

Condition of 44-Year Naturally Aged Cable

**Pyrotrol III,
Raychem
Flamtrol,
and RSCC
Firewall III
Cable** (15 years)



**Condition of
Rockbestos
(Cerro)
Pyrotrol III
Outer Jacket.**

Once the braid and jacket were removed, the underlying conductor insulation was generally in good shape, intact, and moderately flexible



The Surprise:
Once we recovered the Cerro Pyrotrol III cable, we discovered that instead of the name “Cerro” they were “Rockbestos” Pyrotrol III cable.



INDIVIDUAL PYROTROL III CONDUCTOR WITH OUTER JACKET REMOVED.

The Chemically Cross-linked polyethylene conductor insulation was in reasonably good condition after 44 years of installation in an average of 150°F (65.5°C) ambient environment. There were ambient excursions up to about 180°F (82.2°C). These were control conductors with little or no heat rise.

The stranded copper conductors did not exhibit any corrosion or rust.



CONDITION OF PYROTROL III AT THEIR TERMINATION LUGS.

The shiny clear substance on and behind the terminal lug is Patel Engineers Conformal Coating (PECC).

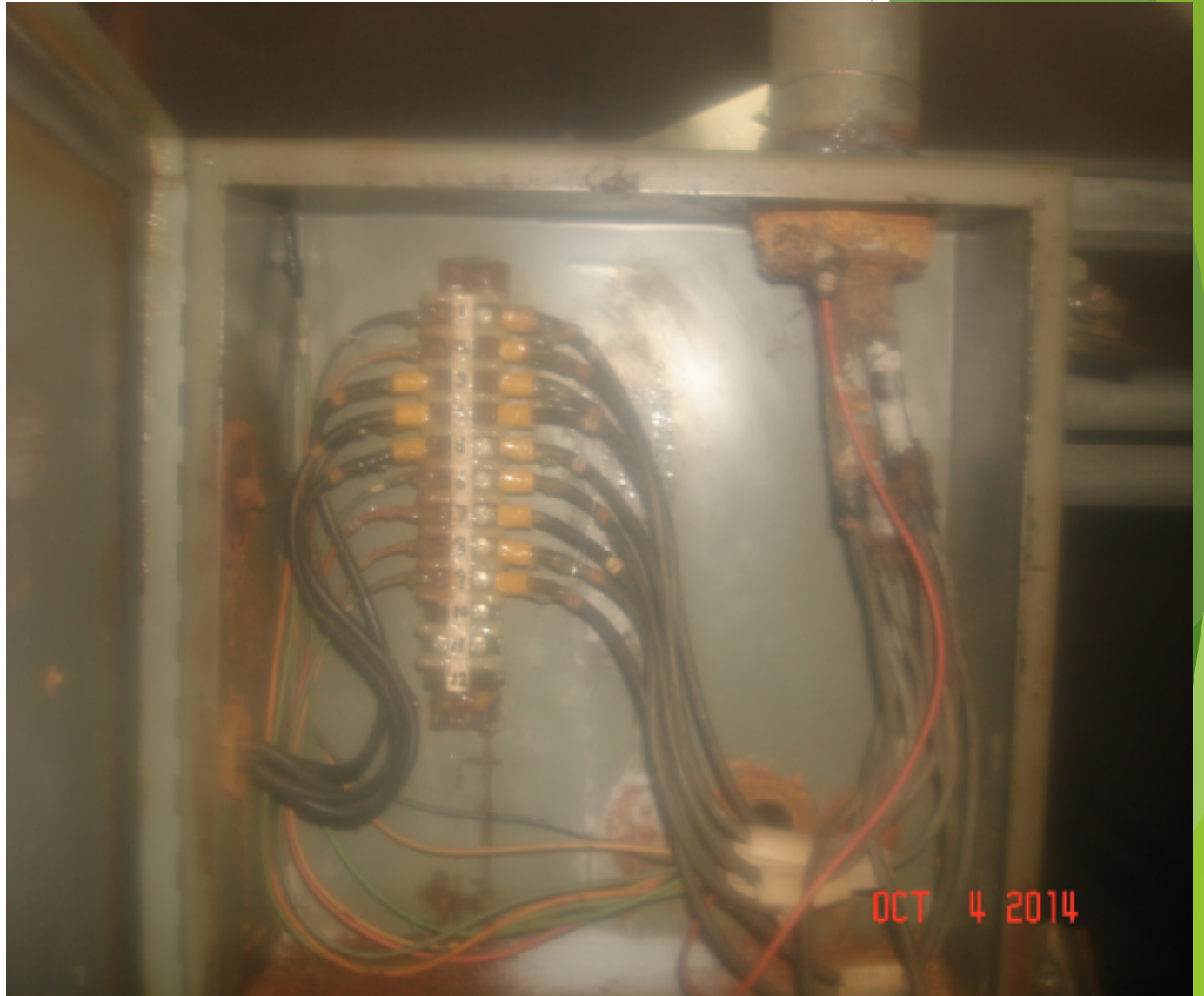


RAYCHEM FLAMTROL wire and cable rated 1000 Volt, Single or Multi-Conductor, Cross-Linked Polyethylene (XLPE) insulated and jacketed Control Cable.

The photo at right shows how the outer jacket had split approximately every $1/8$ " to every $1/4$ " along the entire length of the cable.



Terminal Box Rust and Corrosion: The photo to the right shows a typical CNS terminal box inside the Steam Tunnel. While not all terminal boxes were rusted and corroded, several were. The pictured terminal box is among the worst case examples (2014).



Rust formation in terminal boxes is not necessarily a failure mechanism. In a *static* state, the outer jacket will prevent rust from reaching the conductor insulation. The evidence for this is shown that after 42 years in the hot and humid Steam Tunnel, the rust had not reached a point where it would cause any damage to the cables.



THE PROBLEM WITH EXCESSIVE RUST IS IT MAY AFFECT CABLE RATING

When cables were being removed, the electrical team used brushes as they pulled the old cable out and the new cable in through the conduit.

They reported that there were significant quantities of rust and corrosion from the conduit walls - along with moisture.



RSCC (Rockbestos) Firewall III cable was also inadvertently removed during the 2016 outage. It was a small length between two terminal boxes in close proximity to one another in the Steam Tunnel.



Rockbestos Firewall III after 15 years in the Steam Tunnel ... in pristine condition

The general results are that all cables removed proved to be in good condition, consistent with their aging levels.

The features used for testing the cables by AMS were:

- ▶ Visual and optical microscope inspections
- ▶ **Insulation Resistance (IR)**
- ▶ Indenter Modulus
- ▶ **Elongation at Break (EAB)**
- ▶ Oxidation Induction Time
- ▶ Thermo-Gravimetric Analysis
- ▶ Relative Density
- ▶ Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy

BALANCE OF CABLES PULLED IN 2018.

More precisely,
their Elongation-At-
Break and
Insulation
Resistance would
likewise have been
about the same as
the 2016 cables.



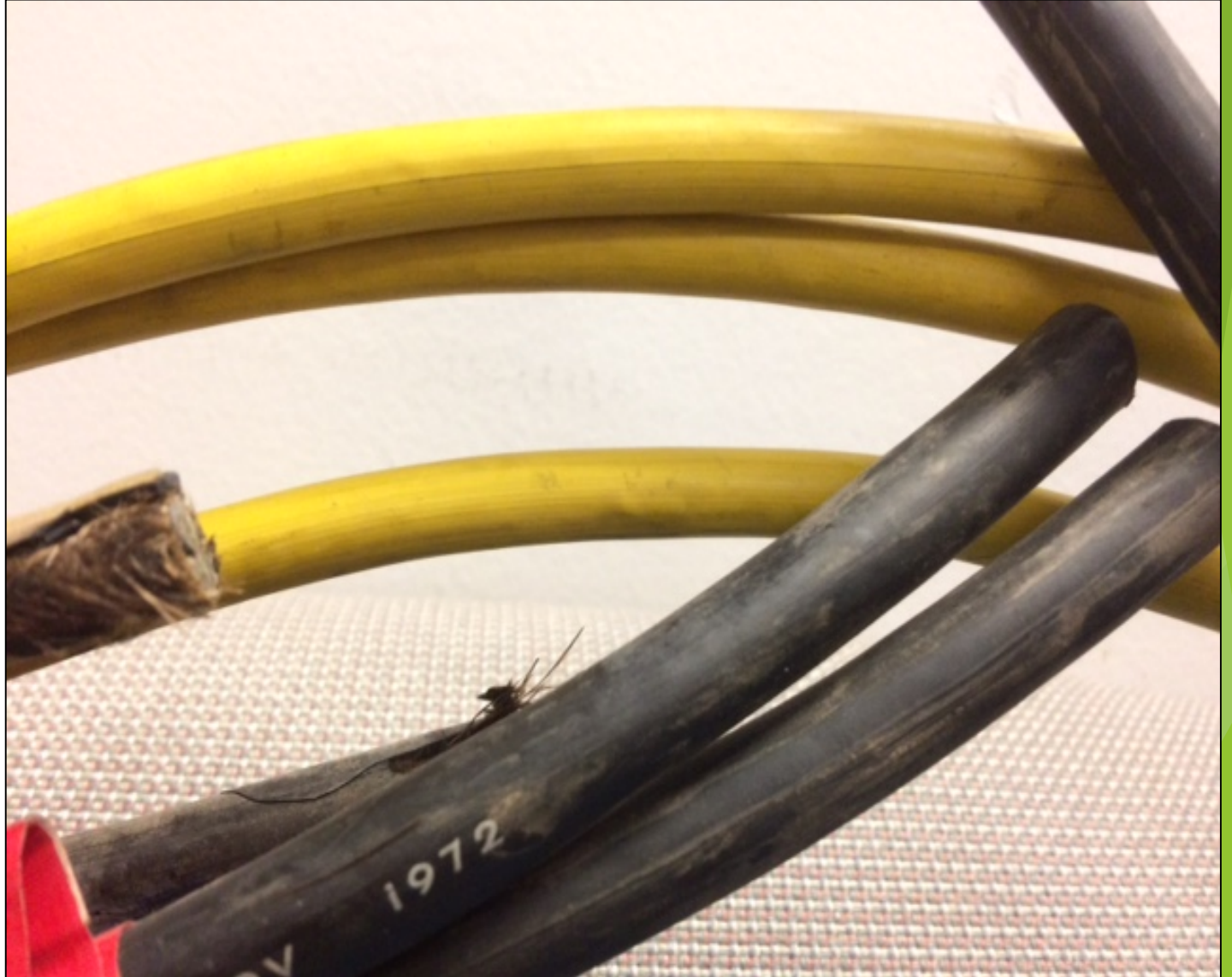
The remaining life of 15-years for the Pyrotrol III cable and 5-years for the Raychem Flamtrol Cable is based on a minimum of 50% EAB as determined by AMS.



CNS

**conservatively
chose to replace
the Pyrotrol III
Cables**

... because the
remaining life also
has to account for
any HELB
accident.

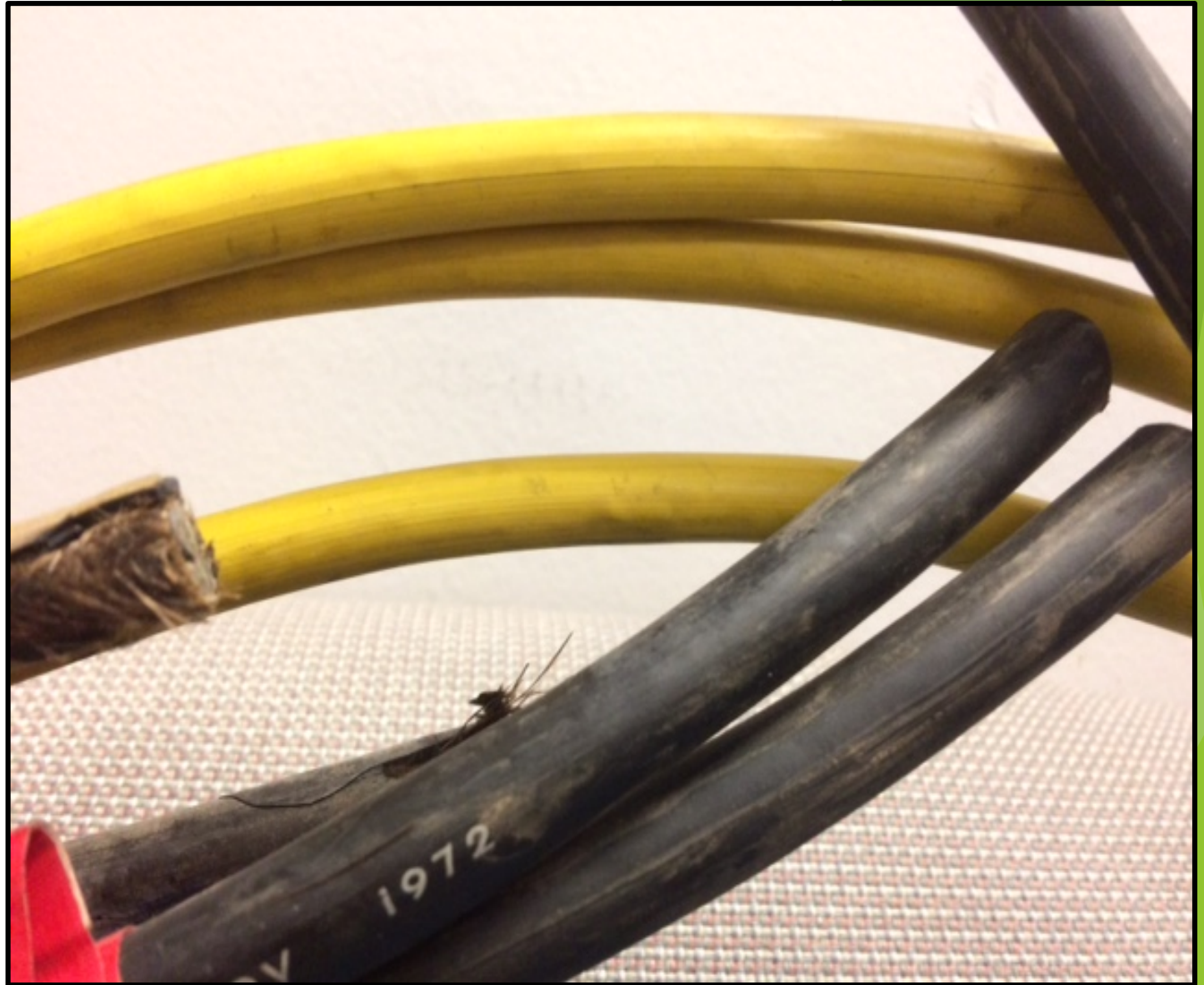


SAMPLES OF CABLE LENGTHS PASSED OUT FOR YOU TO LOOK CLOSELY

The four packages are from the 2018 cable pull. They represent the vintage, manufacturer, and condition.

One yellow cable shows a transition from being in very good condition to being severely degraded within about a foot. This suggests that the load or nearby equipment was extremely hot at one end.

The conductors, however, are still in good condition and flexible.



RECOMMENDATIONS

- ▶ Know various heat loads affecting cables
- ▶ Get Temp Element data to track ambient
- ▶ Apply as many TEs or Monitors as possible
- ▶ Inspect condition of cable ends periodically
- ▶ Inspect terminal boxes & conduit entry for rust and corrosion
- ▶ Make sure cable qualified life is solidly based (DOR)
- ▶ Have cables replaced in a conservative time frame