FLUKE®
Biomedical

Victoreen 07-494

Wide-Range Digital kVp Meter

Operators Manual

December 2006
Manual No. 168001 Rev. 4

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Section 1
General Information

1.1 Product Description

The Model 07-494 Wide-Range Digital kVp Meter (Figure 1-1) is a portable, battery operated unit which non-invasively measures the effective peak potential applied to a tungsten target diagnostic x-ray tube. It uses two differentially filtered x-ray detectors whose ratio of integrated outputs is calibrated over the ranges of 50 to 90 kVp and 80 to 150 kVp. The desired range is selected using the range selector on the top of the unit.

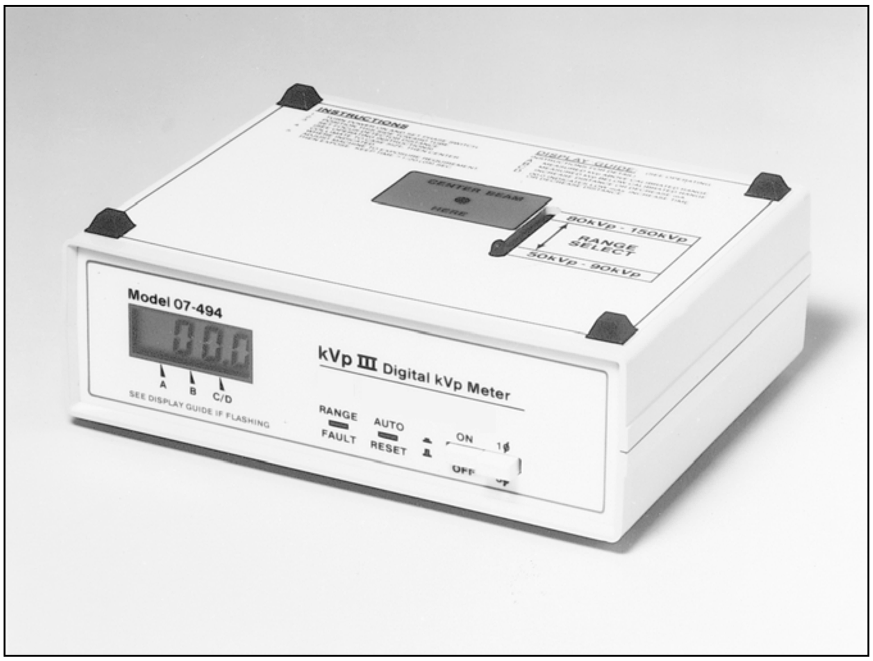

Figure 1-1. Model 07-494 Wide-Range Digital kVp Meter

1.2 Specifications

Range	**Low**: 50 kVp to 90 kVp **High**: 80 kVp to 150 kVp
Resolution	0.1 kVp
Accuracy	± 3% or 3 kV, whichever is greater (tungsten target x-ray tube with 4.5 mm Al total filtration)
mAs Requirements	See Figure 1-2
Reproducibility	± 1 kV or 1%, whichever is greater
Filtration Effects	**50 kVp - 90 kVp range:** less than 3.5% with 5.3 mm aluminum added **80 kVp – 150 kVp range:** less than 3% with 8 mm aluminum added
Calibration Frequency	One (1) year
Battery	**Type:** 9 V alkaline, NEDA 1604 (IEC 6F22) or alkaline equivalent **Life:** 75 hr. typical
Display	3 ½ digit, 0.5" high LCD with LO BAT indicator; **Below Range kVp:** Flashing middle decimal point **Above Range kVp:** Flashing left decimal point **Above Range mAs:** Flashing right decimal point **Below Range mAs:** Flashing right decimal point and 00.0 display
LED Indicators	**Auto Reset:** New exposure detected, last kVp reading cleared **Range Fault:** Range select sliding filter not properly engaged
Controls	**Power Switch:** ON/OFF **Phase Selection Switch:** Single phase/3 phase **Filter Range Selection Switch:** 50 to 90 kVp or 80 to 150 kVp
Connectors	BNC connector for waveform output
Dimensions (H x W x D)	2.5 in. x 8 in. x 6 in. (6.4 cm x 20.3 cm x 15.2 cm)
Weight	2.4 lbs. (1.1 kg)
Environmental Specifications	**Temperature:** **Operating:** 59 to 104° F (15 to 40° C) **Storage:** - 0 to 122° F (-18 to +55° C) **Relative Humidity:** **Operating:** 0 to 90% non-condensing **Storage:** 0 to 90% non-condensing

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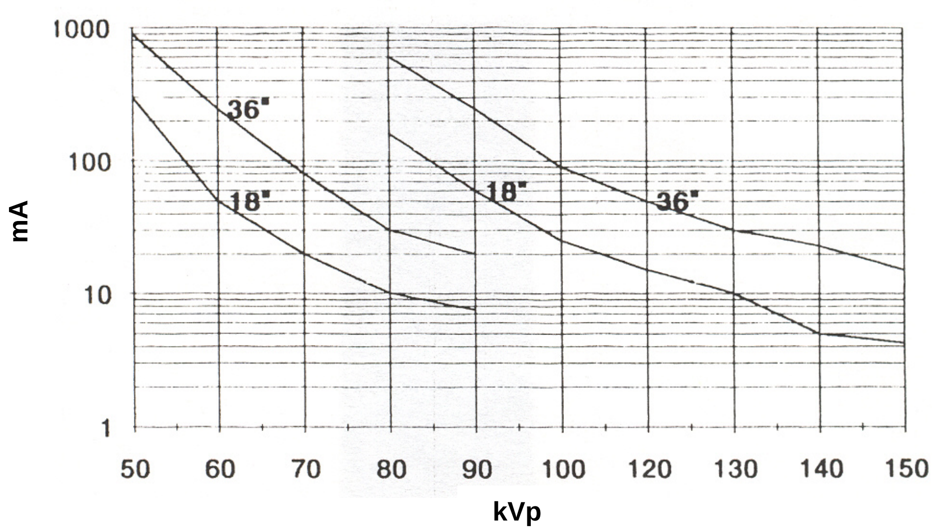

Figure 1-2. mAs vs. kVp, Minimum Requirements (Typical Single Phase X-ray Unit)

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Section 2
Getting Started

2.1 Receiving Inspection

Upon receipt of the instrument:

1. Inspect the carton(s) and contents for damage. If damage is evident, file a claim with the carrier and contact Fluke Biomedical, Radiation Management Services 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. The following items are shipped with the Model 07-494 kVp Meter
   a. Part No.168005, Model 07-494 kVp III.
   b. Part No.16-29, 9 V Alkaline Battery
   c. Part No.168001 Instruction Manual
   d. Part No. 010023 Registration Card

NOTE

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

2.2 Storage

If necessary to store the kVp meter prior to use, pack it in the original container if possible. Be sure the storage area is free of corrosive materials, vibrations, and fluctuations in temperature and humidity. Also be sure the environmental specifications (refer to Section 1-2, Specifications) are not exceeded.

2.3 Routine Cleaning

CAUTION

Do not immerse the Model 07-494 Wide-Range Digital kVp Meter. This unit is not waterproof. Liquid could damage the circuits. The unit should be kept clean and free of dirt and contamination. The unit may be cleaned by wiping with a damp cloth using any commercially available cleaning or decontaminating agent.

2.4 Indicators and Controls

Top Panel

The top panel (Figure 2-1) includes brief operating instructions, beam center indication, display guide for warning indicators A through D, and the range selector switch.

The range selector switch allows the operator to select the appropriate kVp range for the measurement. When the range selector is set to 80 - 150 kVp, a second filter pair is positioned above the photodiodes and a separate calibration is applied to the measurement circuit.

Front Panel

Refer to Figure 2-2 for front panel layout.

Numeric Readout: A 3-½ digit LCD display indicates the kVp value, provides warning status (flashing decimal points), and indicates low battery voltage (LO BAT). Warning indications are listed on the top panel and discussed further in Section 4, Operation.

Auto Reset LED: The auto reset LED is lit whenever the kVp Meter detects an x-radiation. The LED will be on for 0.5 seconds or for the duration of the exposure, whichever is greater. The previous reading is cleared when the LED turns on.

Range Fault LED: The range fault LED is lit whenever the range selector is between ranges or not properly engaged.

Power Switch (ON/OFF): The power switch is an alternate action switch used to turn the instrument on or off. The LCD readout is active when power is applied.

Phase Switch (1ϕ-3ϕ). The phase switch allows the operator to select either single phase (1ϕ) or three-phase (3ϕ) operation. When the phase switch is in the 1ϕ position, the displayed value corresponds to a single-phase waveform produced by a single-phase x-ray machine. When the phase switch is in the 3ϕ position, the displayed value is the single phase calibrated output multiplied by a constant to compensate for differences between 3 phase (or DC) and single phase waveforms.

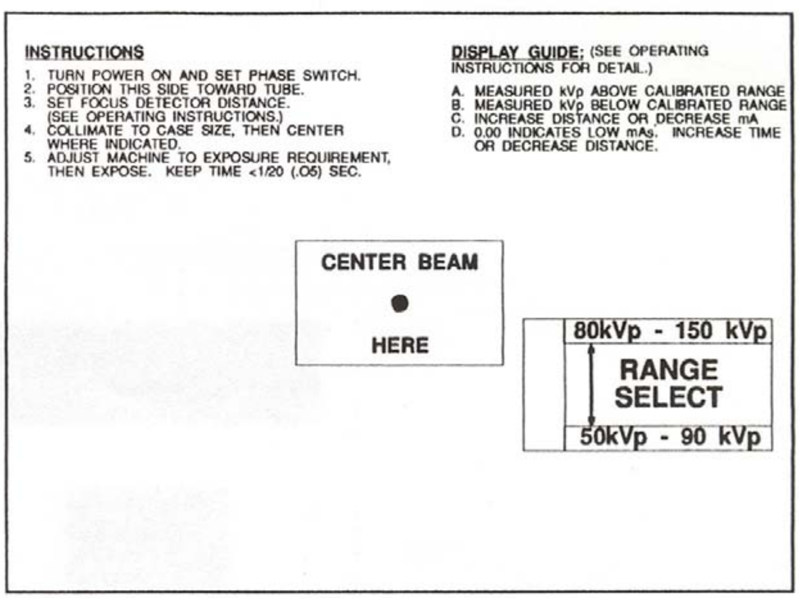

Figure 2-1. Top Panel

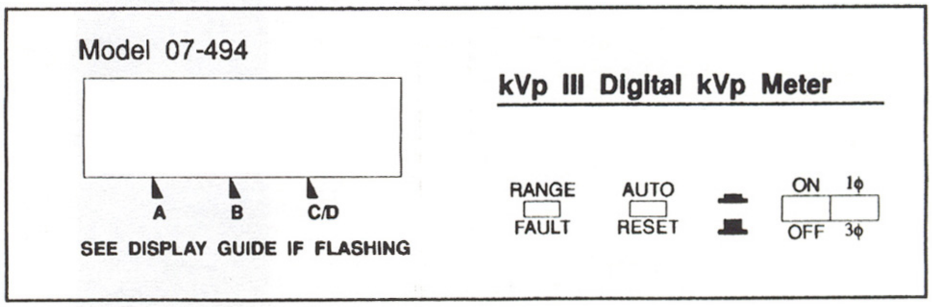

Figure 2-2. *Front Panel*

Rear Panel

Refer to Figure 2-3 for rear panel layout.

Battery Access Cover: The battery access cover is located on the rear panel. Refer to Section 5, Maintenance for battery replacement procedures.

NOTE

Be sure the unit is turned OFF before removing the batteries.

BNC Connector: A BNC connector, located on the rear panel, provides a signal from the radiation detection diodes. The signal can be observed on an oscilloscope during an exposure. However, the signal lasts only as long as the exposure. Therefore, a storage scope or camera is required to view the signal for extended periods of time.

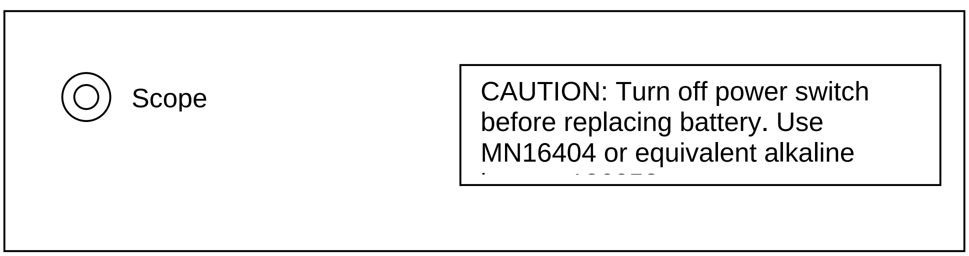

Figure 2-3. *Rear Panel*

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Section 3
Theory and Applications

3.1 General

The kVp measurement is computed from a measurement of the linear absorption coefficient (μ) of the hardened x-ray beam. As the kV increases, μ increases, as discussed in the following paragraphs.

An x-ray beam is composed primarily of two parts - the bremsstrahlung radiation and the characteristic radiation. Bremsstrahlung radiation predominates below 70 kV. When the beam potential crosses the 70 kV threshold, an apparent beam hardening takes place due to the sudden increase in the emission of higher energy x-rays. The linear absorption coefficient, μ, increases at continually faster rates until approximately 90 kV. Above 90 kV, the characteristic radiation becomes less important and contributes less hardening to the beam. The bremsstrahlung radiation again dominates, and μ increases at a slower rate. Use of dual range filters above 90 kVp helps minimize this effect.

3.2 Filtration Effects

A slight change in the beam spectrum being measured results in a change in the μ as described above. This change may be caused by filtration differences with respect to the calibration beam. With lower filtration, the x-ray beam is as hard as the calibration beam and the results are lower. With more filtration, the beam is harder than the calibration beam and the results are higher. Refer to Table 3-1.

Table 3-1. Filtration Effects

Selected Range	kVp	Display Increase (%/mm Al)
50 – 90 kVp	65 80	0.34 0.40
80 – 150 kVp	100 120	0.40 0.45

The results in Table 3-1 were reduced from data taken with a single-phase machine with 4 mm Al inherent filtration. The values in the display increase column represents the % change in displayed kV for each added mm Al filtration. The correlation coefficient (r) was above 0.99 for all curves. The filtration varied from 0 to 8 mm Al.

To correct the display for tube filtration above 4 mm Al, reduce the display by F% where:

F = (%/mm Al) x (Tube Filtration - 4 mm Al).

Use the %/mm Al value closest to the kVp results.

Tube filtration effects below 4 mm Al have not been studied. It is suggested for the best accuracy in kVp measurements that the tube filtration be increased to 4 mm Al if it is less than that. To test the filtration present on the tube, measure the HVL of the beam with 80 kVp set on the tube. For 80 kVp and 4 mm Al filtration, the HVL should be 3.5 mm Al. An HVL less than 3.5 mm Al indicates that the filtration is less than 4 mm Al.

3.3 Waveform Effects

Beam spectrum changes also occur with different waveforms. Single-phase waveforms display different readings than three phase waveforms, depending on the position of the range selector switch. Correction for waveform effect is made by selecting the appropriate position (i.e., single phase or three phase) using the front panel phase selection switch.

3.4 Focus to Detector Distance (FDD)

The Focus to Detector Distance (FDD) affects the mAs requirements as discussed in Section 3.5, mAs Requirements. Table 3-2 lists FDD settings generally used to keep the mAs requirement between 20 and 100. The FDD does not affect the accuracy of the kV results.

Table 3-2. FDD Settings

Selected Range	kVp	FDD
50 – 90 kVp	50 to 70 70 to 90	18 in. (45 cm) 36 in. (30 cm)
80 – 150 kVp	80 to 100 100 to 150	18 in. (45 cm) 36 in. (30 cm)

3.5 mAs Requirements

The curves in Figure 1-2 (see Section 1-2, Specifications) are provided as guidelines for selecting the mAs required for a particular kVp measurement. Any mAs beyond the required amount is not used in the measurement.

To determine the mAs required:

1. Locate the kVp to be measured on the horizontal axis.
2. Read the mAs from the selected FDD. It may be necessary to interpolate between distances using the inverse square law.

As examples:

For kVp = 70 and FDD = 18 in.,
the mAs = 20.

For kVp = 100 and FDD = 30 in.,
the mAs = (30 in. /36 in.) (30 in. /36 in.) 90 = 62.5

The curves in Figure 1-2 (see Section 1.2, Specifications) are derived from single-phase measurements. Three phase machines generally require 70% of the mAs determined from the curves.

Specific mAs requirements depend on the following factors:

- Detector sensitivity
- Tube filtration
- Radiation waveform
- FDD
- mAs errors in the x-ray machine

3.6 Detector Positioning

The kVp Meter should be positioned in the center of the beam. The measurement area of the meter is 2 square inches, and is located on the top panel of the unit. Measurements made on other parts of the beam will result in inaccurate readings due to the fact that the beam spectrum is different for different parts of the beam. The heel effect is an example of such a beam spectrum change. As an illustration of the effect of detector positioning, place the kVp meter in a selected part of the beam, make an exposure, and observe the displayed measurement. Then move the detector to another part of the beam, make another exposure, and observe the displayed measurement. Notice that the two measurements are significantly different.

3.7 Low Battery

A low battery indication is displayed when the battery voltage drops below a factory-preset value. The preset value is high enough that there is not an immediate noticeable effect on the measurement results. However, prolonged use of the Instrument in the low battery condition will result in decreased accuracy.

3.8 Applications

kVp Accuracy Determinations

With the Digital kVp Meter, it is possible to enter a diagnostic x-ray room and, within one minute, determine kVp accuracy for several stations of the x-ray machine. As a result, a significant cause of poor image quality can be immediately diagnosed without affecting patient throughput.

Calculating Generator Loading Effects

In an x-ray generator, when the load (mA) changes, the kV may also change. Often, the generator circuitry has been designed to compensate for this effect so that there is not a change in kV as different mA stations are selected. To test for this effect:

1. Determine the kV to be investigated and the maximum mA to be tested.
2. Determine the minimum mAs requirements for the kV from Figure 1-2 (see Section 1.2, Specifications).
3. Set the distance (FDD) such that the high-test mA and 50 ms (1/20 sec.) correspond to the minimum mAs requirements.
4. Make an exposure.

NOTE

If a low mAs indication appears on the kVp meter, set the timer to the next station.

5. Record the value displayed on the kVp meter.
6. Set the mA to the next lower position.
7. Increase the exposure time so that the mAs remains greater than or equal to the value determined in Step 3.
8. Make an exposure.
9. Record the value displayed on the kVp meter.
10. Compare the values recorded in Step 5 and Step 9 to determine how well the generator compensates for mA changes.

To eliminate time as a variable, decrease the FDD and mA while holding time constant. Utilizing the inverse square law:

$FDD_{NEW} = FDD_{MAX}$ X SQRT (mA_{NEW}/mA_{MAX}):

where:

FDD_{NEW} = FDD to be used with new mA,

FDD_{MAX} = FDD used with the maximum mA, and

SQRT = Square root.

kVp vs. Time Studies

During an x-ray exposure, the kVp may vary as a function of time. This can be illustrated by keeping the mA constant and changing the FDD to vary the measurement time.

The kVp Meter accumulates data until certain internal values are reached, and then it displays the result. The measurement time is independent of the generator time. For example, if the minimum mAs requirement for a particular kV position is 50, the mA is set to 500, and the exposure time is set to 1 second, the kVp meter will accumulate data only during the first 100 ms interval (=50 mAs). (Refer to the discussion in Section 3.5, mAs Requirements.) Nine tenths of the shot is wasted and the displayed result does not indicate what occurs during the tail end of the exposure. A greater portion of the total exposure can be included by increasing the mAs requirement by increasing FDD. There is no limit on maximum exposure time.

To implement this application:

1. Select the kV, the mA, and the longest exposure time to be studied. The product of the mA and time should correspond to the minimum mAs requirements determined from Figure 1-2 (refer to Section 1.2, Specification).
2. Set the FDD to correspond to the longest exposure time.
3. Make an exposure and record the results.
4. Decrease the FDD, which, in effect, decreases the exposure time according to the inverse square law.

   ISF = inverse square factor = SORT (TMAX)

   where,

   T= kVp measurement for the kVp, mA and distance values.
5. Make an exposure and record the results.

For a value of 65 kVp at a maximum FDD of 36 inches, using the low range filter set the minimum required mAs is 150 (from Figure 1-2).

If TMAX = 2 sec, tube current = (150 mAs/2 s) = 75 mA (Table 3-3). If TMAX = 0.5 sec, tube current = (150 mAs/0.5 s) = 300 mA (Table 3-4).

Table 3-3. kVp vs. Time Study at 75 mA

mA	T (sec)	ISF X FDD_{MAX}	FDD (Inches)	Measured kVp
75	2.000		36.0	
75	1.000	0.707	25.5	
75	0.500	0.500	18.0	
75	0.250	0.354	12.7	
75	0.1250	0.250	9.0	

Table 3-4. kVp vs. Time Study at 300 mA

mA	T (sec)	ISF X FDD_{MAX}	FDD (Inches)	Measured kVp
300	0.500	1.000	36.0	
300	0.250	0.707	25.5	
300	0.125	0.500	18.0	
300	0.067	0.365	13.1	

mAs Reciprocity Corrections

A mAs reciprocity examination of an x-ray system involves variation of the mA or time or both simultaneously. An ionization chamber (RAD-CHECK Plus, Model 06-526) is used to measure the output of the machine and mR values are then calculated. The mR values should be proportional to the mAs quantity. Normally the kV is held constant on the generator.

As discussed above, the kV may not be a constant function of mA and time if there is a malfunction in the machine.

When mAs reciprocity is being tested, noted variations in the mR value may be due to kV fluctuations as well as mA and timer nonlinearities. A simple correction for mAs reciprocity fluctuations due to kV changes can be made if the kV fluctuations are known. If the percent change in kV is small, the mR output will change as the square function of the kVp. That is, the percent change in mR output is double the percent change in kV over a small percentage range (Table 3-5).

Table 3-5. mAs Reciprocity

Measured kVp	mA	Time	mAs	mR	mR/mAs
80	100	0.1 s	10	160	16.0
82	300	0.1 s	30	525	17.5

In Table 3-5 there is a 9.4% increase in mR/mAs values. There is a 2.5% increase in kVp value which would contribute to an approximate 5% increase in mR output. The 94% non-linearity in mAs reduces to 9.4% -5% = 4.4% which is acceptable.

From this analysis, it is evident that the mA/kV compensation needs correction, whereas, without this analysis, the mA or time looks suspect. If the changes in kV and mAs are in the opposite direction, the mAs reciprocity results from the mR values may be very nearly linear and a simple reciprocity check would indicate that the machine seems to be functioning properly. However, the use of the kVp Meter would indicate the kV error and possibly an error in the mAs which was being cancelled out by the kV error.

Waveform Diagnostics

If the mA is held strictly constant, and filtration does not change through the exposure, then variations in the radiation waveform can be interpreted as variations in the kV waveform. It is difficult to reduce the kV waveform from a single detector waveform even if the mA is held strictly constant. Relative judgments can be made from the radiation waveform; however, absolute judgments should be avoided. For example, the maximum observed point on a radiation waveform corresponds to the maximum kV point in the waveform, but it may also be closely aligned to a maximum in the mA waveform.

The radiation waveform can exhibit symptoms of one or more type of malfunctions in an x-ray system as listed in to Table 3-6.

Table 3-6. Waveform Diagnostics

Problem	**Symptom**
Preheat problems	Waveform intensity continues to increase over the first few cycles.
Arcing	Waveform exhibits sharp rises and spikes with a duration of 10 to 1000 microseconds.
Overshoot Problems	Waveform exhibits overshoot on the first 2 or 3 pulses (3 phase machine).
Contactor Bounce	Waveform peaks contain noise or smaller peaks riding on major peaks.
Rectifier Imbalance	Relative peak heights are different and repeatable (i.e., one high and one low, or, in a three phase machine, high-medium-low, high-medium-low, high-medium-low.)
Load Effects	Waveform exhibits drooping during a long exposure.

Section 4
Operation

4.1 Making a Measurement

Use the following procedure to make a kVp measurement:

1. Turn the power switch to the ON position. The following should appear on the display:
   00.0

NOTE

If the low battery indication is displayed, or if the display fails to respond, replace the battery. Refer to Section 6, Maintenance for battery replacement procedures.

2. Set the phase switch to the single-phase (1ϕ) or three-phase (3ϕ) position according to the type of machine being measured.

NOTE

If a fluoroscopic or constant potential is being measured, set the switch to the three-phase (3ϕ) position. (For an x-ray machine operated in the fluoroscopic mode, the loading on the generator is much lighter than normal and the radiation spectrum more closely resembles that produced by a three-phase, rather than single-phase, generator.)

3. Set the range selector switch (located on the top panel) to the appropriate range for the kV to be measured.
4. Set the desired Focus to Detector Distance (FDD), using the guidelines listed in Table 4-1.

Table 4-1. FDD Settings

Selected Range	kVp	FDD
50 – 90 kVp	50 to 70 70 to 90	18 in. (45 cm) 36 in. (30 cm)
80 – 150 kVp	80 to 100 100 to 150	18 in. (45 cm) 36 in. (30 cm)

5. Collimate the beam to the case size, using the light field.
6. Position the detector so that it is centered in the beam as indicated on the top panel.
7. Determine the mAs value using the guidelines discussed in mAs Requirements (refer to Section 3, Theory and Applications).
8. Make an exposure and read the displayed kVp.

NOTE

If a kVp value is not displayed, try doubling the exposure time or decreasing the FDD by 30%.

9. Observe any displayed warnings, including flashing decimals or a low battery indication.

NOTE

Warning indications are interpreted on the top panel and in the following paragraphs.

The Digital kVp Meter has an auto reset feature. It senses when a new exposure takes place, resets the display for a new reading and turns on the Auto Reset LED for 0.5 seconds or the duration of the exposure, whichever is greater.

4.2 Interpreting Front Panel Warning Indications

Front panel warning indications are listed in Table 4-2.

A flashing decimal point above the A on the front panel indicates that the measured kVp is above the calibrated range; that is, the kVp is above 150 kVp with the range selector in the 80 to 150 kVp setting or above 90 kVp with the range selector in the 50 to 90 kVp setting.

A flashing decimal point above the B on the front panel indicates that the measured kVp is below the calibrated range; that is, that the kVp is below 80 kVp with the range selector in the 80 to 150 kVp setting or below 50 kVp with the range selector in the 50 to 90 kVp setting.

Indication	Explanation
A	Measured kVp > calibrated range.
B	Measured kVp < calibrated range.
C/D (Display ≠ 00.00)	Beam intensity too high; measurement time too short.
C/D Display = 00.0	Beam intensity too low; measurement time too long.

A flashing decimal point above the C/D on the front panel with a displayed value other than 00.0 indicates that beam intensity is too high and the measurement is completed with less than 50 ms of radiation waveform. Increase the FDD or decrease the mA to produce more accurate results. This is particularly important for single-phase x-ray machines because the radiation spectrum changes dramatically throughout e duration of 4 pulses. If the measured waveform contains less than 6 pulses of single-phase rectification, a partial pulse has a significant contribution to the value of the average of the pulses. It is less important for 3 phase machines because the radiation spectrum remains relatively constant throughout the exposure.

NOTE

For displayed values greater than 95 kVp a flashing decimal point above the C/D on the front panel may be impossible to avoid for any combination of mA or distances. The sensitivity of the kVp Meter above 95 kVp increases such that the mAs requirements become very low at short distances. More filtration can be added to the X-ray beam with the sacrifice of accuracy. Filtration effects are discussed in more detail in Section 3, Theory and Applications.

A flashing decimal point the C/D on the front panel with a displayed value equal to 00.0 indicates that the minimum mAs requirements have not been met. Increase either the time or the mA setting or decrease distance to obtain the required results.

4.3 Viewing the Waveform Output

The BNC connector on the rear panel provides a signal from the unfiltered radiation detection diodes in the kVp Meter. During the x-ray exposure, a voltage is present at the BNC connector and available for display on an oscilloscope. Examination of the waveform will require photographing it on a conventional oscilloscope or using a storage oscilloscope.

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Section 5
Calibration and Adjustment

This instrument has been factory calibrated. Recalibration should be performed by the factory or a qualified calibration facility every 12 months. Other than calibration, there are six potentiometers which may require adjustment. The procedures are outlined in this Section. Refer to Figure 5-1 for potentiometer location

5.1 Low Battery Threshold Adjustment

Potentiometer R25 adjusts the threshold for indicating LO BAT on the LCD display. Use the following procedure:

1. Open the battery compartment on the rear panel.
2. Remove and disconnect the battery.
3. Connect a voltmeter between battery plus (TP3).
4. Connect a voltmeter between battery plus (TP3) and analog ground (TP4).
5. Turn on the power supply and adjust it for 9 V.
6. Turn on the kVp Meter. The voltmeter should read between 2.4 V and 3.2 V.
7. Slowly decrease the power supply voltage until the voltage at the test point starts to drop (between 6.5 V and 7.5 V).
8. Slowly increase the power supply until the voltage across the test points just returns to the value it had prior to dropping off.
9. Turn R25 until LO BAT disappears from the display.
10. Turn R25 slowly in the opposite direction just until LO BAT reappears on the display.
11. Connect the voltmeter between analog ground and the power supply negative terminal.
12. Increase the power supply voltage until the voltmeter reads 4.5 V, being careful not to exceed 9 V from the power supply. LO BAT should turn off at this point.
13. Replace the battery and close the battery compartment.

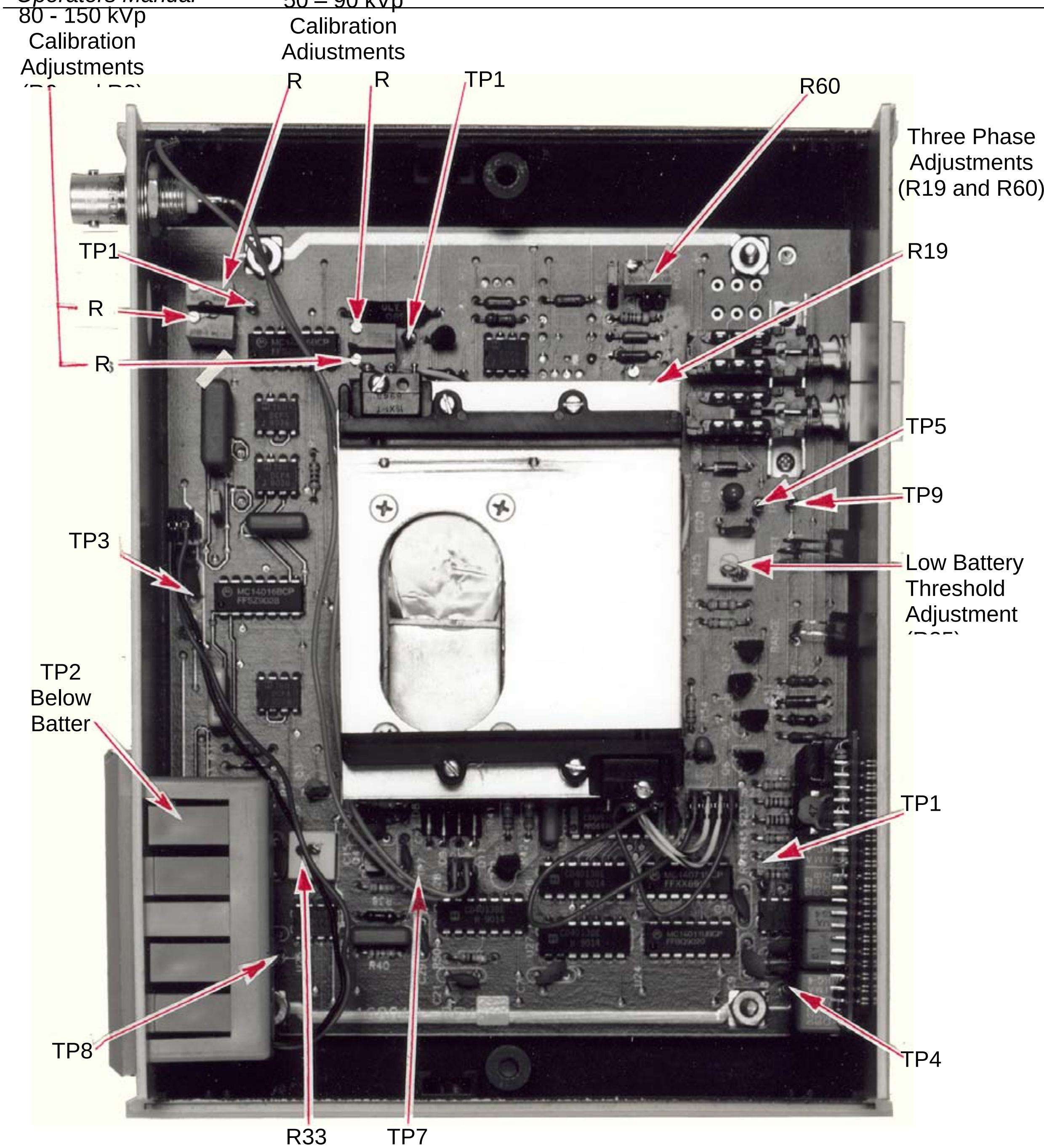

Figure 5-1. Adjustment and Test Point Locations

5.2 End of Shot Adjustment

R33 provides adjustment of the radiation detection diode sensitivity. Use the following procedure:

1. Connect the positive lead of a DVM to TP3.
2. Connect the negative lead of the DVM to TP4.
3. Record the DVM reading.
4. Connect the positive lead of the DVM to TP8.
5. Adjust R33 to obtain a reading on the DVM equal to 50% of the reading recorded in Step 3 (at TP3).

NOTE

The reading obtained in Step 5, after adjustment of R33 should be between 1.2 and 1.5 V.

5.3 50 - 90 kVp Calibration

The adjustments for the 50 - 90 kVp range are R4 and R5. An independent accurate means of measuring the kVp of the x-ray machine is necessary for proper calibration. The kVp meter must be calibrated at 50 kVp and 85 kVp (+1%) to be within specification. Use the following procedure:

1. Set the front panel phase switch for single-phase or three-phase depending on the type of x-ray machine used for calibration.
2. Set the range selector switch to the 50 - 90 kVp range.
3. Remove the cover from the meter.
4. Locate the meter at an FDD of 24 inches.
5. Set the x-ray machine to 50 kVp, 300 mA, and 1.5 seconds.
6. Make an exposure.
7. Adjust R5 until the display reads 50 kVp.
8. Set the x-ray machine to 85 kVp, 300 mA, and 0.3 seconds.
9. Make an exposure.
10. Adjust R4 until the display reads 85 kVp.
11. Repeat Steps 5 through 10 until the readings are accurate.

5.4 80 - 150 kVp Calibration

The two adjustments for the 80 kVp to 150 kVp range are R3 and R6. In this range the kVp meter must be calibrated at 85 kVp and 140 kVp (±1%) to be within specification. Use the following procedure:

1. Set the front panel phase switch for single-phase or three-phase depending on the type of x-ray machine used for calibration.
2. Set the range selector switch to the 80 - 150 kVp range.
3. Remove the cover from the meter.
4. Locate the meter at an FDD of 24 inches.
5. Set the x-ray machine to 85 kVp, 50 - 100 mA, and 0.3 seconds.
6. Make an exposure.

7. Adjust R6 until the display reads 85 kVp.
8. Set the x-ray machine to 140 kVp, 50 mA, and 0.3 seconds.
9. Make an exposure.

NOTE

If the C/D decimal point is flashing, indicating that the intensity of the exposure is too high, decrease the mA or increase the FDD and repeat the exposure.

10. Adjust R3 until the display reads 140 kVp.
11. Repeat Steps 5 through 10 until the readings are accurate.

Section 6
Maintenance and Troubleshooting

6.1 Battery Replacement

When the internal battery no longer provides sufficient voltage for proper operation, a LOW BAT indicator will appear in the upper left corner of the display. When this indication appears replace the battery as follows:

1. Turn the power OFF.
2. Open the battery compartment on the rear panel.
3. Remove and disconnect the old battery.
4. Insert and connect a fresh 9 V NEDA type 1604 (or equivalent) battery.
5. Snap the battery compartment door closed.

6.2 Accessing the Circuit Boards

Use the following procedure to gain access to the circuit board components and test points:

NOTE

Refer to Figure 5-1 (see Section 5, Calibration and Adjustments) for adjustment and test point locations.

1. Remove the two screws from the case bottom.
2. Carefully lift the top cover to expose the circuit board.
3. If necessary, remove the four screws which attach the slide filter to the circuit board to gain access to the circuitry below the slider.
3. If required, remove the circuit board by removing the 4 nuts which hold it in the lower case.

To reassemble the unit:

1. Position the circuit board so that the mounting holes align with the screws in the lower case.
2. Position the standoff on the diode lead shield and attach the slide filter plate.
3. Carefully fit the top and bottom covers together.
4. Replace the two cover screws

6.3 Performance Verification (Calibration Constancy)

In this section, two methods are described for verifying the accuracy of the kVp meter. Both methods require a careful collection of installation data and periodic re-measurement of that data. The voltage divider method is more direct than the multiple x-ray machine method. However, if at least five x-ray machines are used in the multiple machine test, the results are very positive.

Voltage Divider Method

If available, an x-ray voltage divider should be used concurrently during the initial testing of the kVp Meter.

1. Choose two x-ray machines suited for the test. It is recommended that different types of machines be used (e.g., use one three phase machine and one single phase machine).
2. Make comparative measurements of the voltage divider and the kVp Meter.
3. If an oscilloscope is used to measure the voltage divider, use an independent voltmeter to measure the scope sensitivity each time.

NOTE

Data with a kVp test cassette may be useful. Be sure to note positioning error and film usage when using the cassette.

4. Record all parameters of the measurement, including geometry, cable connections, tube ID, generator ID, divider and kVp Meter waveform oscilloscope pictures, oscilloscope and voltmeter ID.
5. Periodically (every 6 months) or when a serious discrepancy occurs, repeat Steps 1 through 4 to determine which piece of equipment is in error.

NOTE

If two dissimilar x-ray machines are used, the possibility of a systematic error is reduced. The kVp Meter, divider, cassette results, and x-ray settings should also be examined for constancy.

Multiple X-Ray Machine Method

If a voltage divider is not available, the following method may be used:

1. Choose several (if possible, at least five) x-ray machines suited for the test.
2. Make comparative measurements with each machine.

NOTE

Data with a kVp test cassette may be useful. Be sure to note positioning error and film usage when using the cassette.

3. Record all parameters of the measurement, including geometry, cable connections, tube ID, generator ID, and kVp Meter waveform oscilloscope pictures, oscilloscope, and voltmeter ID.

4. Periodically (every 6 months) or when a serious discrepancy occurs, repeat Steps I through 3 to determine which piece of equipment is in error.

NOTE

If the kVp meter suddenly produces different results from previous tests on only one machine, then there is a strong probability that the kVp Meter is operating correctly. If all of the x-ray measurements suddenly change, then the kVp Meter may not be operating correctly.

6.4 Verifying Supply Voltages

Troubleshooting the kVp meter consists of verifying the supply voltages.

Equipment recommended for troubleshooting the kVp Meter includes:

1. A digital voltmeter (Fluke Model 77 or equivalent).
2. A storage oscilloscope (Tektronix Model 2430 or equivalent).

Use the following procedure:

1. Connect the DVM negative lead to TP4 (circuit ground).

NOTE

All measurements will be made with reference to TP4.

2. Apply power to the unit under test.
3. Test for the voltages listed in Table 7-1.
3. If any of the voltages cannot be verified, replace the faulty component (refer to the comments column of Table 7-1).

The waveforms in Figures 6-2, 6-3, and 6-4 are provided for reference.

Table 6-1. Test Point Voltages

Test Point	Voltage	Comments
TP3	2.4 to 3.2 V	Derived from U101 on VRM board.
TP5	-5.0 to 6.0 V	Derived from U101 on VRM board.
TP10	1.2 to 1.6 V	Derived from voltage divider R22, R23

CH1 = TP1

CH2 = TP8

Setup: Single phase x-ray machine

74.5 kVp @ 300 mA

28 “ SDD

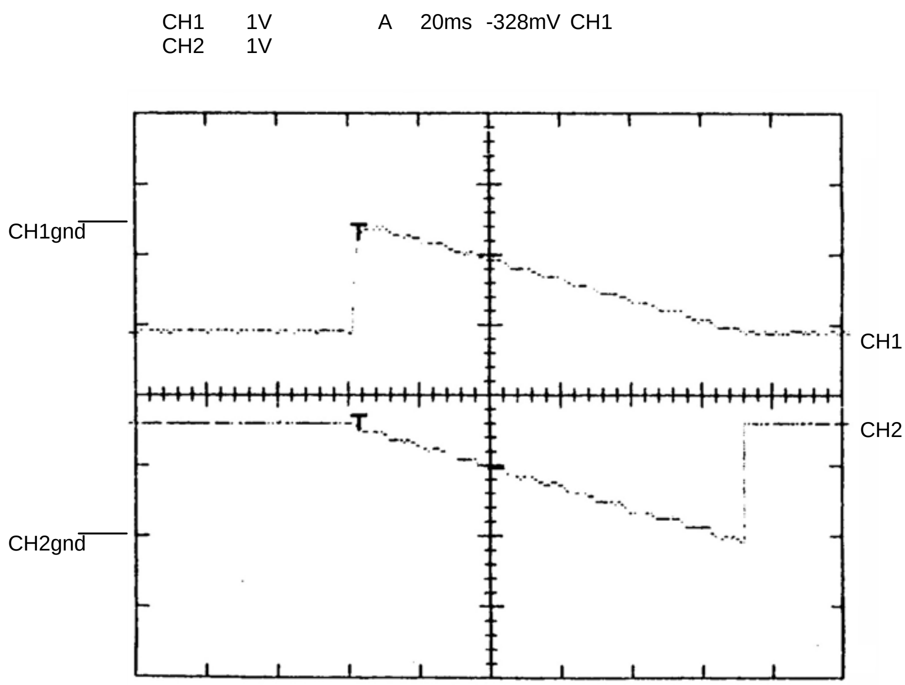

Figure 6-2. Oscilloscope Waveform A

CH1 = TP1

CH2 = TP9

Setup: Single phase x-ray machine

74.2 kVp @ 300 mA

28 " SDD

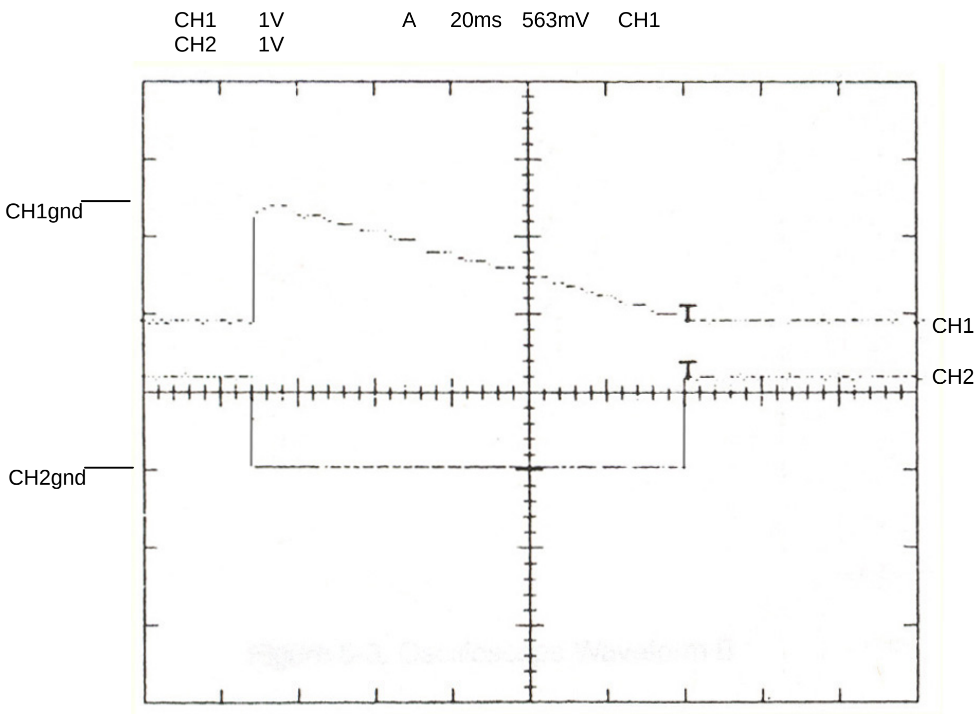

Figure 6-3. Oscilloscope Waveform B

CH1 = TP1

CH2 = TP2

Setup: Single phase x-ray machine

75.5 kVp @ 300 mA

28 " SDD

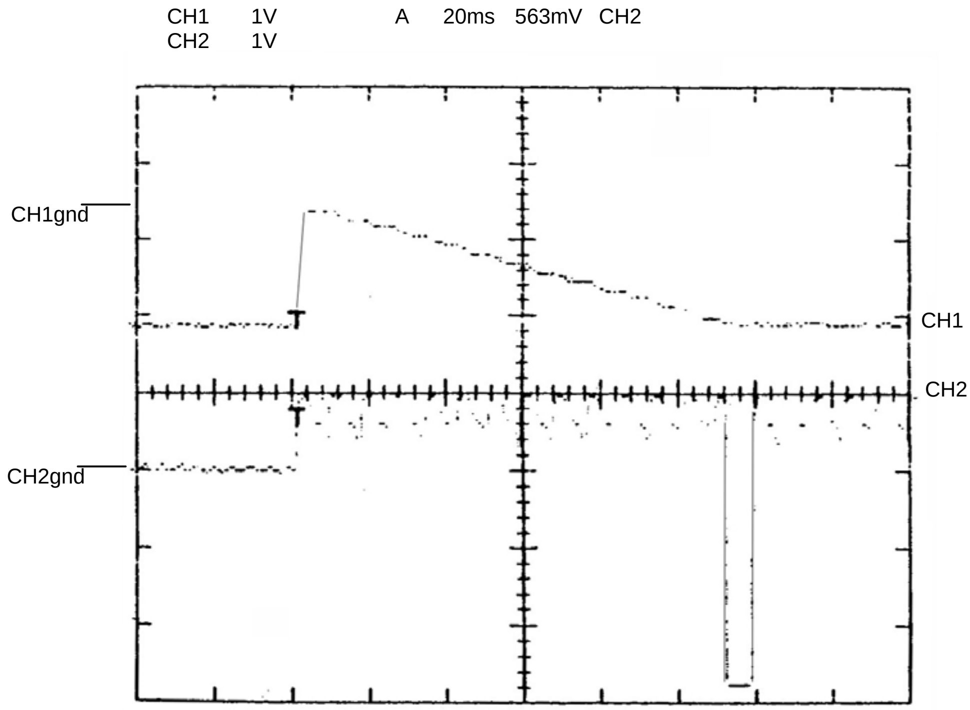

Figure 6-4. Oscilloscope Waveform C

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