Dry-type transformers

Dry-type transformers for railways
Transforming ideas into movement
ABB dry-type transformers are the best solution for railway applications for both indoor and outdoor infrastructure installations. Thanks to continuous investment in research and development (R&D) and close client relationships, ABB offers a large and complete portfolio to meet customer needs. The company offers the most reliable solutions because the success of ABB’s client is also ABB’s success. Welcome to the most economical and ecological solution

**Dry-type advantages for railways application**

Dry-type transformers are the only transformers that can be installed close to the utilization point. This allows optimized installation design, reduces to a minimum the low voltage circuits with corresponding savings in losses and low voltage connections. Other customer values include:

- It is the safest choice for people and property
- Dry-type transformers are fire certified by class F1 test which considers the emission of toxic substances and opacity of fumes almost eliminated
- Ecological and environmentally friendly product as there is no risk of leakage of inflammable or contaminating substances such as oil or silicon. Approximately 90 percent of the total weight of the transformer can be recycled, because the manufacturing materials are steel, iron, aluminum and copper
- Dry transformers are free of maintenance because there’s no need of checking the level of the oil, nor oil analyses or substitution
- Easy installation and fast commissioning
- Upgraded technical performance according to customer requirements
- Optimum investment by reducing the total cost for the customer because dry transformers can be installed close to the loads
Technical features

ABB dry-type transformers factories manufacture their products according to the IEC EN 60076-11 standards meeting the customer expectations in each step.

- From 250 kVA up to 63 MVA
- High voltages up to 72.5 kV
- Classes E2, C2 and F1
- Partial discharges <10 pC
- Insulation class F or H
- Overloads from duty class
- 6, 12 or pseudo 24 pulses
- Shift phase (±7.5°±15°...)
- Indoor or outdoor operation
- Double secondary
- Coupling factor:
  
  $k < 0.2$

  $0.2 < K < 0.9$

  $k > 0.9$

Applications

Dry-type transformers may be used in electrical distribution systems, connected to variable speed drives and for feeding traction systems in fixed substations of undergrounds, light trains and tramways.

The traction applications might be both AC and DC: transformers which feed systems in alternative current as for example autotransformers up to 52 kV insulation level for catenary feeding, and transformers which also feed systems in direct current respectively. ABB also manufactures isolation and 16 2/3 Hz transformers.

Standard duty for traction transformers includes demand overload cycles that far exceed the typical load duty for distribution transformers - even under extreme conditions. In addition to special demand overloading, traction transformers must be capable of withstanding rectifier harmonics. ABB designs, builds and tests traction transformers to meet the stringent duty requirements per EN 50329, IEC 61046 or customer specific requirements to ensure reliability and longevity. Harmonics are distortions of the main supply occurring at multiples of the supply frequency. Any equipment which uses electronics to change one voltage and/or frequency to another will generate harmonic currents and consequently voltage distortions.
ABB offers an extended portfolio to supply customers with the best tailored option. Different initiatives such as high insulation levels, efficiency, large power or high voltages levels are the key to finding the best solution for covering the customer needs. These transformers can be customized with all accessories.

**Hi-T Plus**
ABB Hi-T Plus for traction transformers are particularly designed for this application, adding to the ABB dry-type traction transformers the superior performance of Hi-T Plus concept, helping engineering companies and end users to reduce the additional cost and dimensions impact of traditional oversize of class F transformers by working at class B temperature rise (80 K / 80 K).

Hi-T Plus for traction transformers are designed as standard to work under overloading at a temperature never exceeding their insulation class system, thus granting that no degradation will occur during these cycles.

**EcoDry**
The new ultra efficient dry-type transformers have been greatly improved in terms of efficiency, specially tailored to the particular application identified, for customers with a commitment to environmental protection and cost awareness.

**HiDry**
ABB is proud to offer the widest range of high voltage and large power dry-type transformers in the market, being now able to reach 63 MVA and operating voltages up to 72.5 kV. Choosing HiDry transformers is taking savings on civil works, fire systems, insurance fees, site installation, shorter cables and maintenance.
Special design

According to ABB experience, the transformers connected to variable speed drives and especially to rectifiers should be designed very carefully. There are several technical points very important for the whole system safety.

Flow of harmonics
Due to the flow of harmonic currents in both low voltage and high voltage windings, there are extra losses and extra heating, thus the transformer must be over rated according to a higher equivalent power.

Due to the flow of harmonic currents through the network and the transformer impedance, there is a voltage distortion (harmonics) on the transformer magnetic core, which could saturate it. In order to avoid core saturation, the magnetic core must be over sized.

Electrostatic shield
To avoid capacitive coupling between high voltage and low voltage and protect the power electronics devices on low voltage side from over voltages in high voltage side, it is recommended to place an electrostatic shield between high voltage and low voltage windings.

Insulation levels
In some cases due to floating systems or high du/dt, higher insulation levels on low voltage are needed.

Number of turns
The number of turns of the two low voltage windings must be modified in order to reach the voltage ratio between these two low voltage windings.

Impedance
The impedance between the two low voltage windings must be matched by calculating and manufacturing carefully the winding dimensions.

Space factor
The space factor is more critical because of the insulation gap between windings, and the larger size of the transformer.

Correct losses and good operation guaranteed
In order to guarantee the correct losses and good operation, the high voltage winding is split in two or more parallel circuits with two or more tap changers instead of one circuit.
Due to the presence of the overloads in all traction application, there are different names associated to the different powers (and currents) according to EN 50329. Depending on the load duty, the difference between the base power and the nominal (quadratic power) might be more than 25 percent; in fact the power that fits more with the “real” power of the transformer is the quadratic, therefore the reduction in the size of the transformer has a direct impact in the safety of the whole system. The maximum average temperature rise in the windings of the transformer varies depending on the step of the duty cycle.

ABB design and manufacture according to the requirements of the customer, but for a better understanding of the labeling, a 1000 kVA transformer example has been taken:
- Rated power S: 1000 kVA as base and equivalent power (including the harmonics too)
- Duty class VI (rated power in kVA) and maximum winding temperature rise admissible according to EN 50329. According to IEC 60076-12, for the insulation class F (155°C), the maximum average temperature rise (∆T) is 100 K / 100 K; for the insulation class H (180°C), the ∆T is 125 K / 125 K

As a conclusion, the requested transformer in these conditions would be comparable to a 1215 kVA and not to a 1000 kVA. In these conditions the use of hi-T Plus is ideal because the transformer will never overpass the maximum average temperature rise of 125 K / 125 K and the insulation of the transformer will never be damaged. This allows the end user to overload the system, covers higher than expected temperatures as well as harmonics while having a more compact design.

According to IEC 60076-12 paragraph 7.2, every 6 K that the hot spot temperature of a transformer is reduced, the insulation life expectation is doubled. Since ABB hi-T Plus transformers hot spot is reduced by 25 K, the expected insulation lifetime is at least ten times higher than a class F transformer working at the same hot spot temperature.

| Expected insulation lifetime taking F 100 K as 100% |
| % insulation life |

<table>
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<th>% insulation life</th>
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<tbody>
<tr>
<td>Class F at 100 K</td>
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<tr>
<td>Class F at 80 K</td>
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<td>hi-T Plus</td>
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<tr>
<th>p.u. of Ib</th>
<th>p.u. of In</th>
<th>Duration</th>
<th>Power (kVA)</th>
<th>∆T for class F (K)</th>
<th>∆T for class H (K)</th>
<th>∆T for hi-T Plus (K)</th>
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<tr>
<td>1.215</td>
<td>1</td>
<td>Continuous</td>
<td>1215</td>
<td>100</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>0.823</td>
<td>1.234</td>
<td>2 h</td>
<td>1500</td>
<td>100</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>2.468</td>
<td>60 s</td>
<td>3000</td>
<td>120</td>
<td>145</td>
<td>125</td>
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The correct interpretation and knowledge of the standards is very important.

ABB manufactures its dry-type transformers according to the relative IEC, EN and/or IEEE/ANSI standards and GOST.

ABB designs and manufactures according to the standards used in the railway segment such as EN 50329 or IEC 146, but ABB designs may be adapted to customer standards. These standards are interconnected with the ones of other products of the railways system as rectifiers.