How to test hot-line tools in compliance with OSHA

A practical investigation of testing methods permitted by new regulations

OSHA Rules and Regulations recently published in the Federal Register address the work practices to be used during the operation and maintenance of electric power generation, transmission and distribution facilities. Previous OSHA regulations applied to the construction of power lines but did not apply to operation or maintenance.

The new regulations, portions effective May 31 and November 1, 1994, cover numerous aspects of line operation and maintenance. Live-line tools (hot sticks), including their design, operating condition and periodic testing, now are governed by rigorous rules.

This article briefly summarizes those requirements and includes comments relating the new rules to previous industry standards. For a more extensive discussion of service and test procedures, see section beginning on page 4. For complete documentation and source information, the OSHA and Standard references cited there should be consulted.

Design:

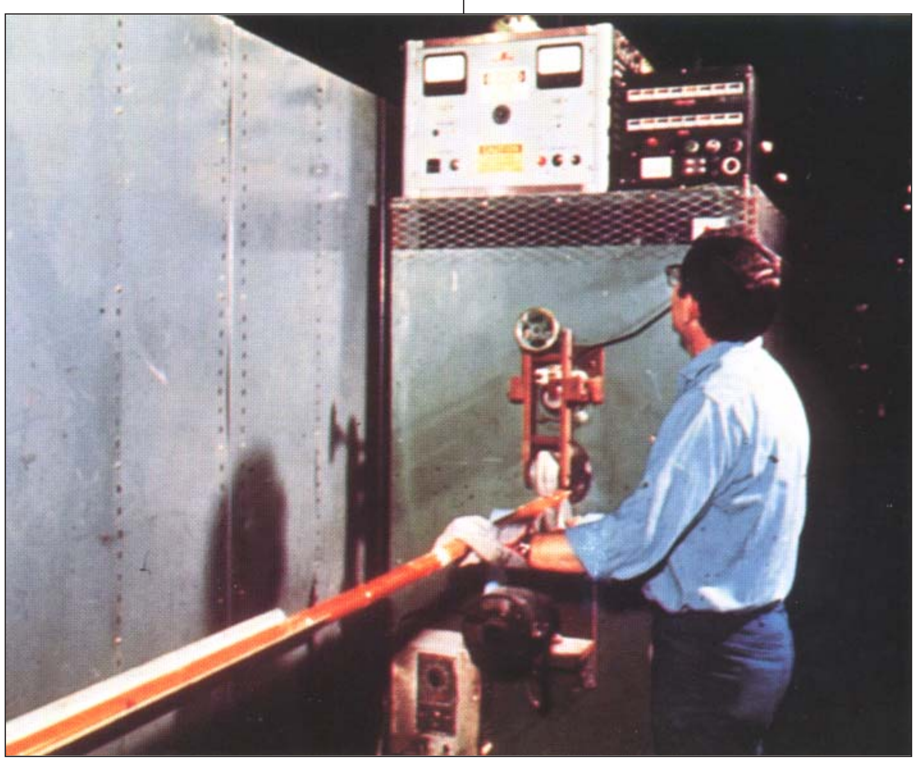
FRP (fiberglass-reinforced plastic) live-line tools must be designed and constructed to withstand 100,000 V/foot for five minutes. FRP tools that meet ASTM F711-89 Standard Specifications conform to this requirement.

Wood tools must be designed and constructed to withstand 75,000 V per foot for three minutes.

Comments

ASTM Specification 711 was originally published in 1981, revised in 1983, and again in 1989 (the current version). Chance has had an active role in the development of this standard. Chance tools have been manufactured in conformance with this standard since its inception.

FRP tools that were manufactured by Chance prior to the initial writing of ASTM F711 were designed and manufactured under proprietary standards that meet



Factory test monitors leakage current and withstand strength at 50 kV per 6" over full length.
All Chance Epoxiglas® hot sticks are manufactured to ASTM requirements.

the current ASTM requirements and which, in large measure, set the requirements which subsequently were adopted by ASTM.

Wooden tools manufactured by Chance (mostly prior to 1960) were designed and manufactured under proprietary standards which also largely set the current requirements for wood hot sticks.

Because of the inherent large variables in wood tool moisture content and because most of those remaining in service are more than 35 years old, Chance recommends that wood tools should be among the first to receive the careful testing required by OSHA.

Condition

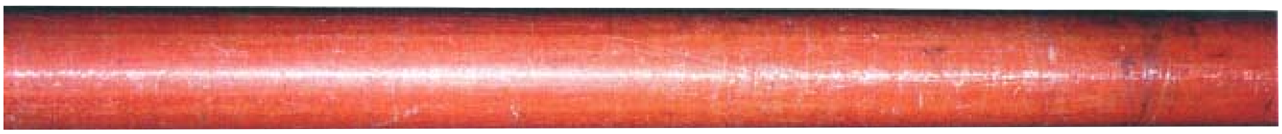
Each live-line tool shall be wiped clean and visually inspected for defects before use each day. If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the tool is present after wiping, the tool shall be removed from service and examined and tested in a manner prescribed by OSHA before being returned to service.

Comments

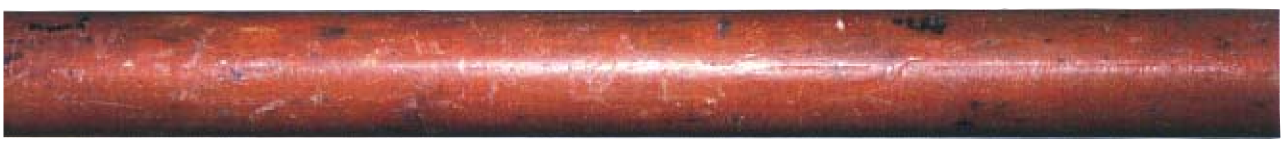
Chance has long recommended that hot-line-tools be wiped with a silicone-impregnated cloth prior to daily use. This, plus the required inspection, are common-sense safety measures which have been a standard practice of many utilities.

Periodic maintenance and testing

Every two years, live-line tools used for primary employee protection shall be removed from service for examination, cleaning, repair and testing. Also, anytime the daily wiping and inspection routine requires a tool to be removed from service, it must undergo the same examination, cleaning, repair and testing procedure that is required



Typical used stick that will not pass the OSHA wet test even with a wax or silicone treatment. Complete refinishing is required to restore glossy surface and enable this tool to pass the OSHA wet test.



Tool as taken from utility service. This tool could not pass the OSHA wet test even after complete factory refinishing. Tools in this condition must be removed from service.

Used tool in basically good condition. With a wax or silicone wipe, this tool will pass the OSHA wet test and is satisfactory for service.

It has always been a good practice to inspect and wipe clean hot sticks before each day's work. This is now an OSHA requirement.

on a two-year basis for all hot-line tools.

All non-FRP (wood) tools must be electrically tested before being returned to service whether they have been repaired, refinished or merely cleaned and waxed.

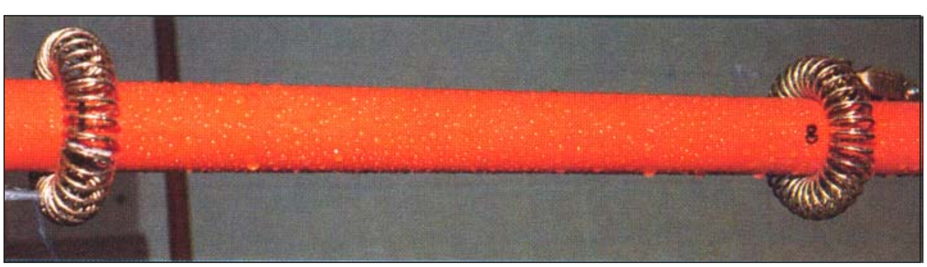
All FRP tools must be electrically tested unless repair or refinishing has not been performed, and the employer can demonstrate that the tool has no defects that could cause it to fail in use.

Chance LS-80 hot-stick tester in laboratory use. This instrument is recommended by Chance as a field check (sticks tested dry) and as an alternate to the OSHA laboratory test (sticks tested wet).

Typical laboratory set up for performance of the OSHA test. 75 kV is required for fiberglass tools: 50 kV is required for wood tools.

(Above) To pass the OSHA wet test, water must bead up rather than wet out the surface. Wax or silicone will enhance this property if the surface is in satisfactory condition.

Close-up of the electrodes, below, and 1-foot test section. Note beading of water, indicating the stick surface is in good condition.



Test methods

When testing of tools is required under any of the circumstances listed above, the specific methods are described in the OSHA Rules and Regulations and in IEEE Standard 978-1984.

FRP tools require a wet test at 75,000 Volts per foot for one minute. Non-FRP tools (wood) require a dry test at 50,000 Volts per foot for one minute. Tests must verify the tool's integrity along its entire working length.

An alternate Watts-loss test method that is performed at lower voltage (2,500 Volts minimum) is also acceptable. Either of these test methodologies require laboratory equipment and techniques.

Comments

Note that wet tests are never performed on wood tools. This is consistent with the long-held practice that wood tools should never be intentionally exposed to water under any circumstances.

"Other tests that the employer can demonstrate are equivalent" are also allowed by the OSHA Rules and Regulations. The following section describes tests at Chance to qualify one such alternate test as equivalent. This method also can be used to provide an enhanced verification of the tool's integrity in the daily use routine. It is a proven and practical field test that does not require laboratory equipment or techniques.

OSHA Regulations and the Chance® LS-80 Hot Stick Tester

In response to the new OSHA regulations, Chance performed an extensive test series in June 1994. Tests on new and used hot sticks compared the results using IEEE tests prescribed in the OSHA Regulations and the Chance LS-80 Hot Stick Tester. Wet tests were of particular interest because of the new OSHA wet test requirements. The purpose was to determine the appropriate uses of the Chance LS-80 Hot Stick Tester in the new program. Other objectives were to obtain a comparison between wet and dry tests and to determine the effectiveness of wax versus silicone oil.

Hot-stick dielectric properties

A hot stick can become electrically unsafe because of either of two general conditions:

1. Internal conductivity can increase from moisture ingress, dielectric deterioration or internal structural changes. Significant loss of dielectric strength from these causes should not occur in a tool that is properly designed, manufactured, used and stored. However, the numerous "ifs and unknowns" in the history of any tool preclude the assumption of a sound internal dielectric.

2. Surface conductivity can result from a combination of loss of gloss, wetting and contamination. Deposits of surface contamination, especially in the presence of moisture, can render even the most perfect tool unsafe. Even surface moisture alone can render a tool unsafe if the surface is non-glossy to the extent that it allows the moisture to wet out the entire surface.

Thus, it is essential that the surface be both clean and glossy. The gloss prevents wet-out or sheeting of moisture that can cause conductivity. In this sense, moisture alone is a contaminant. The best procedure is to avoid the use of hot sticks in damp or rainy weather. If this not always possible, the best defense is a clean, glossy tool that will cause water to bead-up, rather than wet-out the surface.

Test specimens

Nine different hot sticks were used in the test series: Three were brand new and six were taken from long-term utility service. The latter six were selected because of their notably poor condition from a much larger pool of used tools. Surfaces had varying degrees of scratches, scarring, dents and local impact damage points typical of long, hard usage. The surfaces were discolored and dull, but all sticks appeared to be structurally undamaged. Two of the six used tools were prejudged to be unsuitable even to attempt refinishing. Three different diameters were represented: 1¼", 1½" and 2". All were manufactured by Chance. The age of the six used tools could not be determined.

Test methods

Four test methods were used to compare their effectiveness:

- IEEE 978-1984, paragraph 5.3 High-Potential Test Method **(dry)**
- Chance LS-80 Hot Stick Tester **(dry)**
- IEEE 978-1984, paragraph 5.3 High-Potential Test Method **(wet)**
- Chance LS-80 Hot Stick Tester **(wet)**

All hot sticks were tested at intervals of 1 foot over their entire lengths. This produced five to eight tests per hot stick, depending on length. During the wet tests using the LS-80 Hot Stick Tester, it was found advantageous to rotate the hot stick 360 degrees at each test position to completely explore the surface condition. Wet tests were performed with demineralized water purchased in a local grocery. Conductivity of the water measured 3.0 micromho-cm at room temperature. Water was applied to the test specimens using a mist from a laundry-type spray bottle.

Test sequence/Surface preparation

All hot sticks were tested in a sequence designed to preserve the surface conditions before proceeding to the next stage of surface improvement. Surfaces of used tools progressed from the "as received" condition through cleaning, waxing or siliconing and, finally, complete refinishing. New tools proceeded through all test sequences with only a light wipe with a dry cloth prior to each test series.

Sequence A — As received

All tools were first tested as received, with only a light wipe with a dry cloth to remove any extraneous dust from storage. This is considered to represent the condition of last actual field use of the used tools. Dry tests preceded wet tests.

1	IEEE 978-84, 5.3	75 kV	Dry
2	Chance® LS-80 Tester		Dry
3	IEEE 978-84, 5.3	75 kV	Wet
4	Chance® LS-80 Tester		Wet

Sequence B — Solvent cleaned
The used tools were cleaned with a cloth wetted with Chance® Moisture Eater II hot-stick cleaner. The above test sequence was repeated.

Sequence C — Surface waxing or siliconing
After thorough drying to eliminate any residue moisture from the previous wet tests, one-half of each tool length was waxed with automotive carnauba wax and the other half was wiped with a Chance silicone-impregnated cloth specifically designed for hot sticks. Only the wet tests were performed following this treatment as it was now apparent that all dry tests would indicate "good."

Sequence D — Refinished surfaces
Finally, the used sticks were refinished per Chance specifications for hot-stick repairs. This consists of abrasive smoothing of the surface and refinishing with a clear epoxy coat. Only the wet tests followed this treatment.

Discussion

In performing wet tests, it is important to avoid over-wetting. The objective is to have the water either bead up on a glossy surface or wet-out a non-glossy tool. If too much water is sprayed on the tool, water will collect in a line of drops at the undersurface, producing a false rejection because of flashover or high leakage current. The technique we found successful was to thoroughly spray the test section with a mist applicator until drops just start to run down the surface.

In performing wet tests with the LS-80, certain techniques need to be noted:

a) The instrument should be lifted, not slid, from one test position to another. Sliding produces water streaks that can cause a false Reject indication.
b) The stick should be rotated under the instrument in each test position to more thoroughly test the entire surface of the tool.

Waxing with a good grade of wax or wiping with a silicone-impregnated cloth were judged to be basically equivalent in restoring the glossy, non-wetting nature of the surface. The silicone-oil wipe is preferred because it is a more practical daily procedure (one which Chance has long recommended) and it avoids an undesirable heavy wax build-up.

Test summary

243 individual tests compared the effectiveness of the IEEE 978-84, 5.3 test methodology and the Chance® LS-80 Tester.

229, or 94 per cent, gave identical results. That is, both tests either accepted or rejected a particular section of a hot stick. 142 were accepted and 87 were rejected. This high rejection rate reflected the poor condition of the used hot sticks that were selected for the test series.

All of the rejections were from wet tests on the used sticks. No dry test ever rejected a used or new stick, and no wet test ever rejected a new stick. This indicates that all of the tested sticks were internally sound, with no significant loss of internal dielectric strength.

The poor surface condition of the used sticks was the cause of all the rejections. Of the two sticks that were prejudged to be unsuitable for refinishing, one did recover acceptable surface integrity from refinishing.

Of the 14 (6 per cent) individual test comparisons where the LS-80 and the IEEE tests gave conflicting indications, the LS-80 was slightly more discriminating. The LS-80 rejected 11 of these 14; the IEEE test rejected 3. All of the 14 were in the transitional zone between pass/fail criteria.

Four of the eight IEEE-reject/LS-80-pass test results were judged to have resulted from too much water collection. With the encircling electrodes of the IEEE test this produced a flashover along the underside of the stick at or below 75 kV. Upon retest with slightly less water, these four passed.

Another mitigating factor where conflicting indications were given by the two test methods was the pass/fail criterion which we used. The IEEE Standard requires only that the dielectric/leakage current remain stable at full test voltage for one minute test duration. We also applied a more severe criterion that any current in excess of 200 microamps constituted a failure, even if it had stabilized. This reduced the number of disagreements from 14 to 12, or a 95% correlation.

Considering the conservatism that is built into the interpretation of both test methods, any of the tools which were in a transition zone such that one test indicated Pass while the other showed Reject would actually be safe in its tested condition. However, any such tool has obviously deteriorated to some degree and is a probable candidate for a clear Reject on a future test.

Conclusions

A hot stick must have either internal conductivity or a contaminated surface to fail a dry test. None of the test sticks ever failed a dry test, even though the used sticks were selected because of heavy scarring and general surface abuse.

Heavily scarred sticks consistently failed wet tests, even after cleaning and application of either wax or silicone oil.

Complete refinishing of heavily scarred sticks will restore surface integrity up to some limit of damage that is most easily determined by trial.

Surface wet-out when water is applied is evidence that the stick needs maintenance. Simple waxing or siliconing may suffice if the stick is in basically good condition. Complete refinishing will be required for scarred surfaces. Waxing or siliconing alone will not always enable a stick to pass a wet test.

When wet testing, over-application of water can cause a false indication of failure due to collection of water droplets along the bottom of the stick.

The IEEE test and the LS-80 tester had an excellent correlation (94 per cent) of consistency. Of the 6 per cent of tests where the two techniques gave conflicting indications, the LS-80 was slightly more critical (11 fail versus 3). All of these readings were in the transitional zone between acceptance and rejection where the stick had shown some deterioration, but did not yet represent a hazardous condition.

Recommendations

The following recommendations are made to assist utilities in the furtherance of safe hot-stick practices. We believe they are consistent with the new (1994) OSHA Rules and Regulations for hot-stick use.

a) The OSHA requirement that tools be wiped clean and visually inspected before use each day is best accomplished with a special silicone-impregnated cloth. This provides the right degree of texture for dirt removal with the application of silicone for water repellency (beading).

b) Though not required by OSHA, periodic field or shop testing with the LS-80 tester (dry) gives further assurance that there is no defect or contamination that might adversely affect the insulating qualities and that would require removal of the tool from service for more extensive examination and testing.

c) Under the new two-year OSHA Examination, Testing, Cleaning and Repair requirements, for those tools that do not require refinishing but only cleaning and waxing, no further testing is required ". . . if the employer can demonstrate the tool has no defects that could cause it to fail in use."*
Chance believes that the most practical and effective way to accomplish this is a visual inspection and use of the LS-80 tester with the tool tested dry.

d) For those tools requiring repair or refinishing due to application of either the two-year rule or because of a condition found during the daily inspection, the OSHA Rules and Regulations require testing over the full length of the tool. Two alternatives are allowed:

1) Wet testing at 75,000 V/foot for 1 minute (fiberglass tools) or
Dry testing at 50,000 V/foot (wooden tools)

2) Other tests that the employer can demonstrate are equivalent.
It is the belief and recommendation of Chance, based on many years of experience in the use and testing of hot sticks, and based on the comparative tests presented in this paper, that the use of wet tests with the LS-80 tester fulfills this equivalency for FRP tools. For wood tools, all tests should be performed dry.

**Note that this exception to further testing applies to only fiberglass tools, not wooden tools.*
***Never** intentionally expose or apply water to a wood hot stick — for test reasons or any other purpose.*

References

- Department of Labor, OSHA, 29 CFR part 1910; Federal Register, Vol. 59, No. 20, Jan. 31, 1994, Rules & Regulations.
- IEEE Standard 978-1984, Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools.
- ASTM F711-89, Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube used in Live-Line Tools.

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