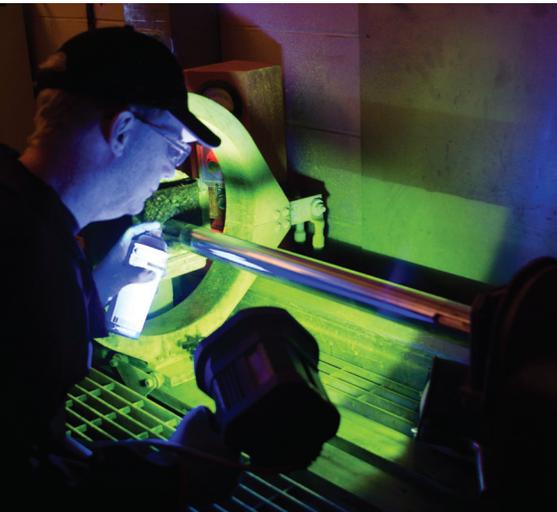


APPLIED MATERIALS

Powertech
The Power of Trust. The Future of Energy.

EXTENDING EQUIPMENT LIFE



Fluorescent magnetic particle inspection



Assessment of fracture features by scanning electron microscopy

Failure analysis, fitness-for-service evaluations, and corrosion inspections

Failure of mechanical components and/or systems can be costly, inconvenient, and dangerous.

Powertech's Applied Materials Department offers engineering solutions for material-related problems to extend equipment life and ensure safe and reliable operation. Department staff have experience with metals, polymers, ceramics, and composites to provide testing, analysis, inspection, and consulting to solve complex materials issues.

The Applied Materials department serves a wide range of industries, including electric utilities, automotive equipment manufacturers, oil and gas suppliers, welding companies, and material suppliers. Offerings include failure analysis, flaw tolerance and fitness-for-service ("run/repair/replace") evaluation, coatings and corrosion inspections and testing, welding engineering, material selection, and a full suite of material characterization testing.

For electric utilities, Powertech performs materials failure analysis of components in generation and T&D infrastructure. Unlike some competitors, every analysis completed at Powertech includes recommendations and suggestions for corrective measures.

Other utility-related materials investigations include corrosion analysis of metallic structures and mitigation through cathodic protection, inspection and testing of paints and coatings on metallic towers and lattice structures, and review and qualification of welding procedures. With a deep knowledge of the industry and in-house non-destructive evaluation (NDE) lab services, the technical team can provide expert consultation to achieve best results.

For the automotive industry, with the emergence of hydrogen fuel, Powertech works with designers, manufacturers, and certification bodies to ensure each material can be safely integrated into the system.



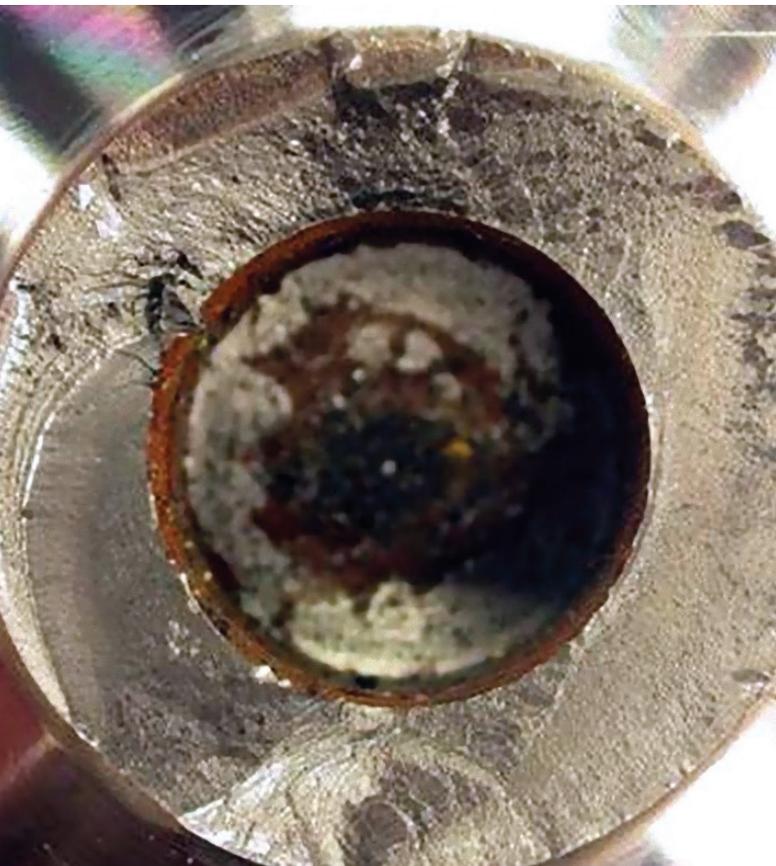
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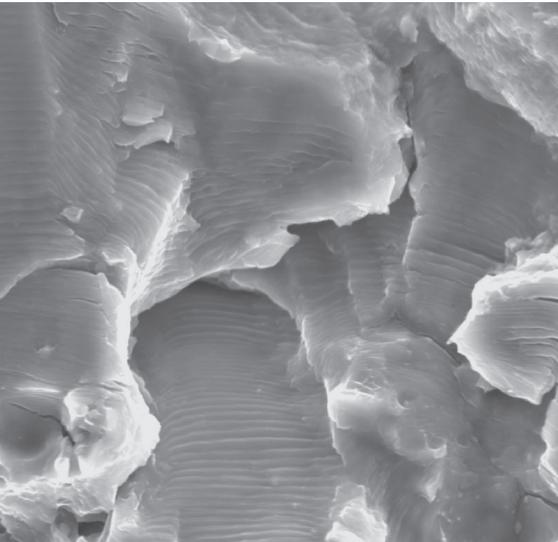
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CAPABILITIES



Fatigue indications in an aluminum alloy



Impact toughness testing

Powertech provides a comprehensive range of materials testing and analysis capabilities for industrial and commercial applications.

Testing services can be conducted in accordance with ANSI, ASTM, ISO, NACE, IEC, CEA, MIL, CSA, and other recognized standards organizations. For customized testing needs, Powertech also has experience designing specialized non-standard tests or setups. The materials lab has ISO/IEC 17025 accreditation.

Access is available to in-house mechanical, applied chemistry, and non-destructive evaluation (NDE) labs for testing that requires cross-disciplinary analysis.

Customers can utilize advanced technical testing including:

- Variable-pressure scanning electron microscope (SEM) for high magnification imaging of metallic and non-metallic parts up to 100,000x
- Energy dispersive x-ray spectrometer (EDS) for elemental analysis
- Metallographic sectioning, preparation, and examination equipment (lab and in-situ)
- Hardness and microhardness testers for Rockwell, Brinell, Vickers, Leeb, and other scales
- Accelerated aging equipment, including salt spray corrosion chamber and UV condensation weathering chamber

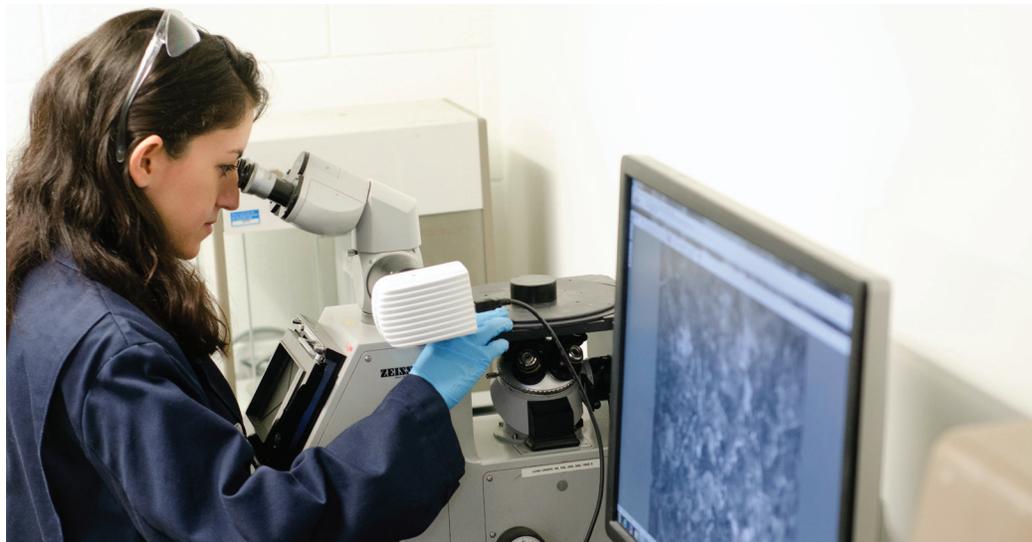
- Various coatings inspection equipment for detecting thickness, pinholes, delamination, and adhesion
- Specialized chamber for assessing material properties in up to 70 MPa (10,000 psi) hydrogen gas

Powertech's NACE-certified coatings inspectors also offer rope access services having IRATA training and certification. Our materials engineers have broad experience with metals, polymers, ceramics, and composites to aid in testing and analysis for industry, government, insurance, litigation, and research purposes. The team can provide expert consultation services to ensure customers receive the most comprehensive and reliable results to support their business decisions.

SERVICES



NDT inspection of turbine runner blade



Microstructure analysis using metallographic microscope

Powertech experts test metallic and nonmetallic specimens using standard and customized test procedures. Analyses typically include recommendations and suggestions for corrective measures.

Offerings include:

Failure Analysis—investigations to determine the root cause of failure, with recommendations to guide manufacturing processes, component replacement, or procedures to prevent future occurrences.

Fitness-for-Service Studies—stress analysis and fracture mechanics calculations applied to damaged equipment or structures to determine their structural integrity.

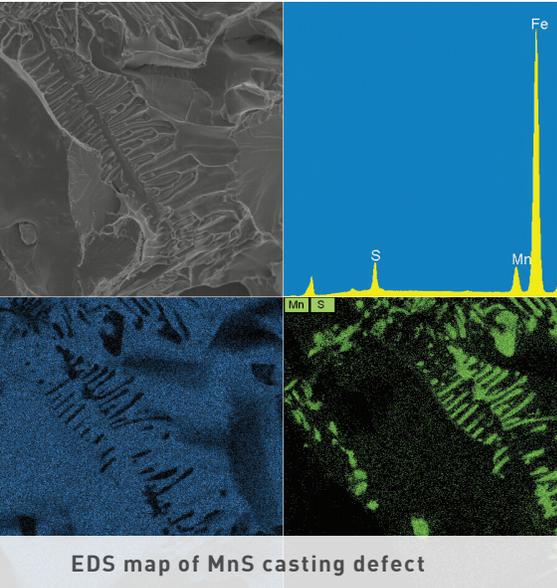
Welding Engineering and Qualification—determination of joint design, material selection, and welding procedure for repair and construction. Certified by the BC Safety Authority to administer qualification tests for procedures and welders per Section 42 of the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation.

Material Selection Consulting—consideration of how material properties will interact with a component's service conditions, including wear resistance, fatigue strength, corrosion resistance, temperature effects, notch sensitivity, cost, machinability, and weldability.

Protective Coatings Testing and Inspection—laboratory simulation of harsh environments (UV, rain, condensation, salt fog, etc.), in-situ testing and inspection, application quality assurance, and coating specification consulting to ensure protection of assets.

Corrosion Testing and Consultation—testing according to NACE and ASTM standards or customized corrosion simulations for testing effects of intergranular corrosion, stress corrosion, pitting, sulfide formation, and hydrogen environment embrittlement.

CASE STUDY — Turbine Inlet Valve Fitness for Service



In a recent project, Powertech conducted a fitness-for-service (FFS) analysis to establish the integrity of a turbine inlet valve (TIV) for continued use in a generating station.

The TIV was a butterfly valve installed at a peaking plant in 1951. Many surface cracks were found along the central location on both sides of the disc.

Replacement of the valve would be costly and require significant downtime.

The Powertech FFS project sought to determine if the TIV could be used as-is or would require repair at specific locations to restore its integrity.

The project was conducted in six phases:

1. NDT assessment. Dry powder magnetic particle inspection was conducted on the disc's upstream side to map cracks.
2. Residual stress analysis of the weldment. A hole-drilling strain gauge method was used to measure residual stress.
3. Metallurgical analysis. Samples were subjected to chemical analysis, scanning electron microscopy, energy dispersive x-ray spectroscopy, Fourier transform infrared spectroscopy, metallographic examination, and microhardness testing.
4. Mechanical testing. Material was removed to test for Charpy V-notch impact energy, fracture toughness, yield strength, ultimate tensile strength, and elongation to failure.
5. Stress analysis. A finite element analysis was carried out to estimate maximum stresses and their locations when the disc is closed.
6. Fitness-for-service analysis. Analysis was conducted for static and cyclic stress conditions.

Analysis indicated that, although the detected flaws were not vulnerable to fatigue cracking under normal operational cyclic stresses of start/stop operations, they may be vulnerable to crack instability under potential high static loading conditions. A plate-cladding weld repair procedure was developed to restore the integrity of the TIV disc.



Installation of SACP system

CASE STUDY — Corrosion Protection of Steel Lattice Transmission Towers

Corrosion mitigation project for BC Hydro

The Applied Materials Department managed a project to implement corrosion mitigation—in the form of sacrificial anode cathodic protection (SACP) systems—to 145 towers with ground conditions considered corrosive to buried grillage.

With age and exposure to environmental conditions, critical load-bearing members of steel lattice transmission towers are susceptible to corrosion. For the above-ground tower structures, zinc galvanizing provides a very effective corrosion barrier by forming a stable protective patina (surface oxide layer) in reaction to the environment and sacrifices itself to protect the steel substrate.

However, for the tower legs buried below the earth, galvanizing is not

always able to form this patina. In these cases, industry practice is to use galvanizing in combination with SACP systems. The systems attach sacrificial anodes—pieces of metal more electrically active than the tower steel—to the base metal. Because the anodes are more active, the corrosive current exits from them rather than the steel tower, thus protecting the steel while sacrificing the anode.

To mitigate impending corrosion attack, the Applied Materials Department oversaw the installation of SACP systems to the separate legs of the 145 towers. Following installation, crews conducted structure-to-soil potential measurement to ensure the installations met industry-accepted criteria to be considered cathodically protected.

SELECTED CLIENTS



THE POWERTECH ADVANTAGE

PowerTech Labs Inc. is one of the largest testing and research laboratories in North America, situated in beautiful British Columbia, Canada. Our 11-acre facility offers 15 different testing labs for a one-stop-shop approach to managing utility generation, transmission and distribution power systems.

PowerTech is home to a broad range of scientists, engineers, and technical specialists, with capabilities in electrical testing, cable condition assessment, mechanical and materials engineering, software technologies, power system studies, chemical analysis, gas systems engineering, and smart utility services. These skilled researchers have decades of collective and real-world experience and often work in cross-departmental teams to investigate, diagnose and solve complex problems.

As an independent, third-party testing facility, we adhere to the **highest** laboratory (**ISO 17025**), quality (**ISO 9001**) and environmental

(**ISO 14001**) management standards. Many of our scientists and engineers chair or participate in various standards committees within their fields of expertise. Additionally we have the capabilities to derive and develop **non-standard testing** methods and setups required to test product prototypes and perform forensic analysis.

Outside of the utilities industry, PowerTech provides routine **testing** capabilities, product **development**, research and **consulting** services to support an array of industrial-type operations, electrical equipment manufacturers and automotive original equipment manufacturers.

