Keep your options open when using EEx d/de motors with inverter drives

Dr Donald C Jackson
Technical Director, Brook Crompton

Background

In the past motor users have been advised that flameproof EEx d/de motors and inverters need to be tested together when used as a system in a potentially flammable atmosphere. Dr Donald Jackson, Technical Director of Brook Crompton, explains that this need not be the case if motor certification was undertaken with the objective of using any manufacturer's inverter.

Application - Motor Sizing and Design

The motor is designed to suit the application from the user specified requirements augmented by the actual inverter generated waveform as it is applied to the motor. The motor insulation thickness is primarily set by the type of inverter waveform, the distance from the motor and the incorporation of either over-voltage negating software or devices at the inverter or motor if fitted.

To accommodate world supply voltages and the over-voltages as applied to the motor causes motor manufacturers to establish pre-defined insulation and winding systems. The voltage at the motor primarily sets the insulation thickness and winding layout. The type of insulation material is based on the operating temperature in the slots and overhangs for a given life. In all cases it has to be with a design margin for overload conditions and long life.

The application dictates the required capability – torques, speed range and temperature limitations. Motors of differing size can meet the torque and speed requirements but the correct selection of working temperatures is obtained through the use of proven derating curves. These curves plot torque against speed to achieve a reliable thermal performance within temperature boundaries.

The use of software in motor performance modeling for torques, currents, efficiency and loss distribution can be applied to motor thermal models to predict temperatures throughout the motor. These calculated results provide a parallel route to assist the selection of materials based on forecast temperatures that are calibrated and mirrored by measurements.

The long term testing of motors supplied by alternative waveforms, from a broad range of inverter manufacturers, leads to a reduction in risk. By having derating curves that are proven in practice from many inverter manufacturers makes it is possible to cater for possible inverter change due to replacement later in life.

Motors and Inverters

All electrical equipment for hazardous areas must be installed with great care as potentially flammable or explosive conditions may arise. Depending on the nature of the risk, different motor construction methods can be used e.g. non-sparking 'n', increased safety 'e', and flameproof 'd'. All designs seek to reduce the risk of sparking or abnormally high temperatures being attained.

For small and medium size Category 2 industrial motors (Zone 1), the flameproof construction is often considered the safest and most economical option. This design concept requires a mechanically rugged enclosure to meet certified internal explosive pressures and impact values. There is also a requirement to keep external surface temperatures within a prescribed value according to the temperature classification, e.g. T4 (135°C).

When used in conjunction with a variable speed drive other design requirements must also be met.
An inverter supply can change the motor thermal performance in several ways.

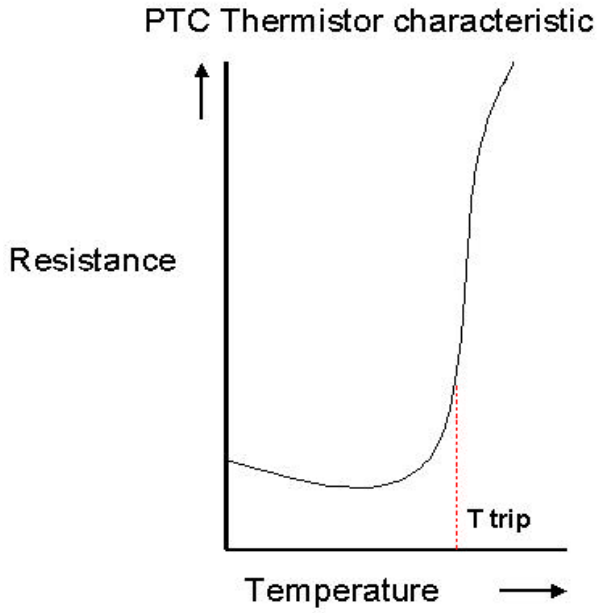
a) Increased running losses due to a non-sinusoidal waveform with increased harmonics, particularly when a higher Pulse Width Modulated switching frequency is employed.
b) Reduced speed operation reduces the cooling effect of the external fan.
c) There is a possibility of running the motor in an under or over-voltage configuration.
d) Changes to inverter settings to those initially tested can affect temperatures.
e) Combinations of all of the above at the same time.

Thermistor Protection

All the above situations manifest themselves as increased temperatures in the motor and hence the external surfaces. Brook Crompton pioneered the development of Ex-certified motors over 80 years ago. They also recognised the benefits of fitting thermistors embedded in the windings. These electronic devices trip at set temperatures and are used to monitor internal heating that would eventually lead to increased external temperatures. Typically a 140°C trip temperature thermistor is used for T4 certification. Brook Crompton has developed this convenient protection concept for EEx d/de motors through testing and evaluation of results using the facilities of BASEEFA at Buxton.

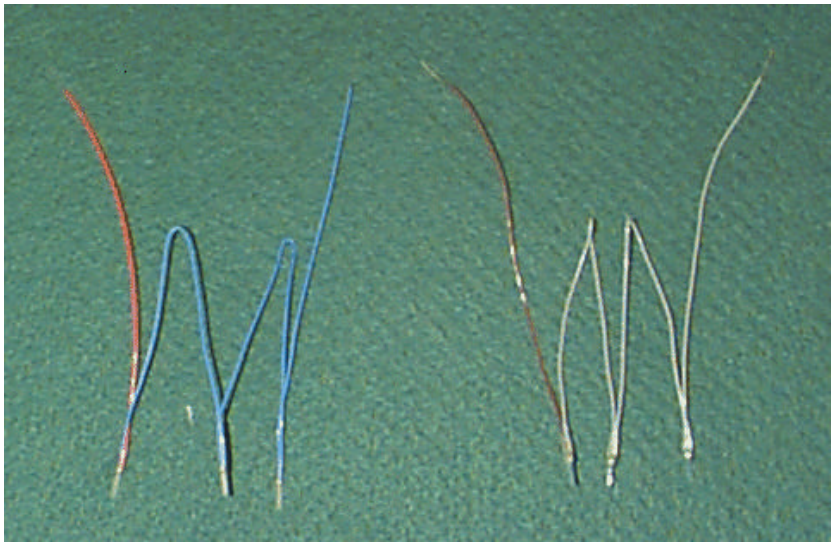
The temperatures attained in a motor must have a design margin to the temperature classification. Under fault conditions, however they arise, the thermistor protection must operate.

The PTC thermistor (Positive Temperature Coefficient) exhibits a rapidly increasing resistance at the trip temperature, which is used to operate the protective circuit.



To cover the risk of over temperature three thermistors are distributed around the winding and one is embedded in each phase. See examples below.

The application commissioning for safety need only confirm that the motor thermistor triplet has a low resistance. The test should be with a low voltage/current to prevent damage. The protection circuit should be checked to operate using a short circuit link that is changed to open circuit to simulate the thermistor operation.



From a safety point of view different temperature classifications are covered in motor sizing and choice of trip setting. This is primarily set by the motor thermal behaviour and not generally influenced by the inverter.

Benefits

Providing a motor used with an inverter has the correct class of thermistor triplet embedded and connected to the protection circuit, any make of inverter can be used with a Brook Crompton EEx d/de motor. The protection circuit should disconnect the motor from the supply.

The benefits to the user are: -

1. No limitation on manufacturer. Existing inverter suppliers can be maintained where sites have a preference.
2. Simple concept gives confidence that excessive surface temperatures will be detected.
3. Changes to the inverter parameters to meet local application requirements or operator changes to inverter settings will not prevent certification conditions and safety being maintained.

To satisfy customer requirements thermistors are fitted as standard on frames 160 and above. Thermistors can be retrospectively fitted in winding pockets that are pre-prepared during motor manufacture, as a modification on frames 90 to 132. This allows applications to be safely fulfilled by Brook Crompton and its modification partners.

As always the simplest solutions are the best.

Atex Worker Protection Directive 1999/92/EC (Atex 137)

The thermistor protection approach has been recognised as a means of meeting the new 'User' Directive ATEX 137.

Since July 2006 it has been necessary for all sites employing 5 or more employees to carry out a site risk assessment. This should record hazardous substances and work involving them, potential causes of fire or explosions and possible consequences for employees or the public. The responsibility for site safety rests with local works management.

To help with the above evaluation the Trade Associations GAMBICA and REMA have published an excellent document:-

'User Guide No4, Variable Speed Drives and Motors, Application of the ATEX Directives to Power Drive Systems'. *

For flameproof applications paragraphs 5.3.7.1 and 5.3.7.2 provide advice for products and installations respectively.

5.3.7 EEx d – Flameproof

5.3.7.1 *Equipment (ATEX 94/9/EC)*

- *Motor*
  - *Can be installed in either Zone 1 or 2 areas*
  - *Explosion proof enclosure*
  - *Maximum surface temperatures limited on the outside of the enclosure*

- *PDS according to EN 50018 : 2000*
  - *Temperature rise shall be measured*
  - *Motors selected using manufacturers proven loadability curves for variable speed duty (See Figure 7), and incorporating a suitable protection device should not require combined tests. In the absence of such curves or evidence of test, the selected motor and BDM shall be tested together as a unit to ensure the motor meets the requirements of a given external temperature classification*
  - *Either a direct temperature control by embedded temperature sensors or other effective measures. The action of the protective device shall be to cause the motor to be disconnected. The motor and converter (BDM/CDM) combination does not need to be tested together; or*
  - *The motor shall have been type-tested for this duty as a unit in association with the converter (BDM/CDM) and with the protective device specified.*

-

5.3.7.2 ***Installation (ATEX 1999/92/EC)***

- *PDS according to EN 60079-14 : 2003*
  - *The motor shall be installed with the protective device specified.*

Conclusion

The matching of a proven motor, using thermal protection, with any inverter is a recommended route to meet the needs of the ATEX Risk Assessment. This procedure is mandatory no matter how selection is achieved. As the motor is in the hazardous area all new applications will require correct sizing using the motor manufacturer's derating curves. Brook Crompton with their engineering expertise in the UK can ensure an optimised result for users and inverter suppliers alike.

References/Terms

1) * GAMBICA Trade Association for Industrial, Control, Automation and Laboratory Technology Industries.
2) * REMA Rotating Electrical Machines Association
   Brook Crompton are members of REMA.
3) ATEX **AT**mosphères **EX**plosible
4) PDS according to EN50018:2000
   a) PDS Power Drive System Complete Drive System + Motor and Sensors
   b) EN 50018 :2000 Electrical apparatus for potentially explosive atmospheres-Flameproof enclosure 'd'
5) PDS according to EN 60079-14:2003
   a) EN 60079-14 Electrical apparatus for potentially explosive atmospheres-General Requirements
6) BDM Basic Drive Module
7) CDM Complete Drive Module
8) Zone 1, Category 2
   a) Zone 1, Hazard likely to occur in normal operation (>10 <1000 hours/year)
   b) Category 2, Certified by a Notified Body
9) Temperature Classification (Maximum surface temperatures)
   a) T1 450°C
   b) T2 300°C
   c) T3 200°C
   d) T4 135°C
   e) T5 100°C
   f) T6 85°C
10) BASEEFA British Approvals Service for Electrical Equipment in Flammable Atmospheres

NB The above Euronorms (EN's) are in the process of being replaced by new harmonised IEC/EN/BS standards.