OPERATING INSTRUCTIONS MANUAL

FIE

HARDNESS TESTING MACHINE
MODEL : RASNE-3

Sr.No. 08/2020-4078

MANUFACTURED BY :

Fuel Instruments & Engineers Pvt. Ltd.

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FUEL INSTRUMENTS & ENGINEERS PVT.LTD.,
YADRAV-416145. MAHARASHTRA (INDIA).

INDEX

1. FOREWORD :

`FIE' Hardness Testing Machines are designed for measuring hardness of metals and alloys of all types hard or soft, whether flat, round or irregular in shape. These machines are simple in design, easy to operate, yet very sensitive and accurate.

`FIE' Hardness Testing Machines, available in different models to suit individual requirements are ideally suited for laboratories, tool rooms, inspection departments, foundries and educational institutions, etc.

2. PRINCIPLE OF ROCKWELL TESTING :

Rockwell hardness test is an indentation hardness test using a verified machine to force a diamond spheroconical indentor, or hard steel ball indentor under specified conditions into the surface of the material under test in two operations, and to measure the difference in depth of the indentations under the specified conditions of preliminary and total test force.

3. DESCRIPTION :

The hardness tester is of fabricated body. The enclosed design protects the internal operating parts from determental dust and extraneous elements. The main screw is also protected by a telescopic sleeve. The basic system is one of weights and levers. The weights are hung on free end of lever and cam operated geared motor transmits the force plunger and thereby on the work piece for determination of hardness value. A clamping device enables the tight clamping of work piece during the test which at times can not be checked under normal conditions.

This machine conforms to relative IS.BS and ASTM standards.

4. TECHNICAL DATA :

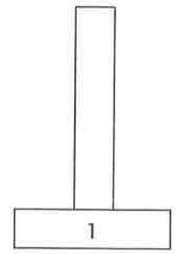
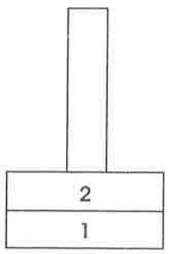
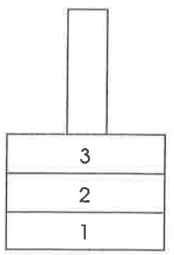
4.1	Manufacturer	Fuel Instruments & Engineers Pvt. Ltd., YADRAV-416145 (INDIA)
4.2	Model	RASNE-3
4.3	Maximum test height	220 mm
4.4	Depth of throat	133 mm
4.5	Maximum depth of screw below base	230 mm
4.6	Dimensions of machine : Base (Approx) Height (Approx)	 180 x 525 mm 645 mm
4.7	Net weight (Approx)	65 kg

5. SELECTION OF LOADS AND IDENTORS FOR VARIOUS HARDNESS TESTS :

There are 15 `Rockwell scales" each of which is best suited to its particular purpose. Each scale differs from the others in one of two respects. In total test force for various application is dealt in detail.

5.1 CHART FOR MOST COMMONLY USED HARDNESS TESTS :-

5.1.1 FOR ROCKWELL AND ROCKWELL SUPERFICIAL HARDNESS TESTS

Total Test Force Preliminary Test Force 98.07 N (10 kgf)	ROCKWELL		
	588.4 N (60 kgf)	980.7 N (100 kgf)	1471.0 N (150 kgf)
Actual weights applied			
Indentors	Diamond 120°	Ball 1.588 mm ∅ (1/16" mm ∅)	Diamond 120°
Scale	A	B	C
Led position on keyboard	Set	Set	Set
Typical application	Thin steel and shallow case hardened steel	Soft steel, Malleable Iron, Copper, Aluminum alloys	Steel, hard cast steel, deep case hardened steel, other metals harder than HRB-100

6. STANDARD EQUIPMENT :

Sr. No.	Description	RASNE-3
6.1	Testing table 50 mm ∅	1
6.2	Testing table 38 mm ∅ with `V' groove for round jobs 6 to 45 mm ∅	1
6.3	Diamond Indentor 120º	1
6.4	Steel Ball Indentor 1.588 mm (1/16" ∅)	1
6.5	Test Block for Rockwell "C" scale	1
6.6	Test Block for Rockwell "B" scale	1
6.7	Telescopic sleeve for elevating screw protection	1
6.8	Allen keys	6
6.9	Clamping device	1
6.10	Instruction manual	1

7. INSTALLATION :

This machine should be handled carefully since it is a precision testing equipment. All necessary precautions are taken to prevent damages in transit. The moving parts of machine like loading mechanism are locked so that they do not move in transit. Machine is packed in two halves of polyethylene foam (PEF) and then put into a corrugated box. So while unpacking first remove PEF packaging from corrugated box and then take out upper PEF packaging. You will then observe the following in addition to basic machine.

1. The standard accessories box.
2. A set of telescopic sleeves for protection of main screw.

   Now check all items as per packing list. Lift and carry the machine to the selected place.

Follow the instruction given for "Getting machine ready to service" and keep the machine ready for testing.

Mount it on firm table having a hole ∅ 55 mm allow main screw (1) to pass through.

The table should be placed so that there is sufficient room for installation and maintenance work and it is free from rust and corrosion. The machine should not be sited in gritty or dusty conditions nor in a position subject to vibration or excessive temperature changes.

Ensure that the machine is properly levelled, aligned and free from vibration. If the bench or table on which the hardness tester is mounted is subject to vibration, such as experienced in the vicinity of other machines, the tester should be mounted on a metal plate having sponge rubber at least 12 mm thickness below or any other type of mounting that will effectively eliminate vibration from machine.

8. GETTING MACHINE READY FOR SERVICE :

Remove top cover of machine. Also take out all screws fixed at corners of left side door and remove door.

1. Remove small M.S. strip, taking out two sides screws (It is used to lock movement during transit and to be used only when machine is to be transported to other place).
2. Until the strings tied between plunge (3) and load hanger (8).
3. Remove two long screws used for locking weights in position. Also remove lather washers kept on top of weights, just below the long screws. The cleaning of machine as explained under "Maintenance Precautions" on page No.11 has to be carried out prior to fixing indentor.

9. LEVELLING OF MACHINE :

Level the machine as per level indicator (35) fixed on machine using leveling screw (36).

10. MOTORISED SYSTEM FOR LOADING / UNLOADING LEVER :

A micro speed motor is mounted on a block which in turn is fixed to the plate inside the body. A cam is mounted on the shaft of this motor, which when rotated by motor will lift or lower the weight. Then selected weights can be used for loading or unloading the lever.

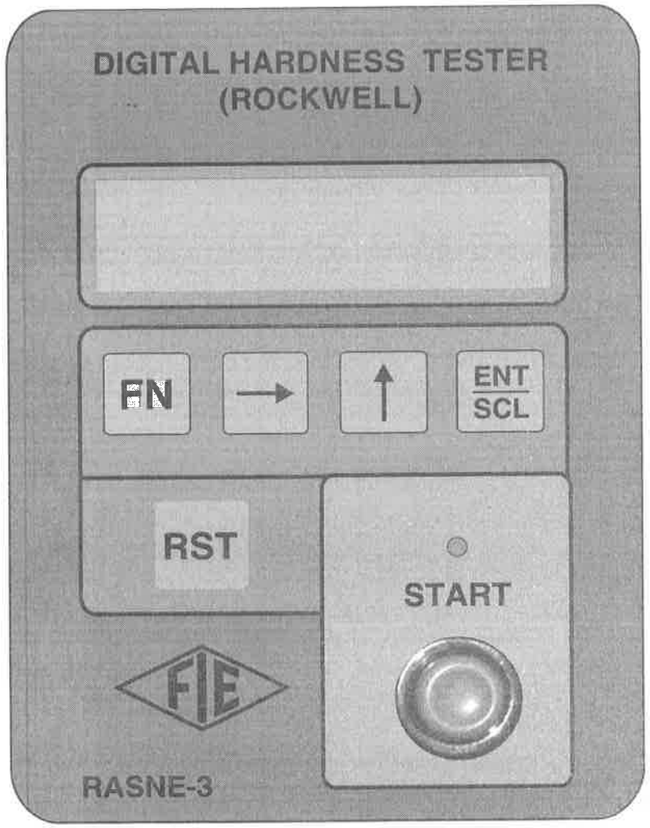
11. MOUNTING AND REMOVING INDENTORS :

Clean the bearing surface and bore of the Diamond Holder (6). The Indentor (5) must be inserted in to the holder upto the neck and tightened by the side screw with slight pressure.

12. LINEAR GAUGE SENSOR :

The linear displacement of the lever is sensed by Linear Gauge Sensor (37). The primary displacement is sensed when the indentor touches the specimen and moves further, till the display (38) shows `SET'. Final displacement is sensed when test load is applied. The hardness can be directly read on the LCD Display (38).

12.1 LCD DISPLAY :



On 2 line x 16 characters LCD, upper line normally displays "Bar graph". Bar graph helps for initial lifting up o set point.

2nd line displays current selected scale and digital dial gauge reading.

To change the scale press and hold "ENT/SCL" key in normal display mode, till you get required scale. If you want the same scale after power OFF/ON then save data in Data entry mode.

DATA ENTRY :

In normal display mode, pressing "FN" key enters data entry mode and displays first parameter "High Limit". Pressing "FN" key again scrolls through all input parameters "LOW Limit", "Dwell Time", "Printer", "Auto Start", "Save data" and then to normal display mode. Note that modified data will not get accepted, if you go to next parameter with "FN" key. You have to press "ENT/SCL" key to accept modified data or for "Save data" operation.

To modify input parameter select required parameter with "FN" key. Shift (→) to select required digit and up arrow key (↑) to change digit. So with → & ↑ key modify data as per required and press "ENT'SCL" key, to accept the modified data.

For "Printer" and "Auto start select", "Start" key toggles for Yes/No selection, select required and press "ENT/SCL" key.

If you want to retain all the input parameters and scale after power OFF/ON, then you have to do "Save data" i.e. In input parameters, go to "Save data" and press "ENT/SCL" key.

If printer selection is "yes", then result will get printed if printer connected.

If printer selection is "No", then result will not get printed automatically after test end, but you can take printout by pressing "FN" key, before releasing the screw. (Selected printout).

If "Auto Start" selection is "No", then after reaching set point, you have to press "Start" button on prompt, to start the test.

If "Auto start" selection is "Yes", then after reaching set point, cycle will start automatically (start button press not required).

* "RST" is system reset key. Pressing it will reset the system.

OPERATION CYCLE :

Select required scale. Confirm data entry OK. Confirm load selection, Indentor, specimen OK. Lift the screw looking bar graph till set point. Display prompt you to press "Start" button (or cycle starts automatically in Auto start mode). (If initial lifting is more than over travel error gets displayed. Release screw and start again).

Loading starts displaying "Loading" on display. When timer switch gets operated dwell starts indicating dwell time on display. At the end of dwell unloading starts displaying "Unloading" on display. When home switch get operated, cycle stops and result gets displayed e.g. "Hardness 60.2". Release servo to start for next cycle.

13. TELESCOPIC SLEEVE (21) FOR PROTECTION OF MAIN SCREW :

This protect the main screw (1) from dirt or dust etc. It can be put over the main screw from the top so that it's top caller rests against the step of main screw (1). The maximum test height can not be used with this cover. Hence, it should be removed in such rare cases.

14. OPERATION OF MACHINE :

For carrying out test, the following procedure should be adopted very carefully. Any negligence may lead damage to the Indentor.

14.1 Adjust the weights on plunger (3) or dash pot according to the Rockwell scale required as shown in charts on page 3 by load selection disc (10).

14.2 Connect power plug and switch `ON' position

14.3 Place specimen securely on testing table.

14.4 Turn the hand wheel (7), till the specimen touches the Indentor and pushes further till display shows `SET'. In case display shows `Over Travel Err', the machine should not be operated. Turn the hand wheel in reverse direction to bring the specimen to original position.

14.5 Press CYCLE START push button (Now loading/unloading cycle starts).

14.6 Read the hardness of the specimen directly on the display, when the cycle ends.

14.7 Rotate the hand wheel (7) and remove the specimen. At this time display should show zero (0) reading. If not press key RST to set zero (0).

14.8 Discard first two readings. Further readings will furnish hardness of the specimen correctly.

15. CHECK ON PROPER INDICATION :

The accuracy of tester can be verified by means of standardised hardness test blocks supplied alongwith the machine. In case of deviation from the indicated value beyond the limits permissible, check the performance of the machine with new Indentor. The standardised hardness test blocks supplied with the machine should only be used in case of doubts in the accuracy of results. If the results are still beyond limits, refer `Maintenance Precautions and Test Requirements'. Also refer table of common causes & errors in hardness testing.

PERMISSIBLE LIMIT FOR DEVIATION :

Take 7 indentations on test block, out of which neglect first two readings. Then average of balance five reading should not exceed following limits :-

Hardness ranges of Test Block	Allowed Limits
HRC 59-65	± 1.5
HRB 80–100	± 2.0

16. MAINTENANCE PRECAUTIONS :

Remove the telescopic sleeve of main screw (1). Clean the grease of main screw by using suitable solvent applying all around the main screw by a brush.

16.1 Lower the main screw (1) to the maximum position. Remove the hand wheel (7) by unscrewing it from the main screw. Make up and down movements of main screw by hand applying the solvent at times. Ensure that main screw slides down freely by its own weight when raised. Clean the bearing surface on which the thrust bearing in hand wheel rests. Also clean the thrust bearing, by removing in it from the hand wheel.

Assemble the hand wheel with thrust bearing and lubricate it with a suitable lubricating oil. The main screws (1) should move up and down through out the range, when the hand wheel is so operated.

Take out the test table (14) from the bore of main screw (1). Check the bearing face of main screw as well as of test table (14) and clean if necessary.

16.2 Remove the top cover (30). Then remove pivot-vee (17) by removing two allen screws, then take out the main loading lever carefully. To facilitate this operation, take out the loading vee (31) and Diamond holder (6) carefully. Clean the resting surface of plug (33) on which the Diamond holder rests. Also clean linear bearing (32). Apply thin grease at all bearing surfaces wherever necessary. Apply little grease on V-grooves and V-knife edges.

Assemble this unit as before and tighten the `Pivot-Vee' (17) firmly. The tapping of diamond holder provided for holding the penetrates should be at right hand side of operator which should be carefully noted.

Diamond Indentor has highly polished surface and is susceptible to damage if not handled properly.

16.3 Main screw should always be lowered before removing or installing a new anvil. This is to avoid the possibility of striking the anvil against the Indentor. An additional safe guard is the placing of a finger over the anvil when removing or inserting it to act as a shield between anvil and indentor (See fig.C on page 23).

17. TEST REQUIREMENT :

In order to obtain consistent and accurate result from hardness testing machines, adhere to the following instructions :-

- Select the proper surface Indentor and load to suit the material under test.
- See that the surface under test is mounted at right angle to the axis of the Indentor.
- The seating and supporting surfaces of all anvil should be free from pits, heavy scratches, dust, dirt and grease.

The surface of the metal under test must be representative of the material so that any scale, hard skin or another surface formation differing from the metal underneath should be removed.

Specimens that have overhang and do not balance them selves on the anvil, should be properly balanced. The distance of the center of an indentation from the edge of the test piece shall be at least 3 times the diameter of the indentation. The distance between any 2 indentations shall be at least 2.1/2 times the diameter of the indentation.

The Indentor should be examined regularly for signs of damage and surface imperfections and replaced whenever these are found.

Occasionally turn the ball in the holder, to minimize errors due to minute distortion of the ball.

The minimum thickness of sheet materials for various hardness ranges are shown in separate figures. The harder the metal the thinner it can be, without introducing in the hardness test results.

18. COMMON CAUSES OF ERRORS IN HARDNESS TESTING :

SR. NO.	CAUSES	SYMPTOMS	REMEDY
1	Improper choice of anvil or scale	Erratic	Select proper scale and anvil according to test requirements.
2	Dirt or nicks on anvil surface or on Indentor shoulder	Erratic	Clean it.
3	Chipped diamond (on striking penetrator with work)	High or Low	Replace Indentor.
4	Scale, oxide film, pits scratches or foreign material on top or bottom test surface. Work not held properly	Erratic Low	Test specimen to be free from foreign material. Test surface of specimen must be perpendicular to Indentor axis.
5	Test piece or case hardening too thin for scale used	High or Low	Refer minimum thickness chart.
6	Improper calibration of testing machine using wrong side of test block	Consistently high or Low	Ascertain accuracy with new test block.
7	Failure to sit and center round work securely in anvil, or failure to use round work correction chart.	Low	Adjust Indentor and anvil axis. Use round work correction chart.

19. CLAMPING DEVICE :

Use of clamping device facilitates testing of overhanging bars within certain limits. It also protects the Indentor from inadvertent damages while placing or removing the specimen from support. This should be used where it is a must as it shows a slight higher value about 0.5 to 1.0 HRC depending upon manual clamping force applied.

Read the following instruction to use it in a proper way :-

Place the Indentor (5) in position, if it was removed earlier.

1. Normally clamping nut (13) is tightened in position with two knurled screws on both side. For removing it, these side knurled screws are to be loosened sufficiently. However clamping ring is required in position for use of clamping cone (12).

2. Engage clamping cone (12) with its check nut (13) in position, so that its bottom face is little above the level on Indentor point (about 1 mm).

3. Keep the specimen on test table and raise the main screw (1) by the hand wheel (7) so that the LCD display shows `SET' .

4. Clamp the job by rotating the clamping device in reverse direction with good pressure (which should generally be more than the applied load). Then fix this position by tightening the check nut (13) to the face of clamping ring. See that clamping nose do not touch the Indentor.

5. Check-up the performance by trials, so that when the specimen is firmly clamped, by moving hand wheel, the LCD display should show `SET' and Check-nut (13) is not loose.

6. To bring the slot of clamping cone (12) in front position, just slightly loosen two side screws, rotate the clamping ring (13) to bring slot in proper position, clamp two side screws again.

20.

WARRANTY OF MACHINE

The performance of `FIE Hardness Testing Machine, Model – RASNE-3, Serial No. 08/2020-4078 is warranted against defective workmanship and material for a period of 15 months from the date of supply or 12 months from the date of commissioning, whichever ends earlier.

The warranty is limited to the free repair / replacement of defective part/s only and does not cover part/s worn out / broken due to mishandling or normal wear and tear.

The warranty on the following items, however, ceases immediately on commissioning of the machine :-

1. Diamond Indentor
2. Linear gauge sensor

FOR FUEL INSTRUMENTS & ENGINEERS PVT.LTD.

PLACE: YADRAV

DATE : 25/08/2020

21. SELECTION OF ROCKWELL HARDNESS SCALES

Scale	Indentor	Load in N	Application	Brinell Value	Working Range
A	Diamond Cone 120°	588.4 (60 kgf)	Carbides, Thin Steel, Shallow Case-hardened Steel, Case Carburized surfaces.	Over HB 400	40 - 91 for hardness greater than C 65
B	Steel ball 1.587 mm (1/16")	980.7 (100 kgf)	Aluminum Alloys, Cropper Alloys Unhardened Steel etc. in rolled drawn, extruded or cast metal.	HB 100-240	30 - 100 for hardness lower than C 20
C	Diamond Cone 120°	1471.0 (150 kgf)	Hard cast irons, Pearlitic malleable iron, Steel, Deep case hardened steel, Titanium.	Over HB 230	20 - 70 for material harden than HRB 100
D	Diamond Cone 120°	980.7 (100 kgf)	Pearlitic malleable iron, Thin steel & medium case hardened steel.	Over HB 400	40 - 77 for intermediate load between A & B scale
E	Steel ball 3.175 mm (1/8")	980.7 (100 kgf)	Cast iron aluminum and magnesium alloys, bearing metals.	Below HB 125	50 - 100 for hardness lower than HRB 0
F	Steel ball 1.587 mm (1/16")	588.4 (60 kgf)	Thin soft sheet metals, annealed copper alloys.	HB 50-120	30 - 100 for hardness lower than HRB 0
G	Steel Ball 1.587 mm (1/16")	1471.0 (150 kgf)	Copper nickel zinc and cupro-nickel alloys, malleable irons.	HB 120-280	30 - 90 for hardness slightly higher than HRB 100. Upper limit G 92
H	Steel ball 3.175 mm (1/8")	588.4 (60 kgf)	Lead, zinc, aluminum magnesium alloys.	HB 30-50	70 - 100
K	Steel ball 3.175 mm (1/8")	1471.0 (150 kgf)	Bearing metals, very soft or thin materials.	HB 100-200	40 - 100
L	Steel ball 6.350 mm (1/4")	588.4 (60 kgf)	Plastic materials, Bakelite, Vulcanised fibre, Nylon.	Variations in hardness reduced by testing with the largest indentor consistent with overall hardness of the material. Moulded finish will give a higher reading than a machined face.	
M	Steel ball 6.350 mm (1/4")	980.7 (100 kgf)	Polystyrene, Flexi-glass Rigid sheet and plastic materials.		
P	Steel ball 6.350 mm (1/4")	1471.0 (150 kgf)	Used for electrical insulation are tested by M & L scale.		
R	Steel ball 12.70 mm (1/2")	588.4 (60 kgf)	When the "Spring constant" or correlation factor is included in the test procedure, only R scale is used.		
S	Steel ball 12.70 mm (1/2")	980.7 (100 kgf)			
V	Steel ball 12.70 mm (1/2")	1471.0 (150 kgf)			

22. APPROXIMATE EQUIVALENT HARDNESS NUMBERS FOR ROCKWELL HARDNESS NUMBERS FOR STEEL (A)

22.1 For Rockwell `B' hardness numbers.

Rockwell Hardness No.	Vickers Hardness No.	Brinell Hardness No. 10 mm ball		Rockwell Hardness No.			Rockwell Superficial hardness No. 1/16" ∅ ball			Knoop hardness No. 500-g load and greater	Scleroscope hardness No.
		500 kg Load	3000 kg Load	'A' scale 60 kg load diamond Indentor	'C' scale, 150-kg. load, diamond indentor	'F' scale 60 kg. load 1/16" ∅ ball	15T scale 15-kg load	30 T scale 30-kg load	45 T scale 45-kg load		
98	228	189	228	60.2	(19.9)	--	92.5	81.8	70.9	241	34
97	222	184	222	59.5	(18.6)	--	92.1	81.1	69.9	236	33
96	216	179	216	58.9	(17.2)	--	91.8	80.4	68.9	231	32
95	210	175	210	58.3	(15.7)	--	91.5	79.8	67.9	226	--
94	205	171	205	57.6	(14.3)	--	91.2	79.1	66.9	221	31
93	200	167	200	57.0	(13.0)	--	90.8	78.4	65.9	216	30
92	195	163	195	56.4	(11.7)	--	90.5	77.8	64.8	211	--
91	190	160	190	55.8	(10.4)	--	90.2	77.1	63.8	206	29
90	185	157	185	55.2	(9.2)	--	89.9	76.4	62.8	201	28
89	180	154	180	54.6	(8.0)	--	89.5	75.8	61.8	196	27
88	176	151	176	54.0	(6.9)	--	89.2	75.1	60.8	192	--
87	172	148	172	53.4	(5.8)	--	88.9	74.4	59.8	188	26
86	169	145	169	52.8	(4.7)	--	88.6	73.8	58.8	184	26
85	165	142	165	52.3	(3.6)	--	88.2	73.1	57.8	180	25
84	162	140	162	51.7	(2.5)	--	87.9	72.4	56.8	176	--
83	159	137	159	51.1	(1.4)	--	87.6	71.8	55.8	173	24
82	156	135	156	50.6	(0.3)	--	87.3	71.1	54.8	170	24
81	153	133	153	50.0	--	--	86.9	70.4	53.8	167	--
80	150	130	150	49.5	--	--	86.6	69.7	52.8	164	23
79	147	128	147	48.9	--	--	86.3	69.1	51.8	161	--
78	144	126	144	48.4	--	--	86.0	68.4	50.8	158	22
77	141	124	141	47.9	--	--	85.6	67.7	49.8	155	22
76	139	122	139	47.3	--	--	85.3	67.1	48.8	152	--
75	137	120	137	46.8	--	99.6	85.0	66.4	47.8	150	21
74	135	118	135	46.3	--	99.1	84.7	65.7	46.8	148	21
73	132	116	132	45.8	--	98.5	84.3	65.1	45.8	145	--
72	130	114	130	45.3	--	98.0	84.0	64.4	44.8	143	20
71	127	112	127	44.8	--	97.4	83.7	63.7	43.8	141	20
70	125	110	125	44.3	--	96.8	83.4	63.1	42.8	139	--
69	123	109	123	43.8	--	96.2	83.0	62.4	41.8	137	19
68	121	107	121	43.3	--	95.6	82.7	61.7	40.8	135	19
67	119	106	119	42.8	--	95.1	82.4	61.0	39.8	133	19
66	117	104	117	42.3	--	94.5	82.1	60.4	38.7	131	--
65	116	102	116	41.8	--	93.9	81.8	59.7	37.7	129	18
64	114	101	114	41.4	--	93.4	81.4	59.0	36.7	127	18
63	112	99	112	40.9	--	92.8	81.1	58.4	35.7	125	18
62	110	98	110	40.4	--	92.2	80.8	57.7	34.7	124	--
61	108	96	108	40.0	--	91.7	80.5	57.0	33.7	122	17
60	107	95	107	39.5	--	91.1	80.1	56.4	32.7	120	--
59	106	94	106	39.0	--	90.5	79.8	55.7	31.7	118	--
58	104	92	104	38.6	--	90.0	79.5	55.0	30.7	117	--
57	103	91	102	38.1	--	89.4	79.2	54.4	29.7	115	--
56	101	90	101	37.7	--	88.8	78.8	53.7	28.7	114	--
55	100	89	100	37.2	--	88.2	78.5	53.0	27.7	112	--

Note : Values in Brackets are beyond normal range and are given for information only.

(a) For carbon and alloy steels in the annealed normalized, and quenched-and-tempered conditions. Less accurate for cold worked condition and for austenitic steels.

22.2 For Rockwell `C' hardness numbers for steel (a)

Rockwell Hardness No.	Vickers Hardness No.	Brinell Hardness No. 3000 kg load, 10 mm ball		Rockwell Hardness No.			Rockwell Superficial hardness No. Diamond Indentor			Knoop hardness No. 500-g load and greater	Scleroscope hardness No.
		Standard ball	Tungsten carbide ball	`A' scale 60 kg load diamond Indentor	'B' scale 100-kg. load, 1/16" ∅ ball	'D' scale 100 kg. load diamond indentor	15N scale 15-kg load	30 N scale 30-kg load	45 N scale 45-kg load		
68	940	--	--	85.6	--	76.9	93.2	84.4	75.4	920	97
67	900	--	--	85.0	--	76.1	92.9	83.6	74.2	895	95
66	865	--	--	84.5	--	75.4	92.5	82.8	73.3	870	92
65	832	--	(739)	83.9	--	74.5	92.2	81.9	72.0	846	91
64	800	--	(722)	83.4	--	73.8	91.8	81.1	71.0	822	88
63	772	--	(705)	82.8	--	73.0	91.4	80.1	69.9	799	87
62	746	--	(688)	82.3	--	72.2	91.1	89.3	68.8	776	85
61	720	--	(670)	81.8	--	71.5	90.7	78.4	67.7	754	83
60	697	--	(654)	81.2	--	70.7	90.2	77.5	66.6	732	81
59	674	--	(634)	80.7	--	69.9	89.8	76.6	65.5	710	80
58	653	--	615	80.1	--	69.2	89.3	75.7	64.3	690	78
57	633	--	595	79.6	--	68.5	88.9	74.8	63.2	670	76
56	613	--	577	79.0	--	67.7	88.3	73.9	62.0	650	75
55	595	--	560	78.5	--	66.9	87.9	73.0	60.8	630	74
54	577	--	543	78.0	--	66.1	87.4	72.0	59.8	612	72
53	560	--	525	77.4	--	65.4	86.9	71.2	58.6	594	71
52	544	(500)	512	76.8	--	64.6	86.4	70.2	57.4	576	69
51	528	(487)	496	76.3	--	63.8	85.9	69.4	56.1	558	68
50	513	(475)	481	75.9	--	63.1	85.5	68.5	55.0	542	67
49	498	(464)	469	75.2	--	62.1	85.0	67.6	53.8	526	66
48	484	(451)	455	74.7	--	61.4	84.5	66.7	52.5	510	64
47	471	442	443	74.1	--	60.8	83.9	65.8	51.4	495	63
46	458	432	432	73.6	--	60.0	83.5	64.8	50.3	480	62
45	446	421	421	73.1	--	59.2	83.0	64.0	49.0	466	60
44	434	409	409	72.5	--	58.5	82.5	63.1	47.8	452	58
43	423	400	400	72.0	--	57.7	82.0	62.2	46.7	438	57
42	412	390	390	71.5	--	56.9	81.5	61.3	45.5	426	56
41	402	381	381	70.9	--	56.2	80.9	60.4	44.3	414	55
40	392	371	371	70.4	--	55.4	80.4	59.5	43.1	402	54
39	382	362	362	69.9	--	54.6	79.9	58.6	41.9	391	52
38	372	353	353	69.4	--	53.8	79.4	57.7	40.8	380	51
37	363	344	344	68.9	--	53.1	78.8	56.8	39.6	370	50
36	354	336	336	68.4	(109.0)	52.3	78.3	55.9	38.4	360	49
35	345	327	327	67.9	(108.5)	51.5	77.7	55.0	37.2	351	48
34	336	319	319	67.4	(108.0)	50.8	77.2	54.2	36.1	342	47
33	327	311	311	66.8	(107.5)	50.0	76.6	53.3	34.9	334	46
32	318	301	301	66.3	(107.0)	49.2	76.1	52.1	33.7	326	44
31	310	294	294	65.8	(106.0)	48.4	75.6	51.3	32.5	318	43
30	302	286	286	65.3	(105.5)	47.7	75.0	50.4	31.3	311	42
29	294	279	279	64.7	(104.5)	47.0	74.5	49.5	30.1	304	41
28	286	271	271	64.3	(104.0)	46.1	73.9	48.6	28.9	297	40
27	279	264	264	63.8	(103.0)	45.2	73.3	47.7	27.8	280	39
26	272	258	258	63.3	(102.5)	44.6	72.8	46.8	26.7	284	38
25	266	253	253	62.8	(101.5)	43.8	72.2	45.9	25.5	278	38
24	260	247	247	62.4	(101.0)	43.1	71.6	45.0	24.3	272	37
23	254	243	243	62.0	100.0	42.1	71.0	44.0	23.1	266	36
22	248	237	237	61.5	99.0	41.6	70.5	43.2	22.0	261	35
21	243	231	231	61.0	98.5	40.9	69.9	42.3	20.7	256	35

Note : Values in Brackets are beyond normal range and are given for information only.
(a) For carbon and alloy steels in the annealed normalized, and quenched-and-tempered conditions. Less accurate for cold worked condition and for austenitic steels.

23. TEST WITH DIAMOND CONE (HRA, HRC, HRD)

CORRECTIONS TO BE ADDED TO HARDNESS VALUES HRA, HRC, HRD OBTAINED ON CYLINDRICAL TEST PIECES

Rockwell Hardness Readings	Radius of Curvature								
	3 mm	5 mm	6.5 mm	8 mm	9.5 mm	11 mm	12.5 mm	16 mm	19 mm
20				2.5	2.0	1.5	1.5	1.0	1.0
25			3.0	2.5	2.0	1.5	1.0	1.0	1.0
30			2.5	2.0	1.5	1.5	1.0	0.5	0.5
35		3.0	2.0	1.5	1.5	1.0	1.0	0.5	0.5
40		2.5	2.0	1.5	1.5	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	1.0	0.5	0.5	0.5	0.0
60	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0.0	0.0
65	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0.0	0.0
70	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.0	0.0
75	1.0	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0
80	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0
85	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
90	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note : Corrections greater than 3 HRA, HRC and HRD are not considered acceptable and are not, therefore included in the above table.

24. TEST WITH 1.585 MM STEEL BALL (HRB, HRF, HRG)

CORRECTIONS TO BE ADDED TO HARDNESS VALUES HRB, HRF, HRG OBTAINED ON CYLINDRICAL TEST PIECES

Rockwell Hardness Readings	Radius of Curvature						
	3 mm	5 mm	6.5 mm	8 mm	9.5 mm	11 mm	12.5 mm
20				4.5	4.0	3.5	3.0
30			5.0	4.5	3.5	3.0	2.5
40			4.5	4.0	3.0	2.5	2.5
50			4.0	3.5	3.0	2.5	2.0
60		5.0	3.5	3.0	2.5	2.0	2.0
70		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

Note : Corrections greater than 5 HRB, HRF and HRG are not considered acceptable and are not, therefore included in the above table.

25. TEST WITH DIAMOND CONE (HRC)

CORRECTIONS TO BE ADDED TO ROCKWELL HARDNESS HRC VALVES OBTAINED ON SPHERICAL TEST SURFACES.

Rockwell Hardness Readings	Diameter of Sphere, mm								
	4	**6.5**	**8**	**9.5**	**11**	**12.5**	**15**	**20**	**25**
55 HRC	6.4	3.9	3.2	2.7	2.3	2.0	1.7	1.3	1.0
60 HRC	5.8	3.6	2.9	2.4	2.1	1.8	1.5	1.2	0.9
65 HRC	5.2	3.2	2.6	2.2	1.9	1.7	1.4	1.0	0.8

The test values (ΔH) given in the above table are calculated by the following formula

$$\Delta H = 59 \times \frac{\left\{1 - \frac{H}{160}\right\}^2}{d}$$

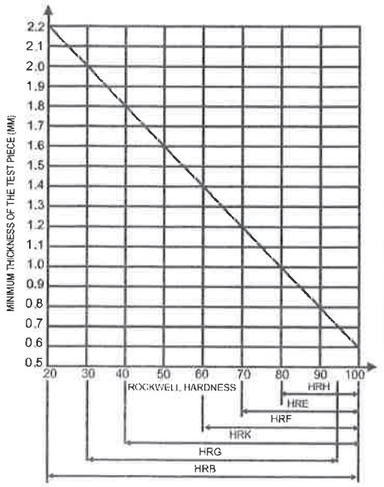
Where

Δ H is the correction to be added and

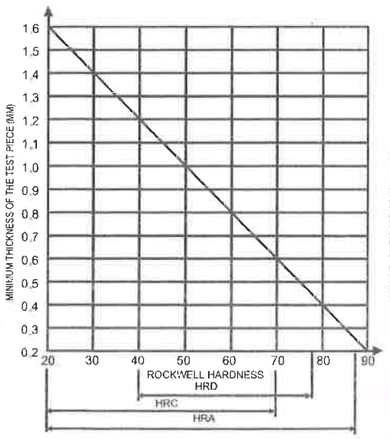
H is the Rockwell hardness reading.

26. MINIMUM THICKNESS OF THE TEST PIECE

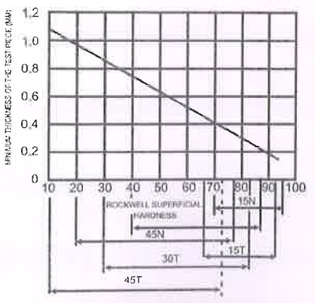
The hardness range for each scale and test force is dependent on the hardness and thickness on the test piece or surface layer tested. Guidance for choice of scale is given in figures below.



TEST WITH STEEL BALL
(HRS, HRE, HRF, HRG, HRH, HRQ)



TEST WITH DIAMOND CONE (HRA, HRC, HRD)



MINIMUM THICKNESS OF THE TEST PIECE IN RELATION TO THE ROCKWELL SUPERFICIAL HARDNESS