
A collection of military medals and a pair of glasses are arranged on a light-colored, textured surface. On the left, a blue and white checkered ribbon is pinned to a dark blue rectangular holder. Below it, a red ribbon with a circular emblem is pinned. A silver star-shaped medal with a central emblem is pinned to the right. A pair of gold-rimmed glasses with a thin wire frame is positioned diagonally across the center. In the bottom left corner, a circular compass is visible. The background is a plain, light-colored wall.

URD CABLE DESIGNS FOR THE FUTURE

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Future URD Cable Designs

Arbitrary Distinction

- ◆ Classical Concepts
 - Improved conventional materials
 - Improved processing
 -
- ◆ Advanced or ‘Novel’ Concepts
 - Non-conventional insulations, shields
 - Modified constructions



**Slide From CIGRE_Advanced Materials
Presentation/ Dec 2000 [Delft]:Anticipated
Advances in Cable Technology**

- ◆ **Metallocene/Single Site Catalyst Polymiz**
 - Controlled MWD/improved properties, cost
 - Insulation, Shields
- ◆ **Polymer Blends**
- ◆ **Conducting Polymers for Shields**
 - Polyaniline
- ◆ **DC Extruded Cables**
- ◆ **HTSC Conductors**
- **Prior talk not limited to URD**
 - **Some concepts applicable**



Future URD Cable Designs

- ◆ Classical concepts/Materials
 - **Improved Cleanliness**
 - **Insulation, shields, jackets**
 - **Insulation: advanced pellet inspection technology (?)**
 - **Even superior tree retardant materials (?)**
 - **Single site catalyst polymerization technology for polyolefins**
 - **blur distinction between TR-XLPE and EPR (?)**

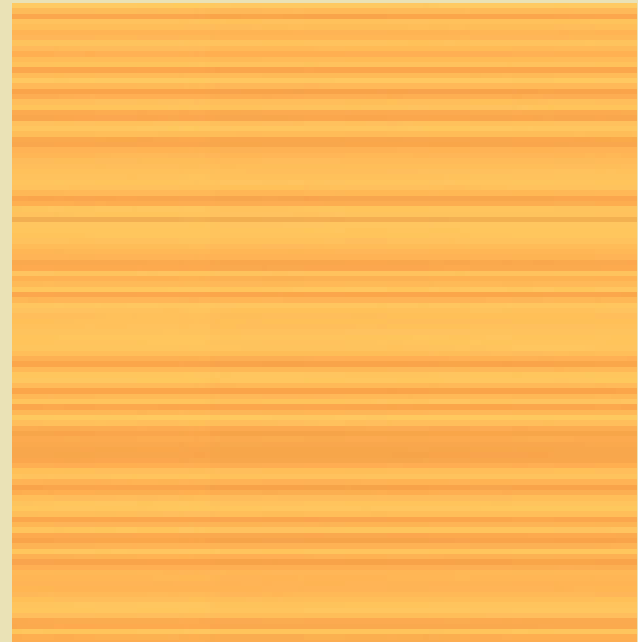
Future URD Cable Designs

- ◆ Conventional EPR
 - Polymer and filler opportunities (?)
 - Clay: smaller/more uniform particle size
 - Superior polymer/clay interfaces
 - Gel prevention
- Inputs from materials suppliers



Future URD Cable Designs

- ◆ **Improved extrusion processing**
 - Screen pack materials (?)
 - Screw design (?)
 - ◆ **Barrier Technology**
 - Superior jackets
- ◆ **Inputs from cable manufacturers**



Future URD Cable Designs: Advanced Concepts

◆ Advanced Concepts

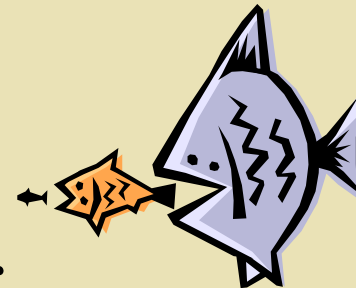
• EPRI Projects

• Novel Materials

- Insulations
- Shields

• Ion Trap Jacket

• All Polymer Moisture Barrier





Ion-Trap Jacket

- ◆ Additives in polymer materials employed as Jackets
- ◆ U.S.Patent 6,005,192
 - ‘Jacket for Insulated Electric Cable’
- ◆ **EPRI Reports TR-104,247: TR-109,365**
- ◆ **Materials and cable tests performed**
- ◆ **Contractor: Univ. Conn.**
- ◆ **Contractor/follow-on work: Southwire Co.**



ION TRAP JACKET

◆ ADDITIVES IN JACKET

– Organic Ion Exchange Resins

- Sulfonic acid resins
- Carboxylic acid resins
- Carboxylic ionomers
- Quaternary ammonium hydroxide resins
- Tertiary amine –based resins

– Zeolites

– Activated bauxite

– Five to 20 % by weight

– Resins Used Alone or in Mixtures

◆ Blended into low density polyethylene



Ion Trap Jacket

- ◆ **Screening Experiments**
 - **Thermal stability after dispersion**
 - **Diffusion**
 - **Migration of salt solutions thru modified materials**
 - **Conductivity measurements**
 - **Compare: Surlyn, EDTA, Zeolites, Kaolin**
 - **Conventional jacket controls**
 - **Trapping Mechanisms**



Ion Trap Jacket

- ◆ Some Observations
 - Additives vary in ability to trap ions
 - Potassium more easily trapped than Calcium
 - Commercial jackets respond differently from each other
 - More
- ◆ Full size cable ACLTs



All Polymer Moisture Barrier

- ◆ **Extrudable polymer moisture barrier**
 - Replace metallic sheath (e.g., Pb)
 - Work in conjunction with conventional jacket
- ◆ **Liquid Crystal Polymers**
 - Extremely high moisture resistance
- ◆ **Issues:**
 - LCP type **extrudability**
 - barrier location **properties**
- ◆ **U.S.Pat. 5,936,204** ‘Moisture Resistant Underground Cable’
- ◆ **EPRI Report TR-112,238**
- ◆ **Contractor: Foster-Miller**



All Polymer Moisture Barrier

- ◆ Liquid Crystal Polymer is bi-axially oriented
 - **Special extrusion equipment**
- ◆ Extrudability of LCP in concentric construction design demonstrated
 - **Three constructions**
- ◆ Limited cable test data generated (CTL)



All Polymer Moisture Barrier

◆ ISSUES

- **Additional mechanical test data**
 - **Final LCP Thickness**
 - **Prior goal / 2 mils**
- **Where to place layer for commercial usage ?**
 - **Under conventional jacket/over insulation shield**
 - **Inside cable core**
 - **Within conventional jacket**
 - **Experimental construction manufactured**

All Polymer Moisture Barrier

ISSUES

Balance Required Between

- Moisture resistance
- LCP layer thickness
- Mechanical properties
- Final location of LCP layer
- Aging





Moisture Barrier Study

- ◆ **EPRI Report EL-6857 (1990)**
- ◆ **Metal foil/adhesive/foam compositions**
 - **Cu, Al, Pb**
 - **Semi-conducting and insulating foams**
 - **Foam to assist in managing thermal expansion (not necessarily a URD issue)**
 - **Modified polyolefins as metal/jacket adhesives**
- ◆ **Tests on models and cable sections**



Conducting Polymers as Shields

◆ Objective

- Replace carbon black
- ◆ **FIR transparent system would facilitate cable inspection**
 - Improved QA, cable quality
- ◆ **EPRI EL-6539**
- ◆ **Contractor: Westinghouse**

◆ Issues

- **CP choice**
 - Dopants
- **Blend compatibility**
- **Conductivity**
 - Stability on aging
- **Processing**
- **FIR Transmission**
- **Qualification**
- **Eventual cost**



Novel Insulation Materials

➤ Survey

- **EPRi Report TR-111, 888**
 - **Polymers from commercial sources**
 - **Not presently employed for URD cables**
 - **Pressed slab study**
 - **Physical/mechanical electrical properties**
 - **Coated wires on selected materials**

➤ Issues


Availability

Extrudability

Properties

Aging

Contractor: Foster Miller



Novel Materials

Survey/Selected Examples

◆ Heterocarbons

- Xydar (LCP)
- Isaryl25(arom. polyester)
- PEEK
- Lexan
- Ultem

◆ Hydrocarbons

- PMP
- PPS
- SPS
- BoPP

◆ PolyImides

- Non-conv. polyimides
- Aurem
- LaRC-TPI
- Upilex



URD CABLE DESIGNS FOR THE FUTURE

- ◆ Potential concepts, ideas noted
- ◆ Any ongoing work by manufacturers
 - **proprietary**
- ◆ Prior EPRI exploratory work summarized
 - **Further work not in plan**
 - Web page 2003
- ◆ Effort required to apply new technologies



Caution

- ◆ Advanced technology not does not necessarily mean cheaper products
- ◆ A superior product may cost more
- ◆ Build into thinking !

THANK YOU

◆ Questions?

