

Charpy Impact Verification

Objective

We evaluate the performance of pendulum impact test machines used worldwide to qualify structural steels for construction. We offer standard reference materials (SRMs) to our customers, support their certification with a traceable measurement system consisting of three master impact machines, and provide post-test analysis to certify machine compliance. This indirect verification of machine performance increases the accuracy of impact data used to predict infrastructure reliability.



Impact and Customers

- Infrastructure reliability remains a key issue for the U.S.: 25 % of our bridges are considered structurally deficient or obsolete; 27 % of our highways need upgrading or rebuilding; 21 % of our rail track is rated "less than good"; 30 % of our airport runways need major repair.
- A healthy steel industry is essential for improving the steel-intensive infrastructure in the U.S. Contractors require an uninterrupted supply of quality steel that they trust to meet performance targets. Impact testing remains an important measure of steel quality.



- >1000 pendulum impact test machines are currently used worldwide to certify construction steel, as described in ASTM E23. NIST has provided SRMs to customers globally for 20 years, with annual sales of approximately 10,000 impact test specimens.

Approach

Charpy impact is a standardized high strain rate test to measure energy absorption during fracture. The absorbed energy provides an indirect measure of fracture toughness. Despite its relative ease of use, complex energy loss mechanisms are involved, making it impossible to verify test machine performance directly. Periodic testing of impact machines with certified test specimens is necessary to indirectly verify machine performance. To achieve the required accuracy, a well-defined target (master machine) for absorbed energy is required. NIST maintains three master impact machines, which are the designated reference machines for the U.S. (per ASTM E23). The average value for these three machines is considered the correct value for certification.

NIST provides a complete certification service for our customers. A set of five SRMs are sold to each customer, and the customer then destructively tests the specimens and returns them for assessment. By evaluating the test results and the fractured specimens, NIST can indirectly assess the machine tolerance and issue either a certificate of compliance or provide suggestions for correction. A customer database is maintained for SRM quality control, tracking of individual machine performance, and for trend analysis for ISO and ASTM.



Accomplishments

Customer Service

For nearly 20 years, NIST has offered Charpy-V-Notch SRMs for verifying the performance of impact machines to meet ASTM E23 "Standard Test Methods for Notched Bar Impact Testing of Metallic Materials." This standard is widely used to assess a material's resistance to sudden fracture, allowing designers of load-bearing structures (e.g., buildings, bridges, railroads, pressure vessels, etc.) to predict how the material will behave in use. We provide SRMs used to verify the measurement of absorbed energy at 3 energy levels: 2092 (low-energy, 14-20 J); 2096 (high-energy, 88-136 J); and 2098 (super-high-energy, 176-244 J). We also provide 2 SRMs that are used to verify the measurement of maximum force in a Charpy impact test.

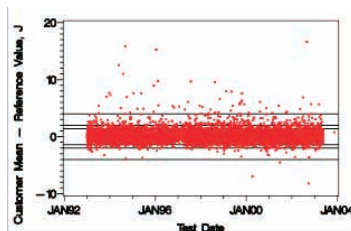
Over the past five years, the Charpy program has supplied an average of 2000 reference material sets per year to customers worldwide (5 SRMs per set), bringing in revenues of \$1.2M per year. In FY09, we evaluated over 1000 verification tests and reported results to customers. We also provided direct support to more than 1500 individual customers by email, fax, or phone. In FY08, we redesigned our customer website and database to make it easier for these interactions to occur. The results have been overwhelmingly positive.

Uncertainty Analysis

Customer service does not stop with NIST providing a certificate of compliance to an impact testing company. NIST maintains an extensive database of customer data and continually strives for further improvement of measurement accuracy through ISO and ASTM activities. Our most recent efforts have focused on improving the use of statistics in Charpy measurements. In 2008, NIST published a new Recommended Practice Guide on uncertainty analysis for Charpy tests (Computing Uncertainty for Charpy Impact Machine Test Results), that

offers users a full explanation of the uncertainty associated with the NIST reference specimens and the customer's verification test.

There is increased interest by our customers in the computation of uncertainty for their impact test results, driven by new requirements for many of our customers to do so per ISO 17025. The new NIST Recommended Practice Guide serves several purposes: (1) it documents uncertainty calculations for the NIST SRMs, (2) it instructs users exactly how to calculate the uncertainty associated with their impact verification test using NIST SRMs, (3) it instructs a user how to use the uncertainty associated with their verification test, along with additional data, to calculate the uncertainty associated with impact tests they perform for their customers, and (4) it instructs the user how to estimate and report the bias between the impact machine being verified and the NIST machines. This guide should help our customers better understand the uncertainty associated with their impact tests, and help them to apply their understanding in appropriate and useful ways.



Example scatter in customer data

New SRM Development

In FY07, NIST added another SRM to its product portfolio. SRM 2115 Izod verification specimens are now being provided for machines set up for the Izod test configuration also listed in ASTM E23. The principal difference between the

Charpy and Izod tests is the manner in which the specimen is supported. By providing an SRM appropriate for Izod configurations, NIST will be able to serve an even broader customer base.

SRM 2115 is made from the same 4340 steel used for the Charpy SRMs; however, its physical dimensions are tuned to the cantilever-beam configuration for Izod testing. Similar to Charpy SRMs, Izod specimens are sold in sets of five and cover an energy range of 15 to 18 J, a target useful in assessing the performance of the machine near the ductile-to-brittle transition of many metals.



Charpy 2092 (front); Izod 2115 (back)

Additionally, NIST has produced two new SRMs related to force verification. Some impact test machines simply use a dial indicator to determine the absorbed energy, but a growing trend is the addition of a calibrated striker to measure the force during the fracture of the specimen. The force data can be integrated over the fracture process to produce an absorbed energy value that is more directly traceable to fundamental SI units. We have measured the force data on several batches of our specimens, and now offer these as new dynamic force SRMs, 2112 for the low energy range and 2113 for high energy. These new SRMs allow customers with instrumented strikers to verify their machines according to these SI units.

Most recently, NIST has been evaluating a new ultra-high energy Charpy SRM of interest to the pipeline industry. We anticipate this new reference material will be available in FY11.

Learn More

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Publications

Lucon E, McCowan CN and Santoyo RL *Instrumented Impact Tests: Effects of Machine Variables and Specimen Position* Journal of Testing and Evaluation, (2009)

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

Siewert TA *Evaluation Specimens for Izod Impact Machines (SRM 2115): Report of Analysis* NIST SP 260-164 (2007)

McCowan CN and Splett JD *Analysis of Charpy Impact Verification Data: 1993-2003* Journal of ASTM International, (2006)