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Standard Test Method for Jaw Crusher Gouging Abrasion Test[1]

This standard is issued under the fixed designation G 81; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

ϵ[1] NOTE—Keywords were added editorially in August 2002.

1. Scope

1.1 This practice covers a laboratory procedure to determine the relative gouging abrasion resistance of materials. Materials homogeneous in structure and properties are the most appropriate test materials; however, surface-treated and composite materials can also be tested. The test involves a small laboratory jaw crusher that crushes presized hard rock materials, such as a hard morainal gravel, or some other crushable substance.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (See 8.1 on Safety Precautions.)

2. Referenced Documents

2.1 *ASTM Standards:*

A 128/A128M Specification for Steel Castings, Austenitic Manganese[2]

A 514/A514M Specification for High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding[3]

A 517/A517M Specification for Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered[3]

E 10 Test Method for Brinell Hardness of Metallic Materials[4]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[4]

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[5]

E 140 Hardness Conversion Tables for Metals (Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness)[4]

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron[5]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

G 40 Terminology Relating to Wear and Erosion[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *gouging abrasion*—a severe form of *abrasive wear* in which the force between an abrading body and the wearing surface is sufficiently large that a macroscopic gouge, groove, deep scratch, or indentation can be produced in a single contact.

3.1.2 The definitions of some other related terms may be found in Terminology G 40.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cheek plates*—the wear liners that protect the sides of the crusher adjacent to the movable and stationary jaws.

3.2.2 *movable jaw*—the part of the crusher that moves against the material being crushed.

3.2.3 *reference plate*—a jaw plate made of a material uniform in microstructure and hardness and not varying significantly from one piece to another; such a plate will give highly reproducible results, to which other materials to be tested may be compared.

3.2.4 *stationary jaw*—the part of the crusher that does not articulate, but is directly opposite the movable jaw and is in direct crushing contact.

3.2.5 *test plate*—a jaw plate made of a material for which the gouging abrasion resistance is to be measured.

3.2.6 *toggle plate*—the plate that holds the bottom edge of the movable jaw relative to the stationary jaw.

4. Summary of Practice

4.1 A small laboratory jaw crusher with a feed opening of about 100 by 150 mm (4 by 6 in.) is modified to accept an easily machined identical pair of reference wear plates and a pair of similar test wear plates. One test plate and one reference

[1] This practice is under the jurisdiction of ASTM Committee G02 on Wear and Erosion and is the direct responsibility of Subcommittee G02.30 on Abrasive Wear.

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[2] *Annual Book of ASTM Standards*, Vol 01.02.

[3] *Annual Book of ASTM Standards*, Vol 01.04.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 03.05.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] *Annual Book of ASTM Standards*, Vol 03.02.

plate are attached to the stationary jaw frame of the crusher, and the other test and reference plate are attached to the movable jaw frame, such that a reference plate and a test plate oppose one another. The minimum jaw opening is set at 3.2 mm (0.125 in.), and a 225-kg (500-lb) load of prescreened material of suitable hardness is run through the crusher. The minimum opening is then reset to 3.2 mm (0.125 in.) and another 225 kg (500 lb) of rock is crushed. This is repeated until a minimum of 900 kg (2000 lb) of rock is crushed. The precleaned and weighed test plates are then recleaned and weighed, and the mass loss (in grams) is recorded. The volume loss may be calculated from the mass loss and the known densities of the test materials, or it may be measured for nonmonolithic materials. A wear ratio is developed by dividing the volume loss of the test plate by the volume loss of the reference plate. This is done separately for the stationary and the movable plates. The two wear ratios are then averaged for a final test wear ratio. The smaller the decimal figure for the wear ratio the better the wear resistance of the test plate compared to the reference plate. When highly wear resistant test and reference plates are used the total amount of rock must be increased to 1800 kg (4000 lb) or more.

5. Significance and Use

5.1 A number of types of jaw crushers have been used for laboratory abrasion tests, see Refs **(1-5)**[8] and a limited amount of data has been published **(6-10).** With emphasis on the crusher which is described in Section 6, the subject practice ranks materials and also indicates differences in wear life for that type of abrasion defined as gouging abrasion, as is found in crushing equipment and in many mining and earthmoving applications. This practice is considered useful for research and development purposes, but not to specify universal wear ratios, since the wear ranking and severity of wear may change dramatically with a change of the characteristics (chemistry, shape, angularity, etc.) of the crushed material or type of machinery.

[8] The boldface numbers in parentheses refer to the list of references appended to this practice.

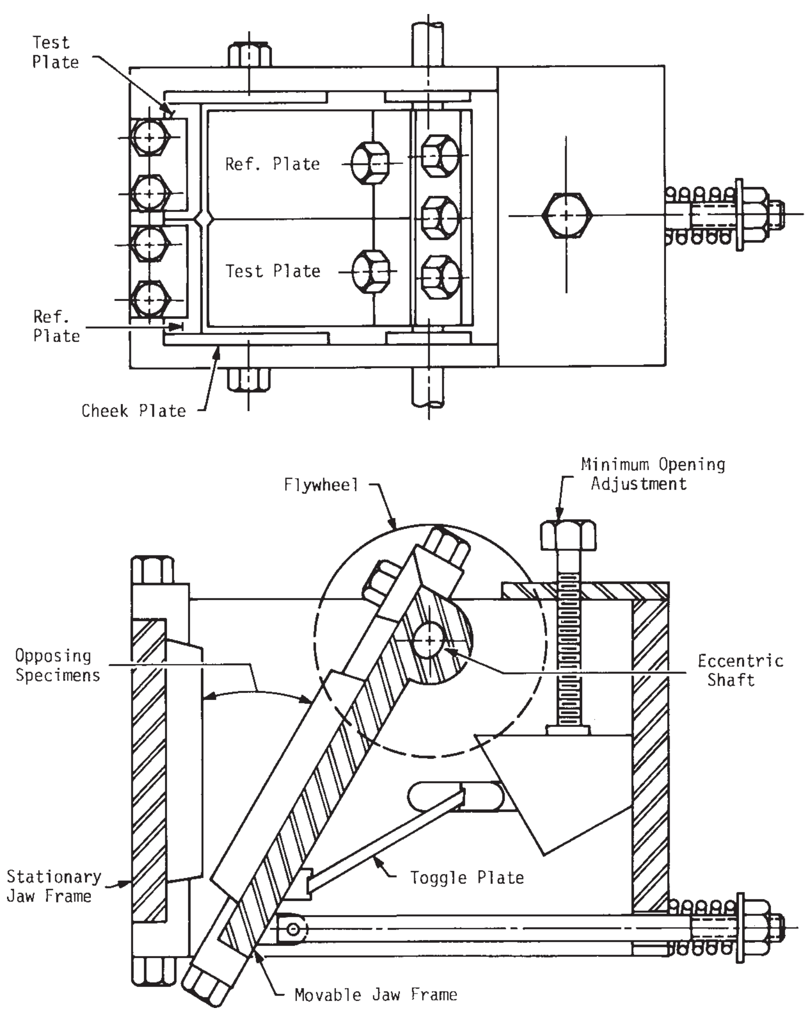

FIG. 1 Typical Jaw Crusher Construction and Layout of the Test Plates

6. Apparatus

6.1 A jaw crusher with an approximate feed opening of 100 by 150 mm (4 by 6 in.) is used.[9] This should have a single movable jaw and be of very rugged construction (see Fig. 1).

6.2 The jaw crusher should be capable of accepting two identical wear plates on the stationary jaw frame and two wear plates of the same design on the movable jaw frame. Plate locating devices should be attached to hold the plates tightly in position. The plate-bottom locating device shall ensure reproducible positioning of the bottom of each test plate for each test. The crusher shaft bearings should be roller or needle bearings to hold consistent tolerances. Spacers may be affixed to the shaft to prevent the movable head from changing the gap on the sides of the jaws. The toggle plate should be easily removed for rebuilding. The machine should have easily replaceable wear liners for the toggle plate holders.

6.3 A motor of higher power than a standard crusher motor may be necessary, since the flat wear plate design takes more power to crush the rock. A5.2-KW (7-hp) motor has been found to be satisfactory for this practice.

6.4 *Important Tolerances*:

6.4.1 Toggle plate length: + 0 to − 1.5 mm (+ 0 to − 0.062 in.).

6.4.2 Wear liners in toggle plate holders: + 0 to − 0.75 mm (+ 0 to − 0.031 in.).

6.4.3 Side to side movement of movable frame: ±0.75 mm (±0.031 in.).

6.4.4 Wear groove in cheek plates: no deeper than 6 mm (0.250 in.).

6.4.5 Shaft movement relative to crusher frame: less than 0.25 mm (0.010 in.).

6.4.6 Movable jaw frame movement relative to shaft: less than 0.25 mm (0.010 in.)

6.4.7 Difference in toe-to-toe spacing: no more than 0.25 mm (0.010 in.) across the width of the crusher exit.

6.5 A frame should be made to support the crusher. The framework must include a hopper above the crusher that will hold a minimum of 225 kg (500 lb) of rock at one time. Below the hopper a lever-actuated control gate and a chute should be attached to deliver the rock into the crusher opening. Below the crusher a removable box may be installed that will hold 225 kg (500 lb) minimum of crushed rock. This box should have a lid with an opening just below the crusher exit.

6.6 An evacuation blower should be installed on the frame to pull dust out of the crushing area and the receiving box and move it to an acceptable collection or dump area. A protective magnetic grate should be installed at the top of the hopper to collect any tramp iron or steel in the rock.

6.7 One or more dump boxes are recommended that will hold 225 kg (500 lb) of rock. This is for weighing the rock and transporting it to the hopper above the crusher.

6.8 A method of weighing 225 kg (500 lb) of rock and the container should be available.

6.9 A balance of sufficient capacity to weigh the test plates is necessary. The sensitivity should be at least ±0.1 g.

7. Materials

7.1 *Reference Plates*:

7.1.1 Reference plates can be made of any readily available material that gives wear behavior consistent with Section 9.

7.1.2 The most common reference wear plate materials are Specification A 514/A 514M, Grade B steel plate, or Specification A 517/A 517M, Grade B plate, quenched and tempered. It is suggested that an effort be made to select a plate as close as possible (±8 HB maximum) to 269 HB hardness (see Test Methods E 10 or E 18 and Hardness Conversion Tables E 140). A large plate should be purchased and cut into pieces suitable to machine into individual plates. The direction of rolling should be in the direction of rock flow through the crusher. Each new batch should be compared with the previous batch.

NOTE 1—The exact hardness of the reference wear plate material is not critical, but most published data are based upon experiments utilizing reference wear plates quite close to 269 HB.

7.1.3 Cast manganese steel reference plates can also be used. Specification A 128/A 128M, Grade A is a consistent cast product and works well as a reference material for testing more wear resistant materials. The plates should be cast oversize and then heat treated. A narrow carbon range of 1.15 % ± 0.02 % is recommended, rather than a specific hardness (see Test Methods E 30 and E 350).

7.1.4 Any material can be used as a reference material if it provides results consistent with Section 9, and if later batches also reproduce original values. Any secondary reference material can be referenced or calibrated by running it against the primary reference material to find by what percentage the wear differs from the primary reference material.

7.2 *Rock*:

7.2.1 The rock to be crushed should be a hard, tough, precrushed material sized to be between 25 mm (1 in.) and 50 mm (2 in.). A hard morainal rock with the following composition is given as an example (proportions are not critical): 18 % quartz and quartzite, 28 % basalt, 20 % granite and gneiss, and 34 % limestone and shale.

7.2.2 However, the rock composition and hardness are not critical to the test. For example, taconite has been used, leading to a large increase in plate wear rate compared to the morainal rock, but with no more than an 8 % variation in the wear ratio measured on the samples tested.

8. Precautions

8.1 *Safety Precautions*:

8.1.1 All belts and flywheels should have metal guards to meet OSHA standards.

8.1.2 A safe means of manual operation of the machine should be provided.

8.1.3 The on/off switch should have a key-operated lockout.

8.1.4 The fill chute should fit well enough so that all rock is directed to the crushing chamber.

8.1.5 A proper ladder should be fixed to the structure so that the operator can climb up to pick tramp iron from the magnetic grate in the hopper and to perform various inspections.

8.2 *Technical Precautions*:

[9] A Massco laboratory jaw crusher from Mine and Smelter, P.O. Box 16067, Denver, CO 80216 has been successfully modified for this test.

8.2.1 The wear test plates must be identified as to test location, and this identification must be retained through final weighing.

8.2.2 Close tolerances, as noted in Fig. 2, must be kept, especially on the toe end of the test plates. This must be controlled carefully to achieve a consistent opening and, therefore, a consistent rock flow across the test specimen.

8.2.3 All decarburized metal should be machined from the test surface and edges prior to testing (see Fig. 2).

8.2.4 Any heat-affected zone from torch cutting should be removed from the test plates.

8.2.5 Samples for testing should be selected from a uniform material lot using accepted statistical practice.

8.2.6 If heat treatment is required, the test specimen blank should be heat treated prior to machining to size. The heat treatment must be identical for both test plates that constitute a single test.

8.2.7 The test specimen should be finished to final size by grinding. Steps should be taken to ensure that no significant heating of the test specimen occurs, either from the grinding operation or during the test, that may cause a change in hardness or structure. It is recommended that a minimum of 2.5 mm (0.100 in.) of material be removed from the wear surface. (This is to ensure the removal of any decarburization that may have occurred during heat treatment.) Ignore this precaution in the case of surface-treated materials. The wear face should also be inspected for grinding cracks. The hardness can be checked on the machined surface in the area of high wear prior to testing.

8.2.8 Tolerances must be developed for each crusher design, so as to ensure a constant operation. Fig. 2 includes tolerances for a test specimen design that fits the modified laboratory jaw crusher noted in 6.1.

8.2.9 Tolerances must be maintained to keep the side-to-side rock flow and crushing even in the crusher. The tolerances are given in 6.4.

8.2.10 For morainal gravel, the test rock can be slightly damp but not dripping wet at time of testing. Holding inside a building for 86.4 ks (24 h) prior to test should be adequate if the water is allowed to drain away from the rock. For materials other than morainal gravel, the effects of moisture have not been studied.

8.2.11 Observe the crushed rock size when the testing facility is first put into operation. If the final crushed rock size gets noticeably larger as machine use continues, then the machine tolerances and calibration should be checked.

9. Calibration and Standardization

9.1 *Calibration*:

9.1.1 The test is calibrated by running three full tests using new plates for each test. All plates are of the same reference plate material.

9.1.2 The wear ratio (defined in 3.1) for the last two tests shall not exceed 1.000 ± 0.030. If the wear ratio exceeds the limit, the machine should be checked for compliance to mechanical tolerance and adjusted or repaired where necessary.

9.1.3 After initial calibration a single calibration check should be run after every 6th test.

9.1.4 After each repair or change made to the machine an initial calibration of three tests should be run.

9.2 *Standardization*:

9.2.1 Standardization is accomplished by running a wear test comparing one reference material versus another, for example, the materials listed in 7.1.2 and 7.1.3.

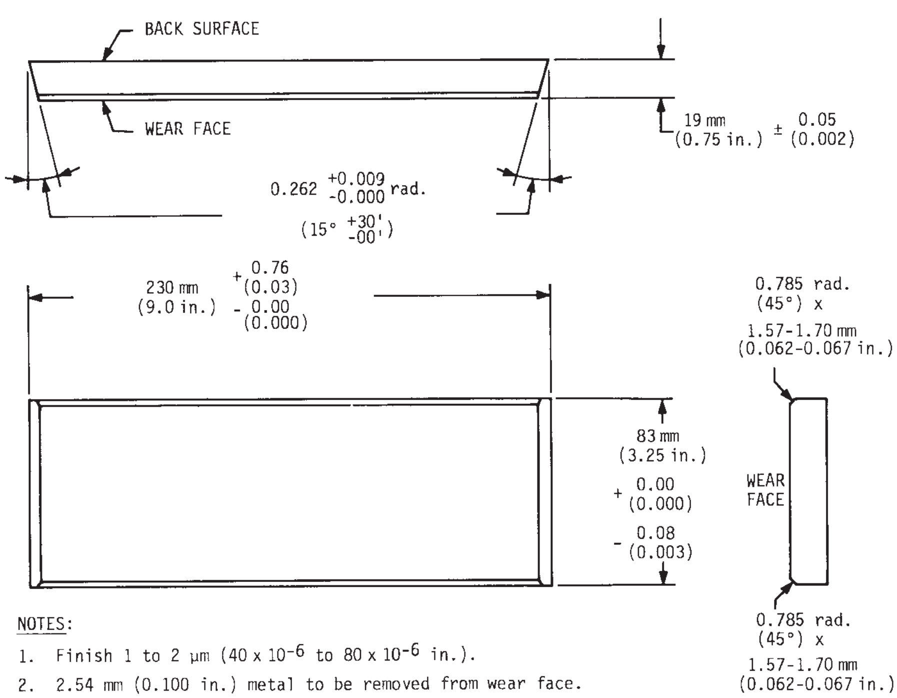

FIG. 2 Example Test Plate Dimensions for Modified Mine and Smelter 100 by 150 mm (4 by 6 in.) Jaw Crusher

9.2.2 Several tests shall be performed to determine the repeatability of the apparatus. All standardization tests shall use the same production lots of reference and test material.

10. Procedure

10.1 Permanently mark the wear test specimen with the specific test number and test specimen location. Mark on the back side of the sample. Identify the location by indicating if the specimen is on the movable or stationary frame and on the left or right side.

10.2 Wash and dry the test specimens to remove grease and dirt.

10.3 Determine the mass of each test specimen to the nearest 0.1 g. Log the results.

10.4 Install the test specimens in their proper locations as marked. (Be sure the motor switch is locked out.) The left movable and right stationary plates should be reference plate specimens, and the right movable and left stationary plates should be test plate specimens. (Tighten the specimens so that no movement will occur during the test.)

10.5 Adjust the minimum jaw opening to 3.2 ± 0.075 mm (0.125 ± 0.003 in.). To do this, put a 6-mm (0.25-in.) diameter soft aluminum wire or rod vertically into the crusher between the stationary and movable jaws. Rotate the flywheel by hand through one rotation. Adjust the toe distance until the crushed portion of the aluminum wire is within tolerances. (Use a knife-edge micrometer.) Check both sides of the bottom opening. The minimum opening should be adjusted using the side with the smallest opening.

10.6 Load the hopper with 227 kg (500 lb) of test rock.

10.7 Crush the rock, throttling the rock flow to keep the crusher full of rock to the top of the frame.

10.8 The adjusting nut that holds the toe of the movable jaw frame back against the toggle plate should be tightened only to the point where the toggle plate does not rattle.

10.9 After the load of rock is crushed, lock out the motor and proceed back to 10.5. Continue this process until 909 kg (2000 lb) of rock has been crushed (Specifications A 514/A 514M or A 517/A 517M reference material) or 1818 kg (4000 lb) of rock has been crushed (when employing low-wear reference materials).

10.10 When all of the test rock for this test is crushed, lock out the motor and remove the test specimen.

10.11 Clean the test specimen by scrubbing with a fiber brush in a detergent water solution, rinsing with water and alcohol and then drying with air.

10.12 Weigh the four test and reference specimens and determine the mass loss for each.

10.13 Calculate the volume loss for each using the following equation:

$$\text{volume loss, mm}^3 = \frac{\text{mass loss (g)}}{\text{density (g/cm}^3\text{)}} \times 1000 \tag{1}$$

NOTE 2—Mass loss can be used instead of volume loss in the subsequent calculation when there is no difference in density.

11. Calculation of Results

11.1 Divide the volume loss of the stationary test plate by the volume loss of the stationary reference plate. This is the stationary wear ratio.

11.2 Divide the volume loss of the movable test plate by the volume loss of the movable reference plate. This gives the movable wear ratio.

11.3 Average the stationary and movable wear ratios to get the final test wear ratio. (It is important to use only the final test wear ratio in any metallurgical decisions. The individual wear ratios of the movable and the stationary jaw are used only to watch for loose tolerances in the test machine.)

11.4 Mathematically, the calculation can be written as:

$$F = \frac{\frac{Xs}{Rs} + \frac{Xm}{Rm}}{2} \tag{2}$$

where:
F = final test wear ratio,
Xs = volume loss from stationary test plate,
Xm = volume loss from movable test plate,
Rs = volume loss from stationary reference plate, and
Rm = volume loss from movable reference plate.

11.5 An alternative procedure for analyzing the results statistically has been reported and discussed in the technical literature **(11,12)**. Users may wish to consider this option.

12. Report

12.1 Report the following information.

12.1.1 Composition and hardness of reference material.

12.1.2 Composition and hardness of test material.

12.1.3 Thermal history of test plates.

12.1.4 Type and size distribution of test rock.

12.1.5 Weight of rock crushed.

12.1.6 Movable and stationary jaw wear ratios.

12.1.7 Mass and volume loss for each test specimen.

12.1.8 Final test wear ratio to the third decimal place.

13. Precision and Bias

13.1 The precision and bias of this test method has not been completely determined. However, some limited results from two laboratories are given in Appendix X1. The comparison does not constitute an interlaboratory test program because specimen materials were not exchanged between the laboratories. Instead, each laboratory used similar but separate specimens of the same type. Data for the T-1 steel represent calibrations of the systems in accordance with 9.1. However, the average wear ratio for Laboratory B exceeds the limit allowed by 9.1.2. Thus, either the homogeneity of the material tested or the equipment used at that location was out of specification and, therefore, the results obtained fail to meet the criteria for acceptance as a reference material. Nevertheless, the individual repeatabilities, as well as results for other materials tested, are remarkably close. The available data for a T-1 steel indicate repeatability standard deviations of about ±0.02. The corresponding coefficients of variation would be ±2.1 % and ±1.8 % and the 95 % repeatability limits would be ±0.059 and ±0.056 for Laboratories A and B, respectively. These repeatability statistics may be considered provisional reproducibility statistics in the absence of specific reproducibility data (see Practice E 691, Reproducibility Standard Deviation, S_R).

13.2 Because there are no generally accepted reference values for wear ratios, as defined in this standard, there can be no determination of bias.

14. Keywords

14.1 abrasion resistance; abrasive wear; gouging abrasion; gouging resistance; gouging wear; jaw crusher

APPENDIX

(Nonmandatory Information)

X1. JAW CRUSHER TEST RESULTS

X1.1 See Table X1.1 for laboratory test results.

TABLE X1.1 Jaw Crusher Test Results[A]

Alloy Type	Laboratory A				Laboratory B			
	Hardness, HB	Wear Ratio, WR	Average WR	WR Standard Deviation	Hardness, HB	Wear Ratio, WR	Average WR	WR Standard Deviation
T-1 steel, Type A—0.19C (WQ and T, 650C)	269	0.983	1.014	0.021	260	...	1.085	0.02
	269	1.024			260	...		
	269	1.022			260	...		
	269	1.027						
Austenitic steel—12Mn (WQ)	...	0.279			199	0.279		
Austenitic steel—12Mn, 2Cr (WQ)	...	0.247			232	0.249		
4340 steel (OQ and T, 650C)	321	0.788			340	0.716		
4340 steel (OQ and T, 205C)	555	0.262			520	0.232		
27Cr white iron (AC and T, 230C)	653	0.166			662	0.144		
15Cr, 3Mo white iron (AC & T, 230C)	>750	0.088			816	0.076		
20Cr, 3Mo white iron—Hardfacing alloy	(HRC = 51.7)	0.201			...	0.170		
0.3C low alloy cast iron (WQ and T, 205C)	514	0.286			499	0.288		

[A] T-1 steel, Type A (comparable to Specification A 514/A 514M, Grade B or Specification A 517/A 517M, Grade B) was used as the reference material.

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