UDC 669.13 : 669.112.227.1

September 1981

Austenitic cast iron

Reference data on mechanical and physical properties

Supplement 1 to DIN 1694

Austenitisches Gusseisen; Anhaltsangaben über mechanische und physikalische Eigenschaften

Supersedes 10.66 edition

As it is current practice in standards published by the International Organization for Standardization (ISO), the comma has been used throughout as a decimal marker

This supplement contains information additional to DIN 1694 but no additional standardized specifications

Tables 1 to 4 contain reference data on the mechanical and physical properties of flake graphite and spheroidal graphite austenitic cast iron.

Table 5 contains reference data on the mechanical properties of the material GGG-NiMn 23 4 at low temperatures.

Table 6 contains reference data on the mechanical properties of spheroidal graphite austenitic cast irons at elevated temperatures.

Table 7 contains reference data relating to the turning of some austenitic cast irons.

Table 8 contains reference data relating to the cutting speeds which should be used when machining some austenitic cast irons.

A horizontal dash in a column of the table indicates that it was not possible to give reference values in this case.

Figures 1 to 3 show coefficients of thermal expansion of some grades of spheroidal graphite austenitic cast iron.

Effect of alloying elements

The austenitic matrix is obtained by the addition of nickel, manganese or nickel and copper. In the case of the lower alloy grades it is important not to go below the lower limits for the nickel content because otherwise the matrix will no longer be purely austenitic. Too low a content of nickel, manganese or nickel and copper will result in the occurrence of ferromagnetism, increase hardness and impair workability. In the case of castings of large wall thickness in particular, i.e. with a slow rate of cooling, the percentage of austenite stabilizing elements must not be at the lower limit. With increasing chromium content, the strength, hardness, resistance to scale formation and resistance to growth increase and the weldability improves.

The workability on the other hand is better as the chromium content is smaller. Grades with a matrix which is not itself magnetizable become increasingly ferromagnetic with chromium contents of more than 2,5 % because the precipitated chromium-rich carbides are themselves ferromagnetic.

In grade GGG-NiMn 23 4 chromium, which is here an unwanted alloying element, shall not exceed 0,2 % because otherwise the values for the notch impact strength given in tables 3 and 5 will not be attainable. Lower carbon contents will increase the strength, hardness and toughness. On the other hand, alloys with higher carbon content can more readily be cast. Normally therefore, the aim shall be to approach the upper limit of carbon content.

In the case of grade GGG-NiCrNb 20 2 it is necessary to maintain the narrow limits for the alloying elements because otherwise weldability may be impaired; in particular, low magnesium and phosphorus contents are necessary.

Testing

In determining the physical properties of austenitic cast iron it is important to bear in mind that the casting skin will not normally exhibit the same properties as the cast metal. This is particularly the case in testing the electrical and magnetic properties.

It is therefore advisable in preparing test samples to carefully remove the casting skin whilst avoiding subjecting the material to mechanical stresses so severe that it exhibits plastic flow on the surface as, in that case, the surface will once again exhibit properties differing from the material in the test sample.

The best test methods are therefore those which average the property being measured over a test piece volume that is not too small. It is advisable to produce from an integrally cast test sample a round test piece of about 10 mm in diameter and 100 mm in length by a machining method, exercising care (low cutting depth and cutting speed). The test piece must then be carefully pickled because any traces of abraded ferromagnetic tool particles adhering to the surface or deformation martensite could seriously alter the test results.

Continued on pages 2 to 7

Table 1. **Reference data on mechanical properties of flake graphite austenitic cast iron**

Grade: Symbol according to DIN 1694	Grade: Material number	Mechanical properties: Tensile strength R_m N/mm²	Compressive strength R_D N/mm²	Elongation A_5 %	Modulus of elasticity E kN/mm²	Brinell hardness HB
GGL-NiMn 13 7	**0.6652**	140 to 220	630 to 840	–	70 to 90	120 to 150
GGL-NiCuCr 15 6 2	**0.6655**	170 to 210	700 to 840	2	85 to 105	120 to 215
GGL-NiCuCr 15 6 3	**0.6656**	190 to 240	860 to 1100	1 to 2	98 to 113	150 to 250
GGL-NiCr 20 2	**0.6660**	170 to 210	700 to 840	2 to 3	85 to 105	120 to 215
GGL-NiCr 20 3	**0.6661**	190 to 240	860 to 1100	1 to 2	98 to 113	160 to 250
GGL-NiSiCr 20 5 3	**0.6667**	190 to 280	–	2 to 3	–	140 to 250
GGL-NiCr 30 3	**0.6676**	190 to 240	700 to 910	1 to 3	98 to 113	120 to 215
GGL-NiSiCr 30 5 5	**0.6680**	170 to 240	560	–	105	150 to 210

Table 2. **Reference data on physical properties of flake graphite austenitic cast iron**

Grade: Symbol according to DIN 1694	Physical properties: Density kg/dm³	Coefficient of linear expansion (20 to 200 °C) 10^{-6}/K	Thermal conductivity W/m · K	Specific heat J/g · K	Specific electrical resistance $\frac{\Omega \cdot mm^2}{m}$	Permeability (where H = 100 Oe)
GGL-NiMn 13 7	7,4	17,7	37,7 to 41,9	46 to 50	1,2	1,02
GGL-NiCuCr 15 6 2	7,3	18,7			1,6	1,03
GGL-NiCuCr 15 6 3	7,3	18,7			1,1	1,05
GGL-NiCr 20 2	7,3	18,7			1,4	1,04
GGL-NiCr 20 3	7,4	18,7			1,2	1,04
GGL-NiSiCr 20 5 3	7,4	18,0			1,6	1,1
GGL-NiCr 30 3	7,4	12,4			–	–
GGL-NiSiCr 30 5 5	7,4	14,6			1,6	> 2

Table 3. **Reference data on mechanical properties of spheroidal graphite austenitic cast iron**

Grade: Symbol according to DIN 1694	Grade: Material number	Tensile strength R_m N/mm²	0,2 % proof stress $R_{p\,0,2}$ N/mm²	Elongation A_5 %	Modulus of elasticity E kN/mm²	Notch impact strength *) A_v (DVM-specimen) J	Brinell hardness HB
GGG-NiMn 13 7	0,7652	390 to 470	210 to 260	15 to 18	140 to 150	–	120 to 150
GGG-NiCr 20 2	0.7660	370 to 480	210 to 250	7 to 20	112 to 130	14 to 27	140 to 200
GGG-NiCrNb 20 2	0.7659	370 to 480	210 to 250	8 to 20	112 to 130	14 to 27	140 to 200
GGG-NiCr 20 3	0.7661	390 to 500	210 to 260	7 to 15	112 to 133	12	150 to 255
GGG-NiSiCr 20 5 2	0.7665	370 to 440	210 to 260	10 to 18	–	–	180 to 230
GGG-Ni 22	0.7670	370 to 450	170 to 250	20 to 40	85 to 112	21 to 33	130 to 170
GGG-NiMn 23 4	0.7673	440 to 480	210 to 240	25 to 45	120 to 140	24 to 34	150 to 180
GGG-NiCr 30 1	0.7677	370 to 450	210 to 270	13 to 18	112 to 130	16	130 to 190
GGG-NiCr 30 3	0.7676	370 to 480	210 to 260	7 to 18	92 to 105	8	140 to 200
GGG-NiSiCr 30 5 2	0.7679	380 to 500	210 to 270	10 to 20	130 to 150	10 to 16	130 to 170
GGG-NiSiCr 30 5 5	0.7680	390 to 500	240 to 310	1 to 4	91	–	170 to 250
GGG-Ni 35	0.7683	370 to 420	210 to 240	20 to 40	112 to 140	20	130 to 180
GGG-NiCr 35 3	0.7685	370 to 450	210 to 290	7 to 10	112 to 123	7	140 to 190
GGG-NiSiCr 35 5 2	0.7688	370 to 500	200 to 290	10 to 20	110 to 145	12 to 19	130 to 170

*) The values in DIN 1694 refer to ISO Vee notch specimens.

Table 4. **Reference data on physical properties of spheroidal graphite austenitic cast iron** *)

Grade: Symbol according to DIN 1694	Grade: Material number	Density kg/dm³	Coefficient of linear expansion (20 to 200 °C) 10^{-6}/K	Thermal conductivity W/m · K	Specific electrical resistance $\frac{\Omega \cdot mm^2}{m}$	Permeability (where H = 100 Oe)
GGG-NiMn 13 7	0.7652	7,3	18,2	12,6	1,0	1,02
GGG-NiCr 20 2	0.7660	7,4	18,7	12,6	1,0	1,04
GGG-NiCrNb 20 2	0.7659	7,4	18,7	12,6	–	1,04
GGG-NiCr 20 3	0.7661	7,45	18,7	12,6	1,0	1,05
GGG-NiSiCr 20 5 2	0.7665	7,35	18,0	12,6	–	–
GGG-Ni 22	0.7670	7,4	18,4	12,6	1,0	1,02
GGG-NiMn 23 4	0.7673	7,45	14,7	12,6	–	1,02
GGG-NiCr 30 1	0.7677	7,45	12,6	12,6	–	–
GGG-NiCr 30 3	0.7676	7,45	12,6	12,6	–	–
GGG-NiSiCr 30 5 2	0.7679	7,45	15,1	12,6	–	–
GGG-NiSiCr 30 5 5	0.7680	7,45	14,4	12,6	–	–
GGG-Ni 35	0.7683	7,6	5	12,6	–	–
GGG-NiCr 35 3	0.7685	7,7	5	12,6	–	–
GGG-NiSiCr 35 5 2	0.7688	7,45	12,9	12,6	–	–

*) As regards preparation of test pieces for testing the mechanical properties see "Testing" clause on page 2.

Table 5. Reference data on mechanical properties of GGG-NiMn 23 4 at low temperature

Temperature	Tensile strength R_m N/mm²	0,2 % proof stress $R_{p\,0,2}$ N/mm²	Elongation A_5 %	Reduction in area after fracture Z %	Notch impact strength A_v (DVM-specimen) J
+ 20	420 to 480	180 to 240	25 to 45	20 to 45	24 to 34
0	420 to 500	200 to 270	25 to 45	20 to 45	25 to 36
- 50	420 to 520	220 to 300	30 to 47	25 to 45	25 to 38
- 100	450 to 550	250 to 350	30 to 50	25 to 50	25 to 41
- 150	480 to 600	300 to 400	30 to 47	25 to 45	25 to 40
- 163	530 to 650	380 to 480	25 to 40	20 to 35	21 to 38
- 196	560 to 700	400 to 500	20 to 35	20 to 30	21 to 34

Table 6. Reference data on mechanical properties of spheroidal graphite austenitic cast irons at elevated temperatures

Properties		Temperature (°C)	GGG-NiCr 20 2	GGG-NiCr 20 2 *)	GGG-Ni 22	GGG-NiCr 30 3	GGG-NiCr 30 3 *)	GGG-NiSiCr 30 5 5	GGG-NiSiCr 30 5 5 *)	GGG-NiCr 35 3	GGG-NiCr 35 3 *)
Tensile strength R_m (σ_B)	N/mm²	20	417	432	437	410	429	450	425	427	430
		430	380	–	368	–	–	–	–	–	–
		540	335	260	295	337	329	426	383	332	343
		650	250	260	197	293	310	337	320	286	326
		760	155	175	121	186	202	153	157	175	219
0,2 % proof stress $R_{p\,0,2}$ ($\sigma_{0,2}$)	N/mm²	20	246	264	240	276	281	312	302	288	288
		430	197	–	184	–	–	–	–	–	–
		540	197	205	165	199	200	291	270	181	201
		650	176	177	170	193	204	239	250	170	210
		760	119	120	117	107	153	130	131	131	171
Elongation (accelerated test)	%	20	10,5	8,5	35	7,5	7	3,5	2,5	7	7,5
		430	12	–	23	–	–	–	–	–	–
		540	10,5	1,5	19	7,5	7	4	3,5	9	7,5
		650	10,5	3	10	7	4	11	8	6,5	6,5
		760	15	14,5	13	18	13	30	24,5	24,5	12,5
Creep strength $\sigma_B/1000$	N/mm²	540	197	–	148	–	–	–	–	–	–
		595	(127)	183	(95)	165	214	120	134	176	225
		650	84	(109)	63	(105)	(127)	(67)	(77)	(105)	(130)
		705	(60)	(77)	(42)	68	77	44	53	70	84
		760	(39)	(42)	(28)	(42)	(49)	(21)	(28)	(39)	(46)
Stress required to reach a minimum creep rate of	N/mm²	540	162	(190)	91	–	(204)	–	–	(190)	(197)
		595	(92)	(112)	(63)	–	127	–	–	(112)	120
		650	56	(67)	40	–	(84)	–	–	(67)	(74)
		705	(34)	39	(24)	–	49	–	–	56	(42)
Stress required to reach a minimum creep rate of	N/mm²	540	63	(127)	–	–	(148)	–	–	–	(127)
		595	(39)	77	–	–	91	–	–	70	77
		650	24	(42)	–	–	(56)	–	–	–	47
		705	(15)	25	–	–	35	–	–	39	28
Creep elongation (1000 h)	%	540	6	–	14	–	–	–	–	–	–
		595	–	5,5	–	7	5	10,5	10	6,5	5,5
		650	13	–	13	–	–	–	–	–	–
		705	–	11,5	–	12,5	16	25	21	13,5	11,5

The values in brackets are interpolated or extrapolated.

*) With addition of molybdenum

Table 7. **Reference data relating to the turning of some austenitic cast irons**

Material [1]) Symbol in accordance with DIN 1694	Material [1]) Brinell hardness HB	Stress cross section: Depth of cut a approx. (mm)	Stress cross section: Rate of advance s up to (mm/U)	Cutting material: S = high-speed steel [2]) HM = hard metal [3])	Smooth cut and rigid cutting conditions – Working angle (degree): Tool orthogonal clearance α	Working angle: Tool orthogonal rate γ	Working angle: Tool cutting edge inclination λ	Working angle: Tool cutting edge angle $\varkappa$	Measured values (m/min): (without edge zone) $V_{60VB0,4}$	Measured values: (without edge zone) $V_{60VB0,0}$	Measured values: (without edge zone) $V_{60K0,3}$	Recommended cutting speed (m/min): with edge zone	Recommended cutting speed: without edge zone
GGG-NiCr 20 2	140 to 200	1,0	0,1	S 10-4-3-10 HM: M 10, K 10, M 15	6 to 10	6 to 12	0 to +4	45 to 90	–	–	–	–	20 to 15 70 to 40
		3,0	0,3	S 10-4-3-10 HM: M 10, M 15, K 10	6 to 10	6 to 12	0 to +4	45 to 90	55	70	80	40 to 25	18 to 11 60 to 30
		6,0	0,6	HM: M 15, K 10, M 10	6 to 8	6	0 to +4	45 to 75	35 [4])	50	–	35 to 20	50 to 25
GGG-NiCr 20 3	150 to 255	1,0	0,1	S 10-4-3-10 HM: M 10, K 10, M 15	6 to 10	6 to 12	0 to +4	45 to 90	66	40	–	–	15 to 8 50 to 35
		3,0	0,3	S 10-4-3-10 HM: M 10, K 10, M 15	6 to 10	6 to 12	0 to +4	45 to 90	35	–	50 to 70	35 to 20	12 to 6 45 to 20
		6,0	0,6	HM: M 15, M 20, K 10	6 to 8	6 to 0	0 to +4	45 to 75	20 to 35	20 to 30	30 to 48	25 to 15	30 to 15
GGG-NiSiCr 30 5 5	170 to 250	1,0	0,1	S 10-4-3-10 HM: M 10, K 10, K 05	6	6	0 to +4	45 to 75	55	–	–	–	40 to 25
		3,0	0,3	S 10-4-3-10 HM: M 10, K 10, M 15	6	6	0 to +4	45 to 75	≦40	≦50	30 to 40	30 to 15	35 to 15
		6,0	0,6	HM: M 15, M 20, M 10	6	6 to –6	0 to +4	45 to 75	≦15	≦20	~35	20 to 12	16 to 10
GGG-NiMn 23 4	150 to 180	1,0	0,1	S 10-4-3-10 HM: M 10, K 10, K 05	6 to 10	6 to 12	0 to +4	45 to 90	–	–	–	–	70 to 40
		3,0	0,3	S 10-4-3-10 HM: M 10, K 10, M 15	6 to 10	6 to 12	0 to +4	45 to 90	20 to 30	30 to 40	60 to 75	50 to 25	60 to 30
		6,0	0,6	HM: M 15, M 20, K 10	6 to 8	6	0 to +4	45 to 75	20 to 30	25 to 35	40 to 50	40 to 20	50 to 25

[1]) As regards grades specified in DIN 1694 which are not listed in the table, these are listed below in order of qualitatively decreasing machinability:
a) flake graphite grades GGL-NiCuCr 15 6 2, GGL-Ni 35, GGL-NiCuCr 15 6 3, GGL-NiCr 20 2, GGL-NiCr 30 3, GGL-NiCr 20 3, GGL-NiSiCr 30 5 5
b) spheroidal graphite grades GGG-NiCr 20 2, GGG-Ni 22, GGG-NiMn 23 4, GGG-Ni 35, GGG-NiCr 30 3, GGG-NiCr 20 3, GGG-NiSiCr 30 5 5

[2]) High-speed steel in accordance with Steel-Iron Material Sheet 320 – 69 [3]) Machinability group in accordance with DIN 4990 [4]) With edge zone

Table 8. **Reference data relating to cutting speed to be used for machining some austenitic cast irons**

Symbol according to DIN 1694	Milling Cutting speed (m/min) for tools made of		Drilling Cutting speed (m/min)	Reaming Cutting speed (m/min) for tools made of		Thread cutting Cutting speed (m/min)
	high-speed steel	hard metal	High-speed steel tools	high speed steel	hard metal	High-speed steel tools
GGL-NiCr 20 2	24 to 18	85 to 60	24 to 18	20	30	17 to 12
GGL-NiCr 20 3	23 to 12	75 to 50	18 to 14	12	21	12 to 9
GGG-NiCr 20 2	12 to 7	55 to 30	12 to 9	9	18	9 to 8
GGG-NiCr 20 3	9 to 6	35 to 25	11 to 6	6	15	8 to 5

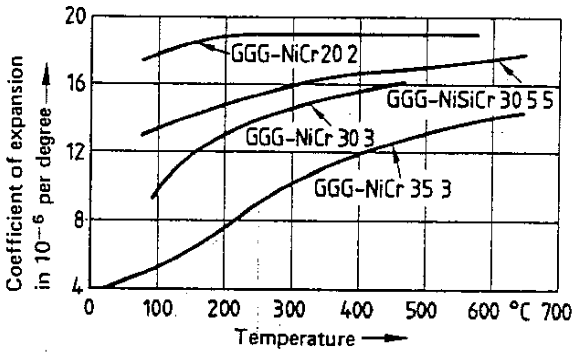

Figure 1. Mean coefficient of expansion (from room temperature up to the specified temperature) for spheroidal graphite austenitic cast iron

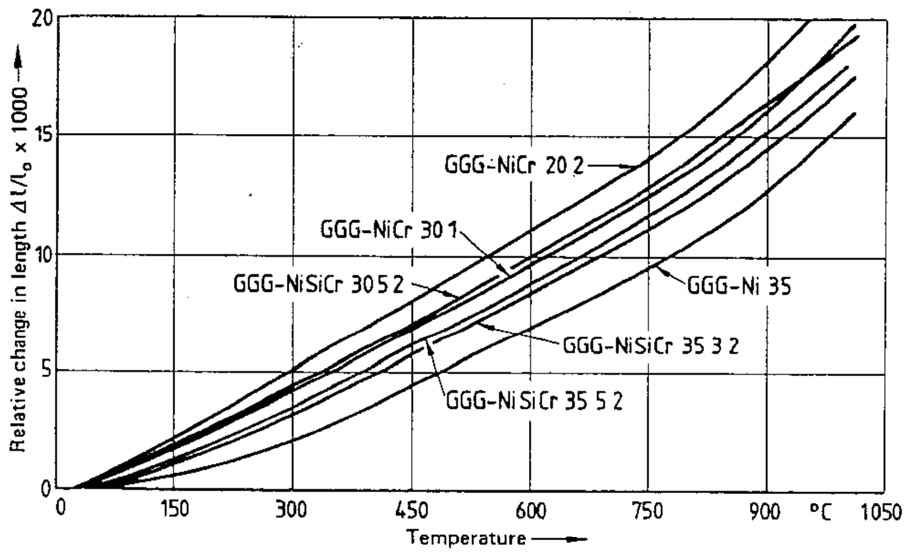

Figure 2. Relative change in length of austenitic GGG materials during the heating-up period as a function of temperature

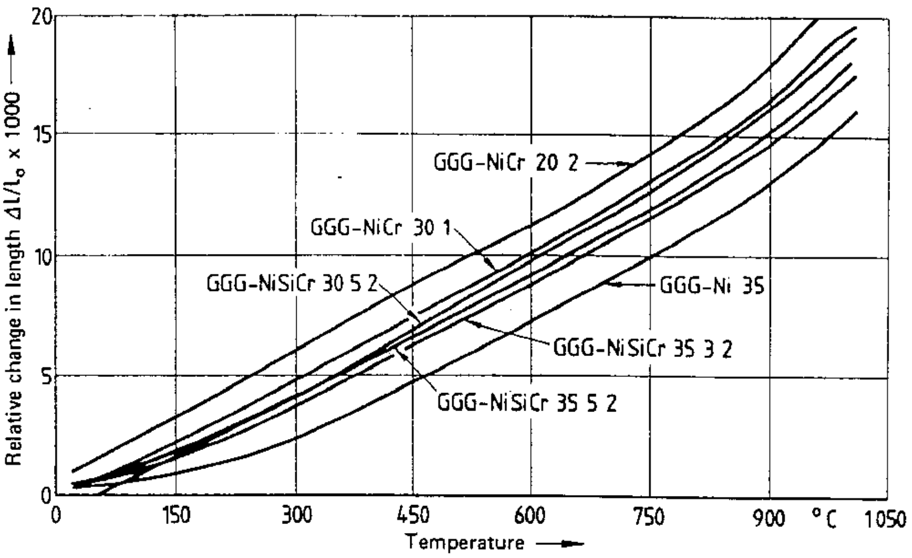

Figure 3. Relative change in length of austenitic GGG materials during the cooling period as a function of temperature

Standards referred to

DIN 1694 Austenitic cast iron
DIN 4990 Groups of application of carbides for machining by chip removal

Previous editions

DIN 1694 Supplement: 10.66

Amendments

Compared with the October 1966 edition the following amendments have been made:

a) The reference data on mechanical and physical properties of flake graphite austenitic cast iron formerly brought together in one table have been split into two tables – mechanical properties and physical properties (tables 1 and 2). The same applies to the reference data on mechanical and physical properties of spheroidal graphite austenitic cast iron (tables 3 and 4).

b) Tables 6 and 8 with reference data relating to
   - mechanical properties of spheroidal graphite austenitic cast irons at elevated temperatures
   - turning of some austenitic cast irons
   - cutting speeds to be used for machining some austenitic cast irons

   have been newly adopted.

c) The thermal expansion values for some grades of spheroidal graphite austenitic cast iron shown in figures 1 to 3 are also new.