

# Transformers and fuses

## Transformer fuses

Fuses come in many different forms. Usually they are designed in the form of a glass or ceramic tube with a metal wire. The fuse characteristic, or how quickly the fuse blows, is of great importance when it comes to fuses. There are a number of different makes and types of fuse. Different makes and types of fuse have different characteristics. The fuse characteristics can be adapted to different loads.

Generally speaking, we can divide fuses into two main types: quick and slow. In some cases the fuse has to blow as quickly as possible. In other cases a fuse has to allow for high surge currents over very short periods. This is typical of transformer connection. Common fuse types include:

### Glass tube fuses

Glass tube fuses are perhaps the most common type of fuse. They come in several sizes and are used widely.

### Miniature circuit-breakers

Miniature circuit-breakers come with both thermal characteristics and current characteristics, or a combination of the two. Miniature circuit-breakers do not have to be replaced when they blow, but are reset manually. It should not be possible to reset them as long as the electric circuit is overloaded. A miniature circuit-breaker is normally slow-acting.

### Thermal fuses

Thermal fuses blow at a given temperature. When the ambient temperature exceeds the melting point of the temperature-sensitive fuse element, it melts and breaks the circuit. This makes it suitable for circuit breaking at high temperatures in most electronic and electrical equipment. A thermal fuse can therefore not be reset. It has to be replaced if possible.



Miniature circuit-breaker and glass tube fuses fitted in transformer. The miniature circuit-breaker can be reset manually, whereas the glass tube fuses have to be replaced when they blow.

## PTC

The PTC is a common form of overload protection in power supplies, battery chargers and transformers. The PTC is a resettable over-load cut-out which is often referred to as a Polyswitch or Multifuse. Today it could easily outcompete miniature circuit-breakers in the majority of applications involving currents of up to 6 A or 12 A with parallel connection.

A PTC has many advantages over ordinary fuses. It can be reset easily by disconnecting the line voltage for a few seconds or the short circuit/load if it is in a secondary circuit.



PTC mounted in an LF transformer

It is only possible to use a PTC as primary protection for 230 V with low powers, and then it should be given the additional protection of a capacitor in parallel. The loss which a PTC gives off in normal operation is roughly that of a slow-acting glass fuse or slightly lower. In the event of a short circuit, on the other hand, the PTC will give off a higher power, resulting in turn in it reaching a temperature in the regions of 100°C. It is therefore important that any nearby material should be able to withstand this temperature. This requirement is usually met in the case of Noratel encapsulated transformer, since the case, encapsulation or circuit board is made of UL94-V0 material and conforms to current glow tests. EN61558, the new transformer standard which has replaced EN60742 and IEC989, sets much tougher requirements for testing when a PTC is used. The greatest disadvantages of a PTC include limitation of the peak current in the event of a short circuit and the maximum rated voltage, which is 40 A/30 V, 40 A/60 V or 100 A/16 V, depending on the type of PTC.

## Choosing fuses

Anyone installing a transformer has to choose both the type and size of fuse. Many factors may have to be taken into consideration, but two factors are of importance as far as the transformer is concerned.

### Secondary fuse

The secondary fuse is placed after the transformer's output points of connection on the secondary side. It acts as overload protection for the transformer, and the total value of the fuses per phase must not exceed the secondary current specified on the rating plate. The choice of characteristic, slow or otherwise, is determined by the load - it is not important in terms of the transformer's operating conditions. If temperature control has been installed in the transformer's windings, overloading can be accepted - maximum load is determined by the operating temperature in the windings.

### Primary fuse

The primary fuse is placed in front of the transformer's points of connection on the primary side. It acts as short-circuit protection for the transformer and cabling from the fuse unit to the transformer. Owing to the transformer's starting current, the value of this fuse has to be oversized in relation to the current specified on the rating plate. Since the starting current can be of the order of 30-35 times higher than nominal current for a short period, it is important that the primary fuse is as slow-acting as possible. A handy rule for Noratel transformers is that the fuse must withstand 35 times nominal current for 5 milliseconds.

In practice this means slow-acting, high-power cartridge fuse-links, and we have to choose a standard fuse size in relation to the current specified on the rating plate.

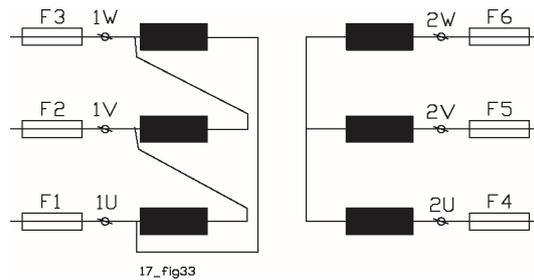
The guiding rule is to find the nearest standard fuse larger than the rated current and choose the next standard size above it.

#### Example:

Supply voltage:	3 x 400 V
Power:	50 kVA
Nominal current on rating plate:	72 A.

The next standard fuse up is 80 A - we choose the next one up from that, which is 100 A.

Note that the supply cables have to be dimensioned accordingly as set out in the regulations. This rule is for guidance only, as transformer constructions can vary. In the case of particularly critical installations please contact one of Noratel's technical advisers.



Fuses placed on transformer's primary side (F1, F2, F3).

Fuses placed on transformer's secondary side (F4, F5, F6)

On the surface fuses as protection for transformers are a poor construction. It is the operating temperature in the windings that determines the permitted load. A transformer can be severely overloaded for brief periods, e.g. in the case of contactor making, which can be many times the power of the transformer.

The heat developed in a transformer increases by the power squared, so when the starting current occurs the heat developed can be equivalent to approx. 1000 times normal.

Transformers which are "started up" many times in quick succession will be ruined as a result of the large amount of heat developed in the primary coil. In such cases the transformer could be saved by connecting a correctly dimensioned fuse in incoming circuit.

If a transformer used for contactor making is exposed to a large number of start-ups in quick succession, it will probably be ruined. It is no good replacing it with a transformer with higher power, as the problem of the starting currents will be the same. It is not the load which ruins the transformer, but the starting currents, which generate so much heat that the insulation in the transformer is destroyed. In such problem systems temperature monitoring with an alarm and/or disconnection can be installed.