



Teknisk bestämmelse
Technical specification

Benämning PROVNINGSBESTÄMMELSE OFÖRSTÖRANDE PROVNING AV STÅLGJUTGODS	Blad nr/Sheet No. 1	Document nr/Document No. 0 804 092	Sensista ändr./ Latest rev. 3
Denomination TEST SPECIFICATION NON- DESTRUCTIVE TESTING OF STEEL CASTINGS	Uppgjord/Prepared Bnt	Kontrollerad/Checked <i>[Signature]</i>	Ant./Dept. KKM/FKL
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1. ALLMÄNT

Denna föreskrift utgör komplement till allmänna bestämmelsen A2003 "Gjutgods, Materialbehandling bestämmelse" vad gäller oförstörande provning under tillverkning.

Hänvisning till denna bestämmelse skall finnas på färdigritning och eventuell ämnesritning.

2. KVALITETSKRAV

Godset skall, om ej annat anges på ritning eller i beställningsunderlag, uppfylla följande krav:

Den yttre kvaliteten bedöms enligt ASTM E 125-63(1980) varvid gäller:

- Type I Linear discontinuities tillåts ej på färdig yta
- Type II Shrinkage Degree 1
- Type III Inclusions Degree 2
- Type V Porosity Degree 1
- Type IV VI VII tillåts ej

Den inre kvaliteten bedöms enligt ASTM E 186-81, E 280-81, E 446-81 varvid gäller:

- Category A, B och C severity level 2 om ej annat anges på ritn.
- Category D, E, F och G tillåts ej

1. GENERAL

This specification augments the general specification A2003 "Castings, Material Handling Prescription" as concerns non-destructive testing during the manufacture.

Any blank drawings, and final drawings shall contain a reference to this specification.

2. QUALITY REQUIREMENTS

The castings shall, unless otherwise stated on the drawing or in the ordering documentation, meet the following requirements:

The external quality shall be assessed according to ASTM E 125-63(1980) and the following shall apply:

- Type I Linear discontinuities not permitted on finished surfaces
- Type II Shrinkage Degree 1
- Type III Inclusions Degree 2
- Type V Porosity Degree 1
- Type IV VI VII not permitted.

The internal quality shall be assessed according to ASTM E 186-81, E 280-81, E 446-81 and the following applies:

- Categories A, B and C Severity level 2 unless otherwise stated on the drawing.
- Categories D, E, F and G not permitted.

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Kvalitetskravet enligt ovan gäller oavsett provomfattningen, om ej annat angives, hela detaljen och alla levererade detaljer även om provningen endast utföres på delar av detaljen eller begränsat antal detaljer.

The quality requirements as above apply irrespective of the extent of the test, unless otherwise stated, throughout the entire part and all parts delivered, even if the test is only carried out on portions of the part or a limited number of parts.

3. PROVNING

Magnetpulverprovning, ultraljudprovning och radiografisk provning användes för att kontrollera att kvalitetskravet under pkt 2 uppfylls.

3. TESTING

Magnetic powder testing, ultrasonic testing and radiographic testing are used to check that the quality requirements of item 2 are met.

3.1 MAGNETPULVERPROVNING

Magnetpulverprovning utföres efter eventuell seghärdning enligt någon av följande normer om ej annat överenskommits. SIS 11 44 01, ASTM E 709-80.

3.1 MAGNETIC POWDER TESTING

Magnetic powder testing shall be used after any hardening and tempering according to one of the following standards unless otherwise agreed SIS 11 44 01, ASTM E 709-80.

3.2 ULTRALJUDPROVNING

Ultraljudprovning utföres enligt någon av följande normer om ej annat överenskommits. SS 11 42 20, ASTM E 114-75.

3.2 ULTRASONIC TESTING

Ultrasonic testing shall be carried out according to one of the following standards unless otherwise agreed SS 11 42 20 ASTM E 114-75 (1981).

3.3 RADIOGRAFISK PROVNING

Radiografisk provning utföres enligt någon av följande normer om ej annat överenskommits. SIS 11 41 01 klass A, DIN 54111 Prüfklasse A, ASTM E 94-68 (1977).

3.3 RADIOGRAPHIC TESTING

Radiographic testing shall be carried out according to one of the following standards unless otherwise agreed SIS 11 41 01 Class A, DIN 54111 Prüfklasse A, ASTM E 94-68 (1977).

4. PROVOMFATTNING

4.1 PROVOMFATTNING AV ENSKILD DETALJ

Magnetpulverprovning skall utföras på hela detaljens yta.

Ultraljudprovning och/eller radiografisk provning skall utföras enligt anvisningar på ritning eller övrigt beställningsunderlag.

4. EXTENT OF THE TEST

4.1 EXTENT OF THE TEST ON INDIVIDUAL PART

Magnetic powder testing shall be carried out over the entire surface of the part.

Ultrasonic testing and/or radiographic testing shall be carried out according to the instructions on the drawing or other ordering documentation.

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Ultraljudprovningens resultat som bedömes ligga på gränsen för att klara kvalitetskravet skall kompletteras med radiografering.

Results of ultrasonic testing that are adjudged to be borderline cases as concerns meeting the quality requirements shall be augmented with radiography.

4.2 PROVOMFATTNING BETRÄFFANDE ANTAL DETALJER SOM SKALL PROVAS

4.2 EXTENT OF THE TEST CONCERNING THE NUMBER OF PARTS TO BE TESTED

Magnetpulverprovning skall utföras på samtliga detaljer.

Magnetic powder testing shall be carried out on all parts.

Antal detaljer, som skall kontrolleras genom ultraljud och/eller radiografisk provning, skall framgå av beställningsunderlaget.

Number of parts to be inspected by ultrasonic and/or radiographic testing shall be shown on the ordering documentation.

5. SVETSLAGNING

5. REPAIR WELDING

Svetslagning skall utföras på följande sätt:

Repair welding shall be carried out as follows:

SS 2225 (W3-2225)

SS 2225 (W3 2225)

Svetslagning före seghärdning med manuell bågsvetsning och elektrod ESAB OK 78.16. Efter svetslagningen skall detaljen seghärdas.

Repair welding before hardening and tempering by manual arc welding and electrode ESAB OK 78.16. The repair welding shall be followed by hardening and tempering.

W3-2229

W3 2229

Alt 1. Svetslagning före seghärdning med manuell bågsvetsning och elektrod ESAB SP 106. Efter svetslagningen skall detaljen seghärdas.

Alternative 1. Repair welding before hardening and tempering by manual arc welding and electrode ESAB SP 106. The repair welding shall be followed by hardening and tempering.

Alt 2. Svetslagning efter seghärdning med manuell bågsvetsning och elektrod Arcos Ductilend 110 eller motsvarande av köparen godkänd elektrod. Efter svetslagningen skall detaljen avspänningsglödgas.

Alternative 2. Repair welding after hardening and tempering by manual arc welding and electrode Arcos Ductilend 110 or corresponding approved by the customer. The repair welding shall be followed by stress-relieving.

SS 1505 (W3-1505)

SS 1505 (W3-1505)

Svetslagning med manuell bågsvetsning och elektrod ESAB OK 48.00 eller med TIG-svetsning och ESAB AUTROD 12.51. Efter svetslagningen skall detaljen avspänningsglödgas.

Repair welding by manual arc welding and electrode ESAB OK 48.00 or by TIG-welding and electrode ESAB AUTROD 12.51. The repair welding shall be followed by stress-relieving.

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17112-W
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BOFORS STANDARD
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This specification is applicable for castings for which "Material Treatment Specification A 2003" has been indicated in the drawing by Bofors Designing Office.. In addition to "General Technical Delivery and Inspection Specifications" according to SIS 11 00 01, the following is applicable.

1. General requirements

- 1.1 The analysis and the heat treatment of the material are to be as indicated in the drawing.
- 1.2 The material is to be free from such cracks, porosities and other defects that can jeopardize its use for the purpose intended.
- 1.3 Repair welding (if permitted in the standard specification) and straightening may be carried out under condition that it is carried out professionally and with the necessary care, i e preheating and postheating. Repair welding is to be carried out at the stage during the heat treatment when it is most suitable from metallurgical and material technical viewpoints. The repaired lot is to be inspected after the repairs by means of non-destructive tests, e g magnaflux, ultra-sonic or x-ray testing.
- 1.4 Deviations from dimensions without tolerances which are normal for the casting method are permitted, provided that no general tolerances are prescribed in the manufacturing specification.
- 1.5 The casting is to fulfil the requirements as regards pressure-tightness and other special properties, indicated in the drawing.

2. Test casting

2.1 Manufacturing of test castings

Test castings are to be made. The test casting is to be carried out according to the same method, with the same material and with the same heat-treatment, as at the subsequent manufacture. Repair welding of the test castings is not permitted.

Note 1. If the same part has previously been cast and no alterations in design, material or casting method have been introduced, after an agreement has been made between the manufacturer and the customer, the test casting can be omitted.

Note 2. If a small quantity of parts or very large parts are ordered, the test castings can be one of the parts ordered, if agreed by the manufacturer and the purchaser.

2.2 Inspection of test castings

The test castings are to be inspected by the manufacturer. This inspection is to include checking of dimensions (to be carried out after having consulted the purchaser), visual inspection, rough machining, magnaflux or ultra-sonic inspection, hardness testing and X-ray testing of zones exposed to particularly severe stresses (indicated in the drawing). After the inspection, the test castings and the inspection records are to be sent to the Bofors Inspection Department, by whom a decision will be made if supplementary tests are required, e g, additional X-ray tests, destructive tests, tensile tests with test bars or pressure tests with finally machined part (in the latter case, if pressure tightness requirements are indicated in the drawing).

2.3 Acceptance of test castings

On the basis of the information from the test castings the Bofors Inspection Department will decide if the test casting has given acceptable results. If the results are not acceptable, information will be given if new test casting is to be carried out after the necessary alterations in design and casting method have been made. After acceptable test castings have been produced, the production can be started.

3. Inspection during the production

3.1 Checking of physical properties

Checking of the requirements stipulated in the drawing for physical properties, to the extent such are stipulated in the manufacturing specification, is to be carried out with separately cast test pieces from each charge (or if specially indicated, with test bars attached to the castings), and the relevant SIS standard shall then be applicable. If there is no SIS standard for the material in question, the test bars may be cast according to the manufacturer's practice. The test bar blanks are to be heat-treated together with the castings they represent. Test bars for tensile tests and impact tests are to have the size and shape prescribed for the SIS standard in question.

If a test bar, at the testing, does not give acceptable results, double retesting is to be carried out, and these test are to be carried out in the same way as the first time. Repeated heat-treatment may be carried out before the retesting, but not more than two times. If, at the double retesting, both test bars fulfil the requirements stipulated, the lot is to be accepted.

3.2 Hardness testing

Hardness testing is to be carried out after the final heat-treatment. If hot straightening has been carried out, the hardness test is to be made after this operation. The extent of the hardness test is to be decided by the manufacturer, unless it is stipulated in the manufacturing specification.

3.3 Checking of dimensions, non-destructive testing

Checking of dimensions and non-destructive testing of the castings is to be carried out to the extent the manufacturer considers it necessary in order to maintain the quality represented by the accepted test castings. Consideration is then to be taken to the requirements indicated in the drawing, e g, for pressure tightness, for zones indicated as being exposed to special stresses and for sealing surfaces.

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Toleranser för gjutgods		Tolerances for castings		

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Orientering

Följande system för dimensionstoleranser för gjutgods är baserat på svensk standard SS 722, utgåva 2, som i sin tur är baserad på omfattande utredningar gjorda av Svenska Gjuteriföreningen.

Internationell standard saknas. Utländska standarder överensstämmer i mycket liten omfattning med denna standard.

Tysk standard har, efter publiceringen av SS 722, utgåva 1, infört samma beteckningar som i den svenska GTA och GTB, men toleransvärdena skiljer sig i flera avseenden.

Användning

Standarden gäller för mått mellan obearbetade ytor, t ex yttermått, innermått, ansatsmått, väggtjocklekar, centrumavstånd och diametermått, för rensade gjutstycken av alla gjutmetaller, t ex gråjärn, segjärn, aducerjärn, gjutstål, kopparlegeringar, zink och lättmetall framställda med sandformning kokillgjutning, pressgjutning etc.

Standarden omfattar ej särskilda formtoleranser, t ex avvikelser från rakhets, planhet, rundhet, vinkelriktighet eller liknande geometriska avvikelser. När sådana krav föreligger skall de anges enligt STD 834 S 04628 (Div T AS V 2424).

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- 4 Instructions for using the standard
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Introduction

This system of dimensional tolerances for castings is based on Swedish standard SS 722, issue 2, which in turn is based on extensive investigations undertaken by the Swedish Foundry Association.

There is no international standard. Foreign standards are in very small proportions in agreement with this standard.

After publishing SS 722, issue 1, the German standard has introduced the same designation as the Swedish GTA and GTB, but in many aspects the tolerance values are different.

Application

The standard applies to dimensions between non-machined surfaces, e.g. outer dimensions, inner dimensions, collar dimensions, wall thickness, centre distances and diameter dimensions for cleaned castings of all cast metals e.g. grey iron, nodular iron, malleable iron, cast steel, copper alloys, zinc and light metal, produced by sand forming, chill casting, die casting etc.

The standard does not include special tolerances of form, e.g. deviations from straightness, flatness, circularity, angularity or other similar geometrical deviations. When such requirements exist they should be specified according to STD 834, S 04628 (Div. T AS V 2424).



1 Basmått

Som basmått vid toleranssättning enligt denna standard gäller:

1 Basic size

When stating tolerances according to this standard the basic size applies as follows:

Typ av mått/Type of dimension		Basmått/Basic size
Utvändiga mått External dimensions	Mått mellan ytor av vilka åtminstone den ena skall bearbetas Dimensions between surfaces of which at least one shall be machined	a) Detaljritningens basmått plus bearbetnings-tillägg. / Basic size of the part drawing plus machined allowance. b) Ämnesritningens basmått. / Basic size of the blank drawing.
	Mått mellan ytor som ej skall bearbetas Dimensions between surfaces where neither surface is machined	Detaljritningens basmått Basic size of the part drawing
Invändiga mått Internal dimensions	Mått mellan ytor av vilka åtminstone den ena skall bearbetas. Dimensions between surfaces of which at least one shall be machined	a) Detaljritningens basmått minus bearbetnings-tillägg. / Basic size of the part drawing minus machined allowance. b) Ämnesritningens basmått. / Basic size of the blank drawing.
	Mått mellan ytor som ej skall bearbetas Dimensions between surfaces where neither surface is machined	Detaljritningens basmått Basic size of the part drawing

För mått på gjutstycken som skall bearbetas med avverkande bearbetningsmetoder, kommer alltså olika basmått att gälla vid gjutning och bearbetning.

For dimensions of castings which shall be machined by a cutting method, different basic sizes apply to casting and machining.

2 Toleranser

2.1 Uppdelning

Toleransvärdena är indelade i två serier GTA och GTB. GTA, tabell 1, innehåller femton toleransgrader betecknade med siffrorna 7 till 21 och avsedda för gjutstycken av

gråjärn
gjutstål
kopparlegeringar
zink
lättmetall
ej värmebehandlat segjärn

GTB, tabell 2, innehåller elva toleransgrader betecknade med siffrorna 10 till 20 och avsedda för gjutstycken av

aducerjärn
värmebehandlat segjärn

2.2 Toleransvidder

Toleransvidderna för de olika toleransgraderna anges i tabell 1 och 2. De har beräknats enligt formlerna i tabell 3. Storleken på faktorn k_n i formlerna framgår av tabell 4 och texten under tabell 4.

2 Tolerances

2.1 Division

The tolerance values are divided into two series, GTA and GTB. GTA, table 1, contains fifteen tolerance grades which are designated with figures 7 through 21 and intended for castings of

grey iron
casting steel
copper alloys
zinc
light metals
non-heat-treated spheroidal graphite iron

GTB, table 2, contains eleven tolerance grades which are designated with figures 10 through 20 inclusive and are intended for castings of

malleable iron
heat-treated spheroidal graphite iron

2.2 Tolerance widths

Tolerance widths for the different tolerance grades are stated in tables 1 and 2. They have been calculated according to the formulas in table 3. The size of factor k_n in the formulas can be seen in table 4 and in the text under table 4.

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Tabell 1 Toleransserie GTA

Toleransvidder för gjutstycken av
gråjärn
gjutstål
kopparlegeringar
zink
lätmetall
ej värmebehandlat segjärn

Table 1 Tolerance series GTA

Tolerance widths for casting of
grey iron
casting steel
copper alloys
zinc
light metals
non-heat treated spheroidal graphite iron

Basmått Basic size (mm)	Toleransvidd/Tolerance width (mm)														
	Toleransgrad/Tolerance grade														
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
— 6	0,06	0,08	0,1	0,14	0,2	0,28	0,4	0,6	0,8	1	1,4	2,4 ¹⁾	3,4 ¹⁾	4,8 ¹⁾	6 ¹⁾
(6) — 10	0,06	0,09	0,12	0,16	0,24	0,32	0,44	0,6	0,9	1,2	1,6	2,4 ¹⁾	3,4 ¹⁾	4,8 ¹⁾	6 ¹⁾
(10) — 18	0,07	0,10	0,14	0,2	0,28	0,38	0,5	0,7	1	1,4	2	2,8	3,8	5	7
(18) — 30	0,09	0,12	0,16	0,24	0,32	0,46	0,6	0,9	1,2	1,6	2,4	3,2	4,6	6	9
(30) — 50	0,1	0,14	0,2	0,28	0,38	0,5	0,7	1	1,4	2	2,8	3,8	5	7	10
(50) — 80	0,12	0,16	0,24	0,32	0,46	0,6	0,9	1,2	1,6	2,4	3,2	4,6	6	9	12
(80) — 120	0,14	0,2	0,28	0,38	0,5	0,7	1	1,4	2	2,8	3,8	5	7	10	14
(120) — 180	0,16	0,22	0,32	0,44	0,6	0,8	1,2	1,6	2,2	3,2	4,4	6	8	12	16
(180) — 250		0,26	0,36	0,5	0,7	0,9	1,4	1,8	2,6	3,6	5	7	9	14	18
(250) — 400			0,4	0,6	0,8	1	1,6	2	3	4	6	8	10	16	20
(400) — 630				0,7	0,9	1,2	1,8	2,4	3,4	4,6	7	9	12	18	24
(630) — 1000					1	1,4	2	2,8	4	5	8	10	14	20	28
(1000) — 1600						1,6	2,4	3,2	4,6	6	9	12	16	24	32
(1600) — 2500							2,8	3,8	5	7	10	14	20	28	38
(2500) — 4000								4,4	6	9	12	16	22	32	44
(4000) — 6300									7	10	14	20	26	36	50
Parttillägg enligt 2.3 Part increase according to 2.3	0,1	0,1	0,1	0,2	0,2	0,3	0,4	0,6	0,8	1	1,4	1,8	2,4	3	4



1) Dessa värden är beräknade på basmättet 10 mm.

1) These values are based on the basic size 10 mm.

Tabell 2 Toleransserie GTB

Toleransvidder för gjutstycken av
aducerjärn
värmebehandlat segjärn

Table 2 Tolerance series GTB

Tolerance widths for castings of
malleable iron
heat-treated spheroidal graphite iron

Basmått Basic size (mm)	Toleransvidd/Tolerance width (mm)											
	Toleransgrad/Tolerance grade											
	10	11	12	13	14	15	16	17	18	19	20	
— 10	0,18	0,24	0,34	0,48	0,6	0,9	1,2	1,8	2,4	3,4	4,8	
(10) — 18	0,2	0,28	0,38	0,5	0,7	1	1,4	2	2,8	3,8	5	
(18) — 30	0,26	0,36	0,5	0,7	0,9	1,4	1,8	2,6	3,6	5	7	
(30) — 50	0,32	0,46	0,6	0,9	1,2	1,6	2,4	3,2	4,6	6	9	
(50) — 80	0,4	0,6	0,8	1	1,4	2	3	4	6	8	10	
(80) — 120	0,48	0,7	1	1,4	1,8	2,6	3,6	4,8	7	10	14	
(120) — 180	0,6	0,8	1,2	1,6	2,2	3	4,2	6	8	12	16	
(180) — 250	0,7	1	1,4	1,8	2,6	3,6	5	7	10	14	18	
(250) — 400	0,8	1,2	1,6	2,2	3	4,2	6	8	12	16	22	
(400) — 630	1	1,4	2	2,8	3,8	5	7	10	14	20	28	
(630) — 1000	1,2	1,8	2,4	3,4	4,6	6	9	12	18	24	34	
(1000) — 1600	1,6	2,2	3	4,2	6	8	12	16	22	30	42	
(1600) — 2500	1,8	2,6	3,6	5	7	10	14	18	26	36	50	
Parttillägg enligt 2.3 Part increase according to 2.3	0,2	0,2	0,3	0,4	0,6	0,8	1	1,4	1,8	2,4	3	

Tabell 3/Table 3

Toleransserie Tolerance serie	Toleransvidd Tolerance width
GTA	$T = k_n \cdot B^{0,33}$
GTB	$T = k_n \cdot B^{0,45}$

Tabell 4/Table 4

Toleransgrad Tolerance grade n	k_n		Toleransgrad Tolerance grade n	k_n	
	GTA	GTB		GTA	GTB
7	0,031		15	0,43	0,32
8	0,043		16	0,6	0,45
9	0,06		17	0,83	0,63
10	0,083	0,063	18	1,16	0,87
11	0,116	0,087	19	1,6	1,2
12	0,16	0,12	20	2,2	1,7
13	0,22	0,17	21	3,1	1,7
14	0,31	0,23			

T = toleransvidd i mm

n = toleransgrad

k_n för GTA = $0,6 (\sqrt[3]{10})^{n-16}$

k_n för GTB = $0,45 (\sqrt[3]{10})^{n-16}$

B = det geometriska mediet av basmåttområdenas gränsvärden utom för det minsta basmåttområdet där B = det övre gränsvärdet

T = tolerance width in mm

n = tolerance grade

k_n for GTA = $0,6 (\sqrt[3]{10})^{n-16}$

k_n for GTB = $0,45 (\sqrt[3]{10})^{n-16}$

B = the geometrical medium of the limit values of the basic size ranges except for the smallest basic size where B = the upper limit value



2.3 Ökning av toleransvidd (parttillägg)

För mått som bildas av två eller flera formdelar, av formdel och kärna eller av två eller flera kärnor, görs tillägg (s k partstillsättning) till toleransvidden med det värde som anges för respektive toleransgrad nederst i tabell 1 och 2. Endast ett tillägg görs, även om mer än två formdelar eller kärnor tillsammans bildar måttet. Se figur 1.

För mått som bildas i en enda formdel eller av en enda kärna, görs ej något parttillägg.

2.3 Increase of tolerance width (part increase)

For dimensions that are formed by two or several mould parts, of mould part and core or of two or several cores an addition is made (part increase) to the tolerance width with that value that is indicated for the respective tolerance grade at the bottom in table 1 and 2. Only one increase is made, even if more than two mould parts or cores form the dimension. See figure 1.

For dimensions, formed by only one part of a mould or by only one core, no part increase is made.

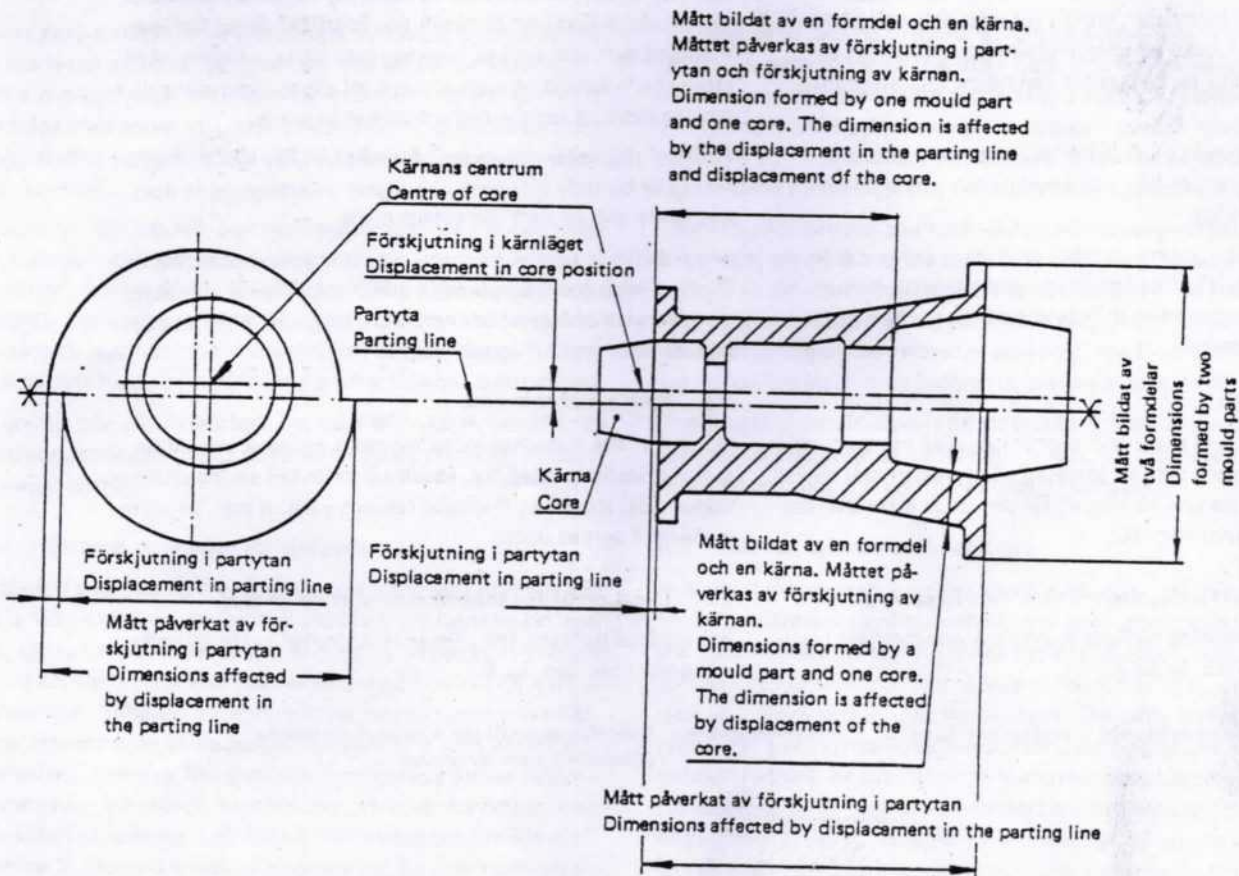


Fig 1

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2.4 Partförskjutning

Partförskjutningen får uppgå till max de värden som anges i tabell 5.

Tabell 5 Max tillåten partförskjutning

Toleransgrad Tolerance grade	Partförskjutning Part displacement max
7-10	0,3
11-13	0,7
14-16	1
17-19	1,5
20-21	2,5

2.5 Väggtjockleksmått

För väggtjockleksmått, varmed avses mått på godsväggar erhållna mellan två formdelar, mellan formdel och kärna eller mellan två kärnor, skall en toleransgrad högre tillämpas än för övriga mått plus parttillägg för den högre toleransgraden.

För väggtjockleksmått blidade i en enda formdel eller av en enda kärna gäller ej den högre toleransgraden och ej heller görs något parttillägg.

När svårigheter kan uppstå att hålla toleranser enligt det första stycket, exempelvis vid komplicerade sammansatta kärnor, kan efter överenskommelse dubbla parttillägg till den högre toleransgraden medges.

2.6 Toleransläge

Toleransen, inklusive eventuellt parttillägg, skall normalt vara symmetriskt förlagd, dvs lika fördelad på plussidan och minusidan. Om särskilda skäl föreligger, får den dock efter överenskommelse vara osymmetrisk.

2.7 Toleransens förläggning vid ytor med släppning

För ytor med släppning förläggs toleransen symmetriskt ut efter släppningsytan. Se fig 2.

2.4 Part displacement

The maximum values for part displacement are stated in table 5.

Table 5 Max allowed part displacement

2.5 Wall thickness dimensions

For wall thickness dimensions, referring to the dimension of casting walls obtained between two moulded parts, between moulded part and core or between two cores, a higher tolerance grade should be applied than for other dimensions plus parting increase for the highest tolerance grade.

For wall thickness dimensions formed by only one part of a mould or by only one core, the higher tolerance grade does not apply and no part increase is made.

When difficulties arise in containing tolerances according to the first part, for example with complicated cores a double, part increase of tolerance width may be made to the increased tolerance grade if agreed upon.

2.6 Position of tolerance

Normally, the tolerance including parts increase, should be symmetrically located, i.e. equally distributed on the plus and minus side. However, if special reasons exist, it may be asymmetrical if agreed upon.

2.7 Location of the tolerance on drafted surfaces

For drafted surfaces, the tolerance is located symmetrically along the line. See fig. 2.

Ritningens basmått + arbetsmån = basmått

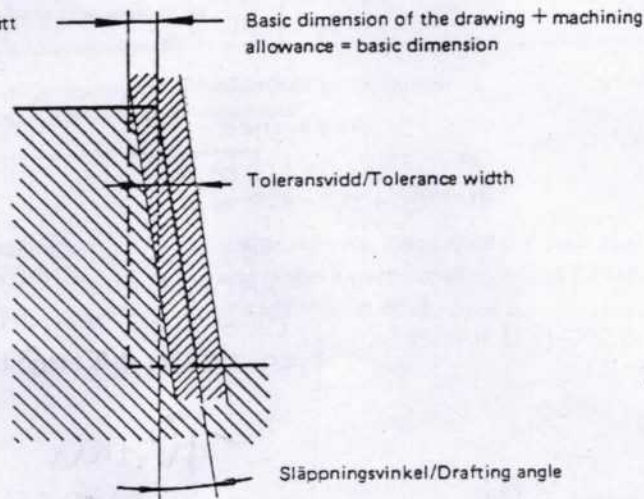


Fig 2

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3 Angivelse på ritning

Tolerans enligt denna standard skall anges på ritningen, antingen med sitt värde i mm i anslutning till basmåtten, t ex $95 \pm 1,4$, eller med uppgift om toleransgrad, t ex "Där ej annat angivits gäller GTA 17, STD 771." Om ej annat anges förläggs toleransen symmetriskt kring basmåtten.

4 Anvisningar för standardens användning

4.1 Samråd

När beställaren har speciella krav ifråga om mått, bör han före toleranssättning, genom kontakt med gjuteriet och med ledning av uppgifterna i avsnitt 4.2, ta reda på vilka toleranser som gjuteriet kan hålla med hänsyn till gjutmetall, gjutmetod och tillgängliga resurser i övrigt.

Valet av gjutmetod är ur ekonomisk synpunkt bl a beroende av storleken på tillverkningsserien. För att få korrekta uppgifter om kostnader och lämpligt framställningssätt bör man samråda med gjuteriet i varje enskilt fall. Högre krav på mått-noggrannhet innebär högre kostnad för utrustning, tillverkning och kontroll.

Kostnaden för modell- och verktygsutrustningen är beroende av material och framställningsmetod, likaså utrustningens livslängd. För att kunna leverera ett mått-noggrant och bearbetningsvänligt gjutgods är det önskvärt att gjuteriet före offert-givning får upplysning om placeringen av referensplan vid exempelvis första uppspänning för efterföljande bearbetning.

Gjuteriet bör alltid rådfrågas om man är tveksam beträffande toleranssättningen. Detta gäller exempelvis placering av part-yta eller partytor.

4.2 Normala toleranser för gjutgods

I tabell 6 anges de toleransgrader som ett gjuteri normalt kan hålla vid olika gjutmetaller och vid olika produktionsbetingelser. Uppgifterna i tabellen grundar sig på omfattande mätningar vid ett flertal gjuterier i samarbete med Svenska Gjuteriföreningen. Tabellen gäller toleranser hos gjutgods tillverkat efter intrimning av de produktionsfaktorer som påverkar mått-noggrannheten hos gjutgods. Exempel på dylika faktorer är modeller, kärnlådor, kärnfixturer, verktyg, formflaskor och maskinell utrustning. I de fall då gjuteriet ej ges tillfälle att trimma in produktionen, exempelvis vid mycket korta serier, innefattar upplysningsvärdena ej måttangivelser orsakade av detta. Det innebär att systematiska måttavvikelse orsakade av att t ex mätten hos modell- och kärnlådeutrustning ej anpassats till aktuell gjutlegering och gjutmetod inte innefattas i tabellen såvida gjuteriet ej beretts tillfälle att justera utrustningen med hänsyn härtill före gjutningen. Detta gäller om modellerna är slitna eller fått felaktiga mått under lagring.

3 Indication on drawing

Tolerances according to this standard should be stated directly on the drawing either with the value in mm in connection with the basic size, e.g. $95 \pm 1,4$, or information on tolerance grade e.g. "Unless otherwise stated the following applies GTA 17, STD 771". Unless otherwise stated the tolerance in this case is located symmetrically around the basic size.

4 Instructions for applying the standard

4.1 Consultation

When the buyer has special requirements on dimensions he should contact the foundry before stating the tolerance and with the aid of information in section 4.2, investigate which tolerances can be kept by the foundry with consideration to the cast metal, casting method and the available resources in general.

The choice of casting method is from an economical viewpoint e.g. dependent on the size of the production series. To receive correct information on costs and suitable method of producing should be consulted the foundry in each specific case. Higher requirements on dimensional accuracy mean higher costs for equipment, manufacturing and inspection.

The costs for pattern and tool equipment depend on material producing method and the useful life of the equipment. To be able to deliver a dimensional accurate and easy to machine casting it is desirable that the foundry receives information on the positioning of the reference plane e.g. the first setting up for following machining before submitting a quotation.

The foundry should always be consulted if there is doubt regarding specification of tolerances. It can, for example apply when positioning the parting surface or surfaces.

4.2 Normal tolerances for castings

In table 6 the tolerance grades which a foundry normally can keep for different casting methods and production conditions are stated. The information in the table is based on comprehensive measurements made at several foundries in co-operation with the Swedish Cast Association. The table states tolerances for castings manufactured after trimming of the production factors, which influence the dimensional accuracy for castings. Examples of such factors are patterns, core boxes, core fixtures, tools flasks and mechanical equipment. In cases when the foundry does not have a chance to trim the production e.g. for short series, informative values do not include dimensional accuracy caused by this. It means that systematical dimensional accuracy caused by e.g. the dimensions of pattern and core box equipment not having been adapted to the actual cast alloy and cast method are not included in the table if the foundry has not had a chance to modify the equipment in view of this before casting. The same is valid if the patterns are worn or have become defective during storage.

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Tabell 6 Toleransgrader som normalt innehålls hos gjutgods

Table 6 Tolerance grades which normally can be kept for castings

Metod Method	Formmaterial Mould material	Modell- material Pattern material	Toleransgrader enligt GTA Tolerance grades according to GTA						Toleransgrader enligt GTB Tolerance grades according to GTB	
			Stål 1) Steel 1)	Gråjärn Grey iron	Segjärn, ej värme- behandlat Nodular iron, not heat-treated	Koppar- legeringar Copper alloys	Zink Zinc	Lättmetall- legeringar Light meta- alloys	Aducer- järn Mallea- ble iron	Segjärn värme- behandlat Spheroidal graphite iron heat- treated
Handformning och formning med sandslunga Hand moulding and moulding with sand slinger	Råsand Green sand	Trä, plast metall Wood, plastic, metal	16-18	16-18	16-18	16-18		14-16	16-18	16-18
	Självstelnande formmassor Self-hardening moulding material	Trä/Wood Plast, metall Plastic, metal	16-18 15-17	16-18 15-17	16-18 15-17	16-18 15-17		14-16 14-16	16-18 15-17	16-18 15-17
Maskinformning (inkl bullformn) och blockform- ning Machine mould- ing (incl. snap moulding) and block moulding	Samtliga All	Trä/Wood Plast, metall, Plastic, metal	14-16	14-16	14-16	14-16		13-15	14-16	14-16
			13-15	12-14	13-15	13-15		12-14	13-15	13-15
Skalformning/Shell moulding			13-15	12-14	13-15	13-15		12-14	13-15	13-15
Kokillgjutning/Casting in permanent moulds						12-14		11-13		
Pressgjutning/Pressure die casting						11-13	9-11	10-12		
Precisionsgjutning 2)/Precision casting 2)						9-12		9-12		

Den toleransgrad, som kan nås inom intervallen i tabell 6, är bl a beroende av hur komplicerat gjutstycket är, av modellernas och verktygens beskaffenhet samt av gjuteriets utrustning i övrigt och dess arbetsmetoder.

Vid stora serier och god produktionsutrustning samt med särskilda åtgärder, exempelvis lägeskontroll av kärnor, är det möjligt att uppnå bättre måttnoggrannhet än tabell 6 anger.

1) Vid gjutstycken av stål med största mått över 2000 mm kan andra förhållanden råda. Aktuellt gjuteri ska kontaktas.

2) Den nedre gränsen bör tillämpas endast då speciella skäl föreligger och då måtten understiger 25 mm.

The tolerance grade, which can be reached within the intervals in table 6, is among other things depending on how complicated the castings are, the character of the pattern and tools and also of the equipment of the foundry and its working methods.

With large series and good equipment for production, and with special measures, for instance, position verification of cores, it is possible to attain more improved dimensional accuracy than is shown in table 6.

1) In the case of a casting of steel with max. dimension exceeding 2000 mm other conditions may occur. It is then necessary to consult the foundry concerned.

2) The lower limit should be applied only when special reasons exist and when the dimensions are below 25 mm.

I sista hand måste dock det enskilda gjuteriet ge upplysning om vilka toleransgrader det kan hålla för olika mått på aktuellt gjutstycke.

Generell föreskrift om en bestämd toleransgrad för ett flertal mått på en detalj enligt avsnitt 3 kan medföra snävare måttkrav än funktionen kräver och därigenom förorsaka högre kostnader för gjutgodset.

5 Exempel

Ett antal gjutstycken enligt figur 3 ska gjutas. Gjuteriet har till kunden uppgett, att det för denna typ av gjutstycken normalt kan hålla toleransgrad GTA 16.

För de angivna måtten beräknar kunden toleranser enligt följande varvid symmetriskt toleransläge förutsätts.

Finally the individual foundry has to make clear which tolerance grades they are able to keep for different dimensions on present casting.

General instructions regarding a fixed tolerance grade for several dimensions of a part, according to section 3, can result in higher dimension requirements than demanded of the function and consequently result in higher costs for the casting.

5 Example

A number of castings according to figure 3 are to be cast. The foundry has told the customer that for this type of casting a tolerance class of GTA 16 can normally be contained.

For the dimensions indicated, the customer can calculate the tolerances according to the following whereby a symmetrical tolerance zone position is required.

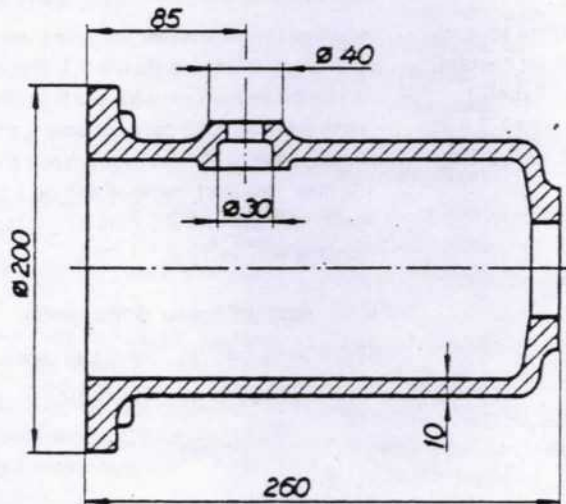


Fig 3

Mått Ø40 Tabell 1 ger toleransvidden 2 mm. Eftersom måttet bildas i en enda formdel ska något parttillägg ej göras. Toleransen blir då ± 1 mm.

Mått Ø30 Tabell 1 ger toleransvidden 1,6 mm. Eftersom måttet bildas av enda kärna ska något parttillägg ej göras. Toleransen blir då $\pm 0,8$ mm.

Mått Ø200 Tabell 1 ger toleransvidden 3,6 mm. Eftersom måttet bildas av två formdelar ska (enligt avsnitt 2.3) parttillägg göras. Enligt tabell 1 är detta tillägg 1 mm. Hela toleransvidden blir då 4,6 mm och toleransen $\pm 2,3$ mm.

Dimension Ø40 Table 1 indicates tolerance width 2 mm. Since the dimension is formed by only one core no part increase shall be made. The tolerance will then be ± 1 mm.

Dimension Ø30 Table 1 indicates tolerance width 1,6 mm. Since the dimension is formed by only one core, no part increase shall be made. The tolerance will then be $\pm 0,8$ mm.

Dimension Ø200 Table 1 indicates tolerance 3,6 mm. Since the dimension is formed by two mould parts, one part increase shall be made (according to section 2.3). According to table 1 this addition is 1 mm. The entire tolerance width will then be 4,6 mm and the tolerance $\pm 2,3$ mm.

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Mått 260 Tabell 1 ger toleransvidden 4 mm. Eftersom måttet bildas av två formdelar ska (enligt avsnitt 2.3) parttillägg göras med 1 mm. Hela toleransvidden blir då 5 mm och toleransen $\pm 2,5$ mm.

Mått 85 Tabell 1 ger toleransvidden 2,8 mm. Eftersom måttet bildas av en formdel och en kärna ska (enligt avsnitt 2.3) parttillägg göras med 1 mm. Hela toleransvidden blir då 3,8 mm och toleransen $\pm 1,9$ mm.

Mått 10 Måttet 10 mm utgör ett väggjockleksmått. Med hänsyn härtill ska (enligt avsnitt 1) väljas en toleransgrad högre än för övriga mått. Tabell 1 ger för toleransgrad 17 toleransvidden 1,6 mm. Eftersom måttet bildas av en formdel och en kärna ska dessutom (enligt avsnitt 2.3) parttillägg göras. Enligt tabell 1 är detta tillägg 1,4 mm för toleransgrad 17. Hela toleransvidden blir då 3 mm och toleransen $\pm 1,5$ mm.

Kunden medger emellertid för detta mått inte större tolerans än $\pm 1,1$ mm, varför han efter kontakt med gjuteriet bestämmer att toleransgrad 16 med parttillägg ska gälla. Tabell 1 ger för mått 10 mm i toleransgrad 16 toleransvidden 1,2 mm. Parttillägget blir 1 mm. Hela toleransvidden blir då 2,2 mm. Måttangivningen på ritningen blir $10 \pm 1,1$ mm.

6 Tillhörande dokument

STD 834 (S 04628) Form- och lägetoleranser
Tillämpning

Dimension 260 Table 1 indicates tolerance width 4 mm. Since the dimension is formed by two mould parts (according to section 2.3), one part increase shall be made with 1 mm. The entire tolerance width will then be 5 mm and the tolerance $\pm 2,5$ mm.

Dimension 85 Table 1 indicates tolerance width 2,8 mm. Since the dimension is formed by one mould part and a core (according to section 2.3), one part increase shall be made with 1 mm. The entire tolerance width will then be 3,8 mm and the tolerance $\pm 1,9$ mm.

Dimension 10 Dimension 10 mm constitutes a wall thickness dimension. Taking into consideration, a tolerance class higher than for remaining dimensions shall be chosen (according to section 1). Table 1 indicates for tolerance class 17 tolerance width 1,6 mm. Since the dimension is formed by one mould part and a core, one part increase shall (according to section 2.3) be made. According to table 1 this increase is 1,4 mm for tolerance class 17. The entire tolerance width will then be 3 mm and the tolerance $\pm 1,5$ mm.

However, the customer for this dimension will not consent to a larger tolerance than $\pm 1,1$ mm, for which reason after he has made contact with the foundry will decide that tolerance class 16 with part increase is to apply. Table 1 indicates for dimension 10 mm in tolerance class 16 tolerance width 1,2 mm. The part increase will be 1 mm. The entire tolerance width will then be 2,2 mm. The dimension indicated on the drawing will be $10 \pm 1,1$ mm.

6 Appurtenant documents

STD 834 (S 04628) Form and positional tolerances
Application

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BOFORS Standard	Denomination Marking in Relation to Moulding	Table Z13-2			
		Edition 1	No. Yr. 9/63	No. pages 3	Page 1

FAT 1/194

This standard applies to sand-moulded goods.

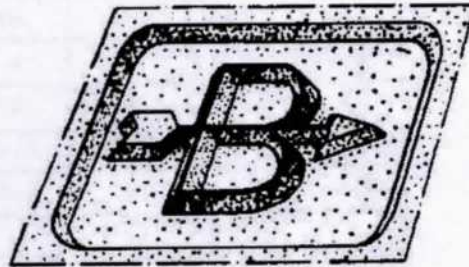
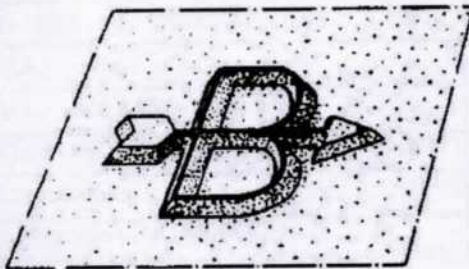
1. General Aspects
2. Dimensions
3. Space Requirement
4. Drawing Indication

1. General Aspects

When marking in relation to moulding, capital letters and large figures of metal should be used, which are affixed to the surface of the pattern by means of pegs. During the moulding procedure the raised and immersed texts diverge from each other in relation to the surface of the goods.

Execution A: Raised text

Execution B: Immersed text

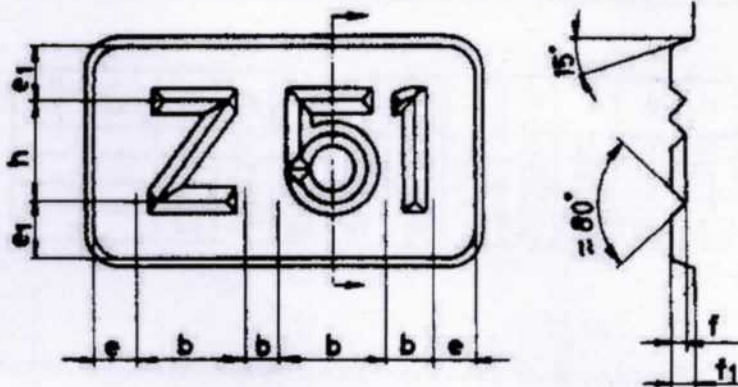


In addition to obvious cases the size and position of the marking is always to be decided in consultation with the pattern-shop and the foundry, since the form of the pattern and the implementation of the moulding is of vital importance for the position of the moulding.

2. Dimensions

The design of the symbols can be seen in the following figure and table. 10, 16, 25 and 40 mm (corresponding to 3/8", 5/8", 1" and 1 1/2") are recommended as heights of the texts. Remaining dimensions in the table are target figures.

The figure shows an immersed marking, i.e. execution B.



Height of text	h	10	16	25	40
Min. distance to edge	e	4	6	9	16
Min. distance to edge	e ₁	5	8	12	20
Raising	f	1,8	2,1	3	4
Immersion	f ₁	2,5	3	4,5	6
Effective width	b	See item 3			

4. Space Requirement

In order to determine the necessary space, consideration must be taken to the effective width of the individual symbols, i.e. the minimum lateral space required by each symbol. The following table indicates the effective width of the individual symbols. When estimating the length of words, the effective widths are to be added together.

Height of text	A	B	C	D	E	F	G	H	I	J	K	L	M	N
10	13	11	11	11	10	10	11	10	5	9	11	9	13	11
16	17	16	16	16	15	15	16	15	6	14	16	14	18	16
25	25	24	24	24	22	22	24	22	10	20	24	20	27	24
40	35	35	35	35	32	32	35	32	14	30	35	30	40	35

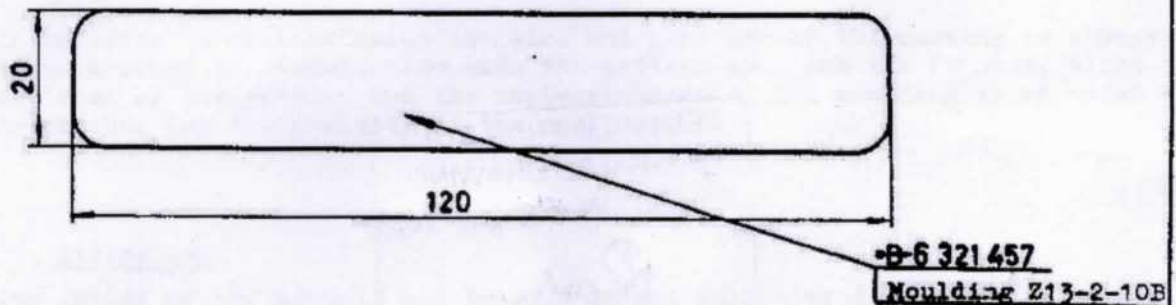
Height of text	O	P	Q	R	S	T	U	V	W	X	Y	Z	-	-B-
10	11	11	11	11	13	11	11	13	15	10	11	11	7	25
16	16	16	16	16	17	16	16	17	21	15	16	16	12	40
25	24	24	24	24	26	25	24	26	30	22	24	24	20	60
40	35	35	35	35	37	35	35	36	42	32	35	35	27	90

Height of text	1	2	3	4	5	6	7	8	9	0
10	6	13	11	13	11	11	11	11	11	10
16	7	17	16	17	16	15	15	16	15	14
25	12	26	24	26	24	22	22	24	22	20
40	16	37	35	37	35	32	32	35	32	30

Distance between words 0.5 x height of text
 Distance between figure groups 0.3 x height of text
 Normal spacing 1.75 x height of text
 Minimum spacing 1.5 x height of text

4. Drawing Indication

The wording, position, spacing, height of text and execution of the marking, as well as reference to Z13-2, is indicated on the drawing. Simplified wording, "Moulding Z13-2-10B", can also be indicated on the drawing. This denotes that moulding is to be carried out according to Z13-2, 10 indicates the height of text and B the execution. In the case of immersed text the immersion is to be dimensioned, see example below.



Performance A: Stamping by Rolling or Impact

1. In General
2. Space Requirement
3. Drawing Identification

Performance B: Rubber Stamping

1. In General
2. Drawing Identification

Performance A, Stamping by Rolling or Impact

1. In General

Stamping by rolling is mainly used for the marking of machined parts that have a max. height or diameter of 175 mm.

Impact stamping can either be carried out mechanically or manually. When mechanical stamping is used the types are fitted into a press, an aligning tool or a special type-holder, all of which can even be used for manual stamping. The use of loose punches for manual stamping often results in an uneven appearance of the marking, and should, therefore, be avoided.

The character of the text corresponds to Z13-1. The heights of the texts are for:

- Stamping by rolling 1.6 - 3 mm
- Impact stamping, mechanical 3 - 5 mm
- Impact stamping, manual 3 - 5 mm

2. Space Requirement

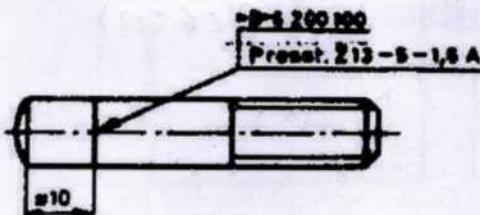
The space needed by each symbol in transversal direction, is dependent of the width of the type. Throughout, this is equal to the height of the text. The length of each word is also equal to the height of text multiplied by the number of symbols. Two symbols are estimated as being sufficient for the B-arrow.

- Distance between word 0.5 x height of text
- Distance between groups of numbers 0.3 x height of text
- Min. spacing between lines 1.5 x height of text

3. Drawing Identification

The following information relating to the marking is to be indicated on the drawing: wording, location, height of text, performance and reference to Z13-5. The following can also be indicated on the drawing in simplified wording: Presst. Z13-5-1.6A, which means presstamping according to Z13-5, 1.6 indicated height of text and A = performance.

Example:



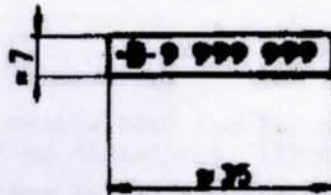
Performance B, Rubber Stamping1. In General

Stamping by rubber stamp is mainly used for marking of non-metallic parts or at such instances, where marking by sign or where stamping by rolling or impact proves to be impracticable. This method of marking can also be used on hardened parts, but not on surfaces that are subjected to rubbing or other means of deterioration, whereby the marking can be obliterated.

The marking is carried out by a rubber stamp. Black or white marking ink is used, depending on the colour of the surface.

Stamp No. 1

(Applicable for marking of article numbers)



Height of text = 3

Stamp No. 2

(Applicable for marking of article numbers)



Height of text = 5

2. Drawing Identification

The following information relating to the marking is to be indicated on the drawing: wording, location, stamp number, performance and reference to Z13-5. The following can also be indicated on the drawing in simplified wording: Colourst. Z13-5-1B, which means colour stamping according to Z13-5, 1 indicates number of stamp and B = performance. See example below.



B-6201345

Colourst. Z13-5-1B