UDC 669.141.25.018.44:669.15-194.57:620.1 December 1987

# Ferritic steel castings with elevated temperature properties

Technical delivery conditions

DIN 17 245

Warmfester ferritischer Stahlguß; technische Lieferbedingungen

Supersedes October 1977 edition.

*In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.*

See Explanatory notes for connection with International Draft Proposal ISO/DP 4991 published by the International Organization for Standardization (ISO).

The clauses and subclauses marked • give specifications which are to be agreed upon at the time of ordering, those marked •• give specifications which are optional and may be agreed upon at the time of ordering.

When selecting the severity level for steel castings, the specifications of this standard shall be supplemented by any other relevant specifications (e.g. for parts of steam boilers which are to comply with the *Technische Regeln für Dampfkessel* (Codes of practice for steam boilers) issued by the *Deutscher Dampfkesselausschuß* (German Steam Boiler Committee)).

## 1 Field of application

1.1 This standard specifies technical delivery conditions for castings made from ferritic steels with elevated temperature properties as listed in table 1.

1.2 Unless otherwise specified in this standard, the general specifications for steel castings given in DIN 1690 Parts 1 and 2 shall apply in addition to those specified here.

## 2 Concept

Steel castings with elevated temperature properties as defined in this standard are steel castings exhibiting a specific strength at elevated temperature.

## 3 Designation

3.1 The symbols identifying the cast steel grades are based on the relevant specifications given in the explanatory notes to *DIN-Normenheft* (DIN Standardization Booklet) No. 3, the material numbers being formed according to the specifications of DIN 17 007 Part 2.

3.2 In addition to the symbol or material number, the designation for order purposes shall give the name of the product (steel casting), the number of this standard and, where required, the symbol identifying the condition of the material on delivery (see subclause 5.2.1), as shown in the example below.

Example:

A casting made from a steel grade identified by symbol GS-C 25 (material number 1.0619), in the normalized condition (N), shall be designated:

Steel casting DIN 17 245 — GS-C 25 N

or

Steel casting DIN 17 245 — 1.0619 N

## 4 Steel grades

Cast steel is classified according to its chemical composition into grades (see table 1). Castings may be made to different severity levels (see DIN 1690 Part 2).

## 5 Requirements

### 5.1 Manufacturing process

Cast steel shall be produced either in the electric furnace, by the basic-oxygen process or by an equivalent recognized process.

•• On request, the purchaser or his representative shall be informed on the steelmaking process used.

### 5.2 Condition of material on delivery

5.2.1 •• Castings made from steel grades complying with this standard shall be supplied in the quenched and tempered condition. The manufacturer shall decide whether quenching and tempering is to take place in air or in oil, his decision being based on steel grade, shape and wall thickness of the casting. In the case of castings intended for use at temperatures where high-temperature strength for prolonged periods is not a design feature, higher impact values may be agreed (cf. table 3, footnote 2), these being obtained by rapid cooling, starting from the austenitizing temperature.

If castings made from GS-C 25 steel are to be supplied in the normalized condition, this shall be indicated by symbol N (see subclause 5.2.2 and appendix A, footnote 4).

5.2.2 •• If castings are to be supplied in the preworked condition, the purchaser may stipulate a stress-relieving treatment. Additional stress relieving, however, is not required if, after preworking, the castings are quenched and tempered or production-welded, followed by heating and cooling from tempering temperature, or annealing temperature after production welding, down to 300 °C at a rate of less than 25 K/h.

Continued on pages 2 to 16

### 5.3 Chemical composition

5.3.1 The chemical composition of cast steel as determined by the cast analysis shall comply with the specifications given in table 1.

5.3.2 If a check analysis of the chemical composition is made on a cast-on test piece, the limit deviations given in table 2 from the limiting values specified for the cast analysis in table 1 shall not be exceeded.

5.3.3 •• If a check analysis of the chemical composition is made for the casting itself and not for the cast-on test piece, deviations exceeding those specified in table 2 are permitted unless this would result in the performance characteristics and weldability of the castings being significantly impaired. The limit deviations may be agreed at the time of ordering, as appropriate.

5.3.4 The purchaser or his representative shall be informed on the chemical composition of the cast.

### 5.4 Mechanical properties

5.4.1 The values of mechanical properties listed in table 3 shall apply for specimens taken from test pieces, up to 150 mm thick, in their as delivered condition.

5.4.2 The minimum values of 0,2 % proof stress and tensile strength as given in table 3 shall also apply to castings.

The other characteristic values given in table 3, except those for the elongation after fracture, shall also apply for castings with a maximum relevant wall thickness of 100 mm, for those parts of the casting for which this relevant thickness applies. If verification of the 0,2% proof stress and tensile strength at ambient temperature has been agreed for castings of greater wall thickness and further characteristic properties are to be determined by the tensile test, limits may be agreed for these properties.

5.4.3 Appendix A of this standard gives guideline values for long-term creep and stress-rupture properties of various steel grades, the values listed in table A.1 representing average values of scatter as determined to date. These values will be reviewed from time to time on the basis of the test results, and amended where necessary.

The fact that values of long-term properties have been given in appendix A for elevated temperatures do not signify that the cast steel grades can actually be subjected to these temperatures in service, the limitations in their use being governed by the overall stresses during operation and, in particular, by the scaling conditions.

### 5.5 Physical properties

5.5.1 The modulus of elasticity of cast steel is a function of the temperature, guideline values being given in table 4.

5.5.2 Table 5 gives guideline values for the coefficient of linear thermal expansion of cast steel.

### 5.6 Quality of castings and severity levels

5.6.1 DIN 1690 Part 2 shall apply for the quality of castings subject to the following.

5.6.2 The weld ends (i.e. nozzle-type ends projecting from the casting and intended to be welded to other parts) shall be made to severity level S1-V1 (as specified in DIN 1690 Part 2) over a depth of 1,5 times the wall thickness, but not more than 40 mm, and to severity level S2-V2 over a length of 1,5 times the wall thickness, but not more than 30 mm.

Note. By way of an alternative, the specifications of DIN 3840 may be applied to valve body materials.

5.6.3 •• The severity levels for other areas of the casting shall be agreed; in the absence of such an agreement, severity level 4 shall be considered as being ordered.

Note. Supplementary to the specifications of subclause 5.6.2 it may be agreed that severity level S1-V1 shall apply only for specific sections of castings, e.g. for fabrication-welded areas on internal walls subject to pressure or for surfaces intended for further machining (see subclause 2.2.3 of DIN 1690 Part 2, June 1985 edition).

The requirements of severity level 5 for castings covered in this standard shall be reserved for special applications.

5.6.4 •• The manufacturer shall decide on the measures necessary to ensure compliance with the requirements regarding the severity levels specified in DIN 1690 Part 2.

The quality of the casting is a function of its design which should be consistent with casting practice and permit easy inspection, thus ensuring compliance with the requirements specified in DIN 1690 Part 2 for the severity level ordered. If, for particular reasons, this principle cannot be followed, the problems involved shall be discussed between manufacturer and purchaser.

### 5.7 Welding and condition of casting after welding

5.7.1 The following shall apply for production-welds, supplementary to the general specifications given in DIN 1690 Part 1.

5.7.1.1 The welding filler metals to be used shall be agreed between the purchaser and the manufacturer, taking into account the details given in table 6.

5.7.1.2 The specifications of table 6 shall apply for preheating and interpass welding temperatures.

5.7.1.3 •• Unless otherwise agreed in exceptional cases, such as for thick-wall castings made of G-X 22 CrMoV 12 1 or G-X 8 CrNi 12 steel, production-welds shall be made after heat treatment, in which case the castings shall be heated to temperatures given in the last column of table 6 for postweld treatment.

Such treatment may be dispensed with for GS-C 25 castings with small weld areas (see subclause 5.7.1.6) subject to agreement with the purchaser (see appendix B).

5.7.1.4 Production-welds shall be ground smooth prior to or after heat treatment, depending on the chemical composition, the steel grade and the welding process.

5.7.1.5 Production-welds shall be subjected to non-destructive testing in accordance with the severity level specified for the casting section concerned.

5.7.1.6 •• Unless otherwise agreed, large production-welded areas shall be identified on an approximately true-to-scale drawing of the casting or shown on a photo, unless the casting is to be subjected to a complete post-weld heat treatment (quenching and tempering as specified in table 7 or normalizing in the case of GS-C 25 N steel).

For the purposes of this standard, a large production-welded area is any area prepared for production welding, the depth of which exceeds 40 % of the wall thickness or the following values:

for severity levels S01-V1, S1-V1 and S2-V2: 25 mm;

for severity level S3-V3: 40 mm;

for severity level S4-V4: 60 mm.

Note. If combination of severity levels has been agreed, the higher, i.e. numerically lower, severity level shall be the one considered.

5.7.2 • The specifications given in subclause 5.7.1 shall apply, by analogy, for fabrication welds (see footnote 5 to table 6), additional requirements regarding the weld quality being subject to agreement at the time of ordering.

## 6 Testing

### 6.1 Certificates

6.1.1 •• It may be agreed at the time of ordering that one of the materials testing certificates specified in DIN 50 049 be issued, taking into account the information given in subclauses 6.1.2 to 6.1.4.

6.1.2 Normally, castings made from steel grades as specified in this standard are to be supplied together with a DIN 50 049 materials testing certificate, except for a certificate of compliance with the order (certificate DIN 50 049 – 2.1).

6.1.3 In compliance with DIN 1690 Parts 1 and 2, consignments of castings accompanied by a test report (certificate DIN 50 049 – 2.2) are only permitted for castings for which severity level 4 or 5 has been specified and where non-destructive testing has not been agreed.

6.1.4 Consignments of castings complying with the requirements of this standard may, on demand, be accompanied by

a) a manufacturer's test certificate (certificate DIN 50 049 – 2.3),

b) an inspection certificate (certificate DIN 50 049 – 3.1 A, 3.1 B or 3.1 C) or

c) an inspection report (certificate DIN 50 049 – 3.2 A or 3.2 C)

which will involve testing as described in subclause 6.2.

Where the issuing of a DIN 50 049 – 3.1 A, 3.1 C, 3.2 A or 3.2 C certificate has been agreed at the time of ordering, the address of the inspector or of the body carrying out acceptance inspection shall be given in the order.

The above certificates shall specify:

a) the results of cast analysis as determined by the manufacturer for all the elements listed in table 1 for the steel grade concerned;

b) the results of tensile test(s) carried out at ambient temperature;

c) the results of impact tests;

d) the results of non-destructive testing if severity levels S01-V1, S1-V1, S2-V2 or S3-V3 (or combinations) have been ordered;

e) the results of any additional tests agreed;

f) the marking, if marking of the castings has been agreed;

g) the inspector's stamp if an inspection certificate or inspection report has been agreed.

### 6.2 Tests on the castings supplied

#### 6.2.1 General

If it has been agreed at the time of ordering that one of the certificates as specified in subclause 6.1.4 be issued, tests in accordance with the details given in DIN 1690 Part 1 (and DIN 1690 Part 2 for non-destructive testing) shall be carried out on the consignment itself or on test units, taking into account the specifications of subclauses 6.2.2 to 6.2.5.

#### 6.2.2 Required tests

The tests referred to under items a) to e) of subclause 6.1.4 shall be carried out.

#### 6.2.3 Scope of test programme for tensile and impact test

6.2.3.1 Products covered in this standard shall not be subjected to batch testing.

6.2.3.2 The mass of batches from which specimens for tensile and impact testing are to be taken shall not exceed

a) 2500 kg, in the case of material batches or cast batches;

b) 1500 kg, in the case of heat treatment batches.

It is, however, permitted that remainders (unless their mass exceeds 50 % of the above mentioned maximum mass) be added to the preceding batch of a consignment concerned or be distributed uniformly across other batches of the consignment.

#### 6.2.4 Preparation of castings for non-destructive testing

The specifications given in DIN 54 111 Part 2 and in SEP 1922, SEP 1935 and SEP 1936 shall be taken into account when preparing castings which shall be tested for compliance with the requirements regarding the appearance and internal condition.

When preparing the surface for magnetic particle inspection, caulking and punching shall be avoided. Parts of the casting susceptible to cracking, such as fillets, shall be ground over during manufacture, prior to testing.

#### 6.2.5 Test methods and test conditions

6.2.5.1 The 0,2 % elevated temperature proof stress shall be determined as described in DIN 50 145.

6.2.5.2 In the case of non-destructive testing, a test instruction shall specify the test procedure, due consideration being given to the areas crucial to the casting process.

The timing of the last non-destructive test shall be so as to permit proof to be provided of compliance with the requirements regarding the casting quality and the assigned severity level.

## 7 ●● Marking

Unless otherwise agreed at the time of ordering, all castings of a consignment accompanied by a certificate of compliance with the order or by a test report shall be marked with the material designation and the manufacturer's mark, the specifications of subclause 6.1 of DIN 1690 Part 1, May 1985 edition, applying for consignments accompanied by a manufacturer's test certificate, inspection certificate or inspection report.

## 8 Heat treatment

See tables 6 and 7 for details of the heat treatment of steel castings with elevated temperature properties.

Table 1. **Chemical composition as determined by the cast analysis**

| Cast steel grade | | % by mass | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | C | Si 1) | Mn 2) | P (Not more than) | S (Not more than) | Cr | Mo | Ni 2) | V | Others |
| GS-C 25 | 1.0619 | 0,18 to 0,23 | 0,30 to 0,60 | 0,50 to 0,80 | 0,020 | 0,015 | ≤ 0,30 | – | – | – | – |
| GS-22 Mo 4 | 1.5419 | 0,18 to 0,23 | 0,30 to 0,60 | 0,50 to 0,80 | 0,020 | 0,015 | ≤ 0,30 | 0,35 to 0,45 | – | – | – |
| GS-17 CrMo 5 5 | 1.7357 | 0,15 to 0,20 | 0,30 to 0,60 | 0,50 to 0,80 | 0,020 | 0,015 | 1,00 to 1,50 | 0,45 to 0,55 | – | – | – |
| GS-18 CrMo 9 10 | 1.7379 | 0,15 to 0,20 | 0,30 to 0,60 | 0,50 to 0,80 | 0,020 | 0,015 | 2,00 to 2,50 | 0,90 to 1,10 | – | – | – |
| GS-17 CrMoV 5 11 | 1.7706 | 0,15 to 0,20 | 0,30 to 0,60 | 0,50 to 0,80 | 0,020 | 0,015 | 1,20 to 1,50 | 0,90 to 1,10 | – | 0,20 to 0,30 | – |
| G-X 8 CrNi 12 | 1.4107 | 0,06 to 0,10 | 0,10 to 0,40 | 0,50 to 0,80 | 0,030 | 0,020 | 11,50 to 12,50 | 0,50 max. | 0,80 to 1,50 | – | 3) |
| G-X 22 CrMoV 12 1 | 1.4931 | 0,20 to 0,26 | 0,10 to 0,40 | 0,50 to 0,80 | 0,030 | 0,020 | 11,30 to 12,20 | 1,00 to 1,20 | 0,70 to 1,00 | 0,25 to 0,35 | 4) |

[1]) If vacuum-treated steel has been ordered, the Si content may be lower than the minimum limit specified.

[2]) If the full quenching and tempering process or the structure of the steel suggest that it would be expedient for the maximum manganese content to be raised to 1,1 % or the nickel content, to 0,70%, this may be agreed at the time of ordering. This is not permitted for G-X 8 CrNi 12 and G-X 22 CrMoV 12 1 steels.

[3]) Nitrogen may be added up to 0,050% to reduce the δ ferrite content.

[4]) A maximum tungsten content of 0,50 % is permitted.

Table 2. **Amounts by which the chemical composition determined for cast-on test pieces may deviate from the limiting values specified for the cast analysis in table 1 (deviations A)**

| Element | Limiting values as determined by the cast analysis, as specified in table 1, as a percentage by mass | Deviations A [1] (see table heading), as a percentage by mass |
|---|---|---|
| C | ≤ 0,26 | 0,02 |
| Si | ≤ 0,60 | 0,10 [2] |
| Mn | ≤ 0,80 | 0,07 |
| P | ≤ 0,030 | 0,003 |
| S | ≤ 0,020 | 0,003 |
| Cr | ≤ 3,00<br>> 3,00 to ≤ 12,50 | 0,08<br>0,20 |
| Mo | ≤ 1,20 | 0,06 |
| Ni | ≤ 1,50 | 0,08 |
| V | ≤ 0,35 | 0,03 |

[1] If several analyses are to be carried out on cast-on test pieces, the deviations shown by an element within one cast shall lie either above the upper limit or below the lower limit of the range specified for the cast analysis, but not both at the same time for one cast.

[2] In the case of G-X 8 CrNi 12 and G-X 22 CrMoV 12 1 steels, the limit deviation of Si shall be 0,05 %.

Table 3. **Mechanical properties**

| Cast steel grade | | Tensile strength, in N/mm² | Minimum 0,2 % proof stress, in N/mm², at a temperature of | | | | | | | | Minimum elongation after fracture ($L_0 = 5\,d_0$) at ambient temperature, in % | Minimum impact value [1] (ISO V-notch test piece) at 20 °C, in J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | | 20 °C | 200 °C | 300 °C | 350 °C | 400 °C | 450 °C | 500 °C | 550 °C | | |
| GS-C 25 | 1.0619 | 440 to 590 | 245 | 175 | 145 | 135 | 130 | 125 | — | — | 22 | 27 [2] |
| GS-22 Mo 4 | 1.5419 | 440 to 590 | 245 | 190 | 165 | 155 | 150 | 145 | 135 | — | 22 | 27 |
| GS-17 CrMo 5 5 | 1.7357 | 490 to 640 | 315 | 255 | 230 | 215 | 205 | 190 | 180 | 160 | 20 | 27 |
| GS-18 CrMo 9 10 | 1.7379 | 590 to 740 | 400 | 355 | 345 | 330 | 315 | 305 | 280 | 240 | 18 | 40 |
| GS-17 CrMoV 5 11 | 1.7706 | 590 to 780 | 440 | 385 | 365 | 350 | 335 | 320 | 300 | 260 | 15 | 27 |
| G-X 8 CrNi 12 | 1.4107 | 540 to 690 | 355 | 275 | 265 | 260 | 255 | — | — | — | 18 | 35 |
| G-X 22 CrMoV 12 1 | 1.4931 | 740 to 880 | 540 | 450 | 430 | 410 | 390 | 370 | 340 | 290 | 15 | 21 |

[1] The values specified shall apply for the mean determined from three individual test results; no individual value shall be lower by more than 30 % than the value specified.
[2] For steels in the water quenched condition, the minimum value shall be 40 J.

Table 4. **Guideline values of modulus of elasticity**

| Cast steel grade | Modulus of elasticity, in $10^3$ N/mm², at | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20 °C | 100 °C | 200 °C | 300 °C | 400 °C | 500 °C | 600 °C |
| G-X 22 CrMoV 12 1<br>G-X 8 CrNi 12 | 216 | 209 | 200 | 190 | 179 | 167 | 127 |
| **Other grades** | 211 | 204 | 196 | 186 | 177 | 164 | 127 |

Table 5. **Guideline values of mean linear coefficient of thermal expansion**

| Cast steel grade | Mean linear coefficient of thermal expansion in the range from 20 °C to | | | | | |
|---|---|---|---|---|---|---|
| | 100 °C | 200 °C | 300 °C | 400 °C | 500 °C | 600 °C |
| G-X 22 CrMoV 12 1<br>G-X 8 CrNi 12 | 10,5 | 11,0 | 11,5 | 11,9 | 12,2 | 12,5 |
| **Other grades** | 12,2 | 12,9 | 13,4 | 13,9 | 14,3 | 14,6 |

Table 6. **Production welding data**

| Cast steel grade | | Suitable filler metals [1] | Composition % by mass | | | | | | | Preheating and interpass temperature for welding [3], in °C | Minimum postweld annealing temperature [4], [5], in °C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | | C | Si | Mn [2] | Cr | Mo | Ni | V | | |
| GS-C 25 | 1.0619 | 1 [6]<br>2 | 0,05 to 0,10<br>0,05 to 0,10 | ≤ 0,50<br>≤ 0,50 | ≤ 1,50<br>≤ 1,50 | —<br>— | —<br>0,40 to 0,70 | —<br>— | —<br>— | ≤ 350 [7]<br>≤ 350 [7] | 580<br>580 |
| GS-22 Mo 4 | 1.5419 | 2 [6]<br>3 | 0,05 to 0,10<br>0,08 to 0,15 | ≤ 0,50<br>≤ 0,50 | ≤ 1,50<br>≤ 1,20 | —<br>1,00 to 1,50 | 0,40 to 0,70<br>0,45 to 0,70 | —<br>— | —<br>— | ≤ 350 [7]<br>100 to 350 | 660<br>660 |
| GS-17 CrMo 5 5 | 1.7357 | 3 [6]<br>4 | 0,08 to 0,15<br>0,10 to 0,15 | ≤ 0,50<br>≤ 0,50 | ≤ 1,20<br>≤ 1,20 | 1,00 to 1,50<br>2,00 to 2,50 | 0,45 to 0,70<br>0,90 to 1,30 | —<br>— | —<br>— | 150 to 400<br>150 to 400 | 660<br>680 |
| GS-18 CrMo 9 10 | 1.7379 | 4 | 0,10 to 0,15 | ≤ 0,50 | ≤ 1,20 | 2,00 to 2,50 | 0,90 to 1,30 | — | — | 150 to 400 | 680 |
| GS-17 CrMoV 5 11 | 1.7706 | 6<br>4 | 0,10 to 0,15<br>0,10 to 0,15 | ≤ 0,50<br>≤ 0,50 | ≤ 1,00<br>≤ 1,20 | 1,00 to 1,50<br>2,00 to 2,50 | 0,90 to 1,30<br>0,90 to 1,30 | ≤ 0,40<br>— | 0,20 to 0,30<br>— | 200 to 450<br>200 to 450 | 680<br>680 |
| G-X 8 CrNi 12 | 1.4107 | 7 [8] | ≤ 0,07 | ≤ 0,50 | ≤ 1,00 | 12,0 to 13,0 | ≤ 0,20 | 1,00 to 1,50 | — | 100 to 350 | 670 [9] |
| G-X 22 CrMoV 12 1 | 1.4931 | 8 [6] | 0,15 to 0,22 | ≤ 0,50 | 0,40 to 1,30 | 10,0 to 12,0 | 0,80 to 1,20 | ≤ 1,0 | 0,20 to 0,40 | 200 to 450 | 680 [9] |

[1] The filler metals to be used shall be the subject of particular agreement between the purchaser and supplier, all data applying to the deposited weld metal. The chemical composition of the weld metal shall be established as described in DIN 8575 Part 1.

[2] The ratio of Mn to Si contents shall be not less than 2.

[3] Temperature determined on the weld bead.

[4] The duration of postweld annealing is a function of the maximum thickness of the welded joint.

[5] The temperatures shall also apply to fabrication welds made on equivalent materials. The tempering temperatures shall not be exceeded.

[6] Not suitable for postweld quenching and tempering.

[7] The minimum temperature of component at weld point shall be 20 °C, it depending on wall thickness and component design whether and to what extent preheating is required.

[8] This material may also be quenched and tempered involving partial austenitizing (i.e. soaking at 790 °C, followed by cooling in air and subsequent heating to 680 °C in a furnace.

[9] After welding, cooling down to a temperature below 130 °C, but not below 80 °C for G-X 22 CrMoV 12 1 steel, is required.

Table 7. **Heat treatment data** [1])

| Cast steel grade | | Quench hardening temperature, in °C | Tempering temperature, in °C | Minimum stress relieving temperature [2]), in °C |
|---|---|---|---|---|
| Symbol | Material number | | | |
| **GS-C 25** | **1.0619** | 920 to 960 | 600 to 700 | 580 |
| **GS-22 Mo 4** | **1.5419** | 920 to 960 | 680 to 730 | 660 |
| **GS-17 CrMo 5 5** | **1.7357** | 920 to 960 | 680 to 730 | 660 |
| **GS-18 CrMo 9 10** | **1.7379** | 930 to 980 | 680 to 740 | 660 |
| **GS-17 CrMoV 5 11** | **1.7706** | 920 to 960 | 700 to 740 | 660 |
| **G-X 8 CrNi 12** | **1.4107** | 1000 to 1060 | 680 to 730 | 660[3]) |
| **G-X 22 CrMoV 12 1** | **1.4931** | 1030 to 1080 | 700 to 750 | 680 |

[1]) See table 6 for guideline values relating to the heat treatment of production welds.

[2]) See subclause 5.2.2 for cooling after stress relieving.

[3]) Value applies for unwelded castings only; otherwise, see table 6.

## Appendix A

a) Table A.1 gives guideline values for long-term creep and stress-rupture properties of cast steels with elevated temperature properties, the values listed below representing average values of scatter as determined to date. These values will be reviewed from time to time on the basis of test results, and amended where necessary. Data obtained from tests lasting more than 10 000 hours to more than 100 000 hours indicate that the lower limit of scatter of the creep rupture stress for the steel grades and temperatures listed is about 20 % lower than the average specified here. The scatter of 1 % creep limit is generally higher.

b) The values listed are to be verified on the basis of creep tests at the steel manufacturer's works or performed by a test house at his request, the tests being conducted for the steel grade concerned or an equivalent steel grade also produced by him, for not less than 10 000 hours at one of the temperatures specified.

c) No values have been given for steel grade G-X 8 CrNi 12, as this steel is not used for applications where long-term creep and stress-rupture properties are required.

Table A.1

| Cast steel grade | | Temperature, in °C | 1 % creep limit [1], [2], in N/mm², for | | | Creep rupture stress [2], [3], in N/mm², for | | |
|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | | 10 000 h | 100 000 h | 200 000 h | 10 000 h | 100 000 h | 200 000 h |
| GS-C 25 [4] | 1.0619 | 400 | 147 | 117 | – | 225 | 177 | (163) |
| | | 410 | 134 | 101 | – | 208 | 157 | (142) |
| | | 420 | 122 | 86 | – | 191 | 138 | (123) |
| | | 430 | 110 | 73 | – | 175 | 121 | (105) |
| | | 440 | 98 | 60 | – | 160 | 105 | (88) |
| | | 450 | 88 | 50 | – | 145 | 90 | (74) |
| | | 460 | 77 | 39 | – | 130 | 78 | (63) |
| | | 470 | 67 | 32 | – | 117 | 68 | (55) |
| | | 480 | 58 | 25 | – | 105 | 59 | (50) |
| | | 490 | 50 | 21 | – | 94 | 53 | (45) |
| | | 500 | 43 | 20 | – | 84 | 50 | (41) |
| GS-22 Mo 4 | 1.5419 | 400 | – | – | – | (360) | (310) | (290) |
| | | 410 | – | – | – | (346) | (292) | (271) |
| | | 420 | – | – | – | (330) | (273) | (251) |
| | | 430 | – | – | – | (312) | (252) | (229) |
| | | 440 | – | – | – | (293) | (229) | (206) |
| | | 450 | 185 | 150 | (130) | 275 | 205 | (180) |
| | | 460 | 180 | 132 | (113) | 250 | 180 | (156) |
| | | 470 | 172 | 114 | (96) | 228 | 157 | (131) |
| | | 480 | 160 | 96 | (80) | 205 | 132 | (109) |
| | | 490 | 144 | 80 | (65) | 182 | 108 | (88) |
| | | 500 | 125 | 65 | (50) | 160 | 85 | (70) |
| | | 510 | 104 | 52 | (39) | 134 | 68 | (54) |
| | | 520 | 85 | 40 | (28) | 110 | 54 | (41) |
| | | 530 | 67 | 30 | (20) | 90 | 43 | (32) |
| | | 540 | 52 | 21 | (14) | 74 | 35 | (26) |
| | | 550 | 41 | 15 | (10) | 66 | 30 | (23) |
| GS-17 CrMo 5 5 [5] | 1.7357 | 450 | 196 | 145 | – | 321 | 244 | 222 |
| | | 460 | 183 | 130 | – | 292 | 214 | 191 |
| | | 470 | 169 | 117 | – | 265 | 186 | 163 |
| | | 480 | 156 | 104 | – | 238 | 160 | 138 |
| | | 490 | 143 | 92 | – | 212 | 137 | 116 |
| | | 500 | 130 | 81 | – | 187 | 117 | 96 |
| | | 510 | 117 | 70 | – | 165 | 98 | 80 |
| | | 520 | 103 | 60 | – | 145 | 83 | 67 |
| | | 530 | 91 | 51 | – | 127 | 70 | 56 |
| | | 540 | 78 | 43 | – | 112 | 61 | 49 |
| | | 550 | 65 | 35 | – | 98 | 55 | 44 |

For [1] to [5], see page 12.

Table A.1 (continued).

| Cast steel grade | | Temperature, in °C | 1 % creep limit [1], [2], in N/mm², for | | | Creep rupture stress [2], [3], in N/mm², for | | |
|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | | 10 000 h | 100 000 h | 200 000 h | 10 000 h | 100 000 h | 200 000 h |
| **GS-18 CrMo 9 10** [5] | **1.7379** | 400 | 350 | 300 | (278) | 404 | 324 | (304) |
| | | 410 | 320 | 258 | (234) | 374 | 298 | (278) |
| | | 420 | 294 | 228 | (208) | 348 | 274 | (256) |
| | | 430 | 272 | 206 | (184) | 324 | 254 | (236) |
| | | 440 | 250 | 186 | (166) | 302 | 236 | (218) |
| | | 450 | 229 | 168 | (148) | 282 | 218 | (200) |
| | | 460 | 210 | 151 | (133) | 262 | 201 | (183) |
| | | 470 | 192 | 136 | (119) | 242 | 184 | (166) |
| | | 480 | 174 | 120 | (106) | 224 | 166 | (151) |
| | | 490 | 156 | 108 | (92) | 206 | 150 | (134) |
| | | 500 | 141 | 96 | (80) | 188 | 136 | (120) |
| | | 510 | 124 | 82 | (68) | 170 | 120 | (104) |
| | | 520 | 110 | 70 | (58) | 152 | 106 | (90) |
| | | 530 | 97 | 59 | (48) | 136 | 92 | (76) |
| | | 540 | 82 | 49 | (38) | 120 | 79 | (64) |
| | | 550 | 70 | 40 | (31) | 106 | 66 | (52) |
| | | 560 | 60 | 32 | (24) | 93 | 56 | (42) |
| | | 570 | 52 | 27 | (20) | 81 | 46 | (34) |
| | | 580 | 46 | 22 | (17) | 72 | 38 | (28) |
| | | 590 | 41 | 19 | (15) | 63 | 32 | (24) |
| | | 600 | 36 | 18 | (14) | 58 | 28 | (22) |
| **GS-17 CrMoV 5 11** [5] | **1.7706** | 400 | 438 | 379 | (356) | 479 | 419 | (395) |
| | | 410 | 410 | 351 | (326) | 451 | 390 | (364) |
| | | 420 | 383 | 322 | (298) | 423 | 360 | (335) |
| | | 430 | 356 | 295 | (271) | 395 | 332 | (307) |
| | | 440 | 330 | 267 | (243) | 368 | 303 | (279) |
| | | 450 | 305 | 240 | (218) | 342 | 275 | (253) |
| | | 460 | 279 | 214 | (192) | 316 | 249 | (226) |
| | | 470 | 255 | 190 | (169) | 291 | 224 | (202) |
| | | 480 | 231 | 168 | (147) | 266 | 201 | (180) |
| | | 490 | 209 | 147 | (128) | 243 | 180 | (160) |
| | | 500 | 188 | 128 | (110) | 222 | 160 | (141) |
| | | 510 | 170 | 112 | (94) | 203 | 144 | (125) |
| | | 520 | 154 | 98 | (82) | 187 | 129 | (110) |
| | | 530 | 139 | 85 | (68) | 171 | 114 | (96) |
| | | 540 | 125 | 72 | (59) | 157 | 101 | (83) |
| | | 550 | 112 | 61 | (49) | 144 | 88 | (71) |
| | | 560 | 100 | 52 | (39) | 131 | 76 | (59) |
| | | 570 | 88 | 43 | (30) | 119 | 64 | (47) |
| | | 580 | 78 | 35 | (22) | 107 | 53 | (36) |
| | | 590 | 68 | 27 | (14) | 96 | 41 | (25) |
| | | 600 | 61 | 19 | (10) | 86 | 30 | (14) |

For [1] to [3] and [5], see page 12.

Table A.1 (concluded).

| Cast steel grade | | Temperature, in °C | 1 % creep limit [1], [2], in N/mm², for | | | Creep rupture stress [2], [3], in N/mm², for | | |
|---|---|---|---|---|---|---|---|---|
| Symbol | Material number | | 10 000 h | 100 000 h | 200 000 h | 10 000 h | 100 000 h | 200 000 h |
| G-X 22 CrMoV 12 1 | 1.4931 | 390 | – | – | – | (529) | (451) | (420) |
| | | 400 | – | – | – | (504) | (426) | (394) |
| | | 410 | – | – | – | (479) | (401) | (369) |
| | | 420 | – | – | – | (454) | (377) | (345) |
| | | 430 | – | – | – | (430) | (354) | (322) |
| | | 440 | – | – | – | (407) | (331) | (300) |
| | | 450 | 305 | 259 | (239) | 383 | 309 | (279) |
| | | 460 | 286 | 240 | (222) | 359 | 288 | (259) |
| | | 470 | 269 | 223 | (204) | 336 | 267 | (241) |
| | | 480 | 251 | 205 | (186) | 313 | 247 | (223) |
| | | 490 | 232 | 188 | (170) | 291 | 227 | (205) |
| | | 500 | 216 | 172 | (153) | 269 | 207 | (187) |
| | | 510 | 198 | 157 | (136) | 248 | 187 | (169) |
| | | 520 | 181 | 138 | (121) | 227 | 171 | (151) |
| | | 530 | 164 | 122 | (105) | 206 | 152 | (134) |
| | | 540 | 148 | 106 | (90) | 185 | 135 | (118) |
| | | 550 | 131 | 91 | (77) | 167 | 118 | (103) |
| | | 560 | 117 | 77 | (63) | 148 | 103 | (88) |
| | | 570 | 102 | 66 | (51) | 130 | 88 | (74) |
| | | 580 | 89 | 54 | (40) | 114 | 74 | (61) |
| | | 590 | 77 | 43 | (31) | 98 | 60 | (49) |
| | | 600 | 66 | 34 | (25) | 83 | 49 | (39) |

[1] Stress related to the initial cross section, which results in a 1 % permanent strain after the time specified.

[2] The bracketed values have been determined by extrapolation.

[3] Stress related to the initial cross section, which results in a rupture after the time specified.

[4] The values apply for grade GS-C 25 in the quenched and tempered condition.

[5] For a bainitic structure with up to 20 % ferrite constituents, the values of long-term creep and stress-rupture may be expected to lie in the upper scatterband range.

## Appendix B

**Information on production-welded GS-C 25 and GS-C 25 N castings subjected to postweld treatment**

Subject to agreement with the purchaser, postweld treatment (stress relieving) may be dispensed with for castings made of GS-C 25 or GS-C 25 N steel and exhibiting small production welds (see subclause 5.7.1.6), taking the following conditions into account.

a) Prior to welding, any surface imperfections (depressions) shall be examined by magnetic particle inspection or penetrant inspection. They shall be permissible only if they give indications that suggest that weldability will not be impaired and if they are not to be classed as serious surface and internal defects which must be made good. The welding supervisor and the responsible inspector of the manufacturer shall jointly decide whether and to what extent imperfections which have not been removed may affect weldability. In case of doubt, it shall be verified by way of internal testing that there are not impermissible defects in the adjoining parent metal.

b) The casting shall be quenched and tempered or normalized and shall have almost reached its final shape. Production-welds made by the casting manufacturer, without postweld stress relieving, are to be considered an exception and shall be agreed with the purchaser.

c) The carbon content shall be 0,25 % maximum (to be determined using cast-on test pieces); if the carbon content of the cast-on test piece is not known, the carbon content as determined by the cast analysis shall not exceed 0,22 %.

d) Testing of welders working to specified welding processes, as specified in SEW 110 or AD HP 2/1.
Welding parameters:
   a) Welding filler metal: grade 1 as specified in table 6.
   b) Preheating temperature: 150 to 200 °C, with maximum local temperatures not exceeding 250 °C (to be measured using thermocouples).
   c) Welding procedure: The procedure shall be equivalent to that required for the welder's test, preference being given to
      a) the weaving technique (with oscillations having an amplitude equal to one to three times the electrode diameter);
      b) side lap welds with at least two runs and a final quenching and tempering run;
      c) welds in the flat position.

e) The impact value for the parent metal shall be not less than 40 J, determined on ISO V-notch test pieces at ambient temperature (in accordance with inspection certificate).

f) The hardness of the weld metal shall not exceed 270 HB, the test being made once per casting, preference being given to the face in contact with the quenching medium.

g) Non-destructive testing of production-welds and of adjoining parent metal as specified in subclause 5.7.1.5; involving testing for surface cracks (100 % inspection) and testing of internal condition (with samples taken by agreement with the purchaser) and assessment as specified in DIN 1690 Part 2.

h) The cast iron products are designed for use in water and vapour circuits and cooling systems operated with conditioned water.

i) Large production-welded areas shall be illustrated as specified in subclause 5.7.1.6.

j) If design calculations as specified in the relevant codes of practice or standards, such as TRD 301, *AD-Merkblätter* (AD Instruction sheets) S1 and S2 and DIN 3840, are to be made for valves subject to alternating stresses, residual stresses due to welding have to be taken into account as average stresses (e.g. at a value equal to the elevated temperature yield strength limit).

## Standards and other documents referred to

| | |
|---|---|
| DIN 1690 Part 1 | Technical delivery conditions for castings made from metallic materials; general conditions |
| DIN 1690 Part 2 | Technical delivery conditions for castings made from metallic materials; steel castings; classification into severity levels on the basis on non-destructive testing |
| DIN 3840 | Valve bodies; design for resistance to internal pressure |
| DIN 8575 Part 1 | Filler metals for arc welding of creep resisting steels; classification, designation and technical delivery conditions |
| DIN 17 007 Part 2 | Material numbers; principal group 1: steel |
| DIN 50 049 | Materials testing certificates |
| DIN 50 145 | Testing of metallic materials; tensile test |
| DIN 54 111 Part 2 | Non-destructive testing; testing of metallic materials by X-rays or gamma rays; radiographic techniques for castings made of ferrous materials |
| *DIN-Normenheft* 3 | *Kurznamen und Werkstoffnummern der Eisenwerkstoffe in DIN-Normen und Stahl-Eisen-Werkstoffblättern* (Symbols and material numbers for ferrous materials dealt with in DIN Standards and Iron and steel material sheets) |
| *Stahl-Eisen-Werkstoffblatt* (Iron and steel materials sheet) 110 [1]) | *Verfahrensprüfung für Fertigungsschweißungen an Stahlguß* (Testing of welders making production-welds on steel castings) |
| *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1922 [1]) | *Ultraschallprüfung von Gußstücken aus ferritischem Stahl* (Ultrasonic testing of castings made of ferritic steel) |
| *Stahl-Eisen-Prüfblatt* 1935 [1]) | *Oberflächenrißprüfung von Gußstücken aus Stahl; Magnetpulverprüfung* (Examination for surface cracks in steel castings by magnetic particle inspection) |
| *Stahl-Eisen-Prüfblatt* 1936 [1]) | *Oberflächenrißprüfung von Gußstücken aus Stahl; Eindringprüfung* (Examination for surface cracks in steel castings by penetrant inspection) |
| AD HP 2/1 [2]) | *Verfahrensprüfung für Fügeverfahren; Verfahrensprüfung für Schweißverbindungen* (Testing of welders; fabrication of welded joints) |
| AD S1 [2]) | *Abgrenzung zwischen der Berechnung gegen vorwiegend ruhende Innendruckbeanspruchung und der Berechnung gegen Schwellbeanspruchung* (Design for stresses both due to predominantly static and dynamic internal pressure) |
| AD S2 [2]) | *Berechnung auf Schwingbeanspruchung* (Design for stresses due to cyclic loading) |
| TRD 301 [2]) | *Zylinderschalen unter innerem Überdruck* (Cylindrical shells subject to internal pressure) |

## Previous editions

DIN 1682: 03.42, 05.43; Supplement to DIN 17 245: 05.52; DIN 17 245 Part 1: 10.51, 01.59; DIN 17 245 Part 2: 10.51, 01.59; DIN 17 245 Part 10: 03.64; DIN 17 245: 07.67, 10.77.

## Amendments

The following amendments have been made to the October 1977 edition.

a) The previous specifications, in particular those applying to severity levels and non-destructive testing, have been replaced, wherever possible, by references to the recently published standards with specifications for castings, DIN 1690 Parts 1 and 2.

b) The limits within which the chemical composition determined for cast-on test pieces may deviate from the values given in table 1 for the cast analysis have been specified (see subclause 5.3.2).

c) The scope of requirements with regard to the mechanical properties of castings as determined in the tensile test and to the impact value has been extended (see subclauses 5.4.1 and 5.4.2). A number of minimum values for the impact strength have been increased.

d) Although the minimum tensile strength specified for G-X 22 CrMoV 12 1 steel has been raised from 690 N/mm² to 740 N/mm² and the minimum values of 0,2 % proof stress have been reduced by up to 55 N/mm² (approx. 12 %) (see table 3), an alteration to the material designation (for quality control reasons) was not considered expedient.

e) Based on the results of recent testing, some of the values for long-term creep and stress-rupture properties have been slightly raised, some slightly reduced, and for some properties values obtained from 200 000 hour tests have been specified. The greatest reductions, some as much as 30 %, were found for the 1 % creep limit of GS-22 Mo 4 and GS-18 CrMo 9 10 steels.

f) The production welding data, in particular the filler metal specifications and the preheating and interpass temperatures, have been revised (see subclause 5.7 and table 6).

g) In line with recent investigations, the previous maximum cooling rate of 15 K/h has been changed to a maximum rate of 25 K/h (see subclause 5.2.2).

h) The standard has been extended by the introduction of appendix B, which gives information regarding production-welds on GS-C 25 and GS-C 25 N castings made without postweld stress relieving.

i) The specifications regarding weld ends have been revised (see subclause 5.6).

---

[1]) Obtainable from *Verlag Stahleisen mbH*, Postfach 82 29, D-4000 Düsseldorf 1.

[2]) Obtainable from *Beuth Verlag GmbH*, Postfach 11 45, D-1000 Berlin 30.

## Explanatory notes

A revision of the October 1977 edition of this standard was considered necessary in order to implement the proposals for amendments, now listed under items a) to i) in the Amendments clause.

During the discussions in the responsible technical committee it was pointed out that results of inter-laboratory testing using the X-ray spectrometric method and carried out on calibration samples with a chromium content of between 3 and 12,5 %, have shown a variability of ± 0,15 % which, in absolute terms, exceed the limit deviations of 0,20 % specified in table 2. For this reason, particular care was taken when reviewing the data given in table 2.

As already mentioned in the then incomplete subclause 5.7.1.3 of the draft standard, investigations have been made to establish whether a postweld treatment of castings made of GS-C 25 or GS-C 25 N steel may be dispensed with. The available results clearly show that this is possible for production-welds on such castings, provided that soft filler metals are used and the correct welding sequence is observed. Reservations were only made in cases, such as in turbine production where it is particularly important for the castings not to become distorted during repair or in service. After conclusion of the above investigations, the technical committee and the *Vereinigung der Technischen Überwachungsvereine* (German Association of Technical Control Boards) jointly laid down the conditions under which postweld treatment may be dispensed with for production-welded castings, the details being incorporated as appendix B in this standard.

Some of the processors and users supported a proposal that a footnote contained in the July 1967 edition of this standard and reading 'After proper execution of the weld, the adjoining parent metal need only meet the severity level specified for the casting' should again be incorporated in this revised edition. The majority, however, dismissed this proposal, because this standard is intended to specify only requirements relating to the condition of the castings at supply and the weld ends are to be made, over a given depth (plus machining allowance), to severity level 1 or 2 to prevent the castings cracking during welding.

Parts of this standard are comparable with ISO/DP 4991, Steel castings for pressure purposes. Apart from steel grades with elevated temperature properties, the ISO document, however, covers ferritic as well as austenitic steel grades, grades with ambient temperature properties and grades with low temperature toughness. In the following table, the steel grades specified in this standard and in other German documents are compared with those intended to be published in ISO/DP 4991.

**Comparison of cast steel grades specified in this standard and in other German documents with those covered in ISO/DP 4991**

| Cast steel grade as specified in German documents | | | | ISO/DP 4991 | [2] |
|---|---|---|---|---|---|
| Symbol | Material number | DIN 17 245 | [1] | | |
| **GS-C 25** | **1.0619** | X | | C 23-45 A<br>C 23-45 AH | ○ |
| **GS-16 Mn 5** | **1.1131** | | DIN 17 182 | C 23-45 B<br>C 23-45 BH<br>C 23-45 BL | ● |
| **GS-20 Mn 5** | **1.1120** | | DIN 17 182 | C 26-52<br>C 26-52 H | ○ |
| **GS-21 Mn 5** | **1.1138** | | SEW 685 [3] | C 26-52 L | ● |
| **GS-22 Mo 4** | **1.5419** | X | | C 28 H | ○ |
| **GS-26 CrMo 4** | **1.7219** | | SEW 685 [3] | C 31 L | ● |
| **GS-17 CrMo 5 5** | **1.7357** | X | | C 32 H | ● |
| | | | | C 33 H | |
| **GS-12 CrMo 9 10** | **1.7380** | | SEW 595 [3] | C 34 AH | ○ |
| **GS-18 CrMo 9 10** | **1.7379** | X | | C 34 BH | ● |
| **GS-17 CrMo 9 10** | **1.7377** | | SEW 685 [3] | C 34 BL | ● |
| **GS-17 CrMo V 5 11** | **1.7706** | X | | C 35 H | ● |
| **GS-12 CrMo 19 5** | **1.7363** | | SEW 595 [3] | C 37 H | ○ |
| **GS-X 12 CrMo 10 1** | **1.7389** | | SEW 595 [3] | C 38 H | ○ |
| | | | | C 39 CH | |
| **G-X 8 CrNi 12** | **1.4107** | X | | C 39 CNiH | ● |
| **G-X 5 CrNi 13 4** | **1.4313** | | DIN 17 445 | C 39 NiH | ● |
| **G-X 5 CrNi 13 4** | **1.4313** | | SEW 685 [3] | C 39 NiL | ● |
| **G-X 22 CrMo V 12 1** | **1.4931** | X | | C 40 H | ● |
| **GS-10 Ni 14** | **1.5638** | | SEW 685 [3] | C 43 L | ○ |
| | | | | C 43 C1L | |

For [1] to [3], see page 16.

Comparison (concluded).

| Cast steel grade as specified in German documents | | | | | |
|---|---|---|---|---|---|
| Symbol | Material number | DIN 17 245 | [1] | ISO/DP 4991 | [2] |
| **GS-19 NiCrMo 12 6** | **1.6783** | | SEW 685 [3] | C 43 E2aL<br>C 43 E2bL | ●<br>○ |
| **G-X 2 CrNi 18 9** | **1.4306** | | SEW 410 [3] | C 46 | ● |
| **G-X 6 CrNi 18 9** | **1.4308** | | DIN 17 445 | C 47<br>C 47 H<br>C 47 L | ○ |
| **G-X 2 CrNiNb 18 9** | **1.4552** | | DIN 17 445 | C 50 | ● |
| **G-X 2 CrNiMo 18 10** | **1.4404** | | SEW 410 [3] | C 57 | ○ |
| **G-X 6 CrNiMo 18 10** | **1.4408** | | DIN 17 445 | C 60<br>C 60 H | ○ |
| **G-X 5 CrNiMoNb 18 10** | **1.4581** | | DIN 17 445 | C 60 Nb | ○ |
| **G-X 2 CrNiMo 18 10** | **1.4404** | | SEW 410 [3] | C 61 LC | ○ |
| **G-X 6 CrNiMo 18 10** | **1.4408** | | DIN 17 445 | C 61 | ○ |

[1] DIN 17 182 Cast steels with improved weldability and greater toughness for general engineering purposes
DIN 17 445 Stainless steel castings; technical delivery conditions
SEW 410 *Stahl-Eisen-Werkstoffblatt* 410 *Nichtrostender Stahlguß; Gütevorschriften* (Stainless steel castings; quality specifications)
SEW 685 *Stahl-Eisen-Werkstoffblatt* 685 *Kaltzäher Stahlguß; Gütevorschriften* (Steel castings with low crude oil and natural gas plants)
SEW 686 *Stahl-Eisen-Werkstoffblatt* 585 *Kaltzäher Stahlguß; Gütevorschriften* (Steel castings with low temperature toughness; quality specifications)

[2] This column indicates the degree of correspondence with regard to the chemical composition, between the cast steel grades specified in German documents and those covered in ISO/DP 4991, the symbols having the following meanings:
- ● slight differences;
- ○ significant differences.

[3] Obtainable from *Verlag Stahleisen mbH*, Sohnstraße 65, D-4000 Düsseldorf 1.

## International Patent Classification

B 23 K 31/00
C 22 C 37/06
C 22 C 38/04
C 22 C 38/12
C 22 C 38/22
C 22 C 38/46
C 21 D 6/02
C 21 D 9/50