Underground Residential Distribution Systems

Historical Review

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Cable History

- 1812: First cable was used in Russia to detonate an explosive with an electrical impulse

- Strips of India rubber were wrapped around a pair of copper conductors to fire a mine under the Neva River in St. Petersburg

Cable History

- 1816: First experimental telegraph cable

- Ronalds made this cable as 500 foot lengths of copper wire drawn into glass tubes; joints were sealed with wax. Cable placed in creosoted wooden trough.

Cable History

- 1842:   Morse submarine telegraph cables
- Copper wire saturated in pitch and covered with strips of India rubber
- In New York Harbor and Washington DC the next year

Cable History

1844: Morse telegraph cables from Washington to Baltimore

- **Four #16 copper conductors were insulated with shellac and drawn into a swedged lead tube. Made in 300 foot coils and plowed.**

Cable History

- 1879: Edison's NYC dc lighting system
- Rigid buried system
- 2 or 3 copper rods insulated with jute were pulled into 20 foot iron pipes filled with a bituminous compound
- Tube joints

Cable History

- 1885: Westinghouse ac system
- OVERHEAD AT 1,000 Volts!

Early Performance

- **1888: "No arc wires had been placed underground in either New York or Brooklyn. The experience in Washington lead to the state-ment that no insulation could be found that would operate for 2 years at 2,000 volts. In Chicago, all installations failed except for lead covered cables."**

Early Performance

- *TERRIBLLE* until Edison's system
- By 1900, rubber cables in lead and installed in ducts became the standard in NYC for lighting and telegraph in subways
- Paper insulation replaced rubber in the 1910s and 1920s

First URD Systems

- **1920s:** **PILC or rubber cables**
  Copper conductors
  Three phase 5 kV service
  Cables in ducts
  Transformers & switches in “dog house” vaults
  Exclusive subdivisions
  Cost $4,000 per lot (avg house)

1950 Era URD

- Three phase 15 kV loop systems
- PILC & rubber cables
- Cables in ducts with manholes
- Transformers & switches in vaults
- Exclusive subdivisions
- Cost $2,000 per lot (Cadillac)

1965+
Era of Beautification

- **Single phase 15 kV systems**
- **Direct buried polyethylene cable**
- **Padmounted transformers**
- **New subdivisions**
- **In 1972, total cost $400/lot**

What Were We Doing?

- **Trying to get cost of underground the SAME as overhead**
- **Lowest reported at about 1.6 times an overhead system**
- **Average was 2:1 in 1975**
- **Builders paid the difference between overhead and underground – price of a TV added to mortgage -- $200/lot**

Polyethylene: The *Perfect* Insulation

- **40 year life**
- **No problem with moisture**
- **Cheap**
- **Easy to splice with unskilled crews**
- **Most problems would be dig-ins**

What did "40 Year Life" Mean?

- **A 1956 paper by Jack Crowdes said:**

"Half the samples (in a test) would fail by the end of the 40^{th} year."

What was meant by "Moisture Resistant"?

- **Polyethylene did not absorb as much water as rubber insulation**

- **Rubber insulations would absorb 5 to 10% of their weight when left in a water bath for 7 days**

Low Cost

- **Keep first cost as low as possible**
- **National pressure from builders**
- **Why worry about replacement cost since the cable would last as long as the house?**
- **Maintenance would be less than overhead**

Workmanship no Problem

- ANYBODY can splice poly!
- No clean, dry environment needed
- No lead to wipe
- No hot compounds to pour
- Splicing and terminating can be done quickly and inexpensively with premolded devices

Dig-ins the Only Problem

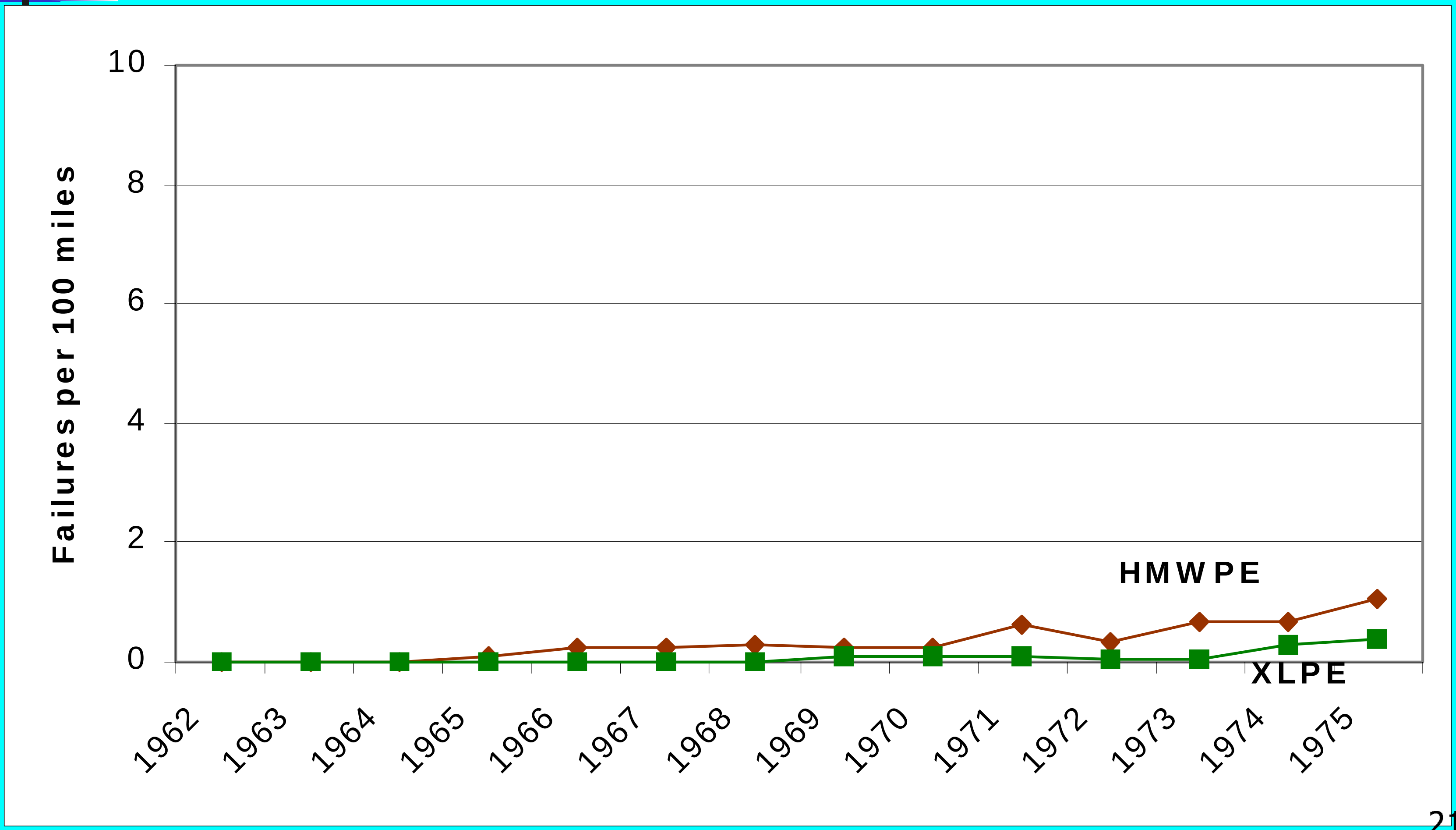
- **90% of all failures would be from dig-ins**
- **Fault location hardly needed (just find the smoking backhoe)**
- **Dig a bigger hole and then splice**

A Few Little Problems by 1970

- Failures without backhoes
- Failures within 2 to 3 years
- Treeing
- Neutral corrosion
- Fault location not so easy
- Customer dissatisfaction
  (they expected better service)

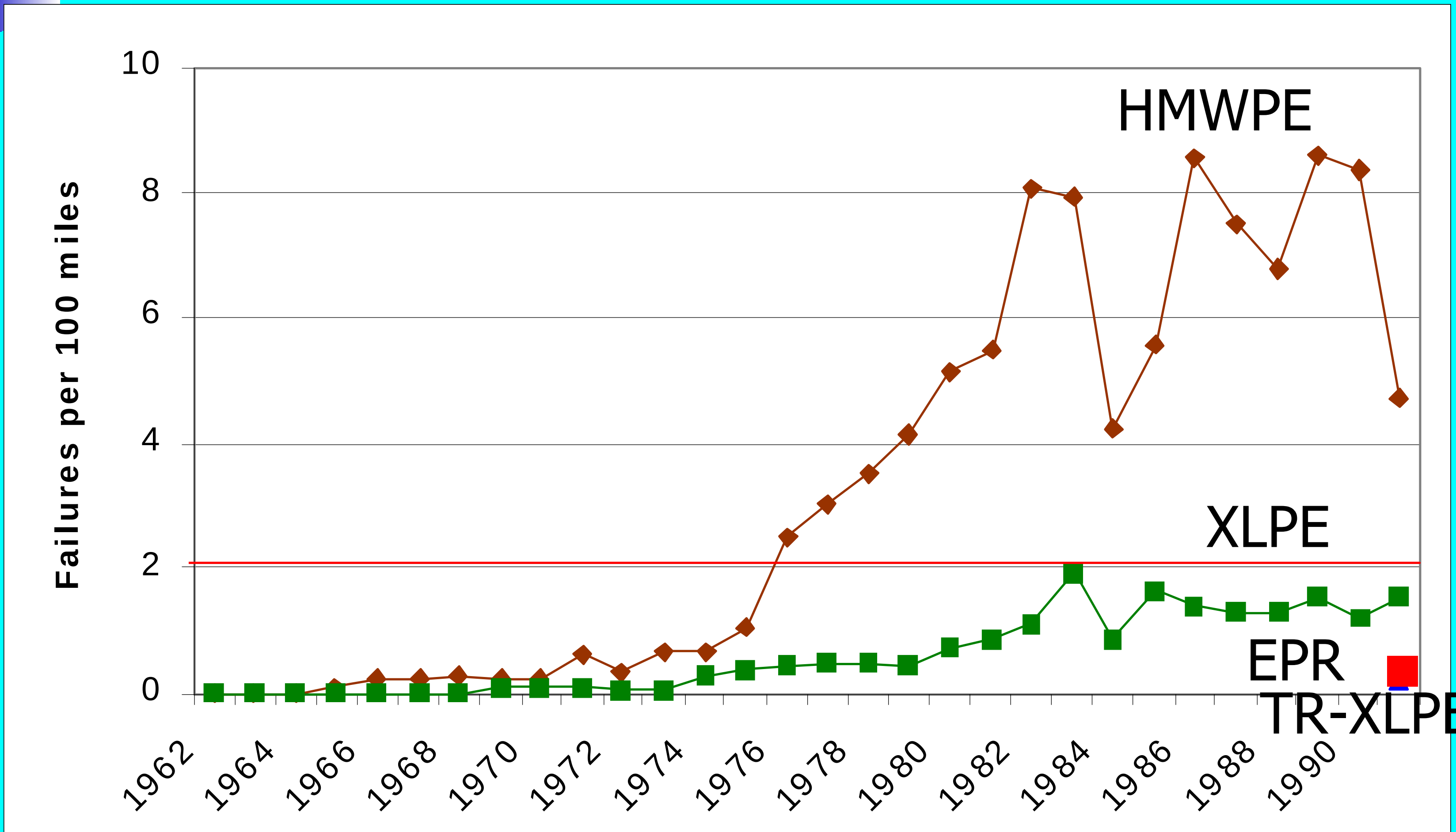
AEIC Cable Failures

per 100 miles, 1962-1975



AEIC Failures

per 100 miles, 1962-1991



Medium Voltage Cable Standards & Specifications

- **1920: NELA Paper cable spec.**
- **1924: AEIC Paper cable spec.**
- **1926: IPCEA VC cable standard**
- **1935: IPCEA Rubber cable stand.**
- **1961: IPCEA Poly cable stand.**

Medium Voltage Cable Standards & Specifications

- **1969: AEIC poly cable “interim”**
- **1971: AEIC poly cable spec.**
- **1973: AEIC EPR spec.**

15 kV Insulation Thickness

- **1920 Paper: 165-190 mils**
- **1930 Rubber: 297 mils**
- **1950 Poly: 220 mils**
- **1965 XLPE/EPR: 175 mils**
- **1995 urban ducts: 165 mils**

Importance of History

- **Find out what works**
- **Find out what doesn't work**
- **Find out how to test new products**
- **Simply avoid same mistakes**

Bright Future