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October 1989

Weldable fine grain structural steel forgings

Technical delivery conditions

DIN 17 103

Schmiedestücke aus schweißgeeigneten Feinkornbaustählen; technische Lieferbedingungen

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.

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.

1 Field of application

1.1 This standard applies to weldable fine grain structural steels as listed in table 1 where these can be supplied as forgings or forged steel bars.

Note. In agreement with EURONORM 79, the concept 'forging' as used here shall be understood to include hot pressed parts (such as headers or vessel courses with pressed-on ends) and parts produced on ring rolling mills (such as seamless rolled rings).

This standard covers products having equivalent diameters up to the maximum values listed in the tables. Products complying with this standard exhibit, in their as delivered condition, a minimum yield strength of between 285 and 500 N/mm^2, as given for the lowest diameter range in table 3.

1.2 ●● This standard also applies to forged or rolled semi-finished products intended for processing into finished products as specified in subclause 1.1, the as delivered condition and the relevant methods of test being, however, the subject of a particular agreement when ordering such products.

1.3 In addition to the requirements specified in this standard, the general technical delivery conditions for steel and steel products given in DIN 17 010 shall apply unless otherwise specified in this standard.

2 Concept

For the purposes of this standard, fine grain structural steel is steel with a minimum yield strength of between 285 and 500 N/mm^2 (see subclause 1.1) whose chemical composition is selected so as to ensure weldability, which is a function of the minimum yield strength. This steel is fully killed and contains elements forming precipitation, e.g. nitrides and/or carbonitrides. These prevent the growth of crystals in the austenite range so that the steel is fine-grained in its as delivered condition (grain size index 6 or finer when tested at ambient temperature as described in DIN 50 601). In this condition, steel exhibits a high resistance to brittle fracture.

3 ● Dimensions and limit deviations

The nominal sizes or forgings and the associated limit deviations shall be agreed at the time of ordering, reference being made, where possible, to the appropriate dimensional standards (see appendix B).

4 Mass

The mass of the steels covered in this standard has been calculated taking the density as 7,85 kg/dm^3.

5 Steel grades

5.1 This standard relates to three series of steel grades as listed in table 1:

a) the basic (StE . . .) series;

b) the high temperature (WStE . . .) series including grades which are to have a 0,2 % proof strength at elevated temperature (see table 5);

c) the low temperature (TStE . . .) series including grades which are to have a minimum impact energy, determined on ISO V-notch test pieces, at temperatures down to −50 °C (see table 6).

5.2 ●● It may be agreed at the time of ordering that the minimum elevated temperature 0,2 % proof strength values given in table 5 for steel of the high temperature series shall also apply for steel of the low temperature series.

6 Designation and ordering

6.1 Designation

6.1.1 See table 1 for the material designations and numbers identifying steel grades.

6.1.2 The standard designation for steel as covered in this standard shall give the name of product (steel), the number of this standard and either the material designation or the material number identifying the steel grade, as shown in the example below.

Example:

Steel DIN 17 103 – StE 420

or

Steel DIN 17 103 – 1.8902

Continued on pages 2 to 16

6.2 Ordering

6.2.1 ● The order shall give the quantity, the product form, the number of any relevant dimensional standard, the dimensions, the material designation, the as delivered condition where this deviates from that specified in subclause 7.2.1, and the number of this standard.

6.2.2 If the designation given in subclause 6.1.2 or 6.2.1 does not fully describe the steel as ordered, e.g. where agreements have been made with respect to clauses or subclauses marked ● or ●●, the designation shall be supplemented accordingly.

6.2.3 ● In the case of products with non-uniform cross section, the equivalent diameter (see table 4) shall be given in the order.

7 Requirements

7.1 Manufacturing process

7.1.1 The steel shall be produced either by the basic oxygen process or in the electric furnace. Subject to agreement with the purchaser, a different but equivalent process may also be used.

7.1.2 The steel shall be fully killed, shall contain sufficient elements for nitrogen control and shall be fine-grained (see clause 2).

7.1.3 The steel shall be hot worked by forging or, in the case of rings, also by rolling.

7.2 As delivered condition

7.2.1 ●● Unless otherwise agreed, the type of heat treatment (normalizing or quenching and tempering) shall be at the manufacturer's discretion. The purchaser shall be informed of the heat treatment condition. Normally, products with equivalent diameters not exceeding 100 mm shall be normalized and those with equivalent diameters exceeding 100 mm, quenched and tempered.

7.2.2 ●● As delivered conditions other than those specified in subclause 7.2.1 may be agreed at the time of ordering.

7.2.3 The machining condition of forgings shall comply with the details given in the order.

7.3 Chemical composition

7.3.1 Chemical composition as determined by ladle analysis

The chemical composition of the steels as determined by ladle analysis shall be as given in table 1, which specifies the permissible contents of alloying elements. The manufacturer shall inform the purchaser of the types of characteristic alloying elements used and of the associated percentages, for the steel grade supplied.

7.3.2 ●● Chemical composition as determined by product analysis

If checking of the chemical composition on the product has been agreed at the time of ordering, the results of the product analysis shall be allowed to deviate, by the amounts stated in table 2, from the limit deviations for the ladle analysis to be notified by the manufacturer as specified in subclause 7.3.1.

7.4 Mechanical properties

7.4.1 Where hardness tests as specified in table 8, columns 10 to 13, are to be carried out to check the homogeneity of the material on one test unit, the difference in hardness between the hardest and softest test piece of the test unit shall not exceed 30 HB.

7.4.2 The values of mechanical properties specified in tables 3, 5 and 6 shall apply for the usual heat treatment condition (see subclause 7.2.1) and for the usual stress relieving condition as specified in clause A.3, for the sizes during heat treatment, which shall be taken as a basis for calculating the equivalent diameter, taking the product form into account (see table 4), and for the test conditions given in clause 9.

7.4.3 The minimum values of elevated temperature 0,2 % proof strength as given in table 5 shall apply for steels of the high temperature series and also for those of the low temperature series if this has been agreed at the time of ordering.

7.5 Weldability

Steel complying with this standard is weldable if the generally recognized rules of the art (see *Stahl-Eisen-Werkstoffblatt* (Iron and steel materials sheet) 088) are observed.

7.6 Surface condition and soundness

7.6.1 Untreated products shall have a smooth surface consistent with the manufacturing process used.

7.6.2 Surface defects that lie within the machining allowance are permitted and may be removed where required, provided that this does not impair the usability of the product.

7.6.3 ●● If non-destructive testing for proper surface condition and soundness is to be carried out or has been agreed (see subclause 9.2.2.3 and table 7, column 10), the details given in subclause 9.4.5 shall apply for the permissible size of indication. Compliance is also required with the specifications relating to surface condition given in the test sheets and intended to ensure that the test can be performed properly.

7.6.4 Removal of surface defects by welding is permitted only with the approval of the purchaser or of the person responsible for acceptance inspection.

8 Physical properties

See *Stahl-Eisen-Werkstoffblatt* 310 (at present at the stage of draft) for guideline values of physical properties.

9 Testing

9.1 Acceptance inspection

Consignments declared compliant with this standard shall be subjected to an acceptance inspection.

9.2 Tests to be carried out and scope of testing

9.2.1 For products supplied in the normalized or quenched and tempered condition, table 7, columns 1 to 5, lists the mandatory tests together with details on the scope of testing.

9.2.2 For products that have not been subjected to final normalizing or quenching and tempering treatment, the specifications of table 7 shall apply, except in the following respects.

9.2.2.1 The test for uniform hardness is not carried out.

9.2.2.2 ●● Tensile and impact tests, and verification of the elevated temperature 0,2% proof strength of products in the as delivered condition are not carried out. However, it may be agreed at the time of ordering, together with the scope of testing, that such tests be carried out on normalized or quenched and tempered reference test pieces.

9.2.2.3 ●● Non-destructive testing of products not yet subjected to final heat treatment may be agreed at the time of ordering.

9.3 Sampling and sample preparation

9.3.1 Test pieces left over from mechanical tests may be used for checking the chemical composition on the product.

In cases of arbitration, the sample chips shall be taken at points uniformly distributed over the entire cross section of the product.

9.3.2 In hardness tests to be carried out for checking the homogeneity of products from one test unit, the test location shall always be the same for all products, on the surface of the product wherever possible, at a point where the product thickness represents the equivalent diameter. Where required, any scale influencing the test results or decarburized surface zones shall be removed prior to testing.

9.3.3 The tensile test pieces and impact test pieces shall be taken

a) either from products subjected to final heat treatment, or

b) from integral surplus material provided on the products,

taking the specifications given in subclause 9.3.3.1 into account. This does not appply to hollow bodies with closed ends.

In the case of hollow bodies with closed ends (unless the test pieces can be taken from a product section), the test pieces shall be taken before the ends are closed and tested after they have been heat treated together with the hollow bodies. In the case of hollow bodies tempered and quenched in a liquid, the test piece sections shall be joined to form hollow bodies, these then being quenched and tempered. For retests, integral surplus material shall be provided on the products to be tested.

9.3.3.1 The details given in table 8, column 24 or 25, shall apply for the distance of the test piece location from the product surface and for the direction of the longitudinal axis of the test pieces in relation to the direction of the grain flow (= test piece direction).

The symbols used to denote the test piece direction shall be taken to mean the following:

L: the longitudinal axis of the test piece lies parallel to the principal direction of the non-curved grain flow;

T: the longitudinal axis of the test piece intersects the curved grain flow as a chord;

Q: the longitudinal axis of the test piece intersects the grain flow at right angles.

Test pieces the longitudinal axis of which lies in the direction of an additional upset deformation (perpendicular to a broadside) of the grain flow (referred to as being 'in the direction of thickness') shall not be regarded as test pieces identified by Q (see subclause 9.3.3.1.2).

9.3.3.1.1 ●● In cases of dispute, sampling and the location of test pieces in relation to the grain flow shall be agreed at the time of ordering, taking these specifications and those listed in table 8, column 25, into account. In the absence of such agreements, the manufacturer shall decide on the test piece location relative to the grain flow.

9.3.3.1.2 ●● Test pieces taken with their longitudinal axis intersecting a broadened grain flow at right angles to the broadside ('in the direction of thickness') only serve to determine elongation after fracture values. Testing of these properties and the requirements to be met shall also be agreed at the time of ordering.

9.3.3.2 ●● At the time of ordering it may be agreed that the direction in which the test pieces are to be taken shall be a function of the product design instead of the grain flow. If, in such cases, the test piece direction does not correspond to the direction defined in subclause 9.3.3.1, the values of mechanical properties to be complied with shall be the subject of particular agreement. This type of sampling is particularly suitable for drop forgings.

The values to be specified by particular agreement shall at least comply with those specified for transverse (Q) test pieces.

9.4 Test methods

9.4.1 The chemical composition shall be tested using the methods developed by the Chemists' Committee of the *Verein Deutscher Eisenhüttenleute*[1]). Methods not specified by the Chemists' Committee shall be the subject of particular agreement.

9.4.2 Hardness testing shall be carried out as described in DIN 50 103 Part 1 (Rockwell hardness testing), DIN 50 133 (Vickers hardness testing) or DIN 50 351 (Brinell hardness testing).

9.4.3 Tensile testing shall be carried out as described in DIN 50 145 using the proportional test piece having an original gauge length, L_0, equal to $5\,d_0$ as specified in DIN 50 125.

If there is no pronounced upper yield strength at ambient temperature (15 to 35 °C), the 0,2 % proof strength shall be determined.

●● The elevated temperature 0,2 % proof strength shall be determined at one of the temperatures specified in table 5. This temperature may be specified at the time of ordering; in the absence of such specification, the test shall be carried out at 300 °C.

9.4.4 Impact testing shall be carried out on ISO V-notch test pieces as described in DIN 50 115.

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1) *Handbuch für das Eisenhüttenlaboratorium* (Handbook for the ferrous metallurgy laboratory).

The test for verification of the impact values specified in table 6 shall be carried out at one of the temperatures specified in that table.

● The test shall be performed at one temperature and for one test piece direction (L or T/Q) which are to be agreed at the time of ordering. Unless otherwise agreed, the values shall be verified at the lowest temperature given in table 6.

9.4.5 Ultrasonic testing of hollow bodies with inside diameters exceeding 80 mm shall be carried out as described in *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1915.

●● In all other cases, where non-destructive testing has been agreed or is to be carried out in accordance with table 7, line 10, the test method to be applied, the criteria for assessing the indications and the permissible indication sizes shall be agreed at the time of ordering.

The influence of the surface condition (see subclause 7.6) on the flaw detection sensitivity shall be taken into account.

Where required, the agreements may be based on

- *Stahl-Eisen-Prüfblatt* 1921 in the case of ultrasonic testing;
- DIN 54 152 Parts 1 and 2 covering penetrant testing;
- DIN 54 130 covering magnetic leakage flux methods;
- Code of practice *Durchführung der Magnetpulverprüfungen* (Magnetic particle inspection procedures), 1980 edition, issued by the *Deutsche Gesellschaft für zerstörungsfreie Prüfung* (German Society of Non-destructive Testing) in the case of magnetic particle testing.

9.5 Retests

DIN 17 010 shall apply for retests, which may, however, be carried out on other products from the same test unit.

9.6 Materials testing certificates

One of the certificates specified in DIN 50 049, August 1986 edition, clause 3, shall be issued for products complying with this standard.

● The type of certificate and, if the tests are not to be carried out by the works inspector, the inspection representative or his company shall be named at the time of ordering.

9.6.1 Details to be included in the certificate

The certificate shall include the following details:

a) the technical delivery conditions and technical rules with which the products supplied comply, all characteristic data, code numbers and symbols necessary for enabling the assignment of the test results to the test units and consignments and, where required, to identify the different sampling and test conditions, and the inspector's mark;
b) the steel making process;
c) the results of the ladle analysis including the characteristic elements determined by this analysis;
d) the as delivered condition as specified in subclause 7.2 (stating the heat treatment temperatures, for quenched and tempered products);
e) the results of the tests to be carried out as described in subclause 9.2.

10 Marking

10.1 The products shall normally be marked with

a) the manufacturer's mark;
b) the material designation or number denoting the steel;
c) the cast number;
d) the test piece number;
e) the inspector's mark;
f) a stamp indicating that ultrasonic testing has been performed.

●● Any further marking to be applied shall be agreed at the time of ordering.

10.2 Marking shall generally be applied by stamping, a different marking method (e.g. labelling the bundle) for products with smaller diameters or thicknesses also being permitted.

11 Complaints

11.1 Under current law, warranty claims may only be raised against defective products if the defects impair their processing and use to a more than negligible extent. This shall apply unless otherwise agreed at the time of ordering.

11.2 It is normal and practical for the purchaser to give the supplier the opportunity to judge whether the complaints are justified, if possible by submitting the product objected to or samples of the products supplied.

Table 1. **Chemical composition of the steels as determined by ladle analysis**

Steel grade		Percentage by mass													
Material designation	Material number	C ≤	Si	Mn	P ≤	S ≤	N ≤	Al_{total}[1] ≥	Cr ≤	Cu ≤	Mo ≤	Ni ≤	Nb ≤	V ≤	Nb+V ≤
StE 285	**1.0486**	0,18	≤ 0,40	0,60 to 1,40	0,035	0,030	0,020	0,020	0,30[2]	0,20[2]	0,08[2]	0,30	0,03	-	0,05
WStE 285	**1.0487**	0,18			0,035	0,030									
TStE 285	**1.0488**	0,16			0,030	0,025									
StE 355	**1.0562**	0,20	0,10 to 0,50	0,90 to 1,65	0,035	0,030						0,30[5]	0,05	0,10	0,12
WStE 355	**1.0565**	0,20			0,035	0,030									
TStE 355	**1.0566**	0,18			0,030	0,025									
StE 420	**1.8902**	0,20			0,035	0,030			0,30	0,20[3]	0,10[4]	1,00[6]		0,20	0,22
WStE 420	**1.8932**				0,035	0,030									
TStE 420	**1.8912**				0,030	0,025									
StE 460	**1.8905**				0,035	0,030									
WStE 460	**1.8935**				0,035	0,030									
TStE 460	**1.8915**				0,030	0,025									
StE 500	**1.8907**	0,21			0,035	0,030								0,22	
WStE 500	**1.8937**				0,035	0,030									
TStE 500	**1.8917**				0,030	0,025									

1) If nitrogen is additionally controlled by niobium or vanadium, the requirement for a minum aluminium content need not be complied with.
2) The sum of the contents by mass of chromium, copper and molybdenum shall not exceed 0,45 %.
3) If copper is added as an alloying element, the maximum content by mass may be 0,70 %.
4) For thicknesses exceeding 150 mm, the maximum molybdenum content shall be 0,15 %.
5) If nickel is added as an alloying element, the maximum content by mass may be 0,85 %.
6) For thicknesses exceeding 150 mm, the maximum nickel content shall be 1,20 %.

Table 2. **Amounts by which the chemical analysis as determined by product analysis may deviate from the limiting values to be specified by the manufacturer for the ladle analysis**
(see subclause 7.3.2)

Element	Permissible percentage by mass as determined by ladle analysis	Limit deviations in the product analysis from the limiting values specified for the ladle analysis[1], percentage by mass
C	≤ 0,21	0,02
Si	≤ 0,60	0,05
Mn	≤ 1,00 > 1,00 ≤ 1,70	0,06 0,10
P	≤ 0,035	0,005
S	≤ 0,030	0,005
Cr	≤ 0,30	0,04
Cu	≤ 0,70	0,07
Mo	≤ 0,15	0,03
Ni	≤ 1,00 > 1,00 ≤ 1,20	0,05 0,08
Nb	≤ 0,05	0,01
V	≤ 0,22	0,02

1) If a number of product analyses are to be carried out, the deviations shown by an element within one cast shall lie either only above the upper limit or below the lower limit of the range specified for the ladle analysis, but not both at the same time for one cast.

Table 3. **Steel grades and mechanical properties of steel when subjected to tensile testing at ambient temperature**

Steel grade						Mechanical properties											
Basic series		High temperature series		Low temperature series		Tensile strength, R_m, in N/mm², for equivalent diameters[2], in mm		Minimum upper yield strength, R_{eH}[1], in N/mm², for equivalent diameters[2], in mm						Minimum elongation after fracture ($L_0 = 5\,d_0$), as a percentage, for equivalent diameters[2], in mm			
														≤ 150		> 150 ≤ 600	
Material designation	Material number	Material designation	Material number	Material designation	Material number	≤ 100	> 100 ≤ 600	≤ 24[3]	> 24 ≤ 50	> 50 ≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	Test piece location relative to direction of grain flow[4]			
														L	T/Q	L	T/Q
StE 285	1.0486	WStE 285	1.0487	TStE 285	1.0488	390 to 510	370 to 510	285		265	245	225	205	24	23	22	21
StE 355	1.0562	WStE 355	1.0565	TStE 355	1.0566	490 to 630	470 to 630	355		335	315	295	275	23	21	21	19
StE 420	1.8902	WStE 420	1.8932	TStE 420	1.8912	530 to 680	510 to 670	420	410	385	365	345	325	20	19	18	17
StE 460	1.8905	WStE 460	1.8935	TStE 460	1.8915	560 to 730	520 to 710	460	450	420	400	380	360	19	17	18	16
StE 500	1.8907	WStE 500	1.8937	TStE 500	1.8917	610 to 780	540 to 740	500	480	450	430	410	390	17	16	16	15

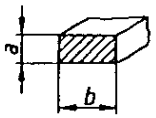
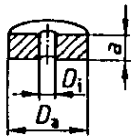
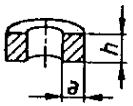
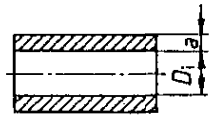
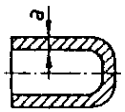
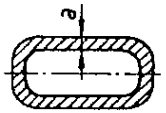
1) If there is no pronounced yield strength, the values shall apply for the 0,2 % proof strength.

2) The dimensions refer to the equivalent diameter (see table 4), which shall be determined on the basis of the dimensions existing at the time of heat treatment. Where required, this should be taken into account when calculating the dimensions.

3) Normally, this dimensional range does not apply for forgings.

4) Letter symbols L, T and Q indicate the test piece direction relative to the direction of grain flow (see subclause 9.3.3.1).

Table 4. **Thicknesses of products other than round bars corresponding to the equivalent diameters specified in tables 3, 5 and 6**

Equivalent diameter, d mm	Thickness, a, in mm, for								
	rectangular bars		discs	rings	cylindrical hollow bodies open at both ends			cylindrical hollow bodies closed at one end	cylindrical hollow bodies closed at both ends	other products
										
	$\frac{b}{a}$ = 1 to 2	$\frac{b}{a} \geq 2$	$D_a - D_i \geq 2a$ $D_i \leq 200$ mm $a = d/1{,}5$	$h > a$ $D_i > 200$ mm $a = d/1{,}5$	$D_i > 200$ mm $a = d/1{,}5$	$D_i \geq 80$ to ≤ 200 mm $a = d/1{,}75$	$D_i < 80$ mm $a = d/2$	$a = d/2{,}5$		
≤ 24	19	16	16	16	16	14	12	10		[1]
≤ 50	40	33	33	33	33	29	25	20		
≤ 100	80	67	67	67	67	57	50	40		
≤ 150	120	100	100	100	100	86	75	60		
≤ 375	300	250	250	250	250	214	188	150		
≤ 600	480	400	400	400	400	343	300	240		

[1] Appendix C gives examples for calculating the equivalent diameter of products of complex shape.

Table 5. **Requirements regarding elevated temperature 0,2 % proof strength[1]**

Steel grade		Minimum values of 0,2 % proof strength, in N/mm², for equivalent diameters[2], in mm																											
Material designation	Material number	100 °C					150 °C					200 °C				250 °C				300 °C				350 °C				400 °C			
		≤ 50	> 50 ≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 50	> 50 ≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600	≤ 100	> 100 ≤ 150	> 150 ≤ 375	> 375 ≤ 600
WStE 285	1.0487	255	245	226	206	186	235	226	206	186	167	206	186	167	147	186	167	147	128	157	137	118	98	137	118	98	78	118	98	78	59
WStE 355	1.0565	304	294	275	255	235	284	275	255	235	215	255	235	216	197	235	216	196	179	216	196	177	160	196	177	157	142	167	147	127	117
WStE 420	1.8932	363	353	333	314	294	343	335	314	294	275	314	294	275	255	284	265	245	226	265	245	226	206	235	216	196	176	208	186	167	147
WStE 460	1.8935	402	392	373	353	333	373	363	343	324	309	343	324	304	287	314	294	275	269	294	275	255	238	265	245	226	212	235	216	196	186
WStE 500	1.8937	422	412	392	373	353	392	382	363	343	324	363	343	324	304	333	314	294	289	314	294	275	257	284	265	245	226	255	235	216	196

1) The yield strength values given in table 3 shall apply for temperatures up to 50 °C. For temperatures between 50 °C and 100 °C, a linear interpolation shall be made between the yield strength values determined at ambient temperature and those at 100 °C.

2) The dimensions refer to the equivalent diameter (see table 4), which shall be determined on the basis of the dimensions existing at the time of heat treatment. Where required, this should be taken into account when calculating the dimensions.

Table 6. **Impact energy requirements to be met in impact tests on ISO V-notch test pieces**

Steel grades of	Test piece direction	Minimum impact energy values, A_V [1], at a test temperature, in °C, of							
		−50	−40	−30	−20	−10	0	+10	+20
		J							
basic series and high temperature series [2]	L	–	–	–	39	43	47	51	55
	T/Q	–	–	–	21	24	31	31	31
low temperature series	L	27 [3]	31 [3]	39 [3]	47 [2]	51 [2]	55 [2]	59 [2]	63 [2]
	T/Q	16 [3]	20 [3]	24 [3]	27 [2]	31 [2]	31 [2]	35 [2]	39 [2]

1) The test result shall be the average of three tests, but only one individual value may be lower, by not more than 30 %, than the lowest average value.

2) The values shall apply for equivalent diameters (see table 4) up to 600 mm.

3) The values shall apply for equivalent diameters (see table 4) up to 375 mm.

Table 7. **Summary of mandatory tests and agreed tests, with scope of test programme, sampling, sample preparation and test procedure**

	1	2	3	4	5	6	7
	The specifications given in columns 4 to 7 shall apply for the following as delivered conditions[1]	X = in any case[2]	X = subject to agreement	Test(s) to be carried out	Scope of testing	Sampling and sample preparation	Testing
1	All as delivered conditions	X		Ladle analysis	(At the manufacturer's discretion.)		
2	All as delivered conditions		X	Product analysis	One test piece each per cast and consignment	See subclause 9.3.1.	See subclause 9.4.1.
3	N	[3]		Hardness test (batch testing only) (see subclause 9.3.2)	See columns 1 to 23 of table 8.	See subclause 9.3.2.	See subclause 9.4.2.
4	V	X					
5	N, V	X		Tensile test at ambient temperature		See subclause 9.3.3 and columns 24 and 25 of table 8.	See subclause 9.4.3.
6	N, V	X		Impact tests			See subclause 9.4.4.
7	N, V	[4]		Tensile test for verification of elevated temperature 0,2 % proof strength (see subclause 9.4.3 for test temperature)	One test piece each per cast, heat treatment condition and consignment	See subclause 9.3.3.	See subclause 9.4.3.
8	All as delivered conditions	X		Visual examination of surface condition	At the acceptance inspector's discretion.	Test on the product	
9	All as delivered conditions	X		Test for accuracy to size and shape			
10	All as delivered conditions	See columns 5 and 6.		Non-destructive testing	Hollow bodies with an inside diameter exceeding 80 mm shall be subjected to an ultrasonic test for longitudinal defects. All other products not less than 300 kg in mass per unit piece (except for seamless rolled rings and rolled bars with an equivalent diameter not exceeding 100 mm) shall be subjected to an ultrasonic test for internal defects. ●● If non-destructive tests are to be carried out in addition on hollow bodies or other products, this shall be agreed at the time of ordering.		See subclause 9.4.5.

1) N = normalized;
V = quenched and tempered.

2) Alternative measures shall be agreed if the shape and size of the products do not permit the required test pieces to be taken or the tests to be carried out.

3) See the specifications given in columns 10 and 11 of table 8.

4) Mandatory for steels of the high temperature series, but subject to agreement for steels of the low temperature series.

Table 8. Scope of testing with regard to hardness testing of homogeneity, tensile testing at ambient temperature, impact testing, and location of tensile and impact test pieces

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Product form and manufacturing process	Requirements to be met by test unit for[1]			Maximum size of test unit					Number of products per test unit to be tested for hardness for				Number of specimens[5] to be taken per test unit for								Number of specimens to be taken per test piece for		Location of tensile and impact test pieces	
		N	V	V	for unit mass, G, in kg[2], or inside diameter, D_i, outside diameter or thickness, D, in mm	for				N		V		N		V									
		EF or SF	EF	SF		N EF or SF	V EF [3]	V EF [4]	V SF	with the same thermal cycle	without the same thermal cycle	FF	SF	$L < 5$ m or DLQ [6]	$L \geq 5$ m, NDL [6]	EF Test unit comprising not more than 10 items	EF $L \geq 5$ m, NDL [6]	EF Test unit comprising more than 10 items	EF $L \geq 5$ m, NDL [6]	SF [4]		tensile test	impact test	Distance from product surface	Test piece direction (see subclause 9.3.3.1)
1	Forgings (including seamless rolled rings) except those specified in lines 2 and 3	In one test unit, a) the products shall originate from the same cast; b) the products shall have been subjected to the same thermal cycle,			$G \leq 15$	150 items		Only subject to the restrictions given in column 3 or 4.		-	20 %[7]	100 %	10 % of the items, but not less than 20 items.	1[9]	2[9] [10]	1	2,	2,	4,	2,				In the case of seamless rolled rings, close to the surface; otherwise, the distance from surface and end face shall be ¼ of product thickness (see table 4) at the location to be tested, but not more than 80 mm.	Unless otherwise agreed, at the manufacturer's discretion. For D less than 160 mm: L, Q or T; for D not less than 160 mm: Q or T.
		or shall have been heat treated and shall meet the requirements for homogeneity as specified in subclause 7.4.1.		and shall meet the requirements for homogeneity as specified in subclause 7.4.1.	$15 < G \leq 150$	100 items				-	20 %[7]	100 %		1[9]	2[9] [10]		i.e. one specimen each from								
					$150 < G \leq 300$	50 items				-	20 %[7]	100 %		1[9]	2[9] [10]		both ends of an item	one end	both ends	the hardest or softest item, determined in the hardness test according to column					
					$300 < G \leq 1\,000$	25 items				-	20 %[7]	100 %		1[9]	2[9] [10]			of two items							
					$1\,000 < G \leq 5\,000$	5 items				-	100 %	100 %		1	2[10]										
					$5\,000 < G$	1 item				-	-	-		1	2[10]										
2	Hollow bodies	c) The equivalent cross section of the products shall have the same shape.			$D_i \leq 300$	100 items				-	20 %[7]	100 %	10 % of the items, but not less than 20 items.	1[9]	2[9] [10]									The distance from surface and end face shall be ¼ of wall thickness, but not more than 80 mm.	
					$300 < D_i \leq 600$	25 items				-	20 %[7]	100 %		1[9]	2[9] [10]							1	3		
					$600 < D_i$	1 item				-	-	-		1	2[10]						12 13				
3	Hammer forged steel bars or steel bars produced on forging machines	d) The equivalent diameters of all products shall lie within one of the ranges specified in table 3 and shall not be lower, by more than 20 %, than the maximum equivalent diameter within the batch.		d) All products shall have the same sizes.	$D \leq 100$	15 000 kg				-	20 %[7]	10 %[8]	10 %[8]	1	2[10]									In the case of condition N, for D up to 40 mm: optional; for D exceeding 40 mm: $D/6$. In the case of condition V, for D up to 25 mm: from the core; for D exceeding 25 mm: $D/6$.	For D not exceeding 160 mm: L; for D exceeding 160 mm: Q, unless otherwise agreed.
					$100 < D$	25 000 kg				-	20 %[7]	100 %	10 % of the items, but not less than 20 items.	1	2[10]										

1) N = normalized condition, V = quenched and tempered condition; EF = one-off production, SF = series production. For the purposes of this standard, series production means the production of more than 50 items, each series meeting the requirements specified in column 2 or 4 for one test unit.

2) 'Unit mass' is to be understood to be the mass of the product without integral test piece material at the time of heat treatment.

3) The specifications shall apply if (as is normally the case where unusually long test pieces are submitted for testing) the specimens to be subjected to tensile and impact testing cannot be taken from the hardest or softest item as determined in the product hardness test.

4) The specifications shall apply if the specimens to be subjected to tensile and impact testing can be taken from the hardest or softest item as determined in the product hardness test.

5) In the case of drop forgings, the slug resulting from hollow forging may be used as the test piece.

6) L = length of item without integral test piece material at the time of heat treatment; DLQ = the respective heat treatment (normalizing or quenching and tempering) has been made in a continuous furnace; NDL = the respective heat treatment has not been made in a continuous furnace.

7) Not less than six items, where available.

8) Not less than ten items.

9) In the case of more than four test units meeting the requirements of column 2, the required number of specimens shall only be taken from four test units.

10) One specimen each from either end of an item.

Appendix A

Guideline values for heat treatment

A.1 The heat treatment temperatures shall be selected as a function of the chemical composition of the steel.

A.2 Depending on the steel grade, normalizing shall generally be performed at temperatures between 880 and 960 °C, quench hardening at temperatures between 860 and 940 °C, partial austenizing, where required, at temperatures between 730 and 780 °C and tempering at temperatures between 560 and 700 °C (the temperatures are for guidance only).

A.3 Stress relieving of normalized steels shall be performed at temperatures between 530 and 580 °C and that of quenched and tempered steels, at temperatures not less than 30 °C below the tempering temperature (to be taken from the materials testing certificates), each with cooling in still air. The soaking time (see DIN 17 014 Part 1 for definition) shall be not less than 30 minutes, but shall not exceed 150 minutes for multiple annealing. Where the soaking time exceeds 90 minutes, the aim should be to maintain the lower limit of the temperature range.

If the relevant technical rules specify longer soaking times for stress relieving of large forgings, the steel manufacturer should be consulted beforehand.

Appendix B

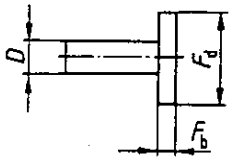
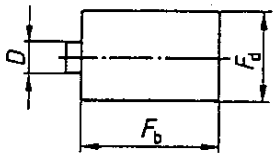
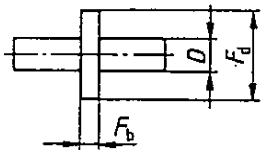
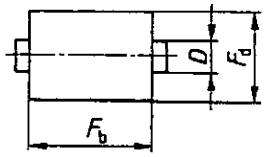
Dimensional standards relating to products covered in this standard

Dimensional standards for forgings

DIN 7521	Steel forgings; technical delivery conditions
DIN 7526	Steel forgings; tolerances and limit deviations for drop forgings
Supplement 1 to DIN 7526	Steel forgings; tolerances and limit deviations for drop forgings; examples of application
DIN 7527 Part 1	Steel forgings; machining allowances and limit deviations for hammer forged discs
DIN 7527 Part 2	Steel forgings; machining allowances and limit deviations for hammer forged pierced discs
DIN 7527 Part 3	Steel forgings; machining allowances and limit deviations for seamless hammer forged rings
DIN 7527 Part 4	Steel forgings; machining allowances and limit deviations for seamless hammer forged bushes
DIN 7527 Part 5	Steel forgings; machining allowances and limit deviations for hammer forged, rolled and welded rings
DIN 7527 Part 6	Steel forgings; machining allowances and limit deviations for hammer forged bars
DIN 15 401 Part 1	Lifting hooks for lifting appliances; single hooks; unmachined parts
DIN 15 402 Part 1	Lifting hooks for lifting appliances; ramshorn hooks; unmachined parts
DIN 15 412 Part 1	Bottom blocks for lifting appliances; cross pieces; unmachined parts

Appendix C

Examples of determining the equivalent diameter, d, of products of complex shape

Flange		$d = \sqrt{F_b^2 + D^2}$
Shaft end		$d = F_d$
Collar		$d = \sqrt{\left(\frac{F_d - D}{4} + D\right)^2 + F_b^2}$
Shaft, roller		$d = F_d$
Hexagon	(Bar) 	$d = 1{,}03 \cdot S_w$
Triangle	(Bar) 	$d = 0{,}7 \cdot a$

If two equations can be used to calculate d, both shall be applied, but the smaller value being taken as the equivalent diameter.

Key to symbols:

D = diameter;
a = edge length;
S_w = width across flats;
F_d = diameter of flange, shaft or roller;
F_b = width of flange, shaft or roller.

Standards and other documents referred to

DIN 17 010	General technical delivery conditions for steel and steel products
DIN 17 014 Part 1	Heat treatment of ferrous materials; terminology
DIN 50 049	Materials testing certificates
DIN 50 103 Part 1	Testing of metallic materials; Rockwell hardness testing; C, A, B, F scales
DIN 50 115	Testing of metallic materials; impact testing
DIN 50 125	Testing of metallic materials; tensile test pieces
DIN 50 133	Testing of metallic materials; Vickers hardness testing; HV 0,2 to HV 100
DIN 50 145	Testing of metallic materials; tensile testing
DIN 50 351	Testing of metallic materials; Brinell hardness testing
DIN 50 601	Metallographic examination; determination of the ferritic or austenitic grain size of steel and ferrous materials
DIN 54 130	Non-destructive testing; magnetic leakage flux method; general
DIN 54 152 Part 1	Non-destructive testing; penetrant testing; procedure
DIN 54 152 Part 2	Non-destructive testing; penetrant testing; verification of penetrants
EURONORM 79	Terminology and classification of steel products by shapes and sizes

Stahl-Eisen-Werkstoffblatt 088*) *Schweißgeeignete Feinkornbaustähle, Richtlinien für die Verarbeitung, besonders für das Schmelzschweißen* (Weldable fine grain structural steels; rules for processing, with special reference to fusion welding)

Stahl-Eisen-Werkstoffblatt 310 (at present at the stage of draft)*) *Physikalische Eigenschaften von Stählen* (Physical properties of steels)

Stahl-Eisen-Prüfblatt 1915*) *Ultraschallprüfung auf Längsfehler von Rohren aus warmfesten Stählen* (Ultrasonic testing for longitudinal defects in steel tubes with elevated temperature properties)

Stahl-Eisen-Prüfblatt 1921*) *Ultraschallprüfung von Schmiedestücken und geschmiedetem Stabstahl ab ~100 mm Durchmesser oder Kantenlänge* (Ultrasonic testing of forgings and forged steel bars of 100 mm diameter or edge length or more)

Richtlinie der Deutschen Gesellschaft für zerstörungsfreie Prüfung Durchführung der Magnetpulverprüfungen (1980 edition)

Handbuch für das Eisenhüttenlaboratorium (in loose-leaf form)*)

See Appendix B for other standards referred to.

Other relevant standards and documents

DIN 17 102	Weldable normalized fine grain structural steels; technical delivery conditions for plate, strip, wide flats, sections and bars
DIN 17 123	Welded circular fine grain steel tubes for structural steelwork; technical delivery conditions
DIN 17 124	Seamless circular fine grain steel tubes for structural steelwork; technical delivery conditions
DIN 17 125	Square and rectangular fine grain steel tubes (hollow sections) for structural steelwork; technical delivery conditions
DIN 17 178	Welded circular fine grain steel tubes subject to special requirements; technical delivery conditions
DIN 17 179	Seamless circular fine grain steel tubes subject to special requirements; technical delivery conditions
DIN 17 200	Steels for quenching and tempering; technical delivery conditions
DIN 17 243	Weldable steel forgings and rolled or forged steel bars with elevated temperature properties; technical delivery conditions
DIN 17 280	Steels with low temperature toughness; technical delivery conditions for plate, sheet, strip, wide flats, sections, bars and forgings

Stahl-Eisen-Werkstoffblatt 550*) *Stähle für größere Schmiedestücke* (Steels for large forgings)

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

Explanatory notes

When *Stahl-Eisen-Werkstoffblatt* 089-70 *Schweißbare Feinkornbaustähle, Gütevorschriften* (Weldable fine grain structural steels, quality specifications) issued by the *Verein Deutscher Eisenhüttenleute* (Society of German Ferrous Metallurgy Engineers) was adopted as a DIN Standard (see DIN 17 102), it was decided that DIN Standards should also be prepared for weldable fine grain structural steel tubes (see DIN 17 123, DIN 17 124, DIN 17 125, DIN 17 178, DIN 17 179) and for weldable fine grain structural steel forgings.

The specifications regarding chemical composition given in the above standards have been included in this standard, except for specifications regarding the Ti content, which is of no relevance for forgings as covered here.

The mechanical property values deviate from those specified in other DIN Standards covering fine grain structural steel, this being partly due to the fact that the products have here been assigned to different thickness ranges. Unlike other fine grain structural steel products, forgings covered in this standard may also be supplied in the quenched and tempered condition, this normally applying for products with an equivalent diameter exceeding 100 mm.

In response to market demand, this standard only specifies steel grades of the basic series, the high temperature series and the low temperature series, covering grades with a minimum yield strength of 285, 355, 420, 460 and 500 N/mm^2. Steel grades with a minimum yield strength of 285 N/mm^2 have been included, in particular, instead of steel grade ASt 41 N (previously specified in DIN 17 135 which has been withdrawn), which was preferably used for the manufacture of lifting hooks.

International Patent Classification

B 21 B
B 21 H 1/00 to 8/00
B 21 J 1/00
B 21 J 5/00
B 21 K 1/00 to 23/04
B 21 K 29/00
G 01 N 9/00
G 01 N 19/00
G 01 N 33/20