

Instructions for Rectangular Core and Coil Assembly Type "SL" Transformers



I.L. 48-060-27

WINDINGS

Type "SL" TRANSFORMERS from 501 to 2500 Kva 34.5 Kv insulation class and below, are equipped with windings made from an annealed copper conductor which is manufactured by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special copper conductor prevents insulation failures resulting from surface imperfections in the conductor.

When insulation is applied to each conductor, it consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought from the inside layers of each coil. With this arrangement, the tapped portion of the winding is not exposed to line surges and the electrical centers are more nearly balanced on all connections.

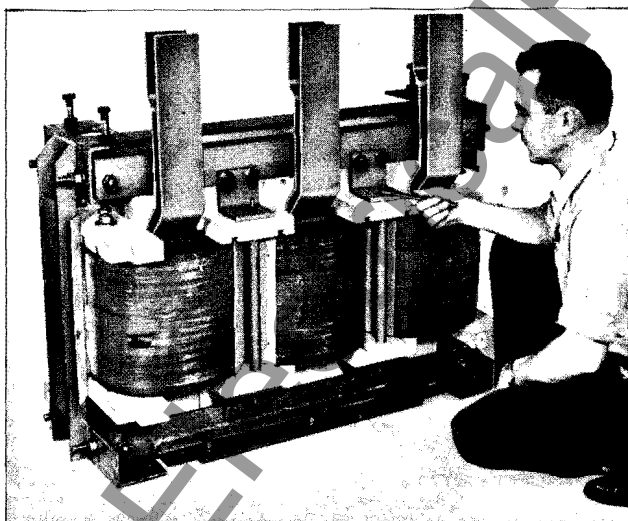


Fig. 1 Core and Coil Assembly Type "SL" Transformer

The high-voltage coils are wound directly over the low-voltage coils and the low-high insulation. If it should be necessary to replace either the high or low voltage winding, the complete high-low coil assembly must be ordered for replacement.

All coils are of a rectangular cross-section in order to obtain a compact design. This coil construction reduces the weight of the transformer by 20% or more as compared with circular cross-section coil designs and permits the efficient use of rectangular tanks.

CONCENTRIC COILS

The concentric coil is used for the high-voltages from 2.5 to 34.5 Kv insulation class. This concentric coil consists of several layers of insulated conductors supported by an insulating cylinder. Each turn consists of one or more copper ribbons of suitable cross-section in parallel. Collars of suitable form and material are used at the end of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that the coil temperature gradients are kept uniformly low.

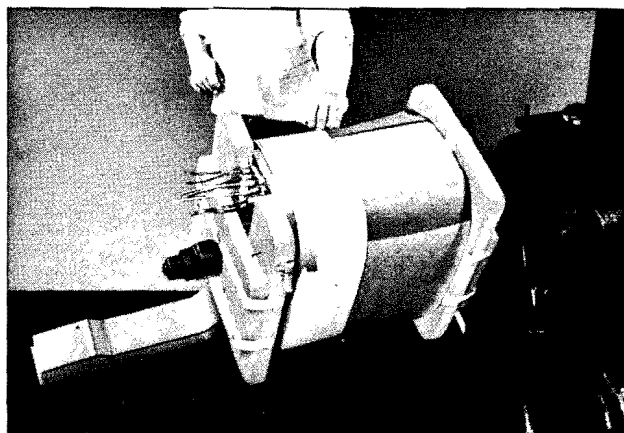


Fig. 2 Rectangular Concentric Coil Winding

In the concentric coils from 15 to 34.5 Kv, shields in the form of static cylinders are located at the line end of the windings. These shields reduce the effective ground capacitance, distribute impulse stresses and increase the surge strength. This coil construction is known as the "Lowgrocap winding".

SPIRAL COILS

The spiral winding is used on low voltage coils up to 1.2 Kv and consists of bare copper sheets, each layer containing only one turn and each turn in width equal to the coil height. The turns are wound on with a continuous strip of pressboard to form layer to layer or turn to turn insulation. The conductors are held in by spiral collars placed on the ends of the coil. The low-voltage leads are copper bars brazed at the start and finish of the copper in the winding and coming vertically out of the coils. Ducts are distributed throughout the coil for adequate cooling.

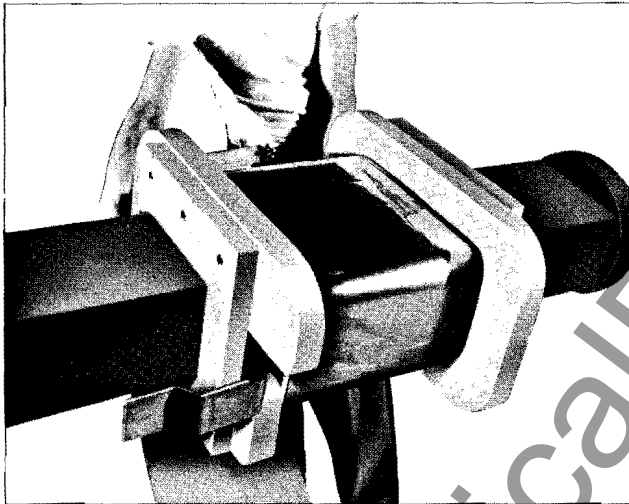


Fig. 3 Rectangular Spiral Coil Winding

Spiral windings are of a very compact design and are very strong mechanically. These windings have a very favorable surge distribution and hold up well under electrical stresses.

THE CORE

The core of this type transformer is made of Hipersil high permeability cold rolled material which carries twenty to thirty per cent more flux than the hot rolled silicon steel it replaced. The use of this material gives a transformer of higher efficiency with from twenty to twenty-five percent reduction in total weight in addition to the weight reduction obtained with the rectangular coil design.

The magnetic circuit is rectangular in shape with a rectangular opening. The cross-section of the core is rectangular. In order to avoid joints of high magnetic density and a condition in which the flux must pass across the direction of the grain, the laminations are cut with 45° angles at each end. Punchings for the yoke are made slightly wider than the leg punchings in order to obtain an overlap. With this design, the flux path at the corner is essentially parallel with the grain of the material in both the yoke and the leg punchings.

THE ASSEMBLY OF CORE AND COILS

The core punchings are assembled into the coils. The leg punchings are wedged in place by two wedges inside the low voltage winding tube. The yoke punchings are held together by the clamping action of the steel and frame angles. Four tie rods brace the core and coil assembly in the axial direction and are tied in with pressure blocks at the ends of the coils and the end frame construction. Additional bracing in the axial direction as well as bracing the coils against short circuit forces is provided by upright channel supports at each end of the core and coil assembly.

TREATMENT

The core and coil assembly is pressed, blocked and thoroughly dried in a heated oven for removal of moisture. After tanking the core and coil assembly the unit is filled with transformer liquid while under vacuum.

HANDLING AND BRACING

The core and coil assembly is lifted by means of lifting holes in the ends of the end frame structure. These holes are located at the center of the assembly to prevent tilting when lifting.

The core and coil assembly is positioned on the tank bottom by means of four centering guides and is held in place by two tie plates pressing on the end frames.

Westinghouse Electric Corporation
Sharon Plant, Transformer Divisions, Sharon, Pa.

Instructions for Core Form Transformers With Pressure Rings



I. L. 48-060-4

WINDINGS

The core and coils of the "SL" and "SLS" line of substation transformers above 2500 kva and above 34.5 kv insulation class are of core form construction with circular coils. The core and coil assembly is mounted in a gas tight weatherproof rectangular steel tank and completely immersed in oil.

Five types of windings best suited to the voltage and current requirements may be used. These are the cylindrical, Helitran, round wire pancake, continuous-wound pancake and Hisercap type of windings.

For the medium voltage range, windings of 350 kv BIL or under, a continuous wound high voltage coil is most often used with a cylindrical low voltage winding. Above 350 kv BIL, a Hisercap high voltage coil is most frequently used with a continuous low voltage coil.

The winding conductors are made with annealed copper strap, specially prepared and die shaved to remove all surface defects. Prior to winding, the conductor is checked by special burr detectors for the presence of any surface defects. The insulation applied to each conductor consists of a number of layers of paper, machine-wound on the conductor. Taps are brought out from the center of the coil stack. With this arrangement the tapped portion of the winding is not exposed to line surges, and the electrical centers are more nearly balanced on all connections.

CYLINDRICAL COILS

The cylindrical coil, normally furnished for winding classes up through 200 BIL and for any current rating up through 2500 amperes, consists of one or more layers of insulated conductors wound on an insulating cylinder. Each conductor consists of a number of copper straps of suitable cross section in parallel which are properly trans-

posed to minimize eddy losses. Collars of suitable form and material are placed at the ends of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that coil temperature gradients are kept uniformly low. For the 110-150 and 200 kv BIL voltage classes, static cylinders are normally used to distribute impulse stresses and minimize impulse oscillations.

When cylindrical coils are used for the lower kva ratings, the high and low voltage coils are wound as a complete unit with the high-low insulation built in. If it should be necessary to replace either the high or low voltage winding, the complete high-low coil assembly must be ordered for replacement.

CONTINUOUS-WOUND PANCAKE COILS

The continuous-wound pancake coil for voltages 15 kv to 69 kv inclusive consists of a number of circular disc coil sections, of rectangular strap conductor with one turn per layer, wound by a continuous process

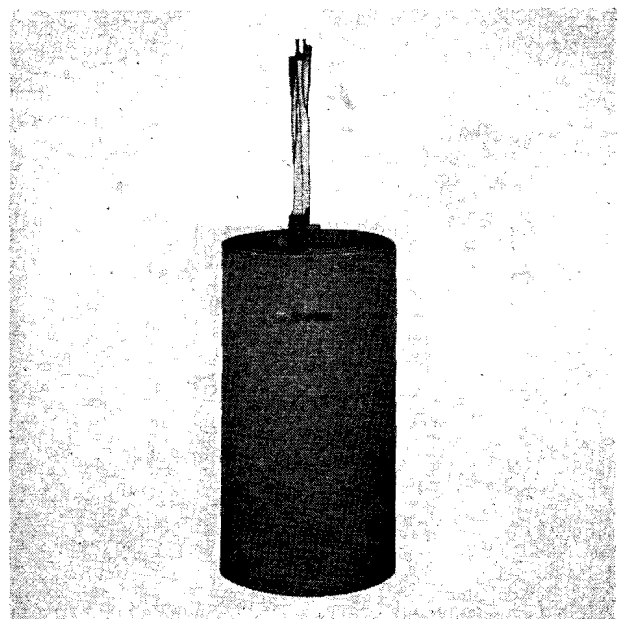


Fig. 1. *Cylindrical Coil Winding*

with no joints at section connections. The conductor may consist of one or more copper ribbons of suitable cross-section and where multi-conductors are used in parallel, they are properly transposed throughout the coil to minimize eddy losses. The circular disc sections are wound on vertical insulating spacers placed over an insulating cylinder. Radial spacers which dovetail with the vertical spacers separate the various sections from each other. Insulating collars or radial spacers are placed at the ends of the coil for electrical strength. The thickness of the coil section is the width of the conductor and the sides of the coil section are the edges of the conductor (see Fig. 2), thus the flat sides only are in contact, eliminating the danger of mechanical forces cutting the insulation and also, each conductor is exposed to the cooling medium. This type of winding gives the highest capacity per unit of space and permits free circulation of the cooling medium. Hot spots are eliminated and high thermal efficiency results.

HISERCAP COIL

The Hisercap coil (for windings of 450 kv BIL or higher and currents of 10 to 100 amperes) is similar to the continuous wound pancake coil, except in each adjacent pair of



Fig. 2. Continuous-Wound Pancake Coil Winding

sections the turns are wound re-entrant to obtain a high series capacitance, resulting in nearly straight line distribution of impulse voltages with a minimum of impulse oscillations in the winding.

ROUND-WIRE PANCAKE COILS

The round-wire pancake coil (Fig. 3) is used for high voltages and current ratings of less than ten amperes where it is necessary to obtain a large number of turns in a minimum space. It is circular in form and consists of a number of layers with several turns of round paper-covered, enameled wire per layer. This coil is wound on an insulating foundation ring with a length equal to the thickness of the coil. The layers of conductor are spaced from each other by insulating sleeves or crimped paper. The sleeve insulation consists of a strip of folded paper around the end turns, forming a double thickness of paper insulation between the layers of conductor. The crimped paper insulation has an extension at each end of the layer. Where it extends beyond the conductor it is crimped, forming a small collar.

These sleeves and crimped paper insulating strips are coated with a thermo-setting plastic. When the coils are wound they are heated in an oven and this plastic softens, filling the voids between adjacent turns and between turns and layer material. After cooling, the plastic sets and forms a bond between turns and layer material, making a mechanically rigid coil.

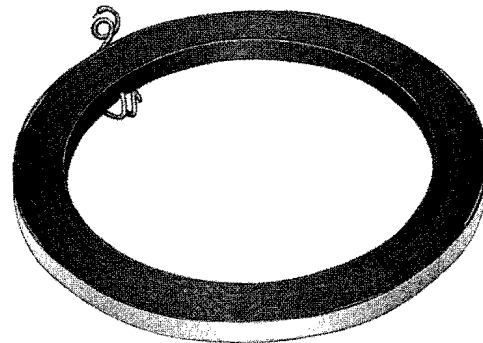


Fig. 3. Round-Wire Pancake Coil

Reinforcing segments are placed in the coil near the outer edge during the winding and are spaced so that they are directly under the radial spacers. The width of the segments is the same as the length of the insulating foundation ring. This construction gives maximum mechanical strength due to the fact that the pressure on the coil stack is transmitted from coil to coil through the foundation ring and the segments, thereby eliminating pressure on the wires of the coil.

HELITRAN COILS

The Helitran coil is helically wound and, in general, is used for medium voltage and high current. The conductor consists of several insulated copper ribbons in parallel completely transposed throughout the winding to reduce the eddy losses to a minimum. This coil is wound over vertical insulating spacers on a heavy insulating tube with the layers spaced from each other by radial insulating spacers. The radial and vertical insulating spacers are dovetailed together giving electrical and mechanical separation and providing ventilating ducts for the circulation of the cooling medium. The ends of the winding are rigidly held in place by properly anchoring the leads and by the use of heavy insulating collars at the ends of the coil. This type of coil construction gives high insulation strength and uniformly low temperature gradients.

ASSEMBLY OF WINDINGS

Coils of the cylindrical type require no further individual assembly after winding.

Continuous wound pancake coils, after winding are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

Round wire pancake coils are assembled in stacks on their insulating cylinder. They are separated from the cylinder by vertical insulating spacers and from each other by radial insulating spacers dovetailed on the vertical spacers. The stack, while hot, is pressed to size axially after which it is ready for assembly on the core.

Helitran coils, after winding, are heated and pressed to size axially while hot, after which they are ready for assembly on the core.

The high and low voltage windings are assembled concentrically on the core with the low voltage winding nearest the core leg. The low voltage winding is centered on the core leg by four maple rods driven tightly in four corners of the cruciform leg between the core and the low voltage insulating cylinder. The high voltage winding is separated from the low voltage winding by one or more insulating cylinders and vertical spacing strips. For the higher voltages the cylinders have insulating angle rings interleaved with them at the ends.

At the ends of the stacks of coils are placed heavy insulating collars interleaved where necessary with angles and washers. These give the required insulation strength and a mechanical structure between the coils and pressure rings which is more than adequate to withstand the mechanical forces set up under short circuit.

All leads, except the very short ones, are run in insulating tubes and are rigidly supported at frequent intervals. They present a neat appearance and are free from vibration or distortion under short circuits.

INSULATION

The major insulation of Types "SL" and "SLS" transformers consists of insulating cylinders and oil ducts so proportioned as to give the necessary dielectric strength and, at the same time, allow the cooling oil to flow naturally across at least one side of all turns. All units are designed to withstand the standard ASA impulse and low frequency tests. Impulse strength is obtained by pre-determining the stress at each point of the winding and providing at each point the necessary insulation. This is done by placing at the ends of the stacks of coils an insulated static plate and using uniform insulation throughout, based on the maximum stress at any point.

www.ElectricalPartManuals.com

TREATMENT

After assembly the core and coils are preheated and then thoroughly dried under vacuum in a heated oven. While still hot and under vacuum they are impregnated with WEMCO "C" transformer oil.

ASSEMBLY OF CORE

The core is built of cold-rolled, high permeability silicon steel, Hipersil laminations. This material carries one-third more flux than ordinary electrical sheet. The grain is oriented for optimum transmittal of flux. The laminations are mitred 45 degrees at the corners and interleaved to produce optimum magnetic qualities for flux flow. The laminations are insulated with non-reacting interlaminar carlite coating. Carlite is a permanent inorganic compound which can withstand annealing temperatures. The cross section of the core legs are cruciform to give greater core area inside of coils of circular cross section.

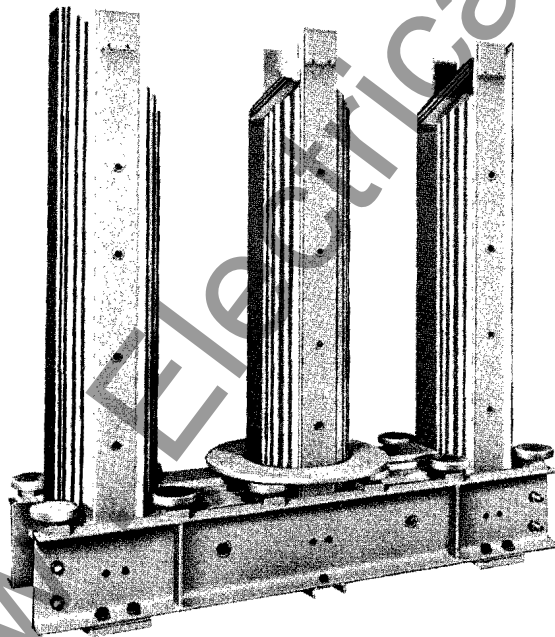


Fig. 4. *Partial Hipersil Core Assembly For a Three-Phase Transformer*

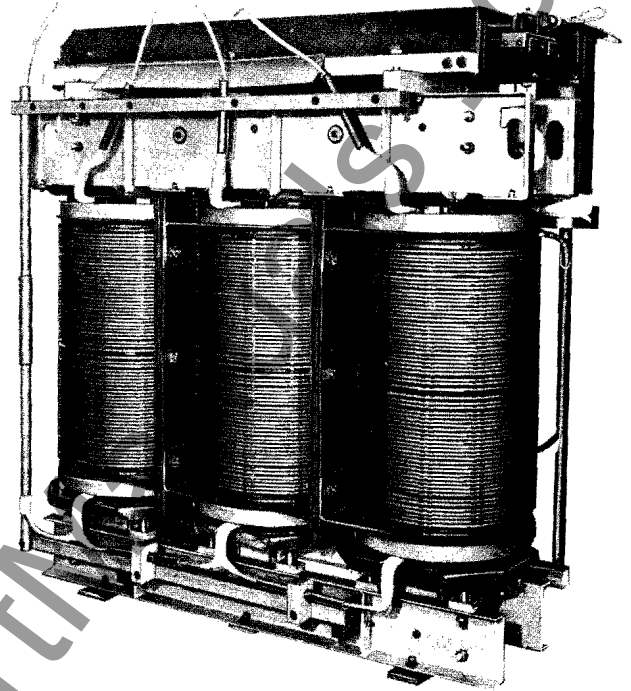


Fig. 5. *Core and Coils for "SL" and "SLS" Assembly*

ASSEMBLY

A combination of steel end frames, lock plates, pressure plates and rings form the mechanical support of the core and coil assembly for lifting and to prevent coil distortions if the transformer is subject to short circuit conditions.

The end frames are formed by heavy structural steel channels attached to each side of both the top and bottom yokes by means of insulated core bolts. These bolts are relieved of any coil forces by means of insulated steel lock plates bolted to the core legs which keep the top and bottom end frames from separating.

The top end frame serves as a support for the terminal board mounting and acts as a guide for the tie plates. Across the lower end frames, steel feet are bolted, which serve to center the assembly in the tank.

Over the bottom adjustable pressure plates and under the top end frames, slotted steel pressure rings are placed. The use of

this ring distributes the coil pressures uniformly over the circumference of the coils with a resulting low unit stress under short circuit conditions. Since the coils are pre-shrunk under heat and hydraulic pressure equivalent to the short circuit stresses and later tightened on the core by means of the adjustable steel pressure plates, the coils will remain securely clamped under service conditions.

HANDLING AND BRACING "SL" AND "SLS"

The core and coil structure is lifted as a unit by means of slotted holes cut in the top

end frames which extend beyond the outer core legs. The transformer is centered in its tank by pins welded to the tank bottom which bear against steel feet bolted to the bottom end frames. At the top of the core, tie plates are bolted to pads welded to the tank wall. The bolts and nuts used with the tie plates are of heat treated steel and are locked with bolt fasteners or Dieter nuts.

Westinghouse Electric Corporation

Sharon Plant, Transformer Divisions, Sharon, Pa.

Printed in U.S.A. (TP)

Instructions for Self-Cooled Transformers



I. L. 48-060-28

GENERAL

Entrapped air is a potential source of trouble in all transformers. In general therefore it is desirable to fill transformers with oil under full vacuum. This is done for transformers shipped in oil from the factory except in a very few cases where it is not considered as essential.

The filling of transformers with oil in the field should be done under a full vacuum provided the transformer tanks are designed for this condition. If the transformer tanks have not been designed for full vacuum and it is imperative to get the maximum impulse strength immediately, the transformers should be filled with oil under full vacuum by placing them in an auxiliary tank. Transformers with round wire coils should always be filled with oil under full vacuum, because of the higher stress across coil groups. For definite information on tank strengths the factory should be consulted.

In those cases where the transformers are not filled under full vacuum, full voltage should not be applied to the windings until inspection reveals that no more gas in the form of bubbles is being released from the core and coil assembly.

When the voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be temporarily operated without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days' service it is advisable to test the oil again for moisture.

OIL SAMPLING

There is always a chance that moisture may get into the oil after the transformer is installed so that a sample of oil should be drawn from the bottom of the tank at least once in every three months and tested for dielectric strength. See Instruction Book 45-063-100, Wemco C Insulating Oil. Operators who do not have facilities for testing oil can send samples to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. Bottles and containers can be supplied by any of our District Offices in lots of six, for this purpose, at a nominal charge. These bottles are vacuum dried and sealed. A container is provided allowing shipment by Parcel Post, which is usually very desirable.

Operators who are not equipped to make their own tests are urged to avail themselves of this service.

TEMPERATURE READINGS

Thermometers should be read as often as good operating practice permits. Temperature limits for any specific condition of loading should be in accordance with ASA STANDARDS AND GUIDES FOR OPERATION (C57) for the loading involved.

INSPECTION

Transformers require less care and attention than almost any other kind of electrical power apparatus. This, however, is not a reason for neglecting them. The conditions under which they operate will determine to some extent the frequency with which they should be inspected. A regular program of inspection should be established and rigidly carried out.

The oil should be tested for dielectric strength and the presence of sludge. If there is an indication of moisture or sludge formation, the oil should be tested further and treated as described in Instruction Book 45-063-100. If tests show the oil to be in bad condition an inspection should be made on the inside of the tank for possible cause of the trouble. However, if the oil tests satisfactorily the case should not be opened but a careful inspection of all accessories should be made to see that they are functioning properly. Transformers equipped with the inert gas protection should not have sludge formation since oxygen is excluded. The record of deoxidizing compound, or nitrogen gas consumption should be studied and if excessive the case should be tested for leaks as described in the Instruction Booklet for Inertaire or Sealedaire Equipment.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined the transformer should be taken out of service and given a thorough inspection.

Any symptoms such as unusual noises, high or low oil levels, operation of relief device, etc. should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions such as overloads, frequent short circuits, or special units such as furnace transformers should be inspected internally at least once a year. This can usually be done adequately by lowering the oil level and inspecting with a light through the manhole.

REPAINTING

It is desirable to repaint the transformer at intervals to maintain the finish in good condition. Local climatic conditions cover such a wide range that definite recommendations as to frequency of repainting are not possible. Repainting by flowing on is preferable because it tends to wash off foreign material and produces a uniform coating. See Instruction Leaflet "Standard Finish for Transformers," I.L. 47-600-12.

Equipment has been developed for flow coating, cleaning and handling transformers and parts in the field. The customer should write to the Company for details.

SPARE TRANSFORMERS

A spare transformer should be given the same routine checks as are given to transformers continuously in

service. The internal parts should be kept free from the condensation and accumulation of moisture. To obtain the maximum advantage from the spare unit it should be kept ready for instant service.

REPAIRING

With proper care, modern transformers seldom give trouble; but, nevertheless, repairs are occasionally necessary.

No general instructions will be given here for repairs of transformers. The operator may write to the Company, describing the nature of the trouble and the extent and character of the damage, and information and instructions for repair will be promptly and freely given.

In writing with reference to any transformer, always give the full nameplate reading, as this furnishes accurate information for identification.

Westinghouse Electric Corporation

Sharon Plant, Transformer Divisions, Sharon, Pa.

Printed in U.S.A. (TP)

Instructions for Self-Cooled Transformers



I. L. 48-060-28

GENERAL

Entrapped air is a potential source of trouble in all transformers. In general therefore it is desirable to fill transformers with oil under full vacuum. This is done for transformers shipped in oil from the factory except in a very few cases where it is not considered as essential.

The filling of transformers with oil in the field should be done under a full vacuum provided the transformer tanks are designed for this condition. If the transformer tanks have not been designed for full vacuum and it is imperative to get the maximum impulse strength immediately, the transformers should be filled with oil under full vacuum by placing them in an auxiliary tank. Transformers with round wire coils should always be filled with oil under full vacuum, because of the higher stress across coil groups. For definite information on tank strengths the factory should be consulted.

In those cases where the transformers are not filled under full vacuum, full voltage should not be applied to the windings until inspection reveals that no more gas in the form of bubbles is being released from the core and coil assembly.

When the voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be temporarily operated without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days' service it is advisable to test the oil again for moisture.

OIL SAMPLING

There is always a chance that moisture may get into the oil after the transformer is installed so that a sample of oil should be drawn from the bottom of the tank at least once in every three months and tested for dielectric strength. See Instruction Book 45-063-100, *Wemco C Insulating Oil*. Operators who do not have facilities for testing oil can send samples to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. Bottles and containers can be supplied by any of our District Offices in lots of six, for this purpose, at a nominal charge. These bottles are vacuum dried and sealed. A container is provided allowing shipment by Parcel Post, which is usually very desirable.

Operators who are not equipped to make their own tests are urged to avail themselves of this service.

TEMPERATURE READINGS

Thermometers should be read as often as good operating practice permits. Temperature limits for any specific condition of loading should be in accordance with ASA STANDARDS AND GUIDES FOR OPERATION (C57) for the loading involved.

INSPECTION

Transformers require less care and attention than almost any other kind of electrical power apparatus. This, however, is not a reason for neglecting them. The conditions under which they operate will determine to some extent the frequency with which they should be inspected. A regular program of inspection should be established and rigidly carried out.

The oil should be tested for dielectric strength and the presence of sludge. If there is an indication of moisture or sludge formation, the oil should be tested further and treated as described in Instruction Book 45-063-100. If tests show the oil to be in bad condition an inspection should be made on the inside of the tank for possible cause of the trouble. However, if the oil tests satisfactorily the case should not be opened but a careful inspection of all accessories should be made to see that they are functioning properly. Transformers equipped with the inert gas protection should not have sludge formation since oxygen is excluded. The record of deoxidizing compound, or nitrogen gas consumption should be studied and if excessive the case should be tested for leaks as described in the Instruction Booklet for Inertaire or Sealedaire Equipment.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined the transformer should be taken out of service and given a thorough inspection.

Any symptoms such as unusual noises, high or low oil levels, operation of relief device, etc. should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions such as overloads, frequent short circuits, or special units such as furnace transformers should be inspected internally at least once a year. This can usually be done adequately by lowering the oil level and inspecting with a light through the manhole.

REPAINTING

It is desirable to repaint the transformer at intervals to maintain the finish in good condition. Local climatic conditions cover such a wide range that definite recommendations as to frequency of repainting are not possible. Repainting by flowing on is preferable because it tends to wash off foreign material and produces a uniform coating. See Instruction Leaflet "Standard Finish for Transformers," I. L. 48-069-15.

Equipment has been developed for flow coating, cleaning and handling transformers and parts in the field. The customer should write to the Company for details.

SPARE TRANSFORMERS

A spare transformer should be given the same routine checks as are given to transformers continuously in

service. The internal parts should be kept free from the condensation and accumulation of moisture. To obtain the maximum advantage from the spare unit it should be kept ready for instant service.

REPAIRING

With proper care, modern transformers seldom give trouble; but, nevertheless, repairs are occasionally necessary.

No general instructions will be given here for repairs of transformers. The operator may write to the Company, describing the nature of the trouble and the extent and character of the damage, and information and instructions for repair will be promptly and freely given.

In writing with reference to any transformer, always give the full nameplate reading, as this furnishes accurate information for identification.

Instructions for Self-Cooled Transformers



I. L. 48-060-28

GENERAL

Entrapped air is a potential source of trouble in all transformers. In general therefore it is desirable to fill transformers with oil under full vacuum. This is done for transformers shipped in oil from the factory except in a very few cases where it is not considered as essential.

The filling of transformers with oil in the field should be done under a full vacuum provided the transformer tanks are designed for this condition. If the transformer tanks have not been designed for full vacuum and it is imperative to get the maximum impulse strength immediately, the transformers should be filled with oil under full vacuum by placing them in an auxiliary tank. Transformers with round wire coils should always be filled with oil under full vacuum, because of the higher stress across coil groups. For definite information on tank strengths the factory should be consulted.

In those cases where the transformers are not filled under full vacuum, full voltage should not be applied to the windings until inspection reveals that no more gas in the form of bubbles is being released from the core and coil assembly.

When the voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be temporarily operated without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days' service it is advisable to test the oil again for moisture.

OIL SAMPLING

There is always a chance that moisture may get into the oil after the transformer is installed so that a sample of oil should be drawn from the bottom of the tank at least once in every three months and tested for dielectric strength. See Instruction Book 45-063-100, *Wemco C Insulating Oil*. Operators who do not have facilities for testing oil can send samples to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. Bottles and containers can be supplied by any of our District Offices in lots of six, for this purpose, at a nominal charge. These bottles are vacuum dried and sealed. A container is provided allowing shipment by Parcel Post, which is usually very desirable.

Operators who are not equipped to make their own tests are urged to avail themselves of this service.

TEMPERATURE READINGS

Thermometers should be read as often as good operating practice permits. Temperature limits for any specific condition of loading should be in accordance with *ASA STANDARDS AND GUIDES FOR OPERATION (C57)* for the loading involved.

INSPECTION

Transformers require less care and attention than almost any other kind of electrical power apparatus. This, however, is not a reason for neglecting them. The conditions under which they operate will determine to some extent the frequency with which they should be inspected. A regular program of inspection should be established and rigidly carried out.

The oil should be tested for dielectric strength and the presence of sludge. If there is an indication of moisture or sludge formation, the oil should be tested further and treated as described in Instruction Book 45-063-100. If tests show the oil to be in bad condition an inspection should be made on the inside of the tank for possible cause of the trouble. However, if the oil tests satisfactorily the case should not be opened but a careful inspection of all accessories should be made to see that they are functioning properly. Transformers equipped with the inert gas protection should not have sludge formation since oxygen is excluded. The record of deoxidizing compound, or nitrogen gas consumption should be studied and if excessive the case should be tested for leaks as described in the Instruction Booklet for *Inertaire or Sealedaire Equipment*.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined the transformer should be taken out of service and given a thorough inspection.

Any symptoms such as unusual noises, high or low oil levels, operation of relief device, etc. should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions such as overloads, frequent short circuits, or special units such as furnace transformers should be inspected internally at least once a year. This can usually be done adequately by lowering the oil level and inspecting with a light through the manhole.

REPAINTING

It is desirable to repaint the transformer at intervals to maintain the finish in good condition. Local climatic conditions cover such a wide range that definite recommendations as to frequency of repainting are not possible. Repainting by flowing on is preferable because it tends to wash off foreign material and produces a uniform coating. See Instruction Leaflet "Standard Finish for Transformers," I.L. 48-069-15.

Equipment has been developed for flow coating, cleaning and handling transformers and parts in the field. The customer should write to the Company for details.

SPARE TRANSFORMERS

A spare transformer should be given the same routine checks as are given to transformers continuously in

service. The internal parts should be kept free from the condensation and accumulation of moisture. To obtain the maximum advantage from the spare unit it should be kept ready for instant service.

REPAIRING

With proper care, modern transformers seldom give trouble; but, nevertheless, repairs are occasionally necessary.

No general instructions will be given here for repairs of transformers. The operator may write to the Company, describing the nature of the trouble and the extent and character of the damage, and information and instructions for repair will be promptly and freely given.

In writing with reference to any transformer, always give the full nameplate reading, as this furnishes accurate information for identification.

Instructions for Rectangular Core and Coil Assembly Type "SL" Transformers



I.L. 48-060-27A

WINDINGS

Type "SL" TRANSFORMERS from 501 to 2500 Kva 34.5 Kv insulation class and below, are equipped with windings made from suitable high quality conducting material which is manufactured by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special conductor prevents insulation failures resulting from surface imperfections in the conductor.

When insulation is applied to each conductor, it consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought from the inside layers of each coil. With this arrangement, the tapped portion of the winding is not exposed to line surges and the electrical centers are more nearly balanced on all connections.

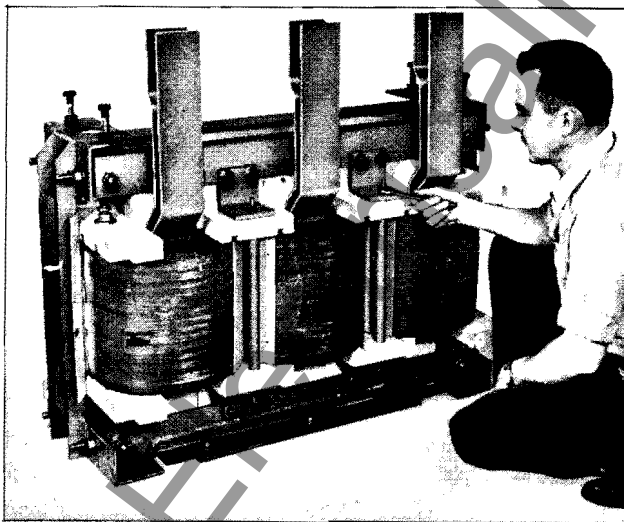


Fig. 1 Core and Coil Assembly Type "SL" Transformer

The high-voltage coils are wound directly over the low-voltage coils and the low-high insulation. If it should be necessary to replace either the high or low voltage winding, the complete high-low coil assembly must be ordered for replacement.

All coils are of a rectangular cross-section in order to obtain a compact design. This coil construction reduces the weight of the transformer by 20% or more as compared with circular cross-section coil designs and permits the efficient use of rectangular tanks.

CONCENTRIC COILS

The concentric coil is used for the high-voltages from 2.5 to 34.5 Kv insulation class. This concentric coil consists of several layers of insulated conductors supported by an insulating cylinder. Each turn consists of one or more conductor ribbons of suitable cross-section in parallel. Collars of suitable form and material are used at the end of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that the coil temperature gradients are kept uniformly low.

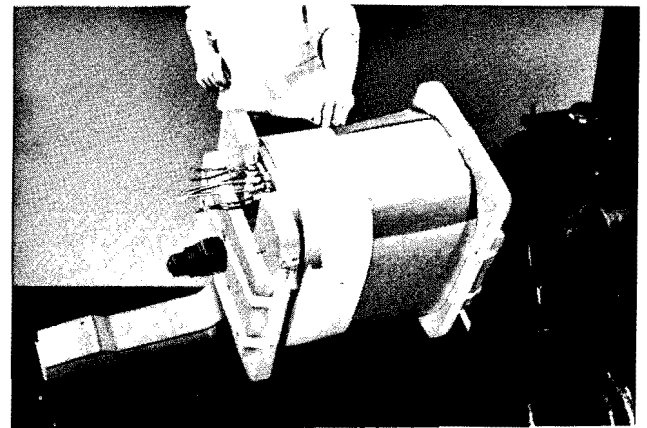


Fig. 2 Rectangular Concentric Coil Winding

In the concentric coils from 15 to 34.5 Kv, shields in the form of static cylinders are located at the line end of the windings. These shields reduce the effective ground capacitance, distribute impulse stresses and increase the surge strength. This coil construction is known as the "Lowgrocap winding".

SPIRAL COILS

The spiral winding is used on low voltage coils up to 1.2 Kv and consists of bare conductor sheets, each layer containing only one turn and each turn in width equal to the coil height. The turns are wound on with a continuous strip of pressboard to form layer to layer or turn to turn insulation. The conductors are held in by spiral collars placed on the ends of the coil. The low-voltage leads are bars brazed at the start and finish of the winding and coming vertically out of the coils. Ducts are distributed throughout the coil for adequate cooling.

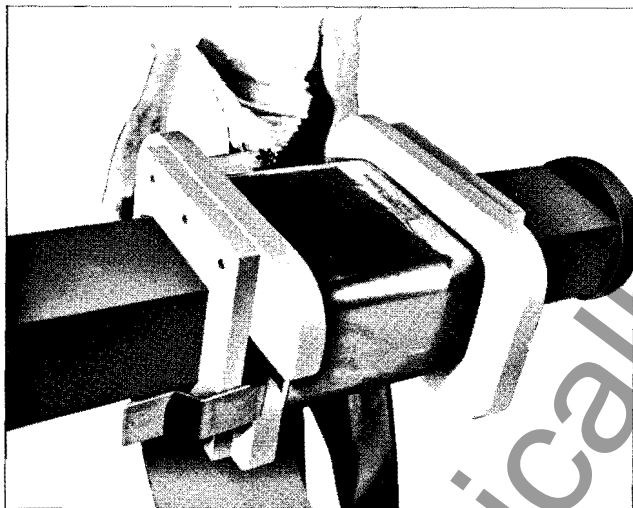


Fig. 3 Rectangular Spiral Coil Winding

Spiral windings are of a very compact design and are very strong mechanically. These windings have a very favorable surge distribution and hold up well under electrical stresses.

THE CORE

The core of this type transformer is made of Hipersil high permeability cold rolled material which carries twenty to thirty per cent more flux than the hot rolled silicon steel it replaced. The use of this material gives a transformer of higher efficiency with from twenty to twenty-five percent reduction in total weight in addition to the weight reduction obtained with the rectangular coil design.

The magnetic circuit is rectangular in shape with a rectangular opening. The cross-section of the core is rectangular. In order to avoid joints of high magnetic density and a condition in which the flux must pass across the direction of the grain, the laminations are cut with 45° angles at each end. Punchings for the yoke are made slightly wider than the leg punchings in order to obtain an overlap. With this design, the flux path at the corner is essentially parallel with the grain of the material in both the yoke and the leg punchings.

THE ASSEMBLY OF CORE AND COILS

The core punchings are assembled into the coils. The leg punchings are wedged in place by two wedges inside the low voltage winding tube. The yoke punchings are held together by the clamping action of the steel and frame angles. Four tie rods brace the core and coil assembly in the axial direction and are tied in with pressure blocks at the ends of the coils and the end frame construction. Additional bracing in the axial direction as well as bracing the coils against short circuit forces is provided by upright channel supports at each end of the core and coil assembly.

TREATMENT

The core and coil assembly is pressed, blocked and thoroughly dried in a heated oven for removal of moisture. After tanking the core and coil assembly the unit is filled with transformer liquid while under vacuum.

HANDLING AND BRACING

The core and coil assembly is lifted by means of lifting holes in the ends of the end frame structure. These holes are located at the center of the assembly to prevent tilting when lifting.

The core and coil assembly is positioned on the tank bottom by means of four centering guides and is held in place by two tie plates pressing on the end frames.

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

Instructions for Rectangular Core and Coil Assembly Type "SL" Transformers



I.L. 48-060-27A

WINDINGS

Type "SL" TRANSFORMERS from 501 to 2500 Kva 34.5 Kv insulation class and below, are equipped with windings made from suitable high quality conducting material which is manufactured by a special process giving high ductility and eliminating the possibility of scale or slivers. The use of this special conductor prevents insulation failures resulting from surface imperfections in the conductor.

When insulation is applied to each conductor, it consists of a number of layers of paper, machine-wound on the conductor.

Taps are brought from the inside layers of each coil. With this arrangement, the tapped portion of the winding is not exposed to line surges and the electrical centers are more nearly balanced on all connections.

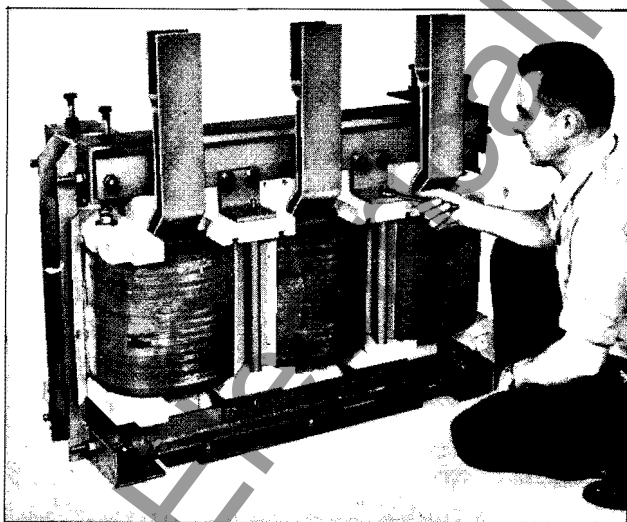


Fig. 1 Core and Coil Assembly Type "SL" Transformer

The high-voltage coils are wound directly over the low-voltage coils and the low-high insulation. If it should be necessary to replace either the high or low voltage winding, the complete high-low coil assembly must be ordered for replacement.

All coils are of a rectangular cross-section in order to obtain a compact design. This coil construction reduces the weight of the transformer by 20% or more as compared with circular cross-section coil designs and permits the efficient use of rectangular tanks.

CONCENTRIC COILS

The concentric coil is used for the high-voltages from 2.5 to 34.5 Kv insulation class. This concentric coil consists of several layers of insulated conductors supported by an insulating cylinder. Each turn consists of one or more conductor ribbons of suitable cross-section in parallel. Collars of suitable form and material are used at the end of the layers and anchored in place to give the necessary electrical and mechanical strength. Ducts are supplied for the cooling medium so that the coil temperature gradients are kept uniformly low.

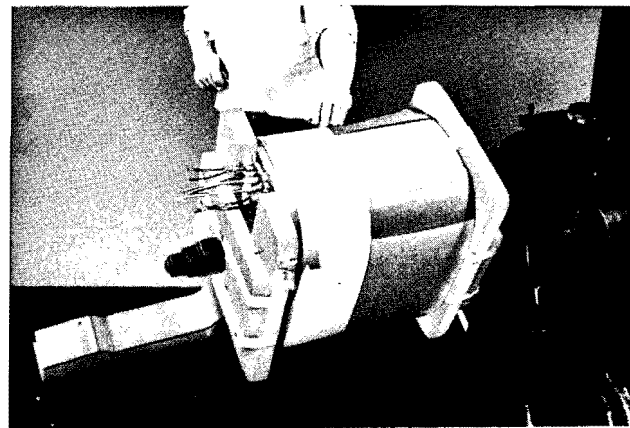


Fig. 2 Rectangular Concentric Coil Winding

In the concentric coils from 15 to 34.5 Kv, shields in the form of static cylinders are located at the line end of the windings. These shields reduce the effective ground capacitance, distribute impulse stresses and increase the surge strength. This coil construction is known as the "Lowgrocap winding".

SPIRAL COILS

The spiral winding is used on low voltage coils up to 1.2 Kv and consists of bare conductor sheets, each layer containing only one turn and each turn in width equal to the coil height. The turns are wound on with a continuous strip of pressboard to form layer to layer or turn to turn insulation. The conductors are held in by spiral collars placed on the ends of the coil. The low-voltage leads are bars brazed at the start and finish of the winding and coming vertically out of the coils. Ducts are distributed throughout the coil for adequate cooling.

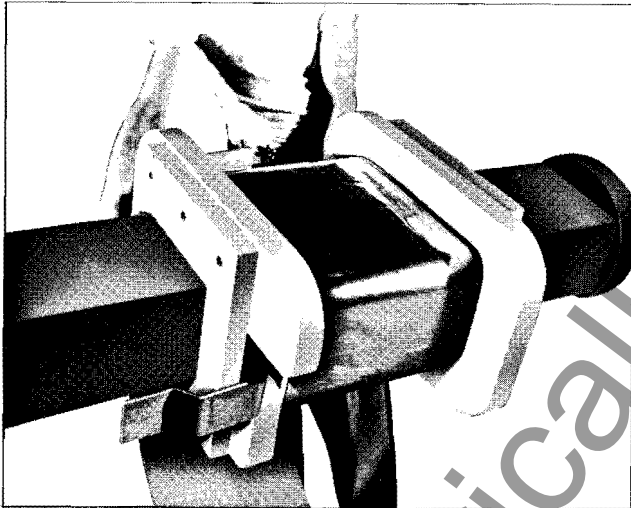


Fig. 3 Rectangular Spiral Coil Winding

Spiral windings are of a very compact design and are very strong mechanically. These windings have a very favorable surge distribution and hold up well under electrical stresses.

THE CORE

The core of this type transformer is made of Hipersil high permeability cold rolled material which carries twenty to thirty per cent more flux than the hot rolled silicon steel it replaced. The use of this material gives a transformer of higher efficiency with from twenty to twenty-five percent reduction in total weight in addition to the weight reduction obtained with the rectangular coil design.

The magnetic circuit is rectangular in shape with a rectangular opening. The cross-section of the core is rectangular. In order to avoid joints of high magnetic density and a condition in which the flux must pass across the direction of the grain, the laminations are cut with 45° angles at each end. Punchings for the yoke are made slightly wider than the leg punchings in order to obtain an overlap. With this design, the flux path at the corner is essentially parallel with the grain of the material in both the yoke and the leg punchings.

THE ASSEMBLY OF CORE AND COILS

The core punchings are assembled into the coils. The leg punchings are wedged in place by two wedges inside the low voltage winding tube. The yoke punchings are held together by the clamping action of the steel and frame angles. Four tie rods brace the core and coil assembly in the axial direction and are tied in with pressure blocks at the ends of the coils and the end frame construction. Additional bracing in the axial direction as well as bracing the coils against short circuit forces is provided by upright channel supports at each end of the core and coil assembly.

TREATMENT

The core and coil assembly is pressed, blocked and thoroughly dried in a heated oven for removal of moisture. After tanking the core and coil assembly the unit is filled with transformer liquid while under vacuum.

HANDLING AND BRACING

The core and coil assembly is lifted by means of lifting holes in the ends of the end frame structure. These holes are located at the center of the assembly to prevent tilting when lifting.

The core and coil assembly is positioned on the tank bottom by means of four centering guides and is held in place by two tie plates pressing on the end frames.

Westinghouse Electric Corporation

Power Transformer Division, Sharon, Pa.