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NIST Technical Note 1500–8
Materials Reliability Series

Recommended Practice: Installing, Maintaining, and Verifying Your Charpy Impact Machine

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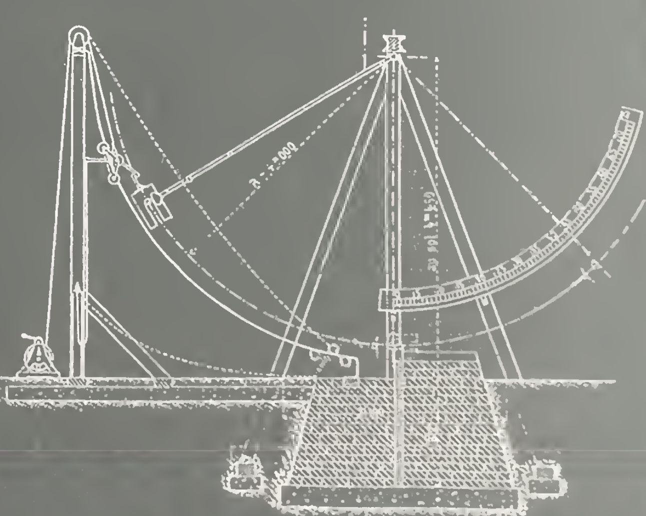

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Contents

Foreword

The Materials Reliability Series of NIST Technical Notes are reports covering significant research accomplishments of the Materials Reliability Division. The Division develops measurement technologies that enable the producers and users of materials to improve the quality and reliability of their products. Measurement technologies are developed for process control to improve the quality and consistency of materials, for nondestructive evaluation to assure quality of finished materials and products, and for materials evaluation to assure reliable performance.

This report is the eighth in the series. It documents recommended practices for installing, maintaining, and verifying a Charpy impact machine. Previous reports in this series are:

Technical Note 1500-1	Tensile Testing of Thin Films: Techniques and Results, by D.T. Read, 1997
Technical Note 1500-2	Procedures for the Electron-Beam Moiré Technique, by E.S. Drexler, 1998
Technical Note 1500-3	High-Energy, Transmission X-ray Diffraction for Monitoring Turbine-Blade Solidification, by D.W. Fitting, W.P. Dubé, and T.A. Siewert, 1998
Technical Note 1500-4	Nondestructive Characterization of Reactor Pressure Vessel Steels: A Feasibility Study, by H.I. McHenry and G.A. Alers, 1998
Technical Note 1500-5	Electron-Beam Moiré Technique: Advances, Verification, Application, by E.L. Drexler, 1998
Technical Note 1500-6	Constitutive Behavior Modeling of Steels Under Hot-Rolling Conditions, by Y.W. Cheng, 1999
Technical Note 1500-7	Structure–Property Relationships in Steel Produced in Hot-Strip Mills, by P.T. Purtscher, Y.W. Cheng, and C.N. McCowan, 1999

Recommended Practice:
Installing, Maintaining, and Verifying Your Charpy Impact Machine

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The quality of the data developed by pendulum impact machines depends on how well the machines are installed, maintained, and verified. This is the reason that ASTM Standard E 23 Standard Test Methods for Notched Bar Impact Testing of Metallic Materials specifies annual direct and indirect verification tests. Each year, NIST provides reference specimens for indirect verification of over 1000 machines around the world. From evaluation of the absorbed energies and the fractured specimens, we attempt to deduce the origin of energies that are outside the ranges permitted by Standard E 23, and report these observations back to the machine owners. This recommended practice summarizes the bases for these observations, and hopefully will allow machines to be maintained at higher levels of accuracy. In addition, we provide details of the NIST verification program procedures and the production of the specimens.

Key words: absorbed energy, Charpy V-notch, impact test, machine repair, misalignment, mounting, pendulum impact test, verification testing, worn anvils

1. Introduction

The low cost and simple configuration of the Charpy impact test have made it a common requirement in codes and standards for critical structures such as pressure vessels and bridges. For many years, engineers and designers have recognized that materials behave differently when loaded statically than when loaded dynamically, and that a number of materials have a brittle-to-ductile transition temperature. The Charpy impact test is a very cost-effective method of evaluating the behavior of materials for applications where these attributes are important.

The history of the pendulum impact test extends back about 100 years. Over the years, procedure improvements, such as the addition of shrouds to prevent specimen jamming and the addition of indirect verification to the verification requirements, have resulted in a simple yet robust test method. The attached bibliography shows how NIST has contributed to the understanding of the test method, and for those interested, points to a brief history of the test method.

Accurate impact results can be obtained only from machines that are installed correctly, then remain in good working condition, such as within the tolerances specified by Standard E 23. Our indirect verification program is referenced in Standard E 23, and supplements the direct verification requirements found there.

Our examination of over 2300 sets of these specimens each year allows us to identify problems that are often not recognized during routine measurement of machine dimensions or routine check procedures (such as the free-swing test). We have learned to recognize which marks on the broken verification specimens indicate factors that could be affecting the results. We can then advise our customers to recheck or replace the anvils or the striker, tighten bolts, check bearings, check machine alignment or level, check cooling bath or thermometer, or review testing procedures. This recommended practice describes the most common problems that we detect, and gives advice on how to avoid or correct most of them. We have divided the description of impact test problems into four major sections: Overview of the NIST Program, Machine Installation, Direct Verification (evaluation of the machine alone), and Indirect Verification (evaluation of the machine by the testing of specimens).

While the following sections give suggestions to improve the accuracy of your impact machine, the machine manufacturer and Standard E 23 also are important sources of information.

2. Overview of the NIST Program

The NIST program focuses on evaluating the performance of pendulum impact test machines through indirect verification (the production and evaluation of standardized verification specimens that we distribute to customers of our verification service), as described in ASTM Standard E 23. In chronological order, the NIST program involves obtaining steel that can be made into verification specimens, heat treatment and machining of batches of verification specimens, inspection of representative specimens from each batch to check quality, assignment of a reference value to each batch, packaging of sets of specimens for shipment to customers, evaluation of the fractured specimens and customer test data, and preparation of a certificate of compliance for the customers or suggestions on how to correct any problems. Further details on these tasks are found in the following sections.

The basic materials and procedures currently used by NIST have remained unchanged for the past 10 years, and date back to the procedures maintained by the U.S. Army at their arsenal in Watertown, Massachusetts (AMMRC).

2.1 Materials

Two materials are currently used to make the specimens for indirect verification of Charpy impact machines to E 23 specifications. A 4340 steel is used to make specimens for the low- and high-energy levels. A type T-200 maraging steel is used to make specimens for the super-high-energy level.

The steels are purchased as square bar. The bar stock is supplied to subcontractors that machine and heat-treat the impact specimens to meet the NIST specification.

In these steels, the hardness, impact energy, and strength are interrelated. Since hardness correlates to impact energy and is a more convenient property to measure during processing, it is used as the initial process control. The low-energy specimens are typically heat-treated to attain a room-temperature hardness (HRC) of 45, which corresponds to a Charpy impact energy near 16 J (12 ft-lbf) at −40° C (−40° F). The high-energy specimens are typically heat-treated to attain a room temperature HRC of 32, which corresponds to a Charpy impact energy near 100 J (65 ft-lbf) at −40° C (−40° F). The super-high-energy specimens are typically heat-treated to attain a room-temperature HRC of 30, which corresponds to a Charpy impact energy near 220 J (163 ft-lbf) at room temperature. Note that the two different steels have different responses to heat treatment, and are tested at different temperatures.

2.2 Acceptance Criteria

Acceptance of a batch of verification specimens is based on the data obtained from a pilot lot of 75 specimens, taken from a heat-treatment batch of 1000 to 1200 specimens. Although impact energy is the desired output, three criteria are combined to determine the acceptability of verification specimens: (1) dimensional tolerances of specimens, (2) mean and standard deviation of impact energy, and (3) the direction in which the specimens leave the machine during impact testing. The evaluation procedures detailed in ASTM Standard E 1271 Qualifying Charpy Verification Specimens of Heat-Treated Steel describe the basic criteria used by NIST, with the following exceptions.

2.2.1 Dimensional Tolerances

The dimensional requirements for NIST specimens exceed some of the E 23 specifications for verification specimens. This minimizes variations in impact energy due to physical variations in the specimens. Also, the notch centering and the length tolerance for NIST specimens is equivalent to the ISO 164 standard, which permits the specimens to be used in impact machines with end-centering devices. The NIST requirement for surface finish is equivalent to the ISO requirement. All of these dimensional requirements can be met with standard machining practices.

2.2.2 Impact Energy Requirements

NIST lots are currently produced to have average energy values that fall within the ranges of 13 J to 20 J (10 to 15 ft-lbf) for low-energy, 88 J to 136 J (65 to 100 ft-lbf) for high-energy, and 176 J to 244 J (130 to 180 ft-lbf) for super-high-energy levels. NIST has never produced a low-energy lot having a reference energy of less than 15 J (11 ft-lbf). The upper limit of the super-high-energy range has been limited by NIST because such energies significantly reduce the final swing velocity for machines with capacities of less than 300 J. (The standard states that machines should not be evaluated with reference specimens that exceed 80 % of the machine capacity).

The reference energy for a lot of verification specimens is determined from the pooled average of 75 specimens (25 specimens tested on each of 3 different impact machines). In addition to the average impact energy, the standard deviation, and a sample size for the verification set are determined (the number of specimens required to estimate the performance of a machine with a specified measurement uncertainty). All 75 specimens are included in these calculations, except for specimens that are determined to be outliers. An outlier is defined statistically, but a specimen identified as an outlier is not removed from the analysis unless it shows physical evidence of jamming, material flaws, or other reason for atypical behavior. At present, any lot with more than 5 % outliers is rejected. The E 1271 standard sets a minimum number of specimens for a verification set at five and the maximum number of specimens in a set is determined by a sample size calculation. Occasionally, a batch has such a small standard deviation that the equation indicates a minimum set size of four.

The average hardness value for a pilot lot is determined for 75 specimens. The variation in hardness for the lot is also determined, and a lot can be rejected on hardness data alone if the variation in hardness exceeds 1 HRC of the lot average. A variation in hardness of 1 HRC results in a very large variation in absorbed energy. In practice, we find that when the variation in hardness exceeds 0.5 HRC the quality of the lot is questionable. The correlation between energy and hardness is much more useful for evaluating variations of high-energy (lower hardness) specimens, because at high hardness, the slope of the trend decreases significantly.

2.2.3 The Direction in Which the Specimens Leave the Machine During Impact Testing

The average hardness of the low-energy specimens also can be used to estimate whether the specimens will have the desired behavior (leaving the machine in the forward or backward direction). When the average hardness value falls below 44 HRC, low-energy specimens begin to exit in a forward direction, which is undesirable.

Low-energy specimens are designed to exit the machine in the direction opposite to that of the pendulum swing to assure that the shrouds around the anvils of U-type machines are functioning properly. If the shrouds are not adjusted properly or of adequate hardness, the specimens will jam between the pendulum and anvils, causing artificially high energy values.

3. Machine Installation

This is the detailed procedure developed by NIST to mount the three Master Charpy Reference Machines. The manufacturer of your machine should be able to supply procedures that are designed specifically for your machine.

A stable foundation for the impact machine is critical to ensure accurate results. Energy losses through the foundation must be kept to a minimum. We recommend using a foundation of high-strength concrete (if your concrete supplier uses a commercial-grade description to characterize the quality of the concrete, you should ask for a 7000-pound mix) that measures 1525 mm (60 in) long by 910 mm (36 in) wide by 450 mm (18 in) thick. Usually you will need to cut a hole in the floor to accommodate the new foundation. If other equipment in the area could affect the machine operation, you may want to isolate it from the floor with expansion-joint material.

Hold-down bolts used to secure the machine to the foundation should be of the inverted "T" or "J" type. (The next section, on direct verification, describes problems with the use of lag bolts, which may be tightened up against the base without gripping the concrete.) The bolts, nuts, and washers should have a strength of grade 8 or higher. We recommend using bolts or rod with a diameter of 22 mm (7/8 in). At NIST we used 22 mm (7/8 in) grade 8 threaded rod, cut into pieces that are 610 mm (24 in) long. We then welded 150 mm (6 in long) pieces of the same threaded rod to the end of the 610 mm (24 in) pieces to make inverted "T" bolts.

We then positioned the machine over the center of the foundation hole. The machine was held approximately 100 mm (4 in) above the floor using spacers suitable to hold the weight of the machine. The "T" bolts were positioned in the machine-base mounting holes with a nut below and above the base of the machine. The nuts were tightened to keep the "T" bolts straight while the concrete was poured. The ends of the T bolts were positioned approximately 25 mm (1 in) from the bottom of the hole. The machine was then leveled on the spacers. Leveling did not need to be as accurate as the final leveling. Reinforcement bars were attached to the top of the horizontal rod previously welded to the bottom of the "T" bolts. The reinforcement bars were attached in the form of a box connecting the four bolts. A second box formation of reinforcement rods was attached to the "T" bolts 25 cm (10 in) above the first box. The concrete was then poured under the machine. The concrete was finished as level as possible at this time. Before the concrete fully hardened, we removed enough concrete, to a depth of approximately 25 mm (1 in), from around each "T" bolt to be able to thread a nut to below the surface of the concrete, and cleaned the exposed threads. The machine was left in this position for 72 h.

After 72 h, the nuts on top of the base plate were removed and the machine was lifted off the "T" bolts. The bottom nuts were then threaded down into the cavities that were created before the concrete hardened. The nuts were left high enough on the "T" bolts to enable the use of an open-end wrench to adjust them after the machine was positioned on them. At this point, the base of the machine was coated with a light oil to keep the grout from adhering to it. The machine was then lifted back onto the "T" bolts and was positioned on the adjustment nuts. The machine was now ready to be leveled. A machinist's level was used to ensure meeting the level tolerance of 3:1000. The critical leveling procedure was done using the four nuts under the machine. After the machine was leveled, we wrapped the outside of the nuts with duct-seal putty to facilitate their removal from the "T" bolts later in the process.

At this point the base of the machine was ready to grout. Heavy cardboard forms were placed around the base of the machine to keep the grout under the machine. The grout was pushed under the machine, so that the base of the machine was in total contact with the grout. The machine was left in this position for 72 h.

After 72 h, the machine was lifted off the "T" bolts one last time. The grout was inspected for cavities and for surface contact with the bottom of the machine. The putty was removed from around the nuts. Some grout leaked around the putty and had to be chipped away from the nuts to enable them to turn. The supporting nuts were removed from the "T" bolts. After removing all debris from the grout, the machine was repositioned on the "T" bolts and rested on the grout. Washers and nuts were installed on the "T" bolts and were tightened to pull the machine tightly against the grout. The level was checked at this point. The "T" bolts were cut off to approximately 12.7 mm (1/2 in) above the nuts. The nuts were torqued to 380 ft-lb. The final level was checked at this point.

NOTE: Special non-shrinking grout is recommended. This grout is available at most industrial hardware stores.

If you have any questions concerning this procedure, please contact Daniel Vigliotti by phone at (303) 497-3351, by fax at (303) 497-5939, by email at daniel.vigliotti@nist.gov, or by mail at NIST, Division 853, 325 Broadway, Boulder, CO 80303-3328.

4. Direct Verification

This section of the practice explains the direct verification requirements of Standard E 23, confirmation that the machine is in good operating condition, without the use of verification specimens. The direct verification tests are physics-based tests, which assure that the machine is functioning as closely as possible to a simple pendulum, with only small losses, due to friction and windage. Direct verification is most important when the machine is first installed or when major parts are replaced, but is also important during the periodic reinspections. While these tests are required for the periodic reinspections, we recommend that the free-swing test and windage-and-friction test be performed each day that the machine is used. The records of these tests then serve as a convenient measure of bearing performance.

Since the Charpy test is a dynamic test with vibration and impact loads, the hold-down bolts may loosen over time. In extreme cases, this may introduce error sufficient to cause a machine to exceed the tolerance limits of the indirect verification test. In marginal cases, the movement may still be sufficient to add a bias to the results that reduces the likelihood of passing. Check the tightness of all bolts, especially the anvil bolts, the striker bolts, and the base-plate bolts. The manufacturer can supply the torque values for the anvil and striker bolts. The base-plate bolts should be torqued to the recommended torque values for the grade and size of the nuts and bolts. We recommend the use of "J" or "T" bolts only. We do not recommend lag-type bolts. These are made to withstand only static loads. We believe that over time, the insert portion of lag bolts can loosen in the concrete. When lag bolts are retightened, they can pull out of the concrete and be pulled against the base of the machine, giving the impression of a properly mounted machine. This condition is very difficult to detect. A machine with this problem will exhibit erroneously high energy values at the low-energy level. The mounting procedure used to eliminate this problem for our Master Reference Machines was described in the previous section.

Standard E 23 describes a routine check procedure that should be performed weekly. It consists of a free-swing check and a friction-and-windage check. The free swing is a quick and simple test to determine whether the dial or readout is performing accurately. A proper zero reading after one swing from the latched position is required on a machine that is equipped with a compensated dial. Some machines are equipped with a non-compensated dial. Such a dial is one on which the indicator cannot be adjusted to read zero after one free swing. The user should understand the procedure for dealing with a non-compensated dial. This information should be available from the manufacturer.

The friction-and-windage test assesses the condition of the bearings. The pendulum should be released and allowed to swing 10 half cycles (5 full swings). (We recommend holding the release mechanism down this whole time to avoid additional friction when the pendulum swings back up to where it may push on the latch.) As the pendulum starts its 11th half swing, the pointer should be reset to about 5 % of the scale capacity. Record this value and divide by the 11 half swings. Divide this number by the machine range capacity, then multiply by 100. Any loss of more than 0.4 % of the machine capacity is excessive, and the bearings should be inspected.

We suggest that the user develop a daily log or shift log to be kept with the machine. The log can be used to track the zero and friction values. The log can also include information such as number of tests, materials tested, maintenance, and any other useful comments.

The anvil and striker radii should be carefully inspected for damage and for proper dimensions. Damage (chips or burrs) can be detected easily by visual inspection and by running a finger over the radii to check for smoothness. Measurement of the dimensions requires more sophisticated equipment. We find that radius gages are usually inadequate to measure the critical radii. We recommend making molds of the radii (such as with silicone rubber) or making an indentation in a soft, ductile material (such as annealed aluminum), then measuring the impressions on an optical comparator. Occasionally, even a new set of anvils and striker may have incorrect radii. We recommend that new anvils and strikers always be inspected before being installed in the machine. Since the radii will not have local wear before use (the radii are consistent along their length), they can be measured directly on an optical comparator or other optical measurement system.

5. Indirect Verification

Indirect verification uses carefully characterized test specimens to stress the test machine components to levels similar to those experienced during routine usage. Since many machine problems, such as loose anvils or striker, cannot be detected during direct verification, indirect verification serves as an important supplemental test of the machine performance.

We recommend using centering tongs, such as those described in ASTM Standard E 23, to insert the specimens at the center of the anvils. The tongs should be inspected for wear or damage. A proper set of tongs is critical for the accurate placement of the specimen. Some machines are equipped with a centering device. The device should be inspected for wear and proper operation. We do not recommend the use of centering devices for low-temperature testing because the centering operation can extend the time between a specimen's removal from the bath and fracture, and so may exceed the five-second interval allowed for transferring and fracturing the specimen.

Some of the reference specimens are designed to be tested at −40° C (−40° F). Since the absorbed energy changes with temperature, accurate temperature control is necessary to obtain valid test data. The temperature indicator should be calibrated immediately before testing. Ice water and dry ice are quick and easy calibration media.

5.1 Post-Fracture Examination

Just matching the reference energies is not sufficient to confirm that the machine is fully satisfactory. For example, worn anvils can combine with high-friction bearings to compensate for each other and produce an artificially correct value during the verification test. These are called compensating errors. Unfortunately, these errors compensate only over part of the range, so the machine produces generally inaccurate values. The post-fracture examination of the NIST standardized verification specimens is a good way to identify such effects. Therefore, the NIST specimens come with a questionnaire (with critical questions about the machine and the test procedure) and a mailing label so the specimens can be returned to NIST. All specimens are examined and compared to the data on the questionnaire before a formal response is sent to the customers.

Following are the most common of these problems. In many cases, suggestions on how to correct or avoid them in the future are included.

5.1.1 Worn Anvils

Most of the wear of an impact test machine occurs on the anvils and striker. We evaluate this wear by examining the gouge marks that are formed on the sides of high-energy specimens when they are forced through the anvils. Anvils that are within the required tolerance of the standard will make a thin, even gouge mark all the way across both pieces of the broken specimen. As the anvils wear, they will make a wider, smeared mark across the specimen halves. Figure 1 shows the change in the gouge marks. When wide, smeared marks are observed on a customer's specimens, we recommend that the anvils be changed, because the reduction in energy needed to push the specimens through worn anvils eventually drops the machine below the lower tolerance in the energy range. You can monitor the wear on your machine by retaining some specimens that are tested with new anvils and comparing them to specimens of similar composition and hardness that are tested as the anvils wear. For specimens at a similar absorbed energy, the gouge marks will grow wider and smoother as the anvils wear.

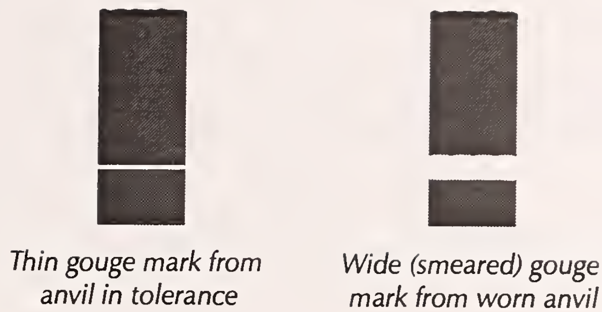

Figure 1. Worn anvils.

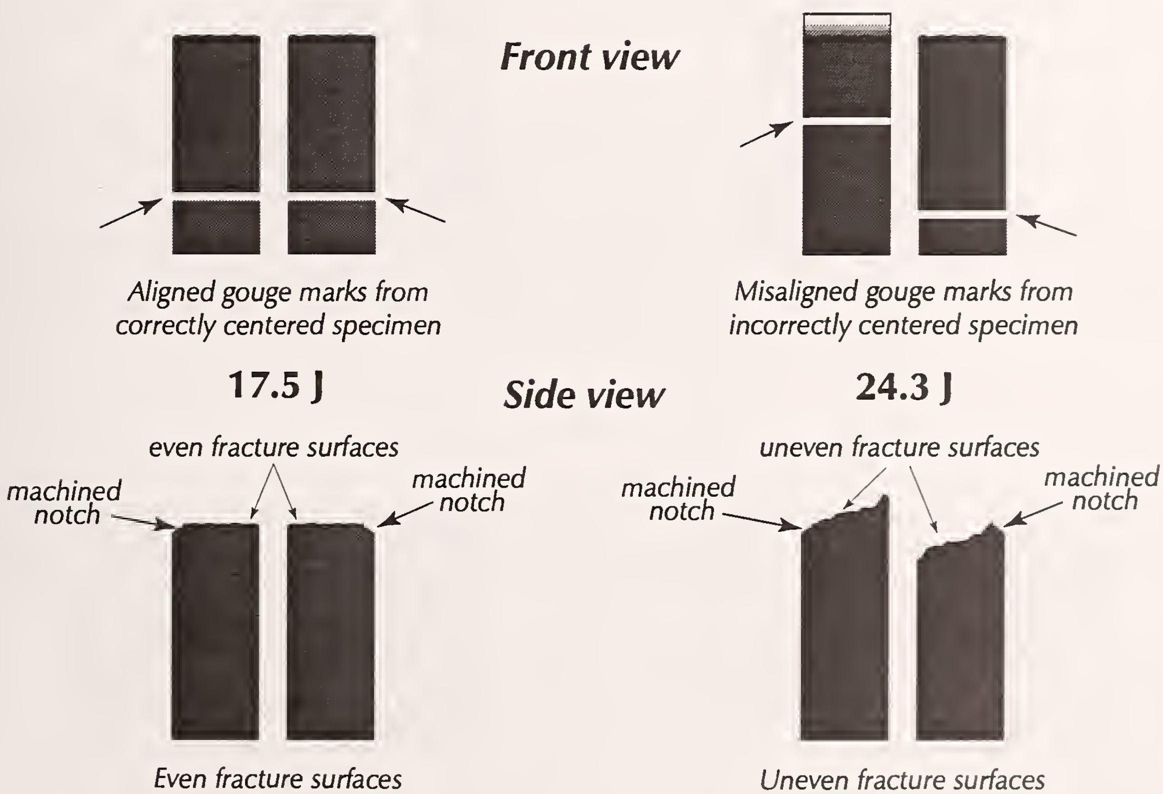

Figure 2. Off-center specimen.

5.1.2 Off-Center Specimen

An off-center specimen strike occurs when the notch is not centered between the anvils, so the striker contacts the specimen to the side of the notch. The low-energy specimen best indicates when an off-center strike occurs. We identify this condition on the specimens by finding that the gouge marks caused by the anvils are not equidistant from the machined notch edges, and the striker gouge mark is offset the same amount from the notch (Figure 2). Also, as seen in Figure 2, the fracture surface of a correctly tested low-energy specimen is flat and both halves are even. However, the fracture surfaces of a specimen that has been tested off-center are on an angle. The more off-center the strike, the steeper the angle will be. This problem increases the energy needed to fracture a specimen. The most common causes for this slipping are worn or damaged centering tongs, a worn or misaligned machine centering device, careless test procedures, or the use of a cooling fluid that is too viscous at the test temperature, which causes the specimen to float on the specimen supports. Most machine manufacturers should be able to provide new centering tongs. We have found that ethyl alcohol is one of the best cooling media because it seems to evaporate quickly from the bottom of the specimen to prevent specimen floating.

5.1.3 Off-Center Striker

This differs from the off-center specimen in that the notch is centered against the anvils so the anvil gouge marks are equidistant from the machined notch edges. However, the striker does not contact the specimen precisely opposite the notch. Figure 3 shows this appearance. An off-center striker is usually attributed to the pendulum shaft shifting off center. This shift can be the result of a loose alignment ring on the shaft or a loose bearing block on the machine. This problem also increases the energy needed to fracture specimens at all energy levels.

5.1.4 Uneven Anvil Marks

Frequent testing of subsize specimens can cause the anvils to wear unevenly. Figure 4 shows an example of these uneven wear marks at each energy level of our reference specimens. Since this wear is restricted to a small area that the full-size reference specimen contacts, there is usually no effect on the energy required to fracture the specimen. This anvil condition presents two problems. First, since subsize wear is usually not indicated by a change in the energy required to break a reference specimen, inspection of the broken specimen is required. This wear will cause the anvils to be out of tolerance according to the requirements in the standard. This means that the machine does not meet the direct verification requirements of the standard and is therefore, not eligible for the indirect verification process. The second, and more important problem, is that the subsize specimens are being tested in an area of the anvil that is worn. When the wear is substantial, this condition will produce artificially low subsized energy values. The anvils should be replaced on a machine with this condition.

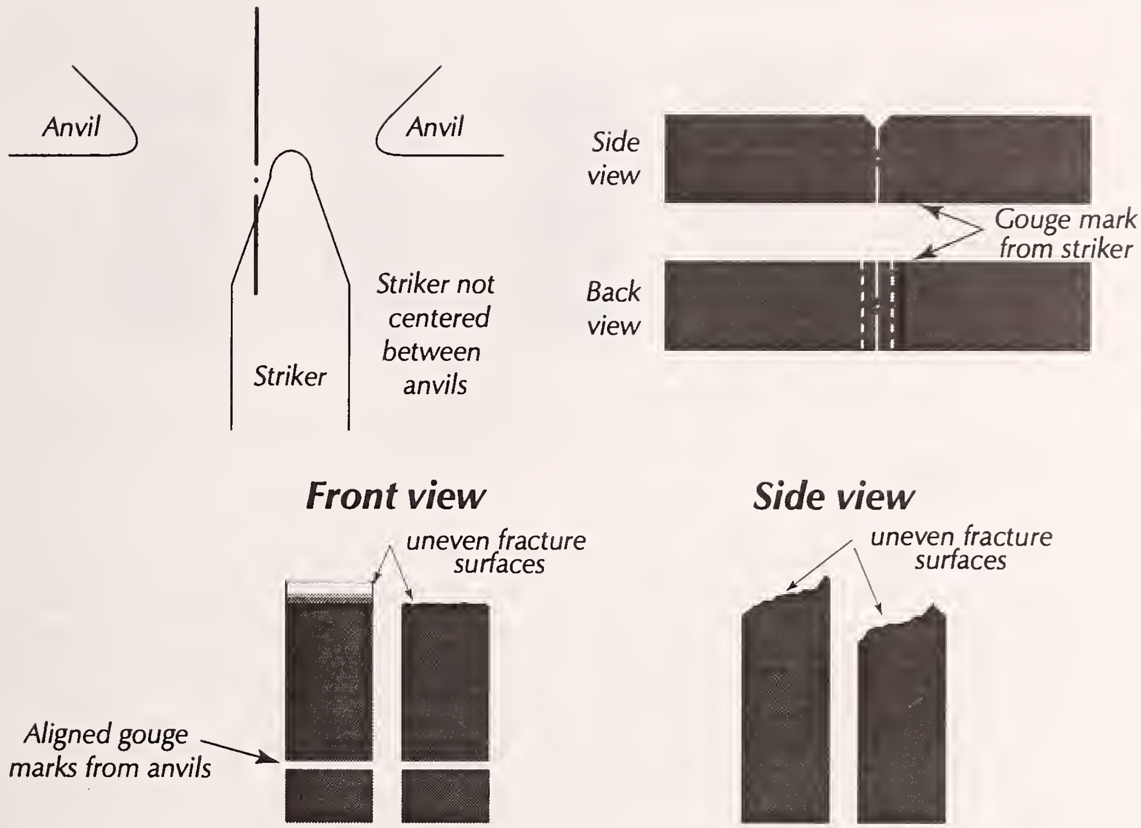

Figure 3. Off-center striker.

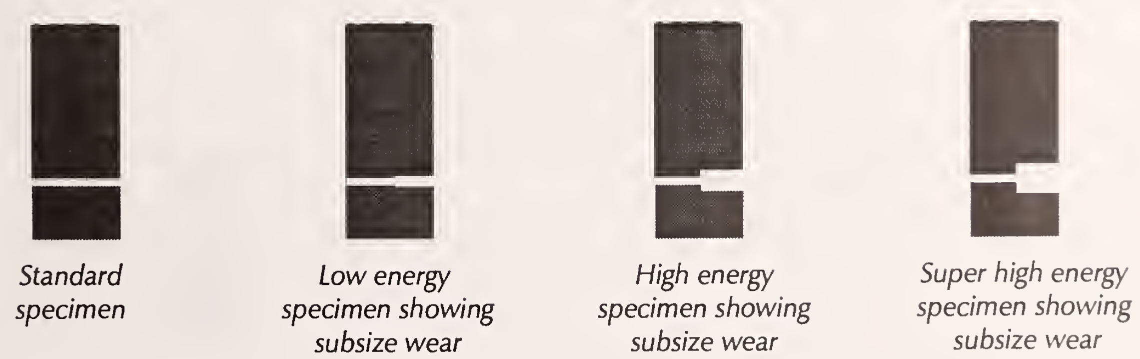

Figure 4. Uneven anvil marks.

Figure 5. Chipped anvils.

5.1.5 Chipped Anvils

Sometimes an anvil can be chipped. Figure 5 shows that this condition can be detected easily on all three energy reference specimens. The low-energy specimen is affected the least because it is the hardest specimen and therefore has a more brittle fracture. The ductile high-energy specimen will produce higher than normal energy results and the very ductile super-high-energy specimens are affected most by a chipped anvil. This condition should be detected easily by a visual inspection before using the machine. New anvils are required when an anvil is chipped.

5.1.6 Anvil Relief

Some Charpy machine manufacturers have designed a machined relief at the bottom of the anvil (Figure 6). This anvil design does not meet the direct verification requirements of ASTM Standard E 23. The relief has caused high-energy results in our ductile high- and super-high-energy specimens. It can also cause twisting of the specimens, during fracture, that may also contribute to energy values higher than normal at all energy levels.

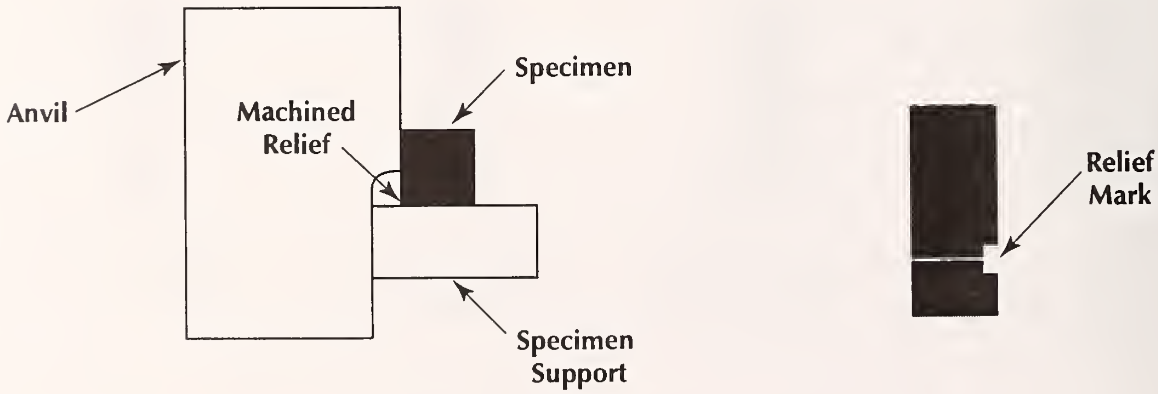

Figure 6. Anvil with machined relief.

Figure 7. Damaged anvils.

5.1.7 Damaged Anvils

Under some test conditions, usually for elevated-temperature testing, the anvils can wear to a rough finish that creates excessive friction (Figure 7). This damaged condition is detected best on the high and super-high specimens. Rough anvils usually cause the gouge marks to become wider and push the specimen material to form a ridge that can easily be detected with the fingernail. This damage usually causes artificially high energy results at the high- and super-high-energy levels. Damaged anvils must be replaced.

5.1.8 Bent Pendulum

Figure 8 shows the gouge marks created by a pendulum bent in the direction of the swing. This gouge mark is usually deeper on the top edge of the specimen as it sits in the machine. As shown in Figure 8, the striker contacts the top edge of the specimen first, causing excessive tumbling and twisting. This excessive activity can cause the specimen to interact with the striker or the pendulum after fracture and create additional energy loss. A bent pendulum can be detected by placing an unbroken reference specimen in the machine and placing a piece of carbon paper on the surface opposite the notch. At this point, lightly tap the striker against the specimen. This will make a mark on the specimen that can be inspected. If the pendulum is not bent, the mark should appear the same width across the specimen. If the pendulum is bent, the mark will be wider at one edge and become thinner or even not visible at the other edge (Figure 9). We recommend that a new pendulum be installed on a machine with this problem.

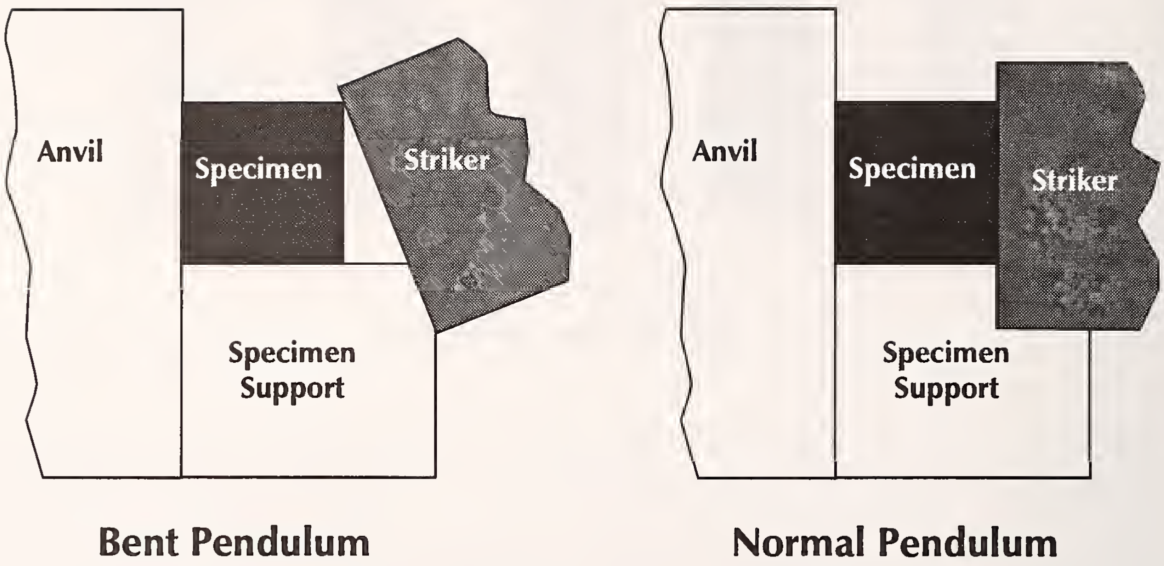

Figure 8. Bent pendulum.

Figure 9. Marks from bent pendulum.

6. Summary

The condition and accuracy of Charpy machines cannot be checked only by comparing results of NIST reference specimens to the Master Reference Machines located at NIST, Boulder, CO. Some machine problems cause artificially low results while other machine problems cause artificially high results. In addition, deviations in procedures can cause similar results. These machine problems and procedural deviations may go undetected for years without some sort of physical check. For this reason, examination of the broken specimens is a critical part of the verification process. Many machine problems can be avoided or corrected with the information presented in this paper. Also, suggested changes in procedure can help to ensure a successful test. To obtain verification specimens or to clarify procedures for verification testing, you may use the following information:

Verification specimens can be ordered from the NIST Standard Reference Materials Program. Phone: (303) 497-6776, fax: (303) 948-3730, or email: SRMINFO@nist.gov

Questions on verification procedures can be answered by the Charpy Program Coordinator. Phone: (303) 497-3351, fax: (303) 497-5939, or email: daniel.vigliotti@nist.gov

7. Bibliography

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