POWDER RESISTANCE FIXTURE
PRF-930

User Manual

PROSTAT®

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PROSTAT® PRF-930 ADVANCED POWDER FIXTURE

I. Introduction & Description

The PRF-930 Powder Resistance Fixture measures the bulk resistance of powder and granulated materials. Test material is placed in the cavity between the measurement plates. Once a measurement has been made in ohms, a fixture calculation, or correction factor, converts the resistance measurement to volume resistivity in ohm-cm. The PRF-930 provides the most accurate measurements when used with a precision wide range resistance instrument, such as the Prostat PRS-801 Resistance System, or equivalent laboratory system. For guarded plate measurements use an instrument ground reference.

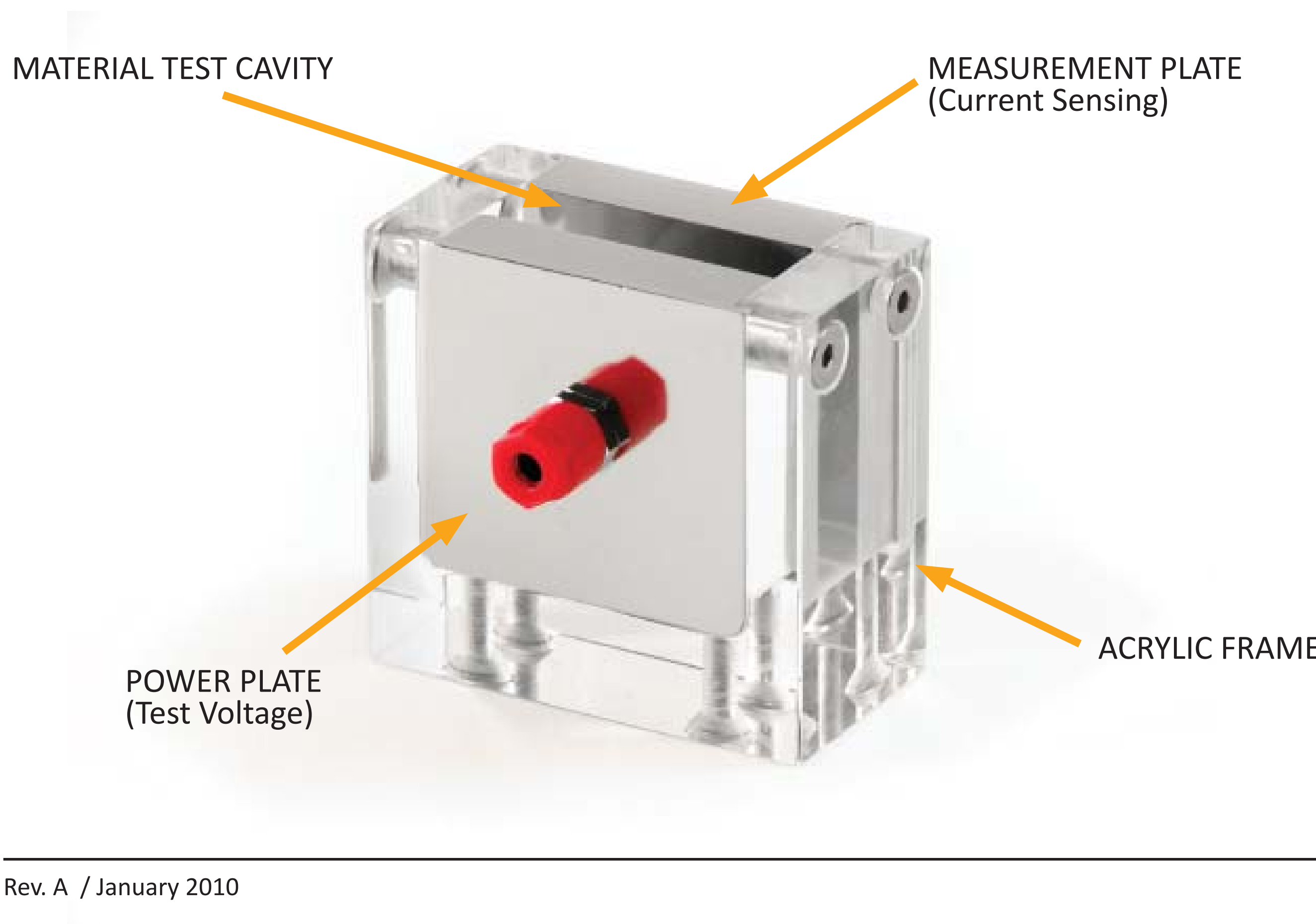
Figure 1: Prostat PRF-930 Powder Resistance Fixture Set

The PRF-930 Powder Fixture meets requirements of "Technical Recommendations of National Institute of Occupational Safety and Health JNIOSH-TR-No. 42 (2007) Recommendations for Requirements for Avoiding Electrostatic Hazards in Industry 2007"

II. Fixture Component Descriptions

A. Acrylic Frame

An electrically insulative acrylic frame provides structural support and precise positioning of the two measurement plates.



Once assembled in the acrylic frame, the two plates form a cavity that becomes the material test area. Powder substances are loaded into the fixture completely filling the test cavity. A test voltage is applied to the power plate and current through the material is sensed on the measure-ment plate.

B. Measurement Plate

The PRF-930 concentric measurement plate assembly consists of a center plate with a diameter of approximately 2.4 cm (0.945 inch), having a surface area of 4.5 cm2 (0.7 in2). The center plate is separated from the measurement guard plate by a virgin Teflon™ insert (Figure 3).

Figure 3: PRF-930 Measurement Plate Assembly – Inner Surface for Sensing Current Through Test Material

When installed in the acrylic fixture the center plate is positioned directly against the test material. The center plate connects to the resistance instrument using the Black receptacle on the plate's outer surface (Figure 4). The measurement guard plate connects to the instrument's ground reference using the Green receptacle on the outer measurement plate assembly.

C. Power Plate

Power is applied to the material under test by the fixture's power plate. Connection to the power plate is made using the Red connector (Figure 5). Test voltage is applied to material under test by contact with the power plate's inner surface.

Figure 4: Measurement Plate – Outer Surface Connections

Figure 5: PRF-930 Resistance Fixture Power Plate

III. Resistance Measurement Procedure

The resistance measurement and resistivity calculation procedure includes the following Steps:

- Filling the fixture cavity with material for testing
- Connecting the fixture to a resistance instrument for measurement
- Making a material **Volume Resistance** measurement in **ohms**
- Consider variables effecting resistance measurements
- Calculating Volume Resistivity of the test material in ohm-cm

A. Filling the Fixture Cavity

Before using the fixture be sure it is clean and properly assembled. (See "Disassembly & Cleaning", below.) The volume of the fixture is approximately 15 cm^3. Depending on material characteristics approximately 1.0 tablespoon will be required to completely fill the fixture cavity. Place the material in the PRF-930 and compress it lightly.

Material compression should be limited to the degree that represents the material's use, transport or storage conditions. This is subjective and best determined by personnel most experienced with the material process and applications. In any event, do not compress the material to an extreme degree beyond that which the material experiences under ordinary conditions.

IMPORTANT
Follow material manufacturer or supplier's safety precautions, procedures and handling recommendations when testing any material.

1. Level the material at the top surface of the fixture. (Figure 6)

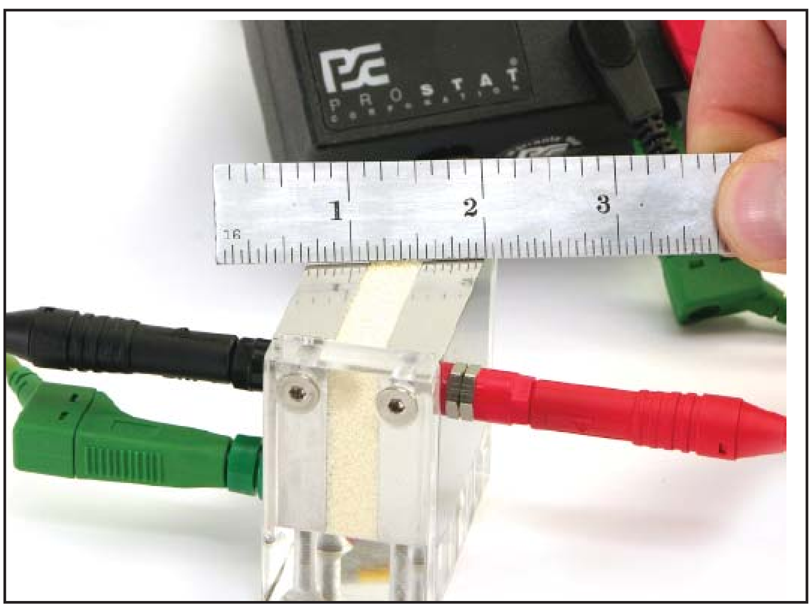


Figure 6: Leveling Material with Straight Edge before Testing

2. Be sure the wipe excess material from the top of the acrylic frame

B. Fixture Connections

Three connections to a precision, wide range resistance system (Figure 7) are required for accurate measurements:

1. Connect the instrument's test voltage (power) lead, usually from the Positive (+) terminal to the Red connection mounted on the fixture's power plate.

2. Connect the instrument's current sensing lead, usually the Negative (-) terminal, to the Black center plate receptical.

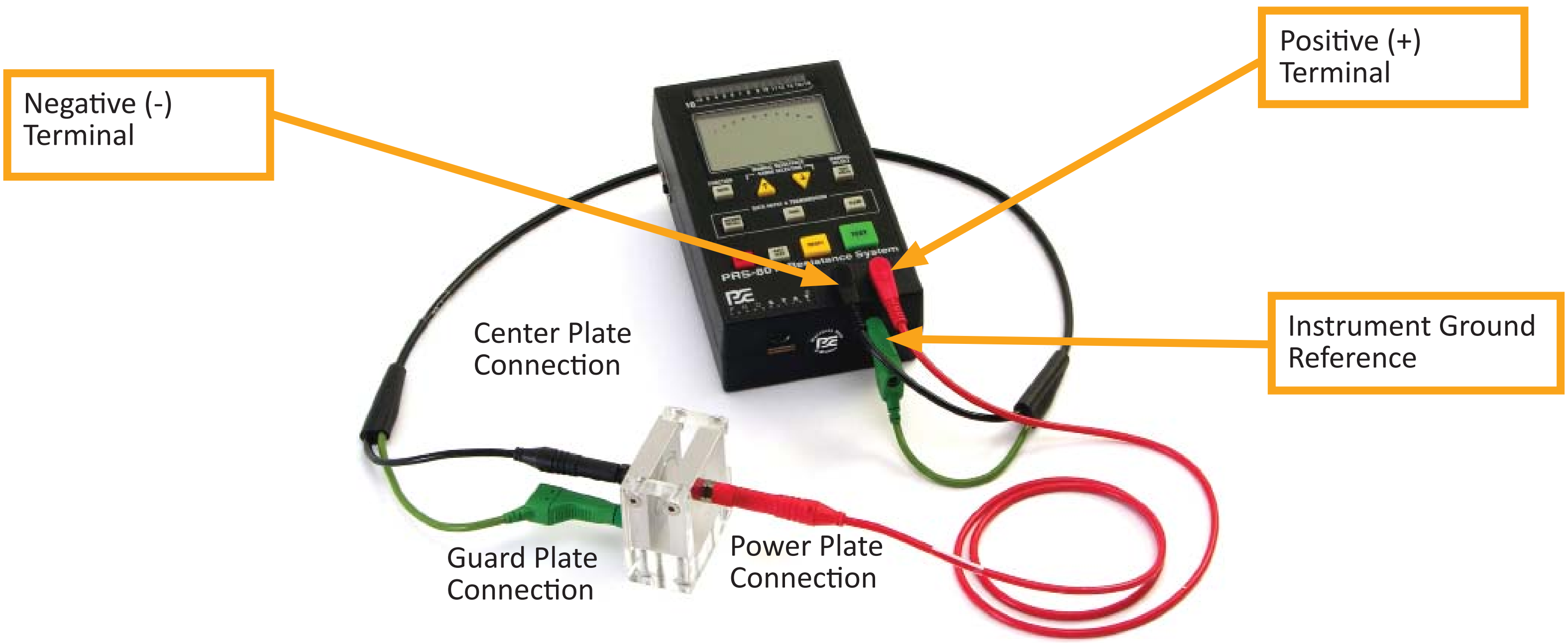


Figure 7: Shielded Lead Set Connections

3. Connect the instrument's ground reference to the Green guard plate receptical

C. Making the Resistance Measurement

The PRF-930 complies with the fundamental requirements of measuring bulk resistance of powdered and granulated materials. Actual procedures and specified conditions may vary between test methods cited by standards bodies in different countries. The PRF-930 was designed in accordance with the Recommended Practice for Protection against Hazard arising out of Static Electricity in General Industrie, published by The National Institute of Industrial Safety, Japan, Technical Recommendation No. RIIS-TR-87-1. Other national committees may be examining similar methods for these measurements.

For illustrative purposes, the following procedure is based on resistance measurement protocol developed by the Electrostatic Discharge Association (ESDA) Standards Committee, which is based in Rome, New York, USA. Use other recommended measurement protocol when suitable and available.

1. Connect material filled fixture to resistance measurement system as discussed above.
2. Energize the instrument in accordance with manufacturer's instructions.
3. Select Test Voltage of 10 volts
4. Start the instrument's TEST sequence where test voltage is applied to the fixture.
5. If indicated resistance is less than $1.0x10^6$ ohms, record the measurement after a steady state value has been reached
6. If indicated resistance at 10 volts is greater than $1.0x10^6$ ohms, stop the test
7. Reset the test voltage to 100 volts
8. Start the TEST sequence and apply 100 volts to the fixture for the instrument's electrification period, or until a steady state value has been reached.

NOTE
Or use the test voltage and electrification period required by the applicable standard test method or procedure

9. Record the measurement in ohms

D. Variables Effecting Resistance Measurements

Several factors will effect resistance measurements, including:

- Temperature
- Humidity
- Material Compression
- Material Moisture Content
- Test Voltage
- Instrumentation Electrification Period
- Material Composition
- Other factors depending on conditions and material characteristics

Repeatability between measurements, and reproducibility between laboratories are effected by all of these variables. One must understand the effect of resistance measurement variables to avoid confusion and misunderstandings between different test results.

Increased ambient humidity or material moisture will reduce the resistance measurement, that is: cause the material to appear more conductive. Lower humditiy, reduces material moisture content, which increases indicated material resistance. High test voltage may (1) "boil" off moisture, or (2) change the material's electrical characteristics. Identify and record all the apparent variables in your measurement situation to provide validity, repeatability and reproducibility to your measurements.

To enhance repeatability of successive measurements allow the meaterial to rest between measurements. One general guideline is recording the electrification period required for a steady state measurement and then add one minute to the measurement time to calculate the minimum rest period between measurements. For example, if 1 minute is used to obtain a steady state measurement – plus 1 minute – the rest time between measurements of the same sample is 2 minutes. On the other hand, if a steady state measurement is obtained in 15 seconds, the total minimum time between measurements is 1 minute 15 seconds. Typically, materials will be preconditioned at defined temperature and relative humidity for 48 hours or more, and measured in the same environment using defined procedures to reduce the effect of ambient variables.

E. Calculating Volume Resistivity (ohm-cm)

Resistance is a measurement, whereas Volume Resisivity is a calculation based on (1) a resistance measurement, (2) fixture dimensions and, (3) material thickness. To convert resistance measurements in ohms obtained with the PRF-930 to volume resistivity (**ρ**) in ohm-cm, we use the following equation to convert the resistance measurement to resistivity.

$$\rho = R\frac{A}{d}$$

Where,

R = Resistance obtained from the material measurement in ohms
A = Area of the fixture's center plate in cm^2
d = Distance in cm between the measurement and power plates.

The relationship of **area A** divided by **distance d** is often referred to as a **correction factor** in cm (***CF***), which is multiplied by the measured resistance to obtain resistivity. (See **Sample Calculations**, below)

Exact fixture dimensions can be obtained during fixture cleaning using the measurement procedures described below. When the fixture is disassembled, and after it is cleaned, measure the concentric center plate with a micrometer as shown in Figure 8, at right.

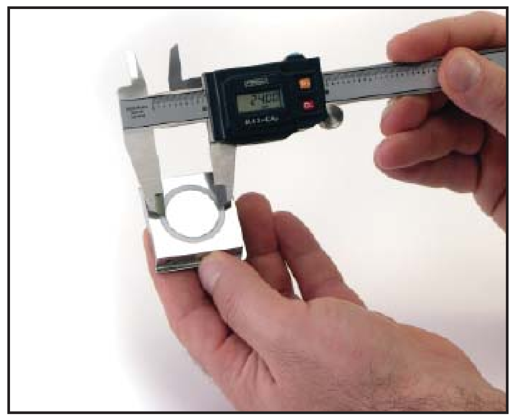


Figure 8: Measuring Diameter of Measurement Center Plate

The center plate area A is calculated using the equation:

$$A = \pi r^2$$

Where π is approximately 3.1416 and **r** is the radius of the center plate, which is one-half the plate diameter. The distance d between plates is measured with a micrometer (Figure 9) after the fixture is reassembled. The measurement is made at the center point of the measurement plates, midway between the acrylic frame vertical supports.

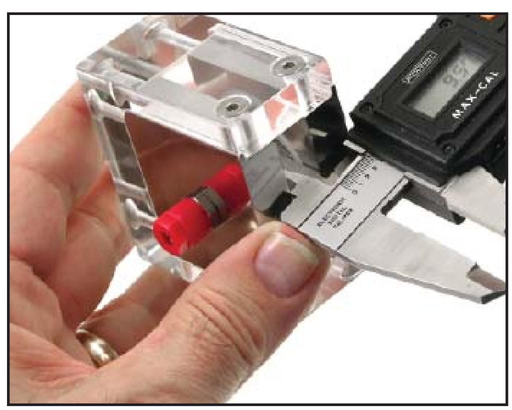


Figure 9: Measuring the Distance d between Plates

Sample Calculations

While the correction factor (***CF***) for each fixture is initially determined by Prostat before shipment, temperature, humidity, handling and use may slightly modify fixture dimensions. Assuming your fixture is typical of the one pictured here, you can confirm dimensions and correc-tion factor, described below.

F. Center Plate Area:

1. Measure center plate diameter (Figure 8): 2.4 cm
2. Divide center plate diameter by 2 to obtain its radius: 1.2 cm
3. Calculate center plate area ***A***:

$$A = \pi r^2$$

$$A = 3.1416\ (1.2\ cm)^2$$

$$A = 3.1416\ (1.44\ cm^2)$$

$$A = 4.52\ cm^2$$

G. Correction Factor:

1. Measure the distance d between the power plate and measurement plate as shown in Figure 9. Assume the measurement is 0.95 cm
2. Divide the area ***A*** by the distance d to obtain the correction factor:

$$Fixture\ Correction\ Factor\ (CF) = \frac{A}{d}$$

$$Fixture\ Correction\ Factor\ (CF) = \frac{4.52\ cm^2}{0.95\ cm}$$

$$Correction\ Factor\ (CF) = 4.76\ cm$$

Converting Resistance (ohm) to Resistivity (Ohm-cm):

As we discussed above, the equation for converting resistance to resistivity is

$$\rho = R\frac{A}{d}$$

Here, the area A of the center plate is divided by the distance d between plates to obtain the correction factor (***CF***) in cm. In our example above the correction factor is 4.76 cm. We simply multiply the correction factor (cm) by the material's measured resistance (ohm) to obtain volume resistivity in ohm-cm. The table below shows four examples:

Instrument Measurement (ohm)	x Correction Factor (cm)	= Calculated Resistivity (ohm-cm)
5.5×10^4	4.76	2.62×10^5
7.5×10^7	4.76	3.57×10^8
6.3×10^9	4.76	3.00×10^{10}
9.5×10^{11}	4.76	4.52×10^{12}

IV. Disassembly & Cleaning

After use, the PRF-930 should be cleaned before storing. There are several reasons to clean the fixture immediately after use:

- Prevent contamination of future measurements by previous material residue
- Insure the fixture performs at its optimum resistance range, which is approximately 1 to greater than 1.0×10^{13} ohm.
- Prevent degradation of the fixture acrylic materials due to crazing, which ultimately weakens the frame.

Cleaning consists of:

1. Emptying the fixture of test materials
2. Disassembly
3. Cleaning the measurement plate assemblies, which is a different procedure from Cleaning the acrylic frame

A. Empty the Fixture:

Dry powder and granulated materials can simply be poured from the fixture and should be disposed of in an appropriate manner. In situations where the material is non-toxic or harmful, small amounts of residue can be blown from the fixture using low pressure compressed air as may be allowed in the using environment. Avoid tapping the fixture against a hard surface to knock materials out of the fixture as this may cause fixture misalignment. Once emptied, another sample of the same material may be loaded and tested.

Before measuring different materials, the fixture should be disassembled and cleaned.

NOTE
Dispose of materials in a safe and appropriate manner as recommended by the material's supplier. Use caution whenever applying compressed air for cleaning purposes.

B. Disassembly

The fixture plates are mounted in the acrylic frame using 8 flat head, socket machined screws. The four long 1 inch (25 mm) screws are used to mount the plates to the bottom of the acrylic frame, and the shorter ⅝ inch (16 mm) screws, hold the plates against the vertical frame segments. To disassemble the fixture, simply remove the eight screws with the wrench provided. (Figure 10)

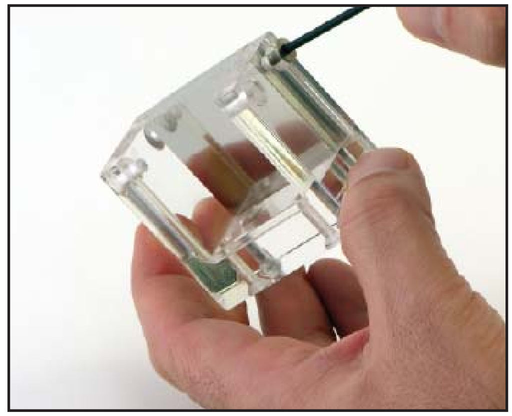


Figure 10: Fixture Disassembly - Removing the Flat Head, Socket Screws

C. Cleaning Fixture Metal Plates

The metal plates can be wiped free of material dust, then cleaned with a 70% solution of iso-propyl alcohol (IPA) and distilled water. The plate should then be thoroughly dried with a clean, low linting cloth or tissue as shown in Figure 11.

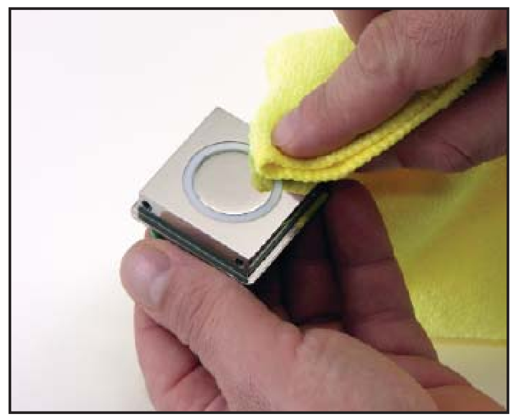


Figure 11: Cleaning Center Plate and Teflon Separator

NOTE
Do not use this alcohol solution on the acrylic frame assembly. The alcohol will damage the material and cause "crazing", which appears as small cracks that seriously weaken the assembly.

Cleanliness of the measurement assembly Teflon separator and center plate are critical to fixture accuracy.

NOTE
The alcohol solution may be used only to clean the metal and Teflon fixture materials. Do Not use alcohol on the acrylic frame assembly.

Be sure to remove any visible particles and wash the Teflon separator twice with the IPA solution, then dry with the provided micro fiber cloth. Allow the fixture to air dry after cleaning for an additional 15 minutes before using the fixture for measurements. Use the same cleaning procedure for the power plate. (Figure 12)

Figure 12: Cleaning the Power Plate with IPA and Micro Fiber Cloth

Notice the edges of the metal plates. Flanges are machined around three sides of the plates. These special edges are to ensure proper alignment when mounting the plates in the acrylic fixture. Be sure to clean the alignment edge flanges so they are free of particles.

When cleaning the metal plates, avoid touching the material contact surfaces. Human contact will transfer finger oils to the test surfaces, which are unnecessary contaminants.

D. Cleaning the Acrylic Frame

The machined acrylic frame must be cleaned carefully. **Do not use alcohol** or cleaners containing alcohol or ammonia as these solutions will cause “crazing” resulting in many hairline cracks and weaken the assembly. Once the metal plates are removed, brush any particles from the frame using the supplied brush. Use a cotton swab where necessary to remove stubborn contaminants

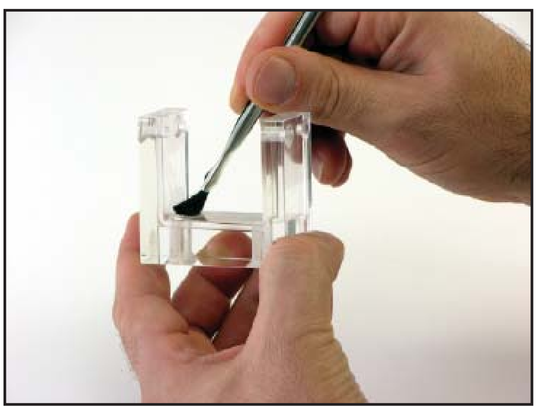


Figure 13: Cleaning Acrylic Frame with Brush using Reference Module

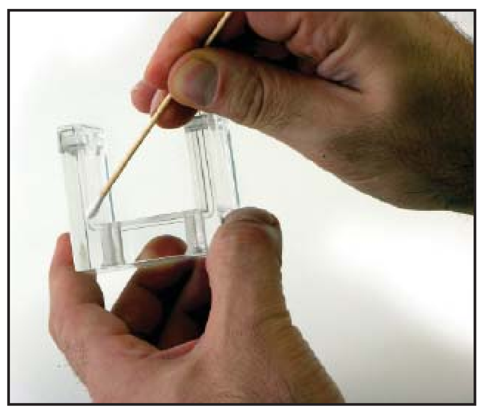


Figure 14: Cleaning Frame Mounting Grooves with Cotton Swab

If necessary, wash the acrylic fixture free of contaminants with clean water, rinse one or more times, then allow to air dry or carefully wipe with a low linting cloth.

Reassembly of PRF-930 Fixture

When preparing to reassemble the fixture, note the three alignment flanges on each metal plate. These edges are designed to fit into the recessed groove surrounding the plate mounting locations. Their function is to insure proper alignment and minimize plate movement.

Position the plates such that they are placed in the acrylic frame with edge alignment flanges seated in the frame’s recessed grooves. (Figure 15 & 16) Insert two long 1 inch machine screws into the bottom of the frame and thread them into the measurement plate. Do not tighten the screws; simply install them to hold the plate into position.

Install the ⅝ inch screws through the vertical segment of the frame and thread into the meas-ure-ment plate. Tighten screws to snug, just to “finger tight”.

NOTE
The alcohol solution may be used only to clean the metal and Teflon fixture materials. Do Not use alcohol on the acrylic frame assembly.

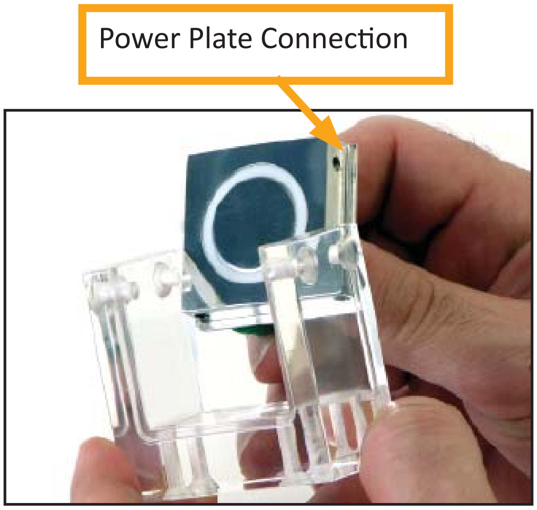


Figure 15: Align Metal Plate Edge Flange with Recessed Frame Groove

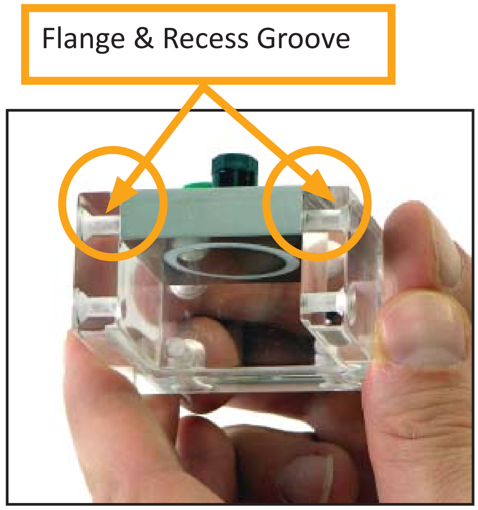


Figure 16: Measurement Plate Alignment Flange seated in Acrylic Frame Recessed Groove

Install the power plate opposite the measurement plate in the same manner. As before, align the edge flanges with the recessed groove (Figure 17). Install the screws and make them just snug – do not over tighten screws.

CAUTION
Improper Handling & Cleaning Causes Damage & Voids Product Warranty.

Figure 17: Power Plate and Screws Prop-erly Installed

If cleaned with alcohol, acrylic will “craze”. Crazing is degradation of the acrylic polymer in ap-pearance and strength (Figure 18). Over tightening screws could cause cracking of acrylic (Figure 19).

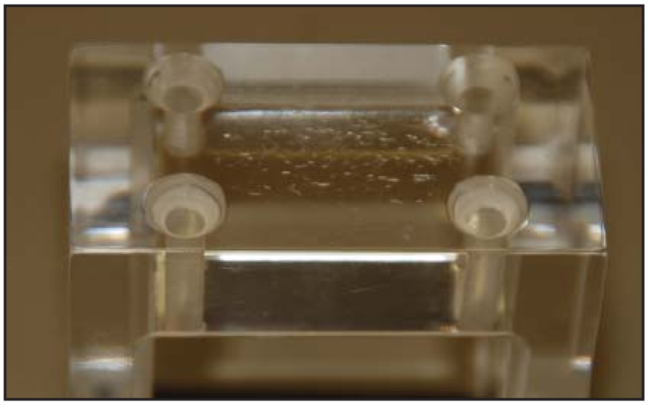


Figure 18: Illustration of Crazing Caused by Cleaning Acrylic with Alcohol

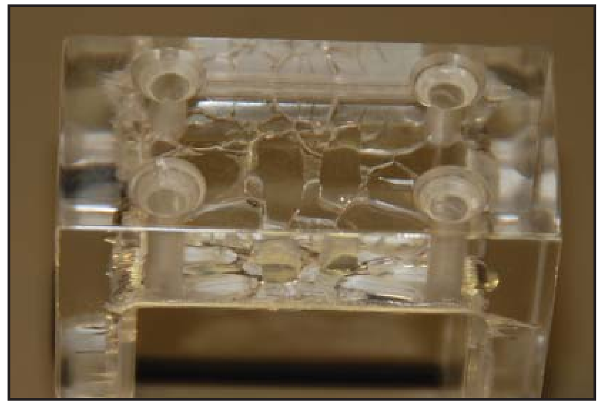


Figure 19: Over Tightening Screws Will Cause Cracks in Acrylic Material

V. Warranty

Prostat Corpoation Warranty

Prostat Corporation expressly warrants that for a period of one (1) year from the date of purchase, that Prostat instruments will be free from defects in material (parts) and workmanship (labor). If Prostat receives notice of such defect during the warranty period, Prostat will replace at its expense such parts that it determines to be defective. Any defective part must be returned to Prostat postage prepaid with proof of purchase date.

Warranty Exclusions – THE FOREGOING EXPRESS WARRANTY IS MADE IN LIEU OF ALL OTHER PRODUCT WARRANTIES, EXPRESS AND IMPLIED, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH ARE SPECIFICALLY DISCLAIMED. The express warranty will not apply to defects or damage due to accidents, neglect, misuse, alterations, operator error, or failure to properly maintain, clean, or repair products. Limit of Liability – in no event will Prostat or any seller be responsible or liable for special, incidental, or consequential losses or damages, under any legal theory including but not limited to contract, negligence, or strict liability.
Fulfillment by Prostat of its express warranty obligations described above will be purchaser’s exclusive remedy and will be Prostat’s and seller’s limit of liability for any breach of warranty or otherwise.

PRF-930 Powder Resistance Fixture Specifications

Basic Description: Acrylic frame fixture with opposing power and concentric ring measurement plates for resistance measurement of small volumes of powder and granulated materials. Correction Factor (**CF**) is used to convert bulk resistance measurement to volume resistivity in ohm-cm.

Upper Resistance Limit: Nominal $1.0\text{x}10^{14}$ ohms ±20% @ 500 Volts, 71°F (21.7°C), 18% Rh, Clean, empty fixture. Note that most resistance measure-ments are made at 100 volts and below.

Material Capacity: Approximately 1.0 Tablespoon (US) (15 cm^3)

Correction Factor (**CF**) to Ohm-cm: Based on: $\rho = R\frac{A}{d}$

Where,

ρ = Volume Resistivity in ohm-cm
R = Resistance obtained from the material measurement in ohms
A = Area of the fixture's center plate in cm^2
d = Distance in cm between the measurement and power plates.

and,

$$\rho = R\,(CF)$$

Where,

ρ = Volume Resistivity in ohm-cm
R = Resistance obtained from the material measurement in ohms
CF = Correction Factor (Area [A] of the fixture's center plate in cm^2 divided by Distance [d] in cm between the measurement and power plates.

Typical **CF** Range 4.6 cm to 4.9 cm, Typical 4.75 cm

Approximate Fixture Dimensions: Note: Dimensions vary slightly from fixture to fixture as they are hand pol ished and assembled. Temperature and humidity will affect fixture dimensions. Approximate dimensions as follows:

W 2.36 in (60 mm) x D 1.25 in (32 mm) x H 2.25 in (57 mm)

Approximate Fixture Weight: 12.35 oz (250 gm)

NOTES

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