Neeltran Inc. - About Us

- Founded 1973 under current management since 1983
- Location: New Milford, CT, USA
- Employees: 98 (30 Engineers)
- Turnover: 21 M$
- Fields of activity: Rectifier Transformers & Rectifiers
- Production per year: 1000 MVA
- Facilities: 85000sq ft Factory
  25000sqft Test bay
  20000sqft Warehouse
  2 Testing Labs for LV & HV Tests

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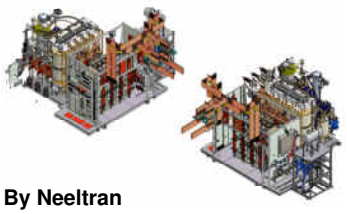
Range Of Product

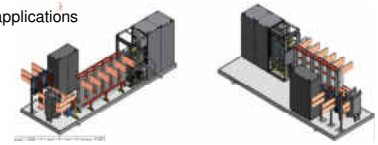
Transformers Designed And Manufactured By Neeltran

- Power up to 100 MVA, present rating (200,000kg)
- Oil Filled Transformer up to 69kV
- Dry Type Transformer up to 34kV
- Specialty Dry and Water cooled
- Reactors Dry and Water cooled
- Repairs and Retrofits



Rectifiers Designed And Manufactured By Neeltran

- Air Cooled, present rating 1 kA to 50 kA_{DC} per 6 pulse, up to 3000 V_{DC}
- Fluid Cooled, present rating up to 110(220) kA_{DC} per each 6(12) pulse, up to 3000 V_{DC}
- Multi-pulse systems are available 6,12,18,24 and more
- Other Small DC Chopper up to 3 kA_{DC} @ 2000 V_{DC} for torch and similar applications
- Other System Comp. HFC & PFC, Turn-key, Studies, etc…



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Combined Test Advantages

Customer can witness, inspect and possibly do preliminary training on **the entire system** at one location.

Test of all interconnected controls/signals between transformer/rectifier and synchronization (phasing) made at the factory will **save time and costs at site**

Total guaranteed losses performed at factory

We typically send **the same test technician** that tested the system at the factory to the field for startup.

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Test Area, Combined Test

- Load banks
- Heat exchangers
- Multiple Test bays
- Helium leak detector
- Power monitor/analyzers
- 600 kV Impulse and chopped
- High Potential AC/DC testers
- Transformer turns ratio testers
- Variable frequency generators
- Partial Discharge Tester
- Variable AC power sources
- Several multi-tapped auto-transformer
- 120Hz large generator for double induced testing
- **50/60 Hz power** for controls and motors
- **6 Engineers/Technicians** directly involved in testing

- **Rated current at reduced system voltage (e.g. 85kA$_{DC}$)**
- **Heat Run test on every unit**

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Applicable Standards

- **IEEE 519 - 1992** Recommended practices / requirements for harmonic control
- **ANSI C34.2 – 1968** Practices and Requirements for Semiconductor Power Rectifier
- **ANSI C57.18.10-1998** Standard Practices and Requirements for Semiconductor Power Rectifier Transformer
- **ANSI C57.12.00-2000** General requirements for liquid immersed distribution power, and regulating transformer
- **IEC 60076** Power Transformers - General
- **IEC 60146** Semiconductor convertors - General requirements and line commutated convertors IEEE
- **IEC 61378** Converter transformers – Part 1: Transformers for industrial applications

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Guaranteed Performance

Factory Acceptance Test (FAT) are defined by the standard to enable the customer and the supplier to perform the test under a common platform of measurement agreed by the parties.

The standard prescribes the tests for the transformer and for the rectifier, **a lot of attention is paid to the real losses caused by the harmonics** generated by the converter. These additional losses can be calculated and have to be taken in consideration for the **Guaranteed Performance.**
Main test involves:

No Load Test
Short Circuit Test
Heat Run Test

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What is written in the standard:

Tests for converter transformers

- ✓ Measurement of commutating reactance and determination of the inductive voltage drop
- ✓ Commutating reactance
- ✓ Inductive voltage regulation
- ✓ Measurement of voltage ratio and phase displacement
- ✓ Dielectric tests
- ✓ Dielectric test between interleaved valve windings
- ✓ **Load loss test**
- ✓ Load loss measurement in rectifier transformers with transductors in the same tank
- ✓ Test bus bars configuration for short circuit of high current valve windings
- ✓ **Temperature rise tests**
- ✓ **Total loss injection**
- ✓ Rated load loss injection
- ✓ Test of temperature rise on dry-type transformers

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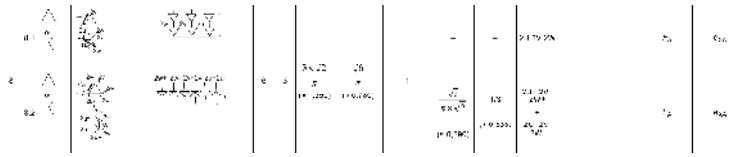
Definition for Converter Transformer

Load Loss Test

This test shall be performed to obtain the load loss in the transformer at rated current (I1) and fundamental frequency.

- The losses are measured for each short-circuit combination A, B and C. The measured loss values PA, PB and PC are used to calculate the total guaranteed loss figure by the relevant equation.

- E.g. Rectifier transformer 12 pulses, all secondary of the transformer in short circuit and losses equivalent to the total measured.



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Definition for Converter Transformer

Temperature Rise Tests

The purpose of the test is to establish the top oil temperature rise in steady-state condition, with dissipation of total loss equal to the loss **at rated non-sinusoidal** converter load current, and **rated sinusoidal** transformer voltage;

- to establish the winding temperature rise above oil under the same conditions;
- to establish the winding temperature rise above ambient for dry-type transformers.

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Definition for Converter Transformer

Total Losses

The actual load loss in service includes additional loss due to distorted current. This value shall be calculated in accordance with the procedure. It is not guaranteed, but shall be provided by the transformer manufacturer for the purchaser.

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Definition for Converter Transformer

Total loss injection

The total loss is the sum of the load loss, the no-load loss and, if present, the IPT and transductors losses.
The load loss is the loss developed from the non-sinusoidal converter current.
The no-load loss corresponds to rated transformer voltage.
The loss injected into the transformer shall be measured at the fundamental power-frequency current, **It shall be adjusted to give the specified test value of the total loss**.

The equivalent test current is equal to

$$I_{eq} = I_1 \left(\frac{I_N^2 \times (R_W - R_C) - (P_{WE} \times P_{WE1})}{I_1^2 \times (R_W - R_C) - P_{WE1}} \right)^{0.5}$$

note: Value are defined in Annex A
harmonics content: $F_{WE} = \sum_{1}^{n} \left(\frac{I_h}{I_1} \right)^2 \times h^2$

However eddy losses, with harmonics, increase in the winding end regions and **a test with sinusoidal current is not able to reproduce the leakage field patterns that occur in service**

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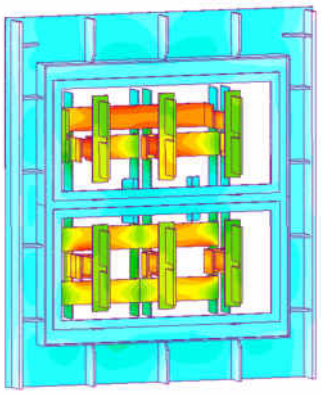
Thermal Studies

Simulations of Tank and Bus Bar



Core Frames

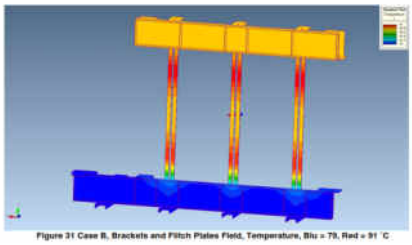


Figure 31 Case B, Brackets and Plitch Plates Field, Temperature, Blu = 79, Red = 91 °C

Simple steel bars shown above but we will use slotted tie-plates and/or stainless steel if necessary to reduce losses and heating due to leakage field.

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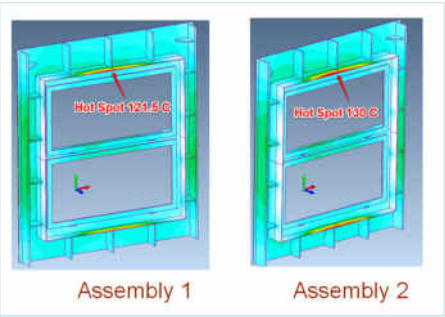
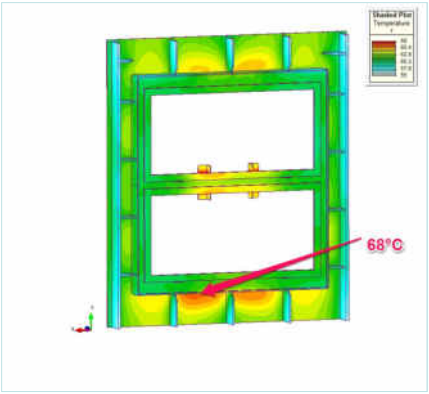
Thermal Studies

Tank First Design



Tank Revised Design



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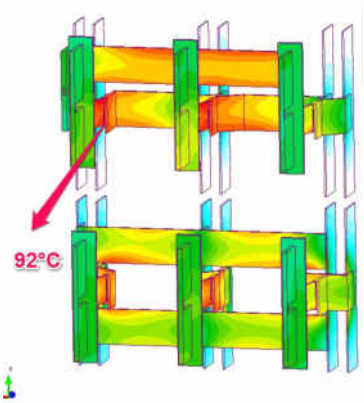
Thermal Studies

Bus Bar and Bushing Temperatures



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Combined Test Summary

Considerations about winding and tank hot spots

- Equivalent test current is computed in order to produce the total losses equivalent to ones when windings are harmonically loaded.
- This equivalent test current does not produce the local loss distribution within the winding that will occur when harmonic currents are present.
- The hot spot temperature and its location is not necessarily the same that will be encountered during converter service.
- Combined testing allows checking for hot spots in the transformer tank and AC connection throat/entry into the rectifier with full current and harmonics present.

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Combined Test Summary

Considerations about testing ANSI 45/46 transformers

- When testing an ANSI 45/46 transformer alone there are no harmonics and the IPT and negative bus are not carrying current.
- Since the LV kVA is 40% higher for this circuit, we are limited on how much extra current and losses we can feed into the primary.
- With the combined test, transformer and rectifier together, the losses are much closer to real operation.

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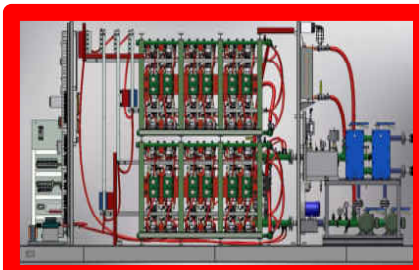

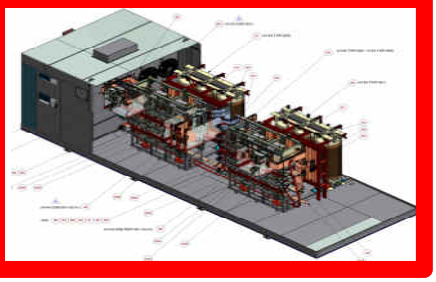

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