

VLF - What Test Voltage & For What Duration

When a voltage stress (proof test) is placed across a cable's insulation, partial discharge can occur in defect locations if the voltage stress is sufficient to initiate the pd, which is the purpose of a VLF AC voltage stress test. If we know how fast electrical trees grow under a given voltage stress, then we know how long the voltage must be applied for significant defects that are triggered into partial discharge to grow to failure during the test. The cable is repaired, retested, and once passing a VLF test, will deliver years of trouble free service. Proper VLF testing exposes serious cable defects, thus preventing in-service failures, while not harming healthy insulation nor aggravating minor defects that will not cause cable failure for many years.

From IEEE 400 Standard

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Std 400-2001

IEEE GUIDE FOR FIELD TESTING AND EVALUATION

Table 1—Tree growth rates as a function of voltage and frequency

Test voltage factor (V/V_0)	Growth rate at 50-Hz test voltage (mm/h)	Growth rate at 0.1-Hz sinusoidal test voltage (mm/h)	Growth rate at 0.1-Hz VLF Cos-Rectangular voltage (mm/h)
2	1.7–2.4	2.3	1.4
3	2.2–5.9	10.9–12.6	3.4–7.8
4	175–611	58.3–64.2	22.2–30.3
5		336	125
Channel tree growth rate on field aged samples of XLPE at different test voltage levels and waveforms where V is test voltage and V_0 is operating voltage to ground.			

From IEEE 400.2 VLF Standard

Table 5: VLF Test Voltage for Sinusoidal Waveform (see Note 1)

Cable Rating phase to phase	Installation (see Note 2) phase to ground	Acceptance (see Note 2) phase to ground	Maintenance (see Note 3) phase to ground
rms voltage in kV	rms or (peak voltage)	rms or (peak voltage)	rms or (peak voltage)
5	9 (13)	10 (14)	7 (10)
8	11 (16)	13 (18)	10 (14)
15	18 (25)	20 (28)	16 (22)
25	27 (38)	31 (44)	23 (33)
35	39 (55)	44 (62)	33 (47)

It is recommended that a cable be tested at 2.5 – 3 times its normal line-to-ground voltage, or $2.5 V_0 - 3V_0$, for at least 30 minutes, longer at frequencies lower than 0.1Hz. For a 15kV cable operating at ~ 7,600 volts line-to-ground, the recommended *maintenance* test voltage is 22 kV but measured as the peak of a sine wave VLF instrument. For 5 kV cable, the multiple is higher since the insulation thickness per kV is greater than higher voltage cables. For HV cable, the multiple is lower.

Summary: To avoid in-service failures following VLF testing, a proper VLF test must be performed. The test voltage must be high enough and for a long enough time for the instrument to do its job of growing major defects to failure. **Test at 2 - 3Vo for 30+ minutes.** If a failure occurs, repair the cable and *re-test* for the full duration. Laboratory research and data from thousands of actual cable tests show that if a cable passes a *proper* VLF test, there is a better than 95% assurance there will be no in-service failure for at least 3 – 5 years.