Task Force Report: Negative Pressure Requirements

WG Tank Pressure Coordination C57.12.39 | IEEE Standard Requirements for Distribution Transformer Tank Pressure Coordination

IEEE PES Transformers Committee

Task Force Scope

- Clarify and coordinate negative pressure requirements, including:
  - Sealing of tank and pressure relief devices
  - Design for tank integrity (mechanical strength)
  - Tank deformation

Recommended Actions

1. Add a footnote to section *4.1 Liquid Preservation* to clarify the intent of the second paragraph.

2. Add a negative pressure requirement to section *4.2.1 Tank Integrity*.

3. Change all instances of “permanent deformation” that are in reference to the transformer tank to “compromising deformation” – 4 identified locations

IEEE PES Transformers Committee

RA1: Footnote for section *4.1 Tank Integrity*

4.1 Liquid preservation

Distribution transformers shall have a sealed-tank liquid-preservation system. Sealed-tank construction is a construction in which the interior of the tank is sealed from the atmosphere and the gas volume plus the liquid volume remains constant. The transformer shall remain effectively sealed for a top liquid temperature range of −5 °C to +105 °C for continuous operation at rated kilovolt-amperes and under the operating conditions as described in IEEE Std C57.91.[4]

The sealed-tank system shall be designed so that the internal gas pressure does not exceed 49 kPa (gauge) (7 psig), or −35 kPa (gauge) (−5 psig).

Rationale for footnote

- Second paragraph *is intended* to give the reader an idea of the pressure range that a typical transformer should be designed to operate within under normal operating conditions, as described in the first paragraph.
  - Designer can manipulate tank size, oil volume, and air space to achieve this.

- *Can be mis-interpreted* as a design requirement for the range of pressures across which the transformer must remain sealed.

RA1: Footnote for section *4.1 Tank Integrity*

Footnote proposed wording

4.1 Liquid preservation

Distribution transformers shall have a sealed-tank liquid-preservation system. Sealed-tank construction is a construction in which the interior of the tank is sealed from the atmosphere and the gas volume plus the liquid volume remains constant. The transformer shall remain effectively sealed for a top liquid temperature range of −5 °C to +105 °C for continuous operation at rated kilovolt-amperes and under the operating conditions as described in IEEE Std C57.91.[4]

The sealed-tank system shall be designed so that the internal gas pressure does not exceed 49 kPa (gauge) (7 psig), or −35 kPa (gauge) (−5 psig).[5]

"[5]The pressure limits described shall be built into the design of the sealed-tank system (without relying upon pressure regulating devices), which involves manipulating the tank size, oil volume and air space while operating within the conditions described in the first paragraph of Clause 4.1."

"

IEEE PES Transformers Committee

RA2: Negative Pressure Requirement for *4.2.1*

Rationale

- It was identified sometime after 2017 that a negative pressure requirement should be added for tank strength.
  - C57.12.39 had already been published by then, and thus it is not included in the current document.

- Such a requirement was added to C57.12.34 section 8.10.1 in the 2022 publishing.

8.10.1 Strength

The tank shall be of sufficient strength to withstand a range of gauge pressures between −35 kPa (−5 psig) to 49 kPa (7 psig) without permanent deformation, and 103 kPa (15 psig) without rupturing or affecting cabinet security as described in IEEE Std C57.12.28.

IEEE PES Transformers Committee

RA2: Negative Pressure Requirement for *4.2.1*

Recommendation

- Add a negative pressure requirement to section *4.2.1 Tank Integrity*.

4.2.1 Tank integrity

a range of internal pressures between -35 kPa (gauge) (-5 psig) to 49 kPa (gauge) (7 psig)

For overhead-type and submersible transformers utilizing round tank construction, the completely assembled transformer enclosure shall be of sufficient strength to withstand ~~an internal pressure of 49 kPa (gauge) (7 psig)~~ without permanent deformation to the enclosure. The enclosure shall also be of sufficient strength to withstand an internal pressure of 138 kPa (gauge) (20 psig) without rupturing or displacing components (excluding any gasket liquid leaks) of the transformer.

a range of internal pressures between -35 kPa (gauge) (-5 psig) to 49 kPa (gauge) (7 psig)

For all other distribution transformers, the tank shall be of sufficient strength to withstand ~~a gauge pressure of 49 kPa (gauge) (7 psig)~~ without permanent deformation and 103 kPa (gauge) (15 psig) without rupturing.

For pad-mounted type distribution transformers, the cabinet security as described in IEEE Std C57.12.28 or IEEE Std C57.12.29 shall not be affected.

IEEE PES Transformers Committee

RA3: Change “permanent deformation” to “compromising deformation”

Rationale

- Intent behind limiting amount of deformation is to ensure that transformer function is not compromised. This includes:
  - transformer sealing
  - cabinet security
  - mechanical operation of covers and doors
  - electrical clearances
  - thermal operation
  - the tank’s ability to shed water
  - ability to withstand corrosion by not creating pockets for material accumulation

- “Permanent deformation” is problematic:
  - If an allowable amount is specified → hard to measure in the field
  - If no amount is allowed → leads to over-built transformers
  - Non-permanent deformation can also compromise functionality

RA3: Change “permanent deformation” to “compromising deformation”

Recommendation

- Change all instances of “permanent deformation” that are in reference to the transformer tank to “compromising deformation” – 4 identified locations

- Define “compromising deformation” in *3.1 Definitions*.

RA3: Change “permanent deformation” to “compromising deformation”

compromising deformation: Is that deformation that compromises transformer operation, and which interferes with transformer sealing, cabinet security, mechanical operation of covers and doors, electrical clearances, thermal operation, the tank’s ability to shed water, or that creates areas where corrosive elements can accumulate.

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[3]

pressure relief device (PRD): A mechanical device for the purpose of relieving liquid or gas pressure buildup.

pressure relief plug: A manually operated threaded tank fitting used to relieve excess pressure. The fitting shall allow slow release of pressure without completely removing the fitting from the tank.

pressure relief valve (PRV): An automatic one-way valve used to relieve excess pressure buildup.

pressure-vacuum bleeder valve: A valve designed to balance pressure and vacuum conditions in the sealed tank, by releasing or admitting air/gas at predetermined positive and negative settings.

rapid transient pressure: A sudden pressure change.

RA3: Change “permanent deformation” to “compromising deformation”

compromising deformation: elastic or plastic deformation that interferes with either transformer sealing, cabinet security, mechanical operation of covers and doors, electrical clearances, thermal operation, the tank’s ability to shed water, or creates areas where corrosive elements can accumulate.

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[3]

pressure relief device (PRD): A mechanical device for the purpose of relieving liquid or gas pressure buildup.

pressure relief plug: A manually operated threaded tank fitting used to relieve excess pressure. The fitting shall allow slow release of pressure without completely removing the fitting from the tank.

pressure relief valve (PRV): An automatic one-way valve used to relieve excess pressure buildup.

pressure-vacuum bleeder valve: A valve designed to balance pressure and vacuum conditions in the sealed tank, by releasing or admitting air/gas at predetermined positive and negative settings.

rapid transient pressure: A sudden pressure change.

RA3: Change “permanent deformation” to “compromising deformation”

compromising tank deformation

Abstract: Certain mechanical requirements relating to tank strength as well as static and dynamic tank pressure mitigation for liquid-immersed distribution transformers are covered in this standard. The electrical and mechanical requirements of any accessory devices that may be supplied with the transformer are not covered in this standard. It is intended to define the mechanical performance requirements to prevent ~~permanent tank deformation~~ or rupture of distribution transformers covered under this standard. These requirements will provide a more standard design of transformer tank and associated components related with both static and dynamic pressure coordination.

IEEE PES Transformers Committee

RA3: Change “permanent deformation” to “compromising deformation”

1.2 Purpose

compromising tank deformation

This standard is intended to define the mechanical performance requirements to prevent ~~permanent tank deformation~~ or rupture of distribution transformers covered under this standard. These requirements will provide a more standard design of distribution transformer tank and associated components related with both static and dynamic pressure coordination.

IEEE PES Transformers Committee

RA3: Change “permanent deformation” to “compromising deformation”

4.2.1 Tank integrity

For overhead-type and submersible transformers utilizing round tank construction, the completely assembled transformer enclosure shall be of sufficient strength to withstand an internal pressure of 49 kPa (gauge) (7 psig) without ~~permanent deformation~~ to the enclosure. The enclosure shall also be of sufficient strength to withstand an internal pressure of 138 kPa (gauge) (20 psig) without rupturing or displacing components (excluding any gasket liquid leaks) of the transformer.

compromising deformation

For all other distribution transformers, the tank shall be of sufficient strength to withstand a gauge pressure of 49 kPa (gauge) (7 psig) without ~~permanent deformation~~ and 103 kPa (gauge) (15 psig) without rupturing.

compromising deformation

IEEE PES Transformers Committee

RA3: Change “permanent deformation” to “compromising deformation”

4.2.2.3 Pressure relief valve (PRV)

To provide automatic relief of pressures that build up slowly in excess of normal operating pressures, a replaceable PRV shall be provided on transformers 2500 kVA and below that do not have a cover assembly designed to relieve excessive pressure.

The PRV shall be designed and located to minimize liquid egress when relieving these excessive pressures. The PRV shall be located above the 140 °C top liquid level, by the manufacturer’s calculation, and shall be located so as not to interfere with any other devices.

The inlet port shall be 1/4 in or larger National Pipe Taper (NPT), sized for a specified minimum flow rate. Exposed parts shall be of weather- and corrosion-resistant materials. Gaskets and O-rings shall withstand liquid vapor and a 105 °C temperature continuously under operating conditions as described in IEEE Std C57.91, without seizing or deteriorating for the life of the transformer.

The PRV shall have a pull ring for manually reducing pressure to the atmosphere using a standard hookstick, and shall be capable of withstanding a static pull force of 112 N (25 lbf) for 1 min without permanent deformation. The PRV shall withstand a static force of 445 N (100 lbf) for 1 min applied normally to its longitudinal axis at the outermost extremity of its body.

Leave as is. This is in reference to the PRV pull ring and not the transformer tank.

IEEE PES Transformers Committee