# International Standard 4957

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# Tool steels

*Aciers à outils*

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**Descriptors :** steels, tool steels, materials specifications, chemical composition, hardness, heat treatment, tests.

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## Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4957 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in April 1978.

It has been approved by the member bodies of the following countries :

| | | |
|---|---|---|
| Austria | Germany, F. R. | Netherlands |
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

United Kingdom
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# Tool steels

## 1 Scope and field of application

This International Standard covers the grades of wrought tool steels listed in tables 2, 4, 6 and 8, namely :

a) unalloyed cold-work tool steels (see table 2);

b) alloyed cold-work tool steels (see table 4);

c) alloyed hot-work tool steels (see table 6);

d) high-speed steels (see table 8).

If not otherwise stated in the following, this International Standard applies to all types of hot-rolled, forged or cold-drawn products which are supplied in one of the surface and heat-treatment conditions given in 3.3.

## 2 References

ISO/R 79, *Brinell hardness test for steel.*

ISO/R 80, *Rockwell hardness test (B and C scales) for steel.*

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.*

ISO/R 404, *General technical delivery requirements for steel.*

## 3 Requirements

### 3.1 Information to be supplied by the purchaser

**3.1.1** The purchaser shall state the following in his enquiry and order :

a) the product form, surface condition and the dimension (see 3.3.3 and 3.8);

b) the steel type (see tables 2, 4, 6 and 8) and its heat-treatment condition (see 3.3.2);

c) the requirement class (see table 1) and, if documentation is requested, the type of document (see 4.5);

d) the number of this International Standard.

### 3.2 Production process

Unless otherwise agreed in the order, the process used in making the steels and the product are left to the discretion of the manufacturer. When he so requests, the purchaser shall be informed what steelmaking process is being used.

### 3.3 Treatment and surface condition of delivery

**3.3.1** The treatment and surface condition of delivery shall be agreed upon between purchaser and manufacturer at the time of enquiry and order.

**3.3.2** The usual heat-treatment condition is the annealed condition. Individually manufactured blocks for moulds and dies are sometimes also delivered in the quenched and tempered condition.

**3.3.3** Usual surface conditions are :

— the hot-rolled or forged condition;

— the machined (ground, polished, turned, planed or milled) condition;

— the cold-reduced condition.

### 3.4 Requirement classes[1)]

The steels covered by this International Standard shall be ordered and delivered in accordance with one of the requirement classes given in table 1.

### 3.5 Chemical composition

**3.5.1** The chemical composition expressed by the cast analysis shall be in accordance with the corresponding requirements in tables 2, 4, 6 and 8.

1) In previous International Standards dealing with this subject, the term "type of condition of delivery" was used instead of "requirement class". It was replaced in order to avoid confusion with the term "delivery condition" which is often used for the treatment condition of the steel at the time of delivery.

**3.5.2** If ordered to the requirement classes 1 or 2 (see table 1), the permissible deviations given in tables 3, 5, 7 and 9, between the limiting values specified in tables 2, 4, 6 and 8 and the product analyses of products up to to 160 mm (6,3 in) diameter or equivalent dimensions, shall apply. If necessary the permissible deviations for products with larger dimensions shall be agreed at the time of enquiry and order.

**3.5.3** If ordered to requirement class 3 the minimum Rockwell C hardness values specified in tables 2, 4, 6 and 8 shall be the governing criteria for acceptance. In such cases, the cast analysis may deviate slightly from the values shown in tables 2, 4, 6 and 8.

### 3.6 Mechanical properties

**3.6.1** When ordering according to the requirement class 2 or 3 the maximum Brinell hardness values given in tables 2, 4, 6 and 8 apply for the delivery condition of steels having been ordered as annealed.

**3.6.2** When ordering according to the requirement class 3, the minimum Rockwell C hardness values given in tables 2, 4, 6 and 8 apply for hardening test pieces which were prepared in accordance with 4.2.3.

**3.6.3** In figures 1 to 4 the hardness-tempering temperature-curves of the steels are given for guidance.

NOTE — The hardness-tempering temperature-curve for a certain steel type can vary to a considerable extent depending on the chemical composition of the cast, the hardening conditions, and the tempering conditions. Consequently the curves in figures 1 to 4 which originate from data from different sources can at the time being only give a rough guide to the tempering behaviour of the steels. They are assumed to apply with the above reservations for test pieces which have been tempered at the relevant tempering temperatures but which in all other respects have been prepared according to the conditions for the hardening test (see 4.2.3). When applying the curves for an estimation of the hardness which can be expected in quenched and tempered tools, it should be taken into account that the optimum heat-treatment conditions for the tools are not necessarily identical with those specified for the test pieces and that especially the times for heating given in 4.2.3 are not valid for thicker tools.

### 3.7 Surface quality

**3.7.1** All products shall have a workmanlike finish and shall be clean and free from surface imperfections likely to have an adverse effect.

**3.7.2** Ground, polished or finish-machined products shall be free from surface imperfections and surface decarburization.

**3.7.3** Hot-rolled, forged, cold-drawn or rough-machined products shall be ordered with sufficient material to be removed from all surfaces by machining or grinding to allow for :

a) surface decarburization and

b) surface imperfections.

As long as no International Standard for the machining allowances of tool steels is available, the allowances shall be agreed at the time of enquiry and order.

### 3.8 Dimensions and tolerances

The dimensions and tolerances for tool steels shall be agreed at the time of enquiry and order so long as no special ISO standards for them are available.

## 4 Testing

### 4.1 Number of sample products

#### 4.1.1 Chemical composition

The cast analysis, if ordered, is given by the manufacturer. If a product analysis is required by the purchaser, and unless otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

#### 4.1.2 Mechanical properties

**4.1.2.1** For material supplied according to the requirement classes 2 or 3 of table 1 with a specified maximum Brinell hardness in the annealed condition :

One sample product shall be taken from each cast, from each heat-treatment batch and from each dimension. If there are only small differences in the thickness of the different dimensions (thickness ratio about $< 1{,}5$) the separation of the products in batches according to the dimensions may be omitted.

If the product is continuously heat treated, one sample product per lot, but at least one sample product for each cast and for each dimension with significant thickness difference, shall be taken.

**4.1.2.2** For material supplied according to the requirement class 3 of table 1 with a specified minimum Rockwell-C hardness of a reference test piece :

one sample product shall be taken per cast.

#### 4.1.3 Surface quality

If the purchaser requires the testing of the surface quality then the number of sample products to be taken shall be agreed at the time of enquiry and order.

### 4.2 Samples and test pieces

**4.2.1** For product analyses, the selection of samples shall be carried out in conformity with the requirements of ISO/R 377.

**4.2.2** For the Brinell hardness test the surface of the sample product or of a test piece taken from the sample product in the delivery condition shall be prepared in accordance with the requirements of ISO/R 79.

**4.2.3** For the hardening test one test piece shall be cut off from the sample product in accordance with the conditions indicated in figure 5.

The test pieces shall be hardened and tempered under the conditions given in tables 2, 4, 6 and 8 and under conditions which avoid decarburization. The total heating time of test pieces in a salt bath shall be as follows :

| Nature of steel | Total heating time for | |
|---|---|---|
| | hardening min | tempering min |
| Cold- or hot-work steels (tables 2, 4 and 6) | 25 ± 1 | 60 |
| High-speed steels (table 8) | 3 | 2 periods of 60 min each |

If the test pieces are not heated in a salt bath the heating time must be extended accordingly.

The cut surface shall be prepared in accordance with ISO/R 80 for the Rockwell C hardness test.

**4.2.4** If the purchaser requires the testing of the surface quality, the details for sampling and for the preparation of the test pieces shall be agreed at the time of enquiry and order.

**4.2.5** General conditions for selection and preparation of samples and test pieces for steel shall be in accordance with ISO/R 377.

### 4.3 Test methods

**4.3.1** In cases of dispute, the methods for the chemical analysis shall be those established by the relevant International Standard. If no International Standards are available, the methods may be agreed upon and specified at the time of enquiry and order.

**4.3.2** The Brinell hardness test shall be made in accordance with ISO/R 79.

**4.3.3** The Rockwell C hardness test shall be made in accordance with ISO/R 80.

**4.3.4** If the purchaser requires the testing of the surface quality the test method shall be agreed at the time of enquiry and order.

### 4.4 Retests

**4.4.1** For retests for the product analysis the relevant clause of ISO/R 404 is valid.

**4.4.2** For retests for mechanical properties the relevant clause of ISO/R 404 is valid.

### 4.5 Certification

For certification, the relevant section of ISO/R 404 is valid, acceptable documents being as follows :

- statement of compliance with the order, or
- report based on quality control, or
- works certificate, or
- test certificate, or
- certificate of acceptance.

## 5 Rectification, internal defects and reclaiming

The conditions given in ISO/R 404 are valid for :

- surface defects;
- rectification;
- internal defects;
- dimensional tolerances;
- reclaiming.

**Table 1 — Requirement classes**

| 1 | 2 | 3 | | |
|---|---|---|---|---|
| No. | Requirement | Requirement to be observed in the case of requirement class* | | |
| | | 1 | 2 | 3 |
| 1 | Chemical composition | X | X | X |
| 2 | Hardness | | | |
| 2a | — in the annealed condition | — | X | X |
| 2b | — of hardened and tempered test pieces | — | — | X |

* The requirement class numbers are provisional. They will be finally fixed as soon as the International Standard for a system of the numbers for the requirement classes has been established.

**Table 2 — Chemical composition (cast analysis), annealed hardness, temperature for hardening and hardness in the hardened and tempered condition for unalloyed cold-work tool steels**

| Type of steel | | Chemical composition[2] | | | | | Hardness (annealed) max. HB | Hardening test[4] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % max. | Mn % max. | P % max. | S % max | | Hardening temperature °C ± 10 | Quenching medium[3] | Tempering temperature °C ± 10 | Hardness min. HRC |
| 1 | TC 70 | 0,65 to 0,74 | 0,35 | 0,35 | 0,030 | 0,030 | 183 | 800 | W | 180 | 57 |
| 2 | TC 80 | 0,75 to 0,84 | 0,35 | 0,35 | 0,030 | 0,030 | 192 | 790 | W | 180 | 58 |
| 3 | TC 90 | 0,85 to 0,94 | 0,35 | 0,35 | 0,030 | 0,030 | 207 | 780 | W | 180 | 60 |
| 4 | TC 105 | 0,95 to 1,09 | 0,35 | 0,35 | 0,030 | 0,030 | 212 | 780 | W | 180 | 61 |
| 5 | TC 120 | 1,10 to 1,29 | 0,35 | 0,35 | 0,030 | 0,030 | 217 | 770 | W | 180 | 62 |
| 6 | TC 140 | 1,30 to 1,50 | 0,35 | 0,35 | 0,030 | 0,030 | 217 | 770 | W | 180 | 63 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) Elements not quoted in the above table shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition from scrap or other materials used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability. Contents of $\leqslant$ 0,20 % Cr, $\leqslant$ 0,25 % Cu, and $\leqslant$ 0,25 % Ni should, however, be regarded as being in conformity with the above requirement.

3) Quenching medium : W = Water.

4) See 4.2.3.

**Table 3 — Permissible deviations between specified analysis and product analyses for unalloyed cold-work steels**
(see table 2 and 3.5.2)

| Type of steel[1] | Permissible deviations[2] | | | | |
|---|---|---|---|---|---|
| | C % | Si % | Mn % | P % | S % |
| 1 to 6 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 |

1) The type numbers are tentative and will be subject to alteration when the relevant International Standards have been established.

2) The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified, the deviations are positive only. The values are valid only if the samples are selected in accordance with ISO/R 377, so that they represent the average composition of the cross-section of the product.

## Table 4 — Chemical composition (cast analysis), annealed hardness, temperature for hardening and hardness in the hardened and tempered condition for alloyed cold-work tool steels

| Type of steel | | Chemical composition[2] | | | | | | | | Hardness (annealed) max. HB | Hardening test[4] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % | Mn % | Cr % | Mo % | Ni % | V % | W % | | Hardening temperature °C ± 10 | Quenching medium[3] | Tempering temperature °C ± 10 | Hardness min. HRC |
| 10 | TCV 105 | 0,95 to 1,10 | ⩽ 0,35 | ⩽ 0,35 | – | – | – | 0,10 to 0,30 | – | 212 | 790 | W | 180 | 61 |
| 11 | 60 SiMn 2 | 0,52 to 0,60 | 1,50 to 2,00 | 0,60 to 0,90 | – | – | – | – | – | 248 | 855 | O | 180 | 55 |
| 12 | 51 CrMnV 1 | 0,48 to 0,55 | 0,10 to 0,40 | 0,70 to 1,00 | 0,90 to 1,20 | – | – | 0,05 to 0,25 | – | 241 | 865 | O | 180 | 55 |
| 13 | 45 WCrV 2 | 0,40 to 0,50 | 0,80 to 1,10 | 0,15 to 0,45 | 0,90 to 1,20 | – | – | 0,10 to 0,30 | 1,70 to 2,30 | 229 | 910 | O | 180 | 56 |
| 14 | 50 WCrV 2 | 0,45 to 0,55 | 0,80 to 1,10 | 0,35 to 0,65 | 1,30 to 1,60 | – | – | 0,10 to 0,30 | 1,70 to 2,30 | 229 | 920 | O | 180 | 57 |
| 15 | 60 WCrV 2 | 0,55 to 0,65 | 0,80 to 1,10 | 0,15 to 0,45 | 0,90 to 1,20 | – | – | 0,10 to 0,30 | 1,70 to 2,30 | 229 | 910 | O | 180 | 58 |
| 16 | 100 Cr 2 | 0,95 to 1,10 | 0,10 to 0,40 | 0,15 to 0,45 | 1,35 to 1,65 | – | – | – | – | 223 | 840 | O | 180 | 60 |
| 17 | 105 WCr 1 | 1,00 to 1,15 | 0,10 to 0,40 | 0,70 to 1,00 | 0,80 to 1,10 | – | – | – | 1,00 to 1,60 | 229 | 820 | O | 180 | 61 |
| 18 | 90 MnV 2 | 0,85 to 0,95 | 0,10 to 0,40 | 1,70 to 2,20 | – | – | – | 0,10 to 0,30 | – | 229 | 790 | O | 180 | 60 |
| 19 | 95 MnCrW 1 | 0,90 to 1,00 | 0,10 to 0,40 | 1,05 to 1,35 | 0,35 to 0,65 | – | – | 0,05 to 0,25 | 0,40 to 0,70 | 229 | 800 | O | 180 | 60 |
| 20 | 100 CrMoV 5 | 0,95 to 1,05 | 0,10 to 0,40 | 0,35 to 0,65 | 4,50 to 5,50 | 0,90 to 1,40 | – | 0,25 to 0,45 | – | 241 | 970 | A | 180 | 60 |
| 21 | 160 CrMoV 12 | 1,45 to 1,75 | 0,10 to 0,40 | 0,15 to 0,45 | 11,00 to 13,00 | 0,70 to 1,00 | – | 0,50 to 0,80 | – | 255 | 1 020 | A | 180 | 61 |
| 22 | 210 Cr 12 | 1,90 to 2,20 | 0,10 to 0,40 | 0,15 to 0,45 | 11,00 to 13,00 | – | – | – | – | 248 | 970 | O | 180 | 62 |
| 23 | 210 CrW 12 | 2,00 to 2,30 | 0,10 to 0,40 | 0,15 to 0,45 | 11,00 to 13,00 | – | – | – | 0,80 to 1,10 | 255 | 970 | O | 180 | 62 |
| 24 | 5 CrMo 4 | ⩽ 0,07 | 0,05 to 0,25 | 0,05 to 0,25 | 3,50 to 4,50 | 0,40 to 0,60 | – | – | – | 121 | 5) | 5) | 5) | 5) |
| 25 | 7 CrMoNi 2 | ⩽ 0,10 | 0,10 to 0,40 | 0,20 to 0,50 | 1,80 to 2,10 | 0,10 to 0,30 | 0,40 to 0,60 | – | – | 156 | 5) | 5) | 5) | 5) |
| 26 | 35 CrMo 2 | 0,30 to 0,40 | 0,30 to 0,80 | 0,50 to 1,50 | 1,50 to 2,20 | 0,40 to 0,60 | – | – | – | 6) | 6) | 6) | 6) | 6) |
| 27 | 20 Cr 13 | 0,16 to 0,25 | ⩽ 1,0 | ⩽ 1,0 | 12,00 to 14,00 | – | ⩽ 1,0 | – | – | 223 | 1 010 | O | 180 | 45 |
| 28 | 30 Cr 13 | 0,26 to 0,35 | ⩽ 1,0 | ⩽ 1,0 | 12,00 to 14,00 | – | ⩽ 1,0 | – | – | 235 | 1 010 | O | 180 | 49 |
| 29 | 40 Cr 13 | 0,36 to 0,45 | ⩽ 1,0 | ⩽ 1,0 | 12,50 to 14,50 | – | ⩽ 1,0 | – | – | 255 | 1 010 | O | 180 | 51 |
| 30 | 38 CrMo 15 | 0,33 to 0,43 | ⩽ 1,0 | ⩽ 1,0 | 15,00 to 17,00 | 1,00 to 1,50 | – | – | – | 285 | 1 010 | O | 180 | 46 |
| 31 | 110 CrMo 17 | 0,95 to 1,20 | ⩽ 1,0 | ⩽ 1,0 | 16,00 to 18,00 | 0,45 to 0,75 | – | – | – | 285 | 1 030 | O | 180 | 58 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) For all steels : Phosphorus ⩽ 0,030 % and Sulphur ⩽ 0,030 %.

3) Quenching medium : A = Air, O = Oil, W = Water.

4) See 4.2.3.

5) This steel is used in the carburized and heat-treated condition.

6) This steel is normally supplied in the pre-heat-treated condition with a hardness of approximately 300 HB.

**Table 5 — Permissible deviations between specified analysis and product analysis for alloyed cold-work steels**
(see table 4 and 3.5.2)

| Type of steel | | Permissible deviations[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % | Mn % | P % | S % | Cr % | Mo % | Ni % | V % | W % |
| 10 | TCV 105 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | – | – | ± 0,02 | – |
| 11 | 60 SiMn 2 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | – | – | – | – | – |
| 12 | 51 CrMnV 1 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | ± 0,02 | – |
| 13 | 45 WCrV 2 | ± 0,03 | ± 0,05 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | ± 0,02 | ± 0,07 |
| 14 | 50 WCrV 2 | ± 0,03 | ± 0,05 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | ± 0,02 | ± 0,07 |
| 15 | 60 WCrV 2 | ± 0,03 | ± 0,05 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | ± 0,02 | ± 0,07 |
| 16 | 100 Cr 2 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | – | – |
| 17 | 105 WCr 1 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | – | – | – | ± 0,05 |
| 18 | 90 MnV 2 | ± 0,03 | ± 0,03 | ± 0,08 | + 0,005 | + 0,005 | – | – | – | ± 0,02 | – |
| 19 | 95 MnCrW 1 | ± 0,03 | ± 0,03 | ± 0,06 | + 0,005 | + 0,005 | ± 0,05 | – | – | ± 0,02 | ± 0,04 |
| 20 | 100 CrMoV 5 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,05 | – | ± 0,03 | – |
| 21 | 160 CrMoV 12 | ± 0,04 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,15 | ± 0,05 | – | ± 0,04 | – |
| 22 | 210 Cr 12 | ± 0,05 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,15 | – | – | – | – |
| 23 | 210 CrW 12 | ± 0,05 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,15 | – | – | – | ± 0,05 |
| 24 | 5 CrMo 4 | + 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,05 | – | – | – |
| 25 | 7 CrMoNi 2 | + 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,07 | ± 0,03 | ± 0,03 | – | – |
| 26 | 35 CrMo 2 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,07 | ± 0,05 | – | – | – |
| 27 | 20 Cr 13 | ± 0,03 | + 0,05 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | – | + 0,03 | – | – |
| 28 | 30 Cr 13 | ± 0,03 | + 0,05 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | – | + 0,03 | – | – |
| 29 | 40 Cr 13 | ± 0,03 | + 0,05 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | – | + 0,03 | – | – |
| 30 | 38 CrMo 15 | ± 0,03 | + 0,05 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | ± 0,05 | – | – | – |
| 31 | 110 CrMo 17 | ± 0,03 | + 0,05 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | ± 0,05 | – | – | – |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been

## Table 6 — Chemical composition (cast analysis), annealed hardness, temperature for hardening, and hardness in the quenched and tempered condition for hot-work tool steels

| Type of steel | | Chemical composition[2] | | | | | | | | Hardness (annealed) max. HB | Hardening test[4] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % | Mn % | Cr % | Mo % | Ni % | V % | W % | | Hardening temperature °C ± 10 | Quenching medium[3] | Tempering temperature °C ± 10 | Hardness min. HRC |
| H 1 | 40 NiCrMoV 4 | 0,35 to 0,45 | 0,10 to 0,40 | 0,35 to 0,65 | 1,70 to 2,00 | 0,40 to 0,60 | 3,60 to 4,10 | 0,05 to 0,25 | – | 277 | 850 | O | 500 | 40 |
| H 2 | 55 NiCrMoV 2 | 0,50 to 0,60 | 0,10 to 0,40 | 0,65 to 0,95 | 0,95 to 1,25 | 0,30 to 0,50 | 1,50 to 2,00 | 0,05 to 0,25 | – | 248 | 850 | O | 500 | 42 |
| H 3 | 35 CrMo 2 | 0,30 to 0,40 | 0,30 to 0,80 | 0,50 to 1,50 | 1,50 to 2,20 | 0,40 to 0,60 | – | – | – | 5) | 5) | 5) | 5) | 5) |
| H 4 | 30 CrMoV 3 | 0,25 to 0,35 | 0,10 to 0,40 | 0,15 to 0,45 | 2,50 to 3,50 | 2,50 to 3,00 | – | 0,40 to 0,70 | – | 229 | 1 040 | O | 550 | 46 |
| H 5 | 35 CrMoV 5 | 0,32 to 0,42 | 0,90 to 1,20 | 0,25 to 0,55 | 4,50 to 5,50 | 1,20 to 1,70 | – | 0,30 to 0,50 | – | 229 | 1 020 | O | 550 | 48 |
| H 6 | 40 CrMoV 5 | 0,35 to 0,45 | 0,90 to 1,20 | 0,25 to 0,55 | 4,50 to 5,50 | 1,20 to 1,70 | – | 0,85 to 1,15 | – | 229 | 1 020 | O | 550 | 48 |
| H 7 | 30 WCrV 5 | 0,25 to 0,35 | 0,10 to 0,40 | 0,15 to 0,45 | 2,00 to 3,00 | – | – | 0,40 to 0,70 | 4,50 to 5,10 | 235 | 1 060 | O | 600 | 46 |
| H 8 | 30 WCrV 9 | 0,25 to 0,35 | 0,10 to 0,40 | 0,15 to 0,45 | 2,50 to 3,50 | – | – | 0,30 to 0,50 | 8,50 to 9,50 | 241 | 1 150 | O | 600 | 48 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) For all steels : Phosphorus ⩽ 0,030 % and Sulphur ⩽ 0,030 %.

3) Quenching medium : O = Oil.

4) See 4.2.3.

5) This steel is normally supplied in the pre-heat treated condition with a hardness of approximately 300 HB.

## Table 7 — Permissible deviations between specified analysis and product analysis for hot-work steels

(see table 6 and 3.5.2)

| Type of steel | | Permissible deviations[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % | Mn % | P % | S % | Cr % | Mo % | Ni % | V % | W % |
| H 1 | 40 NiCrMoV 4 | ± 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | ± 0,04 | ± 0,07 | ± 0,02 | – |
| H 2 | 55 NiCrMoV 2 | ± 0,03 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,05 | ± 0,04 | ± 0,07 | ± 0,02 | – |
| H 3 | 35 CrMo 2 | ± 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,07 | ± 0,05 | – | – | – |
| H 4 | 30 NiCrMoV 2 | ± 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | – | ± 0,04 | – |
| H 5 | 35 CrMoV 5 | ± 0,02 | ± 0,05 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,05 | – | ± 0,04 | – |
| H 6 | 40 CrMoV 5 | ± 0,02 | ± 0,05 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,05 | – | ± 0,05 | – |
| H 7 | 30 WCrV 5 | ± 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | – | – | ± 0,04 | ± 0,10 |
| H 8 | 30 WCrV 9 | ± 0,02 | ± 0,03 | ± 0,04 | + 0,005 | + 0,005 | ± 0,10 | – | – | ± 0,04 | ± 0,10 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified the deviations are positive only. The values are valid only if the samples are selected in accordance with ISO/R 377, so that they represent the average composition of the cross-section of the product.

**Table 8 — Chemical composition (cast analysis), annealed hardness, temperature for hardening and hardness in the hardened and tempered condition for high-speed steels**

| Type of steel | | | Chemical composition[3] | | | | | | Hardness (annealed) max. HB | Hardening test[6] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | No.[1] | Designation[1][2] | C % | Co %[4] | Cr % | Mo %[4] | V % | W % | | Hardening temperature °C ± 10 | Quenching medium[5] | Tempering temperature °C ± 10 | Hardness min. HRC |
| Basic types | S 1 | HS 18-0-1 | 0,73 to 0,83 | – | 3,50 to 4,50 | – | 0,90 to 1,20 | 17,2 to 18,7 | 269 | 1 260 | O | 560 | 63 |
| | S 2 | HS 2-9-2 | 0,95 to 1,05 | – | 3,50 to 4,50 | 8,20 to 9,20 | 1,70 to 2,20 | 1,50 to 2,10 | 255 | 1 200 | O | 560 | 64 |
| | S 3 | HS 1-8-1 | 0,77 to 0,87 | – | 3,50 to 4,50 | 8,00 to 9,00 | 0,90 to 1,40 | 1,40 to 2,00 | 255 | 1 210 | O | 560 | 63 |
| | S 4 | HS 6-5-2 | 0,82 to 0,92 | – | 3,50 to 4,50 | 4,60 to 5,30 | 1,70 to 2,20 | 5,70 to 6,70 | 255 | 1 220 | O | 560 | 64 |
| Increased C + V-content | S 5 | HS 6-5-3 | 1,15 to 1,30 | – | 3,50 to 4,50 | 4,60 to 5,30 | 2,70 to 3,20 | 5,70 to 6,70 | 269 | 1 210 | O | 560 | 65 |
| With Co-content | S 6 | HS 18-0-1-10 | 0,75 to 0,85 | 9,50 to 10,5 | 3,50 to 4,50 | – | 1,30 to 1,80 | 17,2 to 18,7 | 293 | 1 280 | O | 560 | 64 |
| | S 7 | HS 18-1-1-5 | 0,75 to 0,85 | 4,70 to 5,20 | 3,50 to 4,50 | 0,70 to 1,00 | 1,10 to 1,60 | 17,2 to 18,7 | 277 | 1 270 | O | 560 | 64 |
| | S 8 | HS 6-5-2-5 | 0,85 to 0,95 | 4,70 to 5,20 | 3,50 to 4,50 | 4,60 to 5,30 | 1,70 to 2,20 | 5,70 to 6,70 | 269 | 1 230 | O | 560 | 64 |
| Increased C + V-content + Co | S 9 | HS 12-1-5-5 | 1,45 to 1,60 | 4,70 to 5,20 | 3,50 to 4,50 | 0,70 to 1,00 | 4,75 to 5,55 | 11,5 to 13,0 | 293 | 1 240 | O | 560 | 65 |
| | S 10 | HS 10-4-3-10 | 1,20 to 1,35 | 9,50 to 10,5 | 3,50 to 4,50 | 3,20 to 3,90 | 3,00 to 3,50 | 9,00 to 10,0 | 293 | 1 230 | O | 560 | 66 |
| Increased C-content + Co | S 11 | HS 2-9-1-8 | 1,05 to 1,20 | 7,50 to 8,50 | 3,50 to 4,50 | 9,00 to 10,0 | 0,90 to 1,40 | 1,30 to 1,90 | 277 | 1 190 | O | 530 | 66 |
| | S12 | HS 7-4-2-5 | 1,05 to 1,20 | 4,70 to 5,20 | 3,50 to 4,50 | 3,50 to 4,20 | 1,70 to 2,20 | 6,40 to 7,40 | 277 | 1 200 | O | 540 | 66 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) Successively W-Mo-V-Co.

3) For all steels : Silicon ⩽ 0,50 %, Manganese ⩽ 0,40 %, Phosphorus ⩽ 0,030 %, and Sulphur ⩽ 0,030 %.

4) A dash in these columns indicates that these alloying elements should not be intentionally added to the heat and, that in the case of cobalt, the content of the cast should not exceed 1,00 % and, in the case of molybdenum, it should not exceed 0,70 %.

5) Quenching medium : O = Oil.

6) See 4.2.3.

**Table 9 — Permissible deviations between specified analysis and product analysis for high-speed steels**
(see table 8 and 3.5.2)

| Type of steel | | Permissible deviations[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No.[1] | Designation[1] | C % | Si % | Mn % | P % | S % | Co % | Cr % | Mo % | V % | W % |
| S 1 | HS 18-0-1 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | ± 0,10 | – | ± 0,05 | ± 0,20 |
| S 2 | HS 2-9-2 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | ± 0,10 | ± 0,10 | ± 0,07 | ± 0,07 |
| S 3 | HS 1-8-1 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | ± 0,10 | ± 0,10 | ± 0,05 | ± 0,05 |
| S 4 | HS 6-5-2 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | ± 0,10 | ± 0,10 | ± 0,07 | ± 0,10 |
| S 5 | HS 6-5-3 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | – | ± 0,10 | ± 0,10 | ± 0,10 | ± 0,10 |
| S 6 | HS 18-0-1-10 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | ± 0,10 | – | ± 0,05 | ± 0,20 |
| S 7 | HS 18-1-1-5 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | ± 0,05 | ± 0,05 | ± 0,20 |
| S 8 | HS 6-5-2-5 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | ± 0,10 | ± 0,07 | ± 0,10 |
| S 9 | HS 12-1-5-5 | ± 0,04 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | ± 0,05 | ± 0,10 | ± 0,15 |
| S 10 | HS 10-4-3-10 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,15 | ± 0,10 | ± 0,10 | ± 0,10 | ± 0,10 |
| S 11 | HS 2-9-1-8 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | ± 0,10 | ± 0,05 | ± 0,05 |
| S 12 | HS 7-4-2-5 | ± 0,03 | + 0,03 | + 0,04 | + 0,005 | + 0,005 | ± 0,10 | ± 0,10 | ± 0,10 | ± 0,07 | ± 0,10 |

1) The type numbers and designations are tentative and will be subject to alteration when the relevant International Standards have been established.

2) The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified the deviations are positive only. The values are valid only if the samples are selected in accordance with ISO/R 377, so that they represent the average composition of the cross-section of the product.

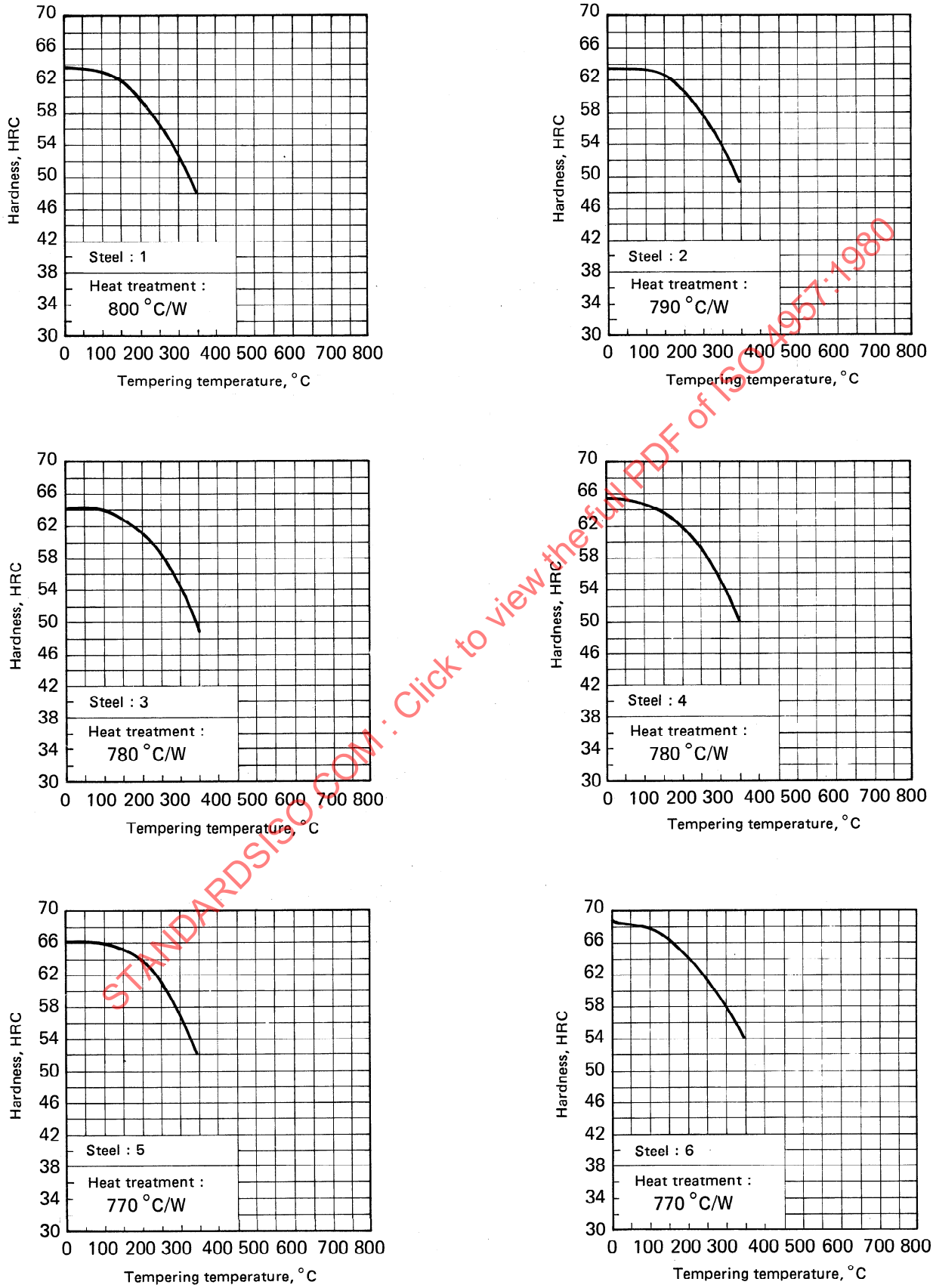
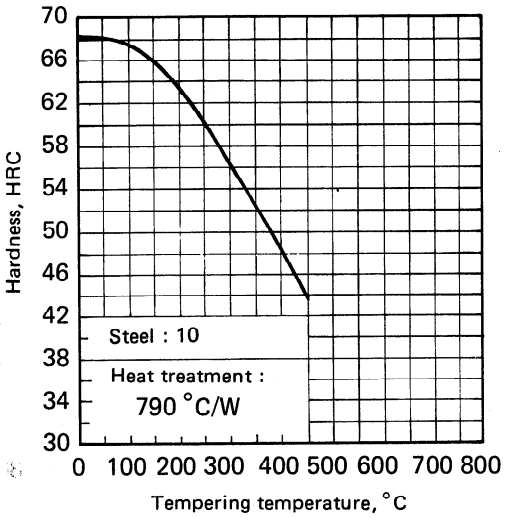
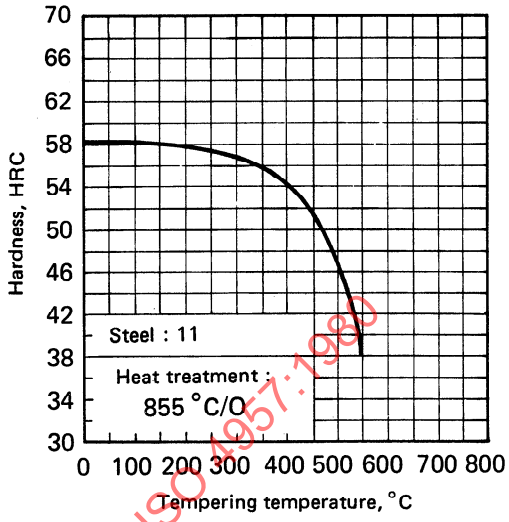
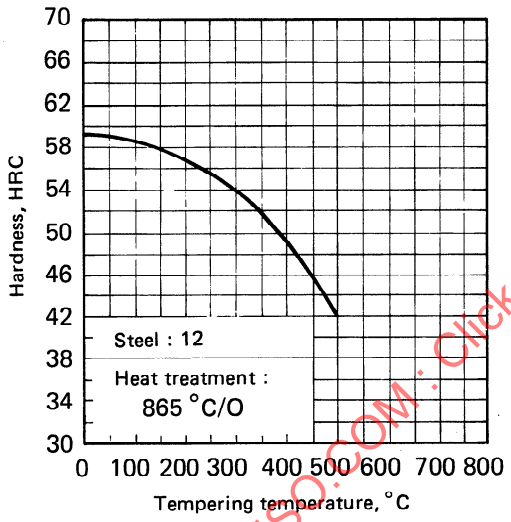
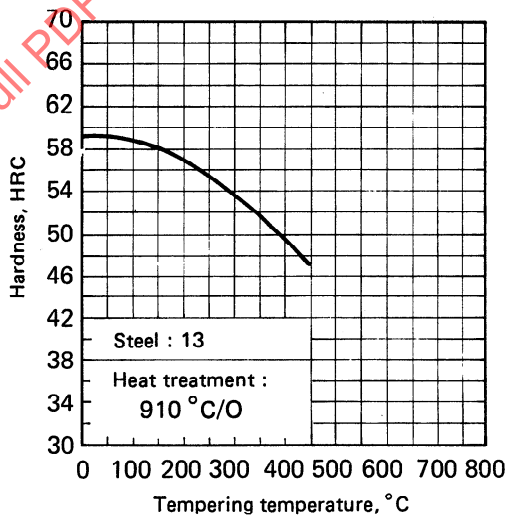


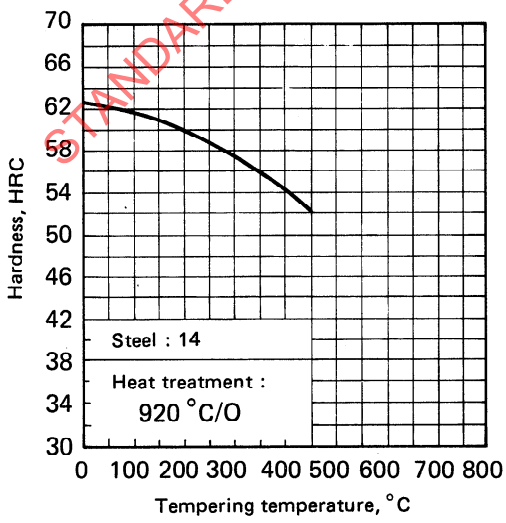

**Figure 1 — Hardness-tempering temperature-curves for unalloyed cold-work tool steels**
(see table 2 and 3.6.3)



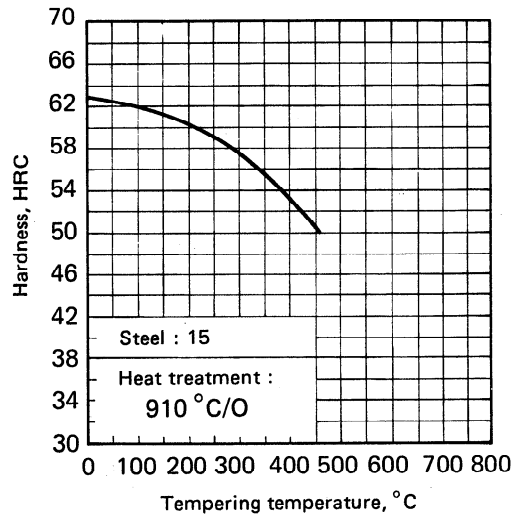






**Figure 2a — Hardness-tempering temperature-curves for alloyed cold-work tool steels**
(see table 4 and 3.6.3)

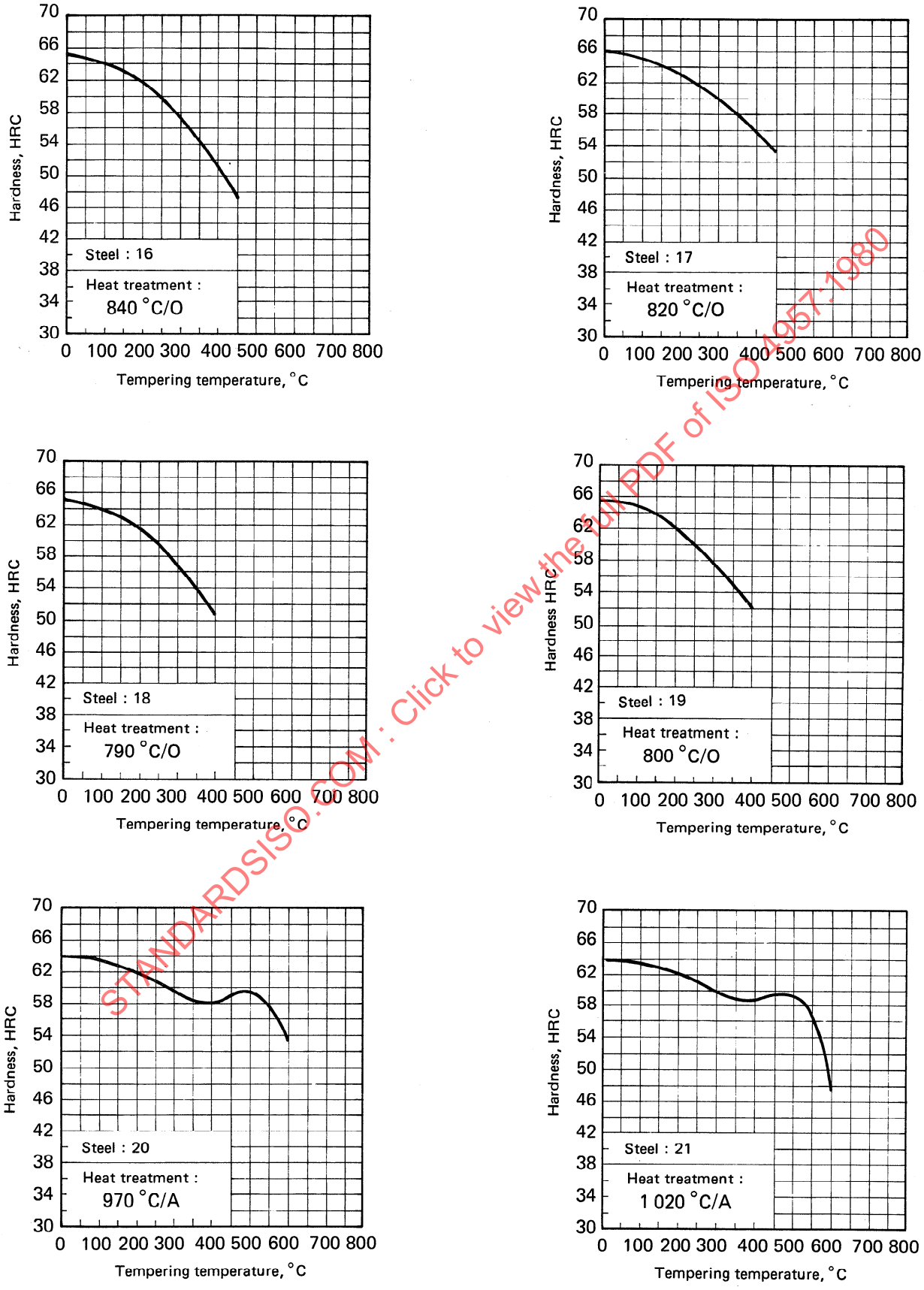



**Figure 2b — Hardness-tempering temperature-curves for alloyed cold-work tool steels**
(see table 4 and 3.6.3)

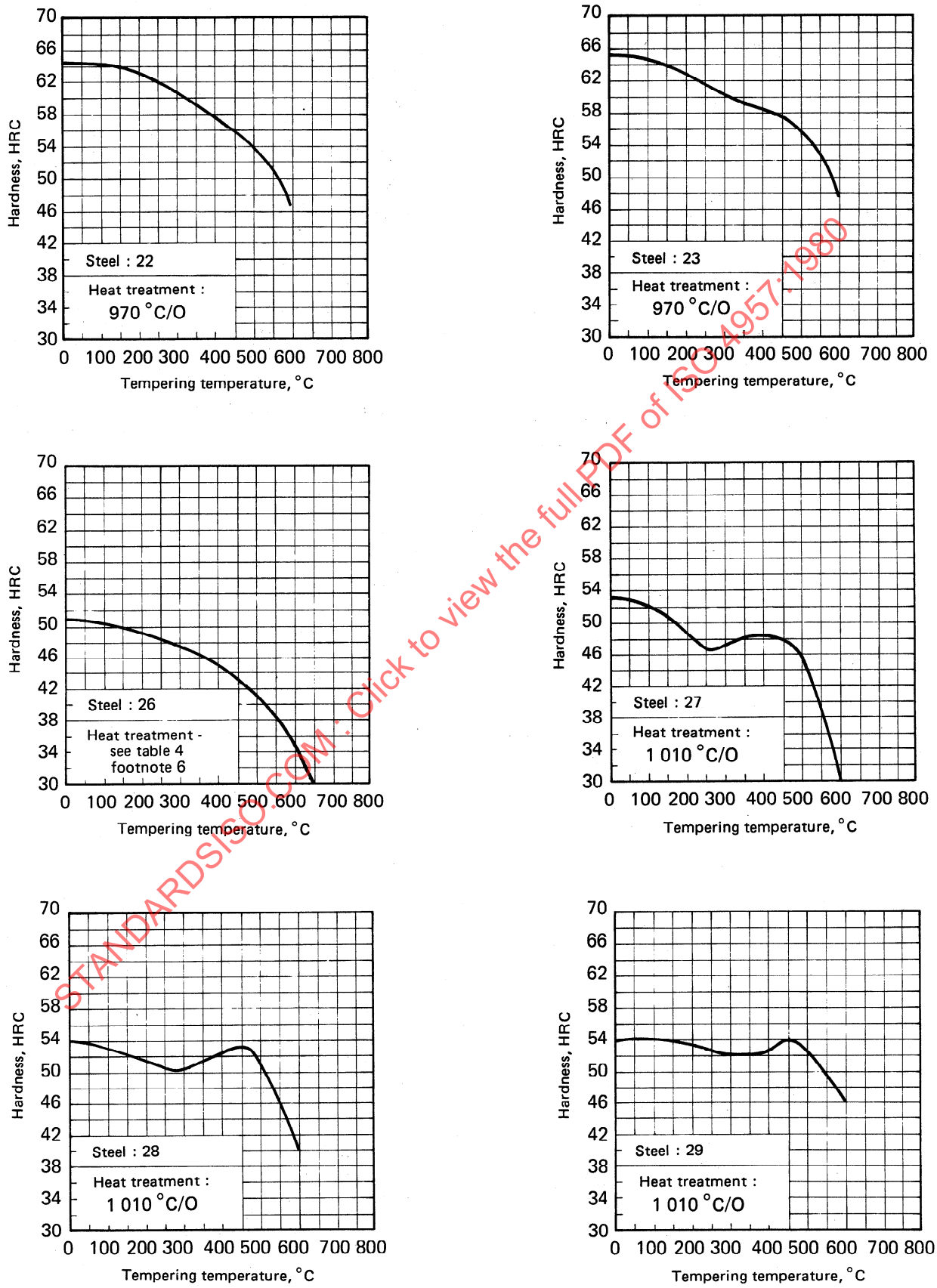



**Figure 2c — Hardness-tempering temperature-curves for alloyed cold-work tool steels**
(see table 4 and 3.6.3)

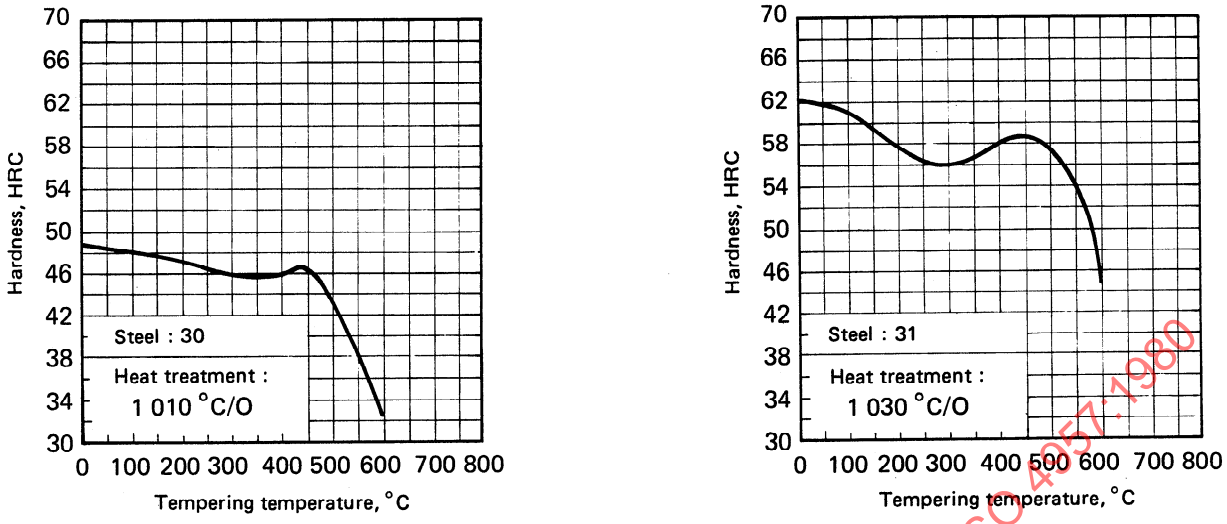



**Figure 2d — Hardness-tempering temperature-curves for alloyed cold-work steels**
(see table 4 and 3.6.3)

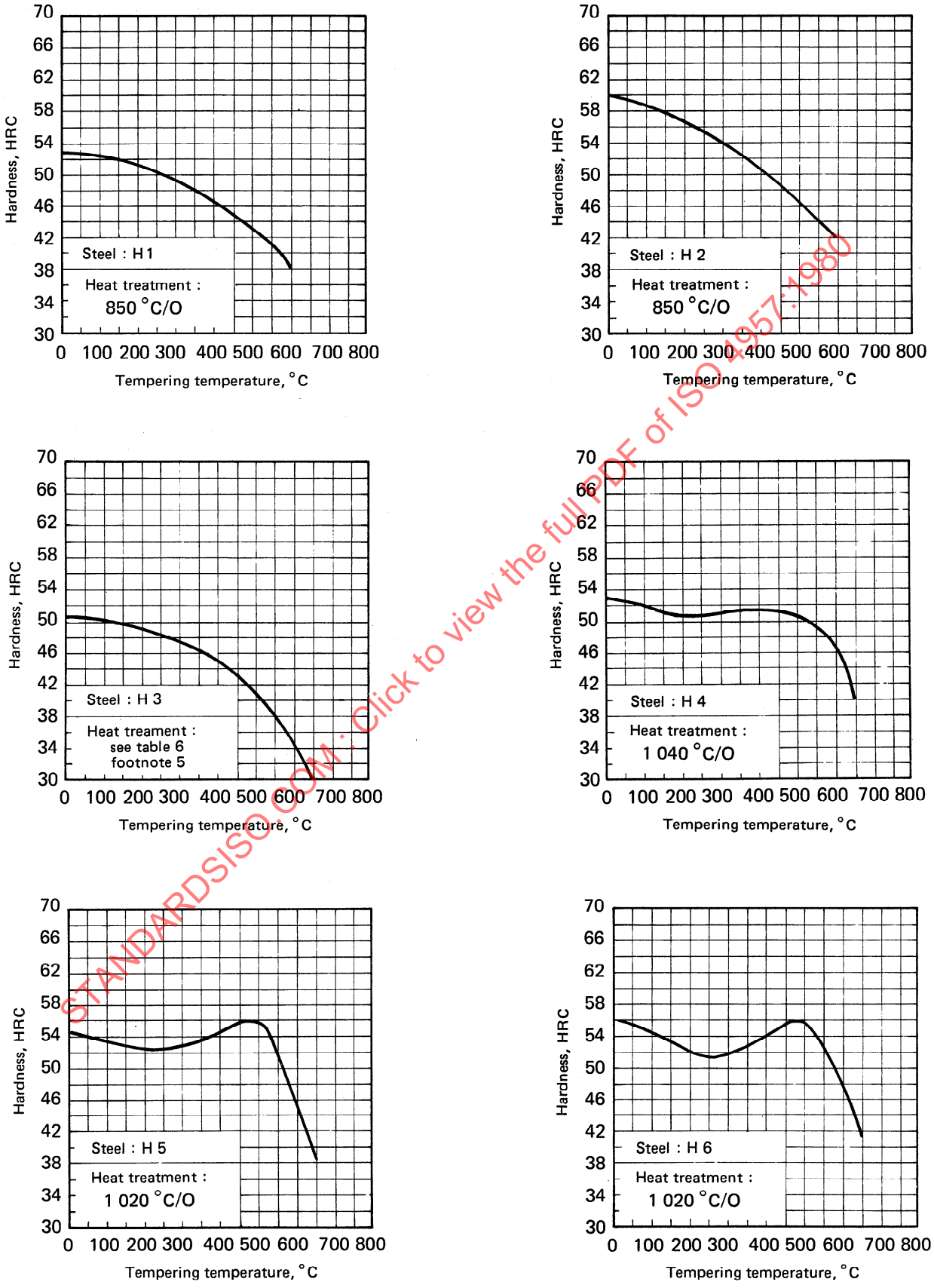



**Figure 3a — Hardness-tempering temperature-curves for hot-work tool steels**
(see table 6 and 3.6.3)

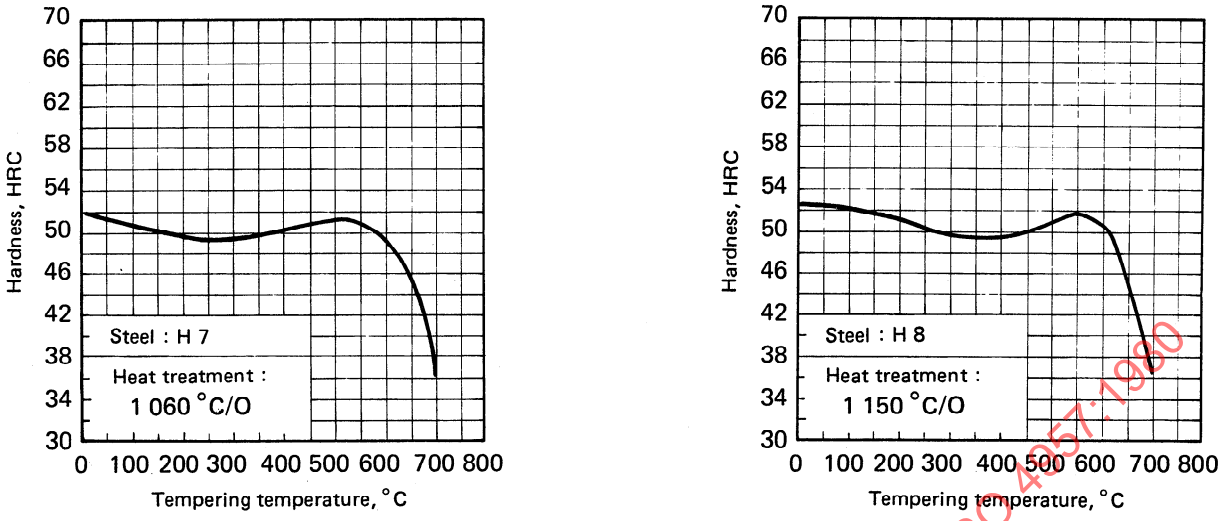



**Figure 3b — Hardness-tempering temperature-curves for hot-work tool steels**
(see table 6 and 3.6.3)

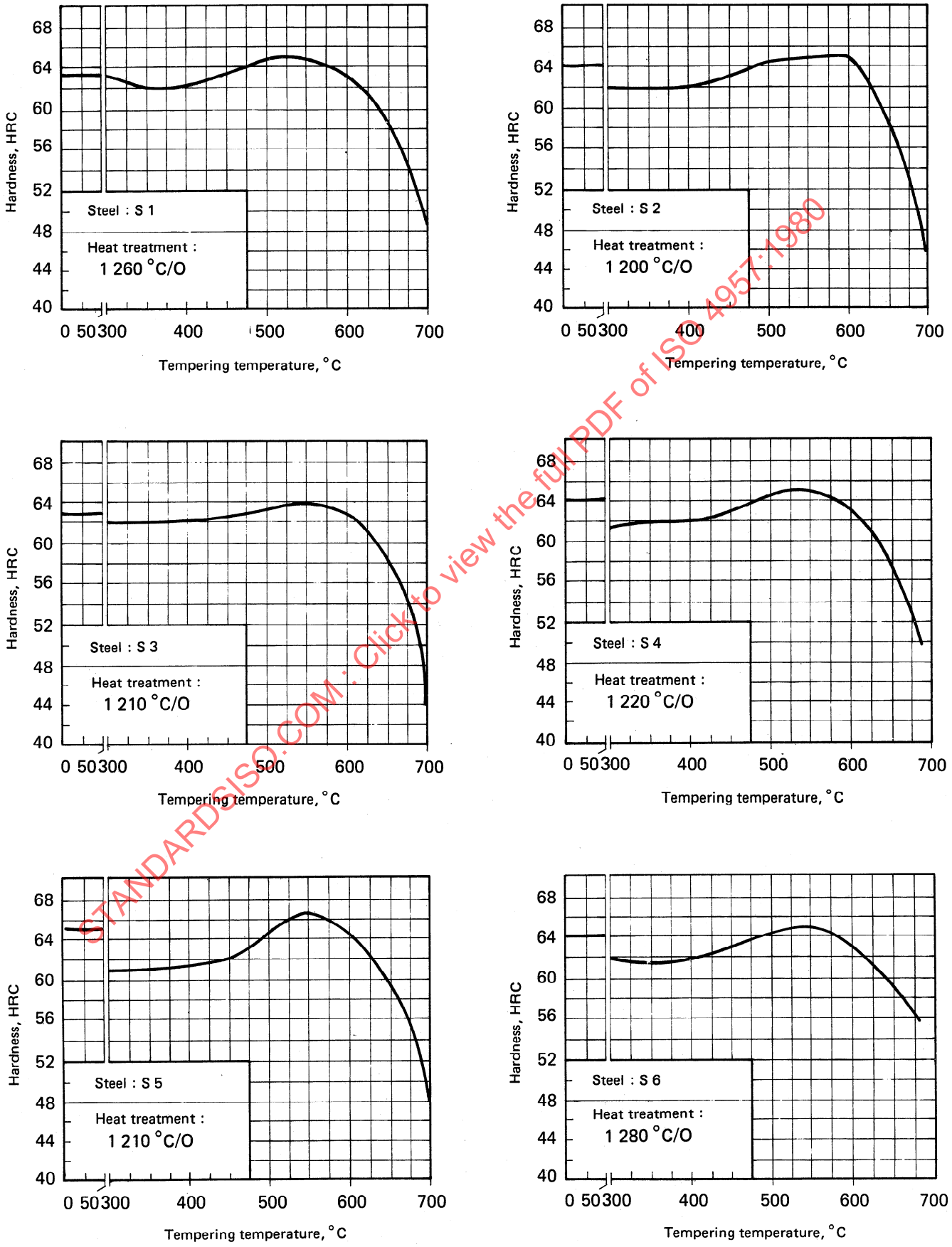





**Figure 4a — Hardness-tempering temperature-curves for high-speed steels**
(see table 8 and 3.6.3)