High-Temperature Low-Sag Conductors

Transmission Research Program Colloquium

Sacramento, California

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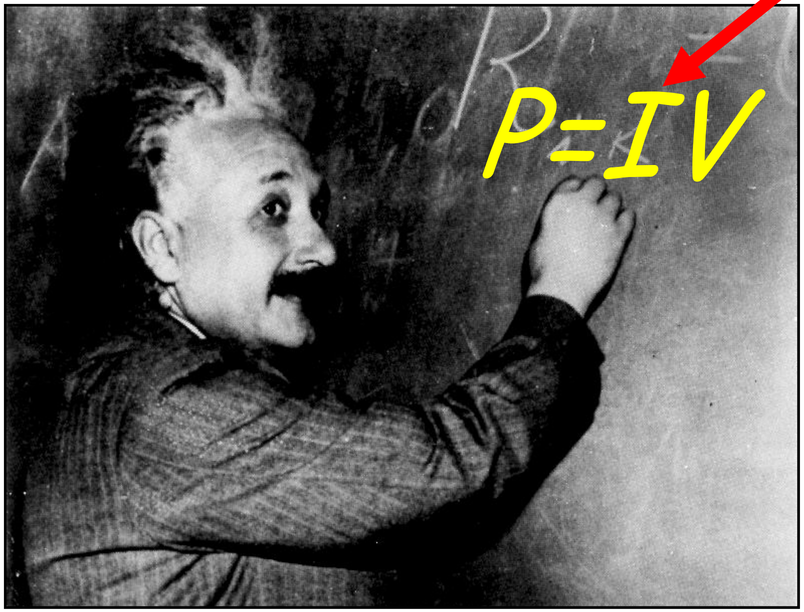
Transmission Line Rating

- **Line rating is the amount of power that can be transmitted (in terms of amps)**

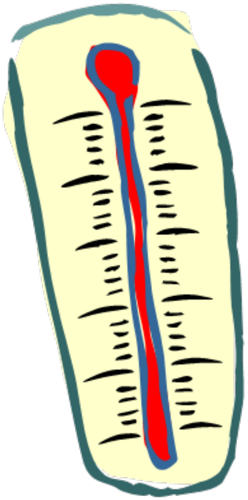


Criterion for Line Rating

Criterion for Rating:

The conductor temperature will be limited to X degC

WHY?



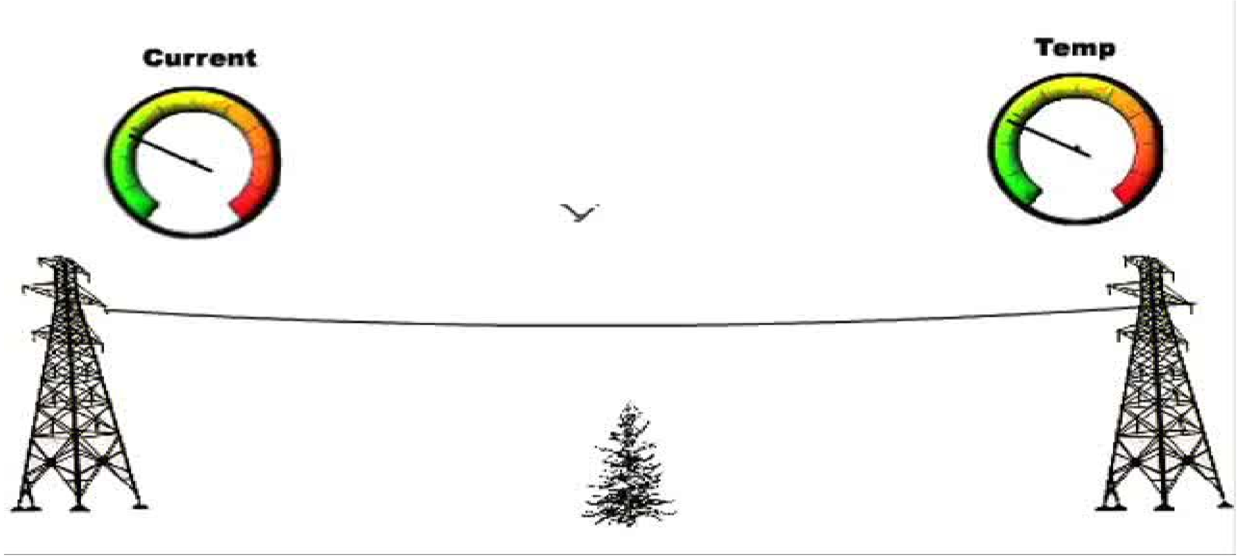
Fear of losing conductor strength

(*Thermally Limited*)

Fear of exceeding clearance limits

(*Clearance Limited*)

EPRI's HTLS Conductor Project – Field Measurements



Why HTLS Conductors

- **Less sag at high temperatures.**
- **Higher annealing temperatures.**
- **Reduced resistance.**
- **Can replace conventional conductors with no (or minimal) modifications to structures or ROWs.**
- **Can significantly increase the rating of TL with no (or minimal) licensing requirements or public opposition**

Manufacturers

Southwire: ACSS (Aluminum Conductor, Steel Supported)

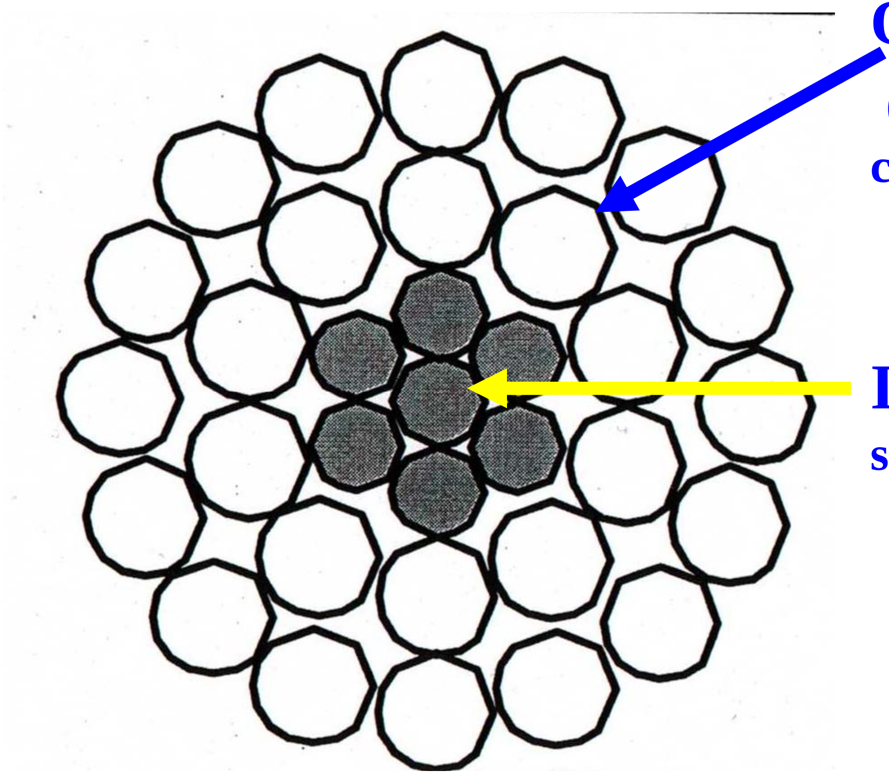
3M: ACCR (Aluminum Conductor, Composite Reinforced)

J-Power: Gap

LS Cable: Invar

CTC: ACCC (Aluminum Conductor, Composite Core)

Basic Conductor Design

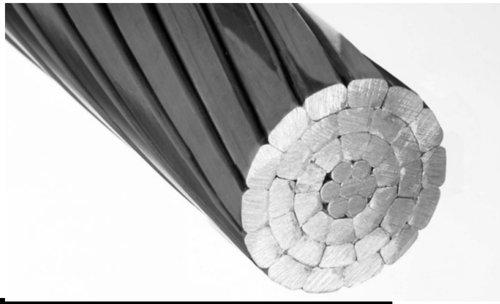


Outer Strands

(for electrical conduction)

Inner Core (for strength and support)

Conventional versus HTLS Conductors



	Conventional	HTLS
Inner Core	Steel	Steel alloy Composite (carbon or aluminum)
Outer Strands	Aluminum Circular	Annealed Aluminum Aluminum Alloy Trapezoidal

Material characteristics:

- Thermal coefficient of expansion of Invar (alloy of steel and nickel) is 1/3 of steel
- Annealing temperatures of aluminum and aluminum zircon are 93^{0}C & 230^{0}C respectively

ACSS/TW Conductor

Installed at CenterPoint

3M Metallic Matrix Composite Core

Gap

Invar

Installed at HydroOne

CTC Carbon Fiber Composite Core Conductor

Installed at APS

Unusual Properties Requires Special Handling

EPRI Project: Objectives & Background

Objectives

- **To provide participants vital information on selecting, designing, installing, operating, and maintaining the HTLS conductors**

Main Tasks

- **Laboratory tests and Field trials**
- **Reports and training materials**

Participants

- **15 US, 2 Canadian, UK, Spain & France i.e. ATC, AEP, CNP, Duke, TVA, Southern, Exelon, Hawaii Electric, Xcel, KeySpan/LIPA, California Energy Commission, SDG&E, SCE, PG&E, Arizona Public Services, National Grid (UK), Hydro One & BCTC (Canadian), REE (Spain), EDF**

Table of Installations

Where	Conductor Type	Size (in.)	Voltage	# Spans	Total Length (ft.)	# Splices
CP	ACSS/TW	1.108	138 kV	4	2280	2
HyOne	Gap	1.108	230 kV	4	1800	2
HyOne	Invar	1.108	230 kV	5	1900	2
APS	CTC	1.108	69 kV	4	956	2
SDGE	3M	1.108	69 kV	3	902	2

Installation Dates, Locations

Conductor	Manufacturer	Installation Date	Location
ACSS	Southwire	May 26, 2003	Houston
Gap	J-Power	Oct. 24, 2004	Ottawa
Invar	LS Cable	Oct. 24, 2004	Ottawa
ACCC	CTC	June 17, 2005	Phoenix
ACCR	3M	July 21, 2005	Oceanside

Cost

Conductor	Current Capacity	Price	Conductor Length (miles)
Conventional **ACSR**	1	1	> 500,000 in US (230 kV and above)
ACSS (Round and Trap Wire, all strengths)	1.8 to 2.0	1.2 (HS steel core) 1.5 (HS285 UHS core)	34,000 in US 800 with HS285
GTACSR (gap)	1.6-2.0	2	6,400
ACIR (Invar core)	1.5-2.0	3 – 5	12,000 (4,000 ZTACIR)
ACCR (Aluminum composite core)	2-3	5 – 6.5	500
ACCC (Carbon Fiber composite core)	2	2.5 – 3.0	1,200

CenterPoint Installation

138 kV, double circuit, vertical

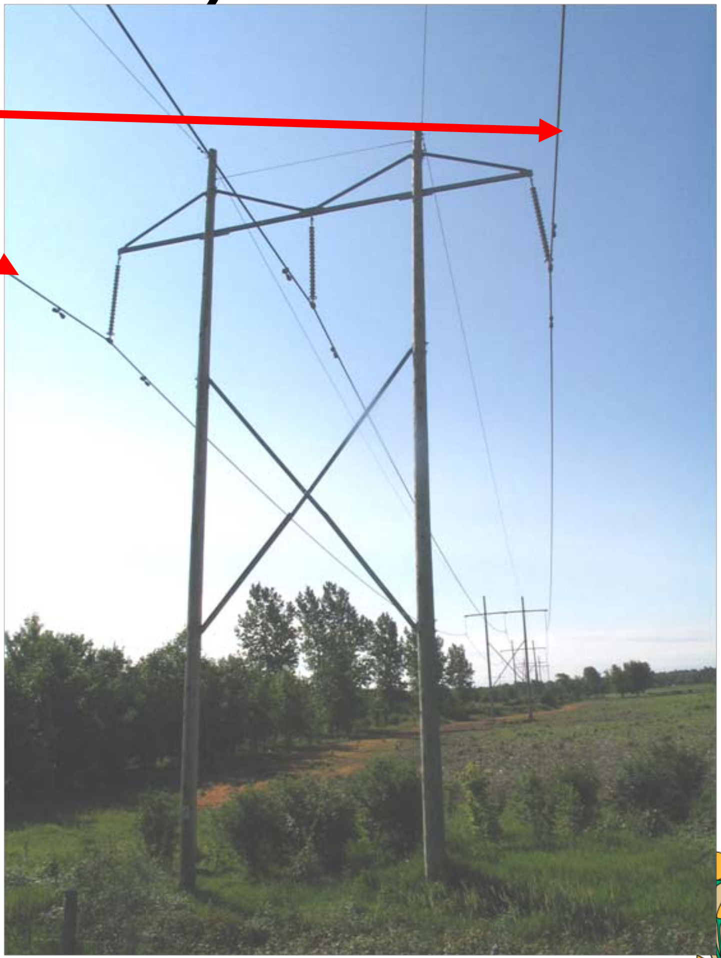
Replace 2-subconductor bundles with single conductors

After Installation (ACSS on Left Circuit)

SDGE 69 kV Line Section Replaced with 3M Conductor

Test Line Arrangement (Before Installation)

Gap & Invar conductors**,** installed parallel to the two outside phases of existing 230 kV line



After Installation

New APS 69 kV Line Section with CTC Conductor

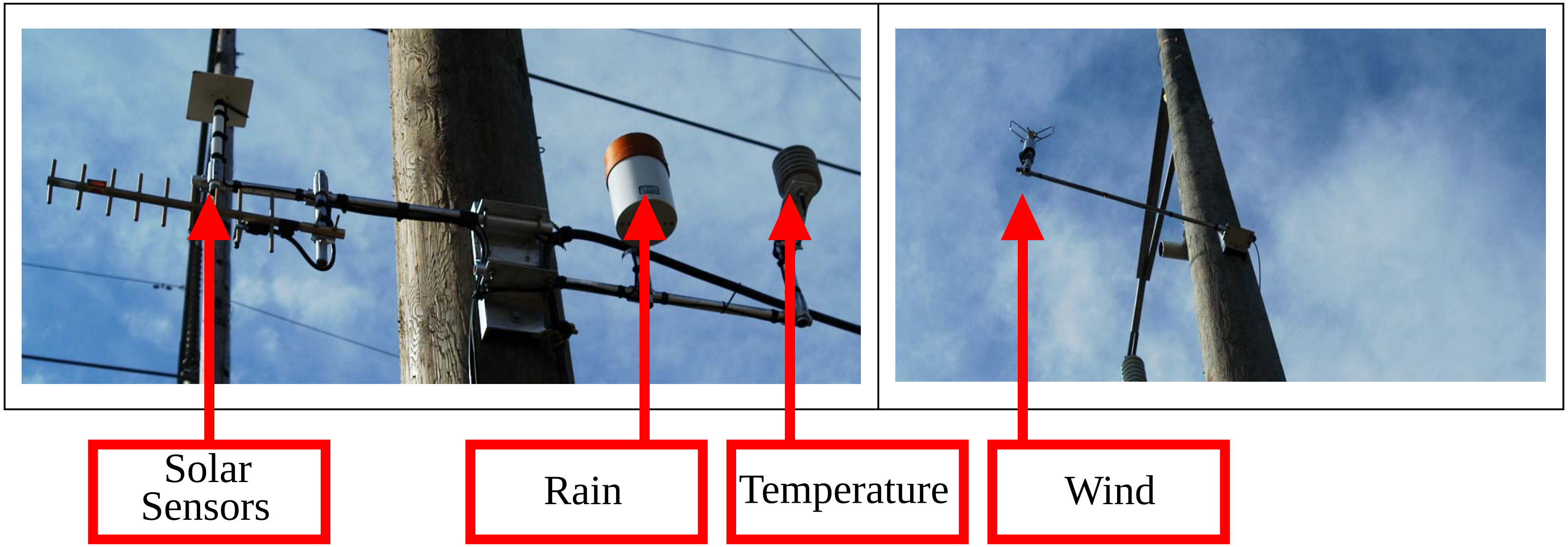
Parameters Measured

Parameter	Frequency of Measurements	Instrumentation
Conductor Sag	10 min	Video Sagometer
Conductor Tension	10 min	Load Cells
Weather	10 min	Weather Station
Conductor Current	~ 10 min	Substation CT
Splice Resistance	Site visits	Ohm Stick™
Cond/Hardware Temp	Site visits	IR Camera (also inferred from sag/tension)
Corona	Site visits	DayCor
EMF	Site visits	STAR 1000™
Visual Appearance	Site visits	Binoculars, camera, etc.
Vibration	Download during site visits	SEFAG recorder

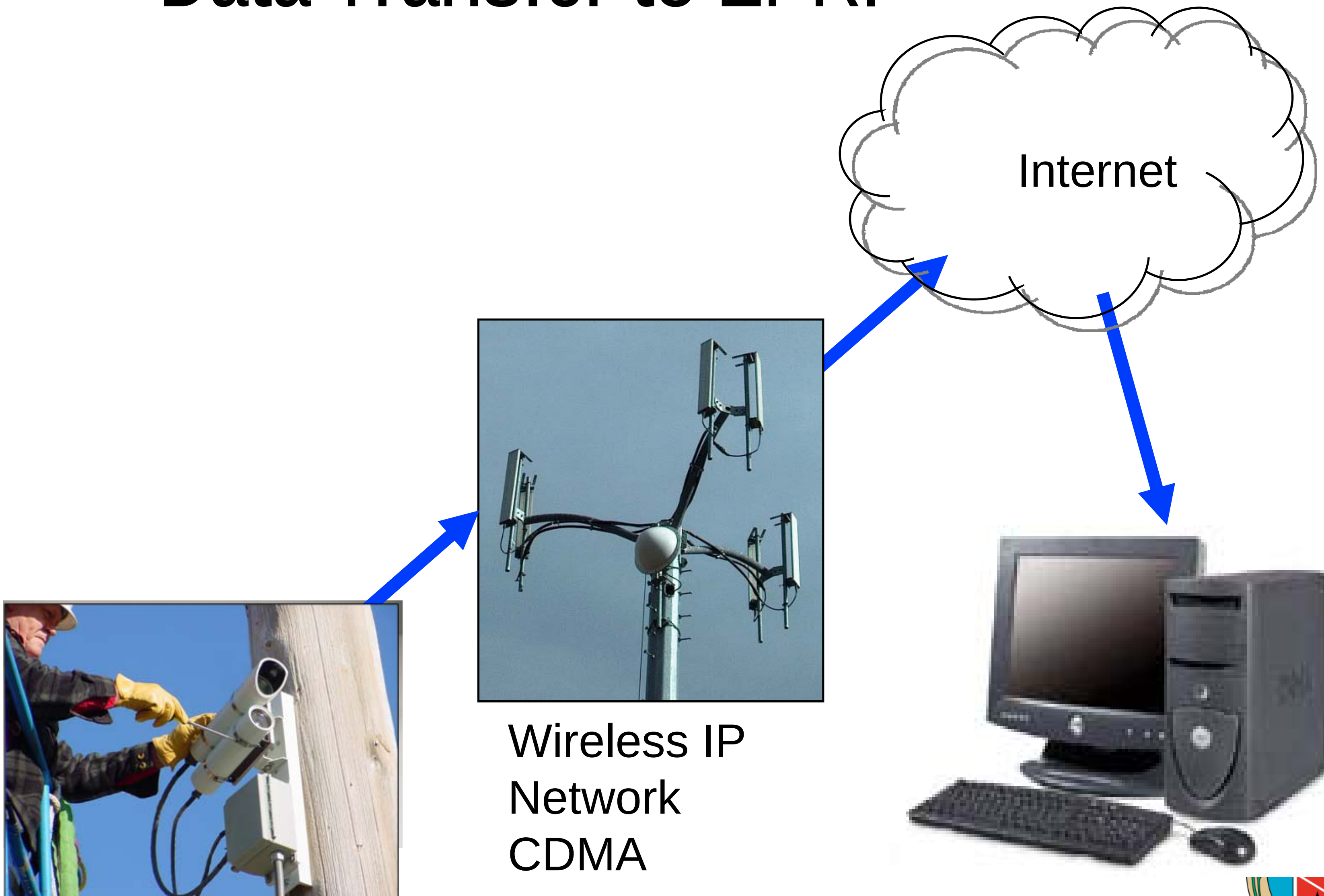
Video Sagometer for Sag Measurements

Load Cell for Tension Measurements

Weather Instruments

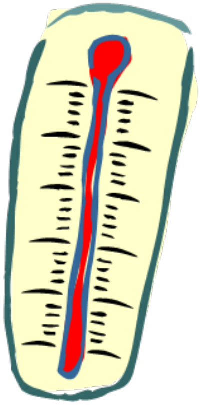


Data Transfer to EPRI



Splice Resistance Measurements

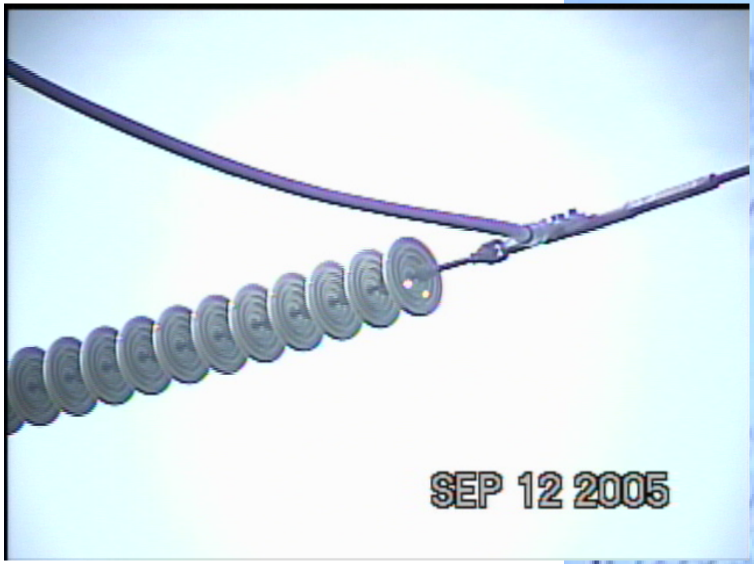
Infrared for
Component Temperature Measurements



Corona Detection

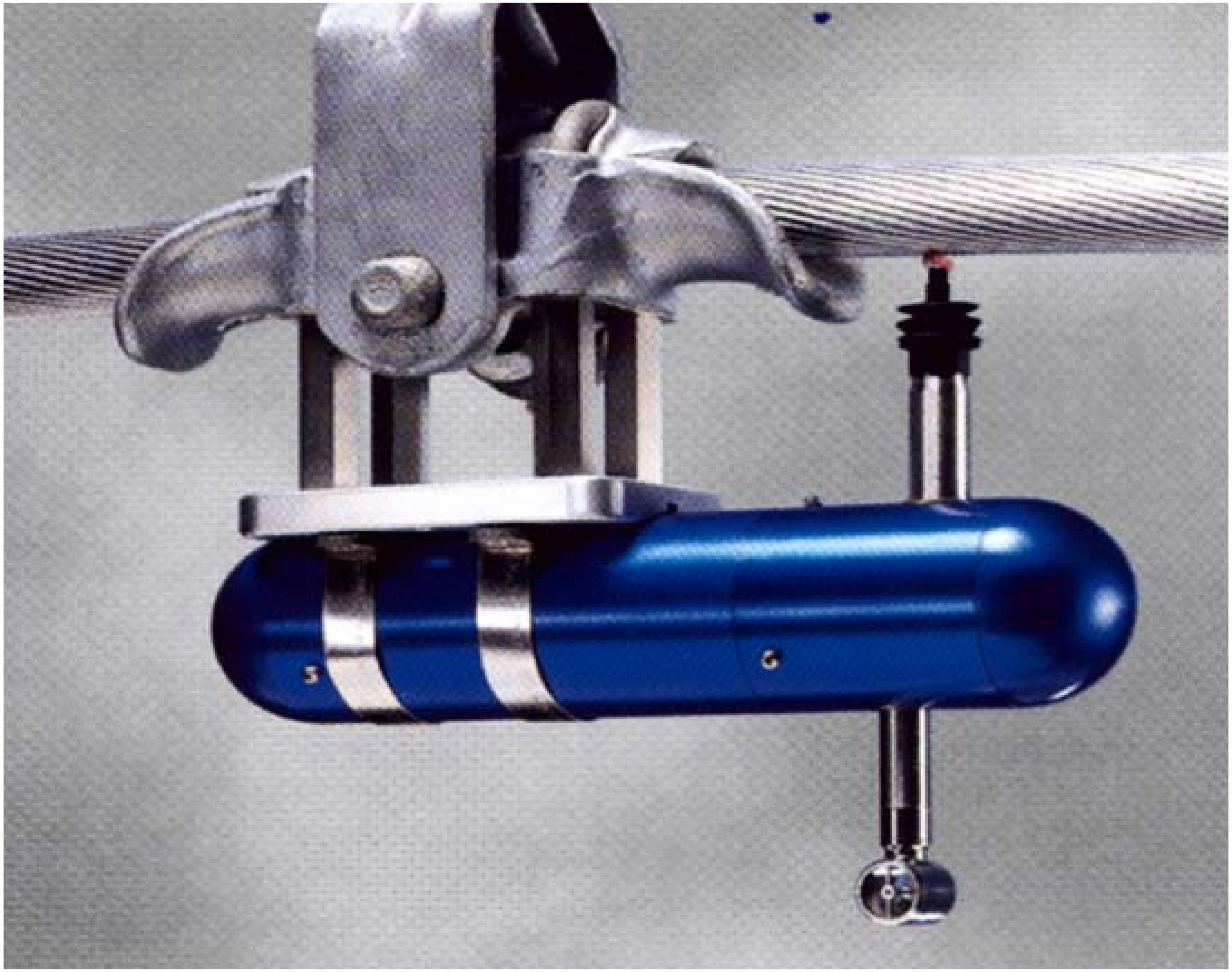
Corona observations using DayCor camera

Corona



EMF Measurements

Vibration Measurements



Visual

Deliverables

- General Report: “Demonstration of Advanced Conductors for Overhead Transmission Lines”, PID 1017448 available on August 1, 2008
- Technical Report “HTLS Conductors and their Applications” to be available early 2009
- EDF Report “Study of the Thermo Oxidation for Organic Matrix Composite Concerning the Reinforcement of Overhead Lines” to be available December 2009
- ORNL Report “Methodology for Predicting the Service Life of HTLS Conductors” to be available December 2009
- “AC Resistance of Bare Stranded Conventional versus HTLS Conductors” to be available December 2009
- Installation Video (dated March 19, 2007): delivered
- Workshop: July 30 & 31, 2008

Follow-up work at EPRI

Advanced Conductors

- Starting in 2008
- Maintenance & longevity issues
- New HTLS developed after HTLS Demonstration

Compression Fittings

- Starting in 2008
- Design & performance

Questions, Comments, Discussion