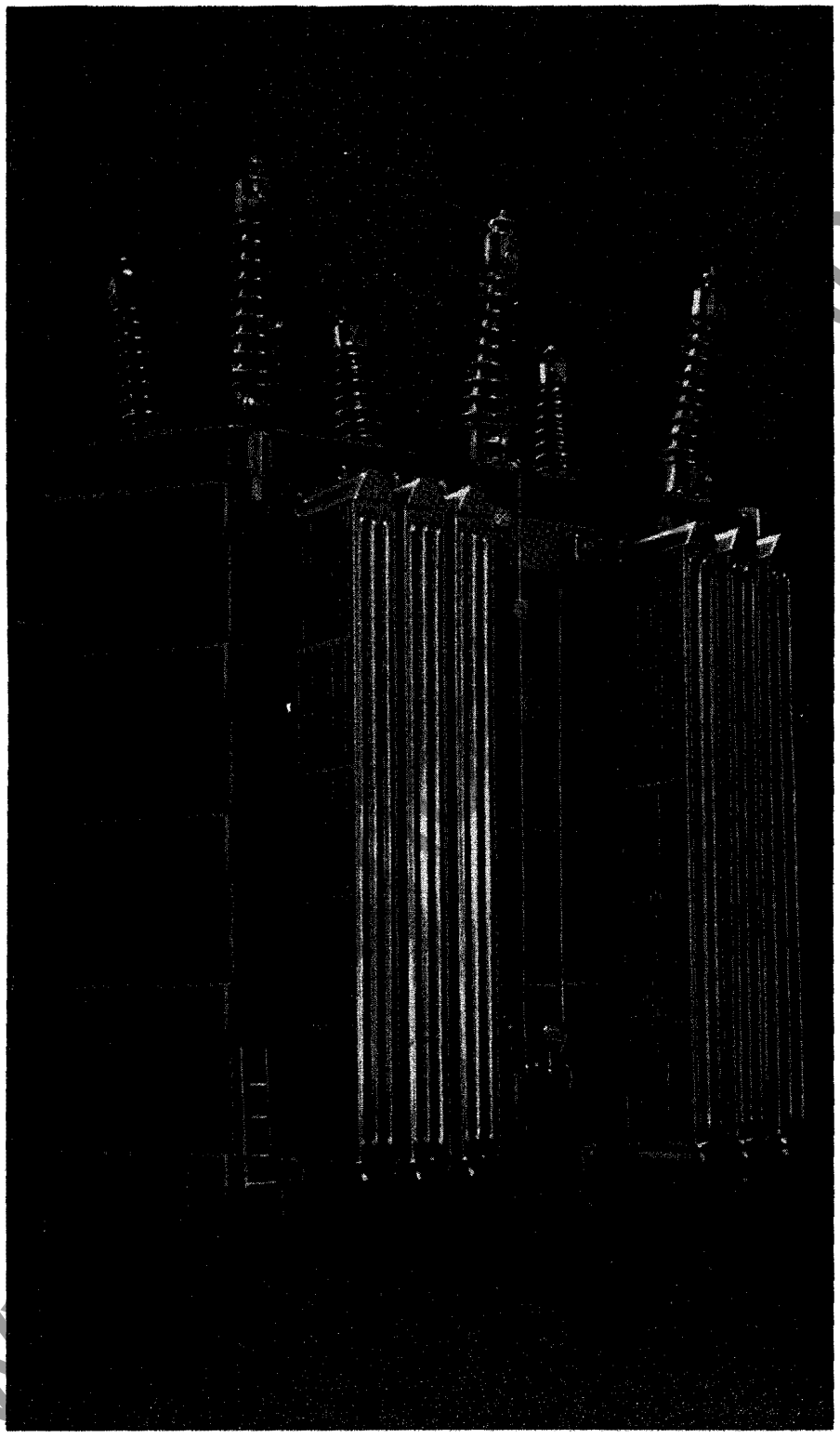
Westinghouse

# Current Limiting Reactors Oil-Immersed

Indoor and Outdoor Service



## Application

Oil-immersed current limiting reactors are used on higher voltage circuits to supply additional impedance and thereby reduce the kva supplied to a short circuit. They are recommended for outdoor service on circuits of 34.5 kv or above, and are also applicable to lower voltage circuits for both outdoor and indoor service.

High thermal capacity, ease of cooling, and complete enclosure make Westinghouse oil-immersed current limiting reactors especially desirable for all applications where additional impedance is required.

## Advantages

**Magnetic Shielding:** Bundles of high permeability steel laminations of suitable dimensions are welded to the reactor tank wall to provide a low reluctance path for the magnetic flux. This minimizes the tank loss and keeps practically all the flux within the tank.

**Interchangeable Bushings:** The bushings normally supplied on the reactors are according to ASA Standards and are interchangeable with bushings supplied on transformers.

**High Safety Factor:** Oil-immersed coils used in current limiting reactors provide highest obtainable protection against flashover. Uniform spacing assures free circulation of oil.

**Easy Installation:** Structural steel base securely welded to the tank bottom permits reactors to be mounted anywhere a transformer can be installed.

## Design Features

### Condenser Bushings

**Two kinds of bushings are furnished—type OS and type O:** Used for voltages above 15 kv, type OS and type O meet all ASA standards and offer complete interchangeability with circuit breakers and transformers. Both kinds are cover mounted and comply with all industry standards pertaining to electrical and mechanical characteristics. All bushings have usable threaded stud length of at least 2⅛ inches, 12 threads per inch, for terminal connections. In both, the condenser surrounds a central copper tube or bar. At specified diameters, metal foil layers are inserted to form the condensers. Thus, a series of equal capacity condensers is arranged between the central conductor and the outermost foil layer which is connected to a grounded flange. Voltage is therefore uniformly distributed to prevent concentration of stress at any point.

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### Coil Assembly

Reactor coil assemblies use sliverless burr-free copper straps for currents 100 amperes and below; concentric-stranded low loss cable for higher than 100 amperes.

**Insulation and Windings:** To obtain high turn-to-turn dielectric strength, oil impregnated paper insulation is used on all copper strap windings. On voltages 34.5 kv and below, the coils are wound either in cylindrical layers or in pancake coils. All above 34.5 kv use pancake coils. Eddy current losses are minimized by suitable proportioning of the strap, and by transpositions when several straps are in parallel.

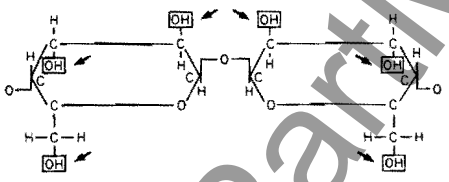
Cotton tape or oil-impregnated paper is used to insulate the cable. On voltages of 34.5 kv and below, the cable is wound in either cylindrical layers or in continuous discoidal layers. Discoidal layers are used on higher voltages. Moldarta spacers are used on discoidal cable wound coils to separate the cables, both in the direction the layer is wound and between layers. When parallel cables are used, they are transposed to eliminate circulating currents.

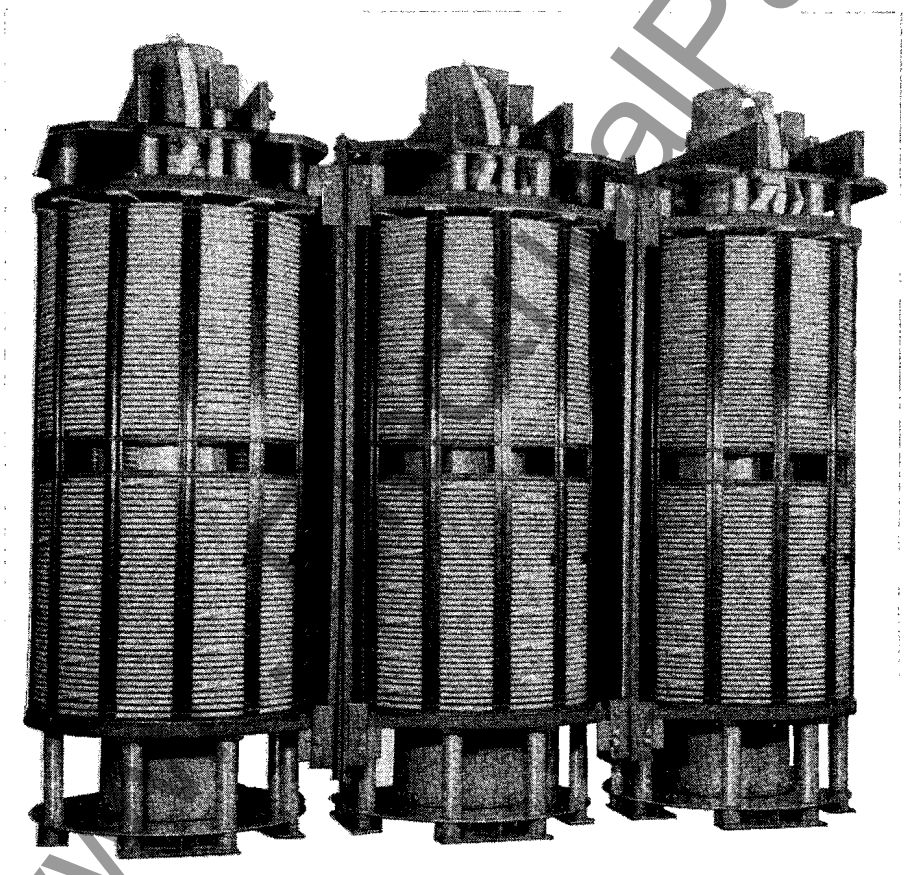
### Insuldur Insulation

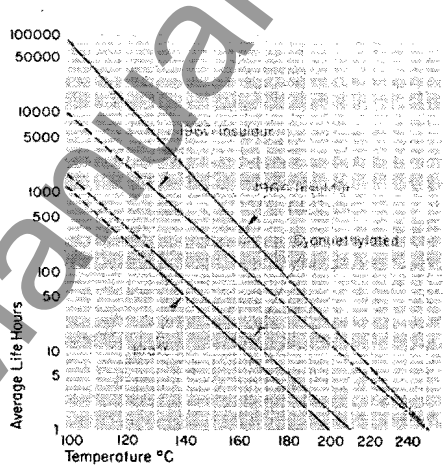
Westinghouse produced the first transformers with stabilized insulation with the introduction of the Insuldur System. This system utilized the addition of an amine compound in the insulating oil. This compound has the ability to stabilize the kraft paper and prevent the break-up of the cellulose chain by hydrolysis.

Cellulose is the basic compound which when properly treated and combined forms paper. Cellulose is a chain of glucose ($C_6H_{10}O_5$) molecules. Two glucose molecules are shown below.

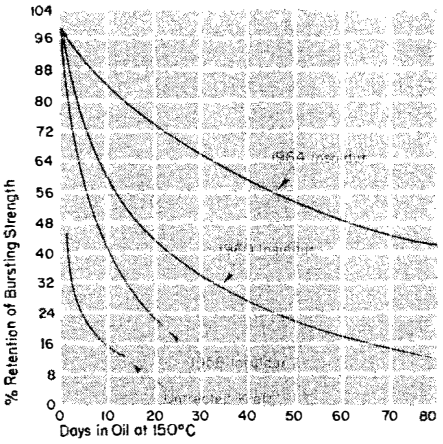
As is noted here, these molecules are connected by a HOH link. Also, there are three (3) hydroxal radicals in each molecule. When the cellulose chain is subjected to excessive heat, there is a breakdown of the molecules and the chain. The resultant is $H_2O$ (water) and a broken chain of molecules of fibres of the paper.








**Aging of 5 Mil Kraft, 1960-1964 Insuldur and Cyanoethylated using 75% as End Point.** ***(Based on Bursting Strength)***




**% Retention of Bursting Strength Aging 1958, 1960 and New Insuldur and Untreated Kraft in oil at 150°C**

The Westinghouse Research Laboratories found that certain amine compounds had the ability to retard this molecular breakdown. From hundreds of tests run and evaluated the first Westinghouse Insuldur system was developed.

Later developments in the art of upgrading cellulose by additives brought about superior Insuldur. These systems utilize a combination of dicyandiamide, melamine, and polyacrylamide added during the manufacture of the paper. These compounds tie up the hydroxyl radicals even more effectively than the original amine.

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There are several other methods to thermally upgrade cellulose chemically such as cyanoethylation. These processes normally involve complicated, expensive, and less effective modification of the glucose molecule during the manufacture of the paper pulp. Evaluation of the insulation mechanical strength is done by determination of the bursting strength rather than just tensile strength of the material. Since the winding insulation is subject to both flexure and tension, this test most closely matches transformer operation.

The curves on page 2 show the comparison of untreated kraft, the original 1958, 1960 and the new, improved 1964 Insuldur.

An important exclusive additional feature of the Westinghouse Insuldur system of insulation is the compatability of the Insuldur with both oil and Inerteen have the many advantages offered by this superior system of insulation stabilization.

**Bracing:** Micarta tubes provide a supporting and insulating structure for all windings. Windings are also clamped between top and bottom pressure plates or Micarta rings. The base of the supporting structure is centered by pins in the tank bottom, and the top is firmly bolted to either the tank wall or cover. The coil is adequately braced to withstand full short-circuit stresses.

### Tank

The tank is made of heavy steel. Construction is similar to that of Westinghouse power transformers. The cover is welded to the tank, thus assuring oil and gas-tight joints.

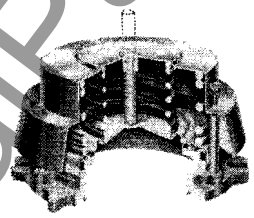
**Base:** The base is made of structural steel and is welded to the tank bottom. Jack lugs and grounding terminals are provided for each installation. Heavy caster type wheels can be supplied to aid in positioning equipment.

**Cooling:** Cooling systems for current limiting reactors are designed to fit individual requirements. Usually the units are self-cooled. The only savings in making a unit forced-cooled is the decrease in size of the cooling system. On small units, tubes welded into headers, which in turn are welded to the tank wall are used to cool the unit. On large units or units that have special shipping clearances, detachable radiators are used. When radiators are used, the top and bottom connections on the tank are provided with valves so radiators can be removed without draining the tank.

### Oil Preservation Equipment

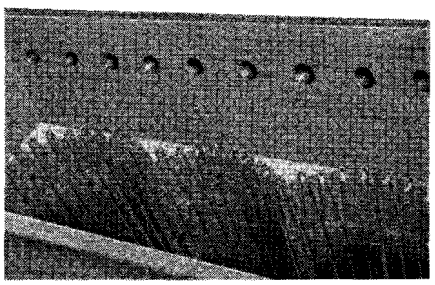
**Intertaire Equipment:** Current limiting reactors of high voltage or large Kva are normally protected by the inertaire system. This system consists of (a) a cylinder of dry nitrogen gas under high pressure, approximately 2000 PSI when first installed. (b) a reducing valve which reduces the nitrogen pressure to ½ PSI and admits gas to the tank whenever the tank pressure falls below ½ PSI. (c) a pressure limiting valve which exhausts to the atmosphere whenever the tank pressure exceeds 8 PSI. Alarm contacts are provided which indicate high or low pressure in the tank and when the gas cylinder is almost empty. This system maintains a blanket of nitrogen over the oil and no possibility of a secondary explosion in case of an internal arc.

**Sealedaire Equipment:** This system of oil preservation excludes oxygen and moisture, thus preventing deterioration of the liquid and insulation. The reactor tank is filled with oil under vacuum. A relief valve assembly keeps the reactor sealed throughout an oil temperature range of 100 C. Pressure and vacuum limiting valves are set to open at ± 6.5 lbs./sq. in. Gas samples for purging or analysis may be taken from a valve at the gauge.



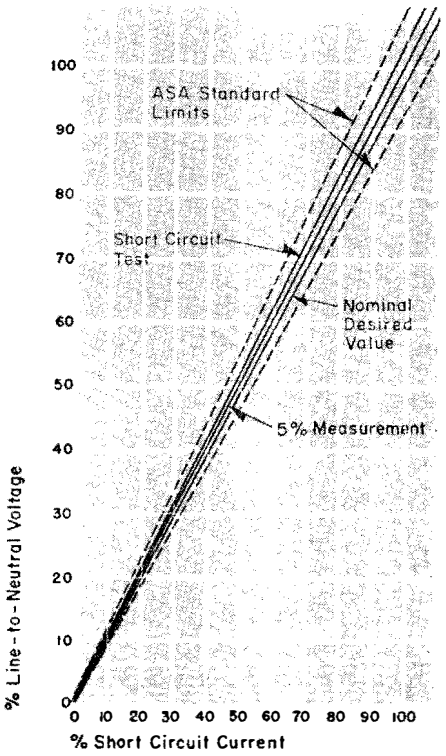
**Mechanical Relief Device:** This device is provided to relieve abnormal internal pressures. After the abnormal pressure has been relieved, the unit resets itself. The travel of the diaphragm in the relief device raises a colored cylindrical semaphore on the cover of the device indicating that the unit has been subjected to abnormal internal pressure.

### Magnetic Shielding



Exclusive Westinghouse shielding confines the magnetic flux within the tank and eliminates large outside stray magnetic fields in case of short circuits. This prevents losses and heating in adjacent steel structures under normal operation, as well as magnetic forces between adjacent reactors during short circuit conditions. Construction consists of bundles of high permeability steel laminations welded to the tank wall at each end. These laminations are designed and located to permit free circulation of the cooling medium. Ample flux carrying capacity is provided to make the volt-ampere characteristic essentially a straight line from zero to full short circuit current.

### Characteristic Curve Volt Amperes




The straight line volt-ampere characteristic of Westinghouse oil-immersed current limiting reactors combines with high electrical and mechanical strength to provide a reliable factor well suited to its individual application. The curve, as shown above, indicates a slight gain in reactance above that of an air-core coil (without magnetic shield).

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## Standard Accessories


**Magnetic-Type Oil Level Gauge:** Hermetically sealed, float operated, weatherproof, shockproof. Requires no maintenance. Supplied with alarm contacts, if specified.


**Dial-Type Thermometer:** Hermetically sealed. Shows accurate temperature of top liquid. Has resettable red, peak temperature pointer. Supplied with alarm contacts, if specified.

**Wheels or Trucks (Optional):** For moving of reactor, narrow-flange standard gauge wheels or trucks can be provided.

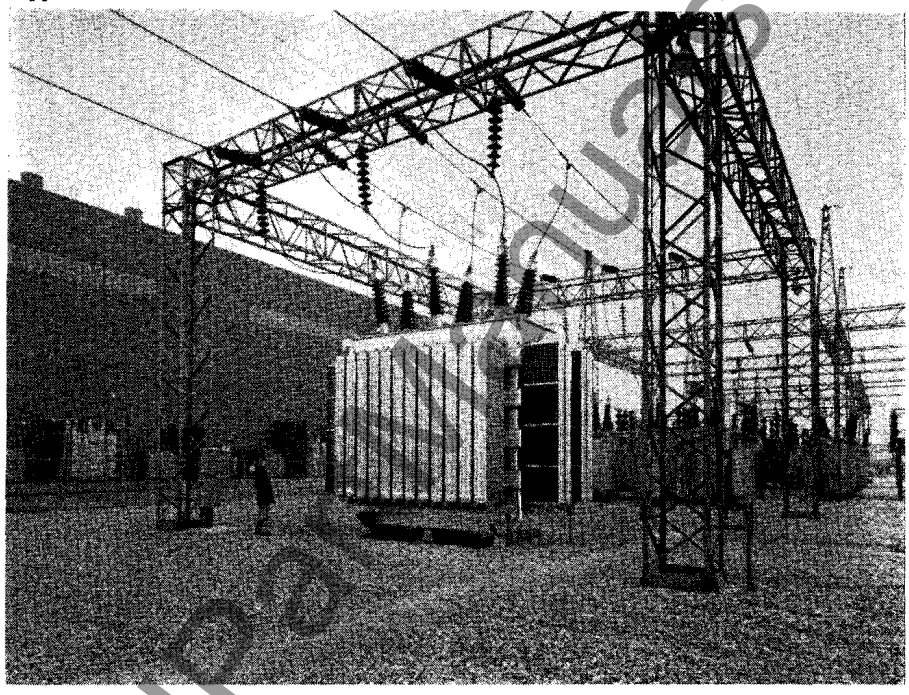
## Further Information

**Dry Type**
Prices: Price List 45-420
Description: Descriptive Bulletin 45-450
Application: Technical Data 45-460

**Dry Type MSP:**
Prices: Price List 45-425
Description: Descriptive Bulletin 45-455

**Oil Immersed:**
Prices: Price List 45-421
Application: Technical Data 45-460

## Typical Installation



**A bank of oil-immersed current limiting reactors, 11,136 kva, type OA, 138 kv high voltage, single phase, 60 cycles, 800 amps installed on the power systems of a large western utility.**

**Westinghouse Electric Corporation**
Power Transformer Division, Sharon, Pa.
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