KINECTRICS
a BWXT company

Overhead Conductor & Accessories Testing Services

Kinectrics India – Facilities & Expertise to Enhance System Reliability

Importance of Independent Testing

Testing Overhead Lines & Accessories ✓ Increased Reliability ✓ Performance Insurance

Phase conductors have always been the backbone of any overhead transmission or distribution network. Notable growth for up-rating and expansion of the electrical power grid to reach the growing demand of transmission and distribution capacity is a challenge faced around the world. High Temperature Low Sag (HTLS) conductors have been developed and designed to meet the increasing needs of network capacity. Operation at elevated temperatures accelerates the aging process, raising the concern of reliable lifelong performance even more critical. Performing testing on all types of overhead conductors, throughout the lifecycle of the line, is an important step to strengthen the network.

Kinectrics is uniquely positioned to provide reliable, one-stop-shop testing services for clients worldwide, to assess the performance of various type of overhead conductors, both conventional and HTLS conductors, and condition assessment for aged overhead line. For over three decades, Kinectrics has been at the forefront of testing both conventional and cutting edge HTLS conductors.

When & Why Test?

Test throughout the lifecycle of your network

Testing validates that the chosen design of your overhead conductor is up for the challenge. Rigorous standards simulate installation or in-service stresses to confirm your conductor will perform as intended. Subjecting your conductor to various mechanical, electrical or environmental stresses, you can be confident that you have a robust design that will help you stay reliably connected and exceed the design life of the line.

As infrastructure ages, testing samples harvested from the field provides accurate information about the condition of your assets to help you make confident decisions to maintain your networks and extend their useful life.

Design & Production Phase

- Type Test to verify performance & assure quality products on new design or new manufacturing process
- Protect investments and avoid future maintenance challenges or early asset replacement

Installation Phase

- Simulate unique conditions such as severe sheave pulling angle, high tension/compression & extreme bending stress
- Validate new installation practices or tools

Operation Phase

- Simulate excessive or unique stresses
- Simulate various vibration or ice loading conditions
- Simulate thermal & mechanical stress to accelerate aging on components

Maintenance Phase

- Health Assessment to evaluate condition of conductor/shieldwire
- Estimate remaining life of a conductor, by simulating stresses
- Determine failure mode and root cause to avoid further unexpected failures

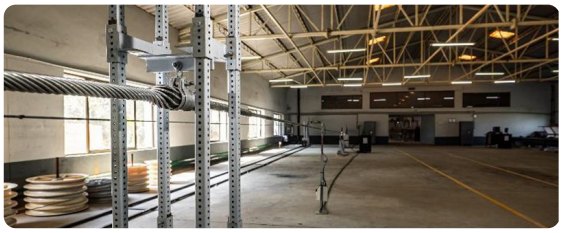
Kinectrics India

A One-Stop Testing Facility

Kinectrics offers one-stop, fully equipped laboratories, managed by highly qualified staff, to provide a wide range of mechanical, electrical and environmental testing services for the electric utility industry.

Kinectrics has over 30 state-of-the-art laboratories and 400,000 sq.ft of operational facilities across the globe to execute efficient and comprehensive tests. We handle everything from new product and aged component testing to custom projects and special studies.

The newest addition to our extensive global setup is our laboratory in Hyderabad, India. With more than 30,000 sq ft of test facility, modern amenities and state of art setups, the lab has been built to make Kinectrics' testing expertise accessible to Asia and surrounding areas.



30+

Years of experience in performing overhead conductor routine/type testing & condition assessment

Accredited to **ISO/IEC 17025:2017** by the Standards Council of Canada and registered to **ISO 9001:2015**

Experience in **testing various type of conductors in a laboratory environment** (i.e., AAAC, ACCC®, ACCR®, ACSR, ACSS, STACIR)

We offer **condition assessment**, **end-of-life** & **forensics services** to support your assets management, supply reliability & public safety

Type tested for **45 manufacturers** on **over 300 HTLS** & conventional conductor projects serving over **38 countries**

One-stop-shop testing services with experts across multi-professional service backgrounds in **T&D**

We Test & Analyze

- Transmission and Distribution Connectors
- Electric Power Connections for Substations
- Ground Grid Connectors
- High Temperature Connectors
- Substation Connectors
- Temporary and Permanent Repair Connectors (i.e., shunts, repair rods)
- Swaged, Implosive and Exothermic Connections
- High Temperature Accessories including spacer, spacer-damper, and suspension assemblies

Facilities & Key Equipment

Our laboratory is setup to be a comprehensive and multi-purpose laboratory equipped with state-of-the-art equipment, instrumentation and data acquisition systems that ensure high quality, accurate and reliable testing.

High Capacity Universal Test Machine

High Temperature Test Bays

- High Tension Capability up to 500 kN
- Sample Temperatures up to 300 °C
- Extra long spans >15 m sample lengths
- Simultaneous thermal & tension cycling
- Current injection up to 6000 A
- Multiple test bays to execute test programs quickly and at short notice

Multi-Purpose Creep Spans

- Over 9 test spans to run multiple tests in parallel
- High Tension Capacity
- Ambient & high temperature options
- Advanced setup for accurate test results: Temperature gradient controls, Reference bar

Long Span Sheave Test Bay

- Meeting CIGRE 426 / PGCIL needs
- Multiple Sheaves to simulate true bending & surface stresses
- Single / Triple Sheave options
- Extra long setup up to 50 m span
- Capable to generate high bending angles up to 70 degrees

Heavy Duty Aeolian Vibration & Galloping Test Setup

- Extra long setup up to 40 m span
- Advanced setup for accurate testing: Closed loop force, amplitude and Resonant frequency control
- Ambient temperature compensation
- Heavy duty state-of-art failsafe Oscillator

ASTM B117 Compliant Salt Spray Chamber

- Advanced Pneumatic Spray System, Closed loop PH and humidity control
- System Setup to avoid droplet deposits

State-of-Art Data Acquisition Systems (DAQ)

- High accuracy, noise free, measurement
- Nested closed loop controls with special alarms and warnings for test parameters
- Resilient systems with multiple power supplies, UPS and backup storage
- NI Suite based HMI & DAQ with tried & tested algorithms
- Optically isolated inputs and high-end sensors to shield from test current injections based disturbances

Connector Testing

Kinectrics conducts qualification and performance tests for the thermal, mechanical, environmental and electrical performance of transmission, distribution and substation connectors according to industry standards and manufacturers' specifications. Other studies are also conducted to confirm the failure mode of overhead connectors, and to determine the most cost-effective measures to prevent future failures.

Example of Connector Testing

Current Cycle

Evaluate electrical & thermal performance of the connectors via accelerated thermal aging test.

Heat Rise

Evaluate electrical performance of the substation connectors by evaluating the thermal profile of connectors.

Pullout Strength

Evaluate mechanical capacity of the connectors when subjected to heavy ice and/or wind loading, or other steady or cyclic loads.

Torque Strength

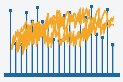
Evaluate torque strength of the bolted connectors.

Corrosion Tests: Salt Fog, Acid Bath

Evaluate effects of corrosive environment on transmission/distribution and underground connectors.

Freeze-Thaw

Evaluate effects of temperature changes on underground connectors.



Vibration

Evaluate the performance of clamps and other hardware when subjected to aeolian vibration.

Condition Assessment of Aged Connectors

Evaluate performance of existing connectors in the line to identify key parameters for inspection of faulty connectors. Assist utilities in identifying potential problems and increase the reliability of the line.

Failure Analysis

Evaluate causal factors to identify the root cause of the failure and take necessary steps to increase the reliability of the line.

Fault Current

Evaluate the ability of new or aged connectors to withstand typical fault currents levels in the line. Especially important for preformed, bolted or automatic connectors.

Tests on Conductors

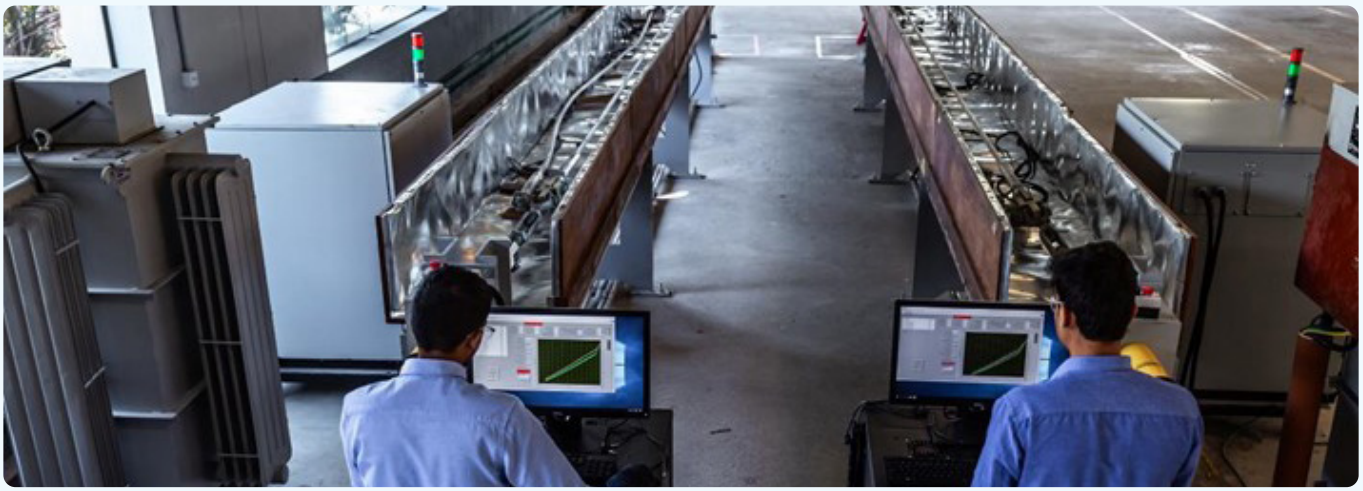
Stress Strain
- Measure basic conductor characteristics
- Develop data required for line design
- Test at elevated temperature (up to 350°C)

Sheave Test
- Simulate installation conditions
- Verify mechanical integrity under repeated bending stresses
- Single or triple sheave tests available

Thermal Mechanical Cycling Test
- Simulate in-service tension and thermal cycles
- Monitor temperature and electrical stability
- Evaluate loss of strength or other degradation

Aeolian Vibration & Galloping Tests
- Simulate fatigue cycles caused by vibration
- Quickly simulate decades of vibration (+100M cycles)
- Inspect for damage to conductor or hardware

Sag-Tension & Ampacity Tests
- Verify conductor sag at increasing temperature
- Evaluate conductor ampacity at increasing temperature
- Side-by-side comparisons of conductors for reconductoring



Good communication, competent & well-trained staff and overall project management reliability have all been key factors to their success. Kinectrics has a consistent, proven track record of delivering the required results within the project constraints and often against tight timescales.

-Midal Cables Ltd., Bahrain

Compatibility Testing

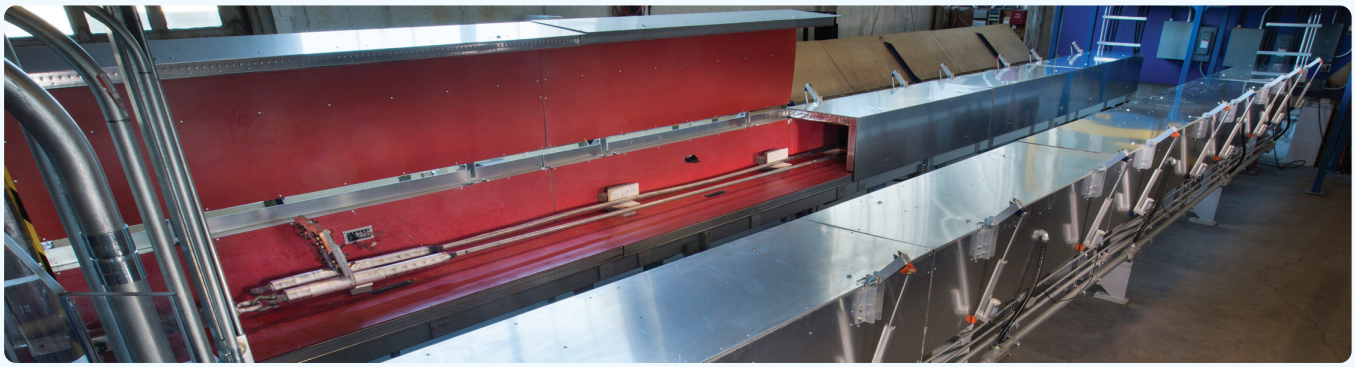
Hardware compatibility is critical to successful long-term operation - improperly designed hardware may lead to high fatigue/bending stresses, loss of mechanical strength, accelerated corrosion or increased line losses. A system test subjects the selected conductor and hardware to various conditions to verify their performance as an assembly.

By testing the conductor and hardware as a system, you can be confident your connectors, suspension assemblies, dampers and other hardware in contact with your conductor are compatible and will not lead to premature failures.

Qualification for Lifetime Performance

To meet ever-increasing load growth, existing and future overhead line components, including connectors, will be required to operate at higher and higher temperatures.

Confidence in the reliable performance of these components is critical, because their failure can lead to a downed line. Operation at elevated temperatures also accelerates the aging process, making the issue of lifetime performance even more critical. Kinectrics provides reliable, confidential performance testing services for clients worldwide, to assess the lifetime performance of these components.



We Test to Industry Standards

- IS/BIS/CEA
- CIGRE
- IEEE
- ASTM
- IEC
- PGCIL
- BS EN
- ISO/IEC
- CSA

We Also Test to...

- Utility/Manufacturer's Specifications
- Custom Specifications
- Other Required Standards

Tests on Aged Overhead Lines

As overhead lines continue to age, it becomes increasingly important to know the existing physical condition of conductors and possibly the rate of deterioration. Many overhead transmission and distribution lines have far exceeded their design life (i.e., > 60 years). Aging systems can seriously impact operational reliability, safety and system planning.

Kinectrics has been performing laboratory and field tests on aged overhead line conductors since early 1990s. Over 100 overhead conductors and shield wire samples are inspected on a yearly basis. It is estimated that Kinectrics has tested over 2000 aged conductors in a laboratory environment.

Kinectrics offers comprehensive in-depth failure investigation and metallurgical analysis services. Understanding the failure mode and root cause of failure, manufacturers and utilities can make informed and confident decisions related to their products and assets. Informed decisions may lead to substantial cost savings by eliminating bad processes, or by reducing unnecessary or inadequate repairs or maintenance of ageing infrastructure.

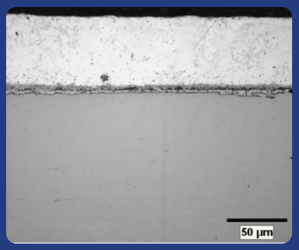
Condition Assessment

- Provides the conductor condition as a snap-shot assessment where properties of individual wires are quantified & evaluated
- Allows for a comparison of degradation against industry standards or how the conductor performed as-new

End of Life (EOL)

- Estimates the remaining life of a conductor by simulating various in-service stresses
- Increases confidence level of continued operation by gathering data of performance under unique or extreme stresses
- Provides input data to asset mangement programs, optimizing the continued operation, or replacement of assets

Forensics Failure Investigations



- Understand the failure mechanism and/or root-cause of failure
- Examination of fracture surfaces, secondary cracking and other surface phenomena
- Assessment of alloy microstructure and its influence on the failure mechanism

LineVue® Conductor Inspection Tool

We inspect what matters.

Kinectrics' inspection tools can help utilities make informed asset management decisions on aged lines, leading to improved system reliability, safety, and reduced replacement costs.

Transmission LineVue® Inspection Unit

LineVue® is a proven technology, used worldwide, that rapidly obtains data on the condition of the steel core of a conductor. Collecting this information aides electric utilities in establishing an accurate health index to support better capital expenditure decisions and reduces safety concerns.

LineVue® is easy to transport and install on the conductor by line crew personnel. It is a non-destructive inspection device that is capable of inspecting energized and de-energized lines. This capability allows utilities to use the device on energized lines up to 500kV with no outage requirements.

Do you know the condition of your lines?

Many transmission and distribution lines are very old. Some conductors and shield wires have been in service for more than 70 years–well past their design life–with rates of deterioration largely unknown.

As lines continue to age, it becomes increasingly important for utilities to know the existing physical condition of conductors to optimize management of these important assets.

Knowledge of actual conductor steel core condition is important for utilities in determining if utilities need to commit to expensive capital programs, such as conductor replacement.

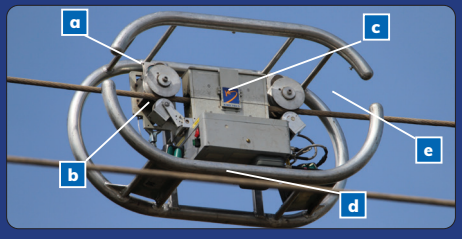
Kinectrics' LineVue® is a cost-effective inspection tool used to collect information about conductor condition. LineVue® helps utilities better manage these key assets, address safety concerns, increase infrastructure reliability, and reduce replacement costs.

Why measure remaining steel cross section?

Zinc galvanizing on steel strands of ACSR (Aluminum Conductor Steel Reinforced) and ACSS (Aluminum Conductor Self-Supporting) conductors will delay deterioration of the base metal, although zinc does not contribute to the mechanical strength. Even after zinc galvanizing has been compromised, the tensile strength of steel wires (and conductors) can remain close to the rated strength for many years.

Measuring the remaining steel core cross-section provides a direct assessment of the most important conductor parameter—actual remaining strength—and LineVue® does this.

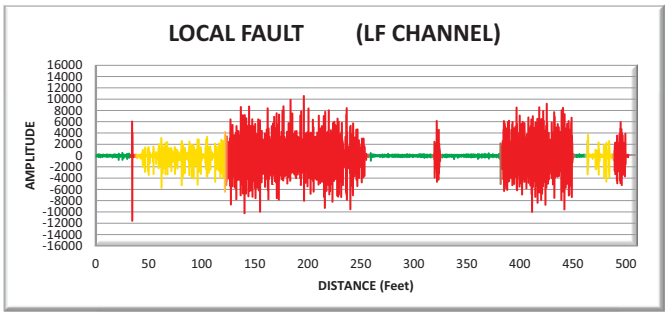
Main Components of LineVue®



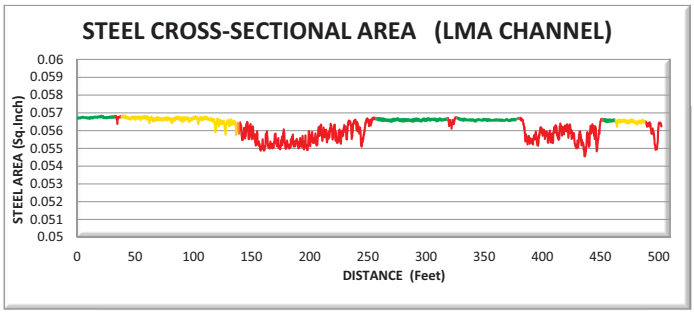
a. Industrial motor drive
b. Free floating encoder accurately indicates distance travelled
c. Sensing head gathers 5 sample readings per inch
d. LineVue® transmits real-time data for on-site review
e. Corona rings enable use on energized lines

LineVue® Data - LF & LMA Graphs Analysis

LineVue® is a non-destructive device for measuring the remaining cross-sectional area of the steel core wires in conductors. The LineVue® tool can also detect any local breaks and corrosion pits in the steel core wires, all accomplished in the field, on both energized and de-energized conductors. The colourized LF and LMA graphs and conductor images below highlight the sections of a single conductor span that were considered to be in good condition with no corrosion and/or pitting (green), had some signs of corrosion and/or pitting (yellow), and had severe corrosion and/or pitting (red).



Local Fault (LF) - Indicator which detects local faults such as severe pitting or broken steel wires



Loss of Metallic Area (LMA) - Measures average of the remaining cross-sectional area of all metallic core wires over an approximate length of 2-3 ft. with better than +/-5% accuracy

These representative pictures demonstrate the extent of deterioration detected along the transmission line, as displayed in the LF and LMA charts above

Kinectrics now utilizes the power of Artificial Intelligence and Machine Learning to analyze the data collected by the LineVue® device. Artificial Intelligence and Machine Learning actively removes signal noise from the collected data, reduces the need for human intervention, and provides a computer system with the ability to make decisions such as selecting the best algorithm for analysis of the data. In addition, using this state-of-the-art technology, Kinectrics is able to reduce the time required for the data reporting process and ensure that this complex task is performed consistently without errors by all operators.

Over 1,000 Engineers

From initial design and type testing to operational deployment and maintenance services, Kinectrics collaborates closely with customers to ensure that utility assets perform safely, reliably and efficiently throughout their entire life cycle.

System Oriented & Quality Conscious

- Integrated Global QMS ISO 9001:2008 & ISO 17025:2017 certified
- Global Quality Dashboards – metrics based on rigorous tracking and follow-up
- Through non-conformity assessment, tracking and corrections – Intelex based NCRs and resolution
- Human performance tools implementation & continuous improvement focus

Kinectrics' accreditation is recognized internationally and demonstrates our unrivalled technical capabilities to provide a full range of engineering and testing services for connectors and accessories.

Execution Excellence

- Competent, highly trained staff
- Highly evolved test setups & testing accessories to ensure uninterrupted & secure testing environment
- Reliable Instrumentation & Data Acquisition custom built from high end systems and fine-tuned over years of operation & continuous improvement cycles

Commitment to Safety

Kinectrics promotes a safe work environment and empowers all employees to create and maintain a safe and healthy environment. We believe that no task is so important that we cannot make the effort to do it safely.

Commitment to Our Customers

Our vision is to be the premier technical solutions provider from concept to completion. Our mission is to improve our customers' business by delivering sustainable and innovative life cycle management solutions to nuclear and electricity industries, through our facilities, processes, and people.

About Kinectrics

Kinectrics' origins can be traced to 1912. With over 100 years of delivering technical excellence, Kinectrics is the category leader in providing life cycle management services for the electricity industry. Trusted by clients worldwide, our experts in engineering, testing, inspection and certification is backed by our independent laboratory and testing facilities, a diverse fleet of field inspection equipment and an award-winning team of over 1,000 engineers and technical experts.

Kinectrics is an internationally recognized company with a reputation for technical excellence in engineering and long-established experience in providing testing services to the electric utility industry. We are uniquely positioned to provide superior services in connector testing, as well as related specialized support for transmission and distribution systems.

> **For us, Kinectrics Laboratory testing services are excellent in all respect among top very few laboratories in the world. The staff are highly committed, and the services provided are always meeting our project deadlines. We shall continue to avail Kinectrics as our most preferred testing partner.**

-Operations, APAR Industries, India

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