

Transmission Circuits

Presented to

Business Issues Committee

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By

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OVERHEAD AND UNDERGROUND CIRCUIT SELECTION

- * Overhead circuits are prevalent
 - Lower cost
 - Longer distance power transfer
 - Carry higher currents – air cooling
 - Limited by thermal expansion – SAG
- * Overhead voltages 34.5kv – 765kv Developing 1100kv
- * Underground voltages 69kv – 400kv developing 500kv
- * Cost comparison:
 - Overhead 230kv single pole rating of 398MW - \$360,000/mile
 - Underground 230kv cable rated 360MW - \$3,300,000/mile
 - Not including right of way costs
- * Planned Transmission Lines in 2003 and 2004 for NERC Regions (United States, Canada, northern portion of Baja California, Mexico)
 - 2003 - 166.2 miles 22.7 @ 345kv 36.0 @ 500kv
 - 2004 - 1238.9 miles 420.3 @ 345kv 667.0 @ 500kv

TRANSMISSION LINE CONSTRUCTION

- * City ordinances
- * Availability & costs of Right of Way (ROW)
- * ROW restoration
- * Mechanical protection
- * Installation location
- * Construction impacts
- * Contingency circuits
- * Circuit repair time

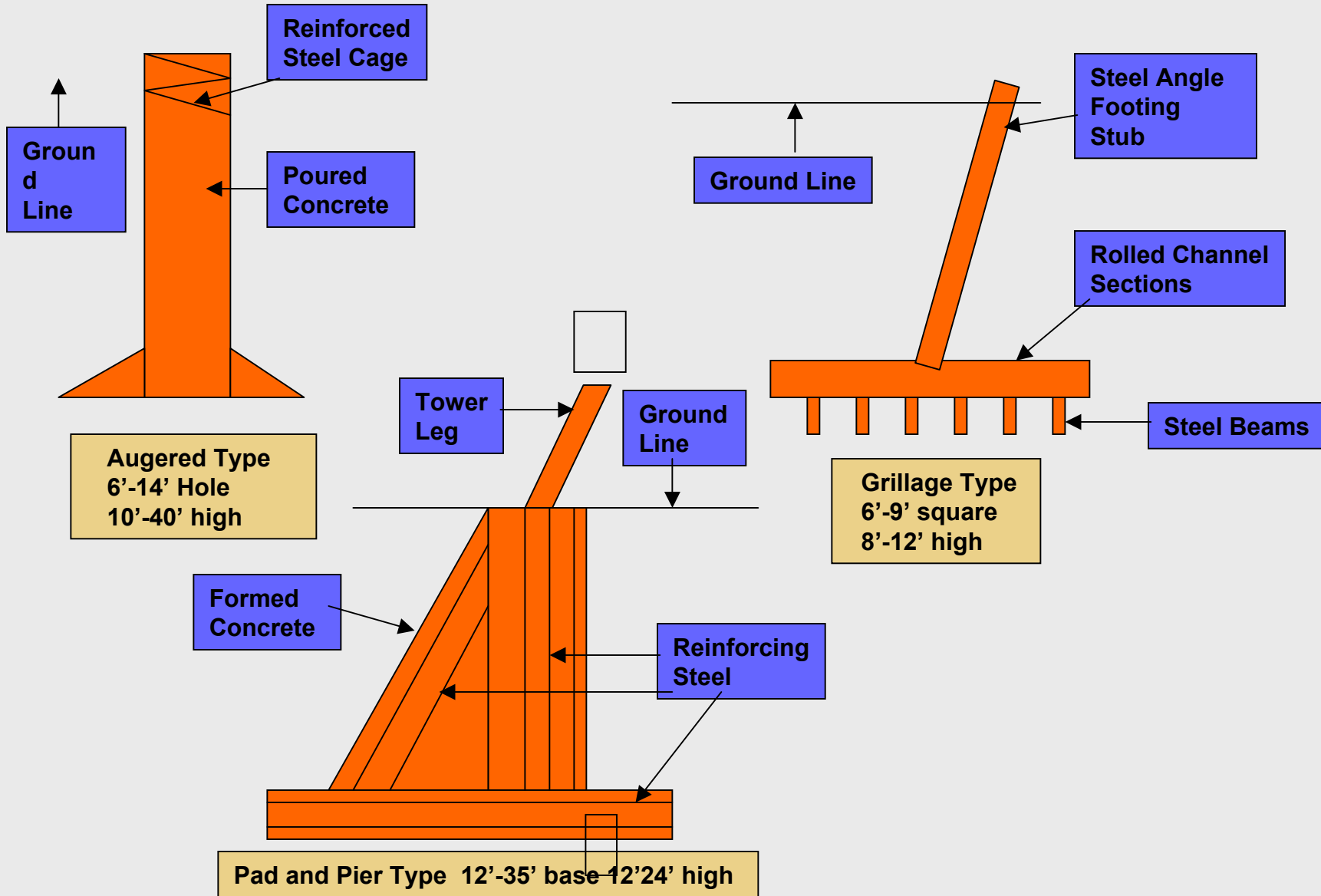


TRANSMISSION LINE CONSTRUCTION

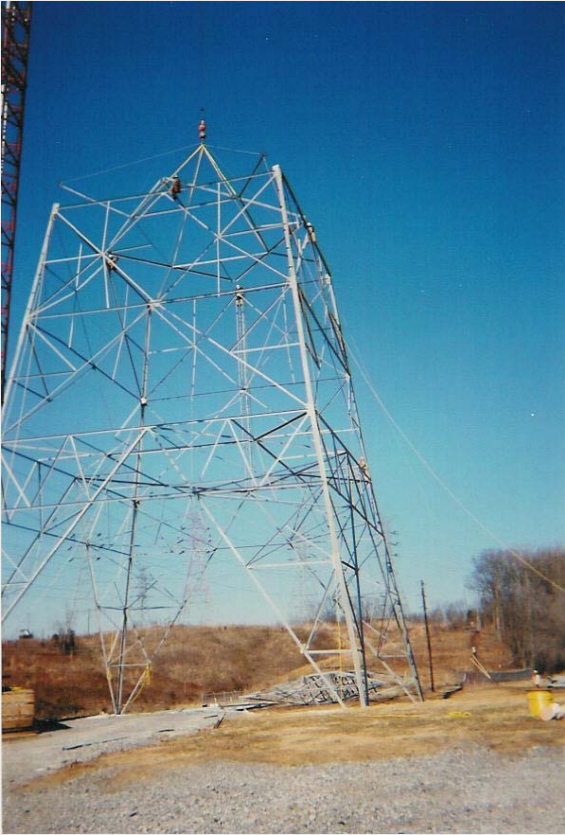
- * Several possible routes
- * Civic reviews
- * Environmental Impact Plan
- * Structure selection
- * Work methods
- * Clearing & access to ROW
- * Restoration & maintenance



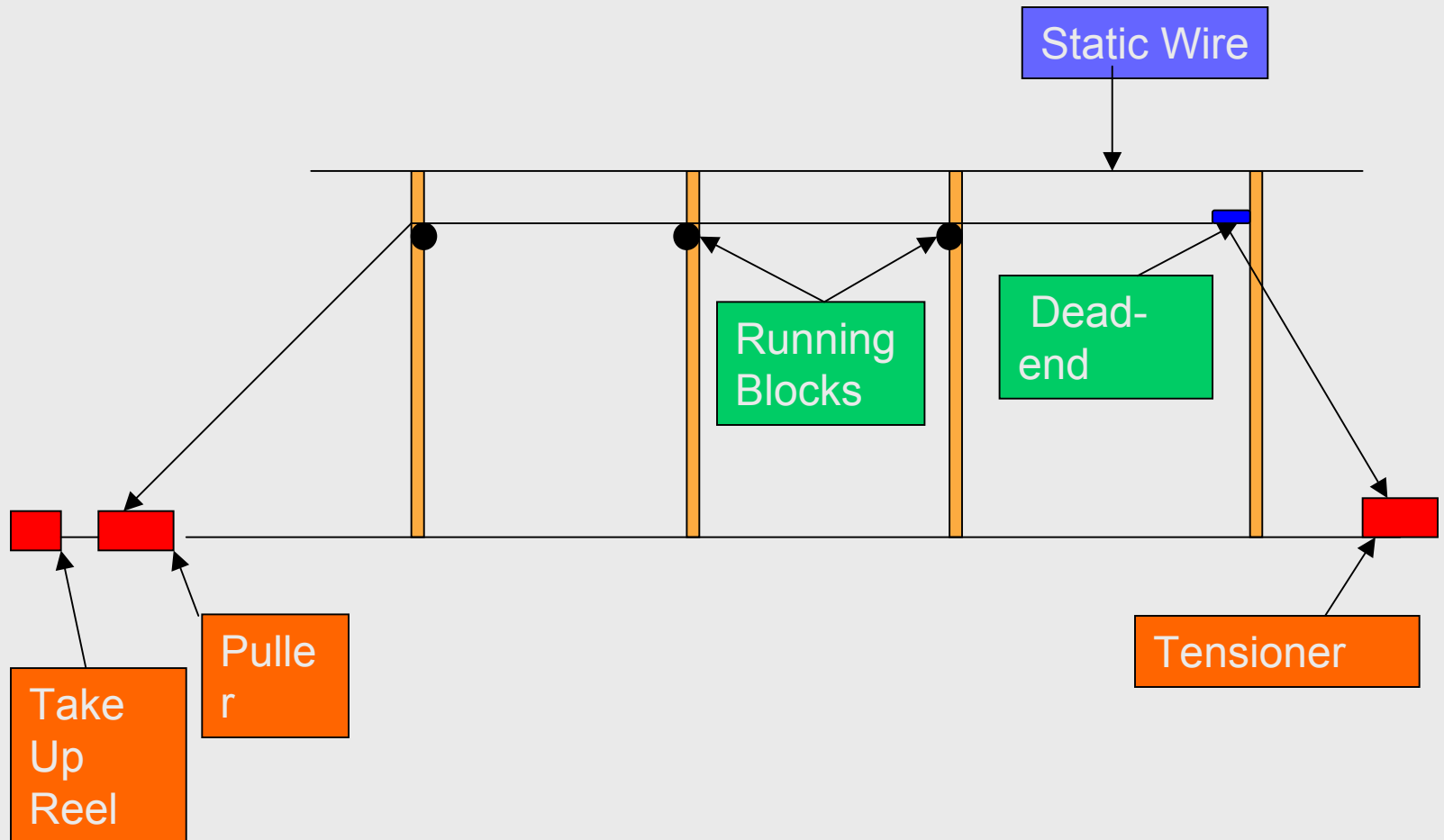
TOWER FOUNDATION TYPES



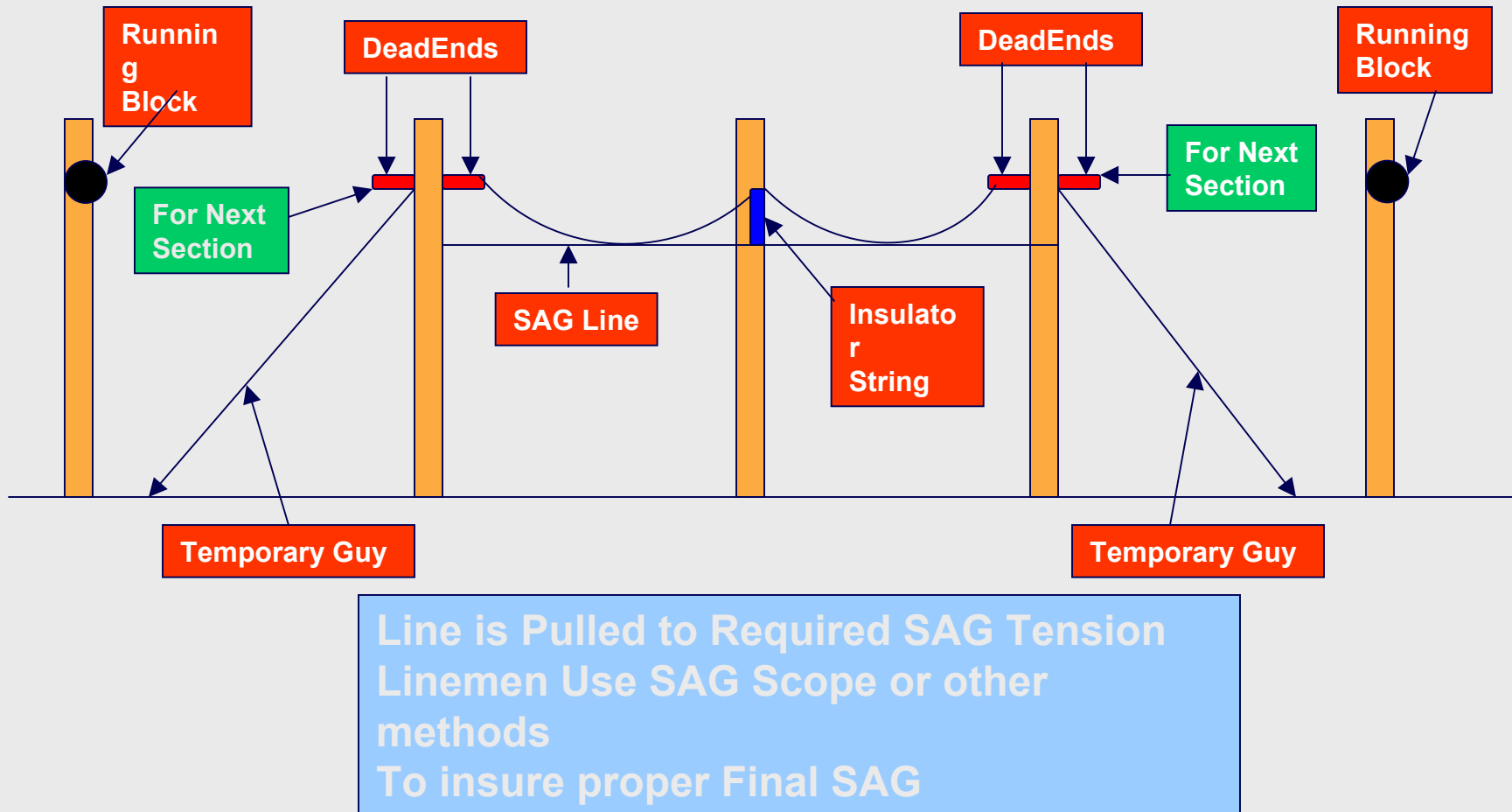
LACING STEEL TOWERS



PULLING CONDUCTOR TO SAG



SECTION PULLED TO SAG

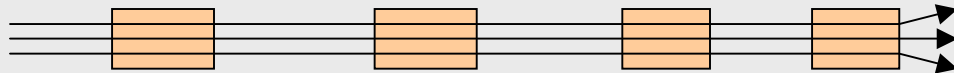


HELICOPTER OPERATIONS

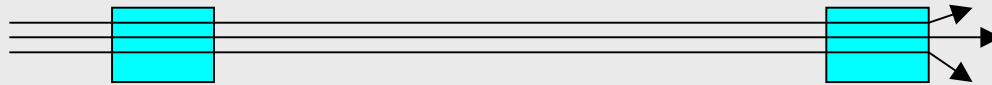
- * Remote Sites
- * Transports personnel, material, equipment
- * Sets poles
- * Installs pulling rope



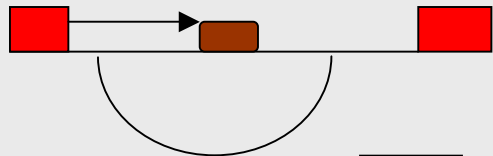
UNDERGROUND & SUBMARINE TRANSMISSION CIRCUITS



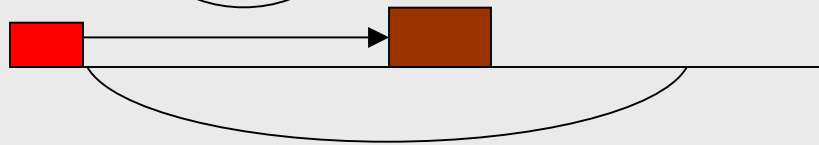
**Pipe Type Oil-o-static
Trenching and Shoring**



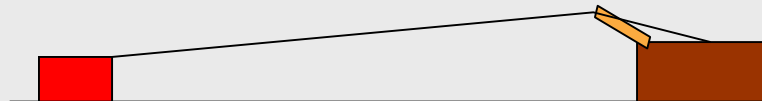
**Direct Buried Solid Di-
electric Trenching and
Shoring**



**Narrow Body of Water
Small Boat Pulls Rope**

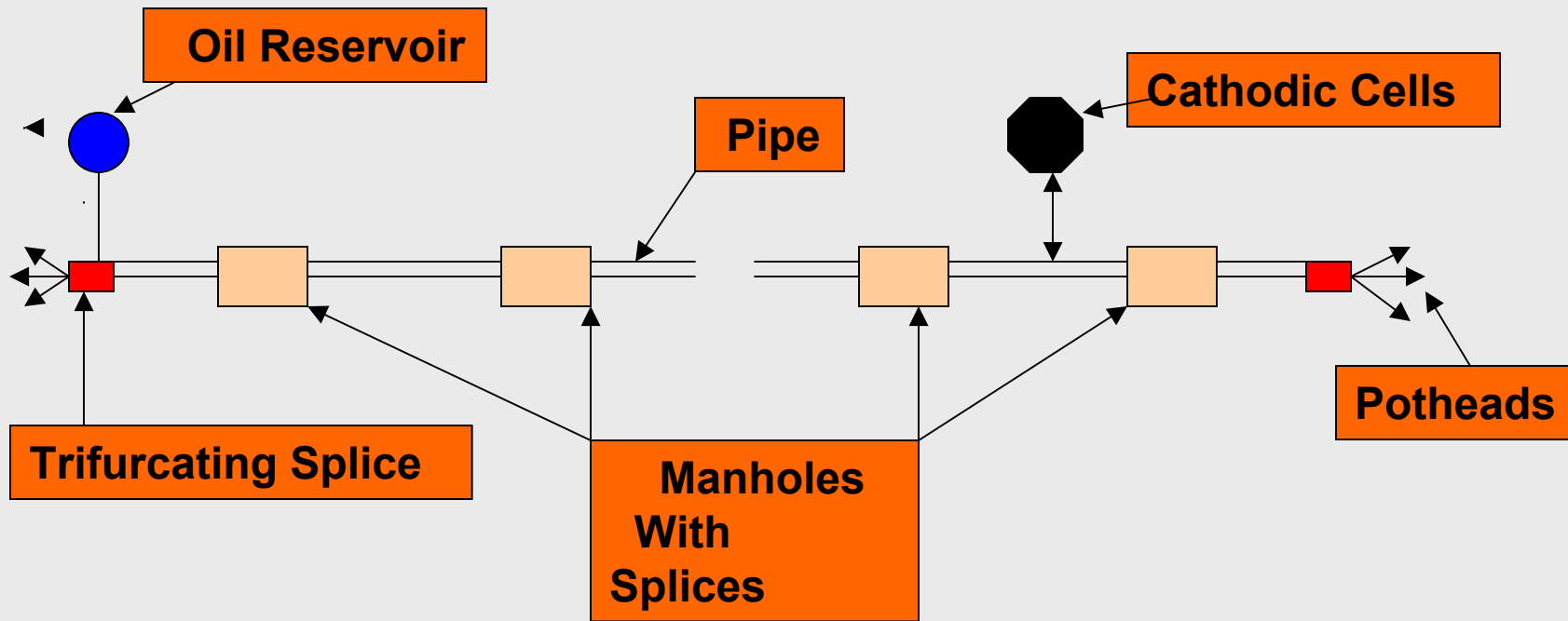


**Wider Body of Water
Barge Lays out
Conductor Splices Made
on Barge**



**Large Body of Water
Cable Laying Ship Utilized
One continuous cable**

PIPE TYPE CABLE CIRCUIT

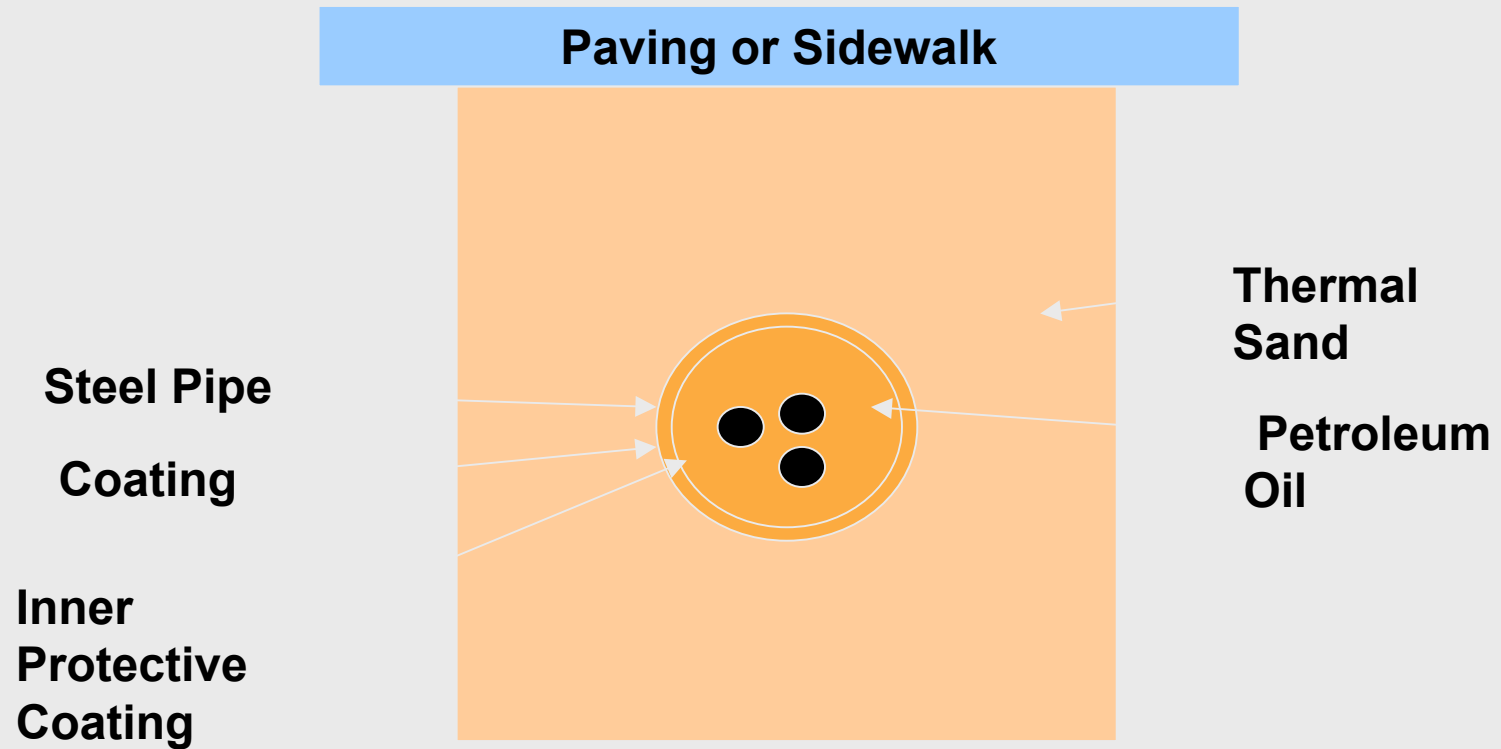


* Cable Reel Lengths

345kv – 1750'

138kv & 230kv 2500'

SINGLE CIRCUIT OIL-FILLED PIPE TYPE CABLE SYSTEM



- * 69kv-500kv
- * Paper insulated oil-filled
- * Trenching, shoring, pipe jacking

MAINTENANCE PROGRAMS

- * Ground inspections
- * Climbing inspections
- * Aircraft inspections
- * Infra-Red inspections
- * ROW maintenance
- * Switch maintenance
- * Emergency stock
- * Corrective work orders



STORM DAMAGE REPAIRS

- * Damage assessment
- * Clearing work area
- * Replacement structures & conductors
- * ROW access & condition
- * Equipment



UNDERGROUND LINES MAINTENANCE PROGRAMS

- * Ground inspections
- * Manhole inspections & entry
- * Cable terminations
- * Oil contamination check
- * Oil loss
- * Faulted cable “Life” testing



LOCATING A DAMAGED OR FAULTED SITE



Leak detection on an oil circuit

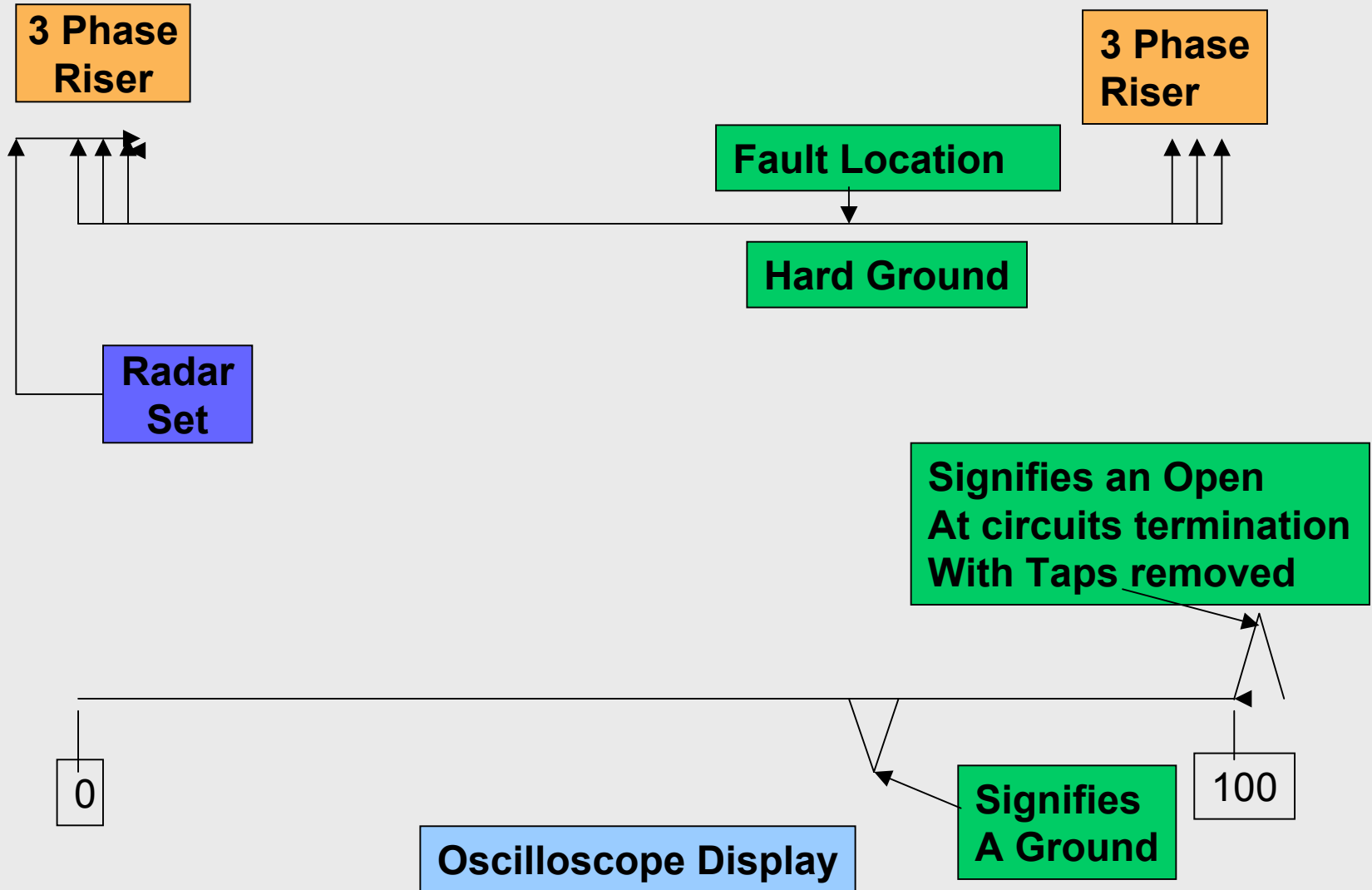
- + Subsurface radar
- + Acoustic method
- + Scent trained dogs
- + Flow direction indicator
- + Freeze method
- + Perfluorocarbon Tracer (PFT) method



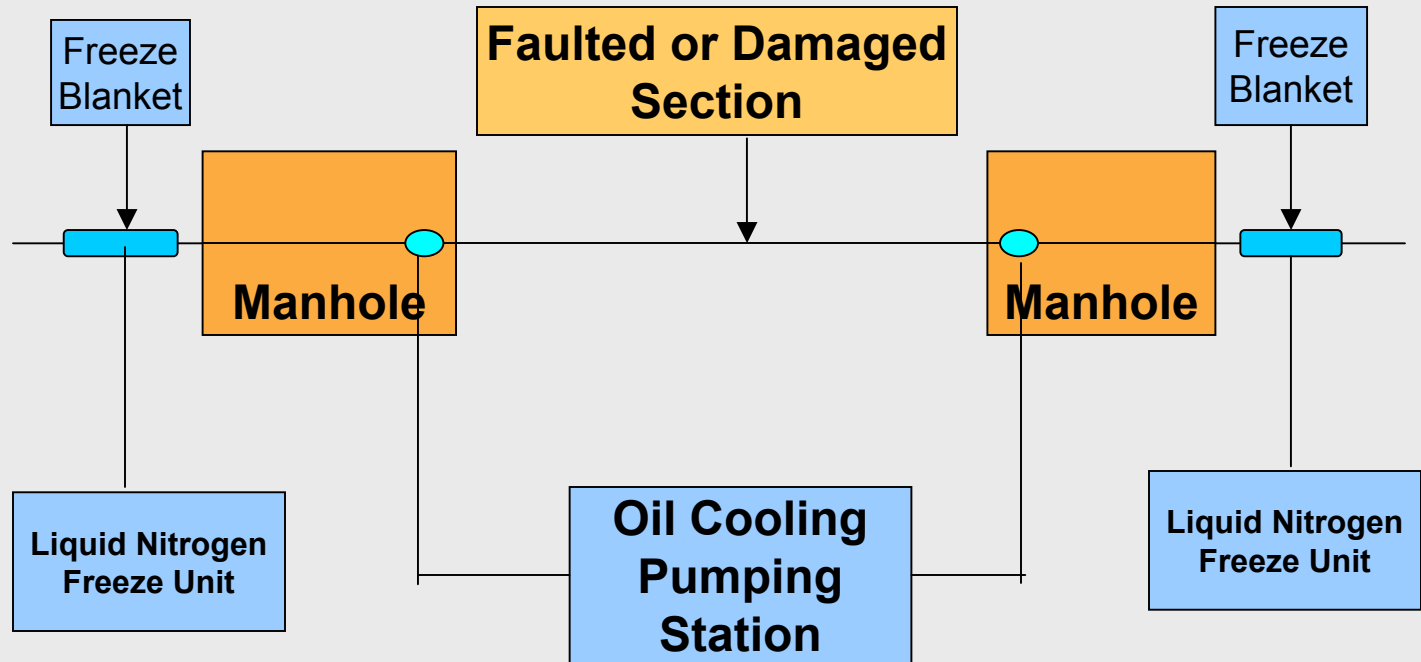
Fault locating on underground circuits (oil & solid di-electric)

- + Radar
- + Impulse
- + Galvanometer
- + X-Ray

RADAR APPLICATION IN FAULT LOCATION



PIPE TYPE CABLE SYSTEM REPAIR OPERATIONS



- * Traffic control
- * Emergency permits
- * Freeze section
- * Controlled atmosphere facility



Looking north west from Command Post during excavation

JUL 13 2002



leak

feeder 71

48" water main

feeder 72

E Gun Hill & Webster Ave

JUL 13 2002



feeder 71

48" water main

feeder 72

E. Gun Hill & Webster Ave - excavation pit

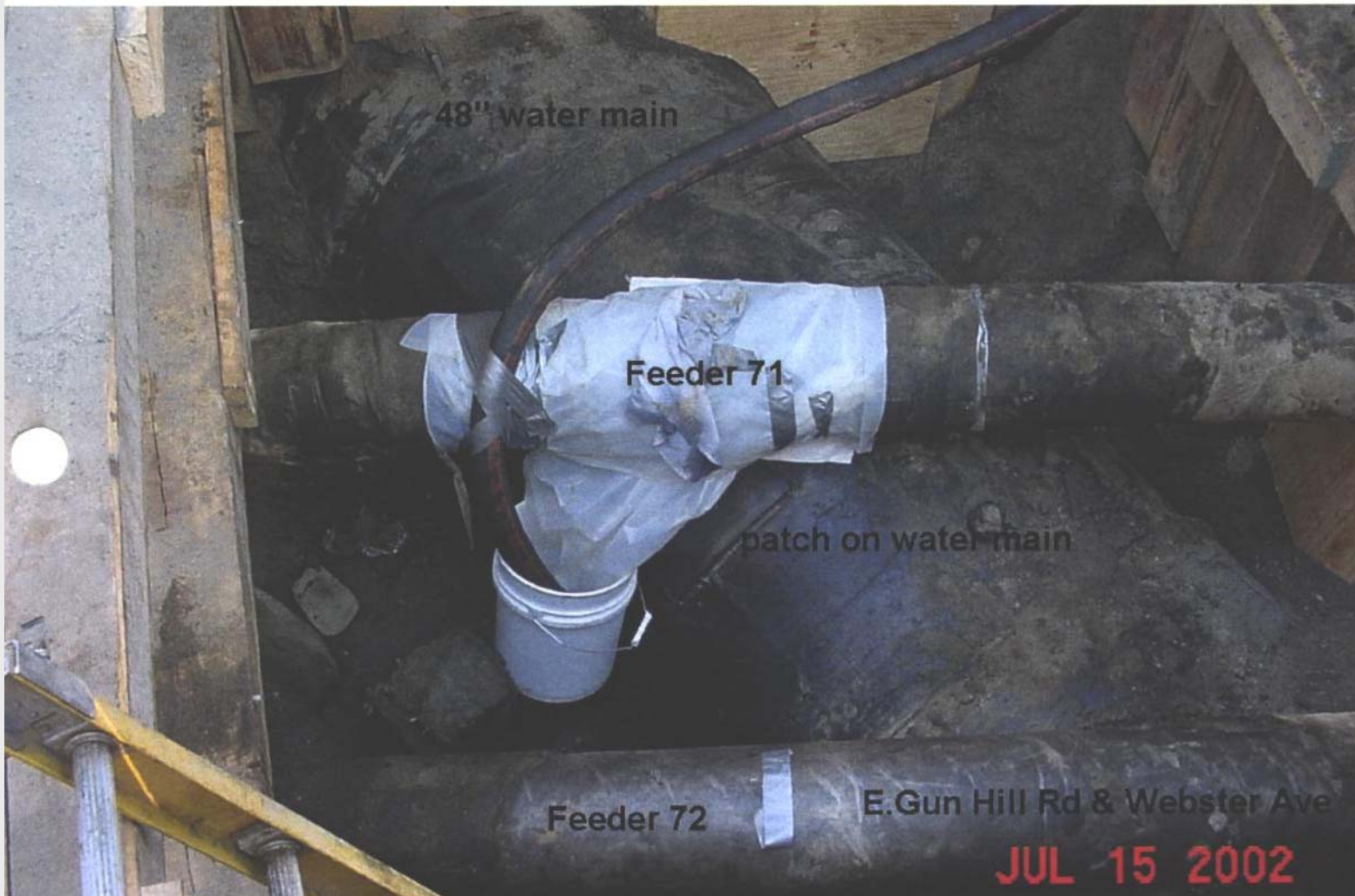
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installing elap on feeder 71

E. C. ... Rd. ...

JUL 13 2002



48" water main

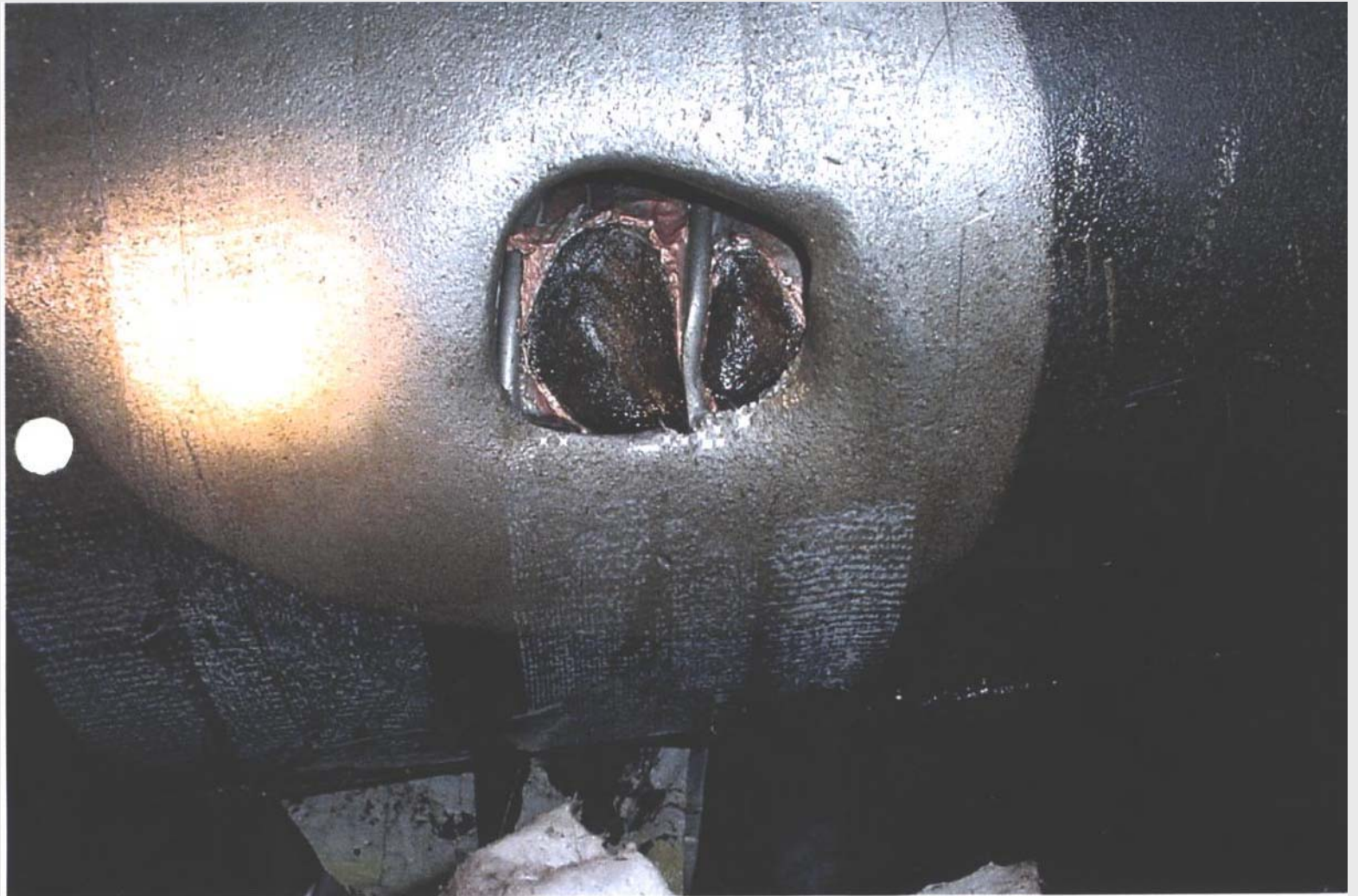
Feeder 71

patch on water main

Feeder 72

E. Gun Hill Rd & Webster Ave

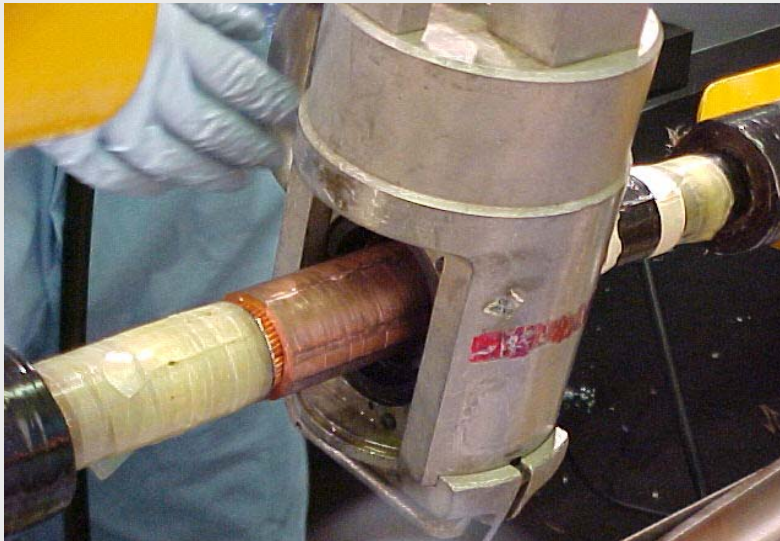
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REPAIR SPLICE PREPARATION



SUBMARINE CABLE MAINTENANCE PROGRAMS

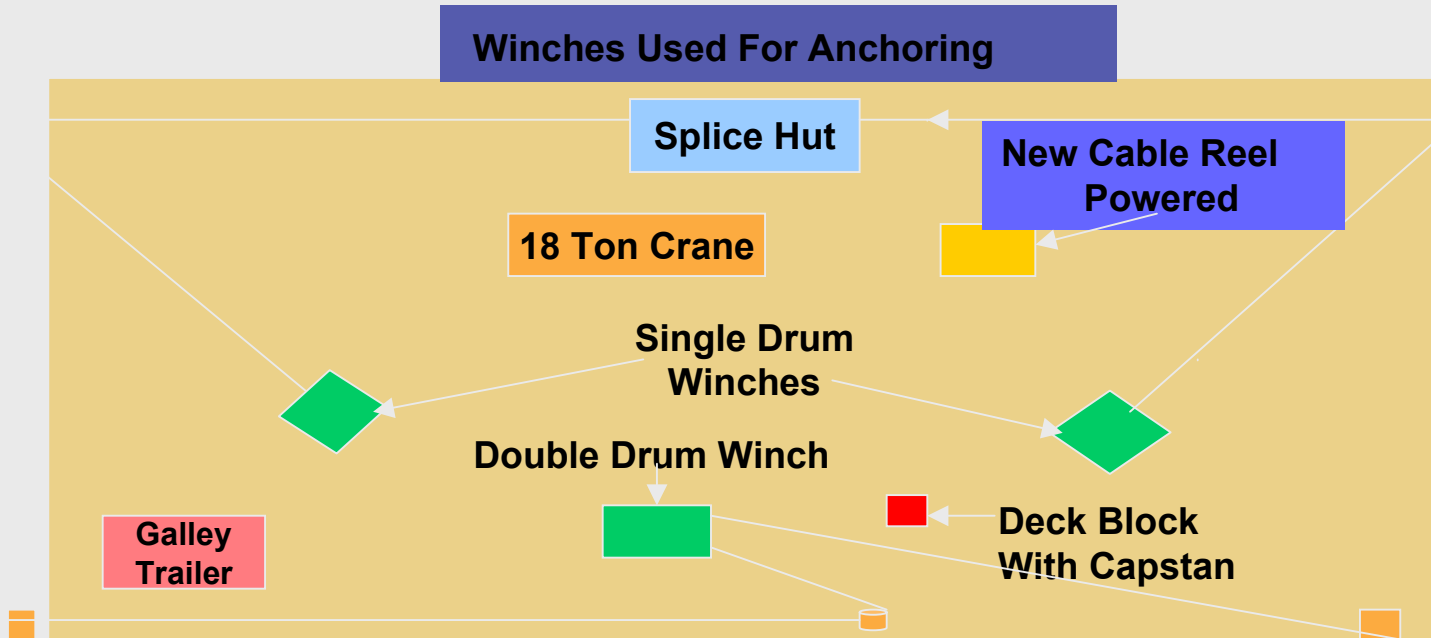
- * Pothead inspections
- * Oil contamination & loss
- * Diver inspection
- * Navigation Charts & Signs
- * Visual Inspections

LOCATING A DAMAGED OR FAULTED SITE

- * Circuit alarms
- * Visual check for vessel activity
- * Oil flow loss ratios
- * Oil bubbles
- * Side scan sonar
- * Divers



REPAIR BARGE LAYOUT



On Deck Equipment: 50kw Generators, Light Towers, Welding Machines, Compressors, Fuel Oil, Sani-Lav

- * Contractor
- * Obtain cable
- * Obtain splices
- * Cap and/or apply Leak Clamps
- * Cut away damaged sections & remove
- * Live end test cap
- * Set up barge
- * Wait for calm seas
- * Splice
- * Test

INCREASING TRANSMISSION CIRCUIT CAPACITY

- ✱ FERC Orders 888 & 889 to EPACT 1992
- ✱ ROW issues



CONSTRAINTS ON POWER TRANSFER

- * Thermal/current – most common limiter of transmission line, cables or transformer
 - Overheating:
 - a. reduces expected life of the line.
 - b. overhead lines SAG can lead to permanent stretch
 - c. underground cables can shorten life

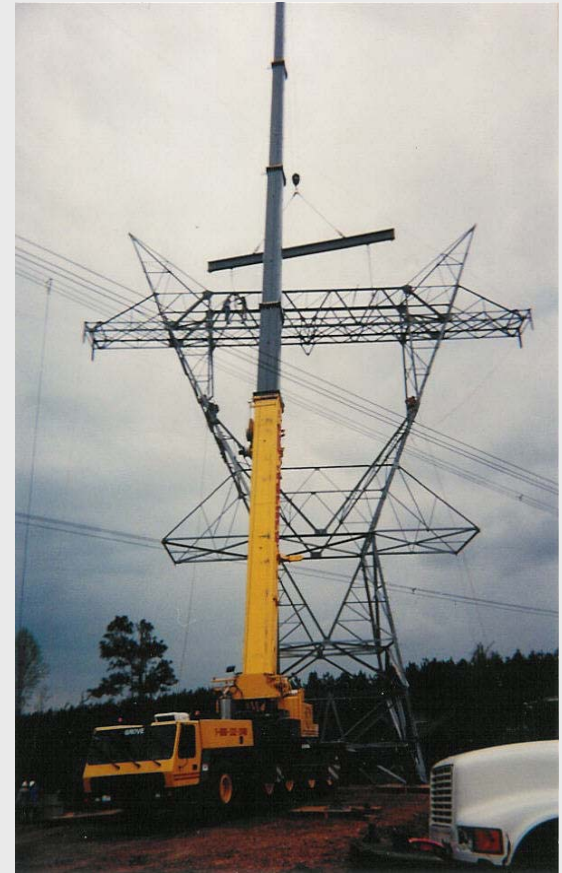
- * Voltage – maximum voltage levels are set in design of the line
 - Exceeding Maximum may cause short circuits, radio interference, noise, damage to transformers , substation equipment and customer facilities.

 - Low voltages cause poor equipment operation and damage motors.

- * System Operating – maintaining power flow in transmission and distribution networks.
 - * preventive operations to avoid interruption of service due to a component outage; operate below thermal limits.
 - * maintaining synchronization among generators preventing collapse of voltage

OVERHEAD CIRCUITS

- * Mid-span structures
- * Add section to towers
- * Increase conductor size or number per phase
- * Replace circuit
- * Convert to DC
- * Install Capacitors
- * Simple & combined cycle turbines for stability



UNDERGROUND CIRCUIT RERATING

* Cable Rerating

- a. most cables operating below their design ratings.
- b. requires accurate ratings to avoid long term operations problems.
- c. accelerated loss of life may be acceptable to increase power transfer during critical periods.

* Ampacity Audit

- a. cable auditors review available data on the line, extruded or oil-filled.
- b. most audits indicate additional power possibility some indicate a need to derate cable.
 1. higher daily load factor
 2. nearby distribution circuits

* Upgrading High-Pressure Liquid Filled Circuits

- a. slow fluid circulation – constant oil pumping between feeders, 10-15 gal/min, smoothes hot spots
- b. rapid fluid circulation – few hundred gal/min
- c. heat exchanger – in combination with rapid fluid circulation

FUTURE TRANSMISSION CAPACITY

- ✱ Utilities expect increased competition and seek to lower costs.
 - a. upgrading less expensive with less lead time
 - b. environmental issues, EMF concerns, property values add to problems experienced with new lines
- ✱ Restructuring of the Electric Power Industry leads to
 - a. increased competition
 - b. Increased wholesale trade
- ✱ Operators of the Transmission System
 - a. ISO's, RTG's, power pools, utilities will experience some upgrading of the transmission lines they are associated with.

