



Model 9230A Series

Precision DC Current Shunt Standards

Operator Manual

NOTICE

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1.0 INTRODUCTION

This manual provides an overview of the 9230A Series of Precision DC Current Shunt Standards and also contains the necessary information required to perform a calibration or verification test. General product information, description of construction styles and performance specifications are also included.

This manual applies to all models of the 9230A Series of Precision DC Current Shunt Standards unless otherwise noted. This includes custom values that are ordered.

The phone number in the USA and Canada to obtain Product Support, Calibration Service or Replacement Parts is (800) 310-8104.

To Contact Guildline Instruments, the following information is provided.

USA and Canada Telephone: (613) 283-3000
USA and Canada Fax: 1-613-283-6082

Outside US and Canada Telephone: + [0] [1] 613 283-3000
Outside US and Canada Fax: + [0] [1] 613 283-6082

You can also contact Guildline Instruments Limited via their Email or Websites.

Email is: sales@guildline.com
Website is: www.guildline.com

1.1 Warranty

Guildline Instruments warrants its products to be free of defects in manufacture and normal operation for a period of two (2) years from the date of purchase, except as otherwise specified. This warranty applies only in the country of original purchase and only to the original purchaser, who is also the end user. Equipment, which is defective or fails within the warranty period, will be repaired or replaced at our factory without charge at the discretion of Guildline Instruments.

In addition, systems engineered by Guildline Instruments are warranted to be free of defects in overall system operation for a period of two (2) years from the date of receipt by the original purchaser.

Third party system components purchased by Guildline carry the warranty of the original equipment manufacturer and will be accepted for claim by Guildline Instruments at our factory only after warranty authorization by the original manufacturer.

Limitation of Warranty

Warranty coverage does not apply to equipment which has failed due to misuse, neglect, accident or abnormal conditions of operation or if modifications or repairs have been made without prior authorization of Guildline instruments.

Temperature probes are not warranted against failure due to mechanical shock.
Fuses, lamps and non-rechargeable batteries are not warranted against breakage.

Damage in Shipment to Original Purchase

Instrument(s) should be thoroughly inspected immediately on receipt for visible damage. Any damage should be reported to the carrier and further inspection and operational tests should be carried out if appropriate to determine if there is internal damage. Contact Guildline Instruments before returning for repair. The Customer or purchaser must complete all final claims with the carrier.

Regular charges will apply to non-warranty service. External service charges and expenses will be billed at cost plus handling.

1.2 To Obtain Warranty or Calibration and Repair Service

Call for a Return Material Authorization (RMA) number. RMA's are required for all Warranty Returns and/or Calibration and Repair Service Requests. Telephone, Fax and email addresses to contact Guildline are provided previously.

Guildline Instruments will pay for all warranty costs including shipping to and from the original shipment point. However, if the instrument is purchased within one country and shipped to another, Guildline will only pay for shipping to and from the original ship to country or customer point.

USA Warranty Return Address.

USA Customers should use the following address to return instruments for warranty service or calibration support.

Guildline Instruments Limited
C/O AN Deringer
800 Proctor Avenue
Ogdensburg, NY 13669

Mark on the outside of the box:

RMA # _____

Model # _____

Serial # _____

The Statement: "Canadian manufactured goods being returned for repair."

For all other countries, including Canada please ship to:

Guildline Instruments Limited
21 Gilroy Street, PO Box 99
Smiths Falls, ON K7A 4S9

Mark on the outside of the box:

RMA # _____

Model # _____

Serial # _____

The Statement: "Canadian manufactured goods being returned for repair."

1.3 Safety Information

WARNING: During usage and calibration high voltages or high currents may be present. Use caution when working above 40 Volts DC or currents above 1 mA. Such voltages or currents can cause death.

The 9230A Precision DC Current Shunt Standards are designed to work within specifications to 100 or 125 Watts of power depending on the particular model. Applying more than the recommended power will damage the unit although a power level 20 % over the limit can be sustained for 1 minute.

It is recommended to use the model 92310 forced air convection unit whenever power levels above 31 Watts are to be encountered.

Inspect the Current Shunt Standard for damage such as cracked connectors prior to use. If unit has a burned smell or smoke is visible during use, discontinue use immediately.

If test equipment used with Current Shunt Standards overloads or trips, this could be a sign that the shunt standard requires repair.

Inspect all test leads used with the Current Shunt Standard for damaged insulation or exposed metal. Check all test leads for continuity.

Ensure all test leads are suitably sized and correctly connected and tightened prior to applying current. Severe arcing and burning can occur if cable connections are not tightened sufficiently.

Do not use Current Shunt Standards around explosive gas, vapor or dust.

2.0 9230A SERIES PRECISION DC CURRENT SHUNT SPECIFICATIONS

2.1 9230A Model Series 12 Month Specifications

Tables 2-1 and 2-2 show the specifications for the 9230A series.

9230A SPECIFICATIONS (12 MONTHS)								
Model ¹	Nominal Resistance Value (Ω)	Initial Tolerance ² ± μΩ/Ω (ppm)	Full Rated Current (A) ³		Full Rated Current Accuracy ⁴ ± μΩ/Ω (ppm) @ 23 °C ± 1 °C	Stability ⁵ ± μΩ/Ω (ppm)	Time Constant (Minutes) ⁶	
			AMBIENT AIR	W/COOLING			92310 Option	Ambient Air
9230A-10	1.0	100	5	10	100	10	3	6
9230A-15	0.5	100	7.5	15	100	10	3	6
9230A-15R ⁷	0.1	400	15	NA	400	10	3	6
9230A-30	0.1	100	15	30	100	10	3	6
9230A-50 ³	0.05	100	22.5	45	100	10	3	6
9230A-100	0.01	100	50	100	100	10	4	8
9230A-150 ³	0.005	100	70	140	100	10	4	8
9230A-300	0.001	100	150	300	100	10	8	16
9230A-500 ³	0.5m	100	225	450	100	10	8	16
9230A-1000	0.1m	250	500	1000	250	25	15	30
9230A-1500 ³	0.05m	250	710	1420	250	25	15	30
9230A-3000	10μ	1000	1500	3000	500	50	20	45

Table 2-1 : 9230A Model Series 12 Month Specifications

- Note 1:** Full Scale current specification is based on use in Ambient Air at 25 W, or use with Air Cooling at 100 W, so may not exactly match the nominal value of the shunt.
- Note 2:** Defined as maximum variation of resistance value as initially adjusted at time of sale, temperature 23 °C ± 2 °C.
- Note 3:** Maximum currents for listed Specifications are applicable for ambient air and for air or oil cooling (e.g. with the 92310 Forced Air Unit).
- Note 4:** Full Rated Current Accuracies apply to the maximum full rated current uncertainties and conditions (i.e. air or cooled) listed. For currents exceeding the full rated currents listed, Power coefficients must be applied to determine total specification at the applied current power level. For example, the 1000 A model can be used to 500 A in ambient air and to 1000 A with forced air, and will meet stated specifications. However for use in ambient air a power coefficient must be applied for currents above 500 A.
- Note 5:** When used as a standard resistor at 1 W Level only.
- Note 6:** Typical specification defined as the time for the resistance value to settle to within 10 parts in 10⁶ of the final value for any change in applied current. The time constant is typically 1 minute for flowing oil.
- Note 7:** The 9230A-15R is the direct replacement for the 9230/15 version shunt. The 9230A-30 has the same resistance value as the 9230A-15R and can be used up to 30 A (with the 92310).
- Note 8:** Power coefficient must be added to the uncertainty when used as a shunt above the calibrated range of currents.

9230A SPECIFICATIONS (12 MONTHS) CONTINUED							
Model	Power Coefficient ⁸ (± μΩ/Ω (ppm))			Size (W x L x H)		Weight	
	92310 OPTION	AMBIENT AIR	FLOWING OIL	mm	inches	kg	lbs
9230A-10	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-15	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-15R ⁷	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-30	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-50	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	2.1	4.6
9230A-100	2	8	0.5	114 x 356 x 139	4.5 x 14 x 5.5	2.2	4.9
9230A-150	2	8	0.5	114 x 356 x 139	4.5 x 14 x 5.5	2.5	5.5
9230A-300	2	8	0.5	114 x 406 x 96	4.5 x 16x 3.8	5.0	11.2
9230A-500	3	10	0.8	114 x 406 x 96	4.5 x 16 x 3.8	5.8	12.9
9230A-1000	8	20	2	117 x 539 x 145	4.6 x 21.2 x 5.3	13.0	28.7
9230A-1500	10	30	3	117 x 530 x 145	4.6 x 17.2 x 5.3	12.8	28.1
9230A-3000	15	30	5	122 x 424 x 216	4.8 x 16.7 x 8.5	29.1	64
92310 Option				121 x 242 x 69	4.75 x 9.5 x 2.7	1.0	2.2
Environmental	Operating: 10 °C to 40 °C <80 % RH non-condensing			Storage Operating: -30 °C to 70 °C <90 % RH non-condensing			

Table 2-2 : 9230A Model Series Specifications (Continued)

2.2 General Specifications

ENVIRONMENTAL	
Operating Temperature	10 °C to 40 °C
Operating Humidity	< 80 % RH non-condensing
Storage Temperature	-30 °C to 70 °C
Storage Humidity	< 90 % RH non-condensing

3.0 OVERVIEW

3.1 General

The Guildline Model 9230A series of four terminal DC current shunt standards are designed for precision measurement of direct current and for use as high accuracy low ohm value resistance standards. They are constructed from specially selected materials supported on an insulating base for mechanical stability and covered with a perforated metal cover to allow air cooling while providing physical protection for the resistive elements.

Particular design considerations take into account the effects of power dissipation levels of up to 125 W from introducing excessive self-heating effects that would exceed the specifications. The types of materials selected for the resistive elements have a very low temperature coefficient of resistance. The size and number of individual element wires or plates for each model provide an optimum surface area to dissipate the specified full scale current.

The performance of the 9230A series of DC current shunt standards can be dramatically improved by operating them in a temperature controlled environment or immersing them in a temperature controlled stirred oil bath where the power dissipation requirements are below 10 watt. The optional Guildline Model 92310 forced air convection unit is essential for thermal dissipation levels above a nominal 25 W up to 125 W and also can be used at lower power levels to improve measurement stability. Performance specifications for use above a nominal 25 W are based on the use of forced air convection. Where forced air convection is not used additional uncertainties apply above the 25 W power dissipation level.

3.2 Design Considerations

The Guildline Model 9230A series of four terminal DC current shunt standards provide a number of features for the purpose of minimizing the uncertainties of measurement with respect to environmental factors, cable connection variations and long term variations in resistance values. Shifts in resistive value due to ambient temperature changes, aging of the materials and other effects due to travel shock are reduced by careful selection of the materials and manufacturing processes. Stress introduced in the manufacturing processes is relieved through artificial aging of the completed assembly before final calibration at the time of shipment.

The terminations for connection cables of the measurement system are designed to keep thermal EMF potentials within acceptably low levels, to reduce errors that may be introduced by variations in cable connections and to ensure that the applied current is distributed through the resistive elements in a uniform manner. Binding post type test current connections are provided for lower current models below a 1000 A full scale rating while hex head bolts are provided for models with a full scale rating of 1000 A and higher. Five way binding posts are provided on all models for potential measurement connections.

For models below a 1000 A full scale rating a single cable connection point is provided such that measurement values are independent of cable orientation. For models with a full scale rating of 1000 A and higher the terminal design is such that multiple cable connections may be made in a symmetrical manner that minimizes resistance value dependency on the connecting cable arrangements. Guidance is provided in this manual with respect to optimum multi-cable connection arrangements.

3.3 Measurement Ranges

Models in the 9230A series range in resistance values from 1 Ω to 5 $\mu\Omega$ with full scale current capabilities from 10 A to 3000 A respectively. Lead sets are available for all models that are designed to carry the maximum shunt current rating. It is imperative that a sufficient number of suitably sized cables are used to connect the shunts to the measurement system such that the thermal dissipation in the cables does not excessively add to that of the shunt itself. As well, where multiple connections are required it is important that the symmetry of the connections horizontally and vertically is maintained around the longitudinal centre line. The preceding considerations give each model in the series a very wide dynamic range from virtually zero to full rated current.

With the use of the Model 92310 Forced Convection Unit full scale power levels at maximum specified test currents vary from 90 W up to 125 W. When the shunts are used with natural air convection cooling full scale power levels at the reduced maximum specified test currents vary from 22.5 W up to 31.3 W. Performance specifications above the nominal 25 W are based on the use of forced convection to reduce power coefficients.

Models may be utilized as precision resistance standards as low as 5 $\mu\Omega$ when used at lower power dissipation levels below a few watts. When maintained in a temperature controlled forced air or circulating oil bath the shunt standards will provide the lowest uncertainties as ambient temperature effects are substantially reduced.

The 9230A Series are designed for use with Direct Current. For AC Current applications see our 7340 or 7350 Series of AC Shunts.

3.4 Design Configurations

3.4.1 10 A to 150 A Standard Shunt Values

The shunt element assembly consists of two large round copper posts to which a number of equal length Evanohm resistance wire loops are brazed. The current terminals are formed at the top of the copper posts with two large knobs to hold the current connection cables. Separate potential terminal 5 way binding posts are attached to the shunt base along with the shunt element assembly. A perforated metal sheet is used to protect the shunt element assembly from physical damage and to allow natural or forced air convection.

Figure 3-1 illustrates an entire shunt assembly for the 10 A to 150 A full scale current ranges.

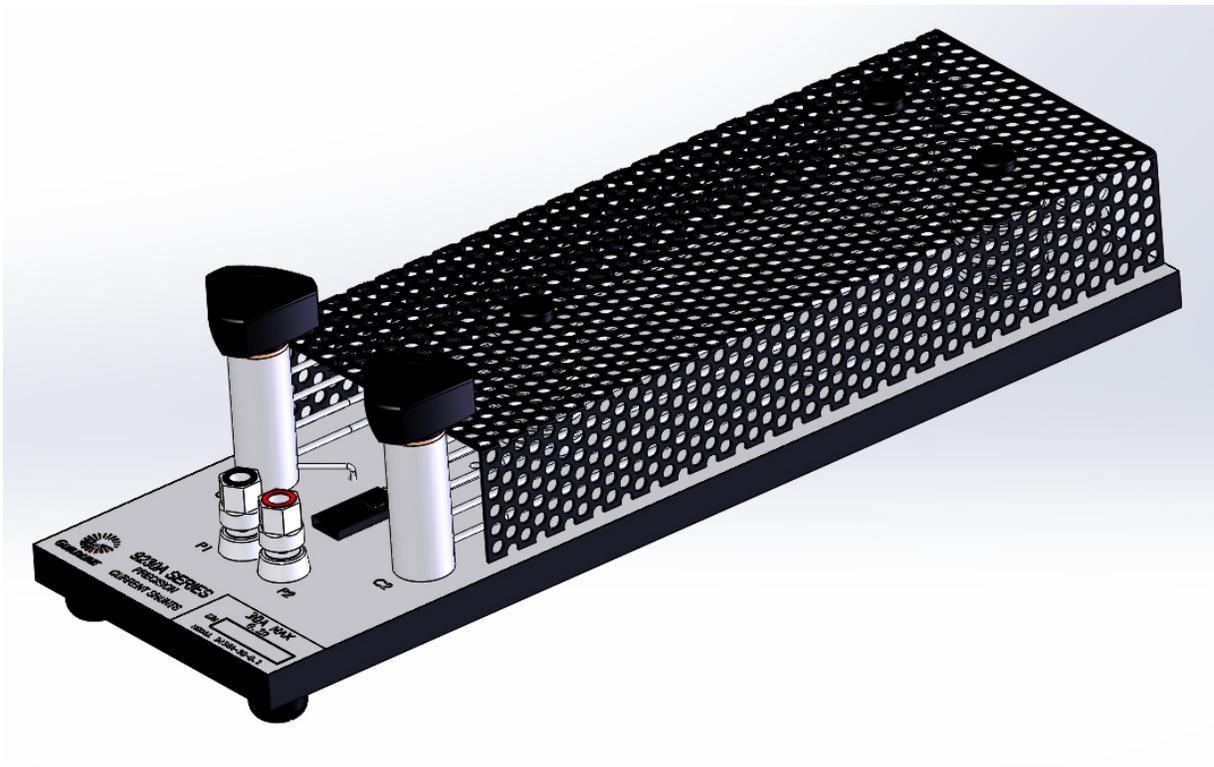


Figure 3-1 : 9230A Series from 10 A to 150 A Full Scale Current

3.4.2 300 A to 500 A Standard Shunt Values

The shunt element assembly consists of two large rectangular copper terminal plates to which a number of equal length straight Evanohm resistance wires are brazed. The current terminals are formed at the top of the copper terminal plates with two large knobs to hold the connection cables. Separate potential terminal binding posts are attached to the current terminal plates as well. The shunt element assembly is attached to an insulated base plate. A perforated metal sheet is used to protect the shunt element assembly from physical damage and to allow natural or forced air convection.

Figure 3-2 illustrates an entire shunt assembly for the 300 A to 500 A full scale current ranges.

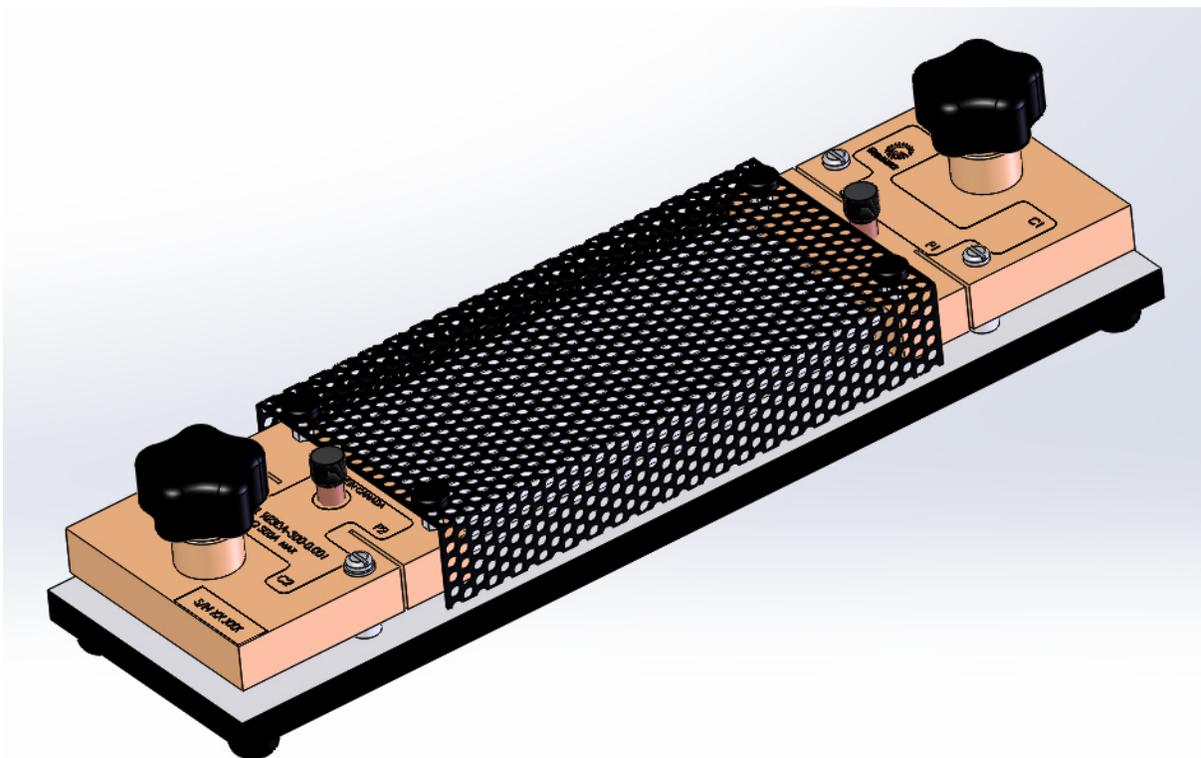


Figure 3-2 : 9230A Series from 300 A to 500 A

3.4.3 1000 A to 3000 A Standard Shunt Values

The shunt element assembly consists of two large copper terminal blocks to which a number of equal length straight manganin resistance plates are brazed. The current terminals are formed into the ends of the terminal blocks to provide multiple cable connection points. Separate potential terminal binding posts are attached to the top of the current terminal blocks. The shunt element assembly is attached to an insulated base plate. A perforated metal sheet is used to protect the shunt element assembly from physical damage and to allow natural or forced air convection.

Figure 3-3 illustrates an entire shunt assembly for the 1000 A to 3000 A full scale current ranges.

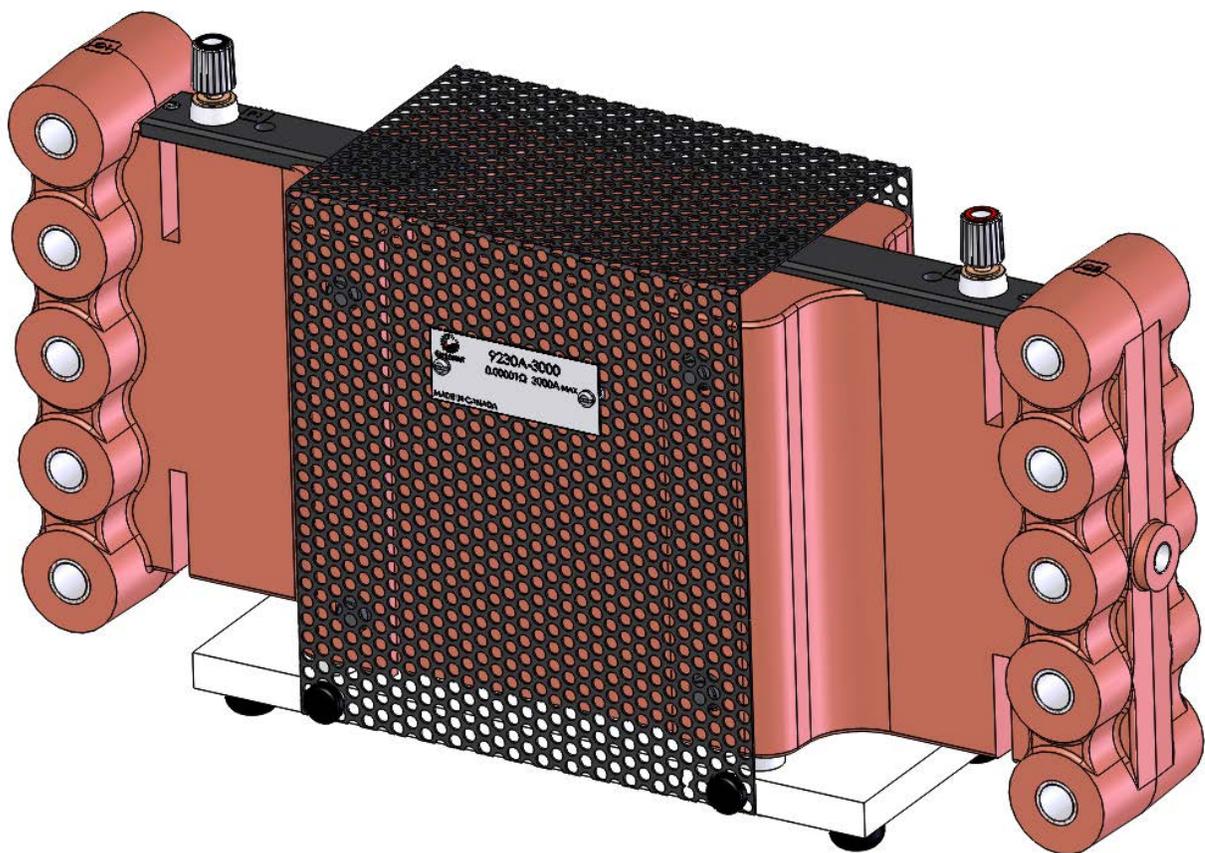


Figure 3-3 : 9230A Series from 1000 A to 3000 A

3.5 Cable Connections

The size and arrangement of the cables that connect the test current source to the shunt standard are of most importance to ensure the repeatability of measurements and the overall quality of the measurements.

3.5.1 Test Current Cable Requirements

In high current measurements, the cables that carry the test current will heat up due to the resistance of the cable itself. The temperature of the cable will vary with the size of the cable and the test current selected. If the cable size is extremely undersized the temperature can increase sufficiently to melt or burn the cable insulation and can cause damage to the measurement system as well as the shunt under test. Also the thermal energy will travel through the terminal connection and increase the temperature of the current terminals of the shunt being measured which will affect its resistance.

Where test currents above 500 A are required more than one cable will be required on the supply and return test current connections. In these cases it is highly recommended to use an even number of cables such that symmetry around the terminal block can be maintained. The cable must be of equal length to ensure even current distribution. Models for use above 500 A are provided with terminals that incorporate multiple cable connections to ensure that cable connection symmetry can be achieved.

Refer to Table 2 for recommended minimum cable size and number requirements..

3.5.2 Test Current Cable Connections

Where multiple connections are required it is important that the symmetry of the connections horizontally and vertically is maintained around the longitudinal centre line. This requires that only an even number of cables be used. All the cables that are connected in parallel must be of equal length and of the same gauge so that the test current is distributed evenly in each cable.

It is of great importance to ensure that cable connection surfaces are clean and tightened to prevent high resistance contacts which will cause overheating of the terminal block and effect the realized resistance value of the shunt.

The following figures illustrate typical connections arrangements for multiple cable connections.

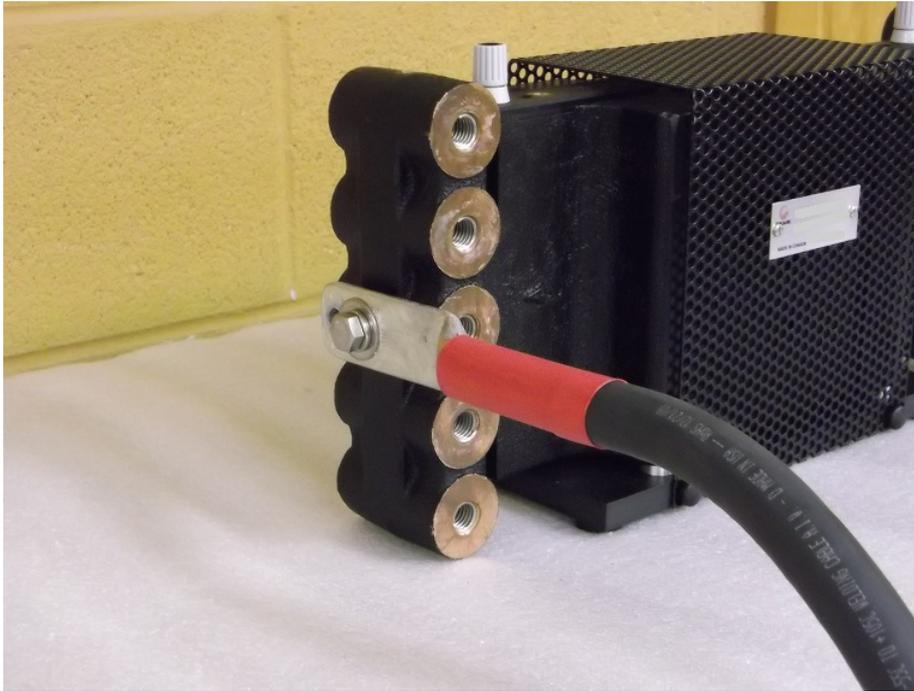


Figure 3-4 : Single Cable Connection, 0 to 500 A

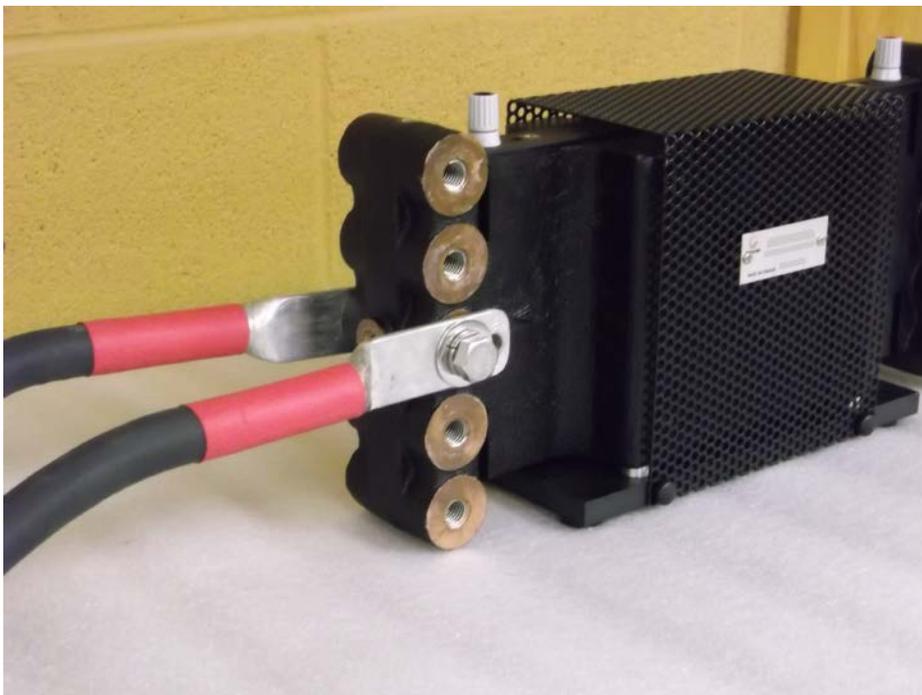


Figure 3-5 : Two Cable Connection, 500 A to 1000 A

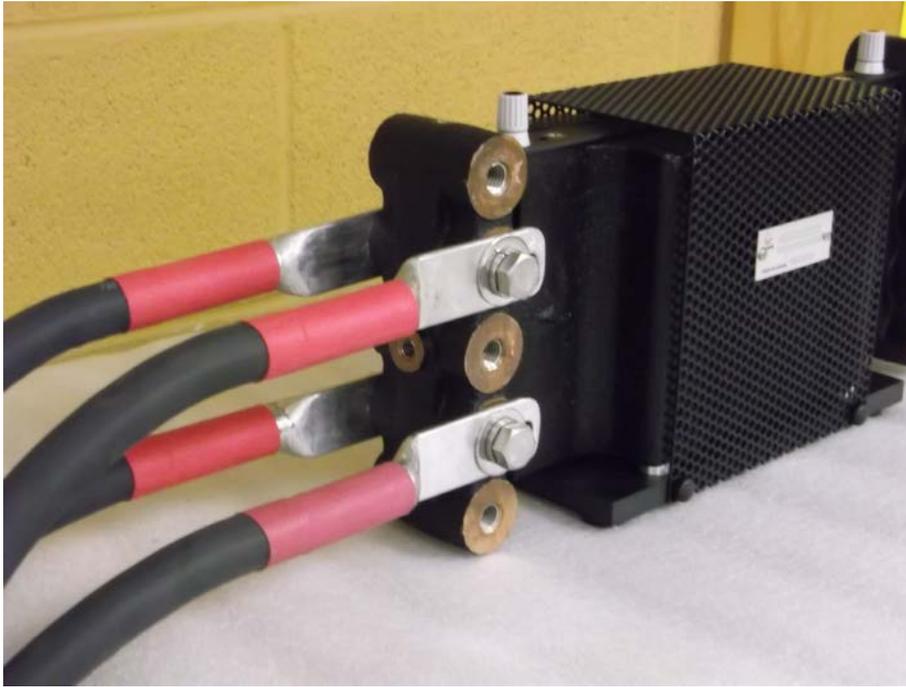


Figure 3-6 : Four Cable Connection, 1000 A to 2000 A

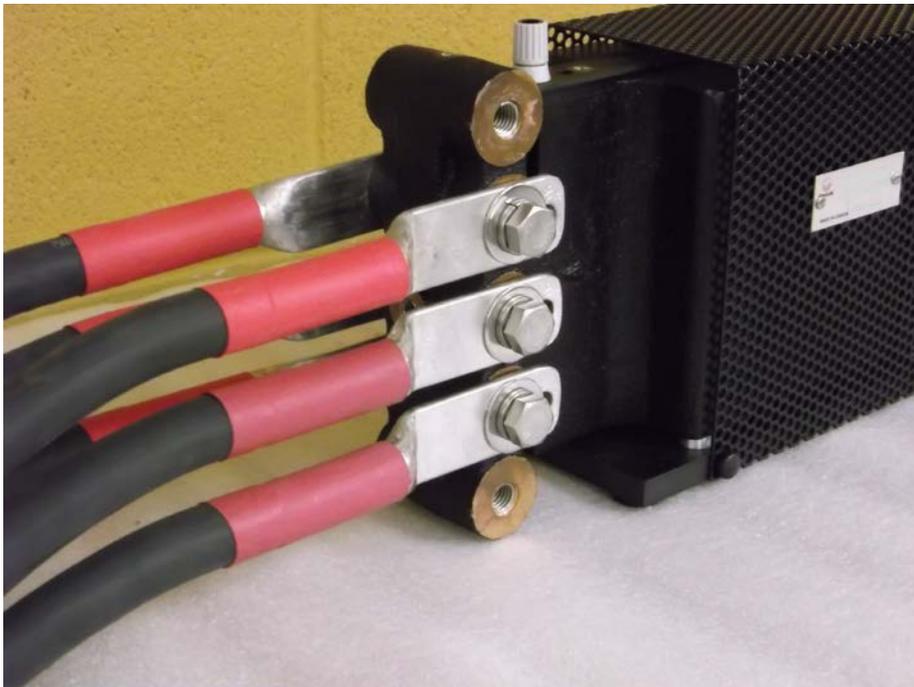


Figure 3-7 : Six Cable Connection, 2000 A to 3000 A

Model	Test Current Range (A)	Number of Cables in Parallel	Minimum Size (AWG)
9230A-10	0 to 10	1	12
9230A-15	0 to 15	1	12
9230A-15R	0 to 15	1	12
9230A-30	0 to 30	1	10
9230A-50	0 to 30	1	10
9230A-50	30 to 50	1	4
9230A-100	0 to 50	1	4
9230A-100	50 to 100	1	1
9230A-150	0 to 75	1	1
9230A-150	75 to 150	1	1/0
9230A-300	0 to 150	1	1/0
9230A-300	150 to 300	1	4/0
9230A-500	0 to 250	1	4/0
9230A-500	250 to 500	1	MCM350
9230A-1000	0 to 500	1	MCM350
9230A-1000	500 to 1000	2	MCM350
9230A-1500	0 to 750	2	MCM350
9230A-1500	750 to 1500	4	MCM350
9230A-3000	0 to 2000	4	MCM350
9230A-3000	2000 to 3000	6	MCM350

Table 3-1 : Cable Size Requirements

3.6 Custom Values

Custom values may be available upon request. For custom values, to determine the uncertainty, use the closest nominal value listed in the specification table. Actual measurements and associated uncertainties will be listed on the calibration certificate and report of calibration.

It is important to consider both the maximum test current requirement and the power dissipation that will be realized for a specific resistance value. Where a specific potential voltage is required for full scale current it is important to consider the power that will be dissipated by the shunt at full scale current. The following formulae are useful in this respect.

Power dissipation based on resistance and full scale current;

$$\text{Power Dissipation} = (\text{Maximum Current})^2 \times \text{Shunt Resistance}$$

For a shunt with a resistance of 1 mΩ and a full scale current of 300 A, 90 W will be dissipated by the shunt.

Power dissipation based on resistance and full scale potential;

$$\text{Power Dissipation} = (\text{Maximum Voltage})^2 / \text{Shunt Resistance}$$

For a shunt with a resistance of 10 mΩ and a full scale potential of 1 V, 100 W will be dissipated by the shunt.

Shunt resistance based on potential voltage and power dissipation;

$$\text{Shunt Resistance} = (\text{Maximum Voltage})^2 / \text{Power Dissipation}$$

For a shunt with a full scale voltage of 0.75 V and a maximum power dissipation level of 112.5 W, the shunt will have a resistance value of 0.005 Ω.

Shunt resistance based on full scale current and power dissipation;

$$\text{Shunt Resistance} = \text{Power Dissipation} / (\text{Maximum current})^2$$

For a shunt with a full scale current of 1500 A and a maximum power dissipation level of 112.5 W, the shunt will have a resistance value of 0.00005 Ω, (0.05 mΩ).

4.0 CALIBRATION AND PERFORMANCE VERIFICATION

4.1 Introduction

The following section describes the calibration and performance verification procedures for the 9230A Series of Precision DC Current Shunt Standards. It is recommended that Shunt Standards be calibrated over at least 3 test current points. Where no forced air convection fan is used shunt test points at nominal 5 W, 10 W power dissipation levels and the specified full scale current are recommended. Where the model 92310 Forced Convection Unit is used shunt test points at nominal 10 W, 25 W power dissipation levels and the specified full scale current are recommended. When a shunt is to be used as a precision low resistance standard a 1 W power diissipation level is recommended. Where the measurement system test current capability is limited below that of the shunt itself, the test current points can be set at 10, 25 and 100 % of the maximum power level capability. The listed points in Table 2 are for most values.

4.2 Calibration Overview

This calibration procedure covers the entire range of the 9230A Series of Precision DC Current Shunt Standards. The 9230A calibration procedure typically requires only a 1 Ω resistance standard for the full range of measurement requirements. It is important to measure and report ambient temperature conditions so that measurements can be repeated in other locations or suitable additional uncertainties can be applied for local in use conditions.

Calibration is normally performed with the shunt standard set up on a bench top where the ambient air temperature can be monitored and kept to within ± 2 °C. For ambient air temperature monitoring purposes with a natural convection setup measure the air temperature approximately 20 mm above the bench top and about 75 mm away from the left or right edge of the shunt base. Where a model 92310 forced air convection fan is used to force air downward into the top of the shunt standard measure the air temperature approximately 50 mm above the top surface of the fan unit.

4.3 Calibration Interval and Performance

It is recommended that the 9230A series be calibrated or verified on either the manufacturer's recommended 6 month or 1 year interval. As with all shunt standards it is highly recommended that past history be used to determine drift rates. Generally, shunt standards will drift in value more significantly in the first 12 months. After the initial 12 months, drift specifications are improved for the following year(s) for all models provided the shunt has not been subjected to extreme environmental or test conditions.

Each 9230A is manufactured to provide some of the best (i.e. lowest) uncertainties when compared to other commercially available shunt standards. After recalibration the user should determine the Resistance Calibration Uncertainties by applying a uncertainty calculation that includes uncertainties for drift, standards and equipment used, the calibration and laboratory environment, and other uncertainties applicable to that calibration.

Guildline offers Shunt Resistance Calibration Services, both accredited and non-accredited, from its Smiths Falls Location. We can provide very good turn-around times with some of the lowest uncertainties available today. 9230A Users may find the use of Guildline Calibration Services an excellent convenience as well as a great alternative to maintaining their own calibration facilities to support these standards.

4.4 Calibration Points

The 9230A Series of Shunts are tested at three different power levels and a 17025 Accredited Calibration Certificate is provided at no additional charge for a newly purchased unit. Additional calibration points can be provided at an extra charge.

If calibrations are requested at different temperature points, a Guildline Instruments model 5032 Temperature Controlled Air Bath (shown to the right) is recommended. When testing at different temperatures it is recommended that 1 mW power be used so the test chamber does not overheat.



4.5 Equipment and Standards Required for Calibration

The following Resistance Standards and Test Equipment is required for calibration.

Complete 6625A Resistance Measurement System with 6623A High Current Range Extender capable of meeting the highest test current requirement (See Below for Alternative Acceptable Equipment Models)

5030 Series Laboratory Grade Temperature Air Bath for temperature coefficient measurements or low power dissipations levels below a few watts.

Or (Alternative Standards)

- (a) Direct Current Comparator Resistance Bridge (Acceptable Models)

Guildline Instruments 6622A Series DCC Resistance Bridge
Guildline Instruments 6675 or 6675A Series DCC Resistance Bridge
Guildline Instruments Model 9975A

- (b) Guildline 6623A Series of Range Extenders from 3 A through to 3000 A in 150 A increments.

- (c) Laboratory Grade Primary Resistance Standard (Acceptable Models)

Guildline Instruments 6634A Temperature Stabilized Resistance Standard
Guildline Instruments 9334A-1 Standard, 1 Ω reference resistance standard

- (d) 9230A Shunt Lead Sets (Acceptable Models for various test current levels described in Table 3)

- (e) Optional (For Automation)

Guildline 6664B/C 4-Wire, 16 Channel Low Thermal Scanner (For Automation)
(Note – the 6664C Scanner is only model capable of 1000 V)
Guildline Bridgeworks- Resistance Software
Guildline 9540 Digital Thermometer

4.6 Routine Calibration

This routine calibration procedure describes the calibration currents required for the 9230A Shunt Standards. The procedure is intended to be used as a reference for qualified metrology personnel who have a primary level standards laboratory with equipment available to support an instrument of this level of accuracy.

Qualified personnel means that the technician or metrologist performing the calibration has the necessary level and understanding on Direct Current Comparator Resistance Measurements and full understanding of the DCC Bridge operation's and will take precautions to avoid introducing errors from sources such as guard errors, thermal emfs, temperature and or EMI errors and others. The procedure assumes operators will make adequate allowance for equipment stabilization and measurement settling times.

For the best uncertainties with least influence on the measurements, it is recommended that the procedure use automation technologies such as Bridgeworks Software, IEEE control and 6664B/C Low Thermal Scanners.

Calibration Notes For All Models

Always check availability of equipment and standards prior to starting the calibration. If the required equipment is not available, do not proceed with the calibration.

Ensure all equipment used is within the calibration validity interval.

Before beginning the calibration, inspect the UUT for damage and cleanliness. If the UUT is not in suitable condition for calibration, please clean or repair before proceeding.

While Table 2 lists recommended calibration points, actual calibration points should include consideration for the intended and/or application of the shunt standards.

$I_{\text{current}} = \sqrt{(P_{\text{power}}/R_{\text{resistance}})}$		Currents for Natural Convection (A)			Currents for 92310 Forced Convection (A)		
Model	Value (Ω)	5 W	10 W	Max A	10 W	25 W	Max A
9230A-10	1.0	2.2	3.2	5	3.2	5	$\leq 10^1$
9230A-15	0.5	3.2	4.5	7.5	4.5	7.1	15
9230A-15R	0.1	7.1	10.0	15	Rated only 25 W		
9230A-30	0.1	7.1	10.0	15	10.0	15.8	30
9230A-50	0.05	10.0	14.1	25	14.1	22.4	50
9230A-100	0.01	22.4	31.6	50	31.6	50	100
9230A-150	0.005	32	45	75	45	71	150
9230A-300	0.001	71	100	150	100	158	300
9230A-500	0.5 m	100	141	250	141	224	500
9230A-1000	0.1 m	224	316	500	316	500	1000
9230A-1500	0.05 m	316	447	750	447	707	1500
9230A-3000	10 μ	707	1000	1500	1000	1581	3000

Table 4-1 : Test Points and Currents

Note 1: Current sources available may not have sufficient voltage compliance to reach the 10 A test point. The highest test current capability should then be used.

4.7 Calibration Procedure

Record information as required into Table 3 (Calibration Data Worksheet)

- (a) Allow 9230A to stabilize for at least 24 hours at calibration temperature (including air or flowing oil baths).
- (b) Connect leads capable of handling the maximum required current from the 9230A Current Terminals to the range extender output current terminals.
- (c) Connect the Bridge Rs terminals to the appropriate standard terminals, (4 wire connection).
- (d) Connect the Bridge Rx potential terminals to the Potential Terminals of the shunt to be measured.
- (e) Setup DCC Bridge and Range Extender and other standards used for appropriate measurement (refer to manuals for equipment being used). Determine if calibration is to be performed with natural convection or if the 92310 forced air unit is required.
- (f) Starting with the lowest Test Point Current (Point 1 of datasheet), apply current and run recommended number of samples per Bridge Manual recommended measurement samples.
- (g) Record results for test (value) point 1 on Calibration Data Worksheet.
- (h) Repeat steps b through f for test point 2 and test point 3.
- (i) Remove all test leads and make sure standards are powered down.
- (j) Calculate drift and determine if within specification per Worksheet.

Note: Measurement Tips.

Consider the following when setting up the measurement

*Verify that the max current applied in the measurement will not exceed the specs for the UUT or the STD.
In no case should you exceed 130 watt level of applied power.*

Verify the reversal rate is appropriate for the measurement and the uncertainty desired.

Ensure that you know whether the measurement you are reading on the bridge is either a ratio or actual ohms value.

If using a PC, verify that the number of samples and logging delay are appropriate.

If using a PC set the environmental parameters in BridgeWorks .

Verify guard and ground connections (see 6622A Manual).

If using a scanner, ensure that the proper channels for Rx and Rs are selected.

Model	Value	Serial Number

LAST CALIBRATION						CURRENT CALIBRATION					
Calibration Date ▶						Calibration Date ▶					
Calibration Temp ▶						Calibration Temp ▶					
Measurement Data Details						Measurement Data Details					
Point 1		Point 2		Point 3		Point 1		Point 2		Point 3	
W	A	W	A	W	A	W	A	W	A	W	A
Value Point 1 ▶						Value Point 1 ▶					
Value Point 2 ▶						Value Point 2 ▶					
Value Point 3 ▶						Value Point 3 ▶					

		Calculated (Actual) (μΩ/Ω)	Listed (Specification)
Calculated Drift (Note Temperature, Power, currents and calibration time frame must match for results to be valid)	Drift Point 1 ▶		
	Drift Point 2 ▶		
	Drift Point 3 ▶		

Table 4-2 : Calibration Data Worksheet

Note 1 – To Calculate Drift Specifications (into ppm) use the following formulas:

For Drift @ Point 1 (μΩ/Ω) Calculate Using formula:

$$((\text{Current Cal}_{\text{Value Point 1}} - \text{Last Cal}_{\text{Value Point 1}}) / \text{Last Cal}_{\text{Value Point 1}}) * 1E^6$$

For Drift @ Point 2 (μΩ/Ω) Calculate Using formula:

$$((\text{Current Cal}_{\text{Value Point 1}} - \text{Last Cal}_{\text{Value Point 1}}) / \text{Last Cal}_{\text{Value Point 1}}) * 1E^6$$

For Drift @ Point 3 (μΩ/Ω) Calculate Using formula:

$$((\text{Current Cal}_{\text{Value Point 1}} - \text{Last Cal}_{\text{Value Point 1}}) / \text{Last Cal}_{\text{Value Point 1}}) * 1E^6$$

5.0 MAINTENANCE

Maintenance of the 9230A series of shunt standards consists only of routinely inspecting the unit for physical damage and cleanliness. Cleanliness is especially important on the high value resistors (1 MΩ and greater). These should be cleaned with isopropanol and a soft brush or cloth. Special care should be taken to ensure that the terminal connectors are clean. In particular the contact surfaces of the current terminals may need to be cleaned with a light abrasive from time to time to remove excessive oxide build up to avoid a high resistance contact that can heat up.

5.1 Replaceable Parts

The following tables list the replaceable parts. **Note that once a part has been replaced, the unit may be required to be recalibrated.**

To Contact Guildline Instruments, the following information is provided.

USA and Canada Telephone: (613) 283-3000
USA and Canada Fax: 1-613-283-6082

Outside US and Canada Telephone: +[1] 613 283-3000
Outside US and Canada Fax: [1] +613 283-6082

You can also contact Guildline Instruments Limited via their Email or Websites.

Email is: sales@guildline.com
Website is: www.guildline.com

5.1.1 Common Parts (All Models)

Part Number (GPN#)	Description
018-00165	Case Foot
30110-02-17	5 Way Binding Post, Red
30110-01-17	5 Way Binding Post, Black
841-01339	Lock Washer, #8
150-31592	Plastic Cap
812-04113	Cap screw
150-31590	Cap base

5.1.2 Models 9230A-10 to 9230A-150

Part Number (GPN#)	Description
30559-01-17	Knob, ¼-20
30105-01-15	Perforated Cover for 9230A-10, -15
30114-01-15	Perforated Cover for 9230A-15R, -30, -50
30122-01-15	Perforated Cover for 9230A-100, -150

5.1.3 Models 9230A-300 and 9230A-500

Part Number (GPN#)	Description
30559-02-17	Knob, 3/8-16
30126-01-15	Perforated Cover for 9230A-300
30126-02-15	Perforated Cover for 9230A-500

5.1.4 Models 9230A-1000 and 9230A-1500

Part Number (GPN#)	Description
817-01200	Cable Bolt, 3/8 – 16 x 1"
839-06666	Cable Flat Washer, 3/8
841-01389	Cable Split Washer, 3/8
30093-01-15	Perforated Cover for 9230A-1000
3009-02-15	Perforated Cover for 9230A-1500

5.1.5 Model 9230A-3000

Part Number (GPN#)	Description
817-01200	End Cable Bolt, 3/8 – 16 x 1"
839-06666	End Cable Flat Washer, 3/8
841-01389	End Cable Split Washer, 3/8
817-02041	Side Cable Bolt, ½- 13 x 1"
839-06667	Side Cable Flat Washer, ½
839-02032	Side Cable Split Washer, ½
30093-03-15	Perforated Cover for 9230A-3000

5.1.6 High Current Cable Lead Sets

Model Number	Description
92301/92304	20A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92318/92319	30A, 1.5 Meter/x Meter Lead set (Current and Sense Leads)
92302/92305	100A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92321/92322	150A, 1.5 Meter/x Meter Lead set (Current and Sense Leads)
92303/92306	300A, 1.5 Meter/x Meter Lead set (Current and Sense Leads)
92307/92308	500A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92309/92311	1000A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92312/92313	2000A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92314/92315	3000A, 2 Meter/x Meter Lead set (Current and Sense Leads)

- Note 1:** Lead sets consist of source leads and return leads of specified capacity and one shielded pair sense lead.
- Note 2:** Lead sets above 500 A capacity consist of multiple cable pairs to meet the total current requirement. The 1000 A lead set consists of two 500 A source leads and two 500 A return leads as well as 1 sense lead.
- Note 3:** Specify lead length required in meters when ordering special lengths.