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NETA WORLD™

FEATURE

UNDERSTANDING AND MAINTAINING CRITICAL SERVICE EQUIPMENT

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All institutions and businesses strive to maintain a reliable and consistent level of service to their customers. Many also establish disaster and recovery plans for unexpected natural disasters or other crisis situations. An often overlooked but foreseeable disaster is the failure of the main electrical service switch for the facility.

The main switch of a facility can fail catastrophically if the manufacturer's required maintenance is ignored.

Extended loss of electrical power to a facility due to catastrophic equipment failure usually disrupts all business function and creates many unexpected and unplanned expenses. Most service equipment failures are preventable by following manufacturers' maintenance recommendations or requirements for the installed service equipment. Electrical equipment failures should be included in the disaster plan, and the process begins with conducting an electrical equipment failure risk assessment.

When performing an electrical equipment failure risk assessment for a facility, one of the most important considerations is the reliability of the service equipment. The National Electrical Code, NFPA 70-2014 Article 100 Definitions defines service equipment as:

> *The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of the service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.*

When the service equipment fails to perform as intended or fails catastrophically, a complete shutdown of all business activities occurs. A catastrophic failure usually results in expediting standby generators to the site and the use of many electricians working around the clock to re-establish power to the facility. Damage to the service equipment makes it very difficult to connect a standby generator at a single termination point. Sometimes the feeder sections need to be subdivided or isolated from the busbars for the standby generator connections.

Recovering from service equipment failures typically includes costs for generator rental and fuel oil, generator power cable rental, overtime electrical trade labor, additional security guard coverage, and equipment transportation. The analysis shown in Figure 1 highlights the total cost associated with standby generator requirements. When long-term outages are expected, temporary transformers or rerouted service conductors may be more cost effective than running generators. Keep in mind that all of these costs are only for the temporary emergency re-establishment of power.

Additional time and expense is expended working with designers and electrical contractors to determine the extent of the damages and solutions for permanent equipment replacement. Catastrophic service equipment failures are often accompanied by electrical equipment meltdown, fire, smoke, and water damage. Depending on the degree of equipment failure, major NEC-code upgrades may be required for the equipment room and electrical equipment before it can pass current electrical and building code requirements.

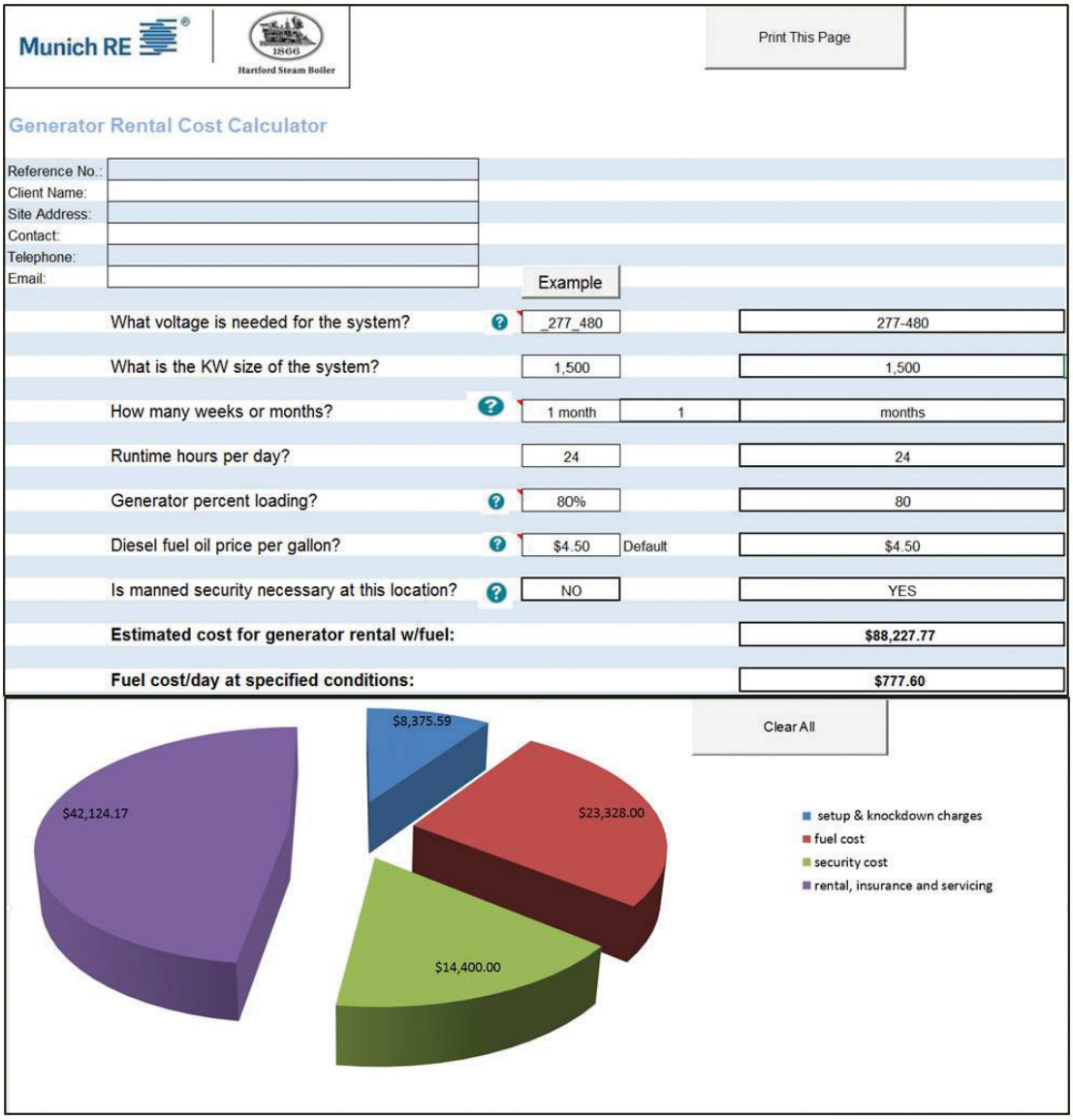


Figure 1: *Standby generator rental cost is a fraction of the total cost associated with the use of a temporary generator installation.*

Required code upgrades can create additional unexpected expenses. Depending on new or used equipment availability, final electrical and building repairs can take weeks or months. In addition to all of the costs for temporary and permanent electrical repairs, the occupants typically suffer a major business interruption. Many key personnel are diverted to expediting activities and emergency resolutions of the current business crisis. Who is left to manage the day-to-day business, and how many customers' needs are not being met because of this unexpected and untimely electrical failure?

The proactive review and execution of main switch maintenance requirements can help prevent switch failures, power outages, and costly business interruptions.

Knowing that all of these costs typically follow an unexpected service equipment failure, the best solution is to avoid the failure in the first place. This requires that the owner is aware of the type of installed electrical equipment and the maintenance requirements specified by the equipment manufacturers. As with any type of service equipment, if the manufacturers' maintenance requirements are ignored, the consequences can devastate a business and result in unrecoverable business losses and crushing financial burdens.

One common type of service equipment switch used by a wide range of facilities is the bolted pressure switch. By evaluating the results of a catastrophic bolted pressure switch failure, the importance of proper service equipment maintenance becomes evident.

No business owner wants to respond to an emergency call at their facility to find a bolted pressure switch failure. The bolted pressure switch failure shown in this photo occurred catastrophically with all of the consequences described previously.

What caused this to happen? How could ignoring required maintenance on this switch result in such total destruction of the switchgear? What could have been done to prevent this catastrophe?

After a service equipment failure of this magnitude, owners, contractors, engineers, and facilities managers quickly assemble to try to understand how this could have happened. The discussions usually include questions such as:

- Was an electrical risk assessment ever conducted for the site?
- Were electrical experts included in the risk assessment process?
- Was there an awareness that the electrical equipment required periodic maintenance?
- Was any preventive maintenance ever performed on the service equipment?
- Was it known that a bolted pressure switch was installed on the premises?
- Were the manufacturer's service requirements and frequencies known?
- Were qualified electrical personnel employed at the facility to evaluate and design

a comprehensive electrical preventive maintenance program?

- Was there an awareness of the potentially catastrophic consequences of not performing the manufacturer's maintenance recommendations?

Knowing that service equipment failures typically follow this response pattern, what can be learned in the interest of prevention? After a disaster has occurred, there is always great interest in what can be done to prevent a recurrence. The real benefit of this discussion is to forewarn owners and facilities managers to proactively consider all of the above questions *before* a catastrophic service switch failure occurs.

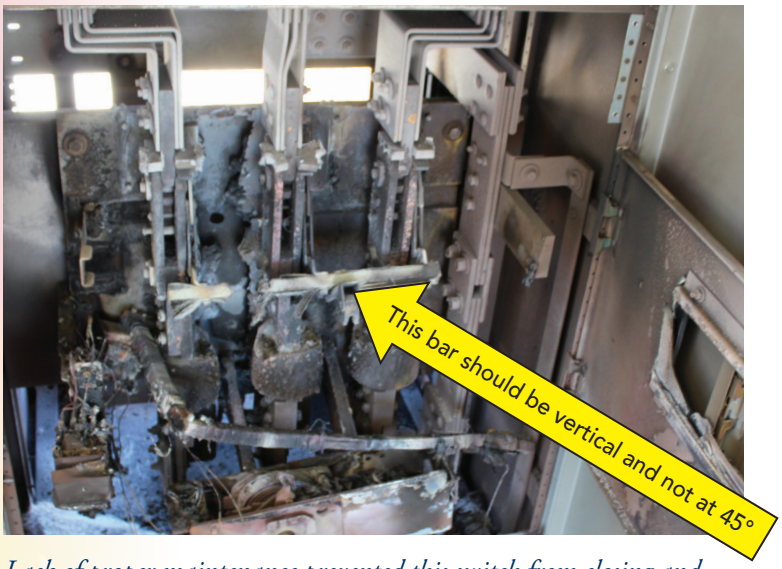
As an example, bolted pressure switch manufacturers typically require annual inspection and lubrication of the conductive blade parts and the operating mechanism. Depending on the presence of adverse environmental conditions, such as excessive temperatures or dirty or wet conditions, more frequent inspection and maintenance may be required. If a bolted pressure switch is involved in an event where fuses have blown or if it has interrupted a ground fault, a complete switch inspection should be performed. One manufacturer states that, after a switch has interrupted a fault, switch design standards indicate that an unserviced switch is not suitable for reuse. After a fault opening, contaminated lubrication may need to be removed. Pitting, splatter and weld marks may need to be addressed. In addition, arc quenchers and barriers may need inspection and repairs. Contamination from the fault may prevent proper future operation of the opening and closing mechanisms. Each manufacturer provides additional details for the type of lubricants to use for the cleaning and re-lubrication process to follow. Even though a riveted nameplate was installed with large font size and bold lettering to stress the requirement of annual lubrication, the proper maintenance was not performed. Note that the instructions use the word *required* versus *recommended.*

Many facilities use bolted pressure switches as the main service equipment for the facility. Annual inspections and servicing of these

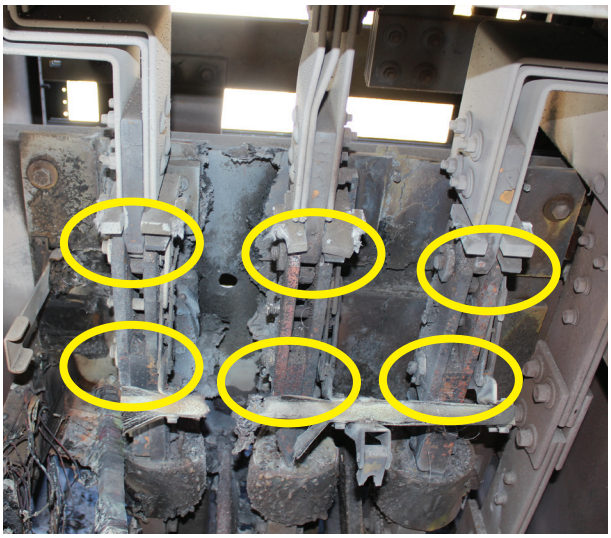
Annual lubrication is stressed by the manufacturer on this nameplate. Many owners and facility managers believe that the main switch is "maintenance-free."

switches requires planned shutdowns. NFPA 70E, *Standard for Electrical Safety in the Workplace* requires electrical equipment to be de-energized, locked out, and tagged out before performing electrical work. NFPA 70E also requires personal protective equipment (PPE) for electrical workers. The frequent requirement for annual maintenance on a bolted pressure switch often conflicts with the typical needs of most businesses trying to maintain continual uptime for 24/7 productivity reasons.

Options exist to replace existing bolted pressure switches with a circuit breaker. This can be accomplished without purchasing all new switchgear enclosures. The benefit of the retrofit is that, under normal operating conditions, many new circuit breakers allow for significantly longer maintenance intervals. The differences in the vulnerabilities of the mechanical operating mechanisms account for the extended maintenance-interval requirements. This can be a good option when it is impractical or logistically complicated to perform frequent annual maintenance on bolted pressure switch service equipment. Not performing the required maintenance on a bolted pressure switch should never be an option.



Lack of proper maintenance prevented this switch from closing and clamping completely.



The six un-clamped switch joints operated with high contact resistance. Excessive heat and arcing destroyed this bolted pressure switch.

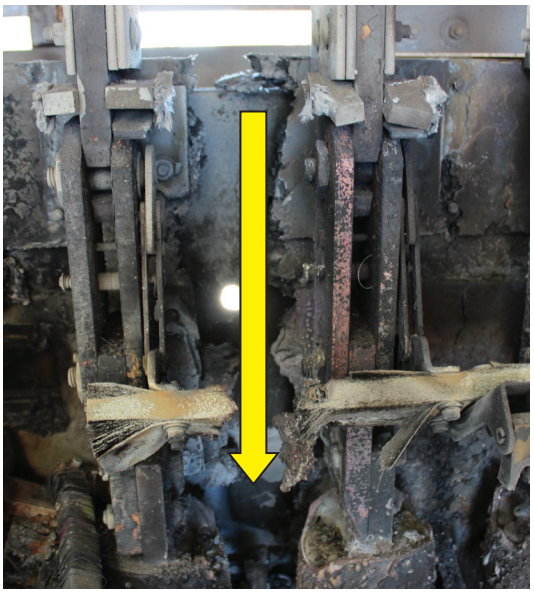
Bolted pressure switches typically have two movable blades per phase. When the switch blades rotate vertically to the closed positon, the two movable blades straddle the upper stationary contacts. With continuous motion, the three pairs of movable blades are clamped tightly at the stationary contacts and at the lower hinge points of the switch blades. The clamping action is usually achieved by rotating a screw that is linked to the switch-closing mechanism.

The insulated crossbar picture shown here indicates that the crossbar arm did not complete its stroke. The bar is at a 45-degree angle. It should be in the vertical position when fully closed and clamped. If the required maintenance is not performed, an event like the one seen in this photo can occur.

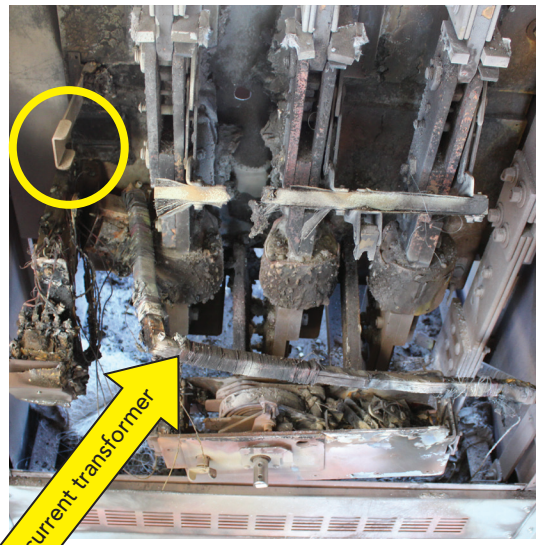
In this case, the switch mechanism did not complete its full stroke to close the blades and clamp them properly. As a result, the switch operated with high contact resistance at all six of the unclamped switch blade locations. High amperage on the main switch caused excessive heat to occur on the blades. This became a worsening condition with increased heating and increased resistance over time. The loose, overheated connections began arcing. Typically, arcing in a nominal 480-volt switch will result in phase-to-ground and phase-to-phase arcing faults. Arcing faults can destroy the switchgear enclosures and the internal switchgear components. The arcing burned a hole through the thick metal mounting plate for this switch. Many owners may not be aware of the arcing fault phenomenon and the degree of equipment destruction associated with arcing faults.

Once established, arc faults tend to travel in a direction moving away from the source. This is caused by the magnetic forces acting between the arc itself and the magnetic flux produced in the busbars. This effect is similar to the electromagnetic forces that cause a motor shaft to rotate. The arc will travel at varying speeds depending on the fault current developed. When the fault currents are over 5,000 amperes, the fault can produce a gun-blast noise. An arcing fault will do the most damage at locations where the arc is physically restrained from traveling due to barriers. In the pair of photos shown here, the insulated fuse sleeves restrained the physical travel of the arc. The intense heat of the arc burned away the thick, switch mechanism crossbar and the insulated switch-mounting panel.

The devastating effects of not performing the required maintenance on bolted pressure



The downward traveling arc burned through the insulated crossbar and burned the tops of the fuses.



The GFPE current transformer melted and fell from its mounting bracket. The mounting bracket can be seen on the left side above the CT.

switches are evident in the top photo.

All three of the main fuses are damaged. The ground fault protection of equipment (GFPE) system is destroyed. The yellow arrow shows the melted and dislodged ground fault current transformer that surrounds all four of the phase and neutral busbars. The GFPE relay is melted beyond recognition. Conductor insulation is damaged. The smoke and combustion products produced in the enclosure have contaminated the entire enclosure.

HOW TO MAKE A POSITIVE CHANGE

It is important to realize that many building owners are not aware of the type of service equipment installed in their facility. In many cases, an owner assumes that a service switch does not require any maintenance. It is understandable that this idea would exist in the owner's mind. Compare the bolted pressure switch annual maintenance requirements to the extended maintenance interval requirements for the circuit breaker installation.

How does the building owner know which one is installed in his facility? Who in the organization is qualified to inspect, identify, and implement the proper preventive maintenance routines for the installed equipment? Although the technical documents for the service equipment and the maintenance requirements probably exist somewhere in an archived file drawer, who is technically qualified to read them and create a maintenance and disaster prevention plan?

In this regard, a positive change and a reduction in catastrophic service equipment failures can be achieved when:

- Electrical design engineers consider the maintenance requirements of service equipment when evaluating and specifying equipment suitable for the customer's actual use. Are the future maintenance requirements ever considered in the electrical equipment selection process? For example, if a building is designed for 24/7 intense manufacturing processes, should a service switch requiring annual maintenance or one requiring extended maintenance intervals be selected? Is it realistic to think that 24/7 types of use could accommodate frequent annual service intervals? Will the intense pressures for productivity always overrule the shutdown requirements for maintenance?
- Electrical contractors proactively notify customers where known service equipment

is not receiving the proper maintenance required by the manufacturer. In many cases, the owner and his employees are not technically qualified to make this assessment. If facility operations and schedules cannot accommodate annual shutdowns, then appropriate extended maintenance interval equipment options could be suggested. This would avoid the continued operation of an unmaintained bolted pressure switch.

- NETA Accredited electrical companies continue a concerted effort to educate owners. Owners and facility managers must be informed of the risks associated with not following manufacturers' maintenance recommendations for bolted pressure switches and other critical electrical equipment.

Owners and facility managers should receive additional resources, such as this article, to explain the destruction of equipment that can occur when a relatively small internal malfunction of a switch mechanism develops into an arcing-fault switchgear meltdown and business interruption disaster.

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