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Machine Shops

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Machine Shops
Overview

HSB, part of Munich Re, is a technology-driven company built on a foundation of specialty insurance, engineering and technology, all working together to drive innovation in a modern world.

Modern Machines Shops can be a marvel in comparison to shops of yesterday. The types of machines will vary from shop to shop. Most Machine Shops use the “Subtractive” method of fabrication of specific parts. In the subtractive process, specific machines and tools are used to remove material from rough casting, a blank, a strip of metal, or some form of feedstock, into the final desired form. In recent years, machine shops have moved to an “Additive” method of fabrication. With Additive Manufacturing (AM) or 3-D Printing layers of a specific material are fused together to form the final part or assembly. It is not unusual for modern Machine Shops to have both Subtractive and Additive capabilities.

Most of the machines used in Machine Shops today are actually driven by computers. These Computer Numerically Controlled (CNC) machines provide a high level of quality and consistency in the production of parts. There are also some general machines that may have older controls called Numerically Controlled (NC) or no computer controls and are completely manual. In the case of CNC and NC machines, replacement components for the controls may be difficult to obtain, if not impossible, based on their age.

Today’s Machine Shop can be an arrangement of a few “general” machines or they can be made up of a large number of machines with a number of specialty machines included. The subtractive fabrication process depends on four principal machining processes. These processes are classified as turning, drilling, milling and miscellaneous.

Specialty locations which produce stamping or forging dies are known as Tool and Die Shops. These machine shops have a wide range of machine tools which are usually of the highest quality and precision. Tool and Die Machine Shops are likely to have power presses, mechanical or hydraulic or both, used for die tryout and qualification. Some qualification

runs require the press to produce several hundred pressings. It is not unusual for these tryout presses to be older machines which were purchased used. In smaller Tool and Die Shops the tryout presses may be in poor condition.

High precision Machine Shops will have a Quality Assurance/Quality Control (QA/QC) organization within it. The QA/QC portion of a Machine Shop will have very precise measuring tools and machines that need to be maintained at fairly consistent temperatures. The offices and work areas for the QA/QC organization require a clean atmosphere, to keep contamination to a minimum. These two requirements can add special equipment and substantial cost to the facility as well as added requirements to the shop's "must haves" for continuous operation.

In all Machine Shops the operating environment tends to be considered moderately dirty. The environment can vary from shop to shop as well as areas within the same shop. Good ventilation and housekeeping standards can make the shop environment better than a shop with poor ventilation and little to no general housekeeping. Smaller machine shops may have little or no preventive maintenance. These shops rely on the skills of their work force to make repairs or they use the services of an outside vendor to make "emergency repairs". Larger shops may have a dedicated maintenance department that not only repairs production machines, but is supporting the facility's infrastructure (plumbing, HVAC, electrical needs, etc.).

Some shop owners develop "Contingency Plans" to protect themselves in the event they do not have required spares for repairs or if the replacement parts have long lead times. These plans could include contact information for other machine shops capable of producing various components to avoid defaulting on contracts, alternate component suppliers, used machine vendors, rental companies for compressors, portable generators, or other equipment that could cause a slowdown or stoppage in production. The compiling of a Contingency Plan is not expensive, but it can be time consuming. Once a plan is created, it should be reviewed periodically with contact information checked insuring the information is still valid. The creation of a Contingency Plan should be a strong suggestion to a Client that has minimal or no access to spares.

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ES952 (New 04/2020)

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Machine Shops
Loss Control

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One needs to consider a Machine Shop as a system of separate but integrated tools. Each tool has a special function to make the shop operate smoothly. If one or more tools were to break down, it can impact production workflow. The shop may slow down its production or it may come to a complete stop. By looking at the major components of the Machine Shop system it is possible to identify areas that need to be properly maintained to keep the system healthy.

1. Typical Equipment

The four principal subtractive machining processes used in traditional machine shops are classified as turning, milling, drilling and miscellaneous. In addition, Additive Manufacturing (AM) (a.k.a. 3-D Printing) is becoming integrated into many Machine Shops. Each process has been developed and used for a specific purpose. Drilling and miscellaneous will not be covered in more detail below.

1.1 Subtractive Manufacturing

1. Turning operations rotate the work piece against a cutting tool as the primary method of removing metal. Lathes are the principal machine tool used in turning. A piece of material is locked into a chuck which is turned by a motor. Older lathes are likely to have numerical controls (NC) to assist the machinist to make proper cuts to the material. Virtually all lathes have automatic feed capabilities to allow smooth cutting of the materials. The power for the auto feed comes from the internal gearbox in the lathe. Despite having different capabilities these machines have commonalities.

2. Milling operations rotate a cutting tool which is then brought against the stationary piece of material to cut or remove metal. This may be done on one or several axes, variable cutter head speed, and pressure. With the advent of computer numerical control (CNC) in the 1960s, milling machines evolved into machining centers:

milling machines augmented by automatic tool changers, tool magazines or carousels, CNC capability, coolant systems, and enclosures. Milling centers are generally classified as vertical machining centers (VMCs) or horizontal machining centers (HMCs).

1.2 Additive Manufacturing

Operations use specialized machines that are computer controlled. These machines can range in size from a small desktop machine for printing small parts or half size models, to machines with working beds as large as 30 feet long by 15 feet wide. AM machines can use a wide variety of materials. Prototyping is often done with some form of polymer (plastic like) material but the final product may be made from a polymer as well. Metal AM is being added to many Machine Shops for the production of intricate parts that could not be made until now. With both the polymer and the metal processes, heat is a large factor in the machine's operation. The heat may come from the injection head to melt the polymer, or it could be in the form of an electrical arc or even a laser. Some processes use nitrogen as a "blanket gas" for the process to insure the final product is clean and absent of contaminants.

After a component has been made in an AM machine, the final exterior finish may need to be addressed, or "support structures" need to be trimmed off. To assist in material flow in the shop, AM machines are being fitted with machining centers. The addition can add substantial complexity to the AM machine, as well as initial cost.

1.3 Quality Inspections and Testing

Quality Assurance and Control (QA/QC) departments will be found in machine shops where close tolerances and high precision are required. These departments use sensitive tools to verify sizes and shape of parts and components that have been made. Coordinate Measuring Machines (CMM) are often found in the QA/QC departments. CMM's can be very expensive tools. The CMM requires a clean, consistent temperature and humidity environment. These requirements will frequently require separate heating, cooling and air filtration systems to be in use where CMM's are used.

2. Loss Control Considerations

Despite having different purposes, these machines have a lot in common. Machinery breakdown can and does happen to the best made machines from a variety of causes. Here are some areas that shop owners can look at and act on to reduce the impact or eliminate the likelihood of machinery failures.

A. Electrical power is a critical item for Machine Shops to operate. "Clean Incoming Power" is essential for the long life of not only the heavy machine hardware but also (and more importantly) for the computer controls. It is extremely important that machine shops have adequate power protection devices such as surge protection devices to protect against poor power quality.

When a Shop is adding new equipment, the overall Shop load should be checked to ensure the incoming power service is adequate. Proper distribution of the power should also be verified as to not overload one phase or transformer. This would also be an ideal time to have the electrical switch gear evaluated. Many people have the feeling electrical switch gear lasts forever. Unfortunately, this is a misconception and can lead to issues and even property loss due to fire.

B. Modern machines depend on one or more motors to rotate the stock material, operate hydraulic pumps, and perform cooling and ventilation functions. While motors are a critical component of any machine they are often located where maintenance on them is difficult. This tends to lead to the motor not being properly maintained which can lead to machine breakdown. Well managed shops will have spare motors for their machines on-site in the event a motor failure occurs. If spare motors are not in-house, Shop owners could have contacts with either local motor repair firms for large motors, or for local distributors of new motors. In many cases, a motor change out can be performed by in-house personnel.

Proper maintenance of motor is fairly simple, when access and personnel are available. Applying fresh grease to the motor bearings takes only a few minutes. The simple practice of wiping down the outside of a motor allows for better heat rejection and helps extend the life of the motor's insulation. Checking the motor's operation for excess vibration can be as simple as listening to it running or even by touching an enclosed area on it. If the motor seems to be vibrating more than normal, a vibration meter could be attached to the motor to find out what the vibration characteristics are.

C. The use of Variable Frequency Drives (VFD) to allow a fine speed control that is often called for with modern machines. The VFD also allows for smoother starting of the machines, especially large ones. This is very important for machines to have good control on the primary speeds being applied.

As with all electronic equipment, VFD controls need to be kept clean of dirt, dust, and oil. These contaminants can cause control cards to fail prematurely. By keeping VFD cabinets closed, contaminants cannot easily cause issues with the sensitive cards. The closed cabinet also serves as a containment in the event of an arcing or electrical. Some people will keep the VFD cabinets open to keep the electronic components cool. Most VFD cabinets are fitted with a small cooler to maintain the internal cabinet temperature fairly constant. Failure to maintain the cabinet cooling can lead to breakdown of the VFD and machine stoppage. Exterior ventilation is also important to allow any rejected heat to be expelled out of the cabinets. A simple daily check of the VFD's inlet and exhaust ports can alert an operator that the VFD may becoming overheated. Dirt, lint, and oil can block the air ports causing a VFD to overheat and fail.

D. Depending on the stock material being turned, a "coolant" is often sprayed on the cutting tool and the stock material. The coolant can be a water-based or an oil-based product. The spraying action tends to allow coolant to flood the machine and splash to the surrounding area. This can create slippery conditions for the machinist and other Shop personnel. It can create a potential fire hazard if it is not monitored and kept under control.

E. Hydraulic oil is a common substance used in almost every Machine Shop. Even though this oil is used in a closed system, it should be tested for moisture content as well as overall condition on a regular basis, and particularly if you change suppliers.

Moisture can enter a hydraulic system during a shutdown period as the hydraulic oil cools down. If the accumulation of this moisture is sufficient, or if the general climate is very humid, water can be noted in the sight glass of the oil sump. Water in hydraulic oil causes cylinders and servo valves to have sluggish response, oxidation (rust) formation inside components, and machine stoppage. Even "wet" hydraulic oil (oil having water in it that cannot be seen easily) can leave moisture in sensitive components resulting in machine stoppage.

F. Shops should have a regular program in place to perform Infrared (IR) Surveys on all electrical systems. The IR survey can expose loose connections, wire system overloads, and other electrical issues. The use of an IR camera is also a very effective way to find hot motors, excessive heat buildup, and other excessive heat issues. If the facility has its own heating system, a simple IR scan can find issues with poor or no insulation, leaking piping, or even leaking exhaust gases.

G. Vibration surveys are a good loss prevention tool. Today's vibration testing equipment is easy to operate. Small to medium sized facilities can use the services of an outside company that specializes in vibration measuring and monitoring or they can purchase the tools and perform their own surveys. The tools often are supplied with software to assist with the trending of each piece of equipment's vibration as well as diagnosing what might be causing any abnormal vibrations. The key to these surveys is that they need to be performed regularly and the data obtained needs to be reviewed and compared to previous surveys.

H. Housekeeping can be very difficult in a Machine Shop environment. However, maintaining simple housekeeping tasks can make a big difference in the safety and equipment breakdown. Keeping swarf from accumulating on the shop floor reduces the chance of slip and fall events for personnel. It also aids in reducing the potential for fire as the swarf is often oil soaked. Electrical panels often have blocked access and electrical rooms tend to become the "other storage room". If there is a need to access panels and switch gear quickly, response time could be delayed because of the blockage. Burnable material can add to the damage caused by an arcing event in an electrical room. Having a routine of placing oil-soaked rags into a covered metal bin is another housekeeping item that aides in reducing fire hazards. Aisles and material staging areas should be clearly marked. Aisles should be kept clear at all times. Material staging areas should have only material that is going into process or has completed process and is awaiting QA/QC or final assembly. Trash should never be allowed to remain in material staging areas.

I. Machine Shops should have a training program established for their employees. With machines becoming more complex and computer driven, there is a need to keep employees up to date on the latest changes and practices in the industry.

When a new machine is added to a Machine Shop, the owner often arranges for training on that specific machine to be presented by the supplier of the machine. This is often good for the machinist to become familiar with new features and capabilities of the new machine. However, it often does not address other advances in the industry. Establishing and maintaining an employee training program empowers the machinist to spot and report issues before they become major problems or a complete machine breakdown.

ES953 (New 04/2020)

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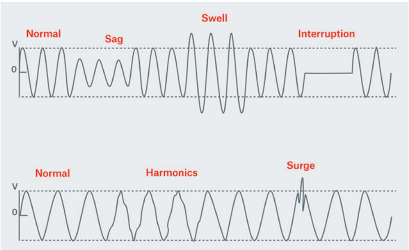
Power Quality — Introduction
Commercial Buildings

Power quality is a general term used to describe the degree of electrical abnormalities negatively affecting the intended electrical system supply. Power quality is a significant concern for all types of businesses. This includes hospitals, universities, commercial businesses and industrial facilities.

Power Quality Related Issues



courtesy of Advanced Protection Technologies

- Voltage transients (surge)
- Harmonics
- Voltage sag
- Voltage swell
- Voltage interruptions

Results of Poor Power Quality

The impact of poor power quality is based on the length, magnitude and timing of the abnormality as well as the sensitivity of the connected equipment. Poor power quality can result in process interruptions, data corruption, data loss, improper operation of computer-controlled equipment and overheating of electrical equipment.

Conditions that Raise Power Quality Awareness

- History of power related issues
- Poorly maintained electrical system
- Weather and utility disturbances are common
- High concentration of electronic equipment

Indications of Potential Power Quality Issues

- Repeated and random equipment failures, tripped breakers or blown fuses with no identified cause
- Lost data or data corruption issues
- Premature equipment failures

Solutions

There are many types of power quality issues. Each power quality issue may need a different solution. A qualified power quality contractor will follow the IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment. Chapter 6 has detailed procedures for site surveys and site power analyses. The survey and monitoring results will identify the power quality problems. The contractor can then present appropriate corrective measures based on the survey and analyses results.

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Power Quality — Advanced
Commercial Buildings

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Background

Power quality is a general term used to describe the degree of abnormality to several different electrical system characteristics. These characteristics are the frequency and amplitude of the voltage, the balance between phases on a three-phase system and the distortion levels of the waveforms. The characteristics that are important and what is considered an acceptable level of power quality varies from facility to facility.

Most of the older electro-mechanical equipment was robust and could handle minor power quality related issues with little or no effect on operations. But, due to the shift in the type of loads from electro- mechanical to electronic, power quality has become a real concern in all types of businesses. This includes hospitals, universities, commercial buildings and industrial facilities. Poor power quality results in a random equipment malfunctions, data corruption, loss of process control, and heating of cables, motors and transformers.

Power Source

An ideal power source offers a continuous, smooth sinusoidal voltage, as shown in Figure 1.

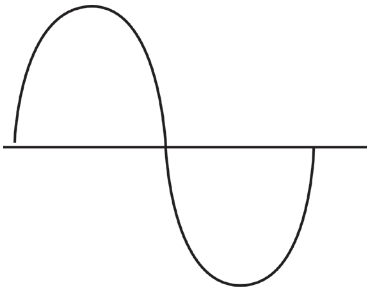


Figure 1

Poor power quality as shown in Figure 2, contains noise, harmonic distortion, voltage sags and swells, interruptions and voltage surge.

Figure 2

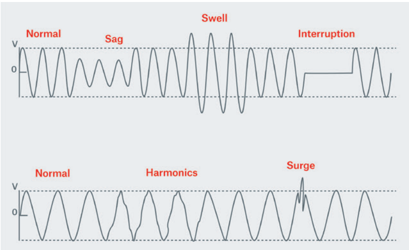
Causes of Poor Power Quality

You might think that poor power quality is primarily the result of weather and utility related disturbances. However, studies have shown that issues such as lightning, other natural phenomena, and utility operations, account for only a small portion of all electrical disturbances.

A large portion of electrical disturbances are from internal sources or from neighboring businesses that share the same building or are in close proximity. Internal sources can be fax machines, copiers, air conditioners, elevators, and variable frequency drives just to name a few.

Power Quality Issues

Typical power quality issues include: voltage transients (surge), harmonics, voltage sag and swell, voltage imbalance and interruptions.



courtesy of Advanced Protection Technologies

Voltage Transient (Surge)	
Description	A sudden high energy disturbance in line voltage typically lasting less than one cycle (< one second) which causes the normal waveform to be discontinuous.
Cause	Switching type loads.
Issue	Data corruption, equipment malfunctions, equipment damage and process interruption.
Harmonic Distortion	
Description	Distortion of the current and voltage waveforms caused by the momentary on/off switching of nonlinear loads.
Cause	Elevators, HVAC equipment, rectifiers and welding machines.
Issue	Data corruption, data loss, computer-controlled equipment malfunctions, excessive heat and equipment failure.
Voltage Sag / Swell	
Description	A decrease (sag) or increase (swell) in line voltage lasting at least 1/2 cycle (1/120 of a second) to several seconds.
Cause	Utility related events, starting and stopping of large loads.
Issue	If equipment is operated slightly outside the design envelope, random malfunctions and failure may occur. If the equipment is operated significantly outside the design envelope, the equipment will not operate and may fail prematurely. The effects are based on the length, magnitude and timing of the sag or swell.
Voltage Imbalance	
Description	Differing voltage levels on each leg of a three-phase system, typically < +/-2% of the average.
Cause	Large loads in a building such as HVAC equipment and elevators are three phase loads. The small but numerous loads such as copiers, control equipment and computers are single phase loads. Single phase loads should be equally distributed among the three phases to prevent imbalance. Imbalance can also be caused by poor connections or blown fuses.
Issue	Depending on the level of imbalance, loads can operate erratically, not operate at all or fail.
Interruptions	
Description	A significant or complete loss of voltage. The loss can be momentary or sustained.
Cause	Weather, utility equipment failures, internal faults or internal equipment failures.
Issue	A momentary interruption can damage computers and other electronically controlled equipment or disrupt processes. The damage can occur on both the loss and the re-energization of power. Electro-mechanical equipment is generally not affected by these brief outages. Sustained interruptions can last from hours to days. Contingency plans should be developed to address orderly equipment and process shutdown and restarts.

Solutions

Each occupancy will have a different sensitivity levels to poor power quality and will have different sources of poor power quality. However, common to all businesses is the importance of a well- maintained electrical distribution and grounding system. The importance of these systems cannot be overstated. When addressing potential or actual power quality issues, the power and grounding system should be the first item addressed. This will ensure personnel safety, allow for the proper operation of surge protection devices, minimize the potential for excessive currents on neutral conductors, and provide a common reference plane for electronic equipment.

Once the power and grounding system deficiencies are addressed, the next steps include, power quality walk-throughs, power quality inspections and surveys, and mitigation strategies.

Walk-throughs provide an overview of a facility from a power quality standpoint. In addition to housekeeping and the overall appearance of electrical equipment, items to note during a power quality walk-through include:

- Type of equipment that is installed
- Concentration of computer and electronic equipment
- Presence of welders, power factor correction capacitors, or variable frequency drives
- Heat discoloration of electrical equipment
- Communication and control wiring in close proximity to power wiring
- Condition of the grounding system
- Presence of surge protection installed on power and data lines

The conditions below are considered warning signs for potential power quality issues in a facility. These conditions do not guarantee a problem. A facility with these conditions usually has an increased likelihood of power quality issues:

- History of power related issues
- Poorly maintained electrical system
- Failure of surge protection equipment
- Weather and utility disturbances common
- High concentration of electronic equipment
- Infrared surveys which identify current flow (heat) on grounding conductors and/or system neutrals
- Repeating and random equipment malfunctions, failures, tripped breakers or blown fuses with no identified causes
- Equipment running hot
- Frequent switching to backup power systems
- Lost data or data corruption

Based on the results of the power quality walk-through and the type of processes and equipment at the site, the following recommendations are common:

- Use infrared thermography to locate troubled areas. Not all power quality related issues will cause hot spots. Loose connections, harmonics and undervoltage will cause an increase in the operating temperature of equipment.
- Conduct a power quality inspection and survey using a properly trained and experienced power quality contractor. The results of the inspection and survey should be reviewed with trained and experienced power quality engineers.
- Perform a power quality study if an expansion is planned or a large load is being added. This study should be completed during the design of the expansion or during the specification process of the new equipment installations.

Power quality inspections and surveys identify the types of problems, the extent of the problems, and the potential solutions. Power quality inspections and surveys should only be performed by qualified power quality contractors. In many commercial or light industrial type businesses, only a few loads are affected by power quality issues and only a few loads are susceptible to poor power quality. By identifying these loads during a survey, targeted mitigation techniques can be utilized.

A power quality survey is the monitoring and recording of the power system supplied to a building or specific areas of a building. It is important to measure power continuously over an extended period of time such as days or weeks. This will capture all of the intermittent events. Due to the special knowledge needed to identify power quality related issues, it is recommended that only electricians trained in the use of power monitoring instruments be utilized. The equipment should be capable of recording very fast events (less than one cycle) and have data storage capabilities. Since it is difficult to monitor all points simultaneously, selecting the best points to monitor is extremely important. This should be done based on the areas of concern that were identified during the inspection. The equipment must be monitored in its normal operating environment. Do not perform a power quality survey during a shutdown.

The review of the data from the survey will determine the type and severity of the problems and assist in recommending mitigation techniques. The data review should be performed by qualified and experienced power quality engineers.

Prior to selecting any type of mitigation equipment, the power quality deficiencies that are responsible for operational issues and failures must be clearly identified. The next step is to estimate the costs of the power quality related issues. This aids in developing a budget for the project.

A wide variety of power quality correction products is available utilizing a range of technologies and providing a range of protection. Common mitigation techniques include surge protection devices, isolation transformers, voltage regulators, motor generators, standby power supplies, uninterruptible power supplies and harmonic filters. Each technique has advantages and disadvantages and should be applied based on the discovered problems.

This list defines different types of mitigation techniques available, but it is not a complete list.

Surge Protection Devices (SPD)	
Function	Diverts surge events to ground.
Description	A device connected between line and ground which has high impedance at normal system voltage levels and very low impedance at higher than normal voltage levels. Because of this low impedance, the SPD acts as a shunt to ground for voltage surge events. Devices vary in their surge current-handling capability and voltage-limiting capability. Since devices have different voltage and current capabilities, a multi-level approach is required to protect against surge events. The multi-level approach is also known as zones of protection. Each zone experiences a different level of surge event and therefore the SPD should be sized appropriately based on the zone. In general terms, the zones of protection are the service entrance line, the remote distributed panelboards, and at the equipment points-of-use. Communications and data equipment are also vulnerable to surges. Special surge protectors are available for line protection of this equipment. Many types of equipment claim to have built in surge protection. But these are often inexpensive varistors. These devices may or may not provide sufficient protection. They should be supplemented by the field installed units for complete surge protection.

Isolation Transformers	
Function	Isolation transformers attenuate common-mode disturbances on the power supply conductors, provides a local ground reference point and allow for voltage output adjustments using internal winding taps.
Description	A transformer with special windings utilizing a grounded electrostatic shield between the primary and secondary. This grounded shield provides attenuation of high-frequency noise. Isolation transformers may step the voltage up or down (i.e. 480v to 208v) or may be used for isolation only with no output voltage change (208 V in and 208 V out).

Voltage Regulator	
Function	Provide a constant output voltage level for a range of input voltages.
Description	A variety of voltage regulation techniques are available such as, ferro resonant transformers, electronic tap-switching transformers, and saturable reactor regulators.

Motor Generator	
Function	Provides voltage regulation, noise/surge elimination, voltage distortion correction and electrical isolation between the electrical system and the connected equipment.
Description	A separate motor and an alternator (generator) are interconnected by a rotating shaft and coupling. Typically, the utility is the power supply for the motor which drives the generator to produce clean power.

Standby Power Supply	
Function	An inverter and battery backup power system operating as an outage protection system. In normal mode, the inverter is in a standby mode and the load is directly supplied from the input power source. On a loss of input power, the load is switched to the battery supply. There is a momentary break in power when the transfer to and from input power occurs.
Description	Usually comprised of a solid-state inverter, battery, and battery charger.

Uninterruptible Power Supply (UPS)	
Function	Maintain uninterrupted supply of regulated voltage for a period of time after a power failure.
Description	A variety of technologies exists. The two common types are rotary and static. A rotary unit consists of a motor generator set with a short ride through capability. A static unit utilizes power electronics and a battery string or other energy storage means as a source of energy during loss of input power. These units depend on properly maintained batteries. The battery system is sized based on the load and duration of required time. Other types include combinations of rotary and static units or UPS systems supplemented with engine driven generators for extended outages. The design of the backup power supply capability should reflect the criticality and size of the loads to be supplied. Redundancy should be in considered for installations with significant power loss consequences. Each element of the backup power scheme needs to be viewed as a point of failure. If appropriate, the design should provide for functional duplication of each system component.

Harmonic Filters	
Function	Acts to reduce the level of harmonic distortion on a power system.
Description	Harmonic filters should be specifically designed to suppress the offending harmonics determined during the monitoring and analysis study. Harmonic filters may be available from equipment manufacturers that manufacturer electrical equipment know to create harmonic distortions on the power lines.

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