Underground Transmission Capacity Increases from Dynamic Rating Analysis

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Background

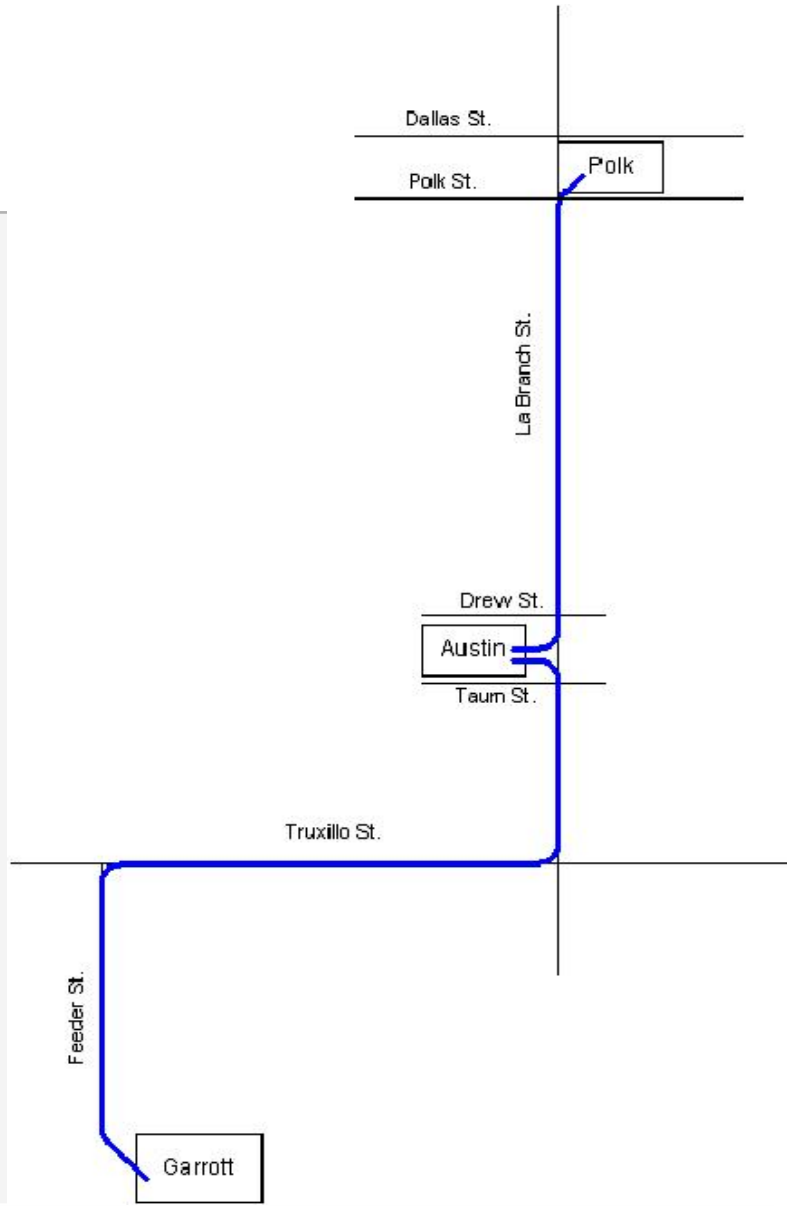
- In 2000, CenterPoint Energy began an ampacity study of 138kV Polk to Garrott circuit
- Addition of new Midtown Substation
- Investigate methods to increase capacity

Circuit Detail

- 138kV Underground
- HPFF Cable
- 8 inch pipe
- 2500 Kcmil conductor
- Oil Dielectric
- Rated 257 MVA
- Installed in 1966

Circuit Route

- Downtown Houston
- 12,300 feet



Approach

- Evaluate dielectric fluid for evidence of aging
- Evaluate paper insulation aging
- Install DTS fiber for temperature profile
- Evaluate impact of crossing pipe-type cable circuit

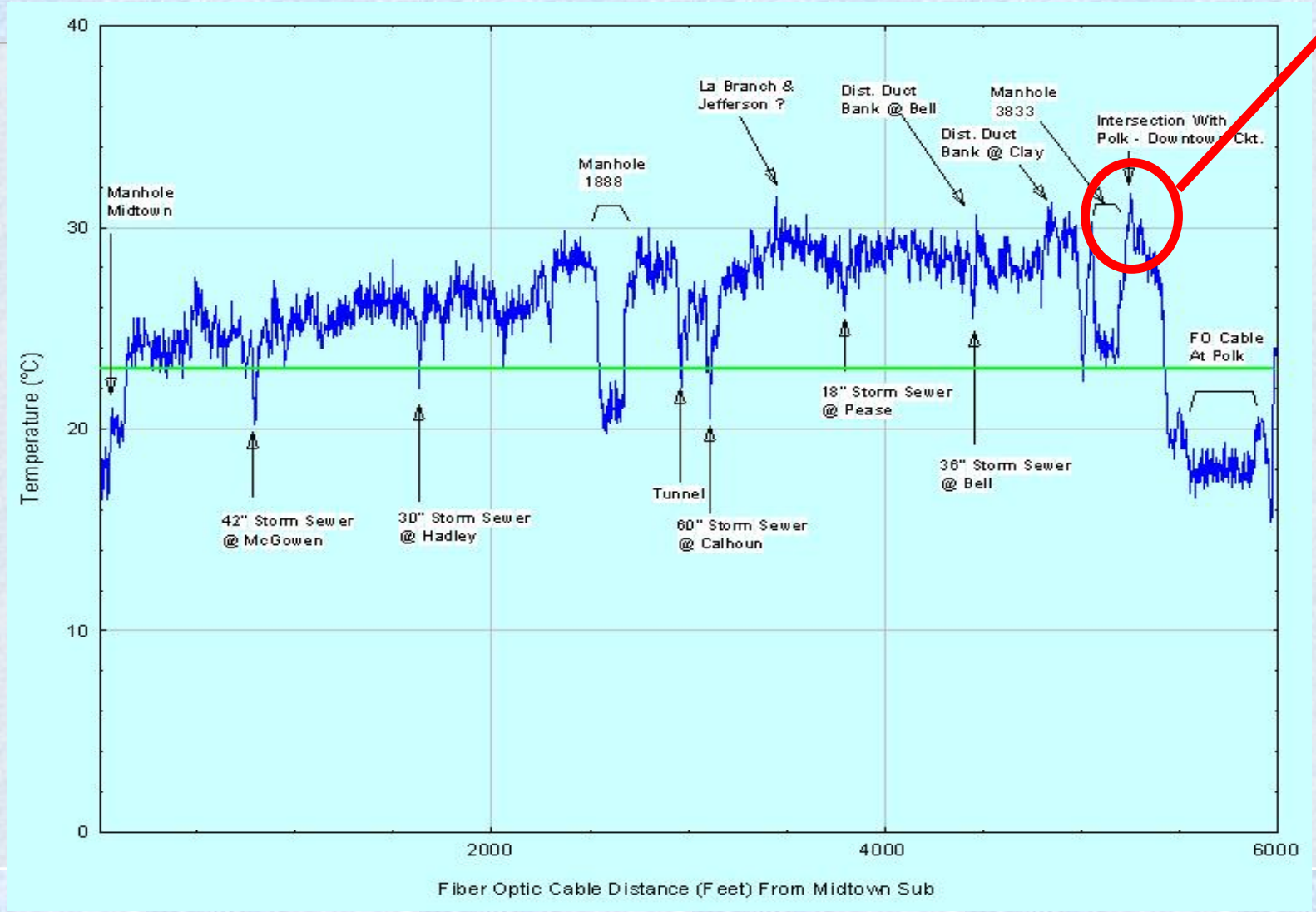
Testing

- DGA test on oil performed by Detroit Edison
- Field Dissipation test performed on paper insulation
- Result showed cables virtually un-aged from initial installation

DTS Installation

- Distributed Thermal Sensing (DTS)
- Installed in parallel duct
- Multi-mode fiber optic

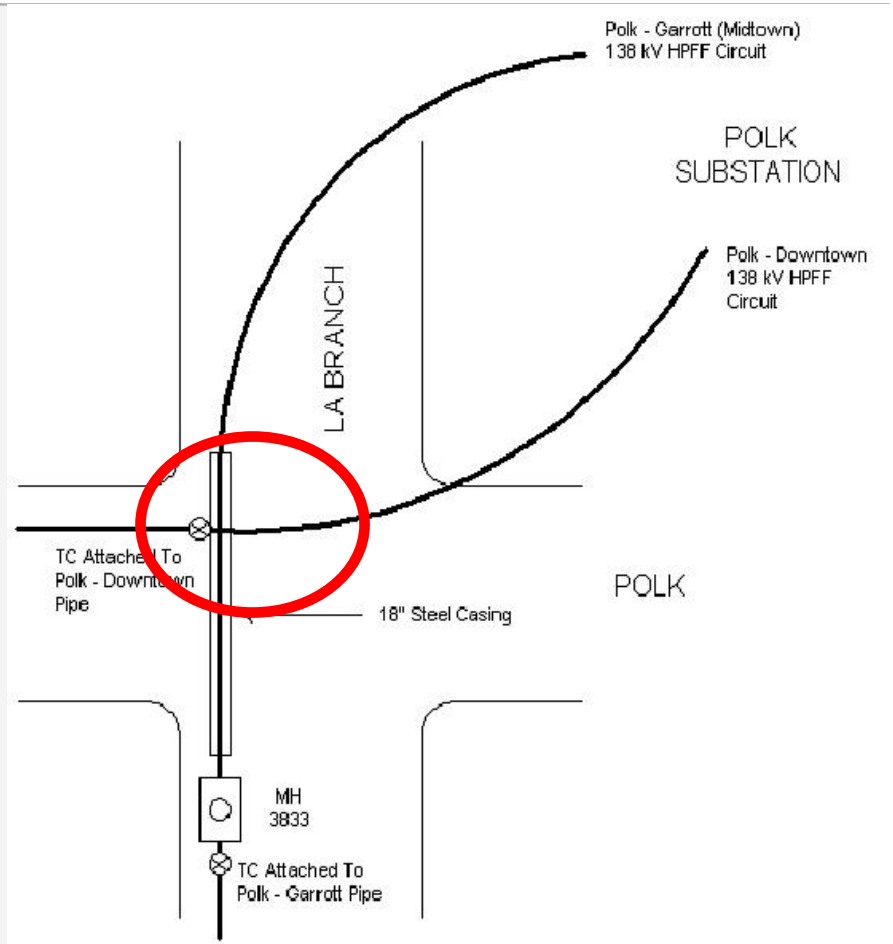
DTS Midtown to Polk



Ampacity Considerations

- Association of Edison Illuminating Companies CS2 recommends reducing max conductor temperature from 85C to 75C when environmental conditions are unknown
- CenterPoint Energy followed AEIC and rated circuit at 75C
- Study of circuit allowed 85C uprate
- Typically this would increase ampacity by 20%

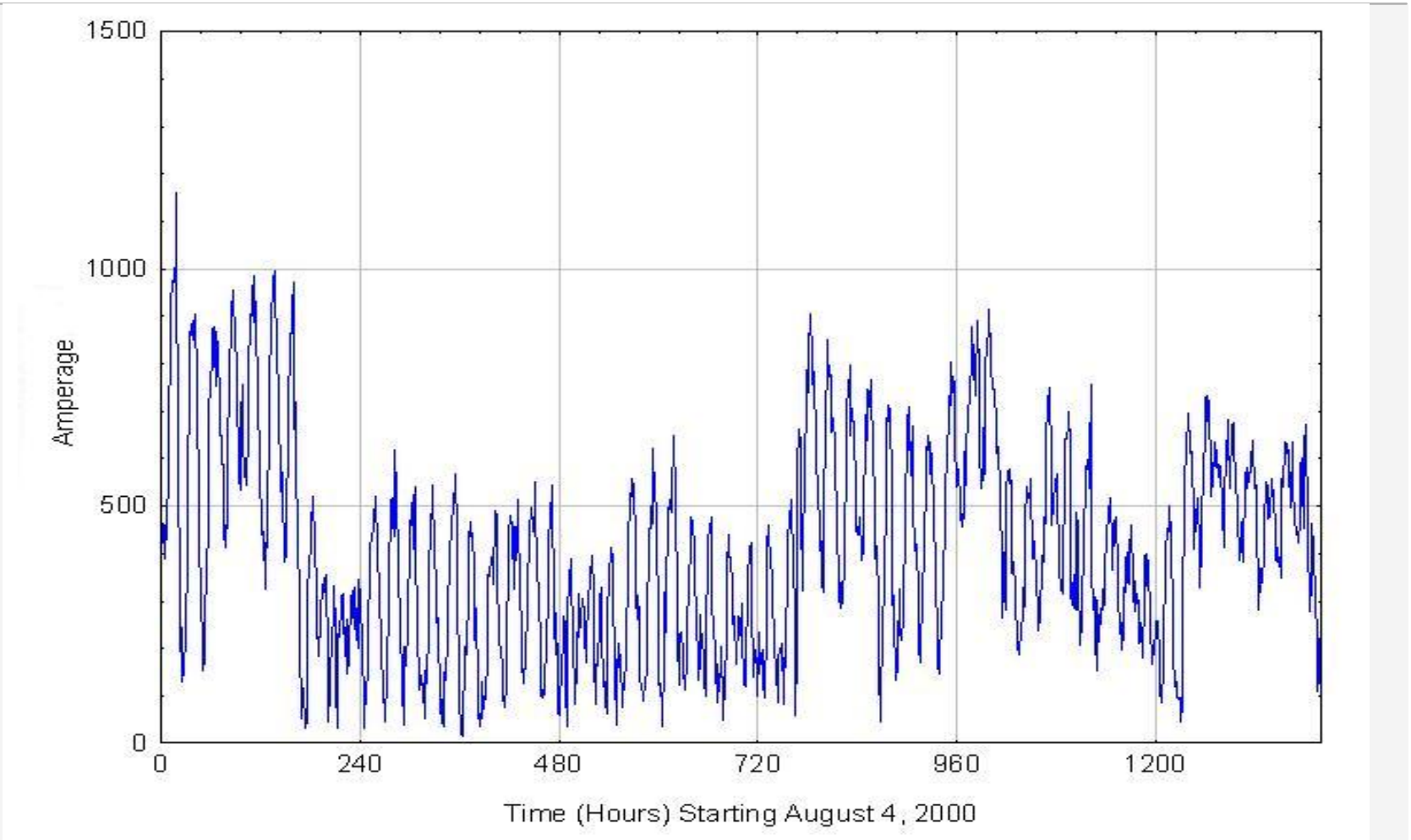
Unfortunately, even with a 10C increase, the result was a 3.4% decrease in ampacity due to crossing circuit hot spot



DTCR Consideration

- Polk to Garrott circuit has a cyclical load pattern
- Short duration of high loads
- The long thermal time constant of underground HPFF circuits is approximately 130 hours

Load Pattern



DTCR Model

- Modified to support a real time temperature interference from a measured source
- This was used to model heating influence from a cable crossing
- Run in simulated mode using summer 2000 data

DTCR Result

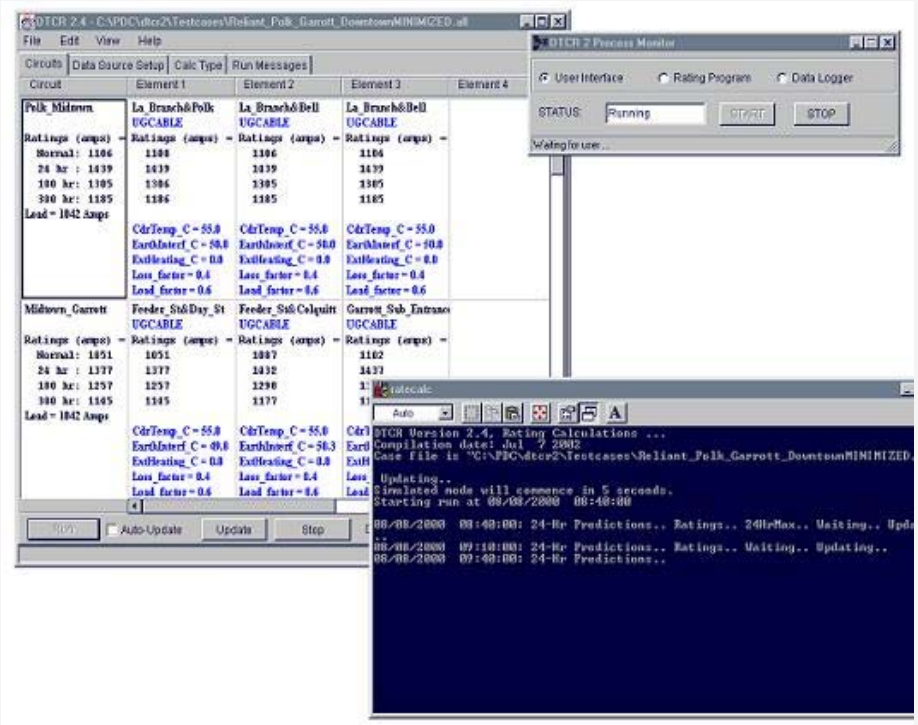
Using summer 2000 data, DTCR showed an increase of almost 21% in dynamic rating over the conventional book rating

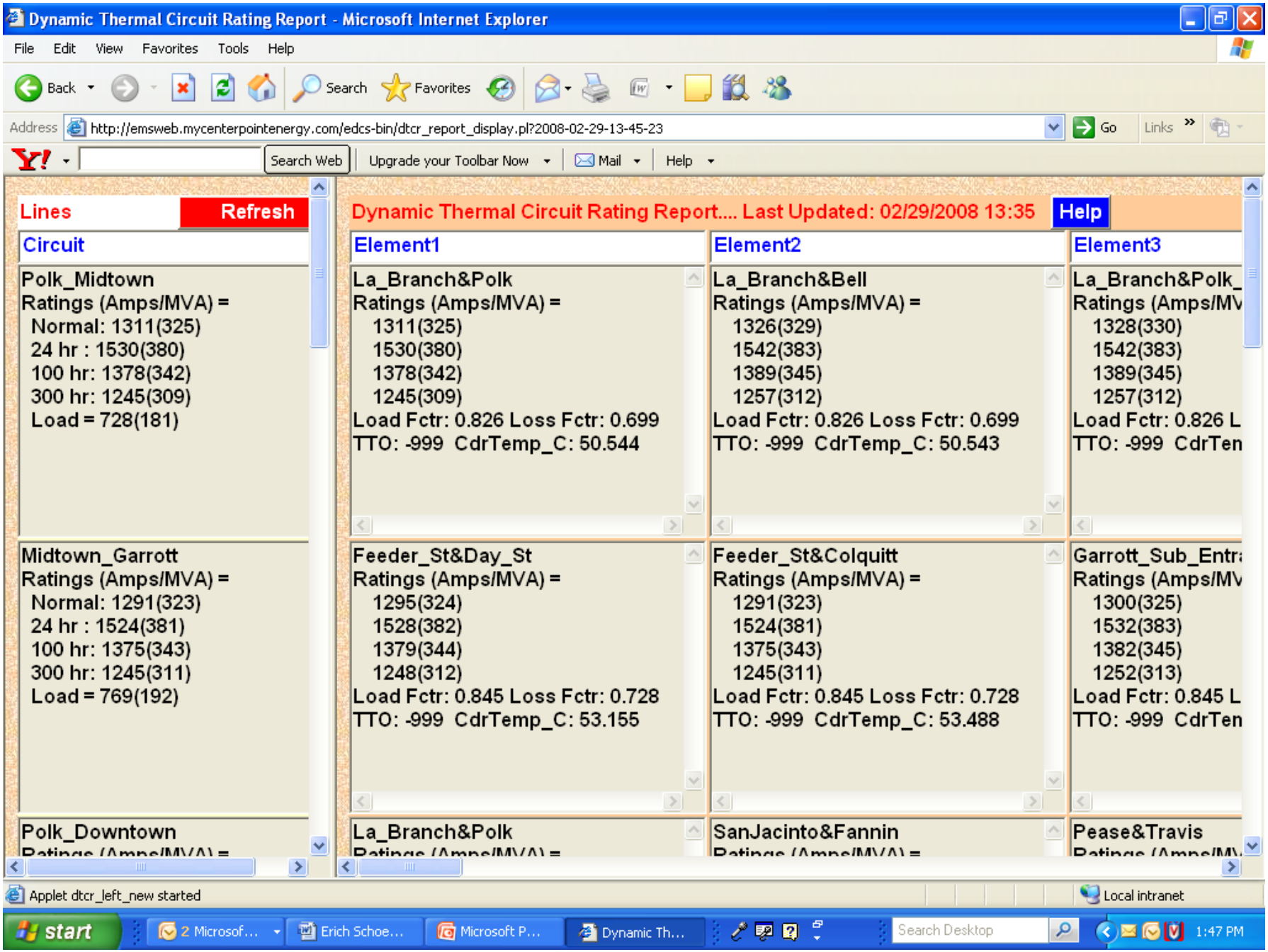
DTCR Components

- Thermocouples
- SCADA
- Simple PC

DTCR Output

- Calculated conductor temperature
- Reported Amperage
- Allowable Amperage
- Input parameters
- Time remaining to thermal overload




Dynamic Thermal Circuit Rating Report - Microsoft Internet Explorer
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Dynamic Thermal Circuit Rating Report.... Last Updated: 02/29/2008 13:35 Help
Circuit
Element1
Element2
Element3
Polk_Midtown
Ratings (Amps/MVA) =
Normal: 1311(325)
24 hr : 1530(380)
100 hr: 1378(342)
300 hr: 1245(309)
Load = 728(181)
La_Branch&Polk
Ratings (Amps/MVA) =
1311(325)
1530(380)
1378(342)
1245(309)
Load Fctr: 0.826 Loss Fctr: 0.699
TTO: -999 CdrTemp_C: 50.544
La_Branch&Bell
Ratings (Amps/MVA) =
1326(329)
1542(383)
1389(345)
1257(312)
Load Fctr: 0.826 Loss Fctr: 0.699
TTO: -999 CdrTemp_C: 50.543
La_Branch&Polk_
Ratings (Amps/MV
1328(330)
1542(383)
1389(345)
1257(312)
Load Fctr: 0.826 L
TTO: -999 CdrTen
Midtown_Garrott
Ratings (Amps/MVA) =
Normal: 1291(323)
24 hr : 1524(381)
100 hr: 1375(343)
300 hr: 1245(311)
Load = 769(192)
Feeder_St&Day_St
Ratings (Amps/MVA) =
1295(324)
1528(382)
1379(344)
1248(312)
Load Fctr: 0.845 Loss Fctr: 0.728
TTO: -999 CdrTemp_C: 53.155
Feeder_St&Colquitt
Ratings (Amps/MVA) =
1291(323)
1524(381)
1375(343)
1245(311)
Load Fctr: 0.845 Loss Fctr: 0.728
TTO: -999 CdrTemp_C: 53.488
Garrott_Sub_Entr
Ratings (Amps/MV
1300(325)
1532(383)
1382(345)
1252(313)
Load Fctr: 0.845 L
TTO: -999 CdrTen
Polk_Downtown
La_Branch&Polk
SanJacinto&Fannin
Pease&Travis
Applet dtcr_left_new started
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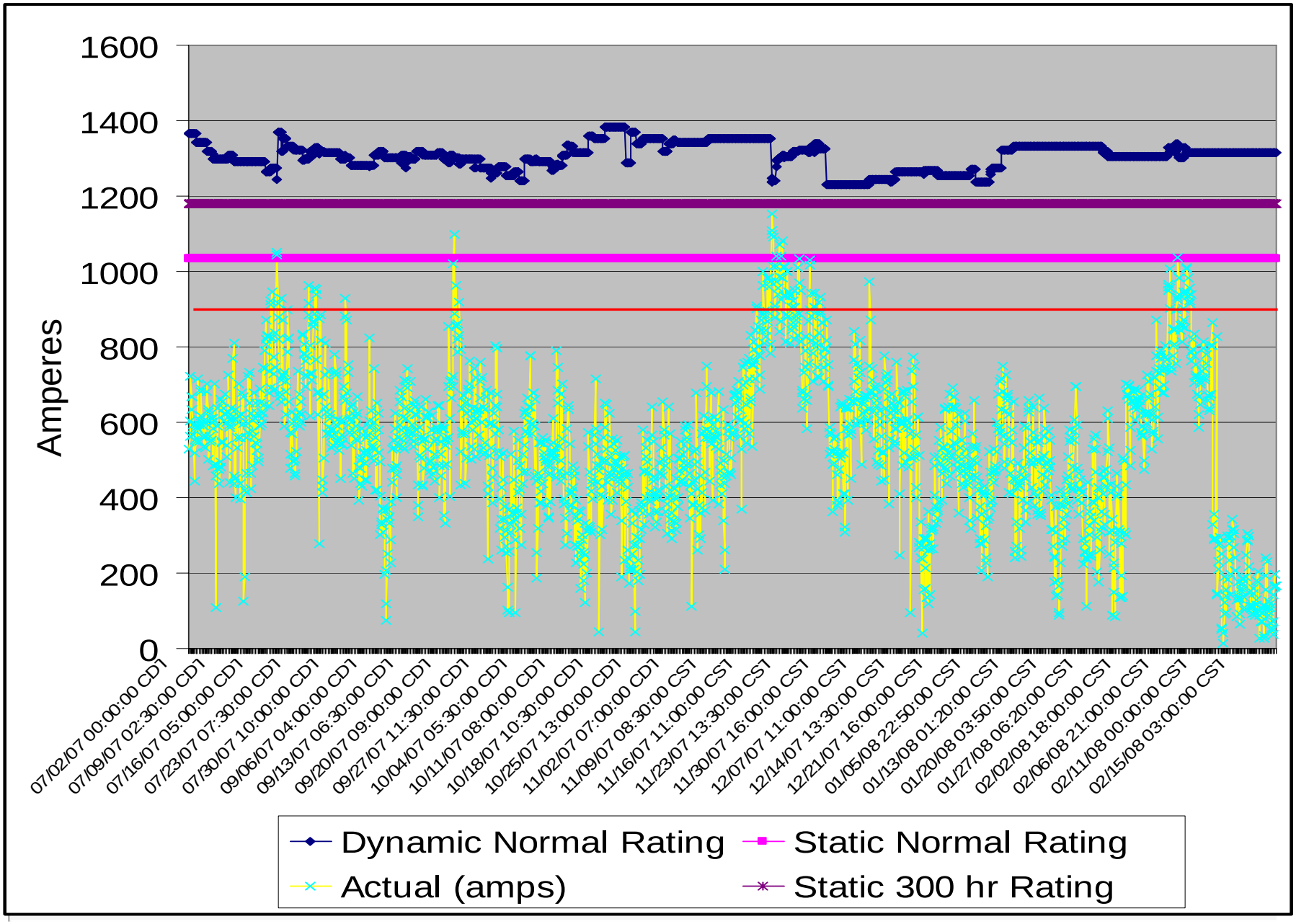


Polk to Midtown Load History

Polk to Midtown Ratings (2/29/08)

- Static Normal Rating = 1035 amperes
- Emergency Rating = 1180 amperes
- Thermal Limit Rating = 1311 amperes

What have we gained?

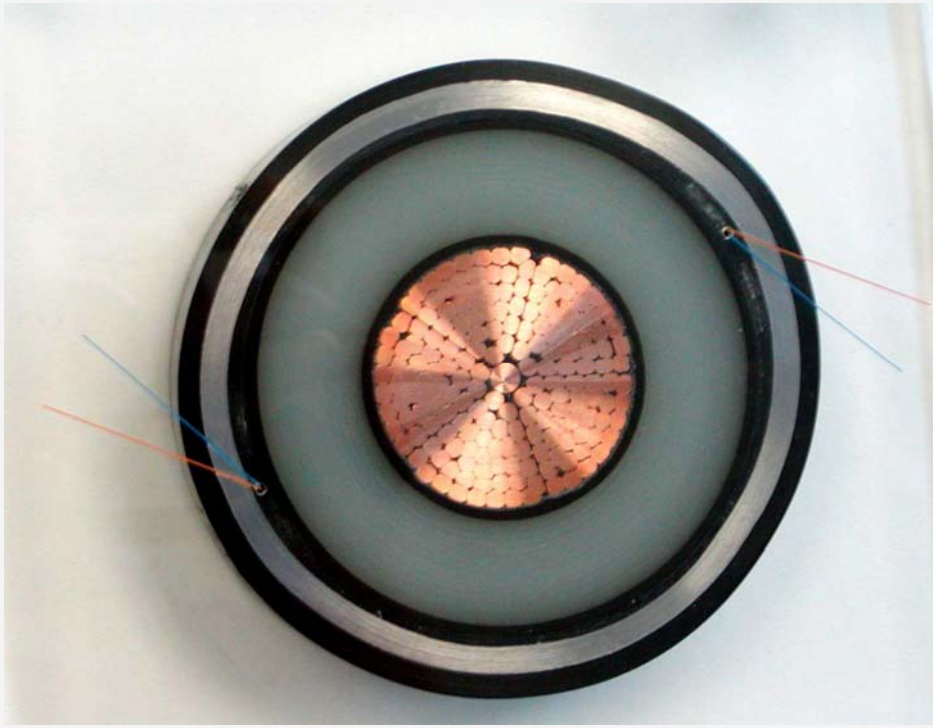
- Time
- Establish a five part upgrade plan
  - Dynamic rating
  - Shuttle oil
  - Additional pipe for circulating
    - Design is ready
  - Reconductor
  - Add a parallel circuit

DTCR Implementation

- Ampacity increase
- RTO tool during high circuit load
- Grid operator predictive tool

Future Use of DTCR

- XLPE Underground Cables
- Overhead circuits



Summary

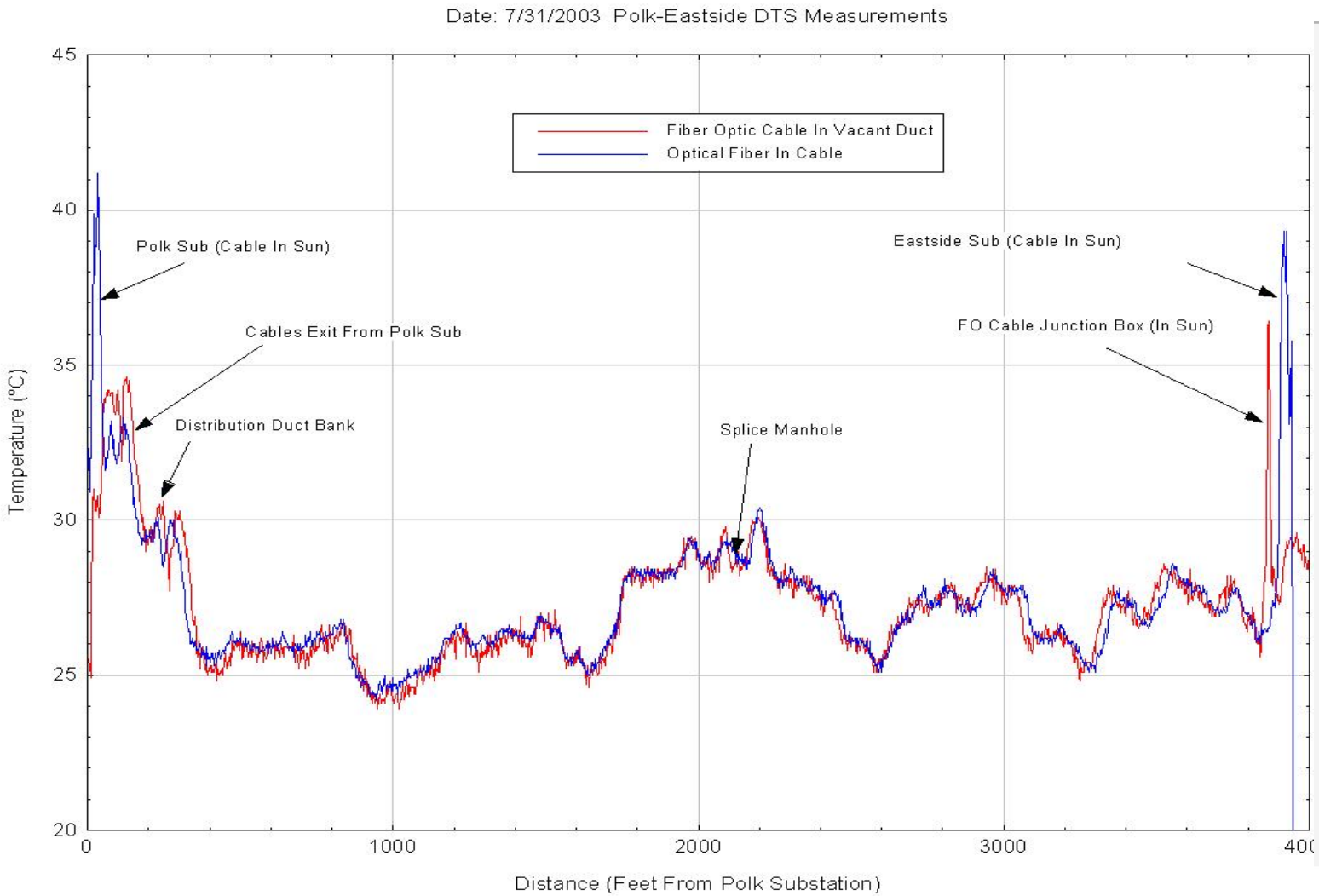
- Ampacity study of Polk to Garrott showed a decrease in book rating using steady state calculations
- DTCR takes advantage of cyclical load pattern and thermal response of UG cable
- Dynamic rating uses real-time temperature and load input
- Polk to Garrott ampacity increased almost 21%
- System operators have a better information tool
- Market predictive tool

Project Team

- EPRI
  - Cable system assessment
  - DTCR development
- Power Delivery Consultants, Inc.
  - DTCR development
  - Ampacity study and condition assessment
- Ulrich Associates, Inc.
  - Software development

Questions?

DTS Correlation



Utilities Using DTCR

- Southern California Edison (XLPE cable)
- PECO Energy (pipe type cable)
- BC Hydro (submarine SCFF cable)
- United Illuminating Co. (pipe type cable)
- ComEd (XLPE cable)