

**Specialized Hazards  
and  
Safety Practices  
When working in  
Energized  
Electrical Substations**

## Overview

Electrical substations contain all of the same workplace components and hazards as any other workplace. Fall, moving equipment, open trenches and excavations, objects on which you can receive cuts and abrasions. Grinding, excavating, welding. Workers need to be knowledgeable in such areas as fall protection, confined space entry, proper equipment operation, working with personal protective equipment related to flying debris, fumes, heat, working from elevated areas and loud noises.

Electrical substations have one additional danger which is not nearly as obvious as an open excavation or something that you can fall off of or moving equipment that you need to avoid. This danger is the electrical energy that runs continuously through the energized substation parts.

Working in an energized electrical substation can be as safe as working on any other construction work site, PROVIDED that PROPER, SAFE working practices are observed. This overview is designed to help you to recognize and avoid the specialized dangers found in an electrical substation. It must be noted here that this in no way touches on ALL possible dangers. All of the normal OSHA requirement for working on ANY commercial work site apply here and one of the best defenses against workplace injuries is observation of your surroundings, communicating well with supervisors and other workers and plain **COMMON SENSE**.

## Specialized Hazards

Certain hazards in substations are not as evident to those who are new to this type of work as they are to those who work in this environment on a regular basis. For example, many pieces of equipment, such as transformers and some breakers, besides being electrically energized, contain parts, such as insulators, that are easily breakable. They may also be filled with insulating oil and have parts, such as cooling radiators, that are easily damaged by equipment, and may therefore leak. In cases of oil leaks, or where an electrical failure ignites the oil, tremendous fires can occur.



**Transformer Oil Fire on an overheated  
69,000 volt substation transformer**

If a fire of this nature should occur on a project on which you are working DO NOT attempt in any manner to try to fight it. The transformer is filled with flammable liquids and the station around it is still energized. Clear the area immediately and call 911 to report the fire. If there is an inspector for the power company normally on site, or a site safety representative, make sure that they are made aware of this immediately as well. DO NOT take ANY action relating to this fire unless you are properly trained and authorized to do so.



The high voltage energy that flows through a substation is invisible and does not make any type of sounds or other indications to warn you that it is present. At the voltages found in substations, you do not have to actually touch the energized parts in order to start an arc. Once an arc is started, it takes several feet of separation to stop it, as seen above. It is important, therefore, that you maintain safe working clearances as shown in the table below. You should not approach any closer than indicated in the table, unless you are properly trained and equipped to do so.

Most substations in which our company works have voltages which range from 13,000 volts on the low side of the station, through about 230,000 volts on the high side of the station.

Per NEC70E, the National Electrical Code safe work practices manual, safe working conditions over 1,000 volts call for workers and equipment to stay clear of energized parts for 10 feet, for the first 50,000 volts, plus an additional 4 inches, for every 10,000 volts above that. This means, that unless you are specially trained and have the proper equipment to do so, the safe working distances from energized parts at some common substation voltages would be:

#### **Station Operating Voltage – Minimum Safe Clearance**

69,000 volts–10.63 ft

115,000 volts–12.17 ft

161,000 volts–13.7 ft

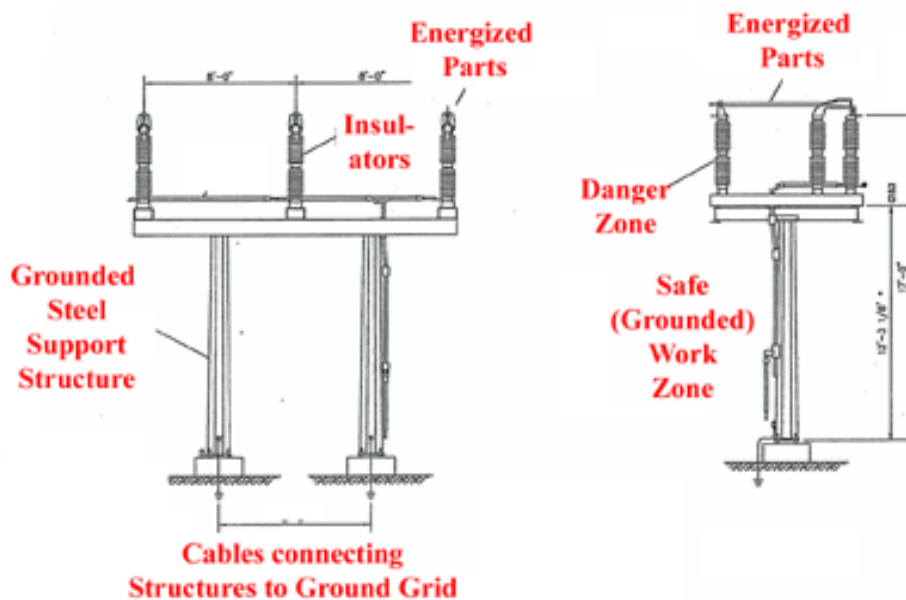
230,000 volts–16 ft

It may not always be possible to maintain these clearances in a substation. For example, if you need to work in the control cabinet on a circuit breaker, the hot jumpers down to the breaker bushings may only be 10 feet or so above the foundation on which it sets. You need, therefore, to make certain that you are familiar with safe working practices for any equipment that you may have to work around, and only work in those areas, and doing those tasks, assigned to you by your supervisor. If you have any doubts or questions about working safely in any area, or on any task, discuss this with your supervisor, to ensure that you are both familiar with how to perform your assigned task safely, and to make any needed changes in order to increase the safety of the assigned task.

## Visible signs to warn of energized parts and areas

Obviously, untrained workers don't need to be working anywhere around energized parts, however, even trained workers need to know some of the things to look for which serve as warnings that they are approaching energized equipment. The first and most common one would be signs and guards that warn of energized equipment in the area. A substation has a fence and signs around it to serve as a warning to anyone who might enter the station that there are electrical dangers within. It is not practical, however, to try to put a label on every structure and every piece of electrical bus to indicate the danger there. Most equipment such as transformers and breakers will have signs placed on them by the factory, however, the steel structures and such do not. A good GENERAL method of looking at this is to understand that the work is divided up into 3 major zones. At the bottom are the steel structures, breakers and similar equipment, which is often made up of steel and which is tied to ground by means of one or more ground cables. The second zone, which usually appears at or near the top of this is the insulators, which are porcelain, fiberglass, or similar insulating materials, and the third zone is the energized conductors themselves. The conductors may be copper or aluminum cable or round, square or angle bus.

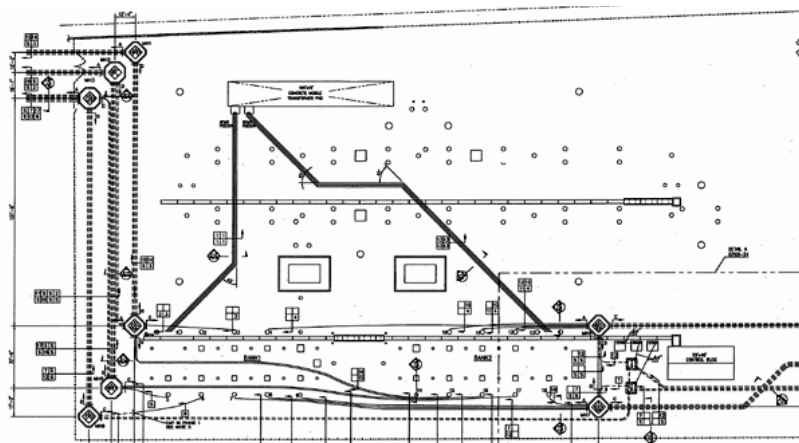
The insulators serve as the materials which hold the energized parts on one end, in rigid relationship to the support structures on the other end. The structure end of the insulator is at ground potential and the bus end of the insulator is at the same potential as the bus work. The entire zone occupied by the insulator should be considered as a "DANGER" zone, and should not be encroached upon **FOR ANY REASON**.



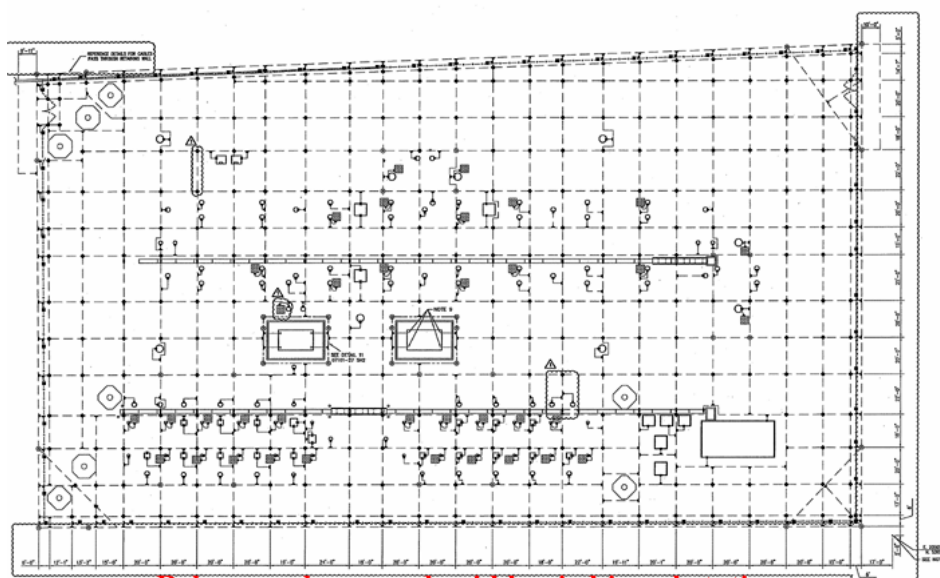
While we are on the subject of overhead clearances, **NEVER** use an aluminum ladder in a substation, and **NEVER** carry or raise conduit, rebar or other conductive item above shoulder level. Even dry wood conducts at these high voltages. Touching an energized bus with a dry 2x4 will kill you just as if it were a piece of steel.

## Below Grade (Underground) Dangers

While any area has the potential to have something buried below ground where you cannot see it, substations tend to have a LOT of things buried below grade. Most notably are the ground grid, which is made up of buried copper cables welded together in a large ground, and the buried conduits and ductbank which carry power and control cables throughout the station. Sometimes these conduits are encased in concrete, but most often they are simply PVC conduit direct buried underground. You must always take care when digging below grade, as some of these are only 18 inches deep.. If you cut a low voltage control conduit, you can trip out the entire station. If you cut a high voltage power conduit you could cut a cable with up to 135,000 volts on it. Even cutting a ground cable can be dangerous. For example, if the tail was the ground for a potential or current transformer or lightning arrester, which has it's opposite end tied to the energized bus, the tail can now be at the same potential as the energized bus. If you cut or damage ANYTHING while digging, let your supervisor know immediately so that he can inspect the damage and determine what actions need to be taken to effect repairs.



**Conduits and ductbanks buried in a substation**



**Below grade ground grid buried in substation**

## Other “Innocent” looking dangers

There are also other dangers to look out for. For example, many substations contain switchgear which feeds outgoing underground circuits. Normally this gear is closed and locked, however, there may be times when it is open for maintenance and inspection. The connections at the back of the gear, where the feeders tie on, can contain several thousand volts, yet look perfectly harmless. Similarly, the switchgear and the entire station are often protected and controlled by sensitive relaying, which is mounted in the gear, or in a control building. Bumping one of these relays, or a control switch can accidentally knock the entire station off line, or worse yet, accidentally energize something that is supposed to be turned off.. This leads us to the subject of lockout and tag out procedures, which follow.



**Underground 15,000 feeder cables  
in rear of metal clad switchgear**



**Relays and switches on panels and switchgear, if bumped  
can lead to large scale power outages**

This might be a good place to mention driving over manholes and cable trench. Some manholes and trench are traffic rated and driving over them should not be a problem. Others, however, are not heavy enough to stand the weight of a vehicle and will collapse. Be sure to know the rating of what you drive on before doing it. Generally speaking, drivable cable trench is easy to spot due to having very heavy lids and side walls. For manholes, you need to resort to the manufacturers rated load strength.



**Traffic rated precast cable trench with lids removed**

Note the extra thick lids and sidewalls on this trench

## Specialized safety procedures

There are certain specific hazards on some jobs which require specialized procedures tailored to that project, in order to ensure safe working conditions. Confined entry is one, especially around place like power plants and places with a lot of other types of underground utilities involved. A second one is Lockout – Tag out.

Because of the highly specialized nature of these procedures, they are discussed in detail in a job specific safety plan, which was written to take into account the unique problems and dangers of that particular job. In some cases, especially in new stations, we often handle our own lockout and tag out procedures, however, especially where we are working in existing powerhouses and substation, we work under the Owner’s procedures and they control the procedure. There is one thing in common with all of these however, which is to say that one of the quickest ways to get someone hurt, or to get run off of a job is to violate these specialized procedures.

The bottom line is that a construction job can be a reasonably safe place for all of us to work if we ALL do our part and help watch out for each other. If you ignore, or violate the rules, however, you stand in danger of hurting yourself, hurting someone else, and disciplinary actions up to an including immediate dismissal.

Your Superintendent will go over these various safety issues with you in jobsite safety meetings and at the start of work on any new work item. If you have any specific questions or concerns, speak to him immediately in order to avoid confusion or getting yourself or someone else hurt.

I would also take a moment here to note that this overview has been tailored to address the specialized hazards found in energized electrical substations. All of the other hazards found on almost any jobsite are also present, such as excavating, concrete forming and pouring, steel handling and erection, fall protection and equipment operation. All of the normal OSHA rules apply to all of this and are a part of the jobsite safety plan. This overview was drawn up in order to bring to your attention the specialized hazards of this type of work, which many construction workers do not work around on a normal day to day basis, and as such these things need to be brought to the forefront of your attention, in order to work safely in this type of work.

**I have read the information included in this handout and have been made aware of the hazards discussed. I also realize that all OSHA rules apply to this work, as in any other commercial construction project.**

Employee Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Supervisor Signature: \_\_\_\_\_

Date: \_\_\_\_\_