[ISSUE 53] MAY 08

TECHNICAL NEWS

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

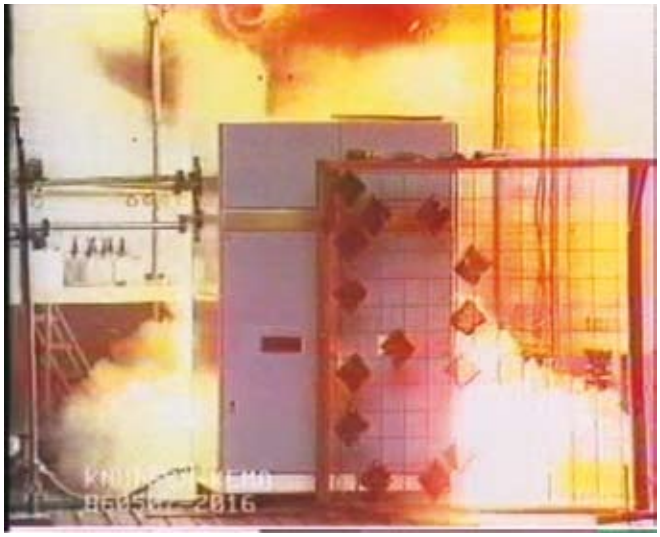
Taking care of business -

Prevention is better than cure

Introduction

User expectation of product reliability varies for different types of products. For the electrical industry where there is the assumption that power will be available no matter what the conditions, product reliability is essential. There are many factors that affect a product's performance and lifespan - some are controllable, others can only be managed. When this is neglected, the consequences can be catastrophic. It is therefore imperative that designers, installers, users and maintainers of electrical systems be aware of these issues and make allowance for them in their designs and operating plans. This Technical News Letter discusses the causes of premature failure and what can be done to prevent or at least minimise failures and highlights the types of electrical products which require regular maintenance.

EXHIBIT A: SWITCHBOARD EXPLOSION



The adjacent picture is of a switchboard under test conditions being subjected to a short circuit.

FEATURING

Causes of premature failure

How to prevent premature failure

Products requiring regular maintenance

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The picture on the previous page dramatically illustrates why electricity must be treated with respect at all times. The destruction to equipment is obvious. If an operator was standing in the vicinity of the switchboard, the result could have been fatal.

The cost to business resulting from product failure can be significant due to replacement costs, downtime and opportunity costs not to mention litigation costs due to safety and service failure. Examples could be cited where switchboard failures due to arc faults have run into the millions of dollars. Sometimes, a minor component can cause major failure, and this could have been prevented by a simple maintenance procedure.

CAUSES OF PREMATURE FAILURE

1. Product Quality

At the end of the day, the old adage, "You get what you pay for" holds true. If you want reliability, then it is important to use reliable products from respected brands. NHP searches the world over to deliver the right product and product solution for local requirements and applications.

NHP's products are tested for compliance to local standards and conditions. Poor quality products result from inadequate design and inferior materials which together combine to result in products that may see out their warranty period but will not provide the required lifespan that the application requires nor meet the arduous conditions normally found "down under".

2. Installation Issues

Even the best quality products are susceptible to premature failure if **installed incorrectly or abused** in their use. The picture below is of a contactor with its cover removed.

The circled terminal (in the photo below) was bent during installation. As a

Abused contactor terminal

consequence, the tag did not sit square on the terminal thus creating a hot spot. The heat generated by this hot spot propogated through to the contact leading to premature failure.

Poor cable crimping (refer image above) can cause hots spots. The heat is transferred into the device as well as causing localised damaged to the cable insulation giving rise to the possibility of an arc fault.

Vibration resulting from transportation of the device or the application can cause screws, nuts and bolts to loosen over time. Under tightened and even over tightened screws, bolts and nuts lead to hot spots which will eventually result in product failure. Manufacturer installation instructions regarding torque tensions should always be followed.

Alternatively, CAGE CLAMP ® technology has eleviated this issue. CAGE CLAMP® terminals are designed so that the clamping force automatically adjusts to the size of a specific conductor. Additionally, any deformation due to temperature variation or settling of the strands is automatically compensated for, by the spring, to ensure that contact pressure is maintained.

Unmaintained equipment performs poorly and fails early

Each CAGE CLAMP® spring applies a pre-programmed force adapted for the specified cross-sectional wire type to a defined contact area. Once the CAGE CLAMP® is opened, a conductor can be inserted (illustrated above). A defined contact pressure presses the conductor into the surface of the current bar ensuring a gas tight, corrosion proof connection.

3. Environment Conditions

Environmental conditions which cannot be controlled must be managed to ensure full life expectancy of electrical equipment. Extreme **ambient temperatures** require air-conditioning or heating to provide suitable operating conditions as well as to prevent condensation accumulation. Equipment installed outdoors may need protection from **UV radiation** as most materials degrade over time when exposed to direct sunlight affecting dielectric properties and the IP rating.

Corrosive atmospheres from sea water and chemicals will often react with bare metals. This leads to increased resistance, build up of oxide deposits, and reduction in material strength leading to fatigue. The end result is heat build up and the potential for arc faults. This is especially true in **humid climates**.

Sand quarries, cement mills, bakeries and flour mills all have one thing in common – **fine dust**. Dust builds up on fans, motors and other devices which restricts cooling effectiveness (illustared on previous page).

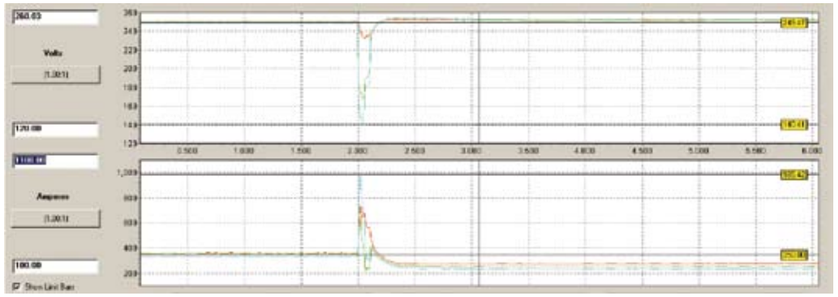
4. Electrical Conditions

The electrical conditions under which an electrical device is expected to operate must be in accordance with the manufacturer's recommendations to achieve full life expectancy.

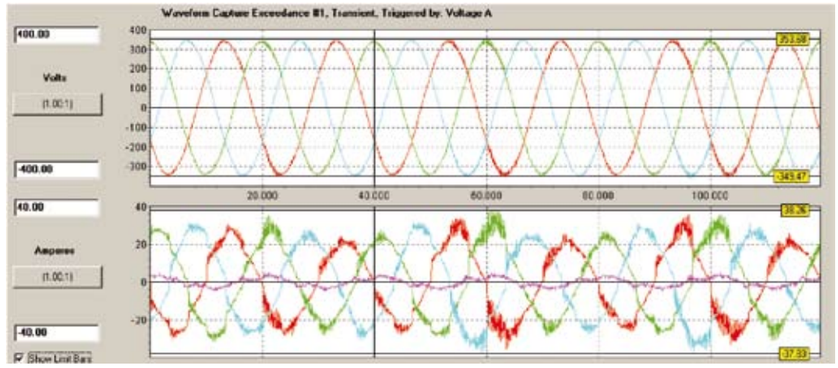
Such requirements include maximum and minimum operating voltage, current load, fault currents, harmonics, power factor, and voltage surges. In short, the quality of power at the site is of utmost importance. If heavy loads are simultaneously started, their combined inrush currents can cause a voltage sag.

The **voltage sag** will result in high current draw in constant power devices. If this is sustained for a relatively long period of time, then the resulting heat will eventually cause devices to fail. The images below of a failed contactor coil and burnt out motor are examples of what can happen in these circumstances.

Under voltage occurrences can cause unseen equipment damage. In contrast, over voltages, viz.: **voltage spikes and**



Failure due to exessive heat



surges can have a dramatic impact on sensitive electrical equipment especially at the PCB level. Over voltages also affect insulation properties and when insulation fails, short circuits are likely.

Overcurrent situations, whether they are overloads or short circuits, should be avoided. Overloads subject the device and accompanying cables to excessive heat leading to performance degradation, insulation failure and power interruption.

If the overload protection is not set correctly, it is possible that fires can occur and components fail. Failures resulting from overloads tend to occur over a period of time and are generally not noticeable until the damage is irrepairable. Short circuits are more dramatic and can be extremely dangerous causing explosions which threaten life, property and equipment in milliseconds.

The electrical disease of the modern era is **harmonics**. A broad variety of products can contribute to the total harmonic content in a supply. Devices include variable speed drives, electronic starters, switch mode power supplies and flourescent lights. In general, any product that distorts the current sine wave will be a source of harmonics.

The distorted sine wave manifests itself in an overcurrent situation and contributes to thermal loads, particularly in neutral conductors. This causes devices to operate erratically or in the worst case to fail totally.

Poor power factor unduly stresses the electrical network causing cables to carry more current than necessary and additional supply to be made available to the site. Poor power factor is the result of highly inductive loads e.g. motors and transformers.

Besides causing electrical inefficiency, some devices are susceptible to low power factor.

Contactor's contacts: AC4 application after 20,000 operations

5. Product Application

Most devices are designed to operate under specific operating conditions. Although these conditions may have wide ranges, it is important to realise the consequences of sustained device overload. For example, a contactor is designed to have an electrical life of over a million operations based on certain parameters including operating voltage, current, power factor and operating cycles.

A common misapplication of contactors leading to early failure is using the AC3 rating and applying it in an AC4 contactor

One too many short circuits

application. In AC4 applications, such as a crane motor that is being constantly started and then stoped whilst still drawing the large starting current will result in a dramatic reduction in the contactor's contact life. AC3 applications will generally provide 1 million operations where as for AC4 applications this is reduced to only 20,000 applications (refer image on previous page).

If a standard Soft Starter or Variable Speed Drives is applied to a high inertia application and not de-rated accordingly, then it will either fail out right or in a very short space of time.

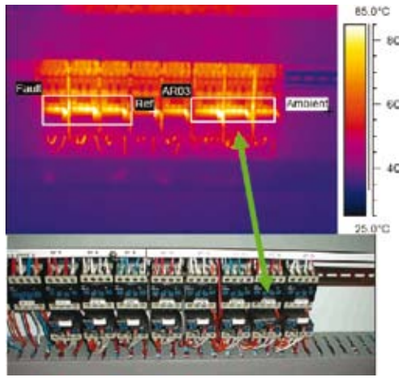
Arduous applications draw larger currents for longer resulting in heat build up. If the heat cannot be dissipated, damage results.

It is not uncommon for Miniature Circuit Breakers (MCBs) to be reset after tripping without due investigation of the trip cause. Admittedly, overloads are much more common than short circuits however, MCBs are designed to safely clear a full short circuit of its rating only 2 or 3 times after which time they should be replaced, not reset. The consequence will be that the MCB may fail dramatically at the next short circuit.

6. System Design

The performance and life of components can be affected by their position in an enclosure or switchboard. Excess heat in cabinets results from insufficient air flow and inadequate heat dissipation.

If devices with high watts losses are installed close to devices with low temperature tolerances, the results can be disastrous for the sensitive devices. The attached picture of a thermographic study illustrates the hotspots resulting from insufficient components spacing.



Thermal analysis can help identify hot spots

Electrical failure caused by "stray" rodents

Poor circuit breaker selection can result in circuit breakers being unable to safely clear fault currents or being underrated for the load current due to high ambient temperature.

To avoid this, fault calculations throughout the electrical installation should be conducted and circuit breaker combinations chosen accordingly. NHP's freely available TemCurve 6 software provides the tools to do this.

6. Maintenance

Lack of maintenance and poor maintenance procedures can lead to early product failure. Most expensive or sophisticated equipment will be supplied with maintenance procedures or the supplier will be available to provide advice in this regards. Some maintenance relies on common sense e.g. periodically cleaning air filters on inlet fans and grills to ensure maximum airflow.

Other maintenance may seem a bit obscure like feeding the site mice or ensuring the duck pond is frog friendly to keep them out of the electrical equipment but it is important nonetheless (refer above images).

HOW TO PREVENT PREMATURE FAILURE

In the case of product failure, prevention is better than cure because the costs associated with downtime usually far exceed the replacement costs. Prevention begins with buying quality products and applying those products in the manner in which they are designed to be used.

This can be as simple as using cage-clamp terminals instead of the traditional screwed type in circumstances where the application or transportation subjects the product system to a large amount of vibration. This also includes ensuring the environmental conditions suit the product and if they don't then managing them so that they do or de-rate the product accordingly.

It can be wise to periodically conduct a power quality analysis of your electrical system to check on power factor, harmonic content, frequency and severity of voltage surges and sags. Extremes of these can be mitigated with the appropriate equipment. NHP is available to assist in conducting power quality analyses. Of course, regular maintenance of most equipment is a must. In general terms, our advice would be:

1. If it looks worn out, it probably is.
2. If it is buzzing or making an unusual noise, further investigation is wise.
3. If it's dirty, clean it (contactor contacts are the exception!).
4. An aggressive environment, e.g. dirty, humid or extreme temperatures will always reduce lifespan, so factor in replacements.
5. Nothing can replace regular testing to confirm that the device operates as intended e.g. push the test button. (Unfortunately, it is inconvenient to do so in most applications as this would shut down power.)
6. If a particular piece of equipment is critical to the plant, always carry a spare or replacement parts.
7. Heat is one of the most common causes of premature failure. Look for discoloured cables as an early warning sign, or use a thermographic study.

PRODUCTS REQUIRING REGULAR MAINTENANCE

The more expensive or mission critical, the more important it is to maintain or at least monitor essential parts to indicate imminent failure. Monitoring can easily be done via on board comms, auxiliary contacts, or external sensors (RTD) connected to a SCADA system via an automation system. Such systems provide remote monitoring and immediate notification of system parameters being outside acceptable tolerances. NHP is available to assist in this area.

Maintaining equipment on a usage basis is generally far more efficient and effective than routine maintenance however, for infrequently used products e.g. air circuit breakers, routine maintenance is still important.

Soft starters & Variable Speed Drives (VSD)

Soft starters and VSD are essentially power electronic devices with no serviceable parts however, they often drive motors and applications which are mission critical. Once correctly setup and commissioned, maintenance with these devices is more about managing the environment in which they operate.

This includes checking fans for operation, filters for cleanliness, and ensuring the ambient temperature conditions are within product specifications.

In circumstances where failure has high downtime costs, it is wise to have spares close at hand.

Power Distribution Equipment

Never reset a circuit breaker before investigating the cause of the fault. Resetting circuit breakers on overload trips is fine however, if a circuit breaker has seen 2 or 3 short circuit at its I_{cu} rating, it should be replaced.

Operating the test function will ensure the device is working correctly. Turning the breaker off and testing voltage on the load side will confirm that contact welding has not taken place. Circuit breakers should be kept clean to minimise the possibility of arcing faults. Terminal covers service this requirement.

Air Circuit Breakers (ACB)

Regular ACB maintenance is strongly recommended. Protective devices must be able to clear a fault, and unmaintained items can "jam" at the critical moment. On site maintenance includes ensuring screws and bolts are at correct tension, visual inspection for cracks, heat, and other damage, and manually operating the breaker. Further maintenance includes contact condition checking and insulation testing. In some cases, extended maintenance or repair is required which may necessitate "returning to base" where primary injection testing can be conducted. NHP offers ACB maintenance contracts to ensure ACB reliability.

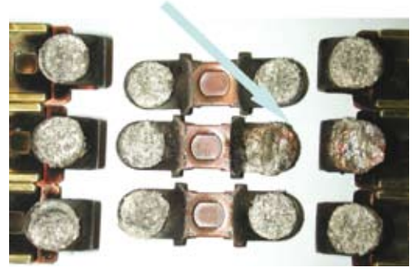
Surge Protectors

Surge protectors require visual inspection to confirm if the unit has activated or not as power will not be interrupted if it has.

Power Factor Correction Unit (PFC)

The most critical component of a PFC is the capacitor as capacitors fail due to high temperature and voltage surges. Capactors have no visible moving parts and this can create the misconception that they do not wear out. Capacitors do degrade and their status can be determined by measuring their current draw. To prevent premature failure, ensure the ventilation fan is working, regularly clean the inlet and outlet filters and do not operate the unit above the temperature rating of the capacitors. Surge protection may assist in dealing with voltage spikes depending on the location of the protection and the source of the surge.

Signs of copper



Silver contacts erode to expose copper base - "end of service life"

A well maintained PFC unit in an electrically clean site should last up to 10 years however, it is not uncommon for mistreated or unmaintained units to fail in less than 3 years. Therefore, it is strongly recommended that regular maintenance is undertaken.

Motor Control Switchgear

Thermographic switchboard surveys highlight hotspots or potential hotspots. To deal with loose joints, periodic tension checking of screws, bolts and nuts is recommended.

Check the operation of ventilation fans and associated filters for cleanliness. If high IP ratings are required, check seals. Visual inspection will reveal decolouration due to excessive heat. De-energising contactor coils and check load side voltage will ensure no contact welding has taken place.

Contactor's contacts are made of copper with silver tin tips. The silver provides low contact resistance between the fixed and moving contact faces. However, silver melts at a lower temperature than copper, therefore under frequent use the silver melts or erodes, exposing the high resistant copper (refer image above).

Conclusion

This Technical News Letter has touched on some of the causes of early product failure. This discussion has not been exhaustive by any stretch of the imagination. The emphasis has rather been on the need to conduct regular and appropriate maintenance of equipment and circuits and to manage the electrical environment to assist in minimizing the likelihood of product failure. We trust this has been of assistance to you. NHP would be pleased to help you develop a maintenance program for the NHP supplied equipment on your site to help you get the best out of your investment.

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- ☐ 5. Set the protection (MCCB breakers and application)
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