ± 4 %. This includes the ± 2 % accuracy specification plus ± 1 % for the verification reference plus ± 1 % for the verification match.
PTB traceable	For PTB traceable calibrations, a chamber will be reported to be outside of its calibration accuracy specification when a new calibration value differs from the old calibration value by more than ± 5 %. This includes the ± 2.5 % accuracy specification plus ± 1.5 % for the verification reference plus ± 1 % for the verification match.

Energy Correction Factors

Diagnostic – Unattenuated Beam (In Front of the Phantom)

The energy correction factors for the 96035B are determined for the unattenuated diagnostic beam using the PTB defined DV series of beam qualities given below in Table B-1.

Table B-1. Specifications for PTB Defined Unattenuated Beam Qualities

PTB Denomination	kVp	Added Filtration in mm Al	First HVL in mm Al	First HVL in mm Cu
DN30	30	2.5	1.05	0.031
DN40	40	2.5	1.42	0.045
DN50	50	2.5	1.82	0.059
DN70	70	2.5	2.45	0.081
DN90	90	2.5	3.10	0.112
DN100	100	2.5	3.60	0.126
DN120	120	2.5	4.30	0.165
DN150	150	2.5	5.40	0.231
DN30	30	2.5	1.05	0.031

Typical energy correction factor curves are obtained by dividing the calibration factor at each beam quality by the calibration factor at a reference point and plotting the result versus first HVL. L100 is chosen as the reference point for chambers receiving the standard calibration while DV70 is chosen for chambers receiving the PTB calibration option.

The energy correction factors are multiplicative, such that multiplying the measured ion chamber output at any beam quality by the appropriate value from the curve will correct readings not made at the calibration factor beam quality.

The typical correction factor curves for the unattenuated beam are shown below normalized to L100 in Figure B-3 and DV70 in Figure B-4.

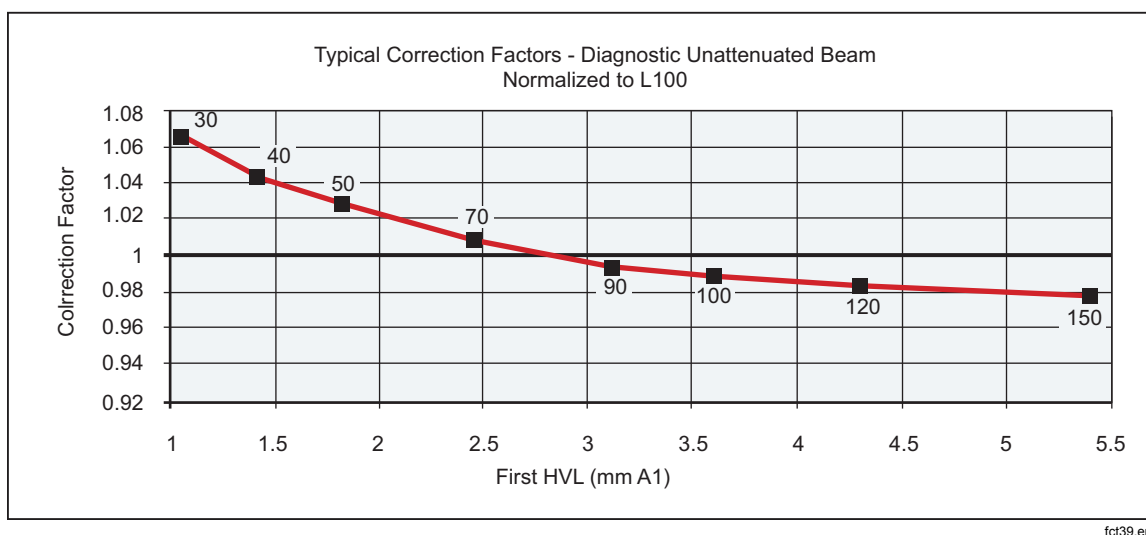


Figure B-3. Energy Correction Factors for Model 96035C in Unattenuated Beam Normalized to L100

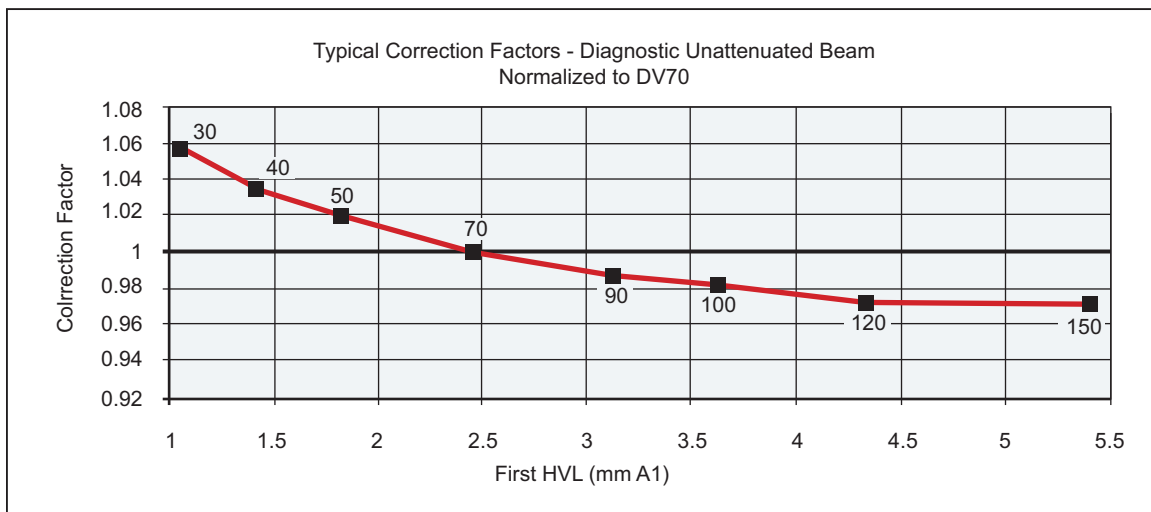


Figure B-4. Energy Correction Factors for Model 96035C in Unattenuated Beam Normalized to DV70

All 96035B ion chambers must have an actual correction factor within $\pm 1.5\%$ of the value shown in the curves at any point.

The numerical value shown beside each point is the kVp value of that point in the DV series of beam qualities. Users making measurements in an unattenuated beam may use these values to easily obtain the appropriate correction factor. For a more precise correction factor value, the user may calculate the actual first HVL and locate the proper correction value on the curve.

Diagnostic – Attenuated Beam (Behind the Phantom)

The energy correction factors for the 96035B in the attenuated diagnostic beam are determined using the PTB defined DN series of beam qualities given below in Table B-2.

Table B-2. Specifications for PTB Defined Attenuated Beam Qualities

PTB Denomination	kVp	Added Filtration in mm Al	First HVL in mm Al	First HVL in mm Cu
DN40	40	6.5	2.2	0.07
DN50	50	12.5	3.4	0.123
DN60	60	18.5	5.0	0.207
DN70	70	23.5	6.2	0.289
DN80	80	29.5	7.8	0.403
DN90	90	32.5	9.0	0.501
DN100	100	36.5	10.1	0.609
DN120	120	42.5	12.0	0.839
DN150	150	52.5	14.1	1.245

Typical correction factor curves are obtained by dividing the calibration factor at each beam quality by the calibration factor at a reference point and plotting the result versus first HVL.

The typical correction factor curve for the attenuated beam is normalized to DH70 in

Figure C-5. DH70 is a new PTB beam quality with an HVL of 6.77, which falls between DN70 and DN80. Since the response of the chamber at H60 is virtually identical to the response at DN70, this curve is also considered normalized to H60.

Users receiving the standard calibration must request a calibration factor at either H60 or DH70 to use the correction factors in this curve.

All 96035B ion chambers must have an actual correction factor within $\pm 1.5\%$ of the value shown in the curve at any point. The numerical value shown beside each point is the kVp value of that point in the DN series of beam qualities. Users making measurements in an attenuated beam with characteristics similar to the PTB DN series may use these values to easily obtain the appropriate correction factor. For a more precise correction factor value, or when making measurements in an attenuated beam not similar to a DN series point, the user may measure the actual first HVL and locate the proper correction value on the curve. See Figure B-5.

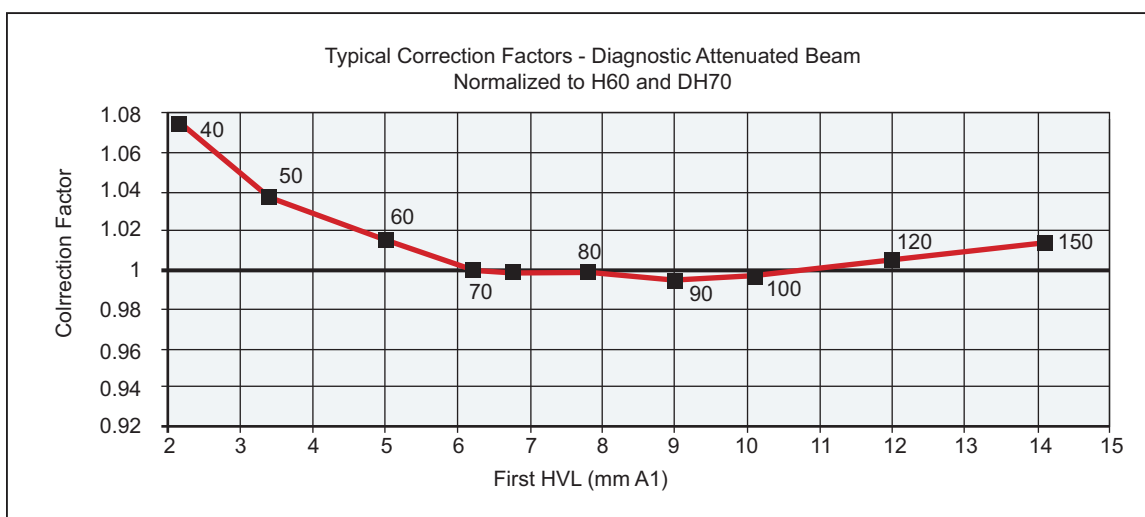


Figure B-5. Energy Correction Factors for Model 96020C in Attenuated Beam

Mammographic Beam Qualities

The energy correction factors for the 96035B are determined for the mammographic beam using the PTB defined MV and MH series of beam qualities given in Table B-3 and Table B-4, respectively.

Table B-3. Specifications fo PTB Defined Unattenuated Mammographic Beam Qualities

PTB Denomination	kVp	Added Filtration	First HVL in mm Al
MV20	20	30 μm Mo	0.223
MV25	25	30 μm Mo	0.282
MV30	30	30 μm Mo	0.337
MV35	35	30 μm Mo	0.374
MV40	40	30 μm Mo	0.402
MV50	50	30 μm Mo	0.440

Table B-4. Specifications for PTB Defined Attenuated Mammographic Beam Qualities

PTB Denomination	kVp	Added Filtration	First HVL in mm Al
MH20	20	30 μ m Mo + 2.0 mm Al	0.45
MH24	25	30 μ m Mo + 2.0 mm Al	0.58
MH30	30	30 μ m Mo + 2.0 mm Al	0.67
MH35	35	30 μ m Mo + 2.0 mm Al	0.75
MH40	40	30 μ m Mo + 2.0 mm Al	0.83
MH50	50	30 μ m Mo + 2.0 mm Al	0.97

Typical energy correction factor curves are obtained by dividing the calibration factor at each beam quality by the calibration factor at a reference point and plotting the result versus first HVL. MV30 is chosen as the reference point for chambers receiving the standard calibration while MH30 is chosen for chambers receiving the PTB calibration option. Since the response of the chamber at MoMo28 is equivalent to the response at MV30, the first curve is also considered normalized to MoMo28.

The typical correction factor curves for mammography are shown below normalized to MV30 and MoMo28 in Figure B-6 and MH30 in Figure B-7.

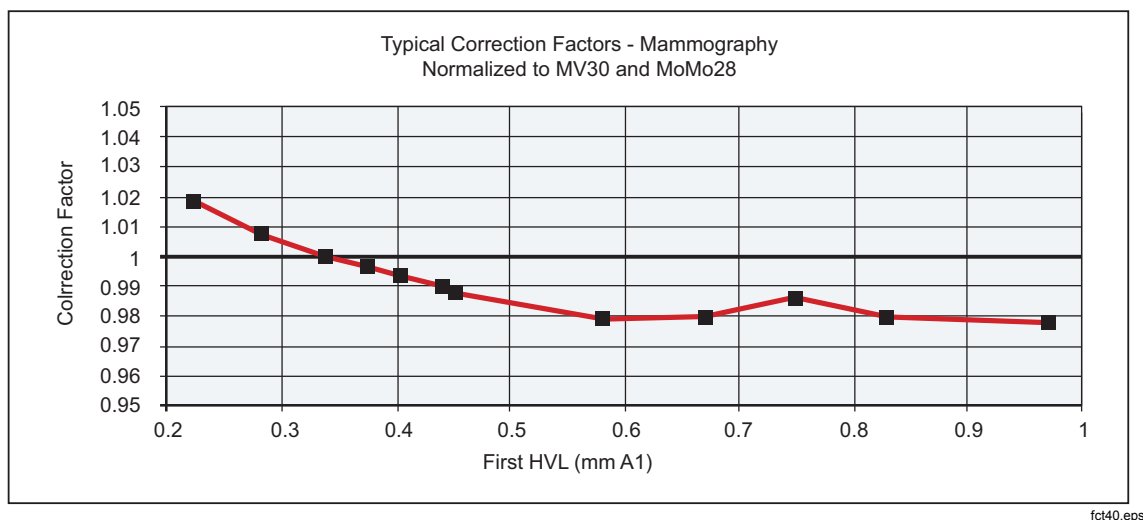


Figure B-6. 96035B Energy Correction Factor for Mammography Normalized to MV30 and MoMo28

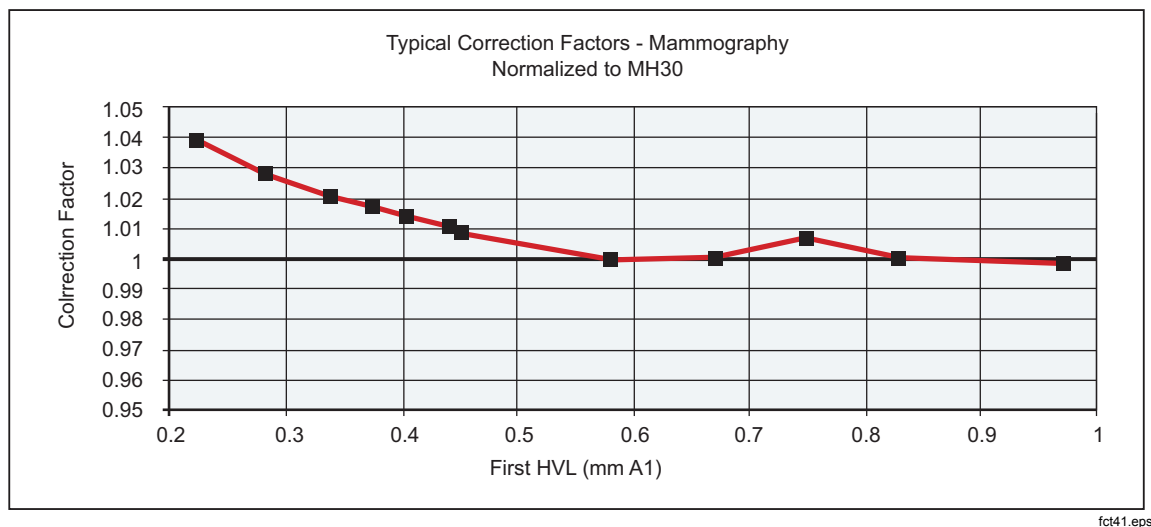


Figure B-7. Energy Correction Factors for Model 96035B for Mammography Normalized to MH30

All 96035B ion chambers must have an actual correction factor within $\pm 1.5\%$ of the value shown in the curves at any point.

The actual points plotted in the graphs below correspond to the points in the MV and MH series of beam qualities. Users making measurements at a beam quality similar to one of the PTB mammographic beams may easily obtain the appropriate correction factor by assuming the HVL of the most equivalent PTB beam. For a more precise correction factor value, the user may calculate the actual first HVL and locate the proper correction value on the curve.

Note

Introduction of material, other than free air, behind the Ion Chamber will cause its response to change due to backscatter.

Appendix C

Model 500-100 CT Probe

Introduction

The 3.2 cc CT Probes consist of a pencil-type ionization chamber with a sensitive length of 10 cm. The intended use of these CT probes, with appropriate phantoms, is to measure exposure produced by computed tomography (CT) scanners.

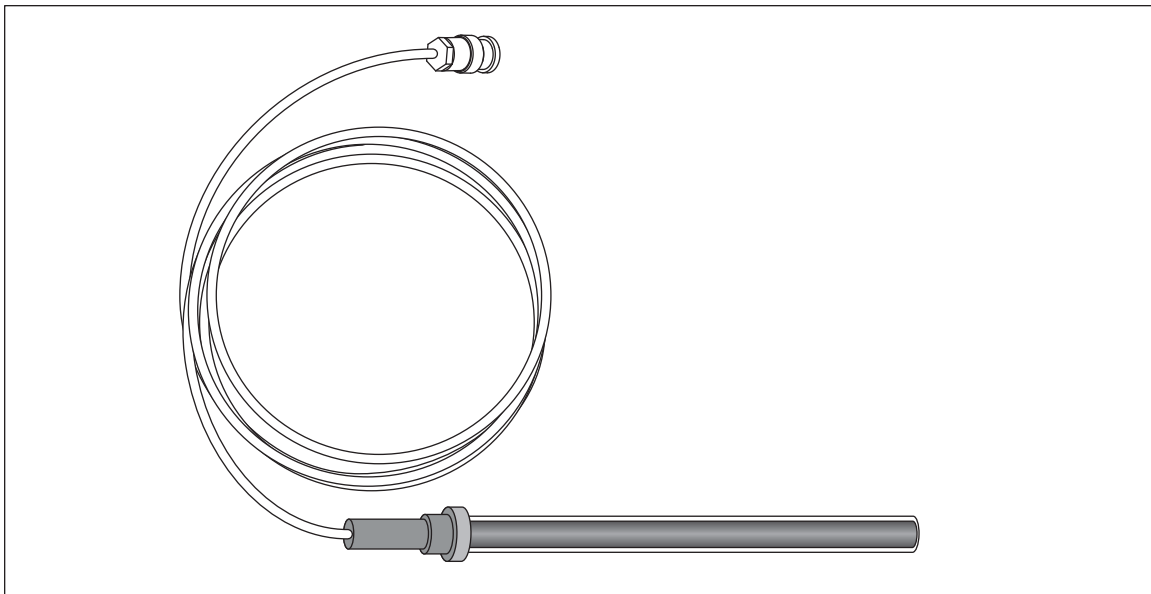


Figure C-1. Model 500-100 3.2 cc CT Ion Chamber

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The 500-100 probe chamber has a 0.9 meter flexible, low noise cable which is terminated in a male triax BNC connector. Calibration is stated in terms of R/Coulomb.

Applications

It has been shown¹ that in a phantom, integration of the radiation exposure profile produced by a single scan from a CT scanner along a line normal to the slice, divided by the table increment, is equal to the exposure to a central slice at that point produced by a series of scans. The line of integration must be of sufficient length to intercept not only the primary beam, but also the Compton scatter produced in the phantom. This integral is then expressed as $R \cdot \text{cm}$.

¹ R.A. Jucius, G.X. Kambic, "Radiation Dosimetry in Computed Tomography (CT)"

A long, thin radiation probe can be used to make this measurement. The probe may be calibrated in a uniform field covering its entire length, generating a correction factor in the conventional manner. Subsequent probe readings, when multiplied by the conventional correction factor, and then by the probe's sensitive length, will be in units of $R \cdot \text{cm}$.

Since the 3.2 cc probes are intended mainly to be used to integrate radiation exposure profiles produced by the CT scanners, this length (10 cm) factor has, for the user's convenience, been built into the calibration.

The correction factor is stated in terms of $R \cdot \text{cm}/\text{Coulomb}$. In the now special case of using this probe to measure uniform field exposures in terms of R , merely divide the 50-100 correction factor by 10.

Specifications

Detector Type	Vented air ion chamber
Volume	3.2 cc
Sensitive Length	10.0 cm
Rated Length	8.9 cm (IEC 61674)
Effective Length	10.1 cm (IEC 61674)
Chamber Material	Polystyrene
Chamber Inside Diameter	6.4 mm
Chamber Wall Thickness	54 mg/cm^2
Electrode Material	Aluminum
Nominal Sensitivity	8.76 mGy/nC (1 R/nC)
Standard Calibration	100 KVCP, 5.5 mm Al HVL (NIST Tech. M100), 100 KVCP, 3.5 mm Al HVL (DV Beam Quality)
Response Uniformity Along Axis	$\pm 3\%$ over central 90 % of rated length
Angular Response	$< 3\%$ for $\pm 180^\circ$ in the plane perpendicular to the ion chamber axis
Beam Orientation	Normal to chamber axis
Phantom Adaptor OD	1.27 ± 0.04 cm (.50 ± 0.015 in)
Leakage Current (300 V collection potential)	Less than 10-13 A at 10 min. polarization time, less than 10-14 A at 2 hr polarization time
Intensity Limits, Continuous beam	42.6 Gy/min (4.86 kR/min) (1 % recombination loss)
Pulsed Beam	0.45 mGy/pulse (51.5 mR/pulse) (1 % recombination loss)
Maximum Pulse Repetition Rate	3.3 kHz
Cable Length	0.9 m (3 ft)
Operating Voltage	- 300 V
Termination	Triax BNC
Air Density Correction	To perform air density corrections when using a calibration factor with a reference temperature of 22 $^\circ\text{C}$, multiply the ion current by the following correction factor, F : $F = (273.15 + T) / (293.15 \times P)$. Where T is the temperature in $^\circ\text{C}$ and P is the pressure expressed as a fraction of a standard atmosphere (1013 hPa). For chambers with a calibration factor normalized to 20 $^\circ\text{C}$, the denominator is 293.15 x P.

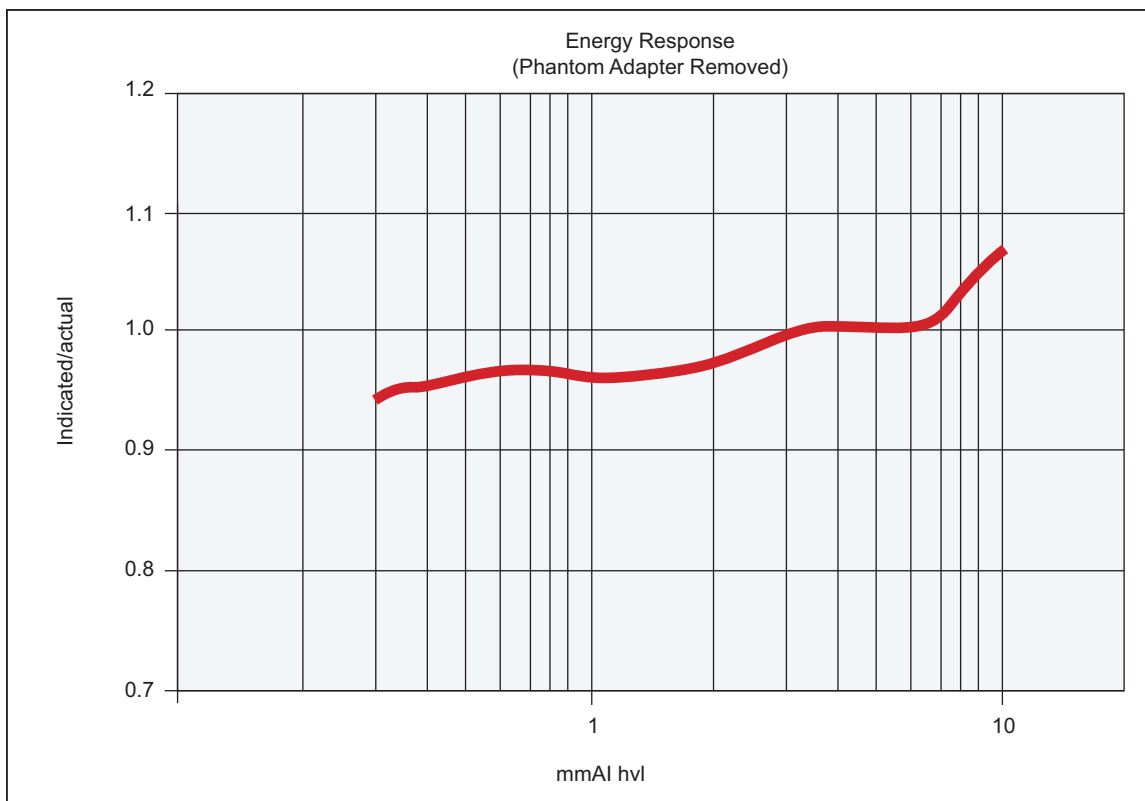


Figure C-2. Typical Energy Dependence of Model 500-100 CT Ion Chamber, normalized to M100

Figure C-3 shows the typical energy response of the Model 500-100 CT ion chamber per IEC 61267 beam qualities. The three plots show RQR normalized for RQR 9, RQA normalized for RQA 9, and RQT normalized for RQT 9.

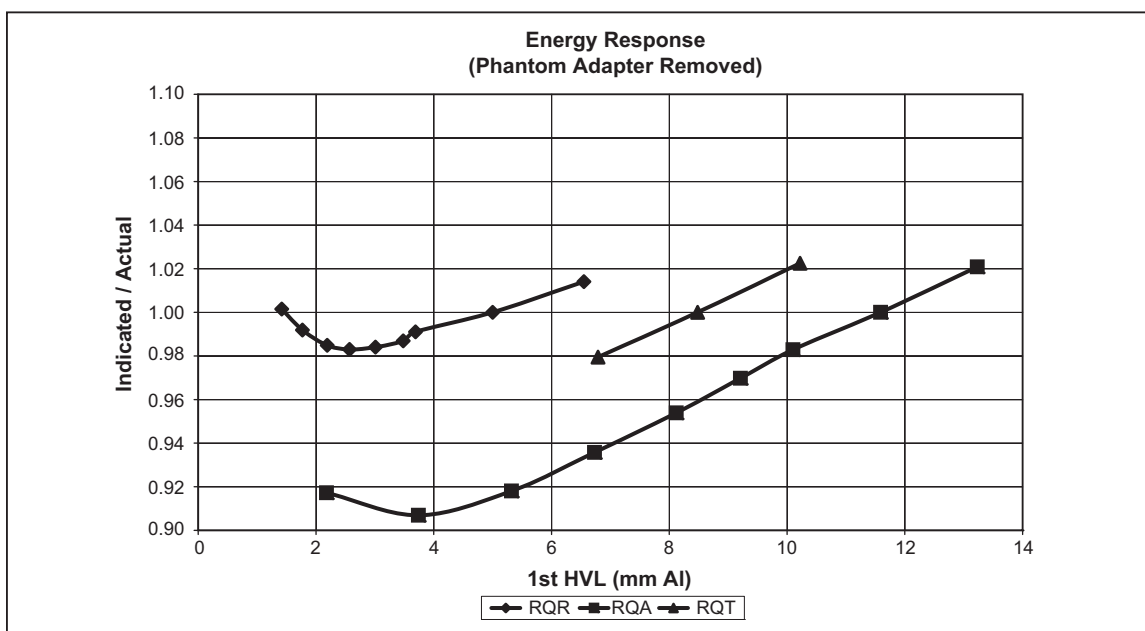


Figure C-3. Typical Energy Response for IEC 61267 Beam Quality

Table C-1. Specifications for IEC 61267 Defined Beam Qualities

kVp						
	Beam Quality	First HVL (mm Al)	Beam Quality	First HVL (mm Al)	Beam Quality	First HVL (mm Al)
40	RQR 2	1.42	RQA 2	2.2		
50	RQR 3	1.78	RQA 3	3.8		
60	RQR 4	2.19	RQA 4	5.4		
70	RQR 5	2.58	RQA 5	6.8		
80	RQR 6	3.01	RQA 6	8.2		
90	RQR 7	3.48	RQA 7	9.2		
100	RQR 8	3.97	RQA 8	10.1	RQT 8	6.9
120	RQR 9	5.00	RQA 9	11.6	RQT 9	8.4
150	RQR 10	6.57	RQA 10	13.3	RQT 10	10.1

500 – 100 Measurement ranges

Values for ion chambers are calculated using nominal sensitivities: 1×10^9 R/C.

Table C-2. 500-100 Measurement Ranges

Units	Effective Range ^[1]	Threshold	Resolution Step Size
R	10 μ - 9999	250 μ	0.1 μ
R/s	10 μ - 100	250 μ	0.1 μ
R/min	1 m – 6 k	15 m	0.01 m
R/hr	0.1 – 360 k	0.9	0.001
R/pulse ^[2]	1 m – 1.67	4.17 μ	0.01 μ
Gy	0.1 μ - 876 m	2.19 μ	0.001 μ
Gy/s	0.1 μ - 876 m	2.19 μ	0.001 μ
Gy/min	0.01 m - 52.5	131 μ	0.1 μ
Gy/hr	1 – 3.15 k	7.88 m	0.01m
Gy/pulse ^[2]	0.01 μ - 14.6 m	36.5 n	0.1n
[1] IEC 61674 effective range at 1 % resolution steps.			
[2] At 60 frames/second (1 to 120 frames/selectable).			

Note

Introduction of material, other than free air, behind the Ion Chamber will cause its response to change due to backscatter.

Appendix D

Model 500-200 CT Probe

Introduction

Fluke Biomedical's High Sensitivity 10 cc CT Chamber consists of a pencil-type ionization chamber with sensitive length of 10 cm for computed tomography (CT) Quality Assurance. This high sensitivity 10cc CT chamber has three times the sensitivity of a standard 3.2 cc CT chamber and is designed to be used with your existing CT phantoms. This new architecture provides more stable, reproducible dose measurements for CT slices from 1 mm to 1 cm in thickness.

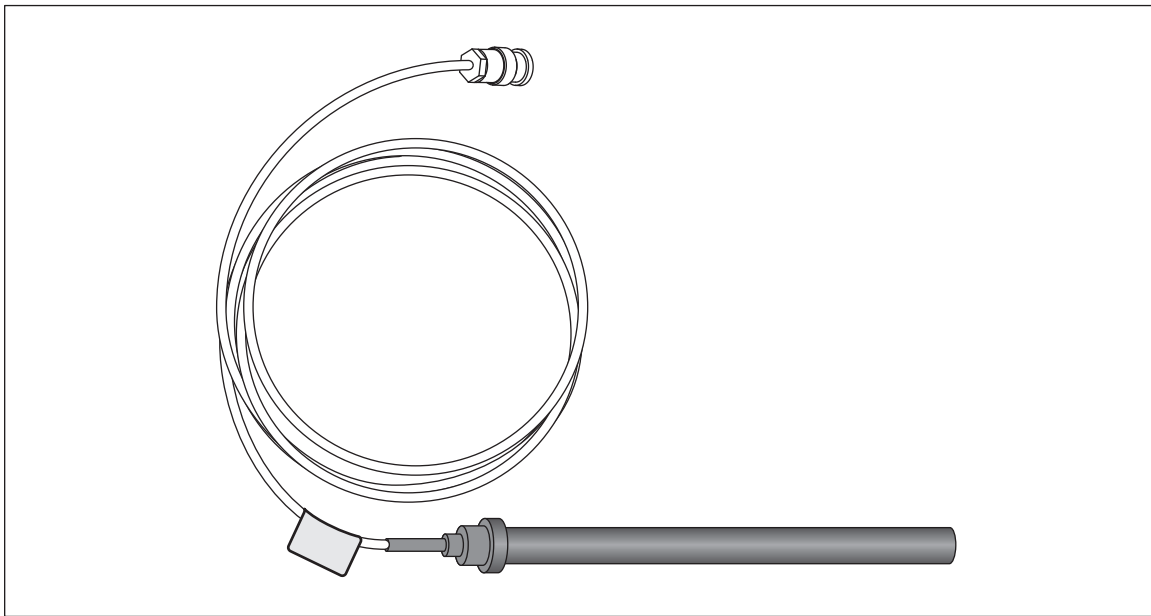


Figure D-1. Model 500-200 High Sensitivity 10 cc CT Ion Chamber

fct44.eps

The 500-200 probe has a 0.9 meter flexible low noise triax cable which is terminated in a male triax BNC connector. Calibration is stated in terms of R/nC .

Applications

It has been shown¹ that in a phantom, integration of the radiation exposure profile produced by a single scan from a CT scanner along a line normal to the slice, divided by the table increment, is equal to the exposure to a central slice at that point produced by a series of scans. The line of integration must be of sufficient length to intercept not only the primary beam, but also the Compton scatter produced in the phantom. This integral is then expressed as $R \cdot \text{cm}$.

A long, thin radiation probe can be used to make this measurement. The probe may be calibrated in a uniform field covering its entire length, generating a correction factor in the conventional manner. Subsequent probe readings, when multiplied by the conventional correction factor, and then by the probe's sensitive length, will be in units of $R \cdot \text{cm}$.

Since the model 500-200 probes are intended mainly to be used to integrate radiation exposure profiles produced by the CT scanners, this length (10 cm) factor has, for the user's convenience, been built into the calibration. Thus, the correction factor provided is stated in terms of $R \cdot \text{cm/Coulomb}$.

Specifications

Detector Type	Vented air ion chamber
Volume	10.1 cc
Sensitive Length	10.0 cm
Rated Length	8.2 cm (IEC 61674)
Effective Length	9.6 cm (IEC 61674)
Chamber Material	Acrylic (PMMA)
Chamber Outside Diameter	12.7 mm \pm 0.4 mm (0.5 in \pm 0.015 in)
Chamber Inside Diameter	11.44 mm (0.45 in)
Chamber Wall Thickness	77 mg/cm ²
Electrode Material	Aluminum, 1100
Nominal Sensitivity	2.8 mGy/nC (0.32 R/nC)
Standard Calibration	100 kVCP, 5.5 mm Al HVL (NIST Tech. M100), 100 kVCP, 3.5 mm Al HVL (DV Beam Quality)
Response Uniformity Along Axis	\pm 3 % over central 90 % of active length
Beam Orientation	Normal to chamber axis
Angular Response	<3 % for \pm 180° in the plane perpendicular to the ion chamber axis
Leakage Current (300 V collection potential)	Less than 10-14 A at 10 min polarization time
Intensity Limits, Continuous beam	270 mGy/sec (31.6 R/sec) (1 % recombination loss)
Pulsed Beam	138 μ Gy/Impuls (15.8 mR/pulse) (1 % recombination loss)
Collection Time	0.478 mSec
Cable Length	0.9 m (3 ft)
Operating Voltage	-300 V
Termination	Triax BNC.
Air Density Correction	To perform air density corrections when using a calibration factor with a reference temperature of 22 °C, multiply the ion current by the following correction factor, F: $F = (273.15 + T) / (295.15 \times P)$ Where T is the temperature in °C and P is the pressure expressed as a fraction of a standard atmosphere (1013 hPa). For chambers with a calibration factor normalized to 20 °C, the denominator is 293.15 x P
Typical Energy Dependence	See Figure D-2

¹ R.A. Jucius, G.X. Kambic, "Radiation Dosimetry in Computed Tomography (CT)"

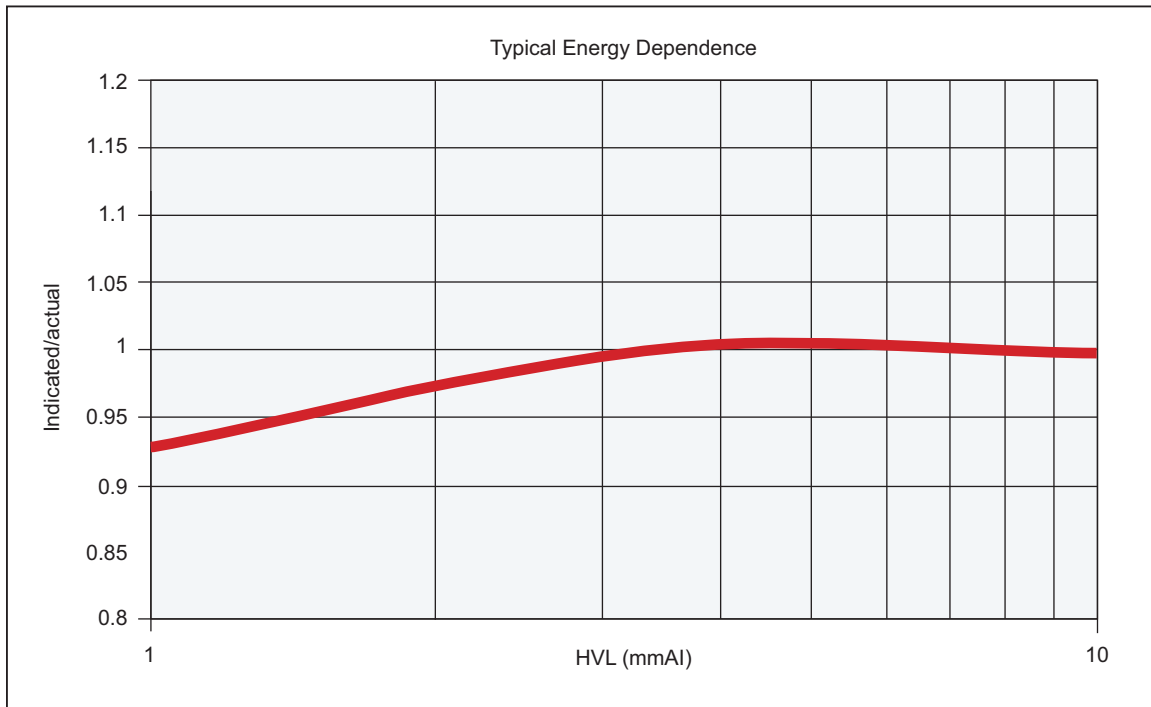


Figure D-2. Typical Energy Dependence of Model 500-200 CT Ion Chamber

Figure D-3 shows the typical energy response of the Model 500-200 CT ion chamber per IEC 61267 beam qualities. The three plots show RQR normalized for RQR 9, RQA normalized for RQA 9, and RQT normalized for RQT 9

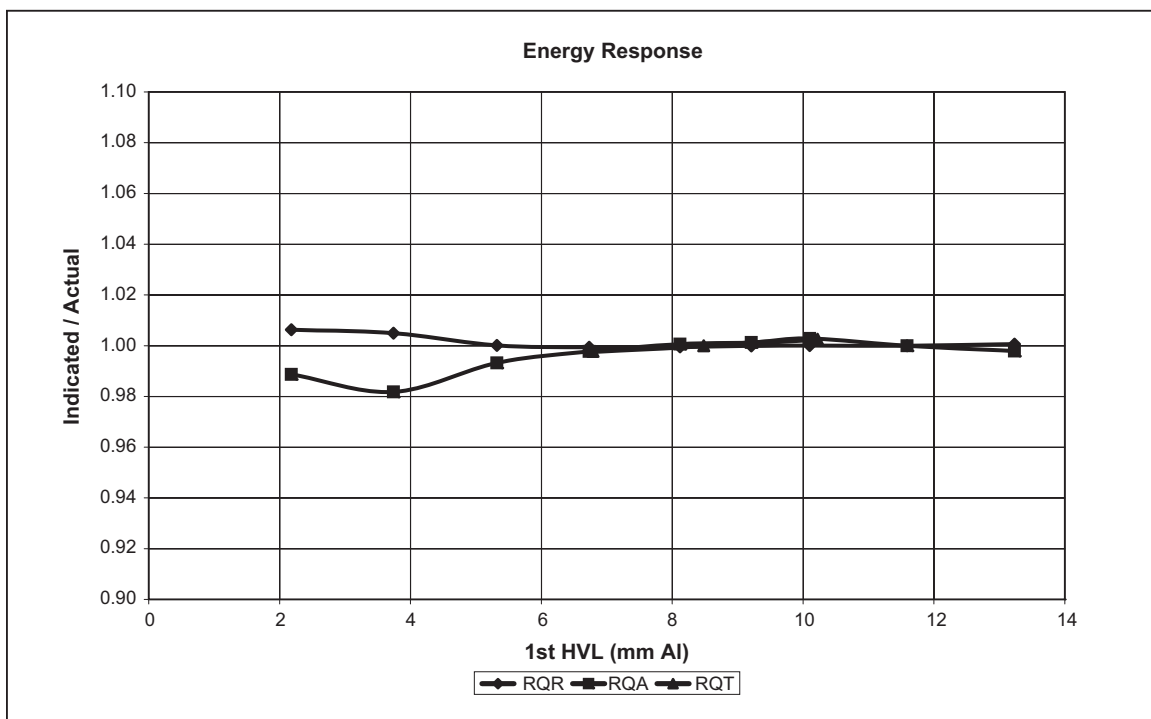


Figure D-3. Typical Energy Response for IEC 61267 Beam Quality

Table D-1. Specifications for IEC 61237 Defined Beam Qualities

kVp						
	Beam Quality	First HVL (mm Al)	Beam Quality	First HVL (mm Al)	Beam Quality	First HVL (mm Al)
40	RQR 2	1.42	RQA 2	2.2		
50	RQR 3	1.78	RQA 3	3.8		
60	RQR 4	2.19	RQA 4	5.4		
70	RQR 5	2.58	RQA 5	6.8		
80	RQR 6	3.01	RQA 6	8.2		
90	RQR 7	3.48	RQA 7	9.2		
100	RQR 8	3.97	RQA 8	10.1	RQT 8	6.9
120	RQR 9	5.00	RQA 9	11.6	RQT 9	8.4
150	RQR 10	6.57	RQA 10	13.3	RQT 10	10.1

500 – 200 Measurement ranges

Values for ion chambers are calculated using nominal sensitivities: 3.2×10^8 R/C.

Table D-2. 500-200 Measurement Ranges

Units	Effective Range ^[1]	Threshold	Resolution Step Size
R	10 μ - 9999	250 μ	0.1 μ
R/s	10 μ - 100	250 μ	0.1 μ
R/min	1 m – 6 k	15 m	0.01 m
R/hr	0.1 – 360 k	0.9	0.001
R/pulse ^[2]	1 m – 1.67	4.17 μ	0.01 μ
Gy	0.1 μ - 876 m	2.19 μ	0.001 μ
Gy/s	0.1 μ - 876 m	2.19 μ	0.001 μ
Gy/min	0.01 m - 52.5	131 μ	0.1 μ
Gy/hr	1 – 3.15 k	7.88 m	0.01m
Gy/pulse ^[2]	0.01 μ - 14.6 m	36.5 n	0.1n
<p>[1] IEC 61674 effective range at 1 % resolution steps. [2] At 60 frames/second (1 to 120 frames/selectable).</p>			

Note

Introduction of material, other than free air, behind the Ion Chamber will cause its response to change due to backscatter.

Appendix E

TNT 12000WD kVp, Exposure, and Exposure Time Measurement

Introduction

The TNT 12000WD measures kV, exposure, exposure time, and HVL for all radiographic x-ray imaging modalities. This includes Radiographic, Mammographic, Fluoroscopic, and Dental, and can measure kV for stationary mode CT. All kV measurements are automatically corrected for beam filtration. All exposure measurements are automatically corrected for kV and beam filtration.

When the measurement mode parameters are set to Auto, the X-ray Detector examines the waveform type. The results of the analysis, along with the X-ray machine type lets the Detector set the applicable analysis procedure for the measurement. Read the sections that follow to learn how the analysis finds the measurement procedure.

Radio Waveform Analysis

In the Radiographic mode, exposure, exposure time, and kV measurements are done as follows:

Single Phase

Exposure time in milliseconds is calculated between the first and last zero crossings of the kV waveform. Exposure time in pulses is measured between the first and last zero crossings of the kV waveform.

The Detector measures average kVp on the pulses in the central 80 % of the kV waveform. It measures Maximum kV and PPV on the complete waveform. Exposure is measured from the start of the exposure to the end of the exposure.

Three Phase

Exposure time in milliseconds is calculated between the 75 % points on the rising and falling edges of the kV waveform.

The Detector measures average kVp on the pulses in the central 80 % of the kV waveform. It measures Maximum kV and PPV on the complete waveform. Exposure is measured from the start of the exposure to the end of the exposure.

HF (High Frequency)

Exposure time in milliseconds is calculated between the 90 % points on the rising and falling edges of the kV waveform.

The Detector measures average kV on the peaks in the central 80 % of the kV waveform. It measures Maximum kV and PPV on the complete waveform.

Mammo Waveform Analysis

In the Mammographic mode, kV, dose, and exposure time measurements are effected by automatic waveform analysis as follows:

With Scout or Sample Exposure or HTC Grid (Lorad)

The Detector measures Average kVp on the central 80 % of the last kV waveform after the scout exposure or the last HTC grid pause. It measures Maximum kV and PPV on the complete waveform after the scout exposure or the last HTC grid pause.

Exposure time in milliseconds is calculated between the 90 % points on the rising and falling edges of the kV waveform after the scout exposure, but including the HTC grid reset time.

Exposure is measured from the start of the exposure to the end of exposure, and includes the scout exposure.

Without Scout Exposure

The Detector measures average kVp on the pulses in the central 80 % of the kV waveform. It measures Maximum kV and PPV on the complete waveform.

Exposure time in milliseconds is calculated between the 90 % points on the rising and falling edges of the kV waveform. Exposure is measured from the start of the exposure to the end of exposure.

Fluoro Waveform Analysis

In the Fluoroscopic mode, waveform analysis of exposure time and dose measurements is done as follows:

Continuous Fluoro

The Detector measures elapsed time and accumulated dose from the moment x-rays are sensed until they stop. It measures KV from one second samples while the x-ray beam is on. The user can set the unit of measure for Dose Rate as Dose (R or Gy) per second, minute, or hour.

Pulsed Fluoro

The Detector measures elapsed time and accumulated dose from the moment x-rays are sensed until they stop. The average pulse width and pulse rate are calculated from each one-second sample. It measures KV from one second samples while the x-ray beam is on. The user can set the unit of measure for Dose Rate as Dose (R or Gy) per second, minute, hour, or pulse.

Dental Waveform Analysis

In the Dental mode, waveform analysis of exposure time and kV measurements is done as follows:

Dental with Filament Preheat (Single Phase)

Exposure time in milliseconds is calculated between the first and the last zero crossings of the kV waveform plus 4 ms (compensates for the waveform time that does not produce x-rays) after the preheat. Exposure time in pulses is measured between the first and the last zero crossings of the kV waveform after the preheat.

Average kVp is measured on the pulses in the central 80 % of the kV waveform after the preheat. Maximum kV and PPV are measured for the complete waveform after the preheat. Exposure is measured from the start of the exposure to the end of the exposure.

Dental without Filament Preheat (Single Phase)

Exposure time in milliseconds is calculated between the first and last zero crossings of the kV waveform plus 4 ms (compensates for the waveform time that does not produce x-rays). Exposure time in pulses is measured between the first and last zero crossings of the kV waveform.

Average kVp is measured on the pulses in the last 75 % of the kV waveform, less the last peak. Maximum kV and PPV are measured for the complete waveform. Exposure is measured from the start of the exposure to the end of the exposure.

Three Phase

Exposure time in milliseconds is calculated between the 75 % points on the rising and falling edges of the kV waveform.

Average kVp is measured on the peaks in the central 80 % of the kV waveform. Maximum kV and PPV are measured for the complete waveform. Exposure is measured from the start of the exposure to the end of the exposure.

HF (High Frequency)

Exposure time in milliseconds is calculated between the 90 % points on the rising and the falling edges of the kV waveform.

Average kVp is measured on peaks in the central 80 % of the kV waveform. Maximum kV and PPV are measured for the complete waveform. Exposure is measured from the start of the exposure to the end of the exposure.

Appendix F

Warnings and Error Messages

Introduction

The Warnings and Error Messages generated by the Test Tools are in Tables F-1 through F-4.

Table F-1. Warnings and Error Messages

Warning/Error Message	Description
XXXXXX ^[1] detector Calibration Overdue	The detector needs to be calibrated. Contact Fluke Biomedical Service Center.
Connection lost with the detector XXXXXX ^[1]	The detector has lost connection with the display or computer. Ensure that the detector is properly connected. Reconnect the components and select the Connection option to reestablish the connection.
Low Battery XXXXXX ^[1]	This message appears along with a beep sound, and the detector battery status LED glows yellow. This happens when the detector battery has approximately less than 20 % of charge remaining. Connect the detector to the power source.
Low Battery Readout	This message appears along with a beep sound, the display battery status LED glows yellow when display battery has approximately less than 20 % of the charge remaining. Connect the display to its ac adapter or a USB port to continue operation.
Low Battery XXXXXX ^[1] shutting down in 2 min	This message appears along with a beep sound, and the detector battery status LED glows red. This happens when the detector battery has less than 10% of charge remaining. Connect the detector to its ac adapter or a USB port to continue operation. If this message is ignored, the detector powers off in two minutes.

Table F-1. Warnings and Error Messages (cont.)

Warning/Error Message	Description
Low Battery Readout shutting down in 2 min	This message appears along with a beep sound, and the display battery status LED glows red. This happens when the display battery has less than 10% of charge remaining. Connect the display to its ac adapter or a USB port to continue operation. If this message is ignored, the display will turn off in two minutes.
NO DETECTOR FOUND Screen/Window	This message screen/window appears when there are no detectors present in the vicinity or if the detector is powered off. Move the detector closer to the display or computer; ensure that the detector is powered on.
Kernel/Application Upgrade Failed	This message appears during a firmware upgrade, if the firmware upgrade fails. Contact the Fluke Biomedical Service Center.
[1] XXXXXX denotes the serial number of the Detector.	

Table F-2. X-ray Detector Warnings and Error Messages

Warning/Error Message	Description
Detector self test failed	One of the detector's internal diagnostic tests has detected a failure.
Detector Zero Error	The signal from one or more of the internal x-ray detectors is too high.
Measured quantities showing HIGH	This message indicates a detector over range. The x-ray intensity is too high.
Measured quantities showing LOW	This message indicates a detector under range. The x-ray intensity is too low to make an accurate measurement.

Table F-3. DoseMate Warnings and Error Messages

Warning/Error Message	Description
High Leakage	The measured leakage current of the system is above 0.25 pA, High leakage may be caused by a faulty ion chamber or cable. To verify, disconnect the ion chamber and/or cable and note if the high leakage message no longer shows in the Display. Leakage may also be checked from the status screen.
Measured quantities showing NNNN HIGH or NNNN LOW (Where NNNN is the measurement data)	This message indicates that the measured quantity is above or below the calibrated range of the measurement.

Table F-3, DoseMate Warnings and Error Messages (cont.)

Warning/Error Message	Description
"Resetting...Please Wait..." message is displayed	<p>This message displays when you select Reset in the Measurement Screen or when the DoseMate dosimeter automatically resets.</p> <p>NOTE: Do not make an exposure when the "Resetting...Please Wait..." message is displayed. If an exposure is initiated while this message is displayed, the message will remain until the exposure is ended.</p>
"Temperature/Pressure Sensor Error" message is displayed	<p>This message displays when the Temperature or the Pressure value sensed by the integrated Temperature/Pressure sensor of the DoseMate is invalid.</p> <p>The Dose and Dose Rate Value measured during the Temperature/Pressure Sensor Error is invalid. Hence, the Manual Entry of Temperature and Pressure is recommended. (Refer section "Air Density Correction: External Temperature/Pressure Mode")</p>
The "Bias Voltage Error, please restart the system" message is displayed	<p>This message displays when the DoseMate Ion Chamber Bias voltage is not within normal operating range. When this occurs, the Ion Chamber bias voltage is turned off. To restore the bias voltage, the DoseMate must be turned off and then on again. The Bias Voltage error may be caused by a faulty ion chamber and/or cable. To verify, disconnect the ion chamber and/or cable, turn the DoseMate off and then on. The ion chamber bias voltage may be checked from the Status screen.</p>
Measured quantities showing HIGH	<p>This message indicates an over range. The current or charge from the Ion Chamber is above the maximum.</p>

Table F-4. mAs Detector Warnings and Error Messages

Warning/Error Message	Description
Measured quantities showing HIGH	<p>This message indicates an over range. The measured mA or mAs is above the maximum current.</p>

Appendix G

Troubleshooting

Introduction

Causes and corrections to potential problems with Test Tools operation are in Tables G-1 through G-3.

Table G-1. Troubleshooting

Problem	Cause	Corrections
The detector or the display does not power on.	The battery is fully discharged.	Connect to the ac adapter and plug in to a power source or connect the unit to a computer via USB cable. If problem persists, the TNT 12000 detector/display needs repair. Contact the Fluke Biomedical Service Center.
The detector or the display battery does not appear to hold the charge.	The battery is faulty.	A fully charged battery can hold the charge for approximately 8 hours when the unit is powered on. If the battery does not appear to hold sufficient charge, verify that the battery is being charged. Connect the ac adapter to the unit and plug it into a suitable power source. The Battery status LED glows green, indicating that the battery is charging. If the Battery status LED does not glow, the battery is not charging, and the unit needs repair. Contact the Fluke Biomedical Service Center.

Table G-1. Troubleshooting (cont.)

Problem	Cause	Corrections
TNT 12000D display is not communicating with detector	The detector is out of the connectivity range.	Move the detector within range when there is wireless communication.
	The USB cable is not connected properly.	Move the detector within range when there is wireless communication.
Detector is not communicating with the computer (Excel Add-In).	The ZigBee dongle is not connected properly.	Connect the ZigBee dongle properly.
	The detector is out of the connectivity range.	Move the detector within range when there is wireless communication.
	The USB cable is not connected properly.	Connect the USB cable properly.
Cursor movement is continuous or uncontrolled on the display.	One of the keys on the display is stuck in the engaged position.	Check each button to see if any key is stuck in the engaged position and needs to be lifted up. If the key's function cannot be restored, the display needs repair. Contact the Fluke Biomedical Service Center.
The detector or the display is not responding.		Press the Reset key on the underside of the unit. If the problem persists, contact the Fluke Biomedical Service Center.

Table G-2. Troubleshooting the DoseMate

Problem	Cause	Corrections
"Temperature/Pressure Sensor Error" message is displayed	Faulty temperature/pressure sensor	Use manual entry of temperature and pressure by selecting User Set Temperature and User Set Pressure from the ModeSetup screen (Refer section " <i>Air Density Correction: External Temperature/Pressure Mode</i> ") The DoseMate should be returned to Fluke Biomedical for repair at earliest convenience.

Table G-2. Troubleshooting the DoseMate (Cont.)

Problem	Cause	Corrections
The “Bias Voltage Error” message is displayed	The Ion Chamber bias voltage is above 340 volts or below 260 volts.	When this error occurs, disconnect the Ion Chamber from the DoseMate input connector and turn the DoseMate off then on again. If the Bias Voltage Error does not occur, there may be a short in the Ion Chamber or cable. If the Bias Voltage Error remains, the DoseMate bias voltage supply may be faulty and should be returned to Fluke Biomedical for service.
“Resetting...Please Wait...” message is displayed	This message displays when you select <i>Reset</i> in the Measurement Screen or when the DoseMate dosimeter automatically resets. NOTE: Do not make an exposure when the “Resetting...Please Wait...” message is displayed. If an exposure is initiated while this message is displayed, the message will remain until the exposure is ended.	
Measured quantities showing HIGH	This message indicates an over range. The current or charge from the Ion Chamber is above the maximum.	Reduce the x-ray intensity by reducing mA or increasing source to detector distance.
		Use a smaller, less sensitive Ion Chamber.
High leakage	A faulty ion chamber or cable.	Disconnect the ion chamber and/or cable and see if the high leakage message goes away. If the high leakage message goes away, the ion chamber or cable may be faulty and should be returned to Fluke Biomedical for service. If the high leakage message persists after the ion chamber and cable have been disconnected, the DoseMate may be faulty and should be returned to Fluke Biomedical for service.

Table G-3. Troubleshooting the mAs Detector

Problem	Cause	Corrections
Measured quantities showing HIGH	The measured mA or mAs is above the maximum that can be measured.	Verify the set mA is within the measurement range of the test tool and the mAs shunt or non-invasive clamp is properly connected to the X-Ray generator. Make sure the mAs shunt is connected in series with the actual current path of the X-Ray tube. If using the clamp, make sure it is connected to the anode cable and that the arrow on the clamp jaw is pointing in the direction of the tube current flow. Make sure the mAs input to the test tool is not connected directly to any mAs circuit without the shunt or clamp.

Appendix H

PTB Information

Introduction

The Fluke Biomedical TNT 12000 measurement system, with the TNT 12000WD detector and the TNT 12000 DoseMate (with the 96035B and 96020C ionization chambers) is approved for calibration by the Physikalisch-Technischen Bundesanstalt (PTB) in Germany. The approval holder company is:

Fluke Biomedical
Division of Fluke Electronics Corporation
6920 Seaway Blvd.
Everett, WA 98203
USA

The Approval sign is:

23.04
11.03

Technical Data of Type Examination by PTB

Display and Detector Units

Dimensions 5.24 cm x 11.43 cm x 4.45 cm

Weight

TNT 12000D Display 347 g

TNT 12000WD X-Ray Detector 560 g

TNT 12000 DoseMate 392 g

TNT 12000WD

The following measurement and calibration nominal ranges apply.

Ranges

Dose 12 μ Gy – 999 Gy (R/F & MAM)

Dose Rate 70 μ Gy/s – 86 mGy/s

Nominal ranges of use for the radiation qualities:

Conventional Diagnostic			
Anode	Quality	Range of Tube Voltage	Reference
W	RQR2 – RQR10	40 - 150 kV	IEC 61267
Mammography			
Anode	Total Filtration	Range of Tube Voltage	PTB Reference
Mo	30 µm Mo	25 - 35 kV	MMV 25 - MMV 35
Mo	25 µm Rh	25 - 40 kV	MRV 25 - MRV 40
Mo	1 mm Al	25 - 50 kV	MAV 25 - MAV 50
Rh	25 µm Rh	25 - 50 kV	RRV 25 - RRV 50
Rh	1 mm Al	25 - 50 kV	RAV 25 - RAV 50

Nominal ranges of use for other factors

Factor	Nominal Range
Direction of beam incidence	Within a cone with a half angle of 5 ° to the preferred direction
Ambient temperature	15 °C to 35 °C
Ambient pressure	800 hPa to 1060 hPa
Relative humidity	20 % to 80 %, <20 g/m

Values of the correction factor k_Q , for the radiation qualities as determined by measurement at the PTB.

RQR – Series

Radiation Quality IEC 61267	Mean Energy, Air Kerma (keV)	$k_Q (Q_n/Q_{70})$
RQR 2	26.2	0.999
RQR 3	29.0	1.014
RQR 4	32.0	1.006
RQR 5	34.8	1
RQR 6	37.8	1.007
RQR 7	41.0	1.007
RQR 8	44.2	1.003
RQR 9	50.8	0.991
RQR 10	61.2	0.996

MMV – Series

Radiation Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
MMV 25	14.9	1.002
MMV 28	15.4	1
MMV 30	15.7	0.999
MMV 35	16.3	0.993

MRV – Series

Radiation Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
MRV 25	15.8	1.014
MRV 28	16.3	1
MRV 30	16.5	0.994
MRV 35	17.0	0.986
MRV 40	17.4	0.995

MAV – Series

Radiation Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
MAV 25	17.6	1.006
MAV 28	18.3	1
MAV 30	18.7	0.993
MAV 35	19.4	0.983
MAV 40	19.9	0.973
MAV 50	20.7	0.960

RAV – Series

Radiation Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
RAV 25	17.6	0.990
RAV 28	18.8	1
RAV 30	19.3	0.995
RAV 35	20.4	0.986
RAV 40	21.1	0.981
RAV 50	22.1	0.976

RRV – Series

Radiation Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
RRV 25	15.6	1.003
RRV 28	16.3	1
RRV 30	16.7	0.997
RRV 35	17.6	0.988
RRV 40	18.2	0.973
RRV 50	19.2	0.962

96020C Ion Chamber

Dimensions (Diameter x Height)..... 129 mm x 18.8 mm

TNT 12000 DoseMate with 96020C Ion Chamber

The following measurement and calibration nominal ranges apply.

Ranges

Dose 0.1 µGy – 18 mGy

Dose Rate..... 0.1 µGy/s – 18 mGy/s

Nominal ranges of use for other factors

Conventional Diagnostic			
Anode	Quality	Range of Tube Voltage	Reference
W	RQR2 - RQR10	40 - 150 kV	IEC 61267
W	RQA3 - RQA10	50 - 150 kV	IEC 61267

Nominal ranges of use for other factors

Factor	Nominal Range
Direction of beam incidence	Within a cone with a half angle of 5 ° to the preferred direction
Ambient temperature	15 °C to 35 °C
Ambient pressure	800 hPa to 1060 hPa
Relative humidity	20 % to 75 %, <20 g/m

Values of the correction factor k_Q , for the radiation qualities as determined by measurement at the PTB.

RQR – Series

Beam Quality IEC 61267	Mean Energy, Air Kerma (keV)	$k_Q (Q_n/Q_{70})$
RQR 2	26.2	1.019
RQR 3	29.0	1.012
RQR 4	32.0	1.005
RQR 5	34.8	1
RQR 6	37.8	0.996
RQR 7	41.0	0.992
RQR 8	44.2	0.989
RQR 9	50.8	0.984
RQR 10	61.2	0.979

RQA – Series

Beam Quality IEC 61267	Mean Energy, Air Kerma (keV)	$k_Q (Q_n/Q_{70})$
RQA 3	37.7	1.021
RQA 4	44.6	1.009
RQA 5	51.0	1
RQA 6	57.4	1.001
RQA 7	62.9	0.997
RQA 8	68.0	0.992
RQA 9	78.4	0.994
RQA 10	93.2	0.996

96035B Ion Chamber

Dimensions (Diameter x Height) 63.5 mm x 13 mm

TNT 12000 DoseMate with 96035B Ion Chamber

The following measurement and calibration nominal ranges apply.

Ranges

Dose 1 μ Gy – 180 mGy

Dose Rate 1 μ Gy/s – 180 mGy/s

Nominal ranges of use for other factors

Conventional Diagnostic			
Anode	Quality	Range of Tube Voltage	Reference
W	RQR2 - RQR10	40 - 150 kV	IEC 61267
W	RQA3 - RQA10	50 - 150 kV	IEC 61267
Mammography			
Anode	Total Filtration	Range of Tube Voltage	PTB Reference
Mo	30 μ m Mo	20 - 50 kV	MMV 20 - MMV 50
Mo	30 μ m Mo + 2 mm Al	20 - 50 kV	MMV 20 - MMV 50

Nominal ranges of use for other factors

Factor	Nominal Range
Direction of beam incidence	Within a cone with a half angle of 5 ° to the preferred direction
Ambient temperature	15 °C to 35 °C
Ambient pressure	800 hPa to 1060 hPa
Relative humidity	20 % to 75 %, <20 g/m

Values of the correction factor k_Q , for the radiation qualities as determined by measurement at the PTB.

RQR – Series

Beam Quality IEC 61267	Mean Energy, Air Kerma (keV)	$k_Q (Q_n/Q_{70})$
RQR 2	26.2	1.035
RQR 3	29.0	1.023
RQR 4	32.0	1.010
RQR 5	34.8	1
RQR 6	37.8	0.991
RQR 7	41.0	0.983
RQR 8	44.2	0.976
RQR 9	50.8	0.966
RQR 10	61.2	0.956

RQA – Series

Beam Quality IEC 61267	Mean Energy, Air Kerma (keV)	$k_Q (Q_n/Q_{70})$
RQA 3	37.7	1.049
RQA 4	44.6	1.020
RQA 5	51.0	1
RQA 6	57.4	0.987
RQA 7	62.9	0.980
RQA 8	68.0	0.978
RQA 9	78.4	0.982
RQA 10	93.2	0.986

MMV – Series

Beam Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
MMV 20	13.5	1.012
MMV 25	14.9	1.004
MMV 28	15.4	1
MMV 30	15.7	0.999
MMV 35	16.3	0.995
MMV 40	16.7	0.993
MMV 50	17.3	0.990

MMH – Series

Beam Quality PTB	Mean Energy (keV)	$k_Q (Q_n/Q_{70})$
MMH20	17.3	0.984
MMH 25	18.6	0.982
MMH 28	19.3	0.981
MMH 30	19.8	0.980
MMH 35	21.0	0.980
MMH 40	22.1	0.978
MMH 50	24.2	0.974

