

**LUDLUM MODEL 194 SERIES
DOSE EQUIVALENT RATE METER**

June 2021

Serial Number 350220

and Succeeding Serial Numbers

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LUDLUM MEASUREMENTS, INC
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS 79556
325-235-5494, FAX: 325-235-4672

STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.

RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

**LUDLUM MEASUREMENTS, INC.
ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556**

**800-622-0828 325-235-5494
FAX 325-235-4672**

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Section
1

Introduction

The Ludlum Model 194 DOSE EQUIVALENT RATE METER is designed to accurately measure gamma radiation doses. It utilizes a special plastic scintillator that converts the radiation to visible light, which is then measured and displayed. It is very sensitive and can measure background levels of radiation as well as higher levels.

The Model 194 is similar to a Micro R meter in sensitivity, but has a flat energy response and measures ambient dose equivalent, not exposure. Most Micro R meters utilize sodium iodide (NaI), which over-responds to many common gamma ray energies, causing incorrect high readings. The Model 194 measures dose, specifically ambient dose equivalent, and has a response that is relatively flat over the most common gamma ray energies. See Figure 1.

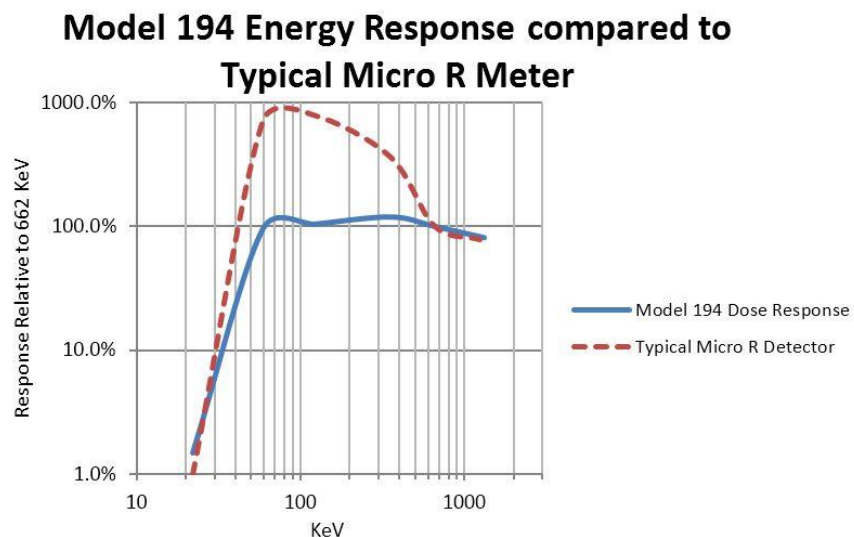


Figure 1. Energy Response Comparison

The Model 194 is built for rugged use, featuring a well-built aluminum body and splash-proof seals on all switches. It is also simple to use, with no firmware or software built into the instrument.

The Model 194 can measure in units of $\mu\text{rem/hr}$ (mrem/hr in the high range) or in the SI units of $\mu\text{Sv/h}$. It features a 3 1/2 digit digital liquid crystal display (LCD) with large, easy-to-read digits. A backlight toggle switch illuminates the display under low lighting conditions.

The Model 194 detector is located inside the aluminum “can” and well protected against shock and possible damage. The “/E” variant is built for extremely low levels of energy. The detector extends from the aluminum can and has a low-energy metallized polyester window to enhance sensitivity for gamma rays in the 10-60 keV range. A vinyl cap covers and protects the thin window when not being used.

The Model 194 is powered by two AA alkaline batteries, located in a sealed compartment on the front panel. Battery life will depend on many factors but is typically 200 hours under typical conditions.

There are options available to add to this instrument's versatility, including a headphone modification (part # 4475-118) and a shoulder strap (part # 4475-120).

This manual encompasses the Model 194 Series, which includes the Model 194 ($\mu\text{rem/hr}$ display and internal detector), the Model 194/E ($\mu\text{rem/hr}$ display and extended detector), the Model 194/S ($\mu\text{Sv/h}$ display and internal detector), and the Model 194/SE ($\mu\text{Sv/h}$ display and extended detector).

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2

Getting Started

Unpacking and Repacking

Remove the calibration certificate and place it in a secure location. Remove the instrument and ensure that all of the items listed on the packing list are in the carton. Check individual item serial numbers and ensure calibration certificates match. The Model 194 serial number is located on the side of the unit.

To return an instrument for repair or calibration, provide sufficient packing material to prevent damage during shipment. Be aware that the thin mica window of the detector may be damaged (imploded) because of pressure differentials if the unit is shipped by air. Protect the unit by putting it inside a sealed can or other protective enclosure.

Every returned instrument must be accompanied by an **Instrument Return Form**, which can be downloaded from the Ludlum website at www.ludlums.com. Find the form by clicking the "Support" tab and selecting "Service Department" from the drop-down menu. Then choose the appropriate Repair and Calibration division where you will find a link to the form.

Note:

Ludlum Measurements, Inc. recommends recalibration at intervals no greater than one year, assuming that regular operational checks are performed. Check the appropriate local, state, and federal regulations to determine required recalibration intervals.

Description of Controls and Functions

Range Selector Switch: A four-position rotary switch marked OFF, BAT, LO, and HI. Turning the range selector switch from OFF to BAT position provides the operator with a battery check of the instrument (see BAT OK lamp function below). Moving the range selector switch to the LO range

position provides the operator with a full-scale reading of 1999 $\mu\text{rem/hr}$ (or 19.99 $\mu\text{Sv/h}$). Moving the range selector switch to the HI range position provides the operator with a full-scale reading of 199.9 mrem/hr (or 1999 $\mu\text{Sv/h}$).

BAT OK lamp: illuminates when the main rotary switch is in the BAT position and when the battery voltage is above 2.1 volts. **NOTE:** Batteries should be replaced if the lamp becomes dim or does not illuminate.

Range Calibration Adjustments: Recessed potentiometers located under the calibration cover (CAL), on the left side of the front panel.

AUD: controls starting point of audio frequency. When completely counter-clockwise, audio is quiet until approximately 100 $\mu\text{rem/hr}$ (1 $\mu\text{Sv/h}$). When completely clockwise, frequency is approximately 3 kHz at background levels of radiation. Typically adjusted to get a few clicks at background levels of radiation.

L-HV: controls detector voltage for low range, typically set to calibrate the high point (~80%) of full-scale reading

LZERO: controls linearity for low range, set at background or at a low point (~10%) of full-scale reading

H-HV: controls detector voltage for high range, typically set to calibrate the high point (~80%) of full-scale reading

HZERO: controls linearity for high range, set at background or at a low point (~10%) of full-scale reading

AUDIO: At low readings, the audio clicks. At higher readings, a continuous tone with increasing frequency as meter reading increases.

AUDIO ON/OFF: Switches audio on or off.

F-S toggle switch: Selecting the fast, "F," position of the toggle switch provides 90% of full-scale meter deflection in 3 seconds. In the slow, "S," position, 90% of full-scale meter deflection takes 15 seconds. The "S" position should be used for slow response and more accurate measurements.

LAMP ON/OFF: turns display backlight on or off.

Center of Detector: The center of the internal detector is indicated by shallow dimples in the instrument's "can," located under the display. The center of the extended detector for the /E or /SE version is on the centerline of the extended cylinder and at the point where the cylinder meets the can.

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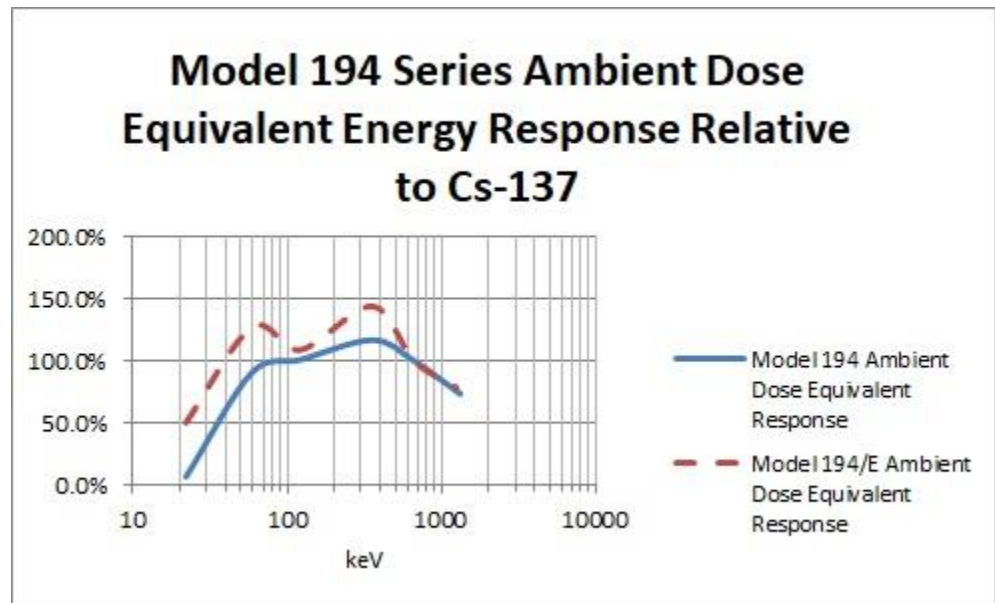
3

Specifications

Detector: 3.2 x 3.2 cm (1.25 × 1.25 in.) lead-loaded plastic scintillator

Linearity: ±10%

Energy Response (Model 194 and 194/S only): energy-flat within 30% ambient dose equivalent from 50 to 1300 keV, relative to ¹³⁷Cs response



Detector Voltage: adjustable from front panel calibration controls during calibration, variable from approximately 250 to 1200 Vdc

Operating Voltage: two ranges, LO and HI

LO: 0 to 1999 μ rem/hr or 0.00 to 19.99 μ Sv/h

HI: 0.0 to 199.9 mrem/hr or 0 to 1999 μ Sv/h

Response Time: in the F (fast) position, response time is 3 seconds, and 15 seconds in the S (slow) position; both measurements made for a response from 10% to 90% of the final reading

LCD Display: 3 ½ digit LCD, digit height 10.2 mm (0.4 in.), 0-2 V input, with over-range indication (leftmost “1” and no other digits)

Battery Dependence: instrument calibration change of less than 3% from fresh batteries to batteries at the threshold of BAT OK, see below.

Power: standard alkaline "AA" cell batteries, secured in an isolated compartment

Battery Life: typically 200 hours without backlight or audio

BAT OK: The BAT position of the main rotary switches shows the battery voltage on the display and turns on the green LED when battery power is good. When battery power is less than 2.1 V, the green LED will not light and the user should immediately replace batteries.

Audio Output: built-in unimorph speaker and AUD ON/OFF switch provided on the front panel

Audio: increasing radiation levels indicated by higher frequency pitch; enabled or disabled by the AUD ON/OFF switch

Temperature: from -10 to 50°C (14 to 122°F). Display will tend to "freeze" if kept below 0 °C (32 °F) for several hours, so users should limit cold temperature exposure to less than two hours.

Environmental Rating: water resistant, IP rating of 65

Construction: aluminum with beige powder-coat finish and silk-screened nomenclature

Size: 19 x 8.9 x 21.6 cm (7.5 x 3.5 x 8.5 in.) (H x W x L)

Weight: 1.1 kg (2.5 lb), including batteries

Section

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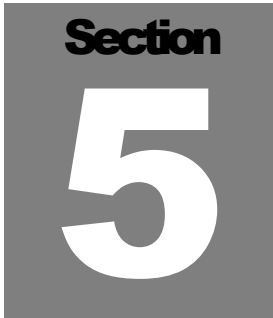
Operating Procedures

Note:

To open the battery lid, twist the slotted, knurled knob counter-clockwise a quarter of a turn. To close, twist clockwise a quarter of a turn.

- Open the lid and install two "AA" size batteries. Note the (+) (-) marks on the bottom of the battery holder. Match the battery polarity to these marks.
- Close the battery box lid.
- Turn the instrument range selector switch to BAT. The BAT OK lamp should illuminate. The display will also show the battery voltage. If the lamp does not illuminate, recheck to be certain that the batteries have proper polarity or replace batteries with fresh batteries.
- Turn the instrument to the LO position. In a non-radiation area, it should show background radiation levels, approximately 10 $\mu\text{rem/hr}$ or 0.1 $\mu\text{Sv/h}$.
- If available, expose the instrument to a gamma check source, placing the source in a reproducible position and distance relative to the detector. If the display over-ranges (showing a leftmost "1" and no other digits), move the rotary switch to the HI position. Confirm that the instrument responds and/or confirm that the check source reading is similar to the last measurement of the check source.
- If used, check the audio by switching the toggle switch AUD to the ON position and verify operation. Optionally, check that backlight works by switching the LAMP switch to the ON position.

- Proceed to use instrument. Use the LO range whenever possible, and switch to the HI range if needed. If the display over-ranges in the HI range, use another instrument to measure the radiation level.

A dark gray square containing the word "Section" in a bold, black, sans-serif font at the top, and a large, white, bold, sans-serif number "5" in the center.

Calibration

Calibration controls are under the CAL cover on the front panel. The controls may be adjusted with an 1/8-inch blade screwdriver.

Non-Radiation Adjustment

AUDIO CALIBRATION: Potentiometer marked AUD may be adjusted as desired. Default setting is to adjust to 2-5 clicks per second with detector at background levels of radiation. If audio potentiometer is set completely counter-clockwise, audio is completely quiet until approximately 100 $\mu\text{rem/hr}$ (1.0 $\mu\text{Sv/h}$).

Calibration Equipment Required

- All instruments used in calibrating the Model 194 must be calibrated by standards traceable to the National Institute of Standards and Technology and must have a current calibration label attached.
- A voltmeter or multimeter, capable of measuring DC voltage from 0.1 mV to 10 V
- A ^{137}Cs gamma range with beta shield, capable of producing a gamma field from 100 $\mu\text{rem/hr}$ to 200 mrem/hr (2 $\mu\text{Sv/h}$ to 2 mSv/h). For the overload check, a source that is ten times bigger is needed.

Initial Calibration Procedures

1. If any calibration procedure cannot be completed satisfactorily, the instrument should be tagged and removed for proper disposition.
2. A "low" gamma background radiation area is needed, defined as an area away from known radiation sources, measuring 15 uR/hr (0.15 μ Sv/h) or less.
3. Ensure that the AA batteries measure at least 2.4 Vdc (turn rotary switch to BAT and battery voltage is shown on LCD). Verify green LED labelled BAT OK illuminates.
4. Check to see if the instrument is marked for international units of μ Sv/h, and if so, ensure that the internal dipswitch SW5 is set for position 1 ON and position 2 OFF. Otherwise, internal dipswitch SW5 is set for position 1 OFF and position 2 ON.
5. Remove the CAL cover on the front panel to access the calibration potentiometers. Open the instrument to access the test points on the main board. Each test point is labelled.

For first time calibration only: In a low-background area with the detector connected, use the voltmeter to measure the following points, and adjust the appropriate calibration potentiometer to the target voltage, in this order:

CAL POT	TESTPT	TARGET
L-HV	HVL	0.750 Vdc
H-HV	HVH	0.500 Vdc

Switch the rotary RANGE switch to LO to adjust LZERO until display shows approximately 5 μ rem/hr (or 0.05 μ Sv/h).

Switch the rotary RANGE switch to HI to adjust HZERO until display reads zero.

Cs-137 Gamma Range Calibration

1. Switch the instrument to LO range.
2. Ensure that the center of the detector is correctly placed and expose the instrument to a calibrated field of 1500 $\mu\text{rem/hr}$ (15 $\mu\text{Sv/h}$). Adjust the front-panel potentiometer marked L-HV until the instrument LCD shows 1500 $\mu\text{rem/hr}$ (15.00 $\mu\text{Sv/h}$) within 10%.
3. Change the calibrated field to 150 $\mu\text{rem/hr}$, expose the detector and adjust the front-panel control marked LZERO until the LCD shows 150 $\mu\text{rem/hr}$ (1.50 $\mu\text{Sv/h}$) within 10%. For a less “jumpy” reading, toggle the F/S switch to S (slow).
4. Switch the instrument to HI range.
5. Ensure that the center of the detector is correctly placed and expose the instrument to a calibrated field of 150 mrem/hr (1500 $\mu\text{Sv/h}$). Adjust the front-panel potentiometer marked H-HV until the instrument LCD shows 150.0 mrem/hr (1500 $\mu\text{Sv/h}$) within 10%.
6. Change the calibrated field to 15.0 mrem/hr , expose the detector and confirm that the LCD shows 15.0 mrem/hr (150 $\mu\text{Sv/h}$) within 10%. IF necessary, adjust the potentiometer marked HZERO in order to correct the reading. For a less “jumpy” reading, toggle the F/S switch to S (slow).
7. Document all four readings above on an appropriate calibration certificate.
8. Open the can of the instrument and use the voltmeter or multimeter to measure the DC voltages at the test points marked HVL and HVH, and document these voltages on the appropriate calibration certificate.

Cs-137 Gamma Range – Overload Check

1. If desired, place the instrument in a high radiation field equal to 10 times the highest measurable value. For the Model 194, this field would be 2000 mrem/hr or 20 mSv/h .
2. Confirm that the instrument, in either LO or HI range, displays the overload symbol on the display (a leftmost single digit “1”). Document on the calibration certificate that this test was performed.

Note:

It may take the instruments a few (less than 5) minutes to recover and measure low radiation fields properly after this overload test.

Section

6

Safety Considerations

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude

Temperature range of -10 to 50 °C (14 to 122 °F). Display will tend to “freeze” if kept below 0 °C (32 °F) for several hours, so users should limit cold temperature exposure to less than two hours.

Maximum relative humidity of less than 95% (non-condensing)

Pollution Degree 3 (as defined by IEC 664): (Occurs when conductive pollution or dry nonconductive pollution becomes conductive due to condensation. This is typical of industrial or construction sites.)

Warning Markings and Symbols

Caution!

The operator or responsible body is cautioned that the protection provided by the equipment may be impaired if the equipment is used in a manner not specified by Ludlum Measurements, Inc.

The Model 194 DOSE EQUIVALENT RATE METER is marked with the following symbols:



CAUTION (per ISO 3864, No. B.3.1): designates hazardous live voltage and risk of electric shock. During normal use, internal components are hazardous live. This instrument must be isolated or disconnected from the hazardous live voltage before accessing the internal components. This symbol appears on the front panel. Be sure to take the precautions noted in the next section whenever necessary.



The “**crossed-out wheeie bin**” symbol notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding. Each material must be separated. The symbol is placed on the label located on the side panel. See section 8, “Recycling,” for further information.

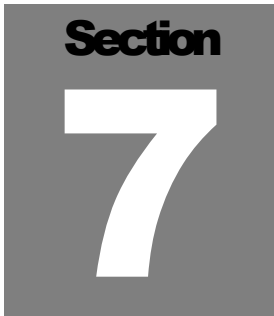


The “CE” mark is used to identify this instrument as being acceptable for use within the European Union.

Cleaning and Maintenance Precautions

The Model 194 may be cleaned externally with a damp cloth, using only water as the wetting agent. Observe the following precautions when cleaning or performing maintenance on the instrument:

1. Turn the instrument OFF and remove the batteries.
2. Allow the instrument to sit for one minute before cleaning the exterior or accessing any internal components for maintenance.



Spare Parts List

Item	Part #
Model 194 DOSE EQUIVALENT RATE METER	48-4364
Model 194/S DOSE EQUIVALENT RATE METER with $\mu\text{Sv/hr}$ Display	48-4364-1
Model 194/E DOSE EQUIVALENT RATE METER with Extended Detector	48-4388
Model 194/SE DOSE EQUIVALENT RATE METER with Extended Detector with $\mu\text{Sv/hr}$ Display	48-4388-1
Portable Calibration Cover	9363-200
LCD DMS-30LCD-1-5B-C with Retainer Ring	07-6212
Switch-Seal N9030-1/4 Shaft Seal	08-6615
Switch-Seal N5032B Toggle Boot (3 ea.)	08-6692
Model 194 Main Board	5475-090
Model 44-225 Lead Loaded Scintillator Detector	47-4363
EJ560-1.10 x 2 mm Optical Pad	01-5804
Model 194 1.14 inch PMT Volts 200A/lm	01-6002
Model 194 1 1/8 inch Voltage Divider Circuit Board	5519-461
Model 194 -HV Circuit Board	5519-466
Sponge	7002-065-04
Detector Housing	7511-468
Detector Cap	8475-107

Section

8

Recycling

Ludlum Measurements, Inc. supports the recycling of the electronics products it produces for the purpose of protecting the environment and to comply with all regional, national, and international agencies that promote economically and environmentally sustainable recycling systems. To this end, Ludlum Measurements, Inc. strives to supply the consumer of its goods with information regarding reuse and recycling of the many different types of materials used in its products. With many different agencies – public and private – involved in this pursuit, it becomes evident that a myriad of methods can be used in the process of recycling. Therefore, Ludlum Measurements, Inc. does not suggest one particular method over another, but simply desires to inform its consumers of the range of recyclable materials present in its products, so that the user will have flexibility in following all local and federal laws.

The following types of recyclable materials are present in Ludlum Measurements, Inc. electronics products, and should be recycled separately. The list is not all-inclusive, nor does it suggest that all materials are present in each piece of equipment:

Batteries	Glass	Aluminum and Stainless Steel
Circuit Boards	Plastics	Liquid Crystal Display (LCD)

Ludlum Measurements, Inc. products that have been placed on the market after August 13, 2005, have been labeled with a symbol recognized internationally as the “crossed-out wheelie bin,” which notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding. Each material must be separated. On the Model 194, the symbol will be placed on the serial number label located on the side of the instrument.

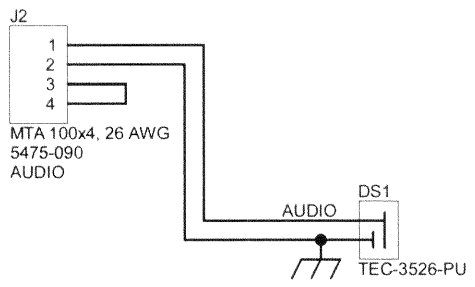
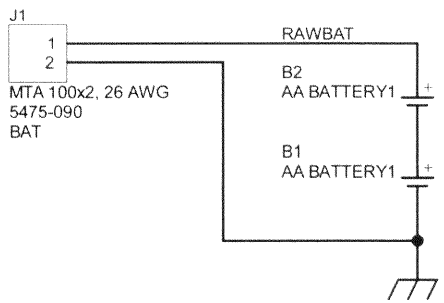
The symbol appears as such:



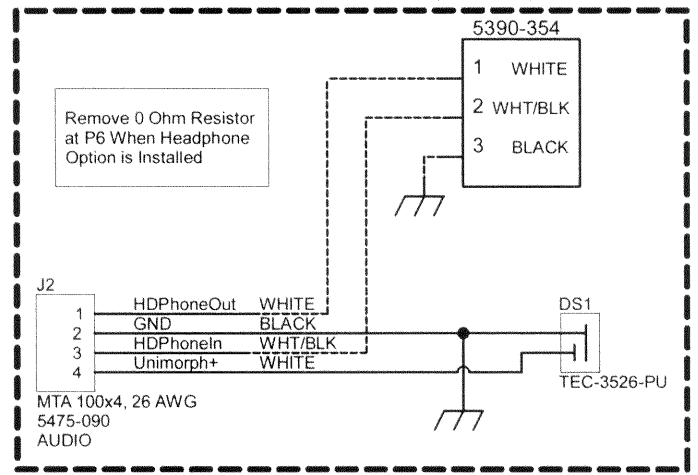
Section
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Drawings and Diagrams

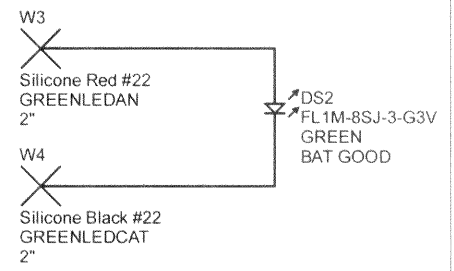
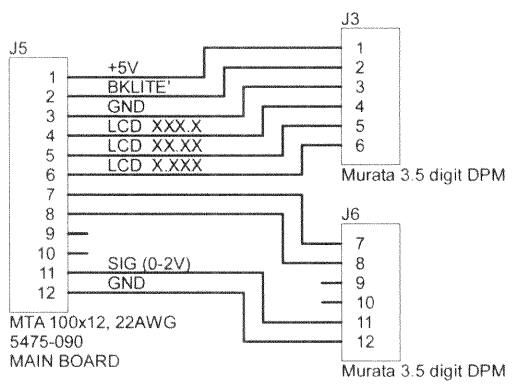
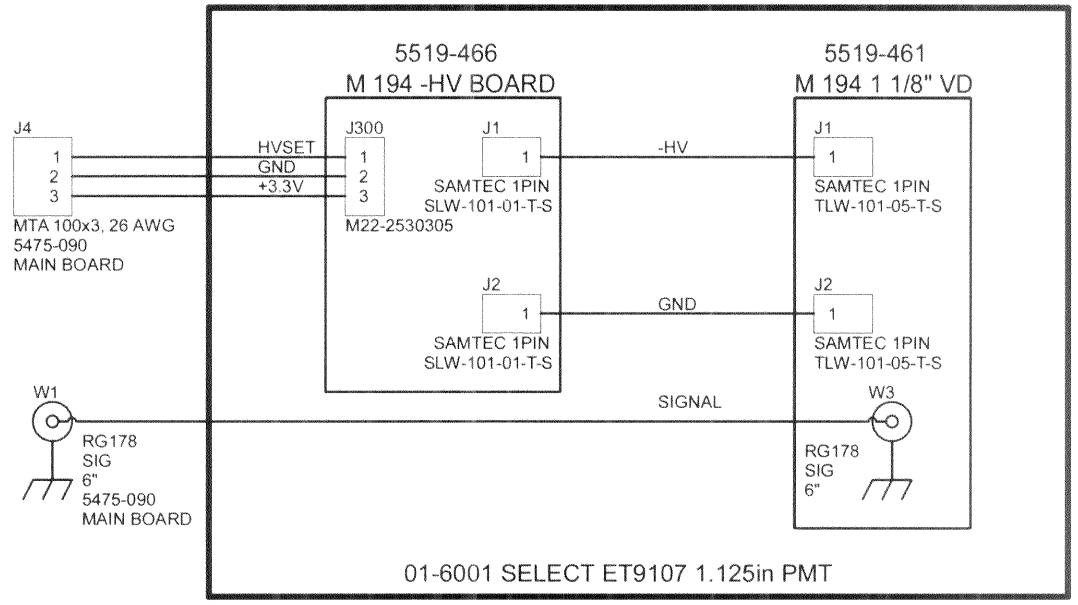
Model 194 Wiring Diagram, Drawing 475 x 103



OPTIONAL HEADPHONE MOD (4475-118)



INTERNAL
EJ-256 PLASTIC
DETECTOR



		PO Box 810 501 Oak Street Sweetwater, Texas 79556 U.S.A. 1-800-622-0828	
Drawn: PAB	10/26/2020	Title: WIRING DIAGRAM	
Design: RSS	10/26/2020	Model: 194	
Approve: <i>[Signature]</i>		Board#: 475-103	
Print Date: 10/26/2020 4:26:44 PM		Sheet: 1 of 1	Series Sheet
Rev: 3		475	103
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