ELECTRICAL POWER - *DANGER BENEATH THE SURFACE*

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Introduction

The plant electrical power system is probably the most taken for granted component of today's industrial infrastructure. When we flip on the light switch, we expect the lights to come on every time. Electrical power is normally out of sight and out of mind until an outage or upset event occurs and at that point it gets major attention.

When correctly engineered and operated, a power system **should be** out of sight and out of mind. Like the air we breathe, it should be where we can take the system for granted. It's going to be there steadily providing energy to our processes – without failure. Upset conditions can occur and a correctly designed system will handle the condition both from a safety and an operational standpoint.

The Basics

The very basic industrial plant power system consists of the following typical major components:

- Primary Service from Utility
- Plant Primary Distribution
- Transformation to Low & Medium Voltage
- Low & Medium Voltage Distribution
- Low & Medium Voltage Controls
- Motor, Lighting & Other Power Loads

There are other components that will vary with each industrial process and some may include power generation at the plant site to supplement or even replace the utility service. Each of these components has its own respective means of protective devices choreographed to work together as one unit. It is the purpose of these protective devices to protect personnel and property from harm caused by failure of any of the power system components or load devices connected to the system. The protective device's function is to safely minimize and isolate a fault or overload condition to a confined area of control without impacting the operation of the remainder of the plant. Improper sizing or lack of coordination of protective devices can result in unsafe outages or major thermal events.

What About Your System?

Is your plant vulnerable to electrical system failure? Could your plant be a candidate for a significant event? Some of the factors that need to be considered include:

System Age
Plants that have been around a few years rarely resemble the original facility that was constructed. Processes change with time. Old equipment is replaced with new, faster equipment most often requiring more power to operate and adding more demand on the electrical distribution system. If these load changes have not been properly engineered and integrated into the existing system, there is the potential for protective device coordination and load flow problems.

Equipment Changes
Many times, equipment is installed in a facility without a proper regard to its fault current rating and the equipment's relationship to the rest of the system. The equipment may be undersized and could pose a threat to personal safety as well as equipment failure.

Growth Plans
If your facility is contemplating substantial growth or major upgrades that will affect the electrical loading and proper engineering has not been done to integrate the load in to the existing system, problems could develop.

Utility System Changes
Most utility systems are continuously upgrading and adding load. With this come new transformers, regulators, conductors and other devices that will have an effect on the available short circuit current to your facility. These changes can have an effect on your plant's protective device settings.

What is the Next Step?

If you are contemplating major growth or if some of the items noted above leave you in doubt about your facility, you are a candidate for a comprehensive Power Study. A power study will provide you the information you and your operations personnel need to make informed decisions in regard to power system safety, usage and maintenance.

What is a Power Study?

A power study is a detailed analysis of your complete power system. It begins with gathering fault current and impedance data from the utility company and the updating or development of a power single line diagram of the facility. This single line diagram is the power engineer's roadmap of the plant system. Data is then gathered from various equipment and devices connected to the system including fuses, circuit breakers, transformers, switchgear, motor control centers and conductors. All this information is entered into a specialized computer program that allows the engineer to view different operating scenarios and to generate reports based upon the specific need. Normally, the engineer will focus on three specific target areas under various operating conditions.

Short Circuit Study
A Short Circuit Study is conducted in accordance with industry standards to determine fault current levels at different points in the electrical distribution system. These levels are then compared with equipment ratings to determine the adequacy of the equipment to handle faults.

The study should be performed if changes have been made to the primary utility supply system or if significant changes have been made within the plant utility system.

Protective Device Study
A Protective Device Study is conducted to establish settings for protective devices. Equipment protection under the American National Standards Institute (ANSI) and the National Electric Code (NEC) rules is the objective. Selection of settings is not a rigorous science, but involves judgment calls for the best compromise between coordination among protective devices during fault conditions and equipment protection.

The objective of a protection scheme in a power system is to minimize hazards to personnel and equipment while causing the least disruption of power service. The Protective Device studies are required to select or verify the clearing characteristics of devices such as fuses, circuit breakers, and relays used in the protection scheme. The studies are also needed to determine the protective device settings that will provide selective fault isolation. In a properly coordinated system, a fault results in interruption of only the minimum amount of equipment necessary to isolate the faulted portion of the system. The power supply to loads in the remainder of the system is maintained. The goal is to achieve an optimum balance between equipment protection and selective fault isolation that is consistent with the operating requirements of the overall power system.

Time current curves are generated by the computer software. The graphics include time current curves with one-line diagrams, and the reports include protective devices and their settings.

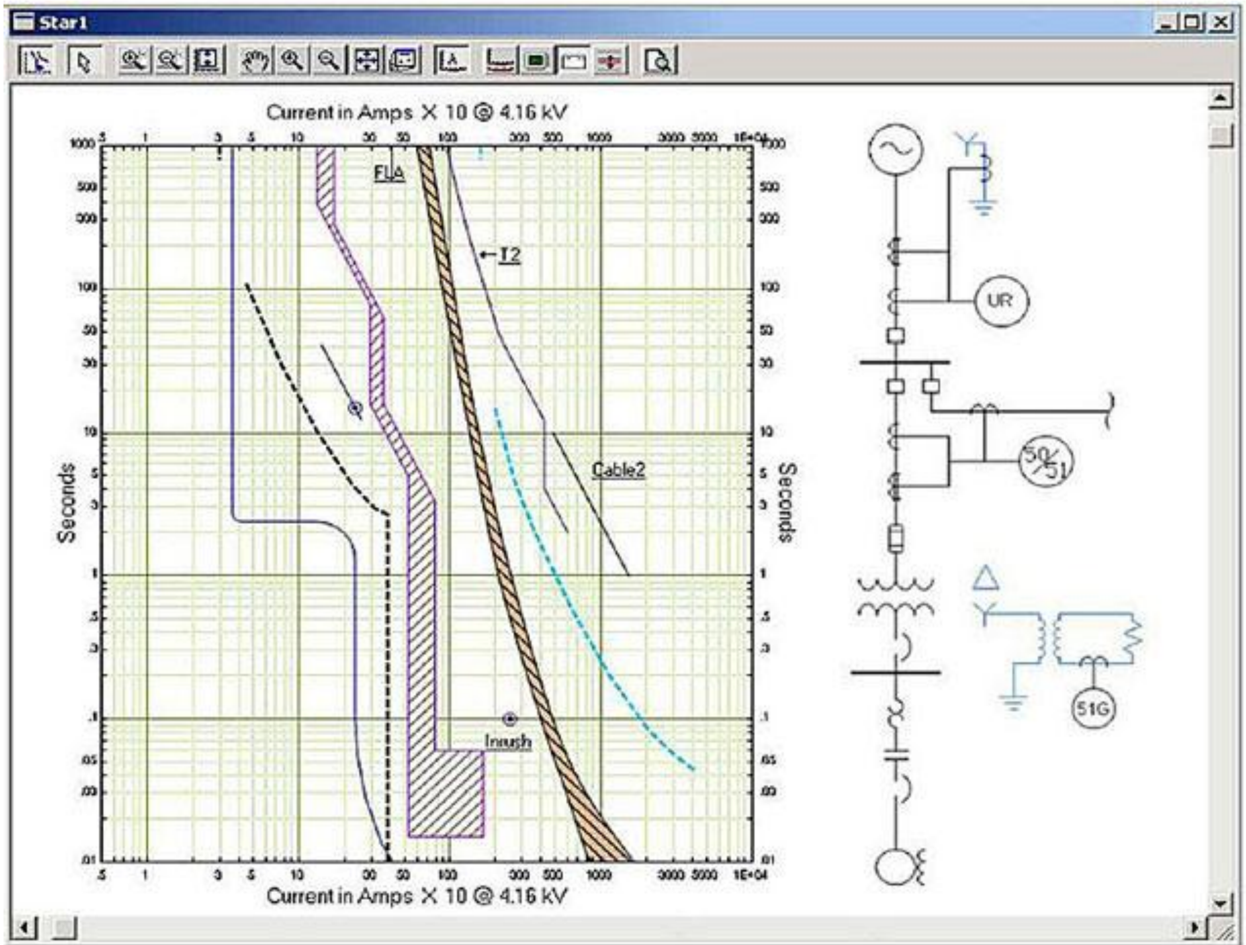
Load Flow Study
A Load Flow Study is conducted to determine the voltage, current, real power, reactive power and power factor in a power system. A number of operating scenarios can be analyzed, including contingency conditions, such as the loss of a generator, a power source, a transformer, or a load.

The studies will alert the engineer to conditions that may cause equipment overloads or poor voltage levels. Load flow studies can be used to determine the optimum size and location of capacitors for power factor improvement.

How Often Should a Power Study be Done?

A power study should be performed whenever major changes in the power system and loading are anticipated. These anticipated loads may be simulated by the computer program to see what effect they may have on load flow and short circuit.

If things have not changed in the plant over a period of time, it is a good idea to have a power study update done every five years to capture changes that may have occurred due to changes in the utility supply.



Arc-Flash

One item targeted by OSHA and other safety concerns is arc-flash. An arc-flash is potentially a very hazardous event in which the heat energy alone can cause ignition of clothing and severe extensive burns, as well as other effects of the arc-flash that can cause severe injuries.

Potential hazards from electricity include electrical shock and arc-flash. Electrical shock occurs upon contact or approach within the breakdown distance of an exposed, energized electrical conductor or circuit part. Arc-flash occurs during breakdown when the arc current exceeds the glow-to-arc transition current. The arc current creates a loud noise, intense heat, a bright flash of light and a fast moving pressure wave that propels products of the arcing fault. Some of the products released from the sudden and violent release of energy include ionized gases, metal vapors, molten metal droplets and shrapnel.

An arc-flash event can be set up by improper selection or application of protective devices. These devices may not be capable of clearing a fault within the time required to prevent a significant thermal event.

Arc-Flash Analysis

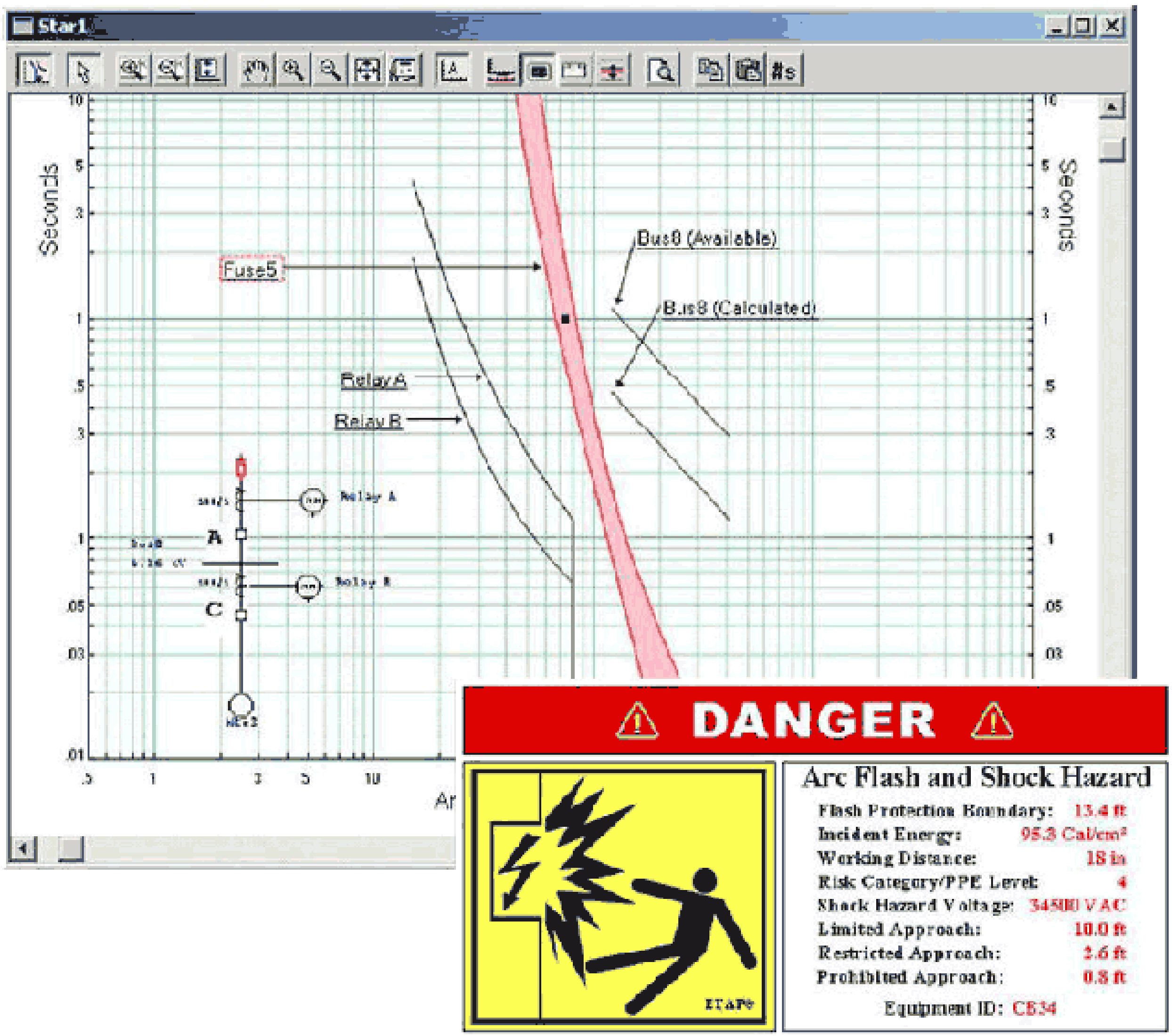
NFPA 70 ***National Electric Code*** Section 110.16 (2002 and later) requires that electrical equipment be marked in the field to indicate where the potential of an arc-flash hazard exists. In order to identify the equipment and determine the extent of the electrical hazard from the arcing fault current, an arc-flash analysis must be performed.

NFPA 70E-2000 Section 220.2(B)(1) states that a flash hazard analysis must be performed before an employee can approach any exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition. The flash hazard analysis shall determine the flash protection boundary and the personal protective equipment that people within the arc-flash boundary must use.

The NFPA 70E-2000 covers a voltage range of 208-600 volts and a current range of 16kA-50kA. The IEEE 1584-2002 standard covers a voltage range of 208kv-15kv and 15kv+ and a current range of .7kA-106kA.

Although NFPA 70E is a voluntary consensus standard, OSHA *considers it a recognized industry practice.*

The computer software calculates the incident energy and arc-flash boundary for each location in a power system. The software automatically determines the trip times from the protective device settings and arcing fault current values from the short circuit study. The incident energy and arc flash boundaries are calculated based on bolted bus fault values. Performing an accurate arc-flash study is not a stand-alone process. A Short Circuit Study is a prerequisite for an arc-flash analysis.



Conclusion

In its controlled environment, electrical power is a safe and efficient means of bringing easily convertible power to industry. Just as mechanical and structural systems need inspection and maintenance, the electrical power system cannot operate without periodic inspection and adjustment. Correct maintenance includes power system analysis, equipment inspection and adjustment of protective device settings for proper coordination. It all begins with the power study.

About HGA ...

Hunt Guillot and Associates, LLC (HGA) is a multi-disciplined project management and consulting engineering firm located in Ruston, Louisiana. HGA is available to assist industrial customers with their power system and energy needs. Services available are power system analyses, engineering design, energy audits and efficiency studies. Other technical services are available.

HGA is a member of the Engineered Wood Technology Association (EWTA).

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About the Author

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