FLUKE®
Biomedical

# Victoreen® 6000-528

## Radiographic Ion Chamber

## Operators Manual

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# *Section 1*
# *Introduction*

## 1.1 General Description

The Model 6000-528 External Ion Chamber is a low profile ion chamber designed to measure diagnostic x-rays from 30 to 150 kVp. The external ion chamber consists of an ionization chamber and a 15-foot cable assembly.

## 1.2 Application

The Model 6000-528 External Ion Chamber is specifically designed to be used with the NERO® 6000B, 6000M, 4000+, or the 4000M+ for measuring exposure from diagnostic x-ray machines. It can also be used with any properly configured charge measuring electrometer. The coaxial BNC on the chamber body is the signal output. The recessed banana plug is the high voltage connection for chamber bias. The middle hole is threaded with a standard 1/4 - 20 thread for accessory mounting.

## 1.3 Specifications

### Chamber

| | |
|---|---|
| ***Radiation Measured*** | X-rays from 30 to 150 kVp |
| ***Nominal Sensitivity*** | 9 nC/R |
| ***Volume*** | Nominal 30 cc |
| ***Energy Response*** | 30 to 150 kVp, within 7% |
| ***Wall*** | 0.031 inch phenolic (0.8 mm) |
| ***Termination*** | Signal - coaxial, fully guarded BNC<br>High Voltage - recessed banana |
| ***Cable Length*** | 15 ft (3.8 m) |
| ***Dimensions*** | 4 in x 4 in x 0.54 in<br>(10.2 cm x 10.2 cm x 1.4 cm) |
| ***Weight*** | 4 oz (113 grams) |

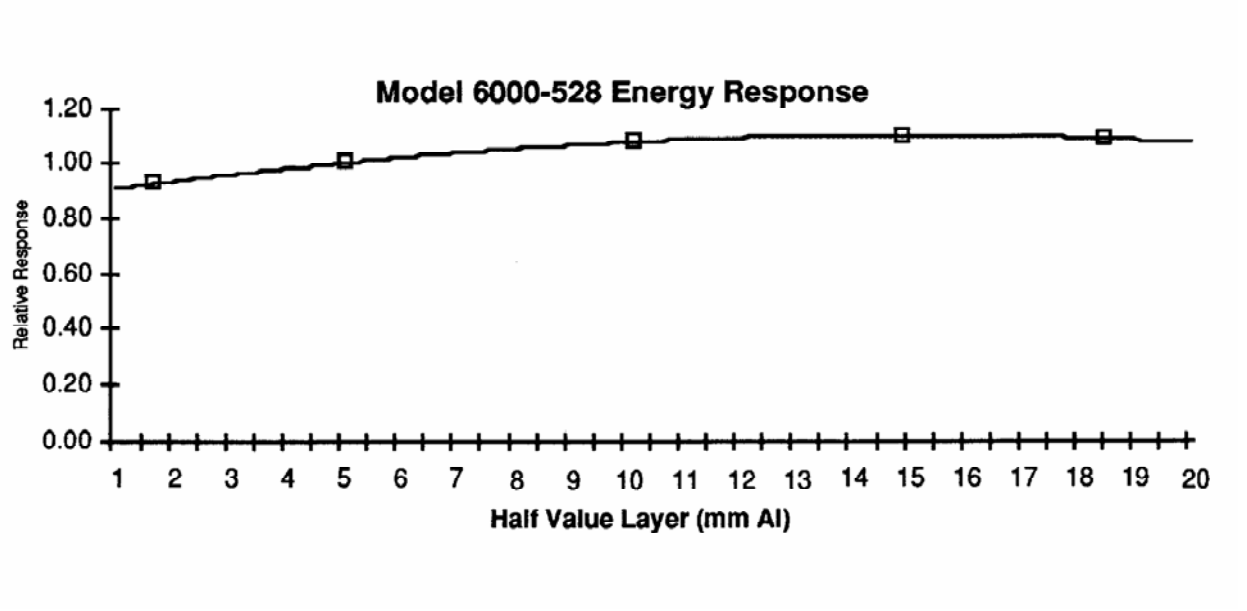


*Figure 1-1. Model 6000-528 Energy Response*

# 1.4 Procedures, Warnings and Cautions

The equipment described in this manual is intended to be used for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

Although the equipment described in this manual is designed and manufactured in compliance with all applicable safety standards, certain hazards are inherent in the use of electronic and radiometric equipment.

**Warnings** and **Cautions** are presented throughout this document to alert the user to potentially hazardous situations. A **Warning** is a precautionary message preceding an operation that has the potential to cause personal injury or death. A **Caution** is a precautionary message preceding an operation that has the potential to cause permanent damage to the equipment and/or loss of data. Failure to comply with **Warnings** and **Cautions** is at the user's own risk and is sufficient cause to terminate the warranty agreement between Fluke Biomedical, Radiation Management Services and the customer.

Adequate warnings are included in this manual and on the product itself to cover hazards that may be encountered in normal use and servicing of this equipment. No other procedures are warranted by Fluke Biomedical. It shall be the owner's or user's responsibility to see to it that the procedures described here are meticulously followed, and especially that **Warnings** and **Cautions** are heeded. Failure on the part of the owner or user in any way to follow the prescribed procedures shall absolve Fluke Biomedical and its agents from any resulting liability.

Indicated battery and other operational tests must be performed prior to each use to assure that the instrument is functioning properly. If applicable, failure to conduct periodic performance tests in accordance with ANSI N323-1978 (R1983) Radiation Protection Instrumentation Test and Calibration, paragraphs 4.6 and 5.4, and to keep records thereof in accordance with paragraph 4.5 of the same standard, could result in erroneous readings or potential danger. ANSI N323-1978 becomes, by this reference, a part of this operating procedure.

# 1.5 Receiving Inspection

Upon receipt of the unit:

1. Inspect the carton(s) and contents for damage. If damage is evident, file a claim with the carrier and notify Fluke Biomedical at 440.248.9300.
2. Remove the contents from the packing material.
3. Verify that all items listed on the packing list have been received and are in good condition.

NOTE

If any of the listed items are missing or damaged, notify Fluke Biomedical at 440.248.9300.

# 1.6 Storage

The storage requirements for this instrument are listed below.

1. The instrument should be stored in a cool, dry location.
2. If the instrument is taken from it's current location and is to be placed in a new location with a different ambient temperature, allow the instrument to reach the new location's ambient temperature before
applying power.

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# *Section 2*
# *Installation*

## 2.1 Installation

CAUTION

Ensure all power is removed prior to installing the Model 6000-528 Ion Chamber.

Installation of the Model 6000-528 External Ion Chamber consists of connecting the signal and high voltage cables, and performing a calibration.

## 2.2 Electrical Interface

Final electrical interface connections between the Ion Chamber, and the host instrument are listed in Table 2-1.

*Table 2-1. Electrical Interface Connections*

| Connector | Description |
|---|---|
| BNC | Ion Chamber Output |
| HV (BIAS) | Ion Chamber High Voltage |

## 2.3 Setup

Because the Model 6000-528 External Ion Chamber may be used with NERO® 6000B, 6000M, 4000+, or the 4000M+ please refer to the applicable instrument manual for instrument set up.

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# *Section 3*
# *Operation*

## 3.1 Theory of Operation

An ionization chamber consists of a defined volume of air in which ions produced by radiation passing through the chamber can be collected and measured. The Model 6000-528 is a parallel plate ion chamber, consisting of a guarded center electrode placed between two outer plates, which also serve as windows. A potential difference in the range of approximately 200 - 300 volts is placed across the plates of the ion chamber. When ionizing radiation passes through the chamber, ion pairs are produced, each pair consisting of one positive and one negative ion. Under the influence of the electric field produced by the potential on the plates, the ions move toward their oppositely charged plate. Upon arrival, they are neutralized by the free charges on the plates, taking an electron from the negative plate and adding an electron to the positive plate. This causes a current to flow through the external electronics connected to the plates, the magnitude of which is proportional to the rate of exposure to radiation.

The sensitivity of an ion chamber depends on the number of air molecules in the chamber; in fact these quantities are directly proportional. The number of molecules is a function of volume, temperature, and pressure. The volume of air in the chamber is fixed, but since it communicates with the atmosphere, temperature and pressure will vary. A correction factor should be applied to the reading given by the ion chamber, based on the ambient temperature and barometric pressure at the time the measurement is made. For diagnostic x-ray use, this is usually unnecessary since the errors are on the order of 0.3% per degree Celsius and 0.1% per mmHg. In any event, the correction factor is calculated by the following expression:

$$cf = \frac{P_0}{P} \times \frac{T + 273.16}{T_0 + 273.16}$$

Where T is the temperature in degrees Celsius and P is the pressure in mmHg. $T_0$ and $P_0$ are the temperature and pressure, respectively, at which the chamber was calibrated.

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# *Section 4*
# *Maintenance, Calibration and Troubleshooting*

## 4.1 Maintenance

The Model 6000-528 Ion Chamber requires no routine maintenance, other than routine inspection of the chamber
for damage.

## 4.2 Calibration

The Model 6000-528 is not factory calibrated (although factory calibration is available). You may easily calibrate the 6000-528 using the internal NERO® or 4000 chamber as a standard.

### 4.2.1 Calibration with a NERO 6000B or 6000M

1. Calibration will be performed on a standard radiographic x-ray machine. Set the machine to 100 kVp, 300 mA, 0.5 sec. Place the Model 6000-528 External Ion Chamber on the table and use a distance of 40 inches. Collimate so as to uniformly irradiate the entire ion chamber.
2. Attach the Model 6000-528 External Ion Chamber to the NERO detector by connecting the BNC connector to the appropriate jack on the back, then plug the banana plug into its mating jack. Position the NERO detector such that no radiation will fall upon it. Connect the NERO detector to the readout unit via the detector cable, plug into AC power and turn the unit on.

NOTE

The NERO detector must be located out of the radiation beam. The Model 6000-528 External Ion Chamber is wired in parallel with the internal ion chamber; therefore, any radiation falling on the internal ion chamber will affect the reading. Shield if necessary.

3. Verify the mR correction factor by pressing the key sequence, "F mR". The correction factor should appear on the LCD. If it is not 1.000, enter 1 and press ENT.
4. To set up for an exposure, press “F-5". The display will clear as NERO measures electrometer drift for twelve seconds. The NERO will beep and display "0.0 mR". Make an exposure, and record the results. Press "NEXT" to clear the display and repeat. Make a total of five exposures in this manner. All five should be within ± 3%. Compute an average and label it "Measured". Press "EXIT" to return to the "Ready" condition.
5. Remove and disconnect the Model 6000-528 External Ion Chamber, and place the NERO detector in the center of the beam. Raise the tube 2.25 inches to compensate for the height of the detector box.
6. Make five exposures using the NERO detector in a similar manner as you did in step 4. Again all five readings should be within ± 3%. Compute an average and label it "True".

7. Compute the correction factor according to the following formula:

   cf = TRUE/MEASURED

This correction factor should be recorded and used when making the Model 6000-528 External Ion Chamber dose measurements. To use, simply enter into the NERO as the mR correction factor by pressing "F mR". The display will then read directly in mR. Remember to return the correction factor back to 1.000 when not using the Model 6000-528 External Ion Chamber.

### 4.2.2 Calibration with a 4000M+

1. Calibration will be performed on a standard radiographic x-ray machine. Set the machine to 100 kVp, 300 mA, 0.5 sec. Place the Model 6000-528 External Ion Chamber on the table and use a distance of 40 inches, Collimate so as to uniformly irradiate the entire ion chamber.
2. Attach the Model 6000-528 External Ion Chamber to the Model 4000M+ detector by connecting the BNC connector to the appropriate jack on the back, then plug the banana plug into its mating jack. Position the Model 4000M+ such that no radiation will fall upon it.

NOTE

The Model 4000M+ must be located out of the radiation beam. The Model 6000-528 External Ion Chamber is wired in parallel with the internal ion chamber; therefore, any radiation falling on the internal ion chamber will affect the reading. Shield if necessary.

3. To set up for an exposure, set the Radio/Fluoro switch to "Radio" and ALL/EXP to "EXP". The Model 4000M+ will beep and display "0.0 mR", Make an exposure, and record the results. Press "ROLL/RST" to clear the display and repeat. Make a total of five exposures in this manner. All five should be within ± 3%. Compute an average and label it "Measured".
4. Remove and disconnect the Model 6000-528 External Ion Chamber, and place the Model 4000M+ detector in the center of the beam. Raise the tube 2.25 inches to compensate for the height of the detector box.
5. Make five exposures using the Model 4000M+ detector in a similar manner as you did in step 3. Again all give readings should be within 3%. Compute an average and label it "True".
6. Compute the correction factor according to the following formula: cf = TRUE/MEASURED

This correction factor should be recorded and used when making the Model 6000-528 External Ion Chamber dose measurements. To use, simply multiply the exposure or exposure rate readings by cf, or if you are using DXS, cf may be entered as the exposure correction factor.

### 4.2.3 Determining Calibration Factor (cf) for Factory Calibrated Chambers

The following can be performed to determine the calibration factor:

1. Obtain the calibration results of your Model 6000-528 ion chamber, reported as R/nC. (Fluke Biomedical can supply this if needed).
2. Locate "Charge Calibration" on the 6000 or 4000 series calibration sheet reported as nc/R.
3. Multiply the two numbers together to obtain cf.

### 4.2.4 Calibration with a Model 6000-530 Preamplifier

The Fluke Biomedical Model 6000-530 preamplifier provides a means of matching your 6000-528 ionization chamber to a Model 6000B, 6000M, 4000M+, or 4000+ so that exposure and exposure rate values may be read directly from the instrument display. The 6000-530 must first be adjusted to accomplish this.

The following describes how to construct the calibration fixture, and how to obtain the value of chamber sensitivity.

1. Turn on the host instrument and allow 3 to 5 minutes to warm-up. The preamplifier automatically powers up when it senses high voltage from the host instrument.
2. Zero the host instrument, with nothing connected to the input, by selecting the fluoroscopic (rate) mode and waiting until the display stabilizes.

NOTE

If the calibration fixture hasn't been constructed, construct the fixture as shown in the schematic below (Figure 4-1):

CAUTION

Ensure that the 9 V DC battery is installed with the correct polarity when constructing the calibration fixture.

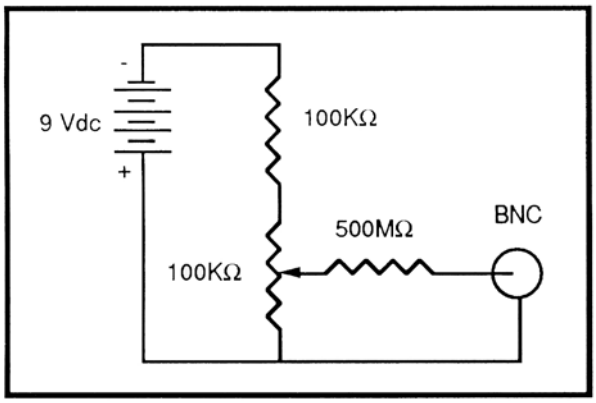


*Figure 4-1.*

3. Connect one end of a coaxial cable to the BNC connector on the calibration fixture. Connect the other end of the cable to the input of the host instrument.
4. Adjust the potentiometer on the calibration fixture until the instrument reads 1.00 R/min.
5. Disconnect the calibration fixture and make no further adjustments to the potentiometer. If the potentiometer is moved, re-perform steps 4 and 5.
6. Turn off the host instrument and attach the preamplifier to the host input. Turn power on and allow to warm up for five minutes.

NOTE

Do not adjust the CAL potentiometer located on the preamplifier. Doing so will change the factory calibration.

NOTE

The ZERO adjust is a fine adjustment and requires multiple turns on the potentiometer to change the least
significant digit.

7. Zero the preamplifier, with nothing connected to the input, by adjusting the pot labeled ZERO.
8. Connect the calibration fixture to the input of the preamplifier.

   Obtain the value of chamber sensitivity in dimensions of exposure per unit charge. Also, obtain the charge calibration factor for the host instrument in dimensions of charge per displayed exposure unit. Multiply these factors together to obtain a unitless correction factor as follows:

   $C_1$ (Rm/nC) x $C_2$ (nC/$R_d$) = F ($R_m$/$R_d$)

   Where $C_1$ and $C_2$ are the calibration factors for the chamber and the host instrument, respectively. F is the combined correction factor. The subscripts; m and d, attached to the Roentgen designation, indicate measured and displayed values. Therefore, the final unitless correction factor, multiplied by a displayed value yields the actual measured value.
9. Select the 30 $cm^3$ position chamber volume, using the rotary switch.
10. Adjust the 30 $cm^3$, gain potentiometer on the preamplifier until the value of F, calculated previously, appears on the display. The preamplifier is now calibrated for the specific chamber.

## 4.3 Troubleshooting

WARNING

Extreme care must be used when troubleshooting a system that has power applied. All standard troubleshooting precautions apply.

Once a problem has been located, remove all power before continuing with the repair.

CAUTION

Personnel performing the troubleshooting must be familiar with the operation of the system and the location of each piece of equipment used.

Troubleshooting consists of checking the wiring and verifying inputs/outputs are present on all connectors, if a problem develops with the Ion Chamber, return the chamber to Fluke Biomedical.

NOTE

If a problem cannot be resolved by applying the troubleshooting procedures described above, contact Fluke Biomedical at 440.248.9300 for assistance.

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