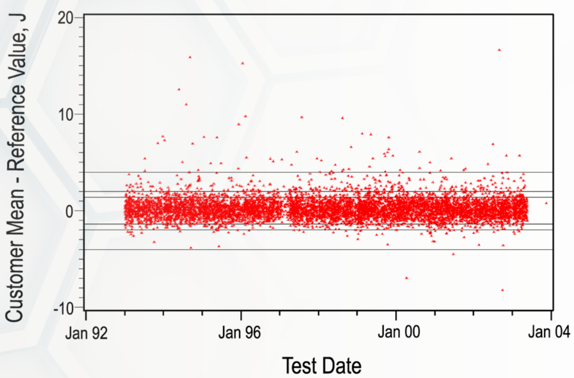
NIST Impact Verification Program

Objective

The objective of the impact verification program is to evaluate the performance of impact test machines used worldwide to qualify structural steels. We offer our customers standard reference materials (SRMs) that enable certification of their impact machines to a traceable measurement system. This indirect verification of machine performance increases the accuracy of impact data, which improves predictions of the reliability of bridges, buildings, railroads and other infrastructure, as well as the safety of products manufactured from structural steel such as oil and gas pipelines, heavy trucks, mining equipment, power plants and wind turbines.

Credit: Geoffrey Wheeler



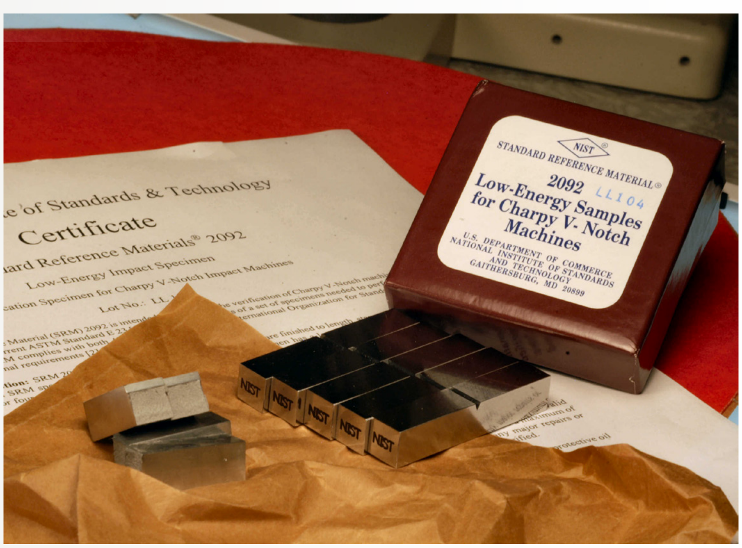
Impact and Customers

Impact testing is required for many critical applications in the construction, machinery and equipment, defense, and energy markets, which accounted for two thirds of the 91 million tons of steel shipped in 2011, valued at $48 billion. Charpy testing provides data needed to insure the quality and reliability of these structural steel products.

Over 1,000 machines per year are evaluated against ASTM standards for our customers around the world. Machines certified through the NIST system provide results within 5%, or 1.4 J, of one another, which to the best of our knowledge is the narrowest distribution of impact results in the world today. Our customers include major steel manufacturers such as ArcelorMittal, Nucor, U. S. Steel and SSAB, as well as heavy equipment manufacturers such as Caterpillar and Westinghouse Nuclear.

Approach

Charpy impact is a high strain rate test that measures energy absorption during fracture, providing an indirect measure of fracture toughness. In order for a Charpy machine to maintain an accurate absorbed energy scale, periodic testing with certified test specimens is required. To achieve the required accuracy for these indirect verifications, NIST maintains three reference impact machines for the United States (per ASTM E23). The average absorbed energy for samples from a given lot tested on these machines is defined as the certified value.



The program provides a complete certification service. A set of five SRMs, manufactured to NIST specifications and certified on our reference machines, are sold to each customer. After customer testing they are returned to our laboratory. Based on our evaluation of the test results and the fractured specimens, NIST will either issue a certificate of compliance or provide suggestions for correction. The accumulated verification results are stored in a database, which is valuable for tracking quality of individual machine performance and for trend analysis to evaluate proposed changes to ISO and ASTM standards.

Accomplishments

The NIST impact verification program has provided 22 years of service to manufacturers and consumers and currently certifies eight SRMs that underpin quality control testing of impact toughness for structural steels. We provide SRMs used to verify the measurement of absorbed energy at three energy levels: low energy (14-20 J); high energy (88-136 J); and super high energy (176-244 J). We also provide two SRMs that are used to verify the measurement of maximum force in a Charpy impact test. SRMs are available for both Charpy and Izod impact testing (Figure 1).

The Charpy program supplies 2,000 units per year to customers worldwide. Typically, we evaluate and report on over 1,000 verification tests per year. We are available to our customers by email, fax or phone (1,500 contacts per year) and continually update our customer website and database to improve customer interactions. Most recently, the program has gone paperless, improving the already short turnaround time for our post-test evaluation to same-day service.

We recently added a means for our customers to obtain a proficiency test result for their impact test (Figure 2). When a customer purchases a set of SRMs, the data from all NIST verification tests for that lot are made available. Customers can compare their test results to this compiled data, giving them an alternate means (aside from meeting ASTM or ISO requirements) to evaluate the performance of their impact machines, and the relative performance of multiple impact machines within their organizations. This information supports efforts by industry to achieve or maintain quality system certification through ISO or other standards bodies.

Figure 1. Examples of Charpy and Izod samples.

NIST maintains leadership positions on ASTM and ISO standards committees and has long been active in improving impact testing standards both in the U.S. and around the world. We maintain an extensive database of customer data in order to further improve measurement accuracy and support our ISO and ASTM activities. For example, we publish a guide on uncertainty analysis for Charpy tests that offers users a full explanation of the uncertainty associated with the NIST reference specimens and the customer's verification test.

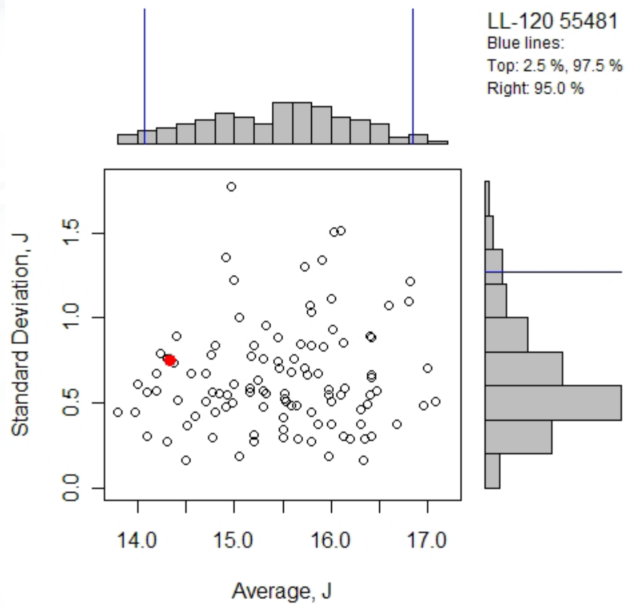


Figure 2. Example of proficiency test data available for production lots.

We are currently working with several national metrological institutes (NMIs) to develop an approach to SRM certification that reduces the bias among the NMIs. Our focus is on standardizing the design of instrumented strikers to provide comparable load-displacement data across all types of Charpy machines. If successful, absorbed energy measured under the instrumented impact curve will be traceable to force and time, moving the underpinnings of the measurement to more fundamental quantities (Figure 3). This approach, like the current approach of measuring the energy absorbed from a pendulum swing (in Joules), has many practical issues that will need to be addressed. However, we see it as the future in impact testing and the best hope for establishing a scale for measuring absorbed energy that can help to reduce bias among NMIs.

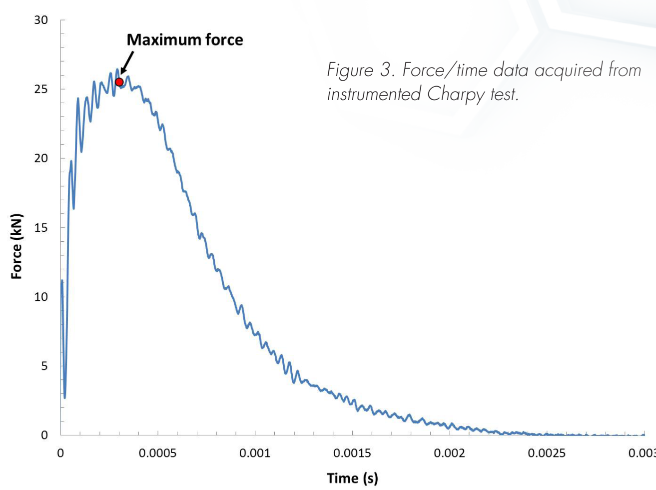


Figure 3. Force/time data acquired from instrumented Charpy test.

Learn More

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Publications

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CN McCowan, E Lucon, RL Santoyo, Evaluation of the Energy Absorbed in Charpy Tests at 100 J versus 300 J, International Symposium on Recent Development in Plate Steels, AIST (2011).

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JD Splett, CN McCowan, H Iyer, CH Wang, Computing Uncertainty for Charpy Impact Machine Test Results, NIST-SP 960-18 (2008).