GEH-230U
Supersedes GEH-230T

INSTRUCTIONS

INSTRUMENT TRANSFORMERS

DRY AND
COMPOUND-FILLED TYPES

GENERAL ELECTRIC

TECHNICAL DATA

This book presents GENERAL INSTRUCTIONS which apply to all dry and compound-filled instrument transformers.

The descriptive bulletins listed below contain ADDITIONAL TECHNICAL DATA — such as characteristic ratio and phase-angle curves, and dimensions — for specific transformers. These bulletins can be obtained on request.

Information on instrument transformers not listed below, and on those with special features can also be obtained on request. Your letter should:

a. Include all information on the transformer nameplate;
b. Clearly state your specific questions.

Address all requests for bulletins and information to your nearest General Electric apparatus sales office.

TYPE NO.	BULLETIN
Indoor Potential Transformers	
E-21 (240 to 2400 V)	GEC-235
E-21 (4200 to 4800 V)	-469
E-22 (240 to 2400 V)	-235
E-22 (4200 to 4800 V)	-469
JE-1	-771
JE-2	-771
JE-25	-1200
JE-41 (2400 volts)	-770
JE-41 (4200 to 7200 V)	-666
JE-41 (7200 to 14400 V)	-608
JE-42 (2400 volts)	-770
JE-42 (4200 to 7200 V)	-666
JE-42 (7200 to 14400 V)	-608
JEF-5	-769
JEG-5	-769
YT-1557-M	-999
Outdoor Potential Transformers	
JEA-3	GEC-448
JEB-1	-890
JEB-3	-891
JEB-4	-925
Indoor Current Transformers	
JCA-0	GEC-1245
JKL-3	-766
JKL-4	-765
JKL-5	-763
JKM-3	-497
JKP-0	-814
JKR-0	-956
JKR-1	-328
JKR-2 (10 to 800 A)	-958
JKR-2 (1200 - 4000 A)	-959
JKR-4	-872
JKR-5	-762
JKR-6	-873
JL-9	-789

TYPE NO.	BULLETIN
Indoor Current Transformers (cont.)	
JLF-5	GEC-896
JS-1	-333
JS-2	-332
JS-5	-334
JY-4	-331
JY-9	-955
KC-59	-606
KC-74	-897
Outdoor Current Transformers	
JK-10	GEC-419
JK-12	-422
JKA-5	-813
JKB-1	-626
JKB-2	-679
JKB-4	-418
JKB-5	-421
JKD-3	-680
JKD-4	-682
JKD-5	-684
JKH-3	-681
JKH-4	-683
JKH-5	-688
JKP-0	-814
JKW-3	-1222
JW-6	-627
JW-14	-416
Portable Potential Transformers	
E-6	GEC-755
JE-9	-609
Portable Current Transformers	
JP-1	GEC-929
JP-2	-1205
JP-3	-980
JP-6	-906
JP-7	-756

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

INSTRUMENT TRANSFORMERS

DRY AND COMPOUND-FILLED TYPES

The several types of transformers covered by these instructions include indoor and outdoor instrument transformers, portable instrument transformers, split-core current-measuring sets, and auxiliary transformers. These instructions apply also to Type Y transformers, which are not strictly standard but which utilize the mechanical construction of standard transformers. For information on the installation and care of transformers with unusual ratings of frequency, secondary voltage, current, etc, consult the nearest sales office of the General Electric Company. When any special information is requested, give the complete nameplate data in order to indentify the transformer.

HANDLING

When unpacking and handling the transformer, exercise care not to damage the insulation. Make an inspection to see whether any damage has occured during shipment. Transformers that are reshipped to the point of installation, even though this be done by truck, should be supported only by the core or mounting supports. Do not use the bushings or leads as handles.

DRYING OUT

Transformers that have been subjected to submersion or have been stored for some time in a damp place should be dried out previous to installation. When drying out is necessary the following method should be used.

Allow the transformer to stand not less than 12 hours in a room of an approximately even temperature, and record that temperature.

Measure the resistance of the secondary winding.

Short-circuit the primary winding and apply an adjustable voltage to the secondary winding. Adjust the voltage so that sufficient current will flow in the winding to raise its temperature to approximately 80 C. The *rate* of rise should not exceed 6 C per half hour. The winding temperature should be held at approximately 80 C until the transformer is dry.

The amount of current necessary to obtain a winding temperature of 80 C varies because of the variations in losses and copper densities in the different types of transformers. It is advisable to start with a current not greater than 2 amperes in the secondary of a potential transformer, or not greater than 5 amperes in the secondary of a current transformer. Gradually increase this current until the proper heating is obtained. Increases of current should be made cautiously with frequent checking of the rise in temperature of the winding.

The temperature of the winding may be determined conveniently by the resistance-change method. Since the resistance of a copper winding increases approximately one per cent for each 2-1/2 C, the temperature rise may be calculated by measuring the "before" and "after" resistances and finding the percentage increase in resistance. For example, if the "after" resistance is 0.244 ohm and the resistance at the starting (room) temperature is 0.200 ohm, the percentage increase is $\frac{0.244-0.200}{0.200}=0.22=22\%$, which corresponds to a temperature rise of 22 x 2-1/2 = 55 C (approximately). The approximate winding temperature at any time is the temperature rise at that time added to the starting (room) temperature.

When facilities for measuring resistance are not available the temperature may be taken by placing the bulb of a spirit thermometer (do not use a mercury thermometer) on each coil as close to the winding as the insulation will permit. The bulb of the thermometer should be covered with clean dry cotton waste so that the bulb will have as nearly as possible the actual temperature of the coil. In the case of current transformers of high current ratings the actual temperature of the primary winding can be quite closely obtained by placing the bulb of the thermometer directly on the primary terminal.

TESTING

Dielectric Tests

If it is desired to make insulation tests after the drying out period, or at any other time,

these tests should be made in accordance with American Standard C-57 for Transformers, Regulators, and Reactors (superseding A.I.E.E. Standards No. 4 and No. 14). These rules should be stricty followed, both as to the value of test voltage and in the method of application. (Note that *periodic* field tests of insulation should not exceed 65% of the factory test voltage. Occasional tests should not exceed 75% of the factory test voltage.)

Polarity Tests

Convenient methods for testing polarity are given in American Standard C-57, the Electrical Metermen's Handbook published by Edison Electric Institute, and General Electric Company's publication GET-97.

Ratio and Phase-Angle Tests

Refer to Electrical Metermen's Handbook and G-E publications GET-1725 and GET-97.

MOUNTING

When connecting instrument transformers into power or distribution lines, it is important to make the connection in such a manner as to avoid placing line strains upon the terminals of the transformers.

Where the primary leads consist of cables, as in the case of certain outdoor transformers, care should be taken not to bend the leads sharply where they enter the bushing. The connection should also be made so as to prevent swaying of the cables.

Where the primary leads are brought out through stud-type bushings or so-called fixed terminals, care should be exercised to prevent either longitudinal or transverse strains upon the bushings.

Instrument transformers of the "window" type (without primary winding) should be installed so that the weight of the transformer is not carried by the bus but by the mounting feet.

For high-current transformer ratings, 2000 amperes and above, there may be some interference from the field of the return bus unless the bus centers are kept at a minimum distance of 15 in. apart; for ratings above 5000 amperes this distance should be not less than 24 in. In case this type transformer is used with more than one primary turn, the loop should be at least 24 in. in diameter. Care should be taken to see that the secondary leads are twisted closely together and carried out without passing through the field of the primary conductors. It is not necessary that the bus exactly fill the window, but the bus or buses should be centralized. For ratings of 1000 amperes and less, these precautions are generally unnecessary.

Ambient Temperature

Instrument transformers must not be subjected to an ambient temperature (temperature of the cooling air) higher than for which they are designed unless certain precautions are taken.

Most transformers are designed to operate on a daily average ambient temperature not exceeding 30 C. This rule permits rated load in an ambient temperature up to 40 C for a few hours a day, provided the average value does not exceed 30 C. A few designs, particularly for use in enclosed switchgear, will operate satisfactorily in an ambient temperature of 55 C. Generally, the allowable ambient temperature for a particular transformer is marked on the nameplate.

Application of instrument transformers in various ambient temperatures should be made in accordance with American Standard C-57.

CONNECTIONS

The resistance of all primary and secondary connections should be kept as low as possible to prevent overheating at the contacts, and particularly in the case of current transformer secondary circuits, to prevent an increase in the secondary burden.

WARNING: Always consider an instrument transformer as a part of the circuit to which it is connected, and do not touch the leads and terminals or other parts of the transformer unless they are properly grounded. (See **Grounding**). Also, do not open the secondary circuit of a current transformer while the transformer is energized.

Secondary Connections

Current-transformer secondary circuits must not be open while primary current flows. *Breaking* the secondary circuit while primary current is flowing is especially to be avoided. In both cases, the entire primary current becomes the exciting current which causes the core to saturate and may *induce voltage dangerous to human life across the secondary terminals.* Also, the transformer core may be damaged (by being magnetized; see **DEMAGNETIZING.**) Therefore, if it should be necessary to change second-

ary connections while primary current is flowing, the secondary terminals *must* be short-circuited while the change is being made. Take care not to disturb ground connections.

Most indoor current transformers are supplied with an enclosed secondary terminal block which can be sealed. When shipped, the cover of the terminal block is in the reversed position because the short-circuiting device between the secondary terminals is closed.

The procedure for making secondary connections is as follows:

Remove the cover, attach the service leads, open the short-circuiting device by loosening the screw or nut and turning the bridge to the open-circuited position, and then retighten the screw or nut. Turn the cover 180 degrees from the shipping position, and reinstall it on terminal block. The cover cannot be replaced after the service leads are in place until the short-circuiting device is opened.

CAUTION: Do not short-circuit the secondary of a *potential* transformer.

Grounding

The casings and frames of instrument transformers should always be grounded. The secondaries should also be grounded close to the transformers. Grounding of instrument transformers should be made in accordance with A.I.E.E. Standard No. 52, March 1951, Application Guide for Grounding of Instrument Transformers Secondary Circuits and Cases. On instrument transformers, the grounding of the feet also grounds the cores, casings, and frames.

If it is necessary to change the secondary connections, be careful not to disturb ground connections.

Secondary Leads

When planning installations of current transformers, the resistance voltage drop of the secondary leads should be included in calculating the secondary volt-ampere burden carried by the transformer. This total burden should be kept within limits suited to the transformers used. For many conditions, secondary leads whose resistance does not exceed that of 100 circuit-feet of No. 10 Awg copper wire (200 feet of wire) are satisfactory. This resistance is 0.2 ohm, requiring 5 volt-amperes at 5 amperes. However, this burden is too great for transformers designed for low volt-ampere metering burdens. For such transformers, lower lead resistance is necessary.

In the case of potential transformers the voltage drop in the secondary leads may affect the indications of the connected instrument and meters. For the usual conditions, leads of 50 circuit-feet of No. 10 Awg copper wire (100 feet of wire) are satisfactory.

The above instructions regarding the length and size of the leads to be used should be considered as general. In cases where instruments and instrument transformers have been furnished as a unit by the factory, no change should be made in the length or size of leads which might change the volt-ampere burden in them. If any change is needed consult the nearest sales office of the Company.

Secondary Burdens

When calibrations are furnished with transformers, it is important that the connected burden be in agreement with the burden used in calibration. If it becomes necessary or desirable to change the connected burden, and if there is any question regarding the effect of such a change on the accuracy of the transformer, the nearest sales office of the Company should be consulted. Questions regarding the maximum allowable burdens should also be referred to the Company's nearest sales office.

If transformer calibrations are required, it is important that complete information be furnished the Company, including the number of devices to be connected in the secondary of each transformer, the rating of the device and type if the device has more than one current or voltage, capacity, size, and length of leads to be used, the frequency of the circuit, and the method of connection.

Polarity

In wiring instrument-transformer circuits, it is necessary to maintain the correct polarity relation between the line and the devices connected to the secondaries. For this reason, the relative polarity of each winding of a transformer is indicated by a marker H_1 (or a white spot) on or near one primary terminal, and a marker X_1 (or a white spot) near one secondary terminal; and in some cases by white bushings. Where taps are present, all terminals will be marked. The primary leads will be H_1, H_2, H_3, etc., in order and the

secondary terminals X_1, X_2, X_3, in order, and the tertiary, if present, Y_1, Y_2, Y_3, in order. H_1, always indicates the same instantaneous polarity as X_1, or Y_1.

Significance of Polarity Markings

When connection is made to a secondary terminal having a polarity marking similar to a given primary terminal, the polarity will be the same as if the primary service conductor itself were detached from the transformer and connected directly to the secondary conductor. In other words, at the instant when the current is flowing toward the transformer in a primary lead of a certain polarity current will tend to flow away from the transformer in the secondary lead of similar polarity.

When connecting instrument transformers with meters or instruments, refer to the Instructions furnished with the meters or instruments involoved.

MAINTENANCE

When working with current transformers, always make certain that the secondary winding is either closed through the instrument circuit or that it is short-circuited at the terminals. Also, do not disturb ground connections on either a current or a potential transformer.

After instrument transformers for indoor installation have been installed, they should need no care other than seeing that they are kept clean and dry. Transformers for outdoor installation should receive the same care in operation as power transformers of similar design and of similar voltage rating.

Considerable care should be exercised to make and keep the resistance of all contacts in the secondary circuit as low as possible.

Cleaning of Bushings

Dirt or other contaminants on the surface of a bushing may cause a decrease in the flashover voltage. Danger of flashover occurs when the surface coating is partly conducting, usually as a result of moisture.

In some locations, operating conditions are such that a periodic cleaning of the bushings is desirable, at which time all foreign matter should be removed from the under, as well as the upper, sides of the petticoats. When the dirt is loose, a wet cloth may serve. If this method proves inadequate, carbon tetrachloride or ammonia may be effective. After cleaning a bushing by any of the above methods, wash the surface thoroughly with clean water to avoid leaving foreign material.

FUSES

Potential transformer fuses are intended primarily to protect the line rather than the transformer, although the modern fuse will afford protection to the transformer in a large number of cases. With the exception of the current-limiting fuses, such as the Type EJ-1, potential-transformer fuses are not designed to open the maximum short-circuit currents which may flow when a short circuit occurs in the transformer. For this reason, current-limiting resistors should be used in series with the fuse when necessary to limit the current to a value which the fuse can interrupt satisfactorily.

Replacing Fuses

Many potential transformers are equipped with two fuses. However, when such transformers are installed on a grounded circuit, it is common practice to substitute a brass tube (or a "solid" connection) for the fuse in the grounded line. This is to establish a permanent unfused ground at all times. Do not disturb this connection when replacing a fuse.

The fuses of some types of potential transformers, 3000 volts and below, are supported by a hinged cover. If it is necessary to replace a fuse while the transformer is connected to an operating circuit, the cover should be opened by an insulated hook. After the new fuse is inserted, the cover should be closed also by means of the insulated hook, which should be of sufficient length to prevent the operator from being burned in case a short circuit exists in the transformer. The cartridge fuse may be replaced by the Type EJ-1, Size A.

In testing fuses for continuity of circuit, not more than 0.25 ampere should be used.

In replacing Type EJ-1 fuses or in substituting the EJ-1 for the ES-1 or the cartridge fuse, care should be taken to select a fuse unit with the nearest voltage rating above line-to-line voltage of the circuit regardless of the rated voltage of the transformer. Do not use fuse units of higher voltage ratings, as undesirable overvoltages may result. One permissible exception to this general rule is the use of the Size A, Type EJ-1 fuse in Type JE-2 transformers. In this case

the size A fuse can be used on either 2400-volt delta circuits or 2400/4160-volt grounded "Y" circuits.

DEMAGNETIZING

If by accident a current transformer becomes magnetized, it should be demagnetized in the following manner before being used for precision work: Connect at least 50-ohms resistance in series with the meters or instruments in the secondary circuit. Bring the primary current up to as near full load as possible and gradually reduce the series resistance by one-ohm steps until it reaches zero, being careful not to open the secondary circuit in the process.

DIFFERENTIAL PROTECTION

Standard General Electric current transformers may be used for differential protection through a considerable range of burden and overcurrent. This range is limited by the difference in burden, the maximum overcurrent, and the mechanical and thermal short-time rating. Information regarding these points may be obtained from G-E publication GET-97 or from the nearest sales office of the Company.

INDIVIDUAL TYPES OF TRANSFORMERS

Outdoor Instrument Transformers

Bushings of outdoor instrument transformers sometimes become broken. For the replacement of bushings on a compound-filled transformer it is recommended that the transformer be returned to the factory.

For the replacement of bushings where the casing is not filled with compound, access is gained by removing a portion of the transformer case.

Conduit connections can be made to the secondary of a *dry-type* transformer having flexible secondary leads, by loosening the screws which hold the bushing in place, removing the bushing, and inserting conduit fitting in place of the porcelain bushing.

Portable Transformers

When used under ordinary conditions, portable transformers, both potential and current, except split-core current transformers, will not vary more than 1 per cent from their marked ratio. When better accuracy is required, the ratio and phase angle certificate should be used. By means of this certificate corrections can be made to within 0.1 per cent on ratio and to within 3 minutes on phase angle.

Portable potential transformers have terminals arranged with thumb nuts. Double-rated transformers have four primary terminals. Connecting links are used to make connections for the different ratios. Care should be exercised to clamp the links firmly in place in order to obtain good contacts.

Since certain portable current transformers have no primary windings, the cable carrying the current to be measured is threaded through the opening in the transformer. The secondary of a single-rated transformer is not tapped. The rating is obtained by use of one turn of cable through the hole, and other ratings may be obtained by threading two or more turns through the hole. The ratings are shown on the nameplate. The secondary of a multi-rated transformer is tapped and the different ratios are obtained by connecting to the proper taps, as shown on the nameplate.

Other types have self-contained primary windings as well as a hole in the core for higher ratings. The lower ratios are obtained by connecting the current to be measured to the correct binding posts as shown on the nameplate. Other ratings may be obtained by threading the cable, which carries the current to be measured, through the hole in the core one or more times as shown on the nameplate.

Still others have all ratings self-contained. Changes in ratio are made by means of metal links located on top of the transformer. The six-rated transformers also have a tap in the secondary. Three of the ratios are obtained by using the full secondary winding with the proper arrangement of links on the primary winding; the other three ratios are obtained by using the tap in the secondary winding with the primary links in the same positions as before. All connections are shown on the nameplate.

High-accuracy laboratory standards are multi-rated. All ratings are obtained by connecting the current to be measured to the proper terminals, which are marked on the cover. The lower current ratings are protected by fuses inserted in the cover adjacent to the corresponding terminals. Unscrew the cap in order to replace a fuse.

All portable current transformers, except the split-core type, are provided with a short-circuiting switch on the secondary. This switch should always be closed whenever it is necessary to

open the secondary circuit with the transformer connected in the line. This short-circuiting switch should always be opened after making connections.

Split-core Current Measuring Sets

Certain split-core current transformers are intended to be used only with the instrument and leads with which the transformer is calibrated. The scales on the ammeters are marked to read primary amperes directly, and the ammeters should not be used to measure current unless used with the transformer with which they are calibrated. Changes in ratio are made by turning the rotating switch in the ammeter.

Split-core current transformers should not be used around any conductor which is not insulated for the full voltage of the circuit.

The butting core surfaces must be kept clean and free from any dirt as a very slight opening between the two halves of the core will affect the calibration of the set. Current-measuring sets consisting of a split-core current transformer calibrated with an indicating ammeter and leads will have an accuracy of plus or minus 2 to 3 per cent of full scale, and with a recording ammeter and leads, an accuracy of plus or minus 3 to 5 per cent of full scale.

A current adapter is used with the split-core transformer for measuring small currents. With the correct size of terminals attached to the adapter, insert it in place of the fuse in the cut-out. Clamp the split-core transformer into the round loop of the adapter and read the ammeter. Compute the line current from the formula on the nameplate of the adapter. The use of the current adapter does not affect the accuracy of the current measuring set, and it may be used with sets having either the indicating ammeter or the recording ammeter.

INSTRUMENT DEPARTMENT

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