STANDARD HARDNESS SPECIMENS

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Standard hardness specimens (SHS) are intended for checking instruments for the measurement of hardness. The measure of hardness obtained by any method depends on the conditions under which it is carried out.

It is evident that uniqueness and accuracy of measurements of hardness on arbitrary scales can be secured only with the organization of a centralized service for hardness and provision of an adequate number of standard specimens for the checking of instruments.

Up to the present time hardness standards for the checking of working instruments have been manufactured in a number of enterprises from various grades of metal, and even in those cases when the same grade of metal has been used the technique has sometimes been different. These circumstances have, in certain enterprises, led to an intolerably large percentage of rejects in the manufacture of hardness standards.

The creation of SHS has as its aim elimination of the excessive variety of hardness standards being produced and the establishment of a minimum number of definite shapes, sizes, and kinds of standard. One of the problems of standardization in this area, that is, acceleration of the output of high quality production and reduction of the consumption of materials and of the cost of production, should be solved as a result of the creation of standard hardness specimens.

Choice of Material for Standard Hardness Specimens. In monitoring the mass production of metal products, the Rockwell system (GOST 9013-63) is the most widely employed. Domestic and foreign practice in the manufacture of hardness standards indicates that various types of steel are used for this purpose.

Table 1

<table>
<thead>
<tr>
<th>HRC</th>
<th>1st order</th>
<th>2nd order</th>
</tr>
</thead>
<tbody>
<tr>
<td>65±5</td>
<td>0.10</td>
<td>0.17</td>
</tr>
<tr>
<td>46±5</td>
<td>0.18</td>
<td>0.30</td>
</tr>
<tr>
<td>25±5</td>
<td>0.22</td>
<td>0.37</td>
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The literature [1-3] shows that hardness standards are manufactured from carbon as well as from alloy steels.

Hardness specimens are made from carbon steels in Japan (U9A steel), USSR (U10A, U12A), the UK (U12A), and from alloy steel in the UK (KhVG steel), the German Democratic Republic (KhGS), the USA (KhG), and the USSR (KhVG, ShKh15SG, and others). Consequently, it may be assumed that SHS should be prepared from a carbon or an alloy steel. At all events, steel with a high carbon content is preferred.

Standard specimens of average and low hardness are produced by appropriately increasing the temperature of the anneal which follows quenching.

In order to examine hardness standards prepared from carbon steel, the U10A and USA steels were used. The U10A type was chosen since considerable experience on the manufacture of standards from it has already been accumulated at the Ivanovo ZIP, while the USA steel was selected on the grounds that a eutectoid steel contains no hypereutectoid cementite, which increases the phase composition by one phase on tempering at a low temperature, as was pointed out by Volkova and Smirnov [4].

On the alloy steels we settled for 9KhS, KhVG and ShKh15SG. The first two, belonging to the class of tool steels which deform slightly on quenching, were
taken as being close in composition to those used in foreign practice. The ball-bearing steel for large races, ShKh15SG [5], was chosen for the following reasons. Alloy tool steel has a tendency to dendritic and carbide liquation [6]. The manufacturers of ball-bearing steel have developed metallurgical techniques which reduce this liquation to a minimum [7]. The carefully timed metallurgical methods for enhancing the quality of steel—electroslag remelting [8], and refinement in a ladle with liquid synthetic slag [9]—are applied primarily to ball-bearing steel. Therefore we chose ShKh15SG which had undergone electroslag remelting.

Choice of Shape of Standard Hardness Specimens. GOST 9031-63 permits the manufacture of hardness standards of rectangular and circular form. In the UK, Poland, and the USSR rectangular standards are used; in the German Democratic Republic, and Japan, circular and, exceptionally, rectangular shapes are employed. In the German Democratic Republic triangular shapes are also encountered.

We decided that the standards should be of a circular shape with dimensions in accordance with GOST 9031-63. In order to eliminate dendritic liquation the metal was subjected to isotropic compression [1, 4, 6], which is more easily carried out on cylindrical billets. Furthermore, according to calculations due to Suvorov [10], 14.5% more indentations may be made on standards of circular form than on rectangular ones of equivalent area. For these reasons, the choice was made of cylindrical billets, and these were forged, after the first precipitation, by compression in dies for the case of the ShKh15SG steel and by free forging in the case of the remaining steels.

For final elimination of the zone of maximum liquation a hole of diameter 12 mm was drilled to the center of the billet.

Manufacture of the Specimens. The first operation in the treatment of all the steels was forging. It was used, on the one hand, in order to reveal flaws in the billets ("shaft flaws," airholes, cracks, and so on) and, on the other, for refinement of the macrostructure and densification of the metal, that is, for the production of more homogeneous specimens.

The forged specimens were subjected to heat treatment (annealing normalization, quenching, and tempering) according to a scheme established for each type of steel. The ShKh15SG steel with HRC hardness of 65 was treated according to the scheme shown in Fig. 1. The normalization of the billets was carried out in order to make the structure uniform (throughout the volume of a grain) and for relief of stresses. On tempering at a high temperature (630°) the lamellar pearlite was spheroidized, the hypereutectoid cementite network, the presence of which always leads to inhomogeneity with respect to hardness, being destroyed.

The billets were then cut and machined, but without the final operation of grinding.

After machining the specimens were quenched from 830° (by heating in a salt bath and cooling in kerosene) and received a low-temperature tempering (160°). The structure after tempering turns out to be fine and uniform (structure-free martensite-gardenite, only negligible traces of the carbide network being tolerated).

The last operation was grinding the working and reference surface of the specimens. The grinding was carried out using a few passes with the minimum feed in order to avoid "burns", which, as a rule, lead to inhomogeneity with respect to hardness on the surface of the specimens.

Certification of the SHS. Calibration of the SHS was carried out on a standard instrument of type TKO-2, σ1 the rms error of the calibration not exceeding 0.1 HRC units.

In accordance with GOST 9031-63 the quality of a standard is characterized by the homogeneity (or "spread") with respect to hardness of its working surface. In measuring the hardness, ten indentations were made in spiral form over the whole working surface of the standard. The rms error of the calibration measurements of the standards is shown in Table 1.

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>Percentage of standard specimens meeting requirements of GOST 9031-63</th>
<th>not meeting requirements of GOST 9031-63</th>
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</thead>
<tbody>
<tr>
<td>ShKh15SG and KhVG</td>
<td>1st order 35 81 14</td>
<td>2nd order 14 5</td>
</tr>
</tbody>
</table>