# Installation

## Table of Contents

## Qualified Persons

**⚠ WARNING**

Only qualified persons who are knowledgeable in the installation, operation, and maintenance of overhead and underground electric distribution equipment, along with all associated hazards, may install, operate, and maintain the equipment covered by this publication. A qualified person is someone who is trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from nonlive parts of electrical equipment
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed
- The proper use of special precautionary techniques, personal protective equipment, insulated and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment

These instructions are intended ONLY for such qualified persons. They are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

## Read this Instruction Sheet

***NOTICE***

Thoroughly and carefully read this instruction sheet and all materials included in the product's instruction handbook before installing or operating your voltage sensors. Familiarize yourself with the Safety Information and Safety Precautions on pages 3 and 4. The latest version of this publication is available online in PDF format at **sandc.com/en/support/product-literature/**.

## Retain this Instruction Sheet

This instruction sheet is a permanent part of your voltage sensors. Designate a location where you can easily retrieve and refer to this publication.

## Proper Application

**⚠ WARNING**

The equipment in this publication is only intended for a specific application. The application must be within the ratings furnished for the equipment. Ratings for the Voltage Sensors are listed in the ratings table in Specification Bulletin 591-31.

## Warranty

The warranty and/or obligations described in S&C's Price Sheet 150 "Standard Conditions of Sale–Immediate Purchasers in the United States" (or Price Sheet 153, "Standard Conditions of Sale–Immediate Purchasers Outside the United States"), plus any special warranty provisions, as set forth in the applicable product-line specification bulletin, are exclusive. The remedies provided in the former for breach of these warranties shall constitute the immediate purchaser's or end user's exclusive remedy and a fulfillment of the seller's entire liability. In no event shall the seller's liability to the immediate purchaser or end user exceed the price of the specific product that gives rise to the immediate purchaser's or end user's claim. All other warranties, whether express or implied or arising by operation of law, course of dealing, usage of trade or otherwise, are excluded. The only warranties are those stated in Price Sheet 150 (or Price Sheet 153), and THERE ARE NO EXPRESS OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. ANY EXPRESS WARRANTY OR OTHER OBLIGATION PROVIDED IN PRICE SHEET 150 (OR PRICE SHEET 153) IS GRANTED ONLY TO THE IMMEDIATE PURCHASER AND END USER, AS DEFINED THEREIN. OTHER THAN AN END USER, NO REMOTE PURCHASER MAY RELY ON ANY AFFIRMATION OF FACT OR PROMISE THAT RELATES TO THE GOODS DESCRIBED HEREIN, ANY DESCRIPTION THAT RELATES TO THE GOODS, OR ANY REMEDIAL PROMISE INCLUDED IN PRICE SHEET 150 (or PRICE SHEET 153).

## Understanding Safety-Alert Messages

Several types of safety-alert messages may appear throughout this instruction sheet and on labels and tags attached to your S&C Voltage Sensors. Familiarize yourself with these types of messages and the importance of these various signal words:

**⚠ DANGER**

"DANGER" identifies the most serious and immediate hazards that will likely result in serious personal injury or death if instructions, including recommended precautions, are not followed.

**⚠ WARNING**

"WARNING" identifies hazards or unsafe practices that can result in serious personal injury or death if instructions, including recommended precautions, are not followed.

**⚠ CAUTION**

"CAUTION" identifies hazards or unsafe practices that can result in minor personal injury if instructions, including recommended precautions, are not followed.

***NOTICE***

"NOTICE" identifies important procedures or requirements that can result in product or property damage if instructions are not followed."

## Following Safety Instructions

If you do not understand any portion of this instruction sheet and need assistance, contact your nearest S&C Sales Office or S&C Authorized Distributor. Their telephone numbers are listed on S&C's website **sandc.com**, or call the S&C Support and Global Monitoring Center at 1-888-762-1100.

***NOTICE***

Read this instruction sheet thoroughly and carefully before installing your voltage sensors.

## Replacement Instructions and Labels

If additional copies of this instruction sheet are needed, contact your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

It is important that any missing, damaged, or faded labels on the equipment be replaced immediately. Replacement labels are available by contacting your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

## ⚠ DANGER


**S&C Voltage Sensors operate at high voltage. Failure to observe the precautions below will result in serious personal injury or death.**

Some of these precautions may differ from your company's operating procedures and rules. Where a discrepancy exists, follow your company's operating procedures and rules.

1. **QUALIFIED PERSONS.** Access to an S&C Voltage Sensor must be restricted only to qualified persons. See the "Qualified Persons" section on page 2.
2. **SAFETY PROCEDURES.** Always follow safe operating procedures and rules.
3. **PERSONAL PROTECTIVE EQUIPMENT.** Always use suitable protective equipment, such as rubber gloves, rubber mats, hard hats, safety glasses, and flash clothing, in accordance with safe operating procedures and rules.
4. **SAFETY LABELS.** Do not remove or obscure any of the "DANGER," "WARNING," "CAUTION," or "NOTICE" labels.
5. **ENERGIZED COMPONENTS.** Always consider all parts live until de-energized, tested, and grounded. The voltage sensors contain components that can retain a voltage charge for many days after the voltage sensors have been de-energized and can derive a static charge when in close proximity to a high-voltage source. Voltage levels can be as high as the peak line-to-ground voltage last applied to the unit. Units that have been energized or installed near energized lines should be considered live until tested and grounded.
6. **MAINTAINING PROPER CLEARANCE.** Always maintain proper clearance from energized components.

## General

Performance characteristics described in this document apply to S&C Indoor Voltage Sensors having 20-VA nominal output. The characteristics of earlier models of voltage sensors (having a 30-VA nominal output) differ somewhat. Particulars on these earlier models can be obtained from the nearest S&C Sales Office.

## Application

The S&C Indoor Voltage Sensor is a compact voltage-monitoring device for grounded-system application, consisting of a high-voltage capacitor series-connected to the primary side of a dry-type transformer completely self-contained within a molded Cypoxy™ Insulator housing. See Figure 1. The S&C Indoor Voltage Sensor provides voltage intelligence for monitoring and nonrevenue metering applications in S&C Metal-Enclosed Switchgear; voltage intelligence for special purpose relays, e.g., for ground detection and voltage-unbalance detection; control voltage for automatic control equipment; and, in S&C Pad-Mounted Gear applications, control voltage for motor-charging and tripping of stored-energy switch operators. The S&C Indoor Voltage Sensor incorporates features that make it ideal as a direct substitute for apparatus support (switch or fuse) or bus-support insulators, thereby economizing on the limited space available in metal-enclosed and pad-mounted gear. See Figure 2 on page 6.

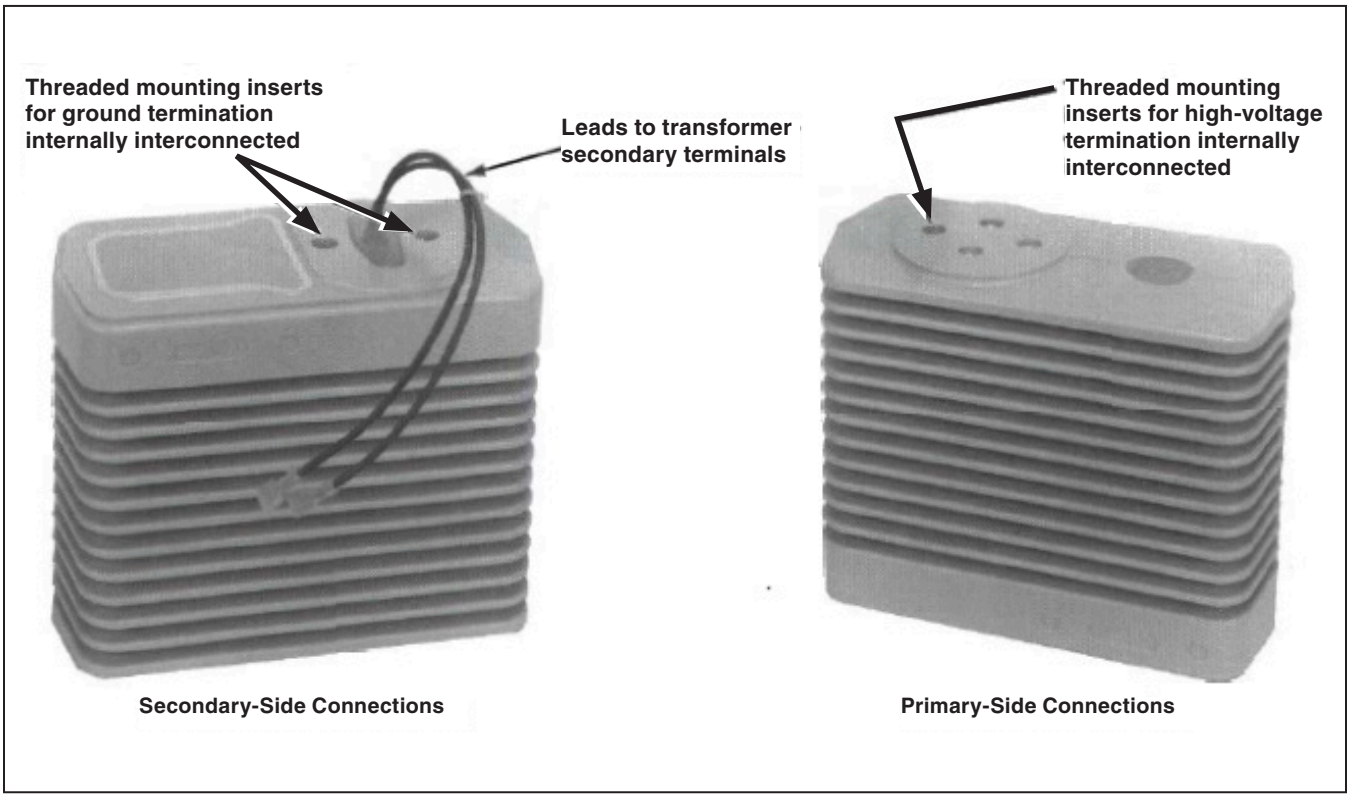


**Figure 1. Views of an S&C Indoor Voltage Sensor rated 14.4 kV nominal.**

The S&C Indoor Voltage Sensor is designed for line-to-ground connection and provides an output voltage directly proportional to line-to-ground voltage. It has relay accuracy over an ambient temperature range of -40°F (-40°C) to +160°F (+71°C).

The S&C Indoor Voltage Sensor is available in two ratings, for application at system voltages of 14.4 kV and 25 kV respectively. Output of each device is nominally 20-VA at 120 Volts, 60 Hertz with a 720-ohm resistive burden connected across the output terminals and with line to-ground voltage corresponding to rated nominal system voltage applied to the line terminal. The 14.4-kV model may also be used on 4.16-kV systems. In this case, the sensor has a nominal output of 3.2 VA at 69.3 Volts, 60 Hertz, with a 1500-ohm resistive burden connected across the output terminals and with 2.4 kV applied to the line terminal.

The S&C Indoor Voltage Sensor is a constant-current output device similar to a current transformer, so primary fusing (required by voltage transformers) is eliminated.

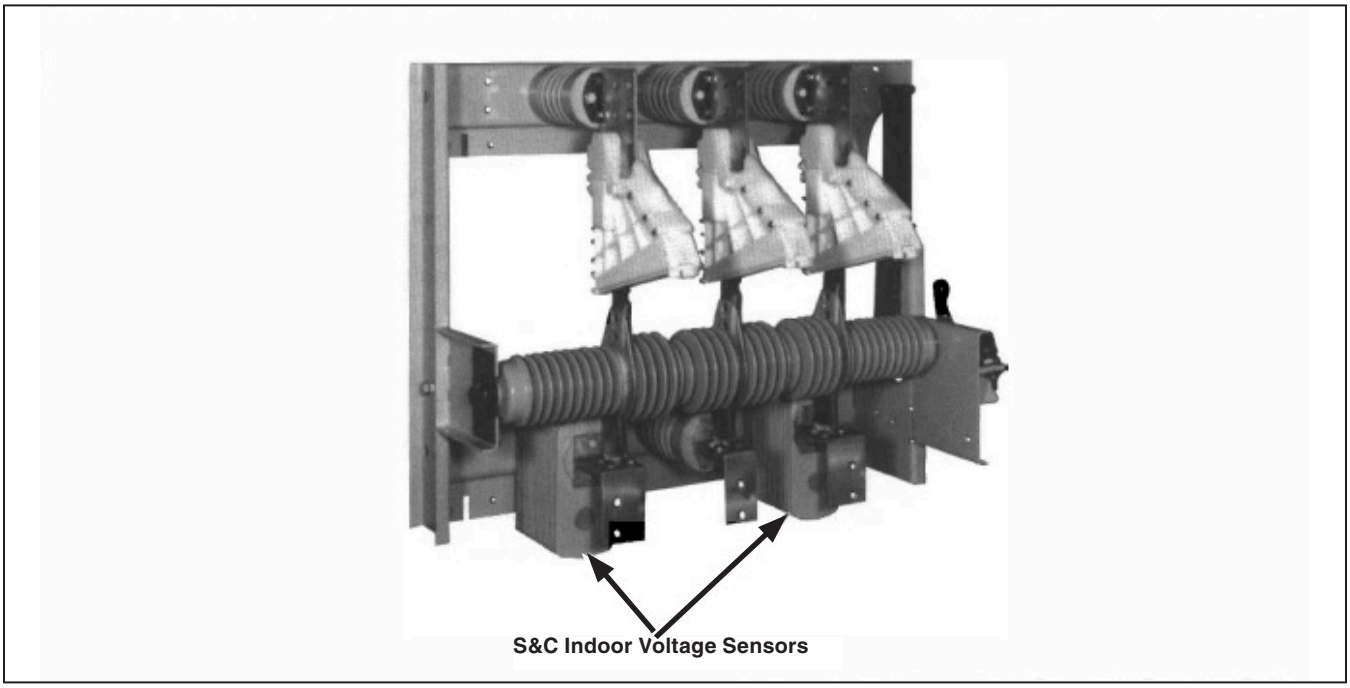


**Figure 2. Typical application of indoor voltage sensors in S&C Metal-Enclosed Switchgear. Here, two indoor voltage sensors are installed on the outboard poles of a 600-amp Mini-Rupter® Switch. Insulating barriers have been removed for clarity. (A separate voltage transformer is Installed, with the switch in an entrance bay of the primary-selective 13.8-kV metal enclosed switchgear lineup, to provide third-phase voltage sensing and control power for an automatic source-transfer scheme.)**

## Accessories

Each S&C Indoor Voltage Sensor requires an S&C Voltage Limiter, a protective device that prevents damage to the sensor's transformer if the secondary circuit is inadvertently opened or the burden is removed. See Figure 3.

An S&C Adjustable Burden-Resistor Assembly is available as an optional accessory for the indoor voltage sensor to provide the necessary secondary burden and to permit precise adjustment of the voltage sensor's output to the voltage level required by the application. See Figure 3. An optional output connector with 4-foot (122-cm) wire leads is available for making connections to the equipment served by the voltage sensors.

The Adjustable Burden-Resistor Assembly is available in two versions. One model permits adjustment of the indoor voltage sensor's input-to-output voltage ratio over sensors applied on 4.16-kV systems and permits adjustment of the sensor's input-to-output voltage ratio over a range from 22:1 to 58:1. The burden-resistor assembly features easily accessible voltage-level test jacks and voltage-adjustment screws to facilitate adjustment of output voltage to the desired level. Each voltage-adjustment screw is equipped with a locking nut to guard against inadvertent changes to the voltage level setting.

An S&C Test Accessory, available for use with the Adjustable Burden-Resistor Assembly, permits preliminary checkout of equipment using an external single-phase 120-Vac control source (before high voltage is connected to the switchgear to expedite full service once high voltage is available. See Figure 3. Transfer of the output connector of the Adjustable Burden-Resistor Assembly to the test accessory isolates the indoor voltage sensor(s) and eliminates the possibility of back feed during test procedures.

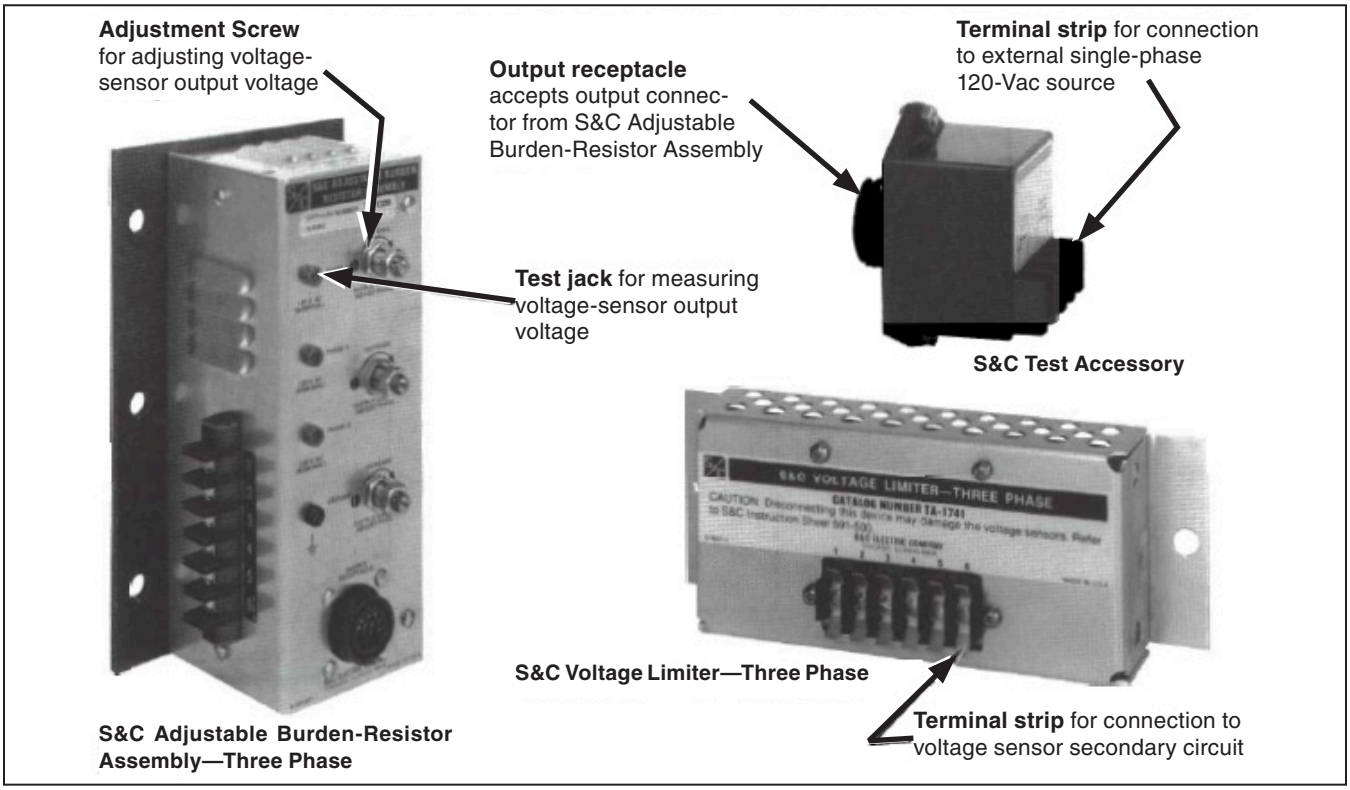


**Figure 3. Accessories for S&C Indoor Voltage Sensors.**

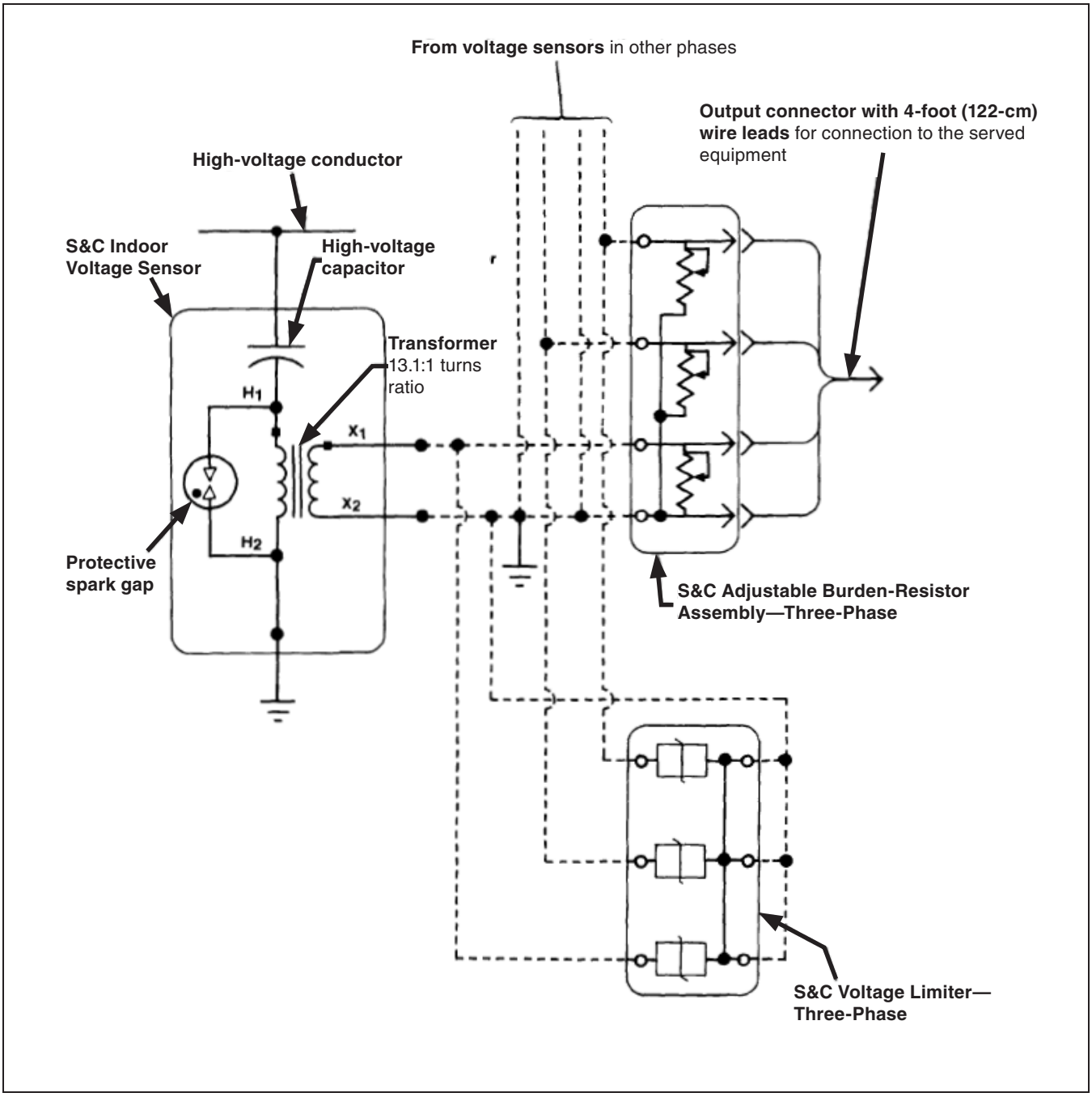


**Figure 4. Schematic showing Interrelationship of S&C Indoor Voltage Sensor and accessories.**

The interrelationship of the indoor voltage sensor and accessories is shown in Figure 4 on page 8.

The indoor voltage sensor's high-voltage series capacitor limits the primary current to approximately 13 milliamperes for all loading conditions, including short circuits. The low capacitance value—4.4 nanofarads for sensors rated 14.4 kV, 2.5 nanofarads for sensors rated 25 kV—has no effect on system behavior or on the performance of cable-fault-locating equipment.

Because of the series capacitor, when a purely resistive burden (such as the Adjustable Burden-Resistor Assembly) is connected across the output terminals, the sensor's output voltage leads the line-to-ground voltage by approximately 79 degrees in the 14.4-kV model and by approximately 84 degrees in the 25-kV model.

The secondary current is approximately 13.1 times the primary current. Although the nominal output is 20 VA when the indoor voltage sensor is energized at rated voltage, a reduced, but still usable, volt-ampere output is available when the indoor voltage sensor is energized at less than rated voltage. See Figure 5.

The 14.4-kV indoor voltage sensor, when applied on 4.16-kV systems, has a nominal output of 3.2 VA at 69.3 Volts, 60 Hertz. Again, a reduced, but still usable, volt-ampere output is available when the sensor is energized at less than 2.4 kV line to ground. See Figure 5.

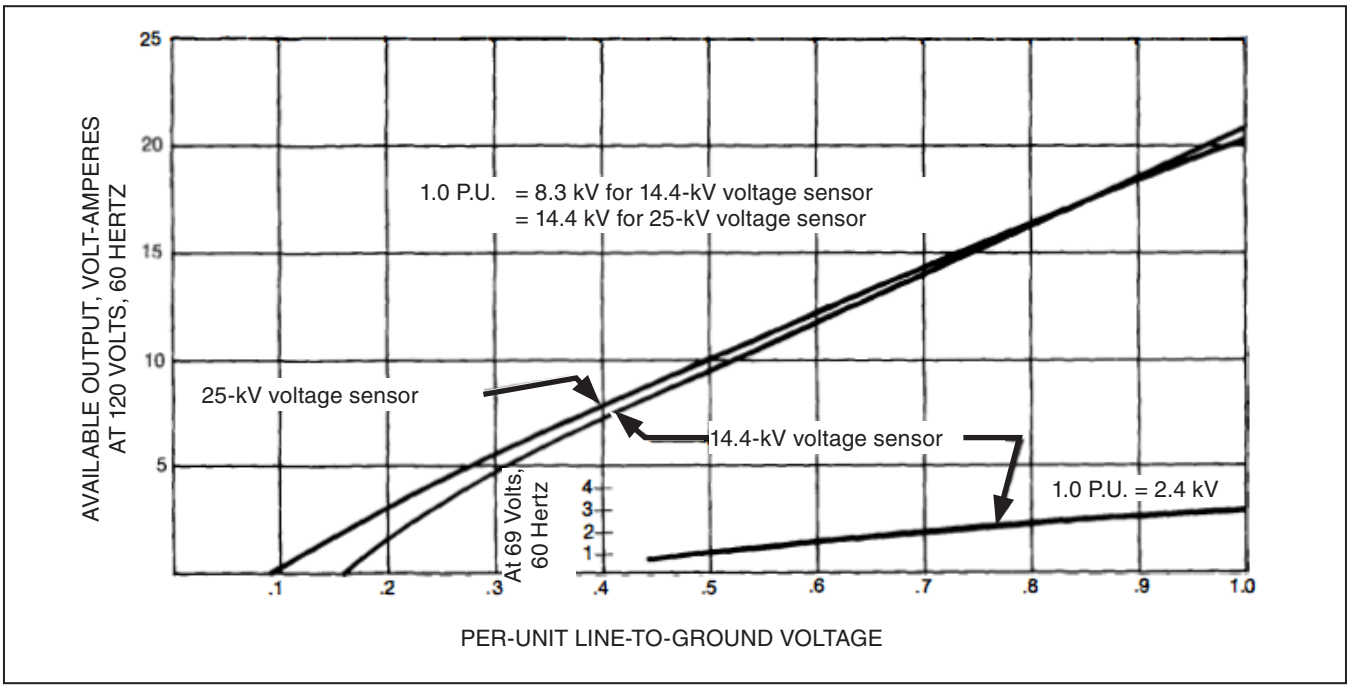


**Figure 5. Available volt-ampere output vs. per-unit line-to-ground voltage for constant 120-Volt, 60-Hertz output voltage. Also, for 14.4-kV voltage sensor applied on 4.16-kV system, available volt-ampere output vs. per-unit line-to-ground voltage for constant 69-Volt, 60-Hertz output voltage.**

## Adjusting the Burden

To obtain the voltage sensor's nominal 20-VA output at 120 Volts, 60 Hertz, the total unity power-factor (resistive) burden presented to the voltage sensor, $R_t$, must equal 720 ohms. In instances where the 14.4-kV voltage sensor is applied on a 4.16-kV system, however, $R_t$ must equal 1500 ohms to obtain the sensor's nominal output of 3.2 VA at 69.3 Volts, 60 Hertz.

If the resistance of the connected equipment is greater than that indicated above, a resistor must be paralleled with the connected equipment so the combined resistance equals the required value.●

Example: If the measured resistance of the connected equipment is found to be 3000 ohms and the required value is 720 ohms, the requisite parallel resistance, $R_p$, would be calculated as follows:

$$\frac{(R_p)\ (3000 \text{ ohms})}{R_p + 3000 \text{ ohms}} = 720 \text{ ohms} \qquad R_p = 947 \text{ ohms}$$

For practical purposes, an Adjustable BurdenResistor Assembly, catalog number TA-1335, would be used and an adjustment made until 120 Volts is indicated across the connected equipment. The voltmeter used for this indication must have a minimum input impedance of 5000 ohms per volt to avoid appreciable additional loading.

In instances where the 14.4-kV sensor is applied on a 4.16-kV system, an Adjustable Burden-Resistor Assembly, catalog number TA-2232, would be used and an adjustment made until 69 Volts is indicated across the connected equipment. Again, the voltmeter used for this indication must have a minimum input impedance of 5000 ohms per volt to avoid appreciable additional loading.

**⚠ DANGER**

The voltage sensor must be properly burdened to prevent output voltage from exceeding 132 Volts, 60 Hertz.

● If a lesser volt-ampere output is available (see Figure 5 on page 9), $R_t$ is equal to ($E_s$)2!(VA available), where $E_s$ = voltage sensor secondary voltage, 120 Volts (69.3 Volts for the 144-kV sensor applied on a 416-kV system). If the measured resistance of the connected equipment is greater than $R_t$, a resistor must be paralleled with the connected equipment so the combined resistance is $R_t$.

## Effect of Burden Variation on Secondary Voltage

The variation of secondary voltage with applied burden for a constant primary voltage is illustrated by the curves in Figure 6. The intention here is to show the characteristics of secondary voltage with variable loading rather than to provide specific values for direct application. The specific value of burden resistance required to obtain a 120-Vac secondary voltage may vary by as much as +10% and -20%, depending upon the characteristics of the particular indoor voltage sensor.

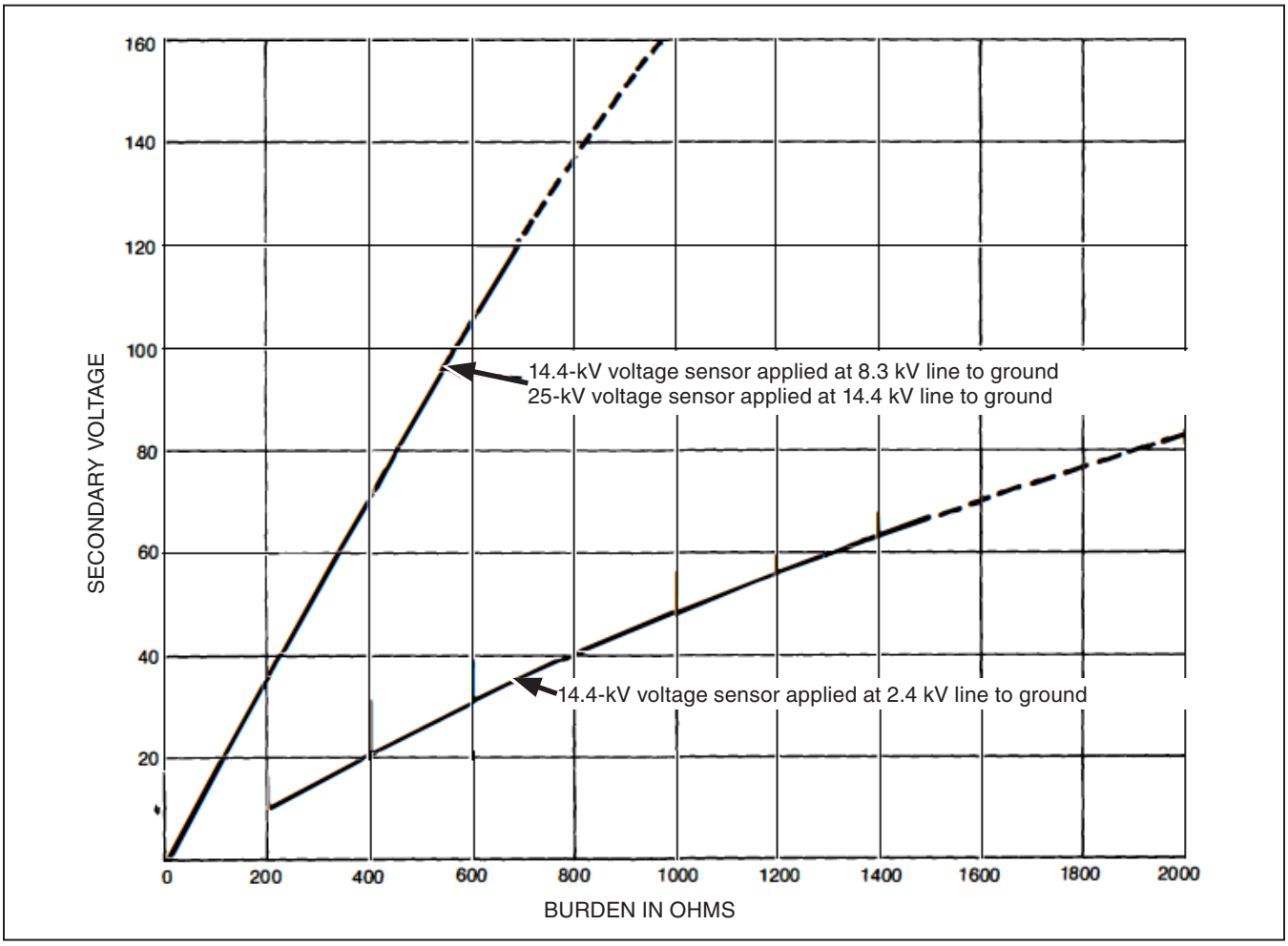


**Figure 6. Secondary voltage vs. burden for constant nominal primary voltage.**

In most instances, the S&C Indoor Voltage Sensor is factory-installed in S&C Metal-Enclosed Gear. In the event the voltage sensor is to be field-installed, care must be taken to ensure the low-voltage output leads are trained and shielded so rated BIL is maintained. Specifically, the following minimum clearances from high-voltage energized parts are required: 6 inches (15 cm) at 14.4 kV; 8½ inches (22 cm) at 25 kV. Conduit or metal duct work must be provided for the low-voltage output wiring.

An S&C Voltage Limiter must be connected across the secondary of each voltage sensor's transformer. Further, the Adjustable Burden-Resistor Assembly, when used with three indoor voltage sensors, must be mounted to a metallic surface having an area of at least four square feet (122 square cm). (This heat-sinking requirement does not apply if the burden-resistor assembly is used with a single indoor voltage sensor, or for 14.4-kV indoor voltage sensors when applied on 4.16-kV systems.)

When high-voltage ac dielectric tests are to be performed on switchgear incorporating S&C Indoor Voltage Sensors, special precautions should be taken to prevent damage to the voltage sensor and the voltage limiter. These precautions include the following:

- Jumper Terminals 1 and 2, Terminals 3 and 4, and Terminals 5 and 6 on the S&C Voltage Limiter or, if a shorting-type terminal block has been furnished, insert the shorting screws.
- In applications involving S&C Type AT Source-Transfer Controls, remove the plug from the input receptacle located at the rear of the source-transfer control and transfer the plug to the control's shorting receptacle. Refer to the S&C instruction sheet furnished with the source-transfer control.

These precautions should also be followed when performing high-voltage dc dielectric tests, although application of rated dc dielectric test voltages will not damage the voltage sensors.

After the tests have been completed, remove the aforementioned jumpers or the shorting screws and transfer the plug from the shorting receptacle on the source-transfer control back to the input receptacle.

Test values which apply to S&C Indoor Voltage Sensors are given in Table 1.

**Table 1. Indoor Voltage Sensor Ratings And Insulation Test Values**

| Catalog Number | Rating, kV | | | | Withstand, kV | | |
|---|---|---|---|---|---|---|---|
| | System | | Applied Line-to-Ground | | | | |
| | Nom. | Max. | Nom. | Max | 60 Hertz, RMS ① | Dc ②③ | Impulse (BIL) |
| 81602R2 | 14.4 | 17 0 | 8.3 | 9.8 | 36 | 50 | 95 |
| 81603R2 | 25 | 29 | 14.4 | 16.7 | 60 | 70 | 125 |

① Ac withstand tests made on this equipment after shipment by S&C should be conducted at no more than 0.75 times the values shown. When making ac tests, the time duration for application of the test voltage should be limited to less than 10 seconds.

② The column headed "Dc" is given as a reference only for those making dc test and represent values believed to be appropriate and approximately equivalent to the corresponding power-frequency withstand test values specified for component of this voltage class. The presence of this column in no way implies any requirements for a dc withstand test on these components.

③ Dc-withstand tests made on this equipment after shipment by S&C should be conducted at no more than 0.75 times the values shown. When making dc tests, the test voltage should be raised in discrete steps-one minute per step.