Measurement Facilities: Mechanical Testing

The Materials Reliability Division has established a unique fatigue and fracture laboratory dedicated to measuring the mechanical properties of metallic and composite materials under a wide range of environmental conditions. The laboratory has nine servo-hydraulic test machines capable of applying static and fatigue loads ranging from a few Newtons (pounds) to 4.5 MN (1 million pounds) at temperatures ranging from 4K (-269 °C) to 1273K (1000 °C). In FY10, this facility is being extended to include a fuel environment test laboratory to measure the effects of microbial induced corrosion on pipeline materials from ethanol fuel blends.

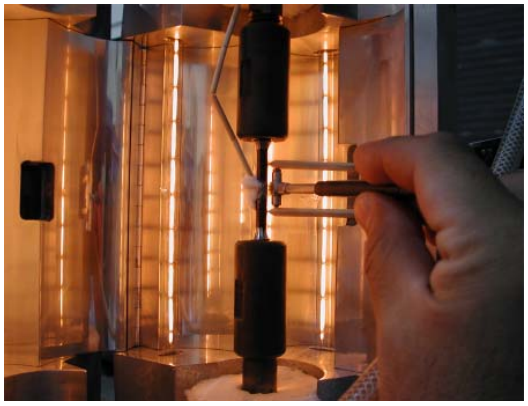
Tensile Testing

The servo-hydraulic machines allow testing at strain rates approaching 100/s on standard ASTM E8 specimens, or about five orders of magnitude faster than standard E8 rates. These high rate capabilities are useful in determining the toughness, strength and ductility as a function of strain rate. Such measurements are important in design of structures and components that are subject to impact or other events that result in high loading rates. Examples include buildings, pipelines and vehicle structures. Some of the test frames have an inverted design (with the actuator on the top) allowing the use of a cryogenic dewar for testing down to 4K. Furnaces equipped on other frames allowing high temperature materials testing at temperatures up to 1000°C. In addition to deep cryogenic testing capability (to 4K), our high capacity (4.5MN) load frame is also equipped with an environmental chamber to conduct large-scale testing at temperatures ranging from -60°C to 250°C.

Toughness and Fatigue Testing

Fracture mechanics is a broad area of interest at NIST. Much of the research conducted at this facility involves the comparison of test methods to determine applicability to various materials, structures and environments.

In addition to standard methods, specimen geometries and environments, research is conducted to develop unique and custom methods of validating fracture mechanics models.



The servo-hydraulic machines are capable of fatigue testing at rates up to 20 or 30 Hz at 1 MN. These frames are equipped with state-of-the-art digital controllers for machine control and data analysis.

Curved - Wide Plate Testing

The increasing demand for cost-effective transportation of alternative fuels and other aggressive fluids has led to increased service requirements for pipelines. In

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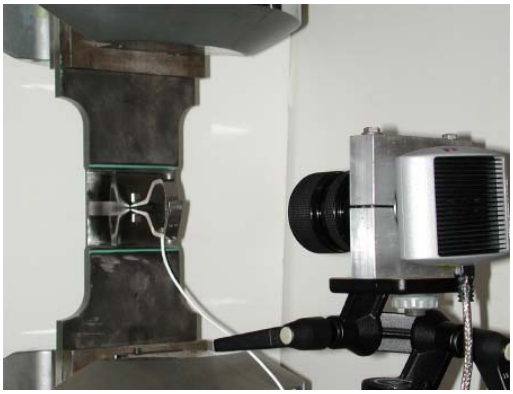
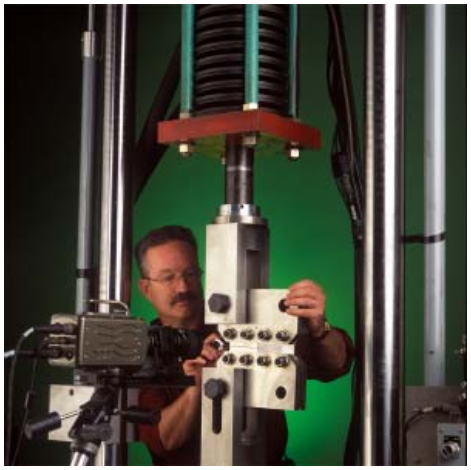
Measurement Facilities: Bulk Mechanical Testing





response, the industry is shifting toward strain-based design for pipelines, which in turn has caused a renewed interest in larger scale testing. Large scale curved-wide plate tests (approximately 2 m long and 0.3 m wide) on full-thickness, X100 girth welded pipeline specimens have been performed to determine the effects of temperature and flaw geometry on the resistance to fracture of base metal, weld metal and the HAZ. The curved-wide plate specimen is sectioned from linepipe in the longitudinal direction. These large-scale tests are performed in the laboratory on a 4.5MN load frame that closely approximates the flaw constraint conditions found in-service. A method of fatigue pre-cracking these large curved-wide plates was a significant challenge for this program. The method was successfully developed and optimized so that the testing could be conducted at temperatures as low as -60 °C.

Hydrogen Testing

NIST has established a high-pressure hydrogen test facility that promises to be the safest and most productive in the world. Two high-pressure chambers equip load frames for mechanical testing, one to 100 MPa and the second to 30 MPa. The lower pressure chamber has a 30 liter volume, capable of holding full-thickness pipeline specimens enabling researchers to understand the differences between hydrogen interaction and surface effects. The test machines in this facility have capacities of 100 kN to 500 kN.

Crack Tip Opening Angle Testing

The crack tip opening angle test is a relatively new ASTM test method (E1272-06) designed to measure the resistance to crack extension. While more common in the aerospace industry, NIST has been evaluating this method for pipeline applications where it can serve to fill the large gap between full-scale pipe burst tests (with costs exceeding $1M per test) and small tensile and impact specimens. With this method, 40 to 50 measurements of the critical angle for each specimen have been possible. The method is also capable of crack extension rates of over 30 meters/second, which approaches the velocity of a running crack in a fracturing pipeline.

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