Composite Conductor Field Trial Summary Report: Hawaiian Electric Company, Inc—Hawaii

Installation Date	April 2002
Field trial Location	Oahu, HI, North Shore within ¼ mile of ocean

Line Characteristics

Utility:	Hawaii Electric
Point of Contact at Utility	Clinton Char, Transmission Engineer
Installation Date:	April, 2002
Conductor Installed	ACCR 477 kcmil *(281 mm^2)*
Length of line:	1,716 feet (523 meters)
Conductor diameter	0.86 inch, *(21.8 mm)*
Voltage	46 kV
Ruling span length	429 feet, (130.7 meters)
Structure Type	Wood poles
Instrumentation:	None, visual inspection on yearly basis
Suspension Hardware	Preformed Line Product, THERMOLIGN™ Suspensions TLS-0101-SE
Termination Hardware	PLP THERMOLIGN™ Dead Ends , TLDE-477-N
Insulator type	Ceramic
Dampers	None
Terminals	Alcoa brand Parallel Groove Clamp – 583.3P

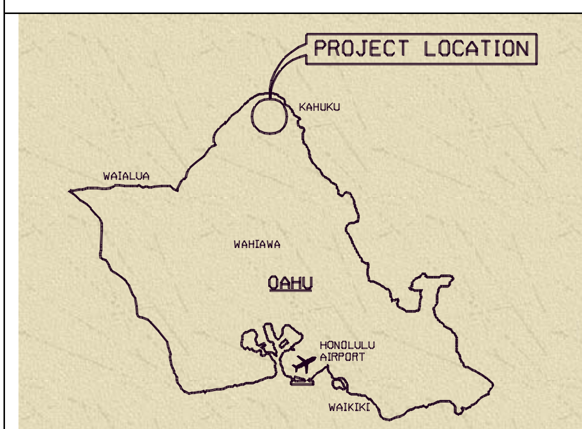
Results and Measurements

- Document installation procedure
- Performance of small diameter ACCR conductors
- Corrosion resistance in coastal environment

Photo Album

Overall view of the 46kV line

PLP THERMOLIGN™ Suspension



Location on North Shore of Oahu

The North Shore has a very corrosive environment due to constant trade winds from the ocean.

Project Scope and Installation

Hawaiian Electric Company (HECO) is actively investigating a new, high-capacity conductor that contains a fiber-reinforced aluminum core. The high-performance conductor, developed by 3M, has significantly reduced sag, enabling utilities to double transmission capacities without changing clearances or increasing structural loads.

While ACCR offered obvious advantages to HECO, the company needed to know how the new material would respond to the highly corrosive environments found on the Hawaiian islands. Even the best galvanized steel can severely corrode within two years in coastal regions subjected to salt-laden trade winds and moisture. Experience has shown that steel-reinforced conductors (ACSR) are particularly vulnerable in what metallurgists have dubbed the most corrosive environments in the world. In fact, the University of Hawaii has built, in the vicinity of the test line, an outdoor corrosion laboratory with conditions that rival some of the world's most adverse environmental test chambers.

In addition to determining corrosion resistance, HECO also needed to understand how ACCR was installed and maintained, what types of accessories, suspensions and dead ends were used, and how it would perform over time. To verify the behavior of ACCR, HECO and 3M developed a pilot project that included installing multiple spans of 3M composite conductor on HECO's sub-transmission grid and monitoring the line for approximately two years.

In early 2002 HECO decided to perform a field test of the composite conductor on a short section of line. Multiple technical objectives had to be achieved including:

1. Installing the conductor with conventional equipment.
2. Installing the conductor with the full range of qualified accessories, including suspensions and terminations.
3. Operating in the most corrosive environment found on the island.
4. Visually inspecting the line on a frequent basis.
5. Selecting a line that was not critical for the reliability of the network

A ½-mile section of a 46-kV sub-transmission line was selected on the north shore of Oahu . The existing conductor on the line was 556-kcmil AAC (All Aluminum Conductor) to be replaced with a 477-kcmil ACCR composite conductor.
The test line consisted of two dead-end towers, three suspension towers, and a single circuit with a ruling span of 430 feet.
The stringing tension of the composite conductor was calculated to match the sag of the existing 556-kcmil AAC conductor at 70 degrees F (1800 lbs tension). Stringing tension was obtained by using Alcoa's SAG-10™ Software.

The installation was similar to that of a typical ACSR conductor, with a few exceptions. When handling the conductor, the bend radius of the conductor must not exceed the breaking limitations of the composite core. To meet this requirement, HECO used 28-inch (70 mm) stringing blocks instead of 20-inch blocks to provide a large safety factor.

Another significant difference was that the accessories were specifically designed for the composite conductor. The dead ends and suspensions made by Preformed Line Products (PLP) looked and installed like hardware typically used by HECO except they were heftier than typical 477-kcmil hardware. The PLP Product Manager, Bob Whapham, explained " the accessories are specifically designed to remain cool when the conductor is hot". PLP THERMOLIGN™ dead-end and suspension assemblies were used as the hardware for the ACCR conductor.
PLP THERMOLIGN™ suspensions have been designed to operate with the high capacity Composite Conductor. The suspension's design allows it to remain cool when the conductor is hot at the maximum ampacity rating .

The 477-kcmil ACCR conductor was electrically connected to the existing 556-kcmil AAC conductor with an Alcoa-Fujikura brand parallel groove clamp, which allows the connection of two different sized conductors.

A standard "sock splice" was used as a conductor grip to pull the ACCR conductor through the stringing blocks. In addition, a swivel was installed between the ACCR conductor and the AAC conductor during this stringing operation to prevent twisting of the ACCR conductor.

When performing the sagging operation, a PLP dead-end assembly was used to grip the conductor. This dead-end assembly was used as a temporary grip and later removed from the conductor.

Other standard installation equipment included a drum-puller to pull in the ACCR conductor, and a standard reel stand with a friction break to provide back-tension during the stringing operation. Standard chain hoists, cable cutters, grounding clamps and dynameters were also used.

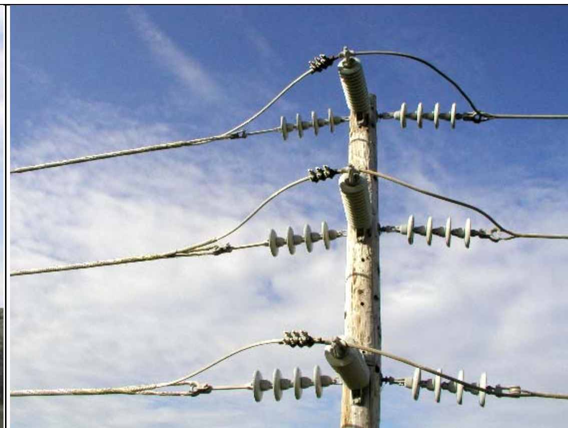
Representatives from 3M and PLP were on site during the installation procedures to help the line crew with any questions that arose. The installation was completed in three working days without problems.

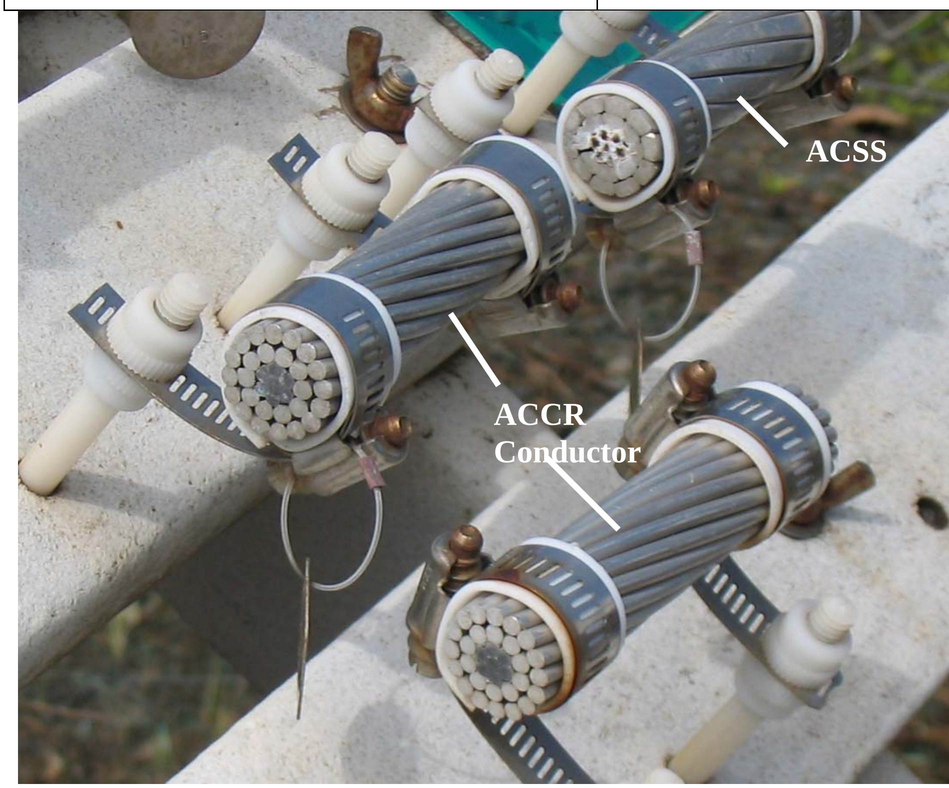
Line Inspections

The line and accessories were inspected in January 2003 after 1 year and March 2004 after 2 years and October 2004 after 2.5 years. Visual inspection of conductor, hardware and accessories confirmed that the new material was performing well.

The conductor sags were within predicted levels and no corrosion or deterioration of any parts were observed. An inspection of a conductor sample at the University of Hawaii's corrosion test facility confirmed that the conductor does perform well under highly corrosive environments as no visual signs of corrosion was noted after 2.5 years. (A photo of this sample is attached.) Based on HEI observations after 2.5 years, the 3M Composite Conductor behaves like a conventional AAC or AAAC conductor in terms of corrosion resistance.

Line Inspection After 2 Years in Operation *(photos obtained courtesy of HECO)*

	
No signs of corrosion on conductor and suspensions	*No signs of corrosion on dead-ends, conductor and jumper*



Several conductors were studied by the University Of Hawaii. The 3M, ACCR conductor shows no signs of corrosion after 2.5 years.

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Conductor Specification

Conductor Properties, 477 kcmil ACCR				
Designation	477-T16		(metric)	
Stranding	26/7			
kcmils	477	kcmil		
Diameter	0.86	in	*21.8*	*mm*
Total Area	0.435	in^2	*281*	*mm^2*
Aluminum Area	0.374	in^2	*241*	*mm^2*
Weight	0.539	lbs/linear ft	*0.802*	*kg/m*
Breaking Strength	19,476	lbs	*86.6*	*kN*
Thermal Elongation	9.2	10^-6 /F	*16.5*	*10^-6 /C*
Resistance				
DC @ 20C	0.1832	ohms/mile	*0.1138*	*ohms/km*
AC @ 25C	0.1875	ohms/mile	*0.1165*	*ohms/km*
AC @ 50C	0.2061	ohms/mile	*0.1281*	*ohms/km*
AC @ 75C	0.2247	ohms/mile	*0.1396*	*ohms/km*
Geometric Mean Radius	0.029	ft	*0.88*	*cm*
Reactance (1 ft Spacing, 60hz)				
Inductive Xa	0.4296	ohms/mile	*0.2685*	*ohms/km*
Capacitive X'a	0.0988	ohms/mile	*0.0618*	*ohms/km*