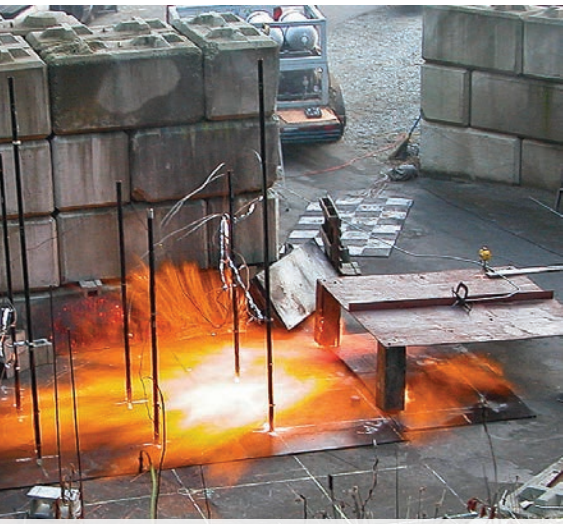
Advanced Transportation: Testing Programs

Powertech

The Power of Trust. **The Future of Energy.**

HIGH-PRESSURE TESTING



Hydrogen release/ignition test

Hydraulic cylinder testing lab

Testing for high-pressure cylinders, components, and fuel systems.

Companies and organizations involved in the design, manufacture, and regulation of high-pressure gas systems need to ensure the systems and their components operate reliably and safely under a variety of service conditions. Achieving this assurance involves standardized, customized, and destructive testing for performance, durability, and end-of-life.

Since 1983, Powertech has provided the technical expertise to support the complex and changing needs of the compressed gas industry. Our Advanced Transportation department is a global leader in independent testing services for high-pressure components and systems used in alternate fuel vehicles and fueling infrastructure. The department's specialized laboratories conduct a comprehensive array of standard and custom design verification, performance, and qualification/certification testing of high-pressure gas cylinders, components, and fuel systems, primarily for the hydrogen and compressed natural gas (CNG) industries.

Clients include equipment manufacturers, automotive companies, research organizations, and regulatory authorities around the world.

The department also offers expert technical consultation to assist customers in designing tests, navigating international certification or regulatory requirements, interpreting test results, and conducting failure analyses. Powertech engineers are able to minimize the costs of prototype development by identifying the critical tests that will determine the ability of a design to successfully pass other tests required in a standard. This expertise comes from Powertech's 30 years of experience with gas systems testing and through participation in the development of industry test standards for hydrogen and CNG.

Unique to the industry, the Advanced Transportation department can also work with other in-house Powertech labs to offer an extended spectrum of services beyond the ordinary purview of component and system testing.

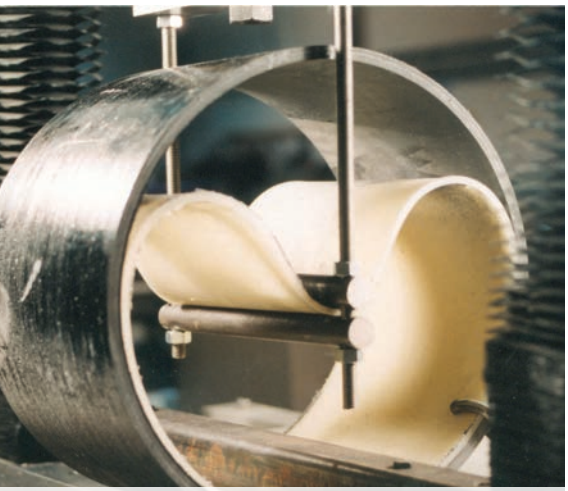
CONTENTS

CYLINDER TESTING

Bonfire test

Gunfire test

Powertech has the capability to test high-pressure cylinders of all types to most EC/ECE, ANSI/CSA, KHK, ISO, SAE, and EN standards for all compressed hydrogen, natural gas, and industrial gas applications.



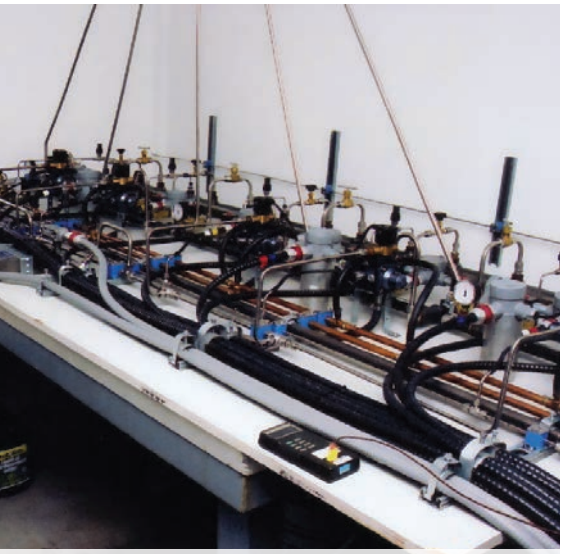
Type 4 liner flexibility test

Cylinders include on-board vehicle (heavy and light duty), stationary storage, tube trailer, transportable, and portable cylinders. Powertech is also able to test to the new UN GTR No. 13, ECE R134, and SAE J2579 test specifications for hydrogen cylinder durability.

The Cylinder Testing Lab offers the following capabilities:

- Pneumatic pressure cycling – with hydrogen up to 95 MPa, with CNG up to 25 MPa
- Ambient temperature pressure cycling (up to 140 MPa)
- Hydrostatic burst testing (up to 280 MPa), with the capability to capture with a high-speed camera (on request)
- Extreme temperature pressure cycling (up to 105 MPa from -50°C to +100°C, air and fluid). Powertech is one of few labs with fluid cooling capability right at the cylinder inlet to ensure the cylinder liner is tested at the correct conditions.
- Permeation or leak testing (from -40°C to +85°C)
- Accelerated stress rupture
- Damage tolerance testing – drop/impact damage, and flaw
- Exposure to chemicals
- Fire testing
- Penetration or gunfire testing
- UV exposure

COMPONENT TESTING



CNG regulator testing

Component Testing Lab

The Component Testing Lab tests high-pressure components, including solenoid valves, regulators, pressure-relief devices, check valves, manual valves, nozzle/receptacles, hoses, fittings, and sensors.

'Fast Fill' hydrogen fueling

Testing is conducted to meet most EC/ECE, UN GTR, ANSI/CSA, KHK, and ISO standards for all compressed hydrogen, natural gas, and industrial gas applications.

The lab operates self-contained, hazardous - location - rated, and customizable test stations with a supply of high-pressure hydrogen (95 MPa), natural gas (25 MPa), and nitrogen available to perform tests, including operating cycle, durability/ endurance cycle, hysteresis, internal and external leakage, and all other required tests in environments from -70°C to +170°C.

In addition to established test standards, Powertech conducts specialized tests such as high-flow hydrogen and other custom durability or performance tests to customer specifications.

The lab works with other Powertech departments to offer test services for corrosion resistance, chemical and fluid resistance, atmospheric exposure, vibration resistance, polymer/elastomer analysis, and electrical testing.

FUEL SYSTEMS TESTING

Fire test preparation of bus fuel system

Puncture and ignition test

The Fuel Systems Testing Lab performs simulated hydrogen fueling tests, hydrogen gas pressure-cycling, static and dynamic hydrogen leakage testing, and drive cycle simulation.

The Fuel Systems Testing Lab can develop custom test apparatuses to meet vehicle OEM internal performance or durability test procedures on high-pressure vehicle fuel systems. Tests include water spray, dust ingress, thermal shock, vibration resistance, mechanical shock or impact, electrical operation, and other specialized tests.

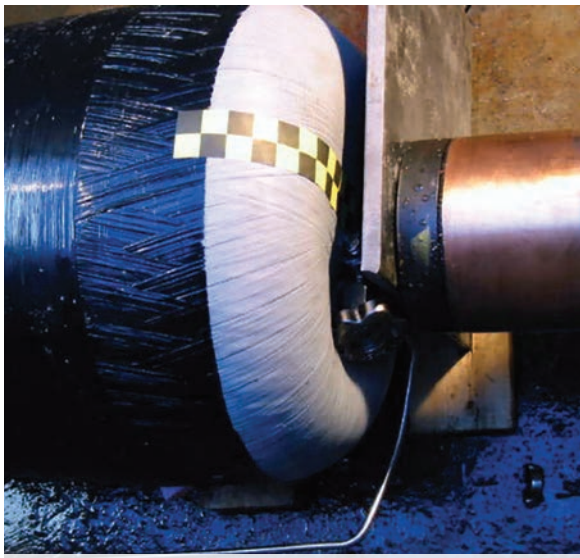
The lab can administer the expected service and localized fire testing required by the UN GTR No. 13, ECE R134, and SAE J2579 test standards.

Powertech's "Fast-Fill" Facility has the means to conduct highly instrumented high-pressure hydrogen fills using a simulated hydrogen station and vehicle fuel system, each with independent ambient temperature control from -40°C to +50°C. The facility has large-capacity 87.5 MPa hydrogen storage, full T40 pre-cooling, programmable pressure ramp rate and profile, flow monitoring, and dynamic leakage monitoring capabilities, complete with break-away, nozzle, and receptacle to meet each customer's unique needs. The facility can be used to evaluate fuel system behavior and performance, and hydrogen station fueling protocols.

The Fuel Systems Testing Lab also has test circuits for hydrogen gas pressure–cycling, with pressures to 95 MPa. These circuits can be flexibly configured and used for typical hydrogen gas pressure–cycling, UN GTR/ECE/SAE expected service tests, and drive cycle simulations. The lab has many of the features of the Fast-Fill Facility, such as programmable pressure ramp rate control, flow monitoring, pre-cooling, and dynamic leakage monitoring, and adds defuel control and back-to-back fill (pressure cycle) functionality. Powertech engineers can work to integrate the lab's instrumentation and controls with a customer's OEM CAN bus or similar control unit for a true operational test.

ADDITIONAL SERVICES

Hydrogen refueling station testing device



Crush test

Powertech designs specialized tests, supports codes and standards development, and is involved in developing new solutions to industry issues.

Safety Studies

In addition to testing to established test standards, Powertech has an extensive background in designing and executing custom durability and destructive tests and safety studies involving fire, static crush, high-energy impact, pneumatic rupture, penetration (mechanical puncture, armour-piercing bullets), or other specialized test requests.

Powertech works with customers to design and build custom, fully instrumented, testing apparatuses to study failure modes, damage-withstand thresholds, or extreme service or upset conditions resulting in rupture.

Engineering Services

Powertech can design and build specialized systems for a customer's testing or research needs. In a recent project, Powertech designed and built a compliance testing device for hydrogen refueling stations. The device—the first of its kind in North America—ensures public hydrogen refueling stations in California meet industry standards. Developed for the U.S. Department of Energy, Sandia National Laboratories, and the National Renewable Energy Laboratory, the device connects to a hydrogen station, simulating a vehicle, and monitors and evaluates pressure, temperature, and communications data to ensure the station operation and fueling process meets HGV 4.3 and SAE J2601 specifications.

Standards Development

Powertech engineers promote the development of national and international codes and standards for compressed hydrogen and CNG fuels. Through their membership on various ANSI, CSA, SAE, and ISO technical committees, they are involved in the technical and safety issues facing the compressed hydrogen and natural gas industries today and, in many cases, are directly involved in developing the solutions. Powertech contributes valuable input at technical committee discussions, helping shape test methods that make compressed gas technologies safer and more reliable.

Advanced Transportation-Testing

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.

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