

*IEEE Standard Requirements for*  
**Direct Current Instrument Shunts**



THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, Inc.

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**IEEE**

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***IEEE Standard Requirements for  
Direct Current Instrument Shunts***

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## Acknowledgement

The present standard, prepared by the Instrument Accessories Subcommittee, contains revisions resulting from suggestions received when the original document was submitted as Conference Paper No. 31 CP 65-672 at the IEEE Summer Power Meeting, Detroit Michigan, June 27 - July 2, 1965. It was presented under the auspices of the IEEE Power System Instrumentation and Measurements Committee of the IEEE Power Group.

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## Notice

The IEEE will maintain this Standard current with the state of the technology. Comments on this Standard as well as suggestions for additional material that should be included are invited. These should be addressed to:

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## Foreword

In the absence of any comprehensive standard on instrument shunts the former AIEE Special Instruments and Auxiliary Apparatus Committee and its later counterpart, the IEEE Power Systems Instrumentation and Measurements Committee sponsored the preparation of such a standard and assigned this activity to the Instrument Accessories Subcommittee for implementation.

The objectives of such a standard are:

- (1) To clarify the shunt terminology
- (2) To eliminate existing confusion as to the nature of shunt requirements, and
- (3) To provide a minimum standard for the level of performance acceptable to the majority of shunt users.

As indicated in paragraph 1, under Scope, no attempt has been made to cover military or other special applications or those shunts intended for approximate indications which do not meet the accuracy requirements of Section 5.

It seemed desirable to the subcommittee to select certain standard values of rated current as well as voltage output. However, since these items do not fall into the designated category of IEEE Standards they have been included as recommendations to indicate the ratings furnished by the majority of manufacturers and to serve as a guide for a possible future American National Standard.

It is hoped that this proposal may have initial application as a "common language" source among those who have an interest in shunts and that many comments will be received from shunt manufacturers, switchboard manufacturers, laboratories, and other shunt users. Comment and criticism are earnestly solicited as only with wide distribution and participation can we expect to produce ultimately the best possible shunt standard.



# *IEEE Standard Requirements for* **Direct Current Instrument Shunts**

## **1. Scope**

1.1 This standard applies to shunts for use in direct current circuits to extend the range of instruments or other measuring devices.

1.2 This standard may apply with suitable exceptions to shunts constructed for special requirements; for example, those having unusually high or low current ratings or voltage drops, special or unusual ranges, and non-standard terminal arrangements for special applications.

1.3 This standard does not apply to the following:

- (1) Shunts for special military applications
- (2) Internal shunts used as a part of a self-contained ammeter
- (3) Shunts for use as standards or for high precision measurements
- (4) General purpose shunts of lower accuracy than specified, to be used where required indications are only approximate

## **2. Classification**

Shunts shall be classified broadly as indicated below:

- (1) Bus-Type Shunts for switchboard use
- (2) Portable Shunts with insulating bases

## **3. Definitions**

3.1 The definitions given herein apply to electrical instrument shunts covered by this standard.<sup>1</sup>

3.2 **Instrument Shunt.** A particular type of resistor designed to be connected in parallel with the measuring device to extend the current range beyond some particular value for which the instrument is already complete. (30.70.010)

3.2.1 **Bus-Type Shunt.** An instrument

<sup>1</sup>For additional definitions see ANSI (American National Standards Institute) C42 Series.

shunt intended for switchboard use and designed so that it can be installed in the bus or connection bar structure of the circuit whose current is to be measured.

3.2.2 **Portable Shunt.** An instrument shunt with insulating base which may be laid on, or fastened to, any flat surface. It may be used also for switchboard applications where the current is relatively low and connection bars are not used.

3.3 **Current Terminals.** Those terminals which are connected into the line whose current is to be measured and that will carry the current of the shunt.

3.4 **Instrument Terminals.** Those terminals which provide a voltage drop proportional to the current in the shunt and to which the instrument or other measuring device is connected.

3.5 **Adjustment Accuracy.** The limit of error, expressed as a percentage of the rated output voltage, in the initial adjustment of the shunt made when employing a low-current measurement method.

3.6 **Rated Accuracy.** The limit of error, expressed as a percentage of the rated output voltage, with two thirds rated current applied for one half hour to allow for self heating. It represents the expected accuracy of the shunt obtainable under normal conditions of use.

3.7 **External Temperature Influence.** The percentage change in the output voltage of a shunt (expressed in terms of rated output and measured with low current) when the ambient temperature is changed from 25°C to 100°C.

## **4. General Requirements**

4.1 **Markings.** The following markings shall appear on all shunts:

- Manufacturer's name (or symbol)
- Current rating
- Voltage drop at rated current

**4.2 Construction.** The current terminals of the shunt shall be so constructed that normal variations in the manner of connecting it in the circuit will not alter the voltage drop by more than one half the rated accuracy. (See 5.7 Reference Test Conditions.)

**4.3 Short Circuit Rating.** Shunts shall be designed to stand ten times rated current for one second without visible damage or change in accuracy.

## 5. Performance Characteristics

**5.1 Adjustment Accuracy.** Shunts shall be adjusted to within  $\pm 0.25$  percent of nominal value with applied current that will not raise the temperature of the terminal blocks more than  $10^{\circ}\text{C}$  over the ambient temperature. (See 5.7 Reference Test Conditions)

**5.2 Rated Accuracy.** Rated accuracy limits shall be:

For shunts rated up to 1000 amperes, 0.33 percent

For shunts rated 1000 amperes and above, 0.5 percent

This allows for self heating variation at the higher current values, and variance in connections. (See 5.7 Reference Test Conditions)

**5.3 External Temperature Influence.** The influence on accuracy due solely to a change in ambient temperature from  $25^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  shall not exceed 0.25 percent for shunts rated up to 1000 amperes and 0.5 percent for shunts rated 1000 amperes and above when held at the above temperatures for four hours and measured with low current to prevent self heating. (See 5.1 and 5.7)

**5.4 Temperature Rise.** Shunts shall be designed for a maximum temperature rise that will produce no physical damage and no permanent change in accuracy greater than that set by the rated accuracy limits after exposure to 110 percent of rated shunt current for 24 hours. This test shall be made in a bus-bar arrangement whose cross-section will give a  $30^{\circ}\text{C}$  temperature rise at rated current (without the shunt installed) with buses extending at least 3 feet in free air on either side of the shunt. Aluminum buses will require a greater cross-section than copper to maintain a  $30^{\circ}\text{C}$

rise, inasmuch as the size prescribed for a given rating in copper will have only 61 percent conductance in aluminum. (See 5.7 Reference Test Conditions)

**5.5 Thermal EMF.** The thermal electromotive force produced in a shunt between instrument terminals shall not exceed 0.1 percent of rated voltage drop when a temperature difference of  $15^{\circ}\text{C}$  is maintained between terminal blocks.

**5.6 Effect of Shifting Current Terminal Connections on Multiple Terminal Shunts.** Shunts shall have sufficient transverse conductance in the terminal blocks to limit the effect of shifting connections to  $\pm 1$  percent of measured output voltage drop when using one half the normal number of connections, locating these in the two extreme locations to lead current into the shunt and inserting copper blades in the unused slots. The test shall be made at a current that will not raise the temperature of the blocks by more than  $10^{\circ}\text{C}$  over the ambient temperature.

**5.7 Reference Test Conditions.** Accuracy and temperature tests shall be made under the following conditions:

Reference Temperature  $25^{\circ}\text{C}$  ( $\pm 2^{\circ}\text{C}$ )

Position, Bus-Type — Current terminals and resistance blades, vertical, allowing free air flow.

Position, Portable Type — Base flat on horizontal surface.

Connections, Bus-Type Shunts — Tightly bolted to current bus using all terminal slots and specified depth of blade insertion.

Connections, Portable Type Shunts — Tightly bolted to lugs with cables of proper cross-section.

NOTE: Accuracy measurements made at low currents may be made without a complete bus arrangement if the method of connection provides for relatively uniform distribution of current in the shunt current blades.

**5.8 Dielectric Test.** Shunts with insulating bases shall be tested on 60 Hz, 2600 volts rms, applied for one minute between the shunt terminals and a metallic platform on which the shunt is mounted.

## 6. Shunt Ratings

**6.1 Voltage Drop.** The standard voltage out-

put at the instrument terminals shall be 50 or 100 millivolts at rated current.

**6.2 Current Ratings.** The preferred shunt ratings expressed in amperes shall be as follows:

1	10	100	1000	10,000
-	-	-	1200	
-	15	150	1500	
-	-	200	2000	
-	25	250	2500	
-	-	300	3000	
-	-	400	4000	
5	50	500	5000	
-	-	600	6000	
-	75	750	--	
-	-	800	8000	

NOTE: The current rating is an approximation of continuous current capacity under reference conditions. Selection of ratings should be based on operation at a normal current of  $\frac{2}{3}$  the rated value (see 3.6 Rated Accuracy). Ratings are based on mounting in accordance with 5.7 Reference Test Conditions, with allowance for air circulation and protection from other heat-radiating sources. Since a shunt is essentially a part of a bus-bar assembly, it depends on the bus structure to conduct away a major portion of the heat generated within the shunt and then to radiate this heat. It is important, therefore, that these connecting buses be of ample size and properly attached to the shunt. Any other types of mounting or environment than described above may require derating of the shunt.

Most manufacturers provide shunts with the recommended voltage drop and each recommended current rating is supplied by at least five major shunt manufacturers.

Shunts may be allowed to run hotter when current terminals are silver plated (usually only as a special feature).

For current ratings higher than 10,000 amperes, two lower rated shunts of equal current rating may be connected in parallel. Separate leads of equal length and size must be connected between the instrument terminals of each shunt and the terminals of the measuring device.

## 7. Dimensions

It is impracticable to suggest standard shunt sizes or dimensions. However, a minimum terminal cross section of one square

inch of copper per thousand amperes rating is recommended.

For future designs the bolt arrangements shown in NEMA (National Electrical Manufacturers Association) Standards SG1 for Electric Power Connectors, paragraphs SG 1-4.04 and SG 1-4.06, should be considered.

On shunts with multiple tang terminals of  $\frac{1}{4}$  inch (6.35 mm) thickness, the terminals should be made to accommodate bus bars 0.250 in.  $\pm$  .005 in. thick. Recommended maximum current values for different bolt sizes are as follows:

Bolt Size diameter (inches) (mm)	Max. current per bolt per pair of surfaces (amperes)
$\frac{3}{8}$ 9.5	350
$\frac{1}{2}$ 12.7	600
$\frac{5}{8}$ 15.9	800
$\frac{3}{4}$ 19.1	1000

## 8. Installation

Shunts should be installed so that they will not be damaged by thermal expansion forces in the connecting bus bars or by short circuit forces. It should be recognized that shunts are inherently weaker than their current connections and that special flexibility may be needed at times.

## 9. Connection

Where possible all shunts should be connected in the grounded side of the line. Portable type shunts with insulating bases, when used on circuits above 750 volts should be mounted in the grounded side of the circuit. Where more than one bus bar is to be connected to each end of single-terminal shunts, these bars should be distributed as equally as possible on each side of the shunt terminals.

## **IEEE Standards of Particular Interest to Power Measurement Engineers**

<b>IEEE Std</b>	<b>Title</b>
<b>4-1968</b>	<b>Techniques for Dielectric Tests (ANSI C68.1-1968)</b>
<b>62-1958</b>	<b>Guide for Making Dielectric Tests in the Field</b>
<b>81-1962</b>	<b>Guide for Measuring Ground Resistance and Potential Gradients in the Earth</b>
<b>118-1949</b>	<b>Master Test Code for Resistance Measurement</b>
<b>119-1966</b>	<b>Master Test Procedure for Temperature Measurement</b>
<b>120-1955</b>	<b>Master Test Code for Electrical Measurements in Power Circuits</b>
<b>121-1959</b>	<b>Guide for Measurement of Rotary Speed</b>
<b>251-1963</b>	<b>Test Procedures for Direct-Current Tachometer Generators</b>
<b>286-1968</b>	<b>Recommended Practice for Measurement of Power Factor Tip-Up of Rotating Machinery Stator Coil Insulator</b>

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