

Visual Inspections



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THIS IS THE FIRST IN A SERIES OF REGULAR ARTICLES that focuses on electrical inspection methods and technologies that are performed while the electrical system remains energized. Although no-outage inspections can be very valuable tools, always remember to comply with the appropriate safety guidelines when conducting inspections.

Visual inspections can be one of the most valuable and convenient on-line tools for determining equipment problems when performed by experienced technicians. Although these tasks are frequently taken for granted by the customer, a “trained eye” can often detect problems by just walking into substations or glancing at switchgear lineups. The power of observation is also very useful during outages when even closer equipment examination can be performed.

NETA certainly recognizes the importance of visual inspections. The visual inspection portion of the testing procedures for various equipment listed in the 2005 Maintenance Testing Specifications (MTS), makes up approximately 30 percent of the overall procedures. Appendix B of the MTS entitled “Frequency of Maintenance Tests” lists the recommended frequency for performing visual inspections (and other procedures) based upon the relative condition of the equipment and the equipment reliability requirements. This guideline can be applied to individual equipment in order to produce a customized visual inspection program for any facility. The guideline recommends monthly visual inspection frequencies for much of the equipment categorized as being in average condition and having medium level reliability requirements. This suggested inspection interval may increase or decrease based upon the specific equipment’s condition and reliability requirements.

In addition to visual inspections, our other senses such as hearing and smell can also help detect problems with energized equipment. Although the other senses generally do not detect as many problems as vision does, the pungent smell of ozone usually indicates advanced corona problems and crackling sounds may indicate similar corona or insulation tracking conditions. The smell of burnt varnish or other insulation mediums can indicate complete insulation failure, or an overload condition, especially with regards to dry-type transformers and motors. Additionally, an unusually high vibration noise or the squeal of a failing bearing can point to a potential mechanical problem.

The following items represent a partial list of potential problems that can be found with a keen eye and awareness of all our senses.

External Inspections – Conducted by observing the outside of the equipment or surroundings.

Vegetation growth – Tree and bush growth can cause clearance problems with overhead conductors, and their root systems can present a hidden but serious problem to underground circuits or structures. Climbing vines can also quickly work their way toward conductors or into switchgear busing compartments, and any type of vegetation can attract unwanted animals. First and foremost, tripping on vines or root systems can seriously compromise safety. Inadequate working clearances should not be overlooked or allowed to exist. One could trip and fall and be injured by a pointed cut off limb or other unseen hazard hiding behind fresh foliage.

Environmental fit – Poor outdoor equipment enclosure condition has caused the sudden premature retirement of many switchgear assemblies. Signs of switchgear moisture entrance can readily be detected by visual inspections. Additionally, signs of condensation may be apparent inside the switchgear, pointing toward possible strip

heater malfunction or improper heater sizing and layout design. Even signs of minor enclosure corrosion at points of paint nicks, cuts, and scrapes should be monitored carefully so that complete environmental deterioration and exposure does not occur.

Gauges and Meters –Outdoor equipment gauges are other often-overlooked items that can provide valuable information related to potential equipment problems as long as simple visual inspections are regularly conducted and logged. Transformer, load tap-changer, bushing, and oil circuit breaker (OCB) fluid levels should be observed regularly. OCB sight glasses that do not allow oil levels to be distinguished present a potential hazard, and if significant oil leaks are also present, safe breaker operation may be compromised.

The picture below shows severe color differences between the closest internal bushing conductor compared to the other two phases. This transformer was only a few years old, and utility personnel entered the substation on a daily basis. However, routine visual inspections along with other maintenance procedures were being deferred due to the utility's need to focus resources on new construction activities related to a sudden local economy boom. The problem was only detected by the casual observation of an outside testing agency's technician who was present on an unrelated switchgear cable problem. After this picture was forwarded to the transformer manufacturer, a new bushing was immediately on its way to the utility at no charge. This casual visual observation by the trained eye of a conscientious technician may have saved the utility millions of dollars, had catastrophic bushing failure occurred.



The dark discoloration of the closest internal bushing conductor indicates a potential serious problem in this large substation transformer.

Pressure gauges located on transformers, SF₆ circuit breakers, and other equipment can also provide solid information regarding potential equipment anomalies.

Finally, transformer temperature gauges are often useful indications of potential problems, and the maximum temperature indicator position should also be noted and logged.

Internal Inspections are conducted by removing enclosure covers and, therefore, require a great deal of care and safety considerations. Adherence to NFPA-70E for PPE requirements should be maintained with diligence while performing internal inspections.

Cleanliness – general equipment cleanliness can sometimes be observed from the outside of the equipment. However, it is not uncommon to find stark contrasts when covers are removed for visual examination. Dust can compromise surface insulation integrity and, if moisture is introduced, insulation tracking can occur rapidly. Many insulation materials which are designed to be hydrophobic (repels water), can become quite hydroscopic (absorbs water) due to this environmental contamination of accumulated dirt on the surface of insulators.

Insulation of the windings of dry-type transformers, motors, and generators depends on only a few mils (thousandths of an inch) of varnish or enamel as the insulation medium between turns of adjoining windings. This thin layer of insulation can be easily damaged by the abrasive effect of infiltrated dirt and normal 60 hertz vibrations. Additionally, the natural cooling of materials by radiation and convection is seriously compromised by even a thin layer of dirt, and air passageways for cooling air can be completely blocked by sufficient accumulation of dust. Dust buildup also impairs lubrication and can cause mechanical problems within circuit breaker operating mechanisms and other mechanical equipment.


Transformer laminations or core steel, are actually isolated from each adjoining layer by a thin surface insulating layer. This isolation of adjoining layers of laminate sheet steel limits or reduces the eddy currents in the core, thus affecting transformer performance. If the core is allowed to have a layer of dust accumulate on the laminations, it will migrate over time into the space between laminate layers. Due to thermal expansion, contraction, and normal 60-hertz vibration, it will wear away the surface insulation of the core steel. The result of this loss of surface insulation is exposure to oxidation of the bare steel surface and electrically shorted layers of lamination. The shorted layers of core steel allow for an increase of eddy currents and performance degradation to the point of pre-mature failure.

Miscellaneous – Severe overheating, insulation tracking, poor workmanship, improper cable bend radii, improper clearances, code violations, incorrect power cable shield routing through current transformers, and many other problems can be detected by thorough internal visual inspections.

Any sign of rodent entrance requires immediate action as rodents can cause sudden short-circuit faults as they crawl throughout the bus or damage critical wiring with their sharp teeth. Often rodents gain access to switchgear via networks of unsealed conduits which is also an indication of potential problems.

Conclusion

Although often underestimated, visual inspections can be one of the most valuable tools when they are performed by a conscientious, trained specialist. These inspections are a good first step in any maintenance program. This article pointed out just a few of the many possible visual inspection applications that exist for electrical equipment. With the relatively low cost of digital cameras today, every technician should have one available at all times. Not only does a picture supplement a test report, it is often the single most coveted prize that a facility manager, fighting hard to keep

electrical testing dollars in the budget, has to convince upper management of the value your services provide. Additionally, a picture can reduce a time consuming written narrative report of perhaps a thousand words or so to an abbreviated phrase or caption attached to a picture. 

Mr. Genutis received his BSEE from Carnegie Mellon University, has been a NETA Certified Technician since 1991, and is a Certified Corona Technician. Don's technical training and education are complemented by nearly twenty-five years of practical field and laboratory electrical testing experience. He is presently the Vice President of Hampton Tedder Technical Services, a NETA Accredited Company. Don co-founded I.Q. Services, in order to provide a quality based and affordable solution for the partial discharge field testing industry.

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