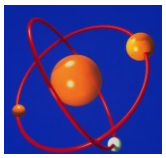

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NEWSLETTER FOR MANUFACTURING COMMUNITY

From time immemorial, man has spent and still spending quite a lot of time - and money - exploring the "invisible" forces that are controlling this earth and all happenings on it. Not to forget the deep "hidden" desire of knowing "future" by interpreting these "invisible" forces. Well, we are not starting to predict your future !! What we are really keen about is to learn how we can protect our "future" – whatever that turns out to be – from one invisible force which if not given proper care can result in a disaster. ELECTRICAL ENERGY. An invisible energy which when used safely and properly will make our life comfortable. If neglected, it sure will damage our "future."

Any end component that utilizes electricity for its functioning, like motors and heaters, are not "smart" enough to protect themselves against any eventualities. Be it short-circuit, overload or grounding fault, these end components "destroy" themselves. Consider a motor connected to some load for example. If the motor is "stalled" due to mechanical jam or is overloaded, the windings overheat gradually melting varnish insulation, short circuiting and eventually failing. Major downtime, production loss, rewinding and lot of man hours obviously follow this breakdown.

Similarly, consider an heating system used for heating the water. If the water has high salt content or is acidic, it will deposit scale on heater tube eventually damaging it. The exposed heater coil will "short-circuit" damaging the system, not to forget possible human fatalities. And the list can be endless.

A comprehensive protective system is therefore necessary in protecting expensive electrical equipments, apart from saving precious human lives. The electrical protective components can be broadly classified into two categories: FAULT SENSING and FAULT TRIPPING or ISOLATING. The devices which sense (measure) electrical parameters but does not directly isolate the power supply fall under fault sensing category. Overload Relays, Current Transformers, Thermocouples, Load cells are few examples. Even the "static" power carrying components like cables, bus bars can be grouped under fault sensing category. Heating of cable is an indication of some fault in the circuit, probably overloading or loose connection. The devices which sense AND isolate or only isolate the power when overload or short-circuit occurs fall under fault tripping or isolating category. Common fuses, MCBs, ACBs, Thermostats are few examples.

REMEMBER:

Direct tripping devices like Fuses, MCBs, OLRs work on the fundamental principle of thermal effect of current. Any metal that carries current gets heated up and expands. This behavior is very proportional to magnitude of current. The expansion of metal is converted into a mechanical force which actuates a mechanism to disconnect load side from power supply

In this newsletter, let us understand a little more about the most common and widely used fault sensing and tripping electrical components. Elaborating on each in is not intended to be covered in this newsletter. Each component needs one full size article, which we will publish soon.

Fuses – The oldest, simple, reliable and widely used method of protecting any electrical system is a small piece of wire enclosed inside a compact insulator housing. Independent of installation of any number of sophisticated protection system, fuses will be installed somewhere in the circuit (Usually, it will be the starting point of a distribution circuit). As the name implies, fuse "fuses" or connects supply and load side of electrical system with a piece of wire, made from silver or silver-oxide (tinned) copper. This piece of wire gets heated up as the current passing thru it increases. As soon

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as the current exceeds carrying ability of wire, it melts and breaks the circuit. Depending on type of fuse, entire fuse assembly – called cartridge – or wire has to be replaced. Although ageing or environmental conditions reduce current carrying capacity of fuse, it will never fail to protect the load. Fuse wires are housed inside variety of insulators.

Ceramic Fuses –

Ceramic is one of the most widely used insulating materials in electrical distribution system and are used in fuses. The ceramic fuses are bulkier, but provide excellent safety during handling. If the wire melts, it can be replaced with equivalent wire and put back into operation. They are the least expensive of all types of fuses. Only requirement is to keep a stock of correct diameter wires. Refer to the following table for current carrying capacity of different wire diameters.

Rated current of fuse Amperes	Diameter of tinner copper fuse wire (millimeter)
6	0.2
10	0.35
16	0.5
20	0.63
25	0.75
32	0.85
40	1.25
63	1.5
80	1.8
100	2.0

Cartridge Fuses – This is a replaceable type of fuse enclosed typically inside a cylindrical or rectangular ceramic housing filled with fine grain of sand or silica. Usually, a metal pin will pop out of the housing if the fuse blows. These type of fuses are generally used in low voltage applications, up to 600 amperes. The cartridge fuses are broadly classified as HRC (High Rupture Capacity) & HBC (High Breaking Capacity) types. For equipments demanding instant protection during short circuit, HRC type is preferred. Expensive CNC machines, drive systems must be protected by HRC type fuses. Equipments which are prone to certain normal overloading must be protected by HBC type of fuses, which has a slight time delay before breaking the contact.

Semiconductor Fuses – They are extremely fast acting current limiting fuses specifically designed for protecting semi-conductor based equipments like UPS, Drives, Inverters. They are sensitive to over-heating, voltage spikes and peak currents. They are broadly identified as gR & aR type.

FUSE – MYTHS & FACTS

- Fuses never fail without a reason. Eliminate the "cause" before replacing the fuse / fuse wire
- Never replace a specific fuse with higher rating type or use large diameter wire
- Do not mix HRC / HBC fuses for an application
- Do not use ordinary fuse for protecting solid state electronic components – Use only semiconductor fuses
- Fuses do not protect against surge currents, harmonics, leakage currents and earth faults
- Use proper fuse holders – and not pliers or screw drivers – to pull fuse from its holder base
- If fuse is installed in neutral line, its minimum rating should be equal to half of phase current
- Fuses are bi-directional – load and line side can be interchanged

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Bottle (glass) Fuses – Small fuses, usually rated up to 10 amperes which are widely used on PCB (Printed Circuit boards).

OLR – Over Load Relay (also called Thermal Relay) – A very simple safety tripping device, generally used to limit the current drawn by electric motors. The current drawn by motor flow thru a bi-metallic strip housed inside plastic case, usually made from phenol formaldehyde. When current flows thru the bi-metallic strip, it becomes hot and expands. This expansion of strip is used to push a lever which actuates two contacts. The opened contact will break continuity of an electrical circuit which usually de-energizes the contactor, thus stopping the motor. Once tripped, the OLR CANNOT be reset immediately. The bi-metallic strip has to "cool" down before it can be reset. Based on current rating, the reset time can vary from few seconds to several minutes. The current adjusting knob on OLR actually increases spring tension inside housing. This is the force that the load current should overcome before tripping. OLR does NOT directly disconnect the load from main circuit. It is only a FAULT SENSING device and not a FAULT TRIPPING device. Because of its electro-mechanical construction, it should only be mounted in horizontal position. The LOAD and LINE side should not be changed. Under no circumstances should the OLR be by-passed or knob be adjusted beyond its marked region.

The current setting on OLR can be set as either DIRECT rating or $\sqrt{3}$ (1.732) of the current rating. Pay attention to the label for proper setting. OLR does NOT trip without a cause. If OLR repeatedly trips, eliminate the cause before adjusting current rating or replacing the OLR. Because of its working principle, OLR DOES NOT protect against SHORT CIRCUIT or INSTANT OVERLOADING. A back-up fuse assembly or Circuit Breaker must be installed for complete protection. Based on current rating, one or two OLRs can be fitted in a motor starting system. It is quite common to use two OLRs, one with main and other with delta contactor in motor systems beyond 30 HP

OLR – MYTHS & FACTS

- OLRs does NOT protect against short-circuits or surge currents
- Load and line side of OLR must not be interchanged – Usually load side is connected to bottom of OLR
- In a three phase system, OLRs can also detect single phasing, since it is sensing current on all phases
- OLRs are rated either to "phase current" or "line current" – Check it before setting
- Apart from motors, OLRs can also be used for fixed load systems like heaters, lighting systems
- If more than one OLR is connected for protection, all their similar auxiliary contacts should be connected in series
- OLR is a simple yet sensitive current sensing device. Do not tamper the internal parts without proper calibrating devices and training. It WILL affect the current settings eventually altering its performance
- Different OLRs have different "trip time" tolerances. There are fast and slow acting OLRs. All OLRs are not same. Select the one appropriate for you

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MCB – Miniature Circuit Breaker, is an electrical FAULT TRIPPING device that breaks the circuits and protects electrical loads. It is designed and selected to protect against a preset overload and short circuit. MCBs are used on low voltage

applications usually upto 63 amperes. The MCBs are available in single phase (single pole), single phase neutral (two pole), three phase (three pole) and three phase neutral (four pole) types. Since direction of current flow is critical for

proper operation of MCBs, the "load" and "line" side must not be interchanged. On a four pole type, the phase must not be connected to neutral contact, since it is not designed to trip beyond the rated current.

MCB – MYTHS & FACTS

- Load and line side of MCBs must not be interchanged. It will affect the tripping characteristics of MCB
- Same current rating MCBs can have different short circuit current settings. Typically, 10kA, 25kA, 50kA are rated short circuit currents. Check your equipments rating for selecting proper MCB
- MCBs must not be directly used for protecting a motor
- Do not use ordinary fuse for protecting solid state electronic components
- Fuses do not protect against surge currents, harmonics, leakage currents and earth faults
- Use proper fuse holders – and not pliers or screw drivers – to pull fuse from its holder base
- If fuse is installed in neutral line, its minimum rating should be equal to half of phase current

MPCB – Motor Protection Circuit Breaker is a combination of MCB and OLR taking advantage of both systems. So, MPCB as the name implies is both a fault sensing and tripping device. It eliminates the additional wiring required for an OLR and current can be adjusted on face plate. MPCBs do not trip on instant load and hence can be directly used in a motor protection circuit.

MCCB – Molded Case Circuit Breaker is the higher version of MCB, used on higher currents usually beyond 100 amperes. MCCBs are available in both fixed and variable current settings. As the option implies, in a variable current type, MCCBs trip current can be adjusted within certain range. Also MCCBs can be fitted with "shut trip coils" which will break the circuit whenever a fault is detected by a "remote" device. For example, an ELR or over current relay can close "shut trip coil" wiring and activate MCCB. On distribution panels, an emergency stop button with its normally open contact wired to the trip coil. In an emergency situation, any nearest person can depress the button to isolate main power, preventing accidents.

CBCT – Core Balance (also called Zero Sequence) Current Transformer is basically a current sensing device thru which the three phase and neutral conductors pass before being distributed to loads. Usually, CBCTs are installed for

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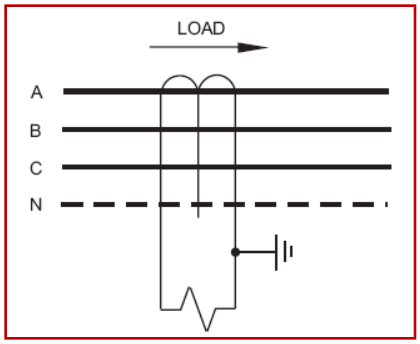
low voltage main incoming point and / or incoming of distribution panels. The CBCT senses differential current arising out of three phase system. Whenever there is an "imbalance" in current, which usually happens due to ground fault or more current flow in neutral conductor, there will be a proportional output across its terminals. The CBCT will be wired to a ELR (Earth Leakage Relay) which breaks the contact of a fault tripping device like ACB or MCCB whenever a fault is detected. To prevent unnecessary tripping which can happen due to high inrush currents or welding machines or solid state electronic components, two important settings are available on the ELR. One, Sense current limit which sets the upper or tripping limit for the circuit. Whenever the CBCT generates current equal to or greater than this value, ELR will trip the circuit. Two, sense time which ensures that the ELR does not trip when CBCT detects instant high currents. If the CBCT senses the "set" current for "set" duration, then ELR will trip the circuit. Most of the time, without proper understanding of the electrical system in a set-up, both these parameters are always set on higher side. If system does not respond to any ground faults and break the circuit, expensive electrical and electronic components can be damaged, apart from posing serious safety thread. Hence, it is essential to adjust both these parameters at the "minimum" level and then gradually increase till the most optimum setting points are reached. From then on, the circuit must be checked periodically to ensure that all components are working in perfect synchronization.



CT – Current Transformer is a very sensitive current sensing device which measure current flow in a conductor. Whenever current flow in a conductor, a proportional but less magnitude of current will be produced in current transformer winding. The conductor current is called "Primary Current" and current in the transformer winding is called "Secondary Current." So, the CT is usually identified by the ratio of primary to secondary current, called CT ratio.

CT – MYTHS & FACTS

- If you have a CT with higher ratio, but intend to measure less current, pass the primary conductor thru CT more than once to increase current that many times. For example, if you pass a 40 ampere conductor twice thru CT, the total primary current sensed by CT will be equivalent of 80 amperes.
- If current carrying conductor is passing thru CT, its secondary must not be left open and to be shorted if CT is not used
- CTs are also directly connected to an ammeter with correct rating for direct measurement
- CTs are not intended to sense short circuit or harmonic currents
- AC & DC CTs are different. They should not be mixed
- CTs of different ratio must not be mixed and all must be installed in same direction

A CT ratio of 400/5 means when 400 amperes of current flow in primary conductor, 5 amperes will be produced in the CT winding. So, if current thru primary conductor reduces to 200 amperes, secondary current will also reduce to 2.5

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amperes and it is proportional. Current Transformer can be connected to various fault tripping devices like Air Circuit Breakers, Vacuum Circuit Breakers, Overload sensors. They are also used for measuring current, energy, power factor and demand ratios.

When connecting CT to a sensing or tripping device, pay attention to its polarity. Usually, CTs will have S1 & S2 as secondary wires. If the primary conductor direction changes, S1 and S2 must be interchanged. If three CTs are used on each phase of a three phase system, it is normal to connect S1 or S2 in common depending on direction of current flow.

RCCB – Residual Current Circuit Breaker, which is also known as Earth Leakage Circuit Breaker is a very sensitive residual current sensing component that detects leakage current in "neutral" or return line of the single or three phase system. Instead of neutral, ground line can also be connected for leakage current detection. RCCBs can detect leakage currents as low as 25 milli amperes and not only protect electrical equipments, but will also save precious human life. They are designed only to detect leakage currents. They do not provide protection against overload or short-circuit. A back-up MCB or MCCB is essential for completion of electrical safety system. RCCB is a fault sensing and tripping device. The RCCB has a small arcing chamber which prevents fire when a fault occurs.

A note on difference between sparking & arcing

One of the important after effects of any electrical fault is fire. If proper safety systems are not installed or necessary maintenance is not carried, many components in the electrical system is prone to fail probably resulting in fire which apart from damaging expensive equipments can put human life as great risk. Fire originates in an electrical system generally from two distinct phenomenon: Sparking & Arcing.

We are all familiar with chattering of contactors, humming of relay coils. The fire which originates due to increased gap between contact points, poor conductivity of contact points, mechanical restrictions preventing complete contact, badly maintained system result in "sparking." intensity of energy released due to sparking is directly proportional to magnitude of current carried by the conductor and if the cause is not corrected, it can result in serious damages to man and machine. It is like one vehicle going on a bad road. Either the road quality should be improved or vehicle should be built more stronger. Sparking does not cause short circuit.

When two or more different current carrying conductors (two phases) or one conductor and neutral or grounding path come in contact with each other, it will result in what is known as "short-circuit" which release immense amount of energy. This generates an "arc" which ionizes surrounding air and temperature could very well exceed few thousand degrees. In high voltage circuits arcing can occur when conductor come very close to each other, even without touching each other. It is like two vehicles, coming from opposite directions colliding against each other. The intensity of collision is directly proportional to vehicle weight and speed. Similarly, arcing is higher in high current carrying conductors.

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ACB / VCB / OCB– Air Circuit Breaker / Vacuum Circuit Breaker / Oil Circuit Breaker - All these are meant to disconnect and connect high current loads. In air circuit breaker, the contacts are exposed to air. So, when the breaker makes and breaks the contact, there will be repeated sparking in "contact" area. Over a period of time, this might cause carbonizing resulting in reduced current carrying capacity. Period maintenance and proper servicing of ACB and its contact prolong the life and increase reliability.

In vacuum circuit breaker, the contacts are sealed inside air-tight vacuum. From fundamentals of science, we know that without oxygen there will be no fire. So, in vacuum enclosure, there will be virtually no sparking between contacts resulting in increased current carrying capacity and contacts does not carbonize. Difficulty of maintenance and bulky construction are some disadvantages of vacuum circuit breaker. In an oil circuit breaker, the contacts are immersed in an oil bath. This not only eliminates sparking, but also acts as a coolant in removing heat from current carrying area. Oil circuit breakers have high efficiency and longer life. Air or Vacuum or Oil circuit breakers are used both low and high voltage systems. In low voltage applications, there breakers are used usually beyond 600 amperes.

What should we keep in mind?

The preceding paragraphs gave a bird's eye view of few of common and widely used electrical protection system. There are many more very specific protection devices that should be selected for protecting specific application. What is chosen for protecting a fully-computerized CNC machine may not be suitable for an air compressor system. But, common sense prevails and plays an important role in protecting all electrical systems.

- Remember, no electrical protection component fails without a cause. Eliminate the cause on war footing basis. Do not neglect. No reverse engineering is applicable for an accident
- Never by-pass the protection system. Do not use over-rated components "just" to keep machine running. Never replace a fuse with solid piece of wire. It may cost you a lot in future.
- Prepare an exhaustive plan and conduct regular audits of all electrical protection components in the set-up.
- All "contact" areas must be kept clean, free of moisture, dust and inflammable materials. Do not use wood or plastic or card-board pieces to provide insulation. If space does not permit, re-design the system itself to provide ample space between conductors and neutral / ground wires.
- Do not try to force more conductors into terminal slots of circuit breakers. Use proper crimping lugs, bus bars and good quality insulators for termination.
- Although PVC insulation tape is the most commonly used "quick fix" insulator, it does NOT provide long term insulation for all conductors.
- Use proper tools to tighten electrical fasteners. When crimping or joining conductors, use joining compound to reduce contact resistance which in turn prevents sparking and residual faults.

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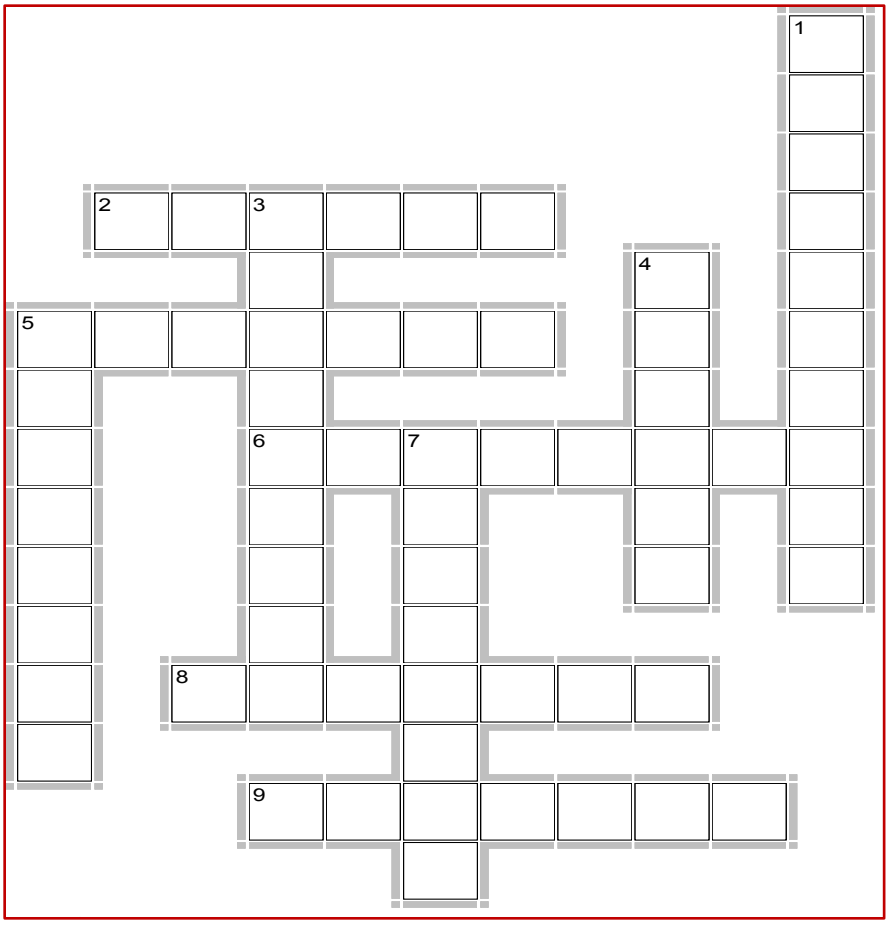
🛠 Cables should not be forced to twist below its "minimum bending radius" and never be used as a support "rope." Provide necessary cable clamps and ensure no "mechanical" load is exerted at the contact point.

Remember, SHORT-CIRCUIT IS NEVER A "CAUSE" OF FIRE. A loose connection, poor insulation or closely located conductors can be THE CAUSE and SHORT-CIRCUIT IS ONLY AN "AFTER-EFFECT" of this cause. Eliminate the cause at the earliest



Across

2.The effect of two conductors touching each other

5.Over load relay is also called ..... relay

6.CBCT senses this type of current in a circuit

8.ELR, when expanded means Earth ..... Relay

9.Air gap increases this resistance

Down

1.Most important part of a overload relay

3.These fuses are replaceable type. Has a pop up lever to indicate failure.

4.Sound does not travel in this medium

5.There are two types of safety: Fault Sensing & Fault .....

7.Chattering of a contact causes this type of fire