Hardfacts

AVIVA

Three Phase Power Protection

Introduction:
Most electricity is generated in either single phase or three phases, with three phase being the predominant method. This means that the electricity is supplied through either one or three conductors simultaneously. In a single phase system the circuit breaker will in most cases interrupt the supply of electricity if problems are encountered. In a three phase system typically each supply wire is protected separately. This configuration can cause one phase of electricity to be disrupted while the other two remain connected. Such a situation can cause severe stresses to the equipment being operated.

Equipment at risk
Nearly all modern commercial buildings have at least one three phase motor within them. Depending upon the electrical supply connection of the motors, and the internal characteristics, they may be susceptible to even small variations in any of the three voltage phases supplied to them. A three phase motor that only gets two phases most likely will not start. A three phase motor, which had three phases when started and loses a phase or suffers a voltage drop on a phase after starting, will continue to operate but will run hot. Such a condition may destroy winding insulation, ultimately burning out the motor. This may only take a few minutes to occur. If the motor is inside a fully hermetic or semi-hermetic refrigeration or air conditioning compressor, the burn will pump carbon; acid and smoke through the sealed system necessitating a difficult and expensive clean up. It is estimated that 15% of all three phase motor failures are as a direct result of a loss of phase or phase imbalance. This percentage is much higher when only refrigeration and air conditioning motors are taken into account.

Voltage Imbalance
Imbalance of a three phase system is less extreme than a complete loss of phase, however it does not take a large imbalance before the motor is damaged beyond operation.

The following chart illustrates the relationship between voltage imbalance and temperature rise. Note the exponential increase with voltage imbalance.

% Voltage Imbalance	% Temperature Rise
2%	8% Hotter
3%	18% Hotter
4%	32% Hotter
5%	50% Hotter

This chart becomes critical when it is understood that as a rule of thumb for every 10% a motor is operated over the rated temperature, insulation life (and therefore motor life) is reduced by half.

If this problem is associated with a hermetic or semi-hermetic compressor motor the problem is worse. The electric motor in these cases is located such that it is exposed to the compressor crankcase where refrigerant oil is present. The excess heat generated by the motor operating with an imbalance may breakdown the chemical stability of the refrigerant and oil causing acids to form. The two acids, which result, are Hydrochloric and Hydrofluoric. For every 18° rise in temperature the activities of the acids double. The acids then go to work on the motor windings at an increased rate and a compressor failure is assured. Even if the imbalance does not last long enough to cause complete motor failure its effects are not reversed by a return to a balanced voltage condition. Instead the imbalance has an additive effect such that even short voltage imbalances can result in the premature failure of the motor.

Causes of Voltage and Current Imbalance
There are three major items, which can cause voltage imbalance and the resulting current imbalance.

i. Poor wiring connections and poor contacts
ii. Internal motor winding problems
iii. Power company or building electrical problems

Any of these problems may be detected by a comprehensive electrical survey dedicated to detecting these problems. If none of these conditions are detected it is important to remember that transient voltage imbalance from the utility may still occur.

Voltage Imbalance Protection
Traditional strategies to protect against voltage imbalance which results in single phasing include voltage relays or time-delay fuses matched to measure motor loading. However these traditional strategies are not 100% effective. Solid-state phase monitoring devices are now available providing much better protection. These devices are available as options when purchasing a motor starter or as stand-alone devices. A motor starter can be specified with a solid-state overload block instead of the thermal overloads. The cost of the solid-state option is comparable to standard thermal overloads. Stand-alone phase monitors are essentially solid-state voltage relays that can sense voltage imbalance. They have output contacts that can be tied into the motor control circuitry to take it off line if a severe voltage imbalance or loss of phase occurs. A good single-phasing sensing relay should be calibrated for the location where it will be used. Improper calibration of the relay can result in nuisance tripping problems. The cost of three phase protection devices is minimal when the value of the equipment being protected is taken into consideration. Also consider the lost wages, production and profit from unexpected downtime, as well as incurred labour costs to repair or replace damaged equipment.

Equipment Survey
A reputable electrical contractor should be employed to perform a comprehensive survey of the electrical equipment being operated at the facility to determine the need for independent protection of the equipment, or whether one three phase protector on the electricity supply will suffice. This type of survey should also determine whether new equipment should be requested with phase protection or if system protection will suffice.

Summary
Three phase electricity is required to run most commercial/industrial electric devices and this electricity is not always supplied at equal voltages. Three phase electricity protection can prevent costly interruptions, repairs, and replacements when voltage imbalances occur.

Key Action Steps
- Carry out electrical survey
- Install protection on vulnerable equipment
- Request protection on new equipment identified as vulnerable

For more information see:
American National Standards Institute/Institute of Electrical and Electronics Engineers
ANSI/IEEE Standard 141-1986 (Red Book)
ANSI/IEEE Standard 241-1990 (Gray Book)
ANSI/IEEE Standard 242-1986 (Buff Book)
How stuff works:
http://science.howstuffworks.com/power3.htm
A-5604 Surge Protection Aviva Hardfact