It’s All In The Interpretation- Outliers Count

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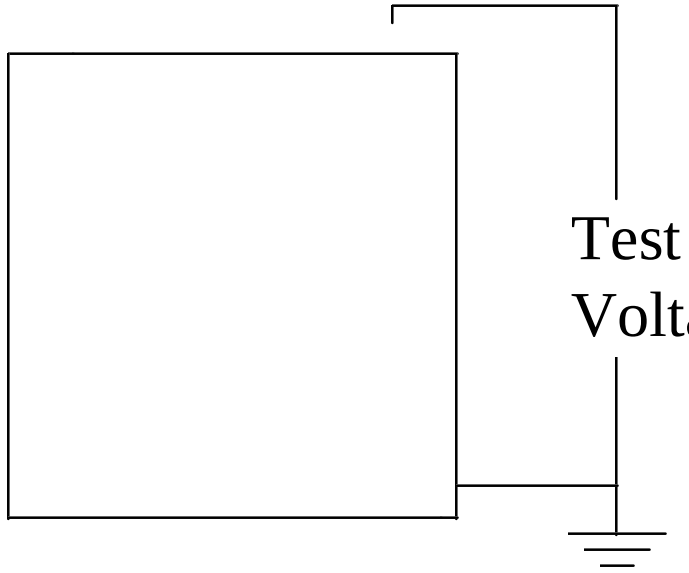
Hendrix Wire & Cable

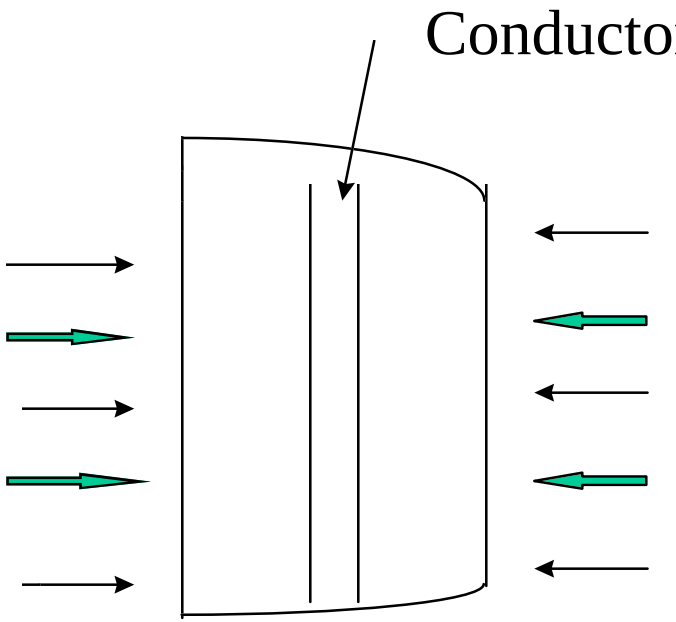
Tests In Which The Temperature Gradient And Water Penetration Act In Unison

Anaconda Wet Tests

Sample With
No Water In
Conductor



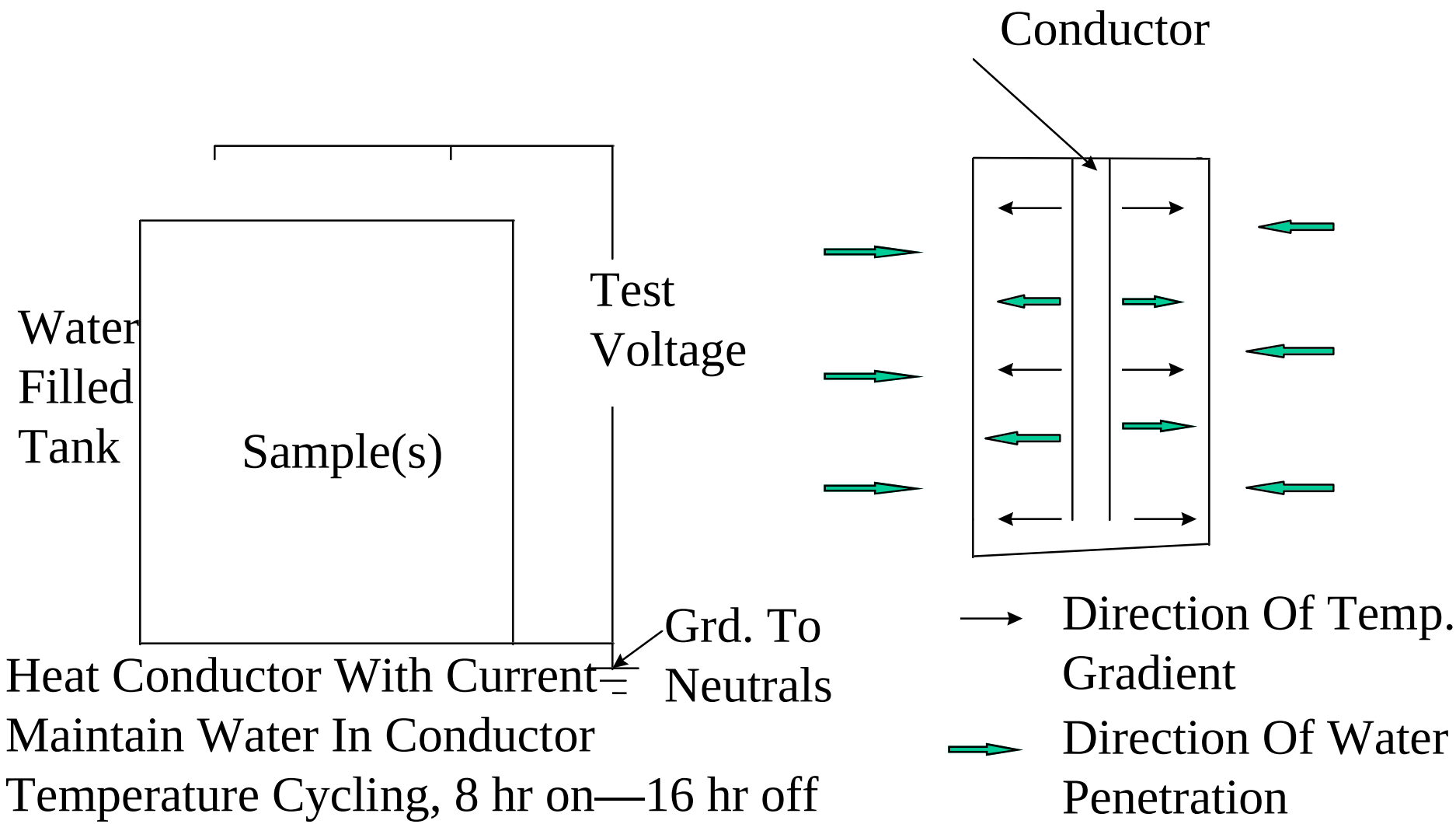
Constant Heat Source
To Heat Water In Tank



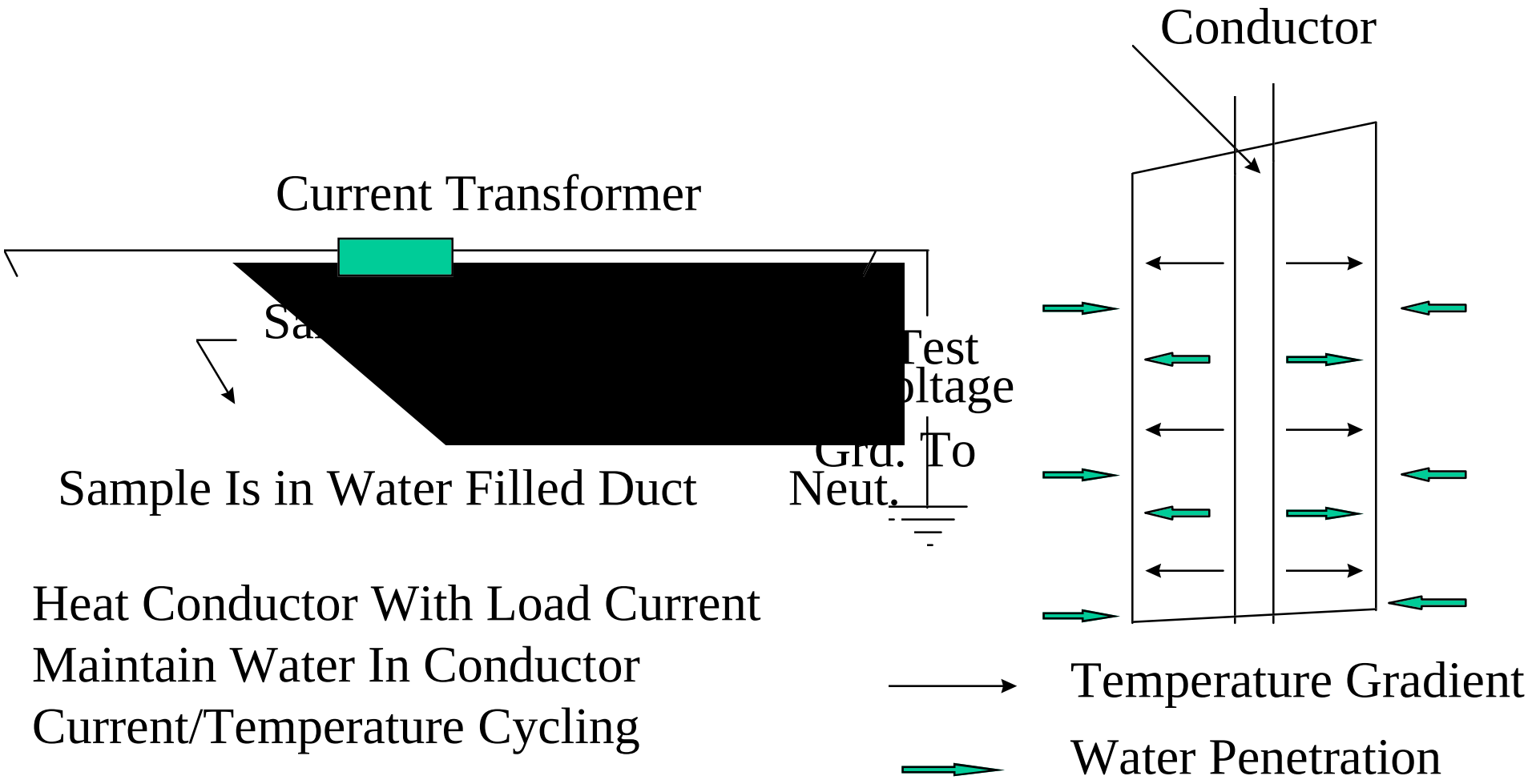
Direction Of
Temperature Gradient

Direction Of
Water Penetration

ALCOA ACLT W/Water In Cdr.
EPRI Accelerated Cable Aging Test

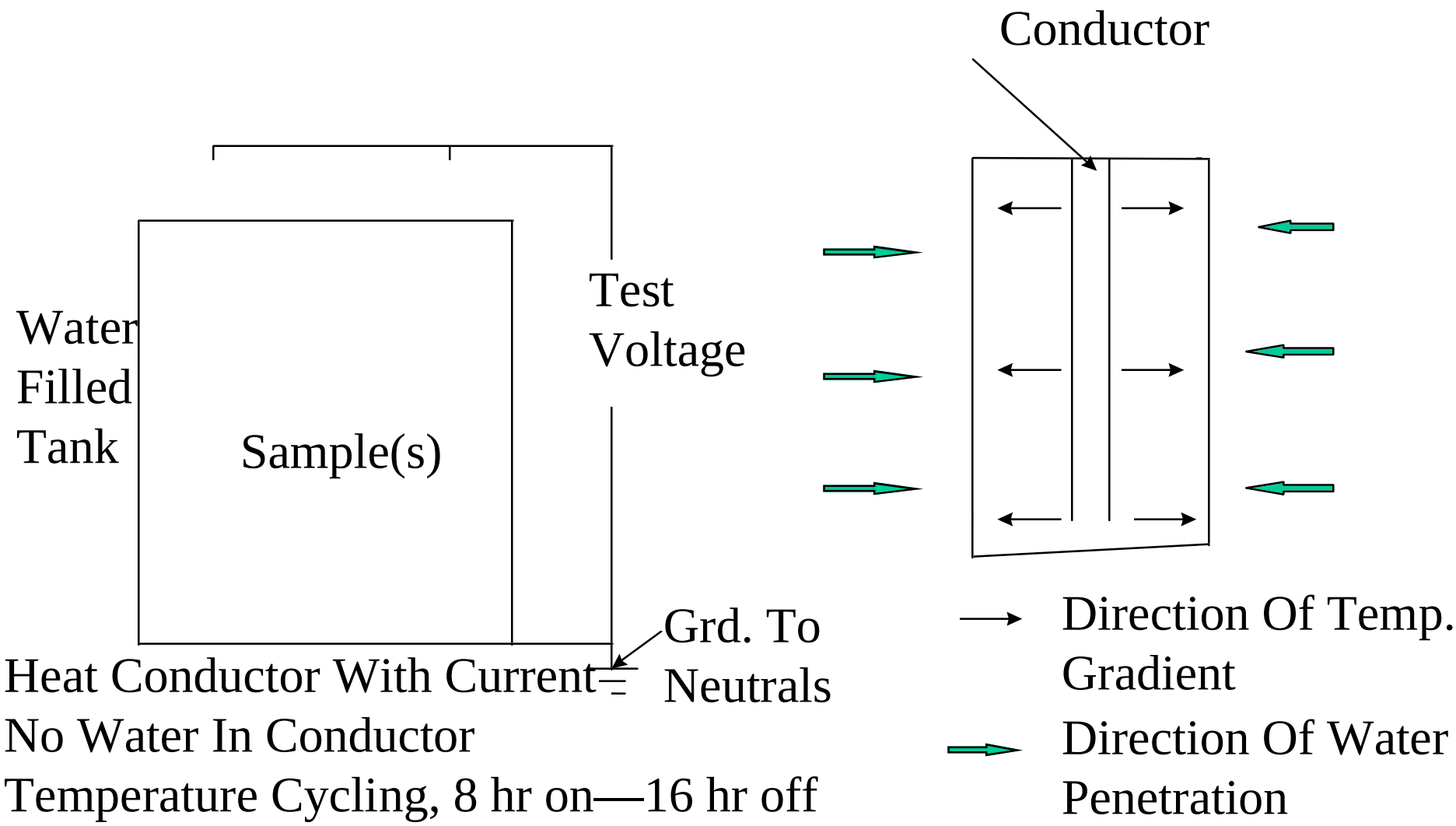


AEIC Water Tree Test W/Water In Cdr.
Pirelli Water Tree Test W/Water In Cdr.

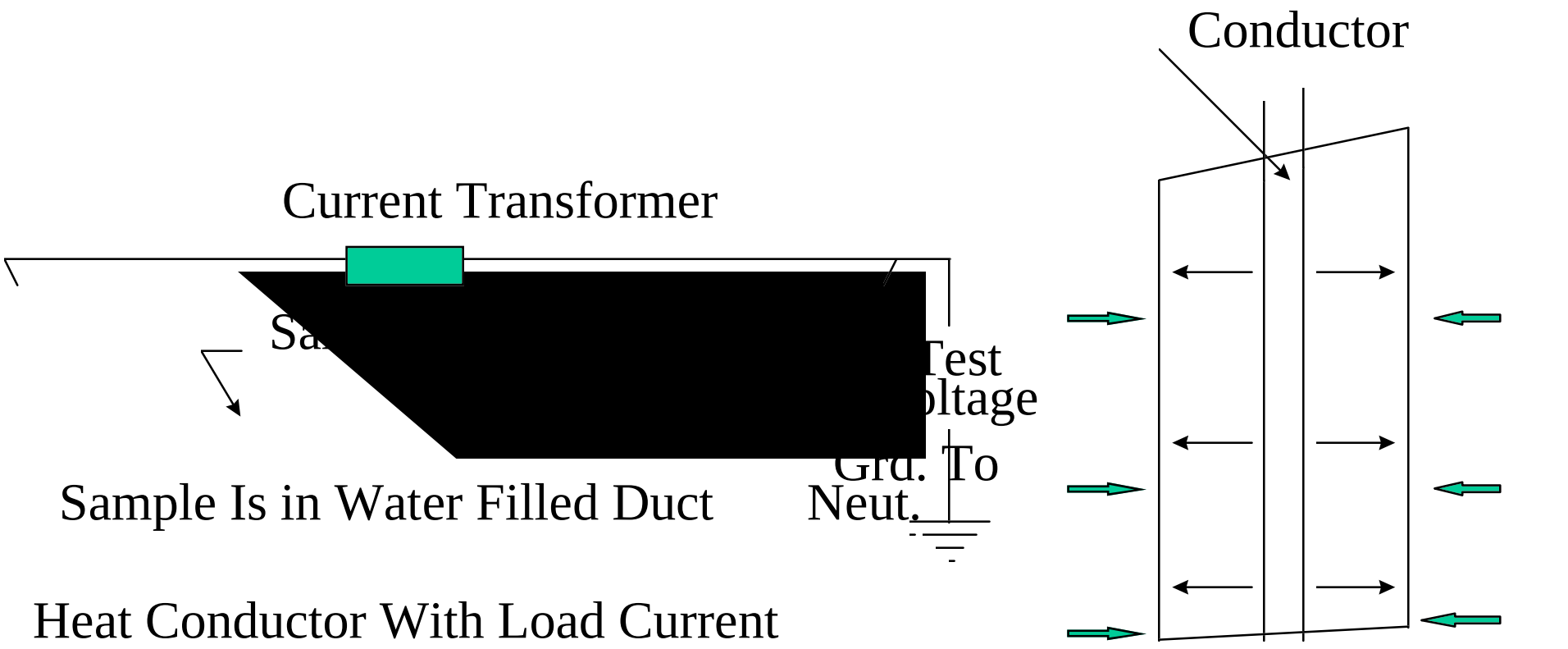


Tests In Which The Temperature Gradient And Direction Of Water Penetration Are Opposing

ALCOA ACLT No/Water In Cdr.

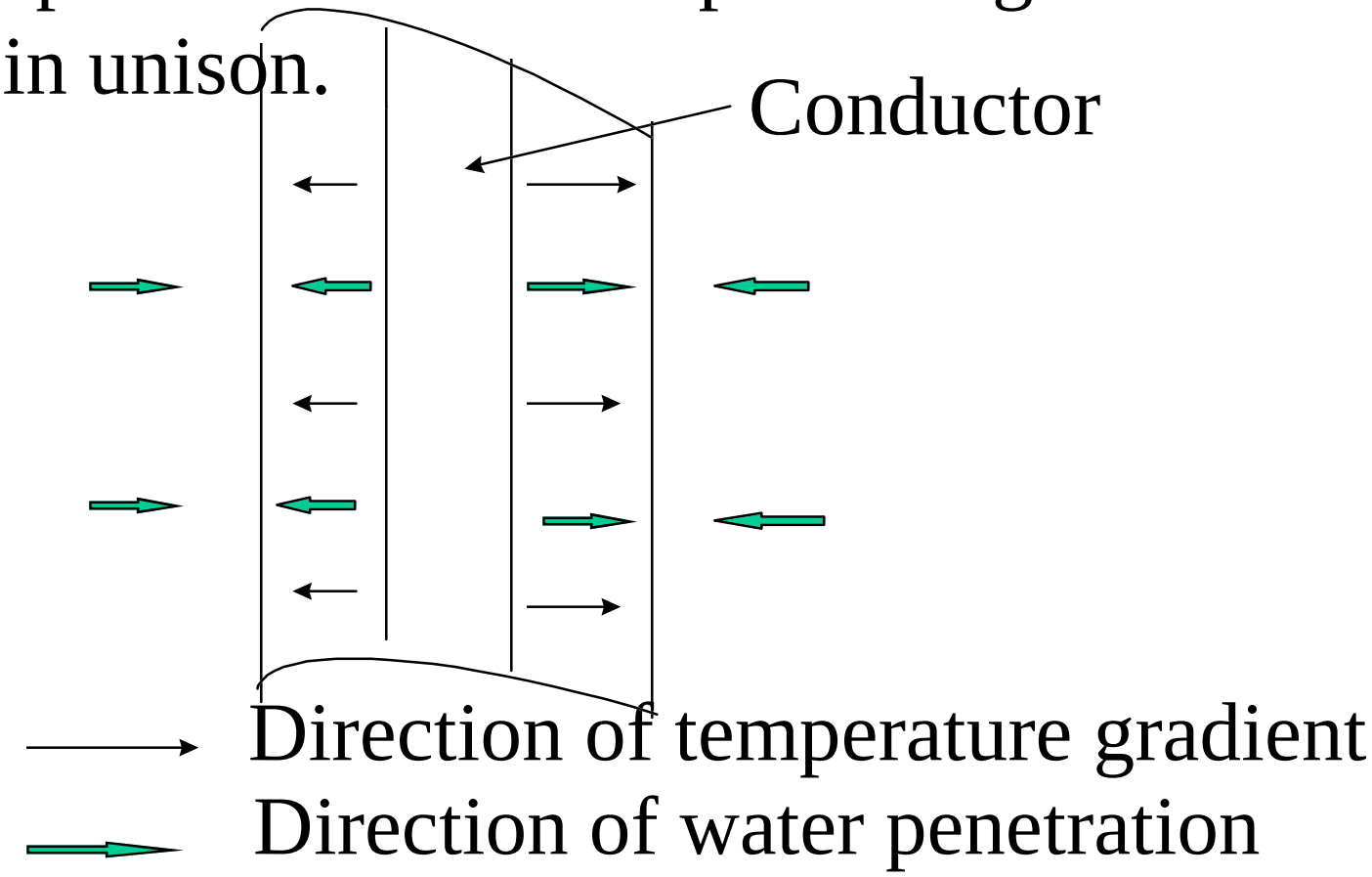


Pirelli Water Tree Test No/Water In Cdr. (Filled Strand)



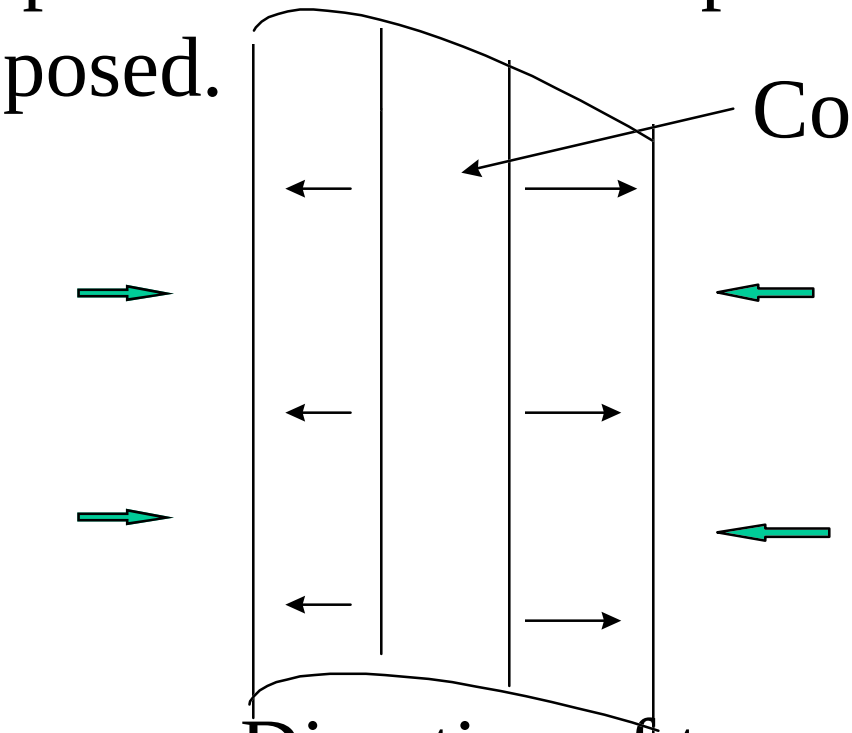
In Service Cables With Water In The Conductor

Water penetration and temperature gradient work in unison.



In Service Cables With No Water In The Conductor

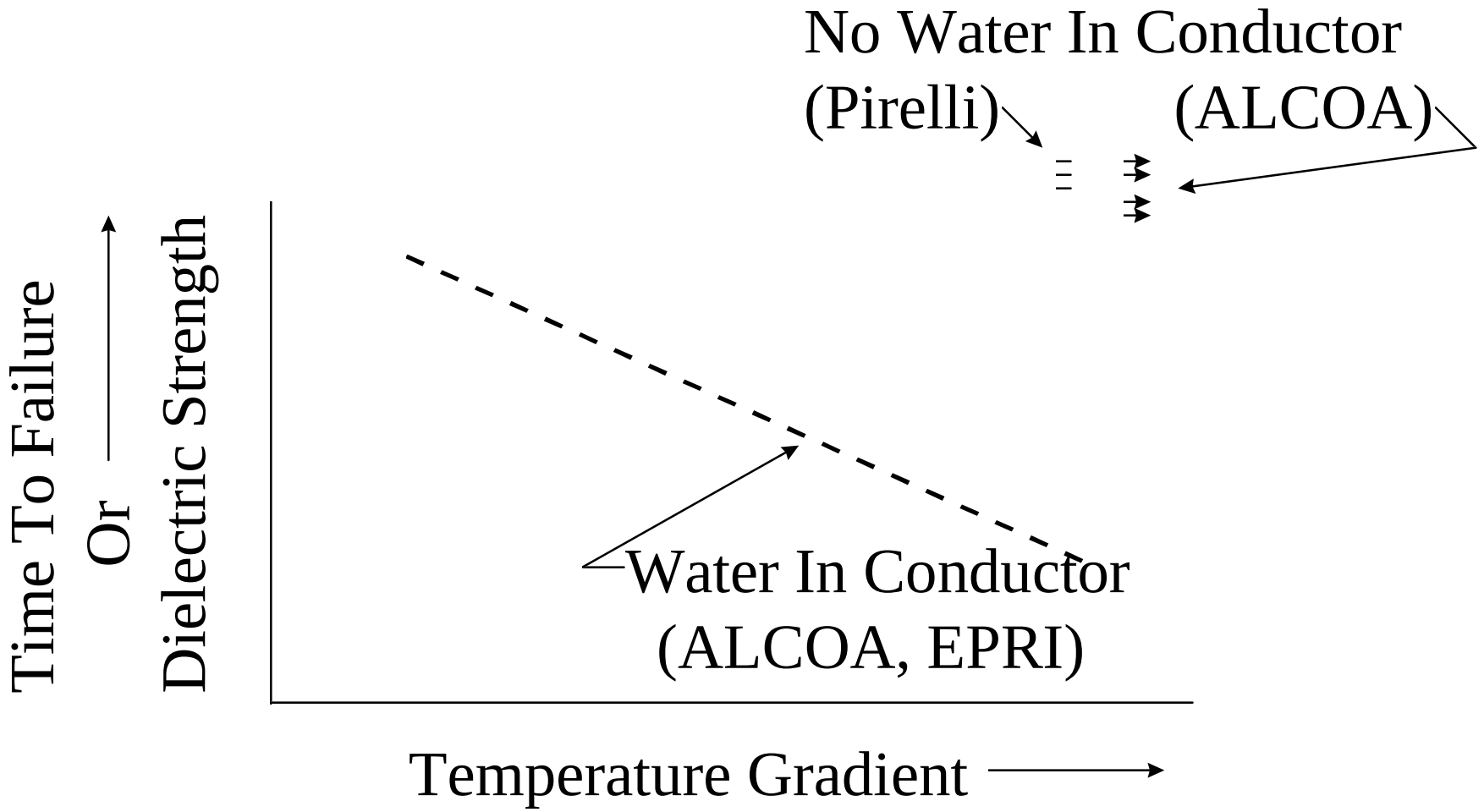
Water penetration and temperature gradient are opposed.



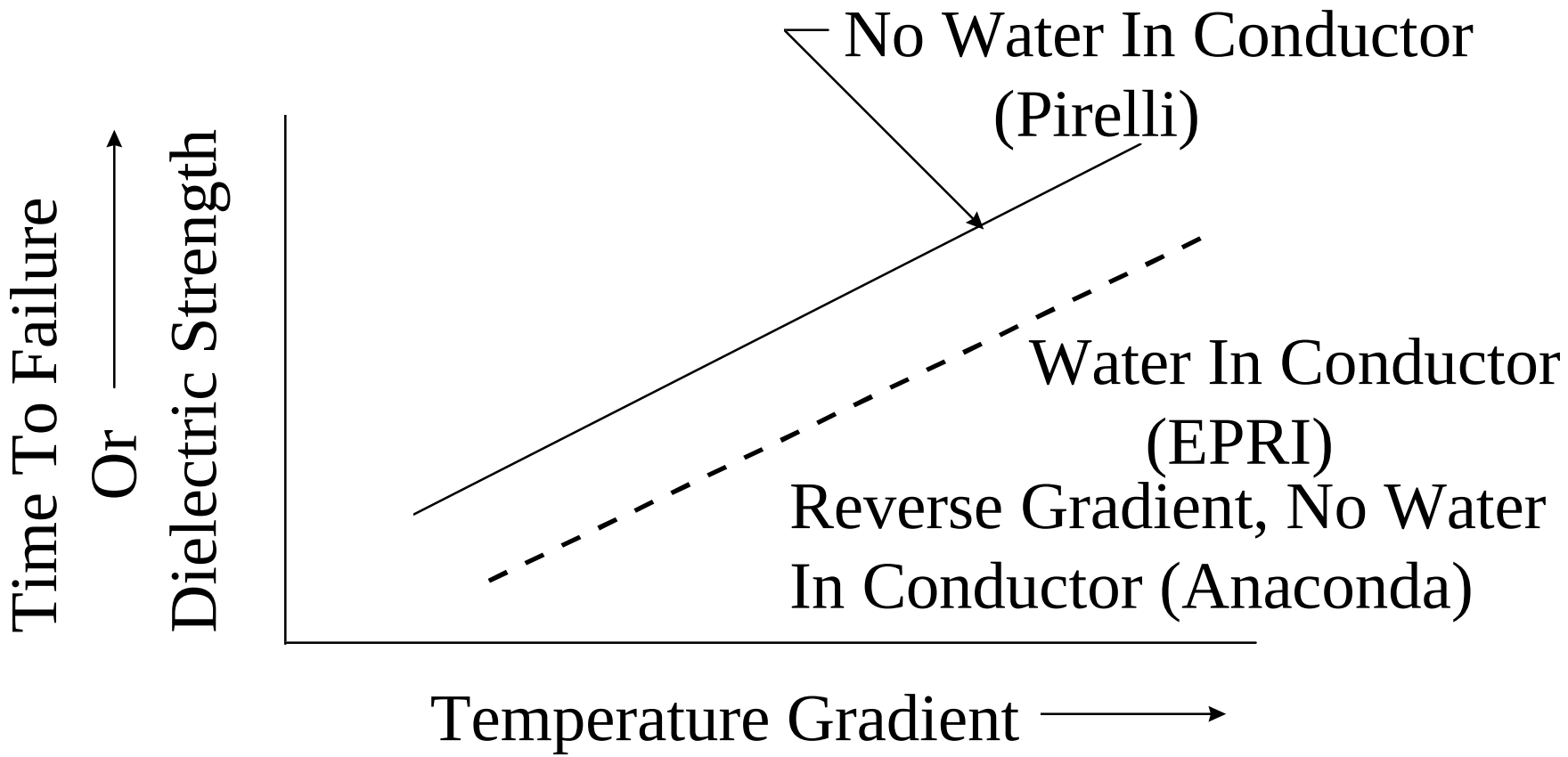
Direction of temperature gradient

Direction of water penetration

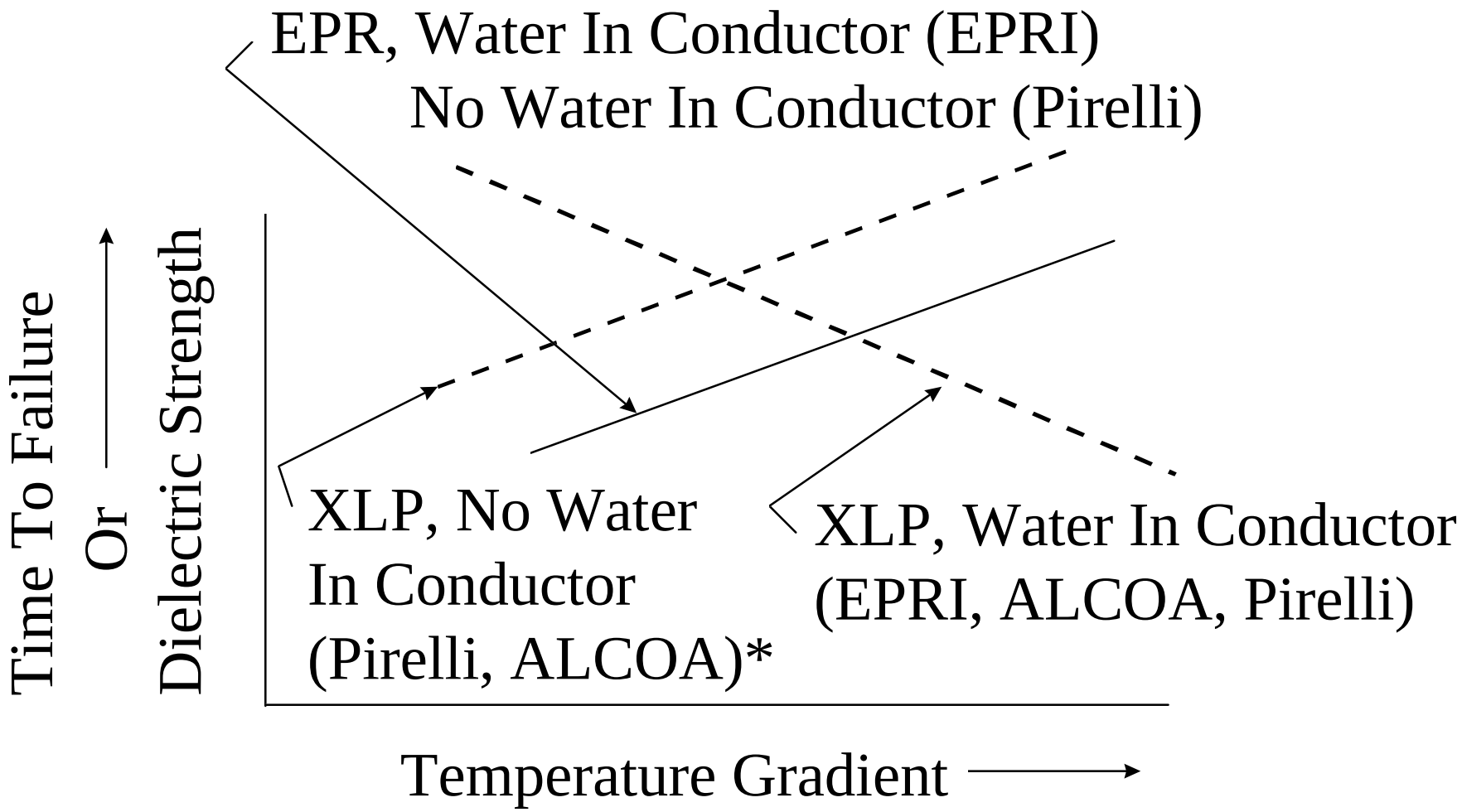
Wet Test Results On XLPE Insulated Cables, Time To Failure Or % Loss Of Dielectric Strength



Wet Test Results On EPR Insulated Cables, Time To Failure Or % Loss Of Dielectric Strength



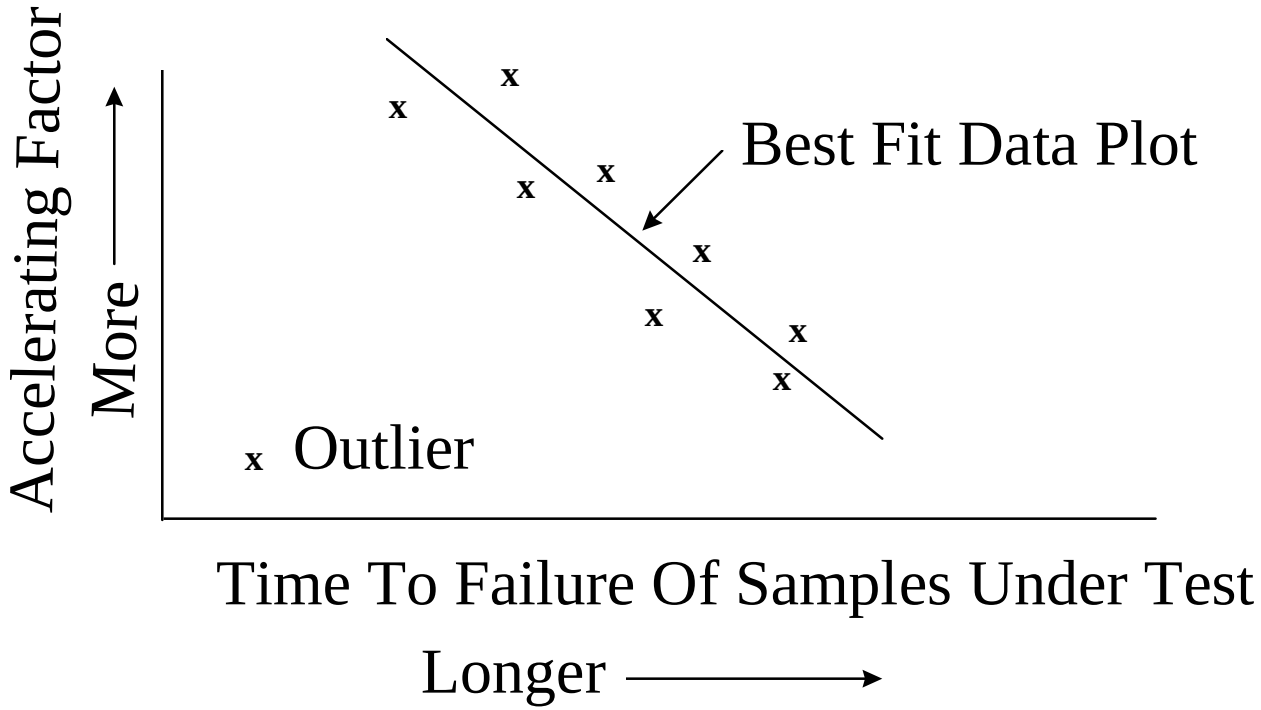
Wet Tests Comparing EPR & XLPE Insulated Cables,
Time To Failure Or % Loss Of Dielectric Strength



*Anticipated

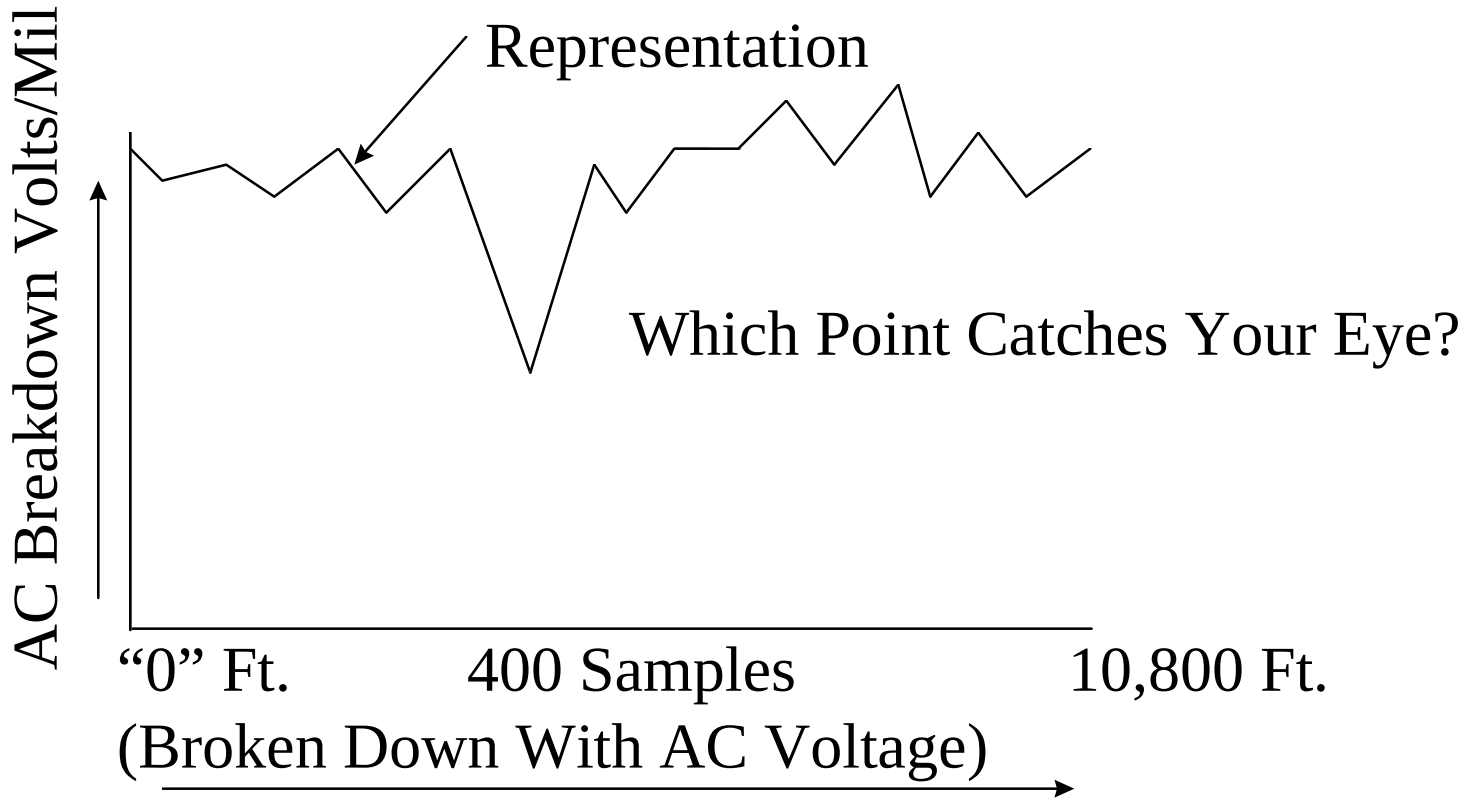
Trying To Estimate Service Life

The Unwelcome Outlier -Which Data Point Most Interests You?



Variation In AC Breakdown With Cable Length, EPRI Proj. IEEE/PES T&D

Paper 89 TD 365-8



Some Necessary Observations

1. Laboratory aging tests are generally conducted on “feet” of cable while service failure rates are quoted in failures “per 100 miles per year”

2. In order for aging tests on “short samples” to give any indication of service life the total cable represented by the samples must be sufficiently homogeneous to be capable of being described (without exception) by normal statistical means (in control). The presence of even an occasional outlier belies this possibility.

OPINIONS

1. Wet tests in which the temperature gradient and water penetration work in unison are suitable to compare a modified material to a known material of similar composition with respect to degradation due to moisture; HMWPE vs HMWPE, XLPE vs XLPE and hopefully EPR vs EPR

2. Wet tests in which the temperature gradient and water penetration work in unison are not a promising means to predict service life of modern cables; dry conductor, jacketed cables

OPINIONS

3. Today's aging tests (short lengths of sample) will not yield useful information on service failure rate of modern cables (unless material change, process problems or defects are present in sufficient quantity to yield poor results).

4. Future life test development will have to test complete designs in a manner duplicating service conditions and in sufficient length to include scattered “defects” and “worst case” operating conditions.

Opinions

5. Modern materials which are relatively long lived in aging tests when compared with past materials having a poor service record will most likely have their service life determined by outliers and field events not included in the tests.

Partial List Of References

1. ICC-IEEE Meeting Minutes, April 1984, Appendix V-F-5 (Pirelli)

2. IEEE Trans. Power Del. April 88, ppgs. 434-439 (ALCOA)

3. IEEE Trans. E.I. Dec. 81, ppgs 521- 527 (Anaconda)

4. I was there! (Anaconda, ALCOA, CPI/ EPRI). Just couldn’t keep a job.