INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

Oil-Immersed

INSTRUMENT TRANSFORMERS
TYPE APT, OPT POTENTIAL TRANSFORMERS
TYPE ACT, OCT CURRENT TRANSFORMERS

Voltage Rating 150 KV BIL (25 KV Class) and above

TYPE OCT 69 TYPE OPT 69 TYPE ACT 650 TYPE APT 550

FIG. 1. Various Types of Oil-Immersed Instrument Transformers

Instrument transformers in general, although they are precision devices and should be carefully handled, are actually of rugged construction and generally simple and foolproof. Usually no special instruction besides what is given on the Instruction Plate is necessary for their operation. A review of the Catalog Section and the Instruction Plate, as well as the data given in this leaflet, is suggested. Also, see Technical Data 44-060.

RECEIVING

Instrument transformers when shipped have been thoroughly tested for defects and are perfectly dry. When received by the customer, they should be carefully examined before they are accepted from the carrier. If any damage is evident, a claim should be filed with the transportation company and the manufacturer should be notified at once.

HANDLING

Instrument transformers are usually of very rugged construction, but they may be damaged by rough handling.

When oil-immersed instrument transformers cannot be moved by a crane, they may be skidded or moved on rollers, but care should be taken not to damage the tank base nor to tip them over. Oil-immersed instrument transformers should not be lifted or moved by means of a jack or pry under the drain valve, and no mechanical force should be applied to the leads or bushings.

In cases where the transformer center of gravity is relatively high, a lifting cable guide is supplied to prevent accidental tipping over when lifting the transformer. In these cases it is not advisable to move the transformer on rollers or by skidding.

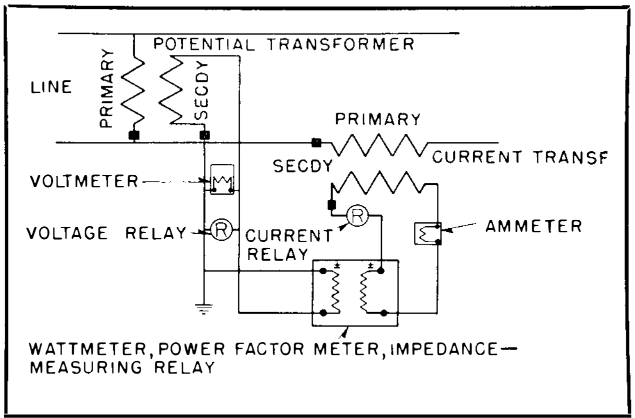

FIG. 2. Connection of Current and Potential Transformers in a Simple Single-Phase Circuit

Avoid acute tilting prior to installation as the air above the oil level in the expansion caps may be forced into the case. When excessive tilting is necessary remove the filling plugs at the top of the primary bushings and fill the expansion caps completely full of clean dry oil. The excess oil can be drained out later to restore the proper oil level. Note that potential transformers of type OPT, without expansion type caps, are almost completely filled with oil. A small addition may be necessary, however, before excessive tilting.

INSTALLATION

Before instrument transformers are installed they should be carefully inspected for breakage, injury or misplacement of parts during shipment or storage, and carefully examined for moisture. All accessible bolts, nuts and studs should be tight. Instrument transformers should be installed on solid supports, and all connections should be made so that no mechanical stress is put on the leads or terminals of the transformers.

These instrument transformers are designed for accurate metering, relaying, and control device applications. They are mounted in pressure tight fabricated steel cases, with cover mounted bushings and are suitable for outdoor service. All current transformers have series-parallel primary windings to provide for double current ratios. When shipped from the factory, they are connected for the higher current rating unless otherwise specified. Secondary leads terminate in clamp or stud type connectors located in a weatherproof junction box suitable for conduit connection.

OPERATION

The Insulating Function of High Voltage Instrument Transformers. The primary reason for use of high voltage instrument transformers is the necessity of insulating instruments and relays from the line voltage. The conventional connection is shown in Fig. 2.

More complicated arrangements are used in three-phase or differential circuits. The secondary circuit must always be grounded because while the secondary circuit and the transformer tank are insulated from the high voltage, they are coupled to it electrostatically as shown in Fig. 3.

The windings of the transformer may be thought of as plates of a capacitor. The electrostatic voltage from the secondary winding to ground will depend on the relative capacitances and may easily reach a dangerous and destructive value unless the secondary winding is connected to ground. ***Therefore, the secondary circuit should always be grounded.*** (See AIEE Application Guide for Grounding of Instrument Transformer Cores and Secondary Circuits).

Short-Circuit of Potential Transformers. Short-circuit of a potential transformer secondary is like short-circuit of any other transformer; it burns out in a very short time. Accidental short-circuits do occur, and the windings are designed to withstand the large mechanical forces which result, but they cannot be practically designed to carry the short-circuit current for much more than one second. ***The secondary winding of a potential transformer should never be short circuited.***

Current Transformers with Open-Circuited Secondary. Normally the secondary winding delivers a secondary current in correct ratio to the primary current into a burden never in excess of a few ohms, requiring only a low voltage at the secondary terminals. But, if the secondary circuit

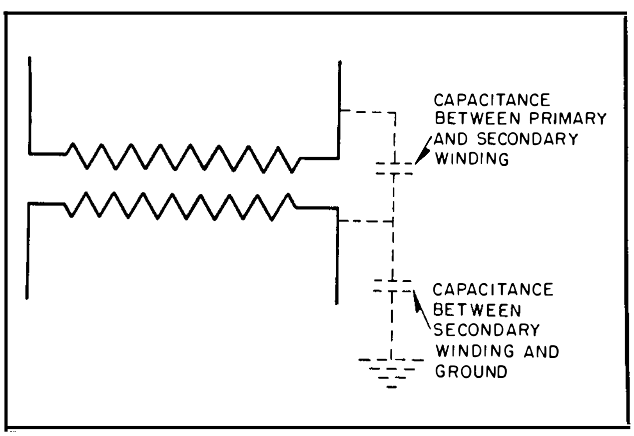

FIG. 3. Equivalent Circuit Showing Capacitance Effect

the ideal method, and 24 hours at 90°—100°C. in vacuum (28 in. mercury , or better) will usually dry the transformer. If a vacuum oven is not available, application of vacuum to the tank for 48 hours after draining the oil, without any heat, will remove moisture which has entered recently. Other means can be suggested by the factory depending on circumstances. Heating at a temperature of 100°C. or more in air can cause sufficient chemical change in oil-impregnated insulation that the power factor may increase instead of decrease. After drying, the transformer should be refilled by applying a vacuum to one filling plug for at least 2 hours, then admitting oil through the drain valve or any other fitting. The oil should be admitted slowly to reduce foaming and the vacuum should be maintained for at least an hour after the transformer is full.

TAKING OIL SAMPLE

Notes on Oil Level and Pressure Variations. These instrument transformers are sealed pressure tight. Therefore the internal pressure will vary with temperature. In cold weather the units are expected to be under negative pressure. For these reasons, before taking an oil sample it is important that the internal pressure be neutralized by opening the filling plug located above the oil level (very top of line bushing stud on potential transformers for 25 through 69 KV classes).

Potential transformers for 25 through 69 KV classes are filled almost completely with oil. Flexible tank members accommodate changes in oil volume; therefore, the oil gage shows full regardless of temperature variations. Other oil immersed instrument transformers of types OPT, APT, OCT, and ACT have bushings which terminate in an expansion cap. In these types the oil level indicator follows temperature variations.

Refinishing Notes. Any portion of the paint film damaged during shipment or installation should be repaired promptly. To repair, clean damaged portion by best means available, i.e., sandpaper, scraper, blasting, etc. If film is broken to the base metal, then apply a coat of primer, intermediate, and finish with the proper drying between coats. Surface scratches and mars can usually be repaired by application of the finish coat only. During the installation process, all exposed nuts and bolts should be given a finish coat of paint. The aerosol dispenser cans are ideal for this type of operation.

The life of transformer paint is not indefinite and, should, therefore, be maintained by periodic inspections, touch-ups and refinishing when necessary.

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is opened, the impedance of the burden in effect becomes infinite, and the current transformer does its best to supply the corresponding infinite voltage. In other words, the entire primary current becomes exciting current for the iron core. Oil-immersed transformers generally can develop more than 5000 volts (crest value) which is both dangerous and destructive. ***The secondary winding of a current transformer should never be open circuited.***

Insulation Structures, Processing, and Dielectric Losses. Modern transformers usually have an insulation structure composed of paper, pressboard, and oil, so arranged that the mechanical and dielectrical strengths of each are used to best advantage. (See Technical Data 44-060).

These insulation structures are thoroughly dried under heat and vacuum to remove moisture, and impregnated with oil. The whole transformer is filled with oil under a vacuum to make sure that no air pockets or bubbles remain inside the insulation structure at any point.

The power factor of the majority of all Westinghouse oil-immersed instrument transformers above 25 kv class is now measured as a part of the routine test to detect excess moisture and other impurities in the insulation or oil. Certain impurities in the oil or in certain insulation parts may cause higher power factor but without reducing the insulation strength, and are not cause for rejection. However, no units exceeding 4% P.F. at 20°C. are at present considered to be acceptable in oil-immersed transformers above 25 kv class.

Insulation Classes, Tests, and Service Voltage. Instrument transformers, as well as other kinds of transformers, are given "Insulation Class" ratings, as the ASA Standard C-57.11, Paragraph 11.030 states: "to indicate the dielectric tests which the apparatus is capable of withstanding."

In addition, the ASA Standards include tables indicating application of standard transformer ratings. Tables 13-11.410 and 13-22.110 are reproduced on pages 4 and 5 (in part, 25 kv and up).

The voltage ratings 24000/24000 Y etc., may need some explanation. This means that the line-to-line system voltage should not exceed 24000 volts whether the transformers are connected in delta, or if they are connected in wye. The 24000 volt transformer is not good for continuous operation with 24000 volts ***line to ground,*** because this is equivalent to a 24000 $\sqrt{3}$ or 41600 volt system. This same principle applies to all transformers in Group 2.

14400 for 25000 Grd.Y indicated in Group 3 means that the transformer is suitable for connection to a 25000 volt system, connected from ***line to ground*** only, but it may be used in this way on grounded or ungrounded systems. According to Paragraph 13.008, these transformers "shall be suitable for operation at 1.73 times rated line to ground voltage under emergency conditions without appreciable injury ....". The 120/200 to 1 ratio means that both ratios are available, for separate or simultaneous use, by means of a double secondary winding or by a tap in the secondary.

Potential transformers connected ***line to ground*** on an ungrounded system may be subjected to destructive voltage caused by the phenomenon called "ferro-resonance" or "neutral inversion". Neutral inversion and means for its control are discussed in Westinghouse Technical Data Section 44-060 and references in its Bibliography.

If one terminal of a transformer is connected to a line, but the other terminal left unconnected, the capacitive current into the winding may induce a rather high voltage. The secondary winding should be loaded with resistance to prevent the high induced voltage.

Operation With Rated Voltage to Ground During Line-to-Ground Faults. Transformers are designed with the expectation that the system to which they are connected will be sufficiently well grounded to maintain the neutral at ground potential, with each line above ground at $1/\sqrt{3}$ of rated line-to-line voltage. No system is really ever totally isolated from ground. The so-called "ungrounded" system is actually connected to ground by the capacitance and leakage resistance of its lines to ground.

If a line becomes grounded, line-to-line voltage is applied from line to ground on the other two lines, and to the terminals of transformers connected to them. This will overstress the line bushings as well as the winding insulation; corona, with resulting radio interference and deterioration of insulation, may result. Continuous operation with one line grounded or partially grounded should not be contemplated.

Yet it is obvious that lines sometimes do become grounded, and transformers must be designed for emergency operation at line-to-line voltage applied from one terminal to ground. Operation under this condition should be contemplated for emergencies only with the knowledge that transformer insulation deterioration is being accelerated.

TABLE 13-11.410 (in Part)

NAMEPLATE MARKING					STANDARD DIELECTRIC TESTS			
						Standard Impulse Tests		
						Chopped Wave		Full Wave
Standard Insulation Class Kv	Standard Marked Ratio	Standard Primary Voltage Ratings Volts	Usual Circuit Voltage Volts	Permissible Transformer Connections	Standard Low Frequency Test Kv RMS	Crest Voltage Kv	Min. Time to FO Sec.	Kv Crest
GROUP 2—25 TO 345 KV, FULL INSULATION, WYE VOLTAGE LIMIT EQUALS DELTA VOLTAGE LIMIT								
25	200:1	24000/24000Y	24000	Delta or Wye	50	175	3.0	150
34.5	300:1	34500/34500Y	34500	Delta or Wye	70	230	3.0	200
46	400:1	46000/46000Y	46000	Delta or Wye	95	290	3.0	250
69	600:1	69000/69000Y	69000	Delta or Wye	140	400	3.0	350
92	800:1	92000/92000Y	92000	Delta or Wye	185	520	3.0	450
115	1000:1	115000/115000Y	115000	Delta or Wye	230	630	3.0	550
138	1200:1	138000/138000Y	138000	Delta or Wye	275	750	3.0	650
161	1400:1	161000/161000Y	161000	Delta or Wye	325	865	3.0	750
196	1700:1	196000/196000Y	196000	Delta or Wye	395	1035	3.0	900
230	2000:1	230000/230000Y	230000	Delta or Wye	460	1210	3.0	1050
287	2500:1	287000/287000Y	287000	Delta or Wye	575	1500	3.0	1300
345	3000:1	345000/345000Y	345000	Delta or Wye	690	1785	3.0	1550
GROUP 3—25 KV TO 345 KV, REDUCED INSULATION AT NEUTRAL END, FOR CONNECTION DIRECTLY TO GRD.								
25	120/200:1	14400 For 25000 Grd.Y	24000	Grd.Y only	50	175	3.0	150
34.5	175/300:1	20125 For 34500 Grd.Y	34500	Grd.Y only	70	230	3.0	200
46	240/400:1	27600 For 46000 Grd.Y	46000	Grd.Y only	95	290	3.0	250
69	350/600:1	40250 For 69000 Grd.Y	69000	Grd.Y only	140	400	3.0	350
92	480/800:1	55200 For 92000 Grd.Y	92000	Grd.Y only	185	520	3.0	450
115	600/1000:1	69000 For 115000 Grd.Y	115000	Grd.Y only	230	630	3.0	550
138	700/1200:1	80500 For 138000 Grd.Y	138000	Grd.Y only	275	750	3.0	650
161	800/1400:1	92000 For 161000 Grd.Y	161000	Grd.Y only	325	865	3.0	750
196	1000/1700:1	115000 For 196000 Grd.Y	196000	Grd.Y only	395	1035	3.0	900
230	1200/2000:1	138000 For 230000 Grd.Y	230000	Grd.Y only	460	1210	3.0	1050
287	1500/2500:1	172500 For 287000 Grd.Y	287000	Grd.Y only	575	1500	3.0	1300
345	1800/3000:1	207000 For 345000 Grd.Y	345000	Grd.Y only	690	1785	3.0	1550

METERING UNITS

Metering units are complicated only in that they consist of two or more transformers in one tank. The individual transformers and their principles of connection and operation are not different from any other instrument transformers.

A diagram nameplate is mounted on all metering units to show the schematic connections between the primary windings of potential and current transformers and the connections to the terminals. This should be studied carefully. All secondary leads are brought out to the secondary terminal block so that they are available for any connection arrangement which may be desired. ***Particular attention should be given to correct identification of secondary leads*** as confusion of current and potential transformer leads can cause severe damage (see Short Circuit of Potential Transformers and Open Circuit of Current Transformers). The marking of the leads of the transformers are in accordance with the EEI Metermen's Handbook.

Primary Bushings. Insulated primary coil leads are brought out through porcelain weather casings. These casings are mechanically supported by rolled-on flanges with synthetic silastic cushion

TABLE 13-22.110 (in Part)

STANDARD INSULATION CLASSES AND STANDARD DIELECTRIC TESTS FOR CURRENT TRANSFORMERS					
		STANDARD DIELECTRIC TESTS			
			Standard Impulse Tests		
			Chopped Wave		
Standard Insulation Class (Nameplate Rating)	Maximum Line-to-Line Voltage	Standard Low Frequency Tests	Crest Voltage	Minimum Time to Flashover	Full Wave
Kv	Kv	Kv Rms	Kv Crest	Seconds	Kv Crest
25	25	50	175	3.0	150
34.5	34.5	70	230	3.0	200
46	46	95	290	3.0	250
69	69	140	400	3.0	350
92	92	185	520	3.0	450
115	115	230	630	3.0	550
138	138	275	750	3.0	650
161	161	325	865	3.0	750
196	196	395	1035	3.0	900
230	230	460	1210	3.0	1050
287	287	575	1500	3.0	1300
345	345	690	1785	3.0	1550

gaskets between flange and porcelain. The bushing flanges are then welded or bolted to the case. All primary bushings are oil filled. Bushings for higher than 69 KV classes and all current transformer primary bushings terminate in an expansion cap with a liquid level gage. Should adjustment of the liquid level be necessary, remove filling plugs at the top of bushings, add clean dry oil to established normal liquid level and reseal the filling plugs with thread cement such as Westinghouse M#6707-3. Bushings for potential transformers of 25 through 69 KV classes are almost completely filled with oil. The potential terminal at the top of the bushing is a standard ASA 1⅛ inch, 12 thread terminal stud.

Changing Weather Casings on Types APT-OPT-ACT-OCT. This is an involved operation requiring special procedure. For information contact nearest Westinghouse Office.

INSPECTION FOR DAMAGE

If there is reason to believe the transformer has been internally damaged by shipment or handling, it may be necessary to remove it from the tank for inspection. Care should be taken to put it back under oil within 8 hours if possible, especially in humid weather.

The transformer should be refilled under vacuum if the oil is drained for any reason, or if the core and coils are removed from the tank. (See following section on Maintenance.)

MAINTENANCE

Modern transformers are sealed to prevent entrance of moisture and oxidation of the oil. This eliminates the deterioration of the oil, and oil maintenance is usually unnecessary. A periodic check of the oil level is all that is usually necessary. In case of doubt as to whether a leak has occurred and moisture has entered, a measurement of oil strength and insulation power factor is desirable. (See I.B. 44-820-1, Insulating Oil for Electrical Apparatus).

Insulation power factor should be measured only after the transformer has been disconnected for several hours to permit it to attain a uniform temperature. The power factor corrected to 20°C. should be approximately 2% or lower.

If measurements indicate that moisture is entering the transformer, the first step is to find the leak and eliminate it; the second, to dry out the transformer. The means to be used depends on the type of transformer and the available equipment. Drying in a vacuum oven after draining the oil is