Our manufacture processes:
Sand Casting, Resin Sand Casting
Investment Casting, Lost Wax Casting or Precision Casting
Lost foam casting
Die casting.
CNC Machining.

The material included: cast gray iron, ductile iron, carbon steel, stainless steel, malleable iron ,brass alloy and aluminum alloy.

We serve and supply parts, components and products to wide varieties of industries as follow:
1. Valve fittings(valve body, wheel, disc, bonnet and others)
2. Pump Parts（Body, impeller and others）
3. Fastener (Bolt, nut, stud and gasket)
4. Automobile/ Motorcycle (drum, …)
5. Pipe Fittings(malleable iron fittings, threaded stainless steel fittings, ductile iron fittings and others)
6. Steel anchor products.
7. Food Processing.
8. Computer & communication Hardware.
9. Sporting Equipment.

Tel: +86 532 82972967 Fax: +86 532 82972913

http://www.castingquality.com mark@castingquality.com

UDC 669.131.7

DEUTSCHE NORMEN

October 1973

Cast Iron with Nodular Graphite
Unalloyed and Low Alloy Grades

DIN 1693 Part 1

Gußeisen mit Kugelgraphit; Werkstoffsorten, unlegiert und niedriglegiert

Dimensions in mm

For connection with ISO Recommendation ISO/R 1083 see Explanations. This Standard provides the basis for the quality specifications and test provisions of the Verband Güteschutz Gußeisen mit Kugelgraphit e.V. (Quality Protection Association for Cast Iron with Nodular Graphite), Düsseldorf, Sohnstraße 70 and for the DIN test and control symbol of the Deutsche Gesellschaft für Warenkennzeichnung GmbH (DGWK) (German Society for the Marking of Goods), Burggrafenstrasse 4-10, 1000 Berlin 30, see Explanations.

1. Definition

Cast iron with nodular graphite (GGG) is an iron-carbon casting material having the carbon component present as graphite which exists almost exclusively in a largely nodular form.

2. Grade classification

The grade classification (see Table 1 and Table 2) is based on tensile strength.
The characteristics for which minimum values are specified for specimens taken from separately cast test pieces (see Section 7) are, for the normal grades, apart from tensile strength, the 0.2 % proof stress and elongation, and, additionally the impact value for grades for which this is guaranteed.
The choice of grade is the concern of the purchaser. Its suitability for the intended casting from the viewpoint of casting practice shall be examined by the casting manufacturer. For castings with special properties or with guaranteed values[1]) going beyond those of Table 1 and Table 2, Sections 4, 5.1, 5.2, 6 and 8 shall be observed.

Table 1. Standard grades

Grade		Guaranteed properties determined from separately cast test pieces[3]) [4])			Reference data
Symbol	Material number	Tensile strength σ_B N/mm² min.	0,2 % proof stress[5]) $\sigma_{0,2}$ N/mm² min.	Elongation δ_5 % min.	Structure
GGG-40[2])	0.7040	400	250	15	predominantly ferritic
GGG-50	0.7050	500	320	7	ferritic/pearlitic
GGG-60	0.7060	600	380	3	pearlitic/ferritic
GGG-70	0.7070	700	440	2	predominantly pearlitic
GGG-80	0.7080	800	500	2	pearlitic

1) A standard dealing with guaranteed characteristic values of specimens taken from integrally cast test pieces or from the casting itself is in course of preparation.

2) The GGG-40 grade resulting from the combining of grades GGG-38 and GGG-42 of DIN 1693, Issue of September 1961, is interchangeable with those of the old issue of DIN 1693. The GGG-40 grade is supplied instead of the previously standardized grades GGG-38 and GGG-42.

3) See also Section 5.1; for section thicknesses >50 mm and compact castings in particular, agreement between manufacturer and user is urged; see also Footnote 1.

4) A Supplementary Sheet with a detailed exposition of the properties of the material is in course of preparation.

5) Instead of the 0.2 % proof stress it is permissible in the case of the ferritic grades to quote the yield point obtained from the testing machine diagram, due regard being paid to the more circumscribed test conditions - compared with DIN 50145 (new issue at present circulating as draft) - as mentioned in the Explanations.

Continued on pages 2 to 4
Explanations on pages 4 and 5

Alleinverkauf der Normen durch Beuth Verlag GmbH, Berlin 30 und Köln 1
DIN 1693 Bl. 1 engl. Preisgr. 5
10.73

Vertr.-Nr. 0105

Table 2. Grades with guaranteed impact values

Grade		Guaranteed properties determined from separately cast test pieces[3] [4]				
		Tensile strength σ_B	0.2 % proof stress[5] $\sigma_{0.2}$	Elongation δ_5	Impact value (DVM specimens) A_V in J min.	
Symbol	Material number	N/mm^2 min.	N/mm^2 min.	% min.	Mean[6] from 3 specimens	Individual value[6]
GGG-35.3	0.7033	350	220	22	14 at −40 °C	11 at −40 °C
GGG-40.3	0.7043	400	250	18	14 at −20 °C	11 at −20 °C

3. Symbols

In orders and on drawings the symbols or material numbers according to Table 1 and Table 2 are to be used, e.g. GGG-60.

4. Manufacturing method

Unless agreed to the contrary, the choice of manufacturing method and chemical composition of the material is left to the casting manufacturer.

5. Requirements and service properties

5.1. Strength properties

Table 1 and Table 2 define the mechanical properties obtained from specimens taken from separately cast test pieces. Differing requirements, e.g. mechanical properties at specific locations on the casting - test pieces to be cast on or removed from the casting[1] - or any additional requirements are to be agreed.

5.2. Physical and technological properties

Reference data on physical and technological properties, which are to be agreed as necessary, can be taken from a Supplementary Sheet in course of preparation. Weight calculations shall be based on a density of approx. 7.2 kg/dm^3. Dimensional changes occurring in the as cast condition after cooling as a result of shrinkage amount to 0 to 2 %, being mainly concentrated in the range from 0 to 0.8 %, according to crystalline structure, shape and casting method.

6. Heat-treatment

Castings made of cast iron with nodular graphite are supplied in the as cast condition or heat-treated. Castings made of GGG-35.3 must be annealed to give a ferritic condition. Heat-treatment to relieve casting stresses shall not result in any change of structure[7].

7. Sampling

The general principles of DIN 1605 Part 1 "Testing of materials, mechanical testing of metals; general and acceptance" apply, as appropriate, also to the sampling and testing of cast iron with nodular graphite. If the customer does not specify the shape and size of the test pieces, the decision on this will be taken by the casting manufacturer.

Separately cast test pieces shall be used for verifying the mechanical properties guaranteed in Table 1 and Table 2 for cast iron with nodular graphite.

For [1] [3] [4] and [5] see page 1

[6] At room temperature the impact value as the mean for a set of 3 specimens is not less than 19 J for GGG-35.3 and not less than 16 J for GGG-40.3. The individual values are as follows: not less than 17 J for GGG-35.3 and not less than 14 J for GGG-40.3.

[7] See VDG Data Sheet N1 "(Relief of residual stresses in castings made of cast iron with nodular graphite)"; obtainable through the library of the Verein Deutscher Gießereifachleute (German Foundrymen's Association), Sohnstrasse 70, 4000 Düsseldorf 1.

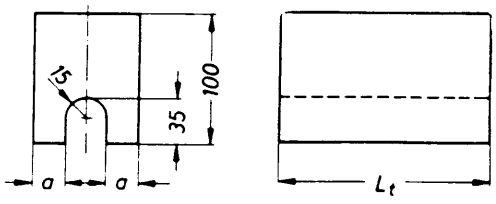

Figure 1. U test piece

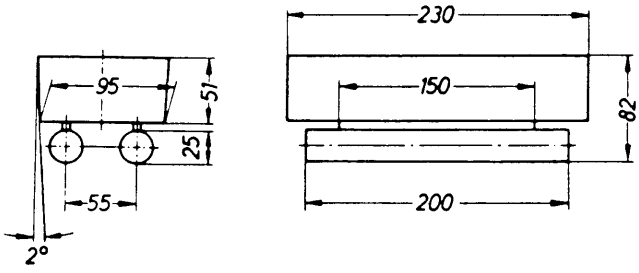

Figure 2. Simplified U test piece (Lynchburg-specimen).

These U test pieces are for making tensile specimens B 14 × 70 DIN 50125

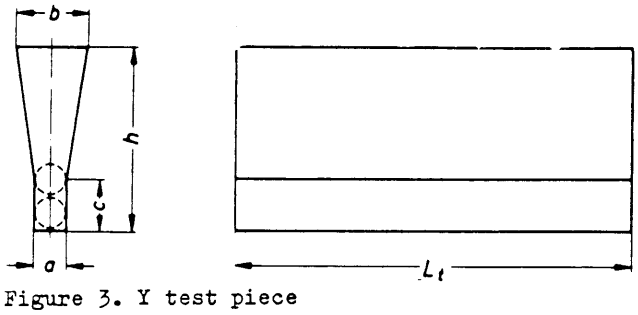

Figure 3. Y test piece

Table 3. Dimensions of U test piece and of tensile test specimens taken from it

No.	a	Overall length L_t Minimum	Test bar Tensile test specimen according to DIN 50125
U 1	25	125	B14 x 70
U 2	30		

Table 4. Dimensions of the Y test piece and of tensile test specimens taken from it

No.	Test piece				Overall length L_t Minimum	Test bar Tensile test specimen acc. to DIN 50125
	a	b	c	h		
Y 1	10	40	20	135	60	B 6 x 30
Y 2	25	55	40	140	125	B14 x 70
Y 3	50	100	50	150		
Y 4	75	125	65	175		

In general, U test pieces according to Figure 1, simplified U test pieces (Lynchburg specimens) according to Figure 2 od Y test pieces according to Figure 3 are used. The castings and associated test pieces are to be poured from the same ladle in direct succession as far as possible. For this purpose sand moulds shall normally be used. The thickness "a" of the U and Y type test pieces should be matched as closely as possible to the ruling section thickness of the casting. Other test piece shapes may be agreed.

When the castings are heat-treated the associated, separately cast test pieces must be jointly heat-treated with them. Integrally cast test pieces shall not be cut off until after heat-treatment.

8. Testing of material

When verification of the guaranteed values according to Table 1 and Table 2 or of values in respect of other properties is required, and when other testings (e.g. testing of chemical composition) are specified, agreement to this effect shall be reached. For assessment of the graphite formation the VDG Data Sheet P 441[8]), August 1962 "Code for identifying graphite formation" may be used.

8.1. Tensile test

The values generally determined are tensile strength, 0.2 % proof stress and elongation, use being made of the test bars indicated in Tables 3 and 4.

The testing is covered by:

DIN 50125 Testing of metallic materials; tensile test specimens, directions for their preparation

DIN 50145 Testing of metallic materials; tensile test (new issue at present circulating as draft)

8) Obtainable through the library of the Verein Deutscher Gießereifachleute, Sohnstrasse 70, 4000 Düsseldorf 1

8.2. Notched bar impact bending test

The notched bar impact bending test shall be performed according to DIN 50115 "Testing of steel and cast steel; notched bar impact bending test" on 3 specimens taken from test pieces according to Section 7.

8.3. Number of specimens and nominal dimensions of specimens

The number of specimens and their nominal dimensions according to DIN 50125 shall be agreed. In the absence of any agreement the manufacturer shall decide.

8.4. Retestings

If, in the first testing, the specimens taken in agreed number from the test piece fail to meet the requirements, substitute specimens shall be taken from the test piece and tested. If these substitute specimens also fail to meet the requirements, or if no substitute specimens can be taken from the test piece, an agreed number of specimens shall be taken from a second test piece or from a casting from the same batch of metal and tested. If these specimens also fail, the associated castings may be rejected (see also DIN 1605 Part 1).

In the case of spot tests on runs of castings, specimens which have failed through defects of material may be replaced - up to an agreed percentage of the sampling quantity - by other specimens taken from the same batch.

9. Certificates concerning testings and acceptance

Certificates regarding testings are to be agreed in the form of statements of compliance with the order, works reports or test certificates according to DIN 50049 "Certificates concerning tests of materials". The type of certificate and the nature and extent of testing must be specified at the time of ordering.

Explanations

The first issue of DIN 1693 was prepared in the years from 1955 to 1959 and it appeared in September 1961. In the meantime both the manufacture and the applications of the material have undergone considerable further development making revision of the Standard necessary. The classification of grades of the unalloyed and low alloy material has been modified as follows to bring it into line with the present state of the art as regards manufacture and use.

The GGG-45 grade, which is listed in the September 1961 Issue of DIN 1693 with the low elongation of 5 % has proved to be of no significance and has been deleted.

The ferritic grades GGG-38 and GGG-42, which were formerly segregated because they were based on different manufacturing technologies, have been combined to form a single grade GGG-40. The two ferritic/pearlitic grades GGG-50 and GGG-60 have been retained although, because of differences in the proportions of ferrite and pearlite in the structure, the first-mentioned grade exhibits a comparatively wide scatter in regard to its mechanical properties in the as cast condition, depending on section thickness casting shape.

The range of high tensile strength grades has been enlarged by inclusion of the GGG-80 grade with a purely pearlitic structure in the non-heat-treated condition. ISO/TC 25 "Cast iron" is also concerned with following up this development. Corresponding proposals are under discussion.

The grades GGG-50, GGG-60 and GGG-70 are approximately in agreement with ISO Recommendation ISO/R 1083. Although the GGG-38 and GGG-42 grades are still contained in ISO/R 1083, their interchangeability with the new grade GGG-40 according to DIN 1693 Part 1 is assured, so that agreement between ISO and DIN exists here also.

In GINA work has been proceeding for some time on the preparation of a DIN standard giving general technical conditions of delivery for castings and it is intended that this shall contain all the general conditions relating to castings. This development has been taken into account and DIN 1693 divided into Part 1 (grades of material) and Part 14 (castings).

With the adoption of this arrangement the work on standards for cast iron with nodular graphite is also in harmony with ISO/R 1083, since this only specifies grades of material. It is proposed to withdraw DIN 1693 Part 14 as soon as the DIN standard dealing with general technical conditions of delivery for castings appears.

Since the mechanical properties of ductile cast iron as a material for centrifugally cast pressure pipes are to be determined on test bars removed from the cast pipe, and not on separately or integrally cast specimens, this grade has not been covered by DIN 1693 Part 1, but instead is dealt with in DIN 28600 "Pressure pipes and fittings of ductile cast iron for gas and water mains".

The increasing importance of the ferritic grades with guaranteed impact values has led to the inclusion in this Standard of the GGG-35.3 and GGG-40.3 grades (Table 2). Manufacture of the GGG-35.3 grade in particular normally calls for the use of special grades of pig iron with the lowest possible content of carbon-stabilizing elements. With regard to content of accompanying elements. the aim is to achieve levels of Si$\leqq$2.1 %, Mn$\leqq$0.1 % and P$\leqq$0.05 %. The guaranteed impact value can usually only be secured by way of heat-treatment.

For denoting the ductility of the material the absolute level of the impact value is of less significance than the level of the transition temperature from the region of ductile fracture to the region of brittle fracture. Impact values at minus temperatures are quoted primarily with a view to allow the level of the transition temperature to be estimated.

Since a natural pronounced yield point occurs only with the ferritic grade, and since an increasing proportion of pearlite in the structure of the higher strength grades precludes its determination from the testing machine diagram with an adequate degree of confidence, the 0.2 % proof stress has been introduced as standard for all grades. With the ferritic grade there is the option of substituting the easier yield point measurement subject to the error limit of the 0.2 % proof stress determination, provided that the following conditions circumscribing the method compared with DIN 50145 (new issue at present circulating as draft) are observed:

- yield point is measured on test bar without preloading
- rate of loading when using method applying load continuously between 0.5 times yield point and 1.2 times yield point to be 2 N/(mm^2 s) max., and beyond this point until fracture occurs at 10 N/(mm^2 s) max.
- when using the method with stepwise unloading, a hold of 0.5 min./load level to be observed.

Mathematical-statistical studies of the relationship between the mechanical properties have confirmed the empirical finding that the guaranteed yield point values in DIN 1693, Issue of September 1961, are only achievable by sacrificing toughness and establishing a tensile strength considerably above the minimum value. In conformity with the natural behaviour of the material, therefore, the minimum values of 0.2 % proof stress habe been reduced by an insignificant amount whilst retaining the interchangeability of grades.

In general, the mechanical properties of metal castings are dependent on section thickness, i.e. they are influenced to a greater or lesser extent by the rate of cooling which in turn depends largely on the geometrical proportions of the casting shape. Moreover, the critical rate of cooling is also influenced by the chemical composition of the molten metal in so far as graphitizing elements such as silicon tend to slow the cooling rate, whereas carbide-stabilizing elements tend to increase it.

With separately cast test pieces the cooling rate depends solely on the section thickness and in this case there are connections between the chemical composition and the cooling rate on the one hand and the mechanical properties on the other.

To identify the values associated with particular properties of cast iron with nodular graphite, therefore, the thicknesses of the U and Y type test pieces must be matched as closely as possible to the ruling thicknesses of the casting. By "ruling thickness" is understood that thickness of section of a casting which is stated by the customer as being the one principally stressed.

After heat-treatment, however, the mechanical properties of castings made of cast iron with nodular graphite are largely independent of differences in section thickness up to a thickness of about 50 mm.
The material symbol GGG, formed from the initial letters of the terms "gegossen" (cast), "Gußeisen" (cast iron) and "globular" (nodular) has been specified in the light of the directions in DIN 17006 Part 4. There is a whole range of other terms for the material in the literature and daily usage, e.g. "spheroidal graphite cast iron", "ductile cast iron", "nodular iron", "spherolitic cast iron", "spheroidal cast iron" etc., which certainly do not denote special grades, but instead designate the same material group. In international usage the term "ductile cast iron" normally denotes cast iron with nodular graphite for making centrifugally cast pipes. The term "spheroidal cast iron" ("Sphäroguß") is a protected trade name.

The Verband Güteschutz Gußeisen mit Kugelgraphit e.V. can grant a quality symbol for the use in this connection. The quality symbol consists of a rounded capital letter "G" with the legend "Quality symbol - RAL" "Cast iron with nodular graphite" enclosing the Arabic numeral "4". The symbol is read as "4 G cast iron" (meaning quality protection (Güteschutz), cast iron (Gußeisen) , cast (gegossen) and nodular (globular); the last "3 Gs" stand for the symbol "GGG" of DIN 1693 Part 1). On castings the quality symbol is used without legend. The object of the Association is to guarantee to purchasers of castings that the products marked with this quality symbol comply with the quality specifications and DIN standards in regard to the material.

Provided that the material and the casting satisfy the requirements of DIN 1693 and any special agreements reached, and provided also that this is verified by external and internal quality control, the castings concerned may be marked with the DIN test and control symbol (see Section 10 of DIN 1693 Part 14, Issue of October 1973).

As supplementary information on the range of applications of cast iron with nodular graphite, particulars of mechanical and physical properties are to be given in a Supplementary Sheet in course of preparation; the values given will be re-examined, supplemented and if necessary corrected from time to time in the light of further test results as these become available.

UDC 669.131.7 : 669.15-196 : 539.4 : 620.1 DEUTSCHE NORMEN October 1977

Cast Iron with Nodular Graphite

Unalloyed and Low Alloy Grades
Properties in Cast-on Test Piece

DIN 1693 Part 2

Gusseisen mit Kugelgraphit, unlegiert und niedriglegiert; Eigenschaften im angegossenen Probestück

1 Scope and application

This Standard applies to the properties of specimens from cast-on test pieces of cast iron with nodular graphite corresponding to Table 1, primarily for casting weights over 2000 kg and/or section thicknesses from 50 to 200 mm (compact castings).

If this Standard is applied to castings with lower weights and smaller section thicknesses [1]) and/or with section thicknesses larger than 200 mm separate agreements shall be reached at the time of ordering regarding the cast-on specimen and the properties to be guaranteed.

Cast-on test pieces are more informative about the properties of the castings indicated above under Scope than are separately cast test pieces.

The properties of specimens taken from separately cast test pieces are covered by DIN 1693 Part 1.

2 Properties in cast-on test pieces

Table 1 gives the criteria to be met by the properties of cast-on test pieces. Any additional requirements, such as mechanical properties in specific parts of the casting, are to be agreed at the time of ordering. For this purpose areas of the casting which are severely stressed mechanically and/or required to exhibit special technological or physical properties, are to be clearly identified by the customer (e. g. in drawings).

Table 1. **Properties in cast-on test pieces**

Grade according to DIN 1693 Part 1		Ruling wall thickness of the casting	Thickness of cast-on test piece	Tensile strength R_m	0.2 % yield limit $R_{p\,0.2}$ [1])	Elongation at break A_5	Absorbed energy [2]) (DVM specimens) at − 20 °C A		Reference data
							average of 3 specimens	individual value	Structure
Symbol	Material number	mm	mm	N/mm² min.	N/mm² min.	% min.	Joule min.		
GGG-40.3	0.7043	from 30 to 60 over 60 to 200	40 70	390 370	250 240	15 12	14 12	11 9	predominantly ferritic
GGG-40	0.7040	from 30 to 60 over 60 to 200	40 70	390 370	250 240	15 12	–		predominantly ferritic
GGG-50	0.7050	from 30 to 60 over 60 to 200	40 70	450 420	300 290	7 5	–		ferritic/ pearlitic
GGG-60 [3])	0.7060	from 30 to 60 over 60 to 200	40 70	600 550	360 340	2 1	–		pearlitic/ ferritic
GGG-70 [3])	0.7070	from 30 to 60 over 60 to 200	40 70	700 650	400 380	2 1	–		predominantly pearlitic

[1]) Instead of the 0.2 % yield limit it is permissible in the case of the ferritic grade to quote the yield point obtained from the testing machine diagram, due regard being paid to the more restricted process conditions compared with DIN 50 145, as referred to in the Explanations.

[2]) For other test temperatures the values for absorbed energy are to be agreed.

[3]) Tensile strength and elongation are not guaranteed if minimum hardness values are specified for reasons of increased wear resistance.

[1]) See also AD-Merkblatt W3-2 Gusseisenwerkstoffe; Gusseisen mit Kugelgraphit, unlegiert und niedriglegiert (AD Data Sheet W3-2 Cast Iron Grades; Cast Iron with Nodular Graphite, Unalloyed and Low Alloy) March 1968, obtainable through: Beuth Verlag GmbH and Carl Heymanns Verlag KG, both of Berlin and Köln.

Continued on pages 2 and 3
Explanations on pages 3 and 4

Translation
Fachtechnisches Übersetzungsinstitut
Henry G. Freeman, Dusseldorf

Sole selling agent for German Standards (DIN-Normen) and VDE Regulations: Beuth Verlag GmbH, Berlin 30
06.81

3 Shrinkage

The dimensional changes brought about by shrinkage amount to 1.2 % at the most.

4 Sampling

The general principles according to DIN 1605 Part 1 "Testing of materials; mechanical testing of metals; general and acceptance" apply as appropriate also to the sampling and testing of compact castings of cast iron with nodular graphite.

For determining the properties according to Table 1 cast-on test pieces conforming to Fig. 1 with dimensions according to Table 2 are used. Other forms of test piece are subject to agreement.

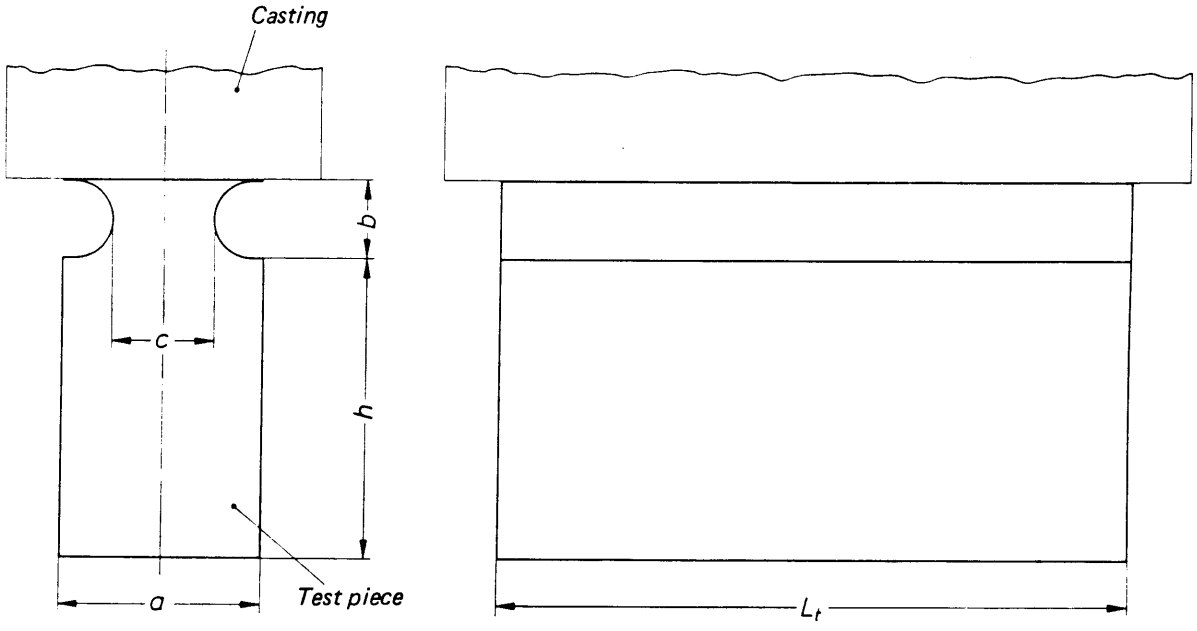

Figure 1. Cast-on test piece

Table 2. **Dimensions of the cast-on test piece**

Form	Cast-on test piece				
	a mm	b mm max.	c mm min.	h mm	L_t mm
1	40	30	20	40 to 60	125
2	70	52,5	35	70 to 105	125

Factors connected with the design of the casting and with the running and feeding system restrict the possibilities of providing cast-on test pieces. The cast-on test pieces shall not create any additional junctions in the casting which might cause casting defects. Instead, they should preferably be provided as short vertical extensions in the downward direction, for example on flanges and webs. To ensure intimacy of thermal linkage they shall be attached to the casting throughout the test piece length L_t. Any use of explosive cores or mould fillets which is intended to facilitate the detaching process and which goes beyond the arrangement shown in Fig. 1 has to be agreed between manufacturer and purchaser. The ruling dimensions for the necked-in portion are $b = 0.75 \cdot a$ and $c = \frac{a}{2}$. Forms other than this have to be agreed. Unless agreed to the contrary with the purchaser, the decision on position, size and form of the cast-on test pieces will be taken by the casting manufacturer in the light of Tables 1 and 2. The cast-on test pieces shall not be detached until after any heat treatment specified has been carried out. Exceptions to this are only allowed in the case of stress relieving [2]) which does not modify the structure.

When the test pieces are cast-on at the side, the specimens shall be taken from the bottom two-thirds.

---

2) See VDG Merkblatt N 1 „Abbau von Eigenspannungen in Gussstücken aus Gusseisen mit Lamellengraphit" (VDG Data Sheet N 1 "Reduction of Residual Stresses in Castings made of Cast Iron with Lamellar Graphite") obtainable through the library of the Verein Deutscher Giessereifachleute (Association of German Foundrymen), Sohnstrasse 70, 4000 Düsseldorf.

5 Test of properties using cast-on test pieces

5.1 Tensile test

The tensile test is to be performed according to DIN 50 145 using the tensile specimen DIN 50 125 – B 14 x 70.

5.2 Notched bar impact bending test

The notched bar impact bending test is to be performed according to DIN 50 115 on 3 DVM specimens at a test temperature of – 20 °C, see Table 1.

5.3 Number of specimens and test piece dimensions

The number of specimens and the form of the test piece according to Table 2 are to be agreed. At the same time allowance shall be made for specimens for possible repeat tests. In the absence of any agreement the decision is the manufacturer's.

5.4 Repeat tests

5.4.1 If the unsatisfactory outcome of a test is obviously attributable to deficiencies in the testing or to faulty preparation of the specimen, which however must not stem from shortcomings in the material itself, then such result shall be disregarded when reaching a decision on fulfilment of the requirements and the test concerned shall be repeated.

5.4.2 If the results of a proper test fail to satisfy the prescribed requirements a repeat test may be performed. In this case for each unsatisfactory test two further tests are to be carried out on another test piece from the same test unit. Test pieces with unsatisfactory results are to be segregated.

5.4.3 The test unit is deemed to conform to the conditions if both repeat tests turn out satisfactorily. It may be rejected if one of the repeat tests is not good enough.

6 Certificates regarding tests and acceptance

If proof of the tests performed is required, the kind of certification according to DIN 50 049 shall be agreed at the time of ordering.

7 Mechanical strength characteristics in the casting (0.2 % yield limit)

The 0.2 % yield limit values in Table 3 are for guidance purposes when making calculations for castings up to 200 mm section thickness. Where concentrations of material (junction points) occur, the value to be used as the basis for the calculation is not the wall thickness but instead the diameter of the largest inscribable cylinder.

Table 3. **Guidance values for 0.2 % yield limit**

Grade	0.2 % yield limit · $R_{p\,0.2}$ N/mm² min. for wall thicknesses			
	up to 50 mm	over 50 up to 80 mm	over 80 up to 120 mm	over 120 up to 200 mm
GGG-40	250	240	230	230
GGG-50	290	280	270	260
GGG-60	360	340	330	320
GGG-70	400	380	370	360

Explanations

It is true that the properties of cast iron with nodular graphite depend less on wall thickness than do those of cast iron with lamellar graphite; from certain casting dimensions upwards, however, and particularly where large hand-moulded castings are concerned, this dependence has to be taken into account.

Thus, where relatively heavy castings and increasing wall thicknesses are involved, the slower progress of crystallization and transformation processes bring about mechanical strength properties which differ from those determined in DIN 1693 Part 1 on separately cast pieces. Various causes account for this:

a) When cooling proceeds slowly the crystallization nuclei arising per unit volume are fewer in number than when solidification is more rapid in areas of smaller wall thickness. This results in relatively large graphite spheres with broader borders of metallic matrix (eutectic cells) surrounding them. In the

regions where these borders are in contact there is a possibility that segregations will occur to a greater extent and will no longer be capable of dispersing sufficiently through diffusion during further cooling. The manufacturer can keep the tendency towards such segregation within limits by choosing a suitable composition and by effective inoculation to increase the number of nuclei, but he cannot avoid this effect entirely.

b) The consequence of the slow progress of the crystallization processes with large wall thicknesses is that the nodular graphite does not always assume the ideal round spherolitic form, instead it often occurs in a form resembling temper carbon or as quasi-flakes. By careful choice of the charge materials and supervision of the treatment process it is possible to keep this technological effect also within limits. Assuming the same kind of basic structure, e. g. ferrite, the consequence of these two effects is that, after transgression of the 0.2 % yield limit which is usually only slightly affected, the ductility of the material is lower. This means that the tensile strength and elongation at break are reduced with increasing wall thickness of the casting.

c) Just as with crystallization, so also is the transformation range traversed more slowly with increasing casting weight and wall thickness. This promotes ferrite formation in the matrix. Pearlite components show a coarser banded structure resulting in reduced hardness and strength. Ferritic basic structures are thus more readily established with the possibility of pearlite borders remaining in the segregation zones. To obtain a predominantly pearlitic matrix it is necessary to use pearlite-stabilizing alloying additions which, however, must not promote cell boundary segregations.

These processes which have to be taken into account in the solidification and cooling of thick-walled and heavy castings call for cast-on test pieces instead of separately cast test pieces. Through the intimate heat linkage with the casting, the cast-on test pieces are better constituted to give information on the mechanical strength properties in the casting. For reasons of standardization, two wall thicknesses, namely 40 mm and 70 mm, are to be used for these cast-on test pieces. The appropriate positioning of these specimens depends on the shape of the castings and on the running and feeding system. Hence only general recommendations can be given for them.

The mechanical strength properties in these cast-on test pieces reflect the properties to be expected in the castings themselves far better than do separately cast test pieces. Nevertheless even they do not necessarily represent the properties of the piece, since it is quite likely that the cooling behaviour of the cast-on test pieces will differ from that of the various regions of the casting.

In a large scale investigation of about 1000 sets of values obtained from specimens which were separately cast, cast-on and taken from the actual castings, the mathematical-statistical method of scatter band analysis was applied for finding relationships which form the basis of this Standard. The objective of this investigation was to disclose guaranteed properties in the casting in relation to those of the cast-on specimen. The amount of material available, however, proved to be still too small to allow guaranteed values of this kind to be defined.

Only for the 0.2 % yield limit, which reveals a relationship with comparatively small scatter in its dependence on section thickness, was it possible to state prospective minimum values in the piece as guidance figures for different wall thickness ranges. They give a 95 % probability of being exceeded and thus provide a useful basis for design. Hence the following alternatives arose:

- delaying standardization until such time as adequate figures for property values are available for defining guaranteed minimum values in the casting;
- or summarizing the present state of knowledge concerning properties in castings made of cast iron with nodular graphite.

The intention is that use of this Standard, which enables the processes of sampling and testing to be unified, will allow experience to be acquired which will facilitate future standardization on a more comprehensive scale.

The following additional information is given regarding the grades quoted in this Standard.

GG-40:

This is a largely ferritic basic grade which makes exacting demands on manufacturing practice. The formation of relatively thick segregation borders has to be prevented for guaranteeing high ductility throughout the casting.

GGG-40.3:

This grade with guaranteed absorbed energy makes exceptionally stringent demands on the charge materials and on melting practice and treatment practice if a largely homogeneous, fine-grained material is to be obtained. When there are large differences in wall thickness in the casting or pearlite components of more than 10 % in the structure, a structure-modifying heat treatment is generally necessary.

GGG-60:

The pearlitic-ferritic basic grade is normally produced in the as-cast condition. It is distinguished by high mechanical strength and good resistance to wear.

GGG-70:

The high 0.2 % yield limit and tensile strength of the GGG-70 grade call for a predominantly fine-banded pearlite matrix in the structure. In view of the slow cooling of thick-section parts in the mould the development of this structure is often only achievable by means of alloying additions with a pearlite-stabilizing action. An alternative approach is subsequent heat treatment at austenite temperatures followed by accelerated cooling through the transformation range. Large wall thicknesses, however, place limits on this method. Sometimes the two methods are also used in combination.

GGG-50:

As regards production practice this grade is not easy to make. With heavy items in particular there may be problems in establishing in different wall thickness regions the same pearlite contents for ensuring both the necessary 0.2 % yield limit and tensile strengths as well as relatively high elongation values. Wherever justifiable from the aspect of casting design, recourse should be had if possible to the basic grades GGG-40 or GGG-60.

The grades GGG-35.3 and GGG-80 have so far not acquired any practical significance where the larger sizes of casting are concerned. They have therefore been left out of account.