

Chapter E 450

TRANSFORMERS AND TRANSFORMER VAULTS (Including Secondary Ties)

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E 450.01 Application. (1) This chapter applies to the installation of all transformers except: (a) current transformers; (b) dry-type transformers which constitute a component part of other apparatus and which conform to the requirements for such apparatus; (c) transformers for use with X-ray and high-frequency; (d) transformers used with class 1 low-voltage power circuits or class 2 remote control low-energy power and signal circuits which shall conform to Wis. Admin. Code chapter E 725; (e) transformers for sign and outline lighting which shall conform to chapter E 600; and (f) transformers for electric discharge lighting which shall conform to chapter E 410.

(2) This chapter applies to the installation of transformers in hazardous locations except as modified by chapter E 500.

Note: Supplementary rules are found also in chapter E 710, Circuits and Equipment Operating at More than 600 Volts Between Conductors; and Service Installations Over 600 Volts as referred to in chapter E 230.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

A. GENERAL PROVISIONS

E 450.02 Location. The location of oil insulated transformers and transformer vaults is covered in sections E 450.24, E 450.25 and E 450.41; dry type transformers in E 450.21 and askarel insulated in E 450.23.

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E 450.03 Overcurrent protection. (1) Overcurrent protection shall conform to the following. As used in this section, the word "transformer" means a transformer or polyphase bank of 2 or 3 single phase transformers operating as a unit.

(a) *Primary side.* Each transformer shall be protected by an individual overcurrent device in the primary connection, rated or set at not more than 250% of the rated primary current of the transformer, except that an individual overcurrent device is not required when the primary circuit overcurrent device provides the protection specified in this paragraph, and except as provided in section E 450.03 (1) (b).

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(b) *Primary and secondary side.* A transformer having an overcurrent device in the secondary connection, rated or set at not more than 250% of the rated secondary current of the transformer, or a transformer equipped with a coordinated thermal overload protection by the manufacturer, is not required to have an individual overcurrent device in the primary connection provided the primary feeder overcurrent device is rated or set to open at a current value not more than 6 times the rated current of the transformer for transformers having not more than 6% impedance, and not more than 4 times rated current of the transformer for transformers having more than 6 but not more than 10% impedance.

(c) *Potential (voltage) transformers.* Potential transformers should be protected with primary fuses. The fuse rating should not exceed 10 amperes for circuits of 600 volts or less, and 3 amperes for circuits of more than 600 volts. A resistor should be connected in series with high tension fuses when necessary to limit the possible short-circuit current to a value within the interrupting capacity of the fuse.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.05 Secondary ties. (1) As used in this chapter, the word "transformer" means a transformer or a bank of transformers operating as a unit. A secondary tie is a circuit operating at 600 volts or less between phases which connects 2 power sources or power supply points, such as the secondaries of 2 transformers. The tie may consist of one or more conductors per phase.

(a) *Tie circuits.* Tie circuits shall be provided at each end with overcurrent protection as required in chapter E 240 of this code, except under the conditions described in subsections (1) (a) 1. and E 450.05 (1) (a) 2., in which cases the overcurrent protection may be in accordance with subsection (1) (a) 3.

1. Loads at transformer supply points only. Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with chapter E 240, the rated ampacity of the tie shall be not less than 67% of the rated secondary current of the largest transformer connected to the secondary tie system.

2. Loads connected between transformer supply points. Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with chapter E 240, the rated ampacity of the tie shall be not less than 100% of the rated secondary current of the largest transformer connected to the secondary tie system except as otherwise provided in subsection (1) (a) 4.

3. Tie circuit protection. Under the conditions described in subsections (1) (a) 1. and (1) (a) 2., both ends of each tie conductor shall be equipped with a protective device which will open at a predetermined temperature of the tie conductor under short circuit conditions. This protection shall consist of one of the following:

- a. A fusible link cable connector, terminal or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of approved construction and characteristics according to the operating voltage and the type of insulation on the tie conductors, or
- b. Automatic circuit-breakers actuated by devices having comparable current-time characteristics.

4. Interconnection of phase conductors between transformer supply points. Where the tie consists of more than one conductor per phase, the conductors of each phase shall be interconnected in order to establish a load supply point, and the protection specified in subsection (1) (a) 3, shall be provided in each tie conductor at this point, except as follows:

a. Exception. Loads may be connected to the individual conductors of a multiple-conductor tie without interconnecting the conductors of each phase and without the protection specified in subsection (1) (a) 3, at load connection points provided; the tie conductors of each phase have a combined capacity not less than 133% of the rated secondary current of the largest transformer connected to the secondary tie system; the total load of such taps does not exceed the rated secondary current of the largest transformer; the loads are equally divided on each phase and on the individual conductors of each phase as far as practicable.

5. Tie circuit control. Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end which when open will de-energize the associated tie conductors and limiters. The current rating of the switch shall be not less than the rated current of the conductors connected to the switch. It shall be capable of opening its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

(b) *Overcurrent protection for secondary connections.* When secondary ties are used an overcurrent device rated or set at not more than 250% of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer, and in addition an automatic circuit-breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.06 Parallel operation. Transformers may be operated in parallel and switched as a unit provided that the overcurrent protection for each transformer meets the requirements of section E 450.03.

Note: To obtain balanced division of load current, both transformers should have the same rated percent impedance and be operated on the same voltage-ratio tap.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.07 Guarding. Transformers shall be guarded as follows:

(1) **MECHANICAL PROTECTION.** Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are located where they are exposed to physical damage.

(2) **CASE OR ENCLOSURE.** Dry-type transformers shall be provided with a non-combustible moisture-resistant case or enclosure which will provide reasonable protection against the accidental insertion of foreign objects.

(3) **EXPOSED LIVE PARTS.** The transformer installation shall conform with the provisions for guarding of live parts in section E 195.17.

(4) **VOLTAGE WARNING.** The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.08 Grounding. Exposed non-current carrying metal parts of transformer installations including fences, guards, etc., shall be grounded where required under the conditions and in the manner prescribed for electrical equipment and other exposed metal parts in chapter E 250.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.09 Marking. Each transformer shall be provided with a nameplate giving the name of the manufacturer; rated kilovolt-amperes, frequency, primary and secondary voltage; and the amount and kind of insulating liquid where used and the transformer rating exceeds 25 kva. Where class B insulation is used in the construction of dry-type transformers rated more than 100 kva, the nameplate shall indicate the temperature rise for this insulation system.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

B. SPECIFIC PROVISIONS APPLICABLE TO DIFFERENT TYPES OF TRANSFORMERS

E 450.21 Dry-type transformers installed indoors. (1) Transformers rated $112\frac{1}{2}$ kva or less shall have a separation of at least 12 inches from combustible material unless separated therefrom by a fire-resistant heat insulating barrier, or unless of a rating not exceeding 600 volts and completely enclosed except for ventilating openings.

(2) Transformers of more than $112\frac{1}{2}$ kva rating shall be installed in a transformer room for fire-resistant construction unless they are constructed with class B (80° C. rise), class F (115° C. rise) or class H (150° C. rise) insulation, and are separated from combustible material not less than 6 feet horizontally and 12 feet vertically or are separated therefrom by a fire-resistant heat-insulating barrier.

(3) Transformers rated more than 35,000 volts shall be installed in a vault. See Part C of this chapter.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.23 Askarel-insulated transformers installed indoors. Askarel-insulated transformers rated in excess of 25 kva shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent shall be connected to a chimney or flue which will carry such gases outside the building. Askarel-insulated transformers rated more than 35,000 volts shall be installed in a vault.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.24 Oil-insulated transformers installed indoors. Oil-insulated transformers shall be installed in a vault constructed as specified in this chapter except as follows:

(1) **NOT OVER $112\frac{1}{2}$ KVA TOTAL CAPACITY.** The provisions for transformer vaults specified in part C of this chapter apply except that the

vault may be constructed of reinforced concrete not less than 4 inches thick.

(2) **NOT OVER 600 VOLTS.** A vault is not required provided suitable arrangements are made where necessary to prevent a transformer oil fire igniting other materials, and the total transformer capacity in one location does not exceed 10 kva in a section of the building classified as combustible, or 75 kva where the surrounding structure is classified as fire-resistant construction.

(3) **FURNACE TRANSFORMERS.** Electric furnace transformers of a total rating not exceeding 75 kva may be installed without a vault in a building or room of fire-resistant construction provided suitable arrangements are made to prevent a transformer oil fire spreading to other combustible material.

(4) **DETACHED BUILDINGS.** Transformers may be installed in a building which does not conform with the provisions specified in this code for transformer vaults, provided neither the building nor its contents present a fire hazard to any other building or property, and provided the building is used only in supplying electric service and the interior is accessible only to qualified persons.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.25 Oil-insulated transformers installed outdoors. Combustible material, combustible buildings and parts of buildings, fire escapes, door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on, attached to, or adjacent to a building or combustible material. Space separations, fire-resistant barriers, automatic water spray systems and enclosures which confine the oil of a ruptured transformer tank are recognized safeguards. One or more of these safeguards shall be applied according to the degree of hazard involved in cases where the transformer installation presents a fire hazard. Oil enclosures may consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse crushed stone. Oil enclosure shall be provided with trapped drains in cases where the exposure and the quantity of oil involved are such that removal of oil is important.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.26 Oil-insulated transformers installed on roofs. Oil-insulated transformers installed on the roof of a building shall comply with the following conditions:

(1) The structure of the building shall be of sufficient strength to carry the weight of the transformers and their enclosures and the equipment used in connection therewith. There shall be a path from the edge of the roof to the transformer location, of sufficient strength to support the transformer.

(2) Where the roof is of 2-hour or greater fire-resistive construction, the transformers shall be installed in a fenced enclosure, vault or other enclosure where the live parts are guarded against accidental contact. Where a fence is used it shall be of a type that cannot be readily climbed and shall not be less than 6 feet in height excluding any barbed wire. A locked gate shall be provided. Where the transformers are installed in other than a vault, a curb or basin shall be

provided. The curb shall be high enough to contain the oil from the largest of the transformers, but in no case less than 6 inches high. A drain shall be provided to carry any oil away from the building.

(3) Where the roof is less than 2-hour fire-resistive construction, the transformers shall be enclosed in a vault complying with chapter E 450, part C—Provisions for Transformer Vaults.

Note: See Wis. Adm. Code sections Ind 51.04 and 51.07 for fire-resistive standards.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

C. PROVISIONS FOR TRANSFORMER VAULTS

E 450.41 Location. Vaults containing oil-insulated transformers shall be located where they can be ventilated to the outside air without using flues or ducts.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.42 Walls, roof and floor. The walls and roofs of vaults shall be constructed of reinforced concrete, brick, load-bearing tile, concrete block, or other fire-resistive constructions which have adequate structural strength for the conditions, and a minimum fire resistance of 3 hours. The floors of vaults in contact with the earth shall be of concrete not less than 4 inches thick, but when the vault is constructed with a vacant space or other stories below it, the floor shall have adequate structural strength for the load imposed thereon and a minimum fire resistance of 3 hours. The administrative authority shall determine the type of construction required to comply with this section.

Note: See Wis. Adm. Code sections Ind 51.05 and Ind 51.06.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.43 Doorways. Any doorway leading from the vault into the building shall be protected as follows:

(1) **TYPE OF DOOR.** Each doorway shall be provided with a tight-fitting class A fire door. The administrative authority may require such a door on each side of the wall where conditions warrant.

(2) **SILLS.** A door sill or curb of sufficient height to confine within the vault the oil from the largest transformer shall be provided and in no case shall the height be less than 6 inches.

(3) **LOCKS.** Entrance doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to qualified persons. Locks and latches shall be so arranged that the door may be readily and quickly opened from the inside.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.44 Ventilation. The ventilation shall be adequate to prevent excessive transformer temperature. See ASA C57.12-58. Vaults containing oil-filled equipment shall be vented to the outside.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.45 Ventilation openings. When required by section E 450.44, openings for ventilation shall be provided in accordance with the following:

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(1) **LOCATION.** Ventilation openings shall be located as far away as possible from doors, windows, fire escapes, and combustible material.

(2) **ARRANGEMENT.** Vaults ventilated by natural circulation of air may have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof; or all of the area required for ventilation may be provided in one or more openings in or near the roof.

(3) **SIZE.** In the case of vaults ventilated to an outdoor area without using ducts or flues the combined net area of all ventilating openings after deducting the area occupied by screens, gratings, or louvers, shall be not less than 3 square inches per kva of transformer capacity in service, except that the net area shall be not less than 1 square foot for any capacity under 50 kva.

(4) **COVERING.** Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(5) **DAMPERS.** Where automatic dampers are used in the ventilation openings of vaults containing oil-insulated transformers, the actuating device should be made to function at a temperature resulting from fire and not at a temperature which might prevail as a result of an overheated transformer or bank of transformers. Automatic dampers should be so designed and constructed to minimize the possibility of accidental closing.

(6) **DUCTS.** Ventilating ducts shall be constructed of fire-resistant material.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.46 Drainage. Where practicable, vaults containing more than 100 kva transformer capacity shall be provided with a drain or other means which will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain when provided.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.47 Water pipes and accessories. Any pipe or duct systems foreign to the electrical installation should not enter or pass through a transformer vault. Where the presence of such foreign systems cannot be avoided, appurtenances thereto which require maintenance at regular intervals shall not be located inside the vault. Arrangement shall be made where necessary to avoid possible trouble from condensation, leaks and breaks in such foreign systems. Piping or other facilities provided for fire protection or for water-cooled transformers are not deemed to be foreign to the electrical installation.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.

E 450.48 Storage in vaults. Materials shall not be stored in transformer vaults.

History: Cr. Register, January, 1968, No. 145, eff. 2-1-68.