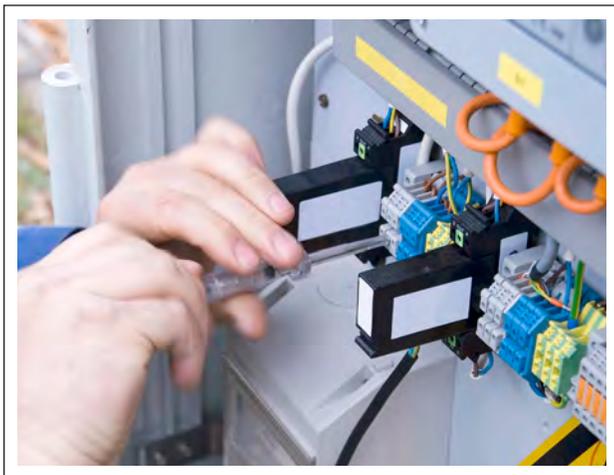


Three-phase power protection

You work hard to build and maintain your business. That's why it's important to ensure you're protected from all potential losses – especially when they're avoidable.

Protecting your business from power disturbances should be part of your overall business protection plan – regardless of the size of your operation.

Understanding the risks and following the proactive steps provided in this guide can help you improve the operational reliability of your electronic equipment, reduce costly repairs, and prevent loss of data and downtime.



Understanding your electrical supply

In North America, most electricity is supplied as alternating current at a frequency of 60 Hz. Generally, distribution to customers is done at a high voltage which is stepped down to a lower voltage using a distribution transformer.

The supply in a building is either provided as a 240 volt single-phase supply or as a 600 volt nominal three-phase supply.

Type of phase means the electricity is supplied through either one or three conductors

simultaneously, with a third or fourth wire designated as the neutral conductor for most installations.

The advantages of three-phase systems include reduced conductor size for a given load and the ability to run single-phase equipment by connecting between one-phase and the neutral line, or in some cases between phases.

In a single-phase system, the circuit breaker will interrupt the supply of electricity if overloads occur.

In a three-phase system each supply wire is protected separately and this configuration allows one-phase of electricity to be disrupted while the other two remain connected. Such a situation may cause severe stresses to the equipment being operated.

To overcome this, a ganged three-pole circuit breaker is used so if one-phase overloads, the breaker trips and cuts power on all three lines.

There may be situations where the imbalance is not severe enough to trip the breaker but bad enough to cause problems such as excess heating in motors.

Equipment at risk

Nearly all modern commercial buildings have at least one three-phase motor and depending on the electrical supply connection of the motors and the internal characteristics, these may be susceptible to even small variations in any of the three voltage phases supplied to them.

A three-phase motor which only gets two-phases is not likely to start. A three-phase motor, which starts with three-phases but 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 and 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's estimated that 15% of all three-phase motor failures are a direct result of a loss of phase or phase imbalance. This percentage is much higher when only refrigeration and air conditioning motors considered.

Voltage imbalance

Imbalance of a three-phase system is less extreme than a complete loss of phase, however it doesn't take a large imbalance to damage a motor beyond operation.

The 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

A useful rule of thumb to remember is: for every 10% a motor is operated over the rated temperature, insulation life (and therefore motor life) is reduced by half.

The problem is worse if it's associated with a hermetic or semi-hermetic compressor motor because the electric motor in these cases is located in place 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 hydrochloric and hydrofluoric acids to form.

The activities of these two acids double with every 18° rise in temperature and they go to work on the motor windings at an increased rate and will cause a compressor failure. Even if the imbalance doesn't last long enough to cause complete motor failure, the effects are not reversed by a return to a balanced voltage condition because even short voltage imbalances can result in the premature failure of the motor.

Causes of voltage and current imbalance

The three major causes of voltage imbalance are:

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

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

Protective devices

Traditional strategies to protect against voltage imbalance (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 which provide superior protection. These devices are available as a stand-alone option or when purchasing a motor starter. 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.

Standalone phase monitors are essentially solid-state voltage relays that can sense voltage imbalance. They have output contacts which 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 you consider the value of the equipment being protected, the impact of downtime and repair costs.

Equipment survey

A licensed, qualified and insured electrical contractor should be hired to perform a comprehensive survey of the electrical equipment 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.

In most jurisdictions, work must be carried out by a licensed and qualified contractor, and where legislated, it must be inspected by your local electrical safety regulator prior to being put into service.

Your electrical maintenance checklist

To manage the risks and help ensure reliable operation of your equipment, you should:

- Conduct an electrical survey to ensure the integrity of your distribution system and identify and document which equipment is vulnerable to three-phase power supply failures.
- Have your local utility inspect their supply side of the system to ensure it's integrity.
- Install protective devices on your identified vulnerable equipment.
- Require protection on all vulnerable equipment that you install, going forward.

Additional resources

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/power>

Carlyle Compressor

<http://www.carlylecompressor.com>

For further information on this topic, please contact your independent insurance broker.

Visit www.avivacanada.com/riskmanagement for more Your guide to... information sheets on other loss control topics.

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