Get the best from the test

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Considering its extreme precision — and the sometimes horrendous conditions in which it is expected to operate — the modern hardness tester is a remarkably dependable machine. Decades of development, topped off in recent years by high technology, have produced a generation of versatile computer-compatible systems able to sustain calibrated accuracies for exceptionally long lives. It is indeed rare for errors in test results to be traced to faults in present-day machines. Human frailty is far more likely.

Surprisingly, little has been written on test procedures for the latest ranges of machines. Apart from manufacturers' handbooks — some of which display elements of partiality — most instruction is by word of mouth. This can sometimes perpetuate techniques more hallowed for their tradition than their contribution of good practice. This article focusses on the effective use of Rockwell type hardness testers. The methods described will enable a competent operator to attain repeatedly consistent test results from any properly serviced machine.

Before launching yourself into full-scale 'production' testing, run a check on the testing machine itself. In the first place, make sure it is located where vibration is absent or negligible. If the environment is dirty — or even if you suspect it is dirty — clean the anvil, anvil seating and indenter seating. Use a grease-free solvent and wipe dry with a lint-free cloth. In fact, you should keep these areas clean all the time the tester is in use. It plainly makes good sense to fit the machine cover when you are not testing. With the machine clean, you can now turn to the three other most common sources of test error — the test block, the indenter and the support anvil.

The test block carries a hardness number — usually etched on the side of the block — and is normally accompanied by support documentation. NAMAS-calibrated test blocks are available for most of the popular scales. Try to use a block whose hardness is close to the hardness of the component you are going to test, say five points. Make sure the block is clean on its top surface and 'squeaky' clean on the bottom support surface, which must also be free from nicks and bruises. You can check its condition by rubbing the block over the anvil; it should almost wring to the anvil surface. If in doubt, give the bottom surface a careful rub with very fine emery over a surface plate. Never ever make a hardness test on the bottom surface.

ROCKWELL SCALE	HARDNESS LEVEL	MAXIMUM ERROR		ROCKWELL SUPERFICIAL SCALE	MAXIMUM ERROR
		GRADE 1	GRADE 2		
HRA	LESS THAN 65 GREATER THAN 65	± 1.5 ± 1	± 2 ± 1.5	HRN	± 2
HRB	LESS THAN 60 GREATER THAN 60	± 2 ± 1.5	± 3 ± 2	HRT	± 4
HRC	LESS THAN 60 GREATER THAN 60	± 1.5 ± 1	± 2 ± 1.5		

Space indentations 2mm apart, for all diamond scales, and 4mm apart for all ball scales.

Do not indent underside of test block.

Do not re-grind the surface of the test block.

Error in hardness value for daily monitoring.

The indenter is the biggest single source of incorrect Rockwell readings when damaged. A flattened ball always gives high results, while a chipped diamond can give low or high results. If you have the slightest doubt about the indenter, change it. With a ball indenter this merely entails changing the ball, so do ensure that you keep a good stock of new, unused balls. The diamond indenter is a rather more difficult proposition. It is often impossible to see — even with a low-powered eye glass — whether there is damage to the indenter tip that could cause measuring errors. The only sure way is to double-check against a new unused indenter, one of which should always be available. If a diamond indenter is at fault, return it to the manufacturer for relapping. Do not make the mistake of putting it on one side. Later, when the background has been forgotten you may attempt to use it again.

Your results will only be as good as the supporting method permits. It must prevent even the slightest downward movement of the part under test. Two microns of movement (80 millionths of an inch) will produce an error of one Rockwell division. You must make sure that the support surface, specimen undersurface, and top of the leadscrew are completely clean and free from nicks and bruises. If the specimen is flat use a flat anvil large enough to prevent overbalancing. If it is not flat employ a spot anvil with the specimen curve uppermost. If it is round use a vee anvil.

Before starting, check again that you have selected the correct test load and indenter for the scale required. With some Combined Rockwell and Rockwell Superficial scales, it is possible to mix the wrong pre-load with the right additional load. All Superficial tests use a 3kgf pre-load and all regular tests a 10kgf pre-load. Make one or two preliminary indentations but ignore the results; these merely bed in the leadscrew and support anvil. Then make two or three indentations for real, record the results and work out the average. Compare this with the declared calibaration of the test block and check that it is within the tolerances allowed by British Standards for daily monitoring. It is important to note that these tolerances are larger than those permitted on recalibration by accredited service engineers.

Do not place your indentations too close together, no closer than 2mm with the diamond indenter and 4mm with the ball indenter. Modern digital machines usually have an automatic loading cycle. If you are using one of the analogue manually loading testers, you must ensure that the total load is fully applied for a period of two to three seconds. Always remove the load smoothly when operating the handlever mechanism. Analogue dial-gauge machines can have up to three graduated scales, generally coloured black, red, and green. You should read off the

black scale with diamond indenters and off the red scale with ball indenters, irrespective of ball size. Always zero on the black scale. Rockwell superficial tests should always be read from the green scale, whether using a ball or diamond indenter.

If you are testing cylindrical parts, the reading will be influenced by the curved surface. An external curve — the outside of the cylinder — will give you a low result, while an internal curve will read high. Both the diameter of the part you are testing and its hardness will affect the result. The smaller the diameter and the softer the surface, the greater the influence. Some modern digital machines incorporate a facility to correct automatically for both these variables. If you are not using such a tester, you should make a 'manual' correction.

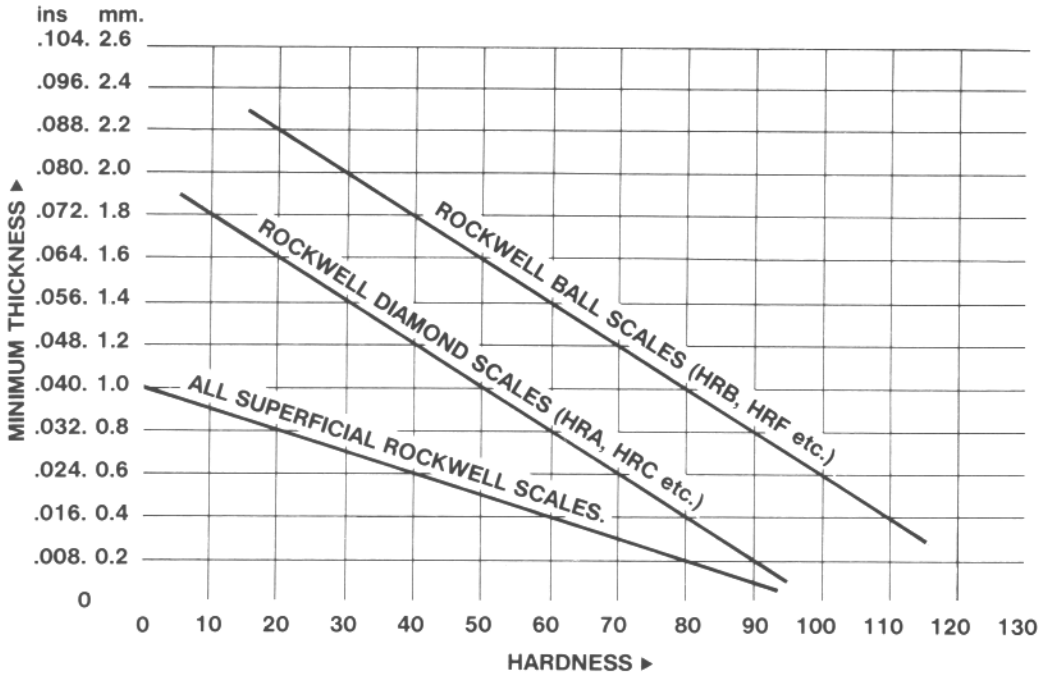
Be wary of the test load when you are testing a thin strip or a specimen with a thin case depth. With too high a load, the indenter can start to break through the case, resulting in low results. On thin strip, the underside will show a 'witness' bulge if the load is too high. This can produce both low and high readings.

As a general guide, the case depth or material thickness should be at least 10 times greater than the indentation depth. This means that a case-hardened component with a nominal hardness of 60 HRC should have a case depth not less than 1mm to avoid the possibility of test errors. If in doubt, check the part on the HRA scale using a 60kg load. The dept of indentation will be approximately halved, allowing a part with a case depth of ½ mm to be tested effectively.

The Rockwell Superficial test, which uses the same procedure and range of indenters as the regular Rockwell test, was developed to ensure effective testing on thin specimens and thin case depths. The lightest Superficial load, 15kgf, enables a component with a equivalent hardness of 60HRC to be tested on a case depth as little as 0.15mm. It is important to be aware of this test because, without a Rockwell Superficial facility, low readings may be due to too high test loads and not to incorrect heat treatment.

There are well-established conversions between all hardness scales, Rockwell, Vickers and Brinell, and they can provide a useful guide. However, care should be exercised, particularly when testing aluminium, softer alloys and stainless steels. Ask your testing-machine manufacturer to provide a wall chart, which should include a conversion table.

There are many different makes of Rockwell types testing machines on the market. However, all should comply with basic criteria in performance and operation. Combined with regular maintenance from a component service organization, the procedures outlined here will enable you to attain a high standard of accurate cost-effective testing, whatever the make or version of machine.



Minimum thickness requirements. Graph is based on internationally accepted recommendation which specifies a minimum thickness not less than 10 times the depth of the indentation. It is also recommended that the indentation causes no visible marker deformation on the under surface of the test piece.

Round Corrections to be added to Rockwell C, A and D values when testing cylindrical specimens.

Hardness Reading	Diameter of Cylindrical Specimens ¼" (6.4 mm)	⅜" (10 mm)	½" (13 mm)	⅝" (16 mm)	¾" (19 mm)	⅞" (22 mm)	1" (25 mm)	1¼" (32 mm)	1½" (38 mm)
20	6.0	4.5	3.5	2.5	2.0	1.5	1.5	1.0	1.0
25	5.5	4.0	3.0	2.5	2.0	1.5	1.0	1.0	1.0
30	5.0	3.5	2.5	2.0	1.5	1.5	1.0	1.0	1.0
35	4.0	3.0	2.0	1.5	1.5	1.0	1.0	0.5	0.5
40	3.5	2.5	2.0	1.5	1.0	1.0	1.0	0.5	0.5
45	3.0	2.0	1.5	1.0	1.0	1.0	0.5	0.5	0.5
50	2.5	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5
55	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0
60	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
65	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
70	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0	0
75	1.0	0.5	0.5	0.5	0.5	0.5	0	0	0
80	0.5	0.5	0.5	0.5	0.5	0	0	0	0
85	0.5	0.5	0.5	0	0	0	0	0	0
90	0.5	0	0	0	0	0	0	0	0

Round Corrections to be added to Rockwell B, F and G values when testing cylindrical specimens.

Hardness Reading	Diameter of Cylindrical Specimens ¼" (6.4 mm)	⅜" (10 mm)	½" (13 mm)	⅝" (16 mm)	¾" (19 mm)	⅞" (22 mm)	1" (25 mm)
0	12.5	8.5	6.5	5.5	4.5	3.5	3.0
10	12.0	8.0	6.0	5.0	4.0	3.5	3.0
20	11.0	7.5	5.5	4.5	4.0	3.5	3.0
30	10.0	6.5	5.0	4.5	3.5	3.0	2.5
40	9.0	6.0	4.5	4.0	3.0	2.5	2.5
50	8.0	5.5	4.0	3.5	3.0	2.5	2.0
60	7.0	5.0	3.5	3.0	2.5	2.0	2.0
70	6.0	4.0	3.0	2.5	2.0	2.0	1.5
80	5.0	3.5	2.5	2.0	1.5	1.5	1.5
90	4.0	3.0	2.0	1.5	1.5	1.5	1.0
100	3.5	2.5	1.5	1.5	1.0	1.0	0.5

Round Corrections to be added to Rockwell Superficial 15N, 30N and 45N values when testing cylindrical specimens

Hardness Reading	Diameter of Cylindrical Specimens ⅛" (3.2 mm)	¼" (6.4 mm)	⅜" (10 mm)	½" (13 mm)	¾" (19 mm)	1" (25 mm)
20	6.0	3.0	2.0	1.5	1.5	1.5
25	5.5	3.0	2.0	1.5	1.5	1.0
30	5.5	3.0	2.0	1.5	1.0	1.0
35	5.0	2.5	2.0	1.5	1.0	1.0
40	4.5	2.5	1.5	1.5	1.0	1.0
45	4.0	2.0	1.5	1.0	1.0	1.0
50	3.5	2.0	1.5	1.0	1.0	0.5
55	3.5	2.0	1.5	1.0	0.5	0.5
60	3.0	1.5	1.0	1.0	0.5	0.5
65	2.5	1.5	1.0	0.5	0.5	0.5
70	2.0	1.0	1.0	0.5	0.5	0.5
75	1.5	1.0	0.5	0.5	0.5	0
80	1.0	0.5	0.5	0.5	0	0
85	0.5	0.5	0.5	0.5	0	0
90	0	0	0	0	0	0

Round corrections