APPENDIX A

(For reference)

TERMS, USED IN THE STANDARD, AND THEIR DEFINITION

Table A.1

Terms	Definition
1. Slag inclusions	Cavity, filled with slag
2. Slag	Melt or hard substances of variable composition, covering the surfaces of molten product in metallurgical process, consisting of empty species, flux, fuel ash, sulphides and oxides, products of interaction of machining materials and lining of melting units.
3. Shrink cavities	Open or closed space/cavity with coarse roughness, sometimes with oxidized surface, formed on account of shrinkage during hardening of metal.
4. Shrink porosity or central porosity	Pores located in central part of ingot section. Formed for the same reasons as for the shrink cavities. Located on the top half of ingots.
5. Gaseous porosity	Defect in the form of small pore, formed as a result of gassing (escape of gas) from the metal during its hardening.
6. Oxide Film	Defect in the form of metallic oxide film on the surface of metal.
7. Liquidation/segregation	Defect in the form of local accumulation of chemical elements or compounds, as a result of discrimination crystallization during hardening.
8 Porosity	Defect in the form of accumulation of minor shrinkage cavities.
9. Foreign inclusion	Defect in the form of foreign metals or non-metals inclusion, having surface division with ingot metal.

APPENDIX Б
(Mandatory)

PROCEDURE FOR DETERMINATION OF GASEOUS POROSITY IN ALUMINIUM CASTING ALLOYS

Б.1 Preparation of macro sections

Б.1.1 While determining the porosity in aluminium casting alloys, shrinkage cavity or central porosity is excluded.

Б.1.2 For determining the gaseous porosity in templates, cut from ingots as per 4.2.6, castings or samples, cut from castings, are machined to surface finish Ra not more than 1.6 microns. While machining with emulsions, the surface of template is cleaned with petrol or acetone.

Б.1.3 Macro section is prepared from template by sequential polishing with abrasive emery papers of different grain sizes: 80 - 100 microns, 40 – 50 microns, 10 – 14 microns, and washing in running water and dried with filtering paper.

The preparation of macro section may be carried out by other processes, which ensures surface finish not more than 1.6 microns.

Б.1.4 For determining the gaseous porosity, the macro section is etched in 10-15% of water solution of sodium hydroxide (NaOH) at a temperature 60° – 80°C. The macro section is immersed in the reagent/chemical agent and held for 10 - 15 days (microstructure is not exposed), then washed in running water and dried with filtering paper. If necessary, the clear macro section surfaces is kept in 20% solution of nitric acid for 2 - 5 days, then washed in running water and dried with filter paper.

Б.2 Test procedure

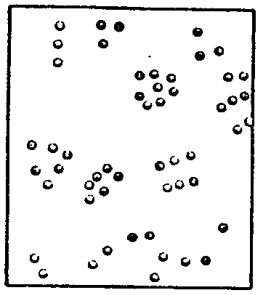
Б.2.1 For determining the gaseous porosity, it is necessary to make use of the scale given in Fig. Б1. Degree of porosity in macro sections, measured in points, in established by comparing it with the etalon/standard of the scale.

Б.2.2 Gaseous porosity in templates of ingots is determined on 3 squares with area of 1 cm^2 each (Fig - Б 2). The quantity and dimension of the pore is determined as the arithmetic mean of the 3 measurements.

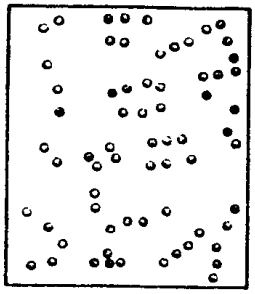
In case of deviation of the pore for mean quantity, dimension or percentage content towards the higher side, the porosity parameter refers to higher point of porosity.

Sequence of marking the squares:

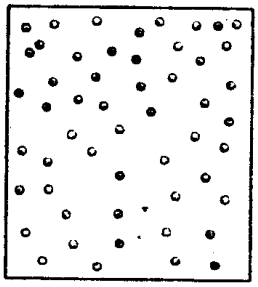
a) On the surface of macro section, draw a diagonal;
b) Measure the diagonal;
c) Divide the diagonals into two equal parts for determining the center of mean square;
d) Mark the central square on the macro section in such a way that the diagonal divides it into two equal parts and the side of the square is perpendicular to it;



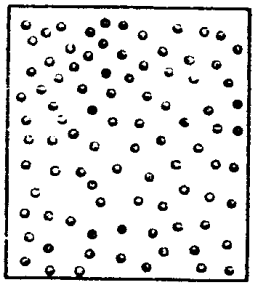
Point 1



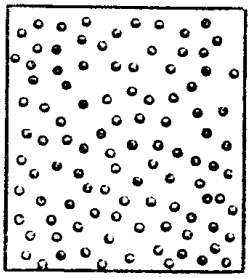
Point 2



Point 3



Point 4



Point 5

e) Measure the distances from the edges of the macro section upto the side of the square along the templates diagonal;

f) Divide this distance in two halves for determining the center of the remaining two squares;

g) Mark the two remaining squares (see point d).

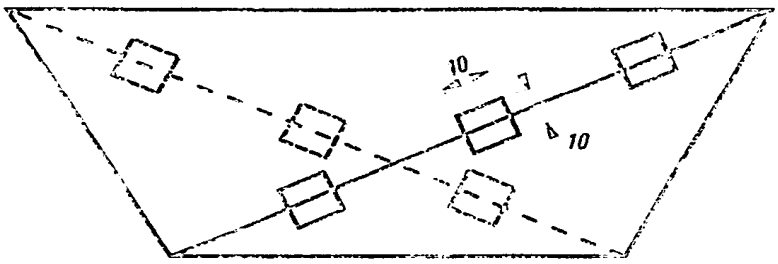


Fig Б.2 Diagram of arrangement of squares on the macro section

Gaseous porosity of the casting is determined on 3 squares with area of 1 cm^2 each. Arrangement of square is arbitrary depending upon the configuration and dimensions of the casting, if not specified specifically in the design documents.

On small castings, it is permitted to determine the gaseous porosity in lesser quantity of squares.

Б.2.3 Porosity point, determined for the 3 squares on the two-macro sections of ingots templates, is applicable for the whole melt.

Б.2.4 Inspection of porosity is carried out visually, with naked eyes. For determining the diameter of the pore, optic devices with 10 times magnification can be used.

Б.2.5 Section consists of 5 standards:

Point 1 – Fine porosity;
Point 2 – Low porosity;
Point 3 – Average porosity;
Point 4 – high porosity;
Point 5 – Very high porosity.

Б.2.6 Permissible quantity of pore in 1 cm^3 surface of section and its diameter depending up on the number of standards given in table Б.1.

Table Б.1

Standard number	Diameter of pore, mm	Quantity of pore on 1 cm^3, each
1	Upto 0.1	Upto 5
2	Upto 0.1 Upto 0.2	Upto 8 Upto 2
3	Upto 0.3 Upto 0.5	Upto 12 Upto 3
4	Upto 0.5 Upto 1.0	Upto 14 Upto 6
5	Upto 0.5 Upto 1.0 Above 1.0	Upto 15 Upto 8 Upto 2

Б.2.7 Usage of standards for porosity level is independent of the alloy grades.

APPENDIX B
(Recommended)

Recommended mode for heat treatment of alloys **Table B.1**

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature, °C.	Holding Time, hours	Cooling medium Temperature, °C	Heating Temperature, °C.	Holding Time hours
АК12 (АЛ2)	Т2	-	-	-	300 ± 10	2 - 4
АК9 (АК9)	Т1	-	-	-	175 ± 5	5 - 17
	Т6	535 ± 5	2 - 6	Water 20 - 100	175 ± 5	10 - 15
АК9ч (АЛ4)	Т1	-	-	-	175 ± 5	5 - 17
	Т6	535 ± 5	2 - 6	Water 20 - 100	175 ± 5	10 - 15
АК9пч (АЛ4-1)	Т1	-	-	-	175 ± 5	5 - 17
	Т6	535 ± 5	2 - 6	Water 20 - 100	175 ± 5	10 - 15
АК8 (АЛ34)	Т1	-	-	-	190 ± 5	3 - 4
	Т2	-	-	-	300 ± 10	2 - 4
	Т4	535 ± 5	10 - 16	Water 20 - 100	-	-
	Т5	535 ± 5	10 - 16	Water 20 - 100	175 ± 5	6
АК7 (АК7)	Т5	535 ± 5	2 - 7	Water 20 - 100	150 ± 5	1 - 3
АК7ч (АЛ9)	Т2	-	-	-	300 ± 10	2 - 4
	Т4	535 ± 5	2 - 6	Water 20 - 100	-	-
	Т5	535 ± 5	2 - 6	Water 20 – 100	150 ± 5	1 – 3
АК7ч (АЛ9)	Т5	535 ± 5	2 - 6	Water 20 - 100	Two stage heating:	
					1) 190 ± 10	0.5
					2) 150 ± 5	2
	Т6	535 ± 5	2 - 6	Water 20 - 100	200 ± 5	2 - 5
	Т7	535 ± 5	2 - 6	Water 80 - 100	225 ± 10	3 - 5
	Т8	535 ± 5	2 - 6	Water 80 - 100	250 ± 10	3 - 5
АК7пч (АЛ9-1)	Т2	-	-	-	250 ± 10	2 - 4
	Т4	535 ± 5	2 - 12	Water 20 - 50	-	-
	Т5	535 ± 5	2 - 12	Water 20 - 50	150 ± 5	3 - 10
	Т6	535 ± 5	2 - 12	Water 20 - 50	175 ± 5	3 - 10
	Т7	535 ± 5	2 - 12	Water 80 - 100	225 ± 10	3 - 5
	Т8	535 ± 5	2 - 12	Water 80 - 100	250 ± 10	3 - 5

Contd., Table **B**.1

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature, °C.	Holding Time hours	Cooling medium Temperature, °C	Heating Temperature. °C.	Holding Time hours
АК5М2 (АК5М2)	Т5	525 ± 5	3 - 5	Water 20 - 100	175 ± 5	5 - 10
	Т8	525 ± 5	3 - 5	Water 20 - 100	250 ± 10	3 - 5
АК5М (АЛ5)	Т1	-	-	-	180 ± 5	5 - 10
	Т5	525 ± 5	3 - 5	Water 20 - 100	175 ± 5	5 - 10
	Т5	Two stage heating:				
	Т5	1) 515 ± 5	3 - 5	-	-	-
		2) 525 ± 5	1 - 3	Water 20 - 100	175 ± 5	5 - 10
	Т6	525 ± 5	3 - 5	Water 20 - 100	200 ± 5	3 - 5
	Т7	525 ± 5	3 - 5	Water 20 - 100	230 ± 10	3 - 5
		Two stage heating:				
		1) 515 ± 5	3 - 5	-	-	-
		2) 525 ± 5	1 - 3	Water 20 - 100	230 ± 10	3 - 5
АК5Мч(АЛ5-1)	Т1	-	-	-	180 ± 5	5 - 10
	Т5	525 ± 5	3 - 10	Water 20 - 100	175 ± 5	5 - 10
	Т5	Two stage heating:				
		1) 515 ± 5	3 - 7	-	-	-
		2) 525 ± 5	2 - 5	Water 20 - 100	175 ± 5	5 - 10
	Т7	525 ± 5	3 - 10	Water 20 - 100	230 ± 10	3 - 5
	Т7	Two stage heating:				
		1) 515 ± 5	3 - 7	-	-	-
		2) 525 ± 5	2 - 5	Water 20 - 100	230 ± 10	3 - 5

Contd., Table B.1

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature, °C.	Holding Time, hours	Cooling medium Temperature, °C	Heating Temperature, °C.	Holding Time, hours
AK6M2 (АК6М2)	T1	-	-	-	180 ± 5	5 - 10
	T5	525 ± 5	3 - 5	Water 20 - 100	175 ± 5	5 - 10
AK8M (АЛ32)	T1	-	-	-	200 ± 10	5 - 8
	T2	-	-	-	280 ± 10	5 - 8
	T5	Two stage heating:				
		1) 505 ± 5	4 - 6	-	-	-
		2) 515 ± 5	4 - 8	Water 20 - 100	150 ± 5	10 - 15
	T6	515 ± 5	2 - 8	Water 20 - 50	170 ± 5	8 - 16
	T6	515 ± 5	2 - 8	Water 20 - 50	Two stage heating:	
					1) 130 ± 5	2 - 3
					2) 160 ± 5	4 - 6
	T6	Two stage heating:				
		1) 505 ± 5	4 - 6	-	-	-
		2) 515 ± 5	4 - 8	Water 20 - 100	170 ± 5	8 - 16
	T6	505 ± 5	4 - 6	-	-	-
	T6	515 ± 5	4 - 8	Water 20 - 100	Two stage heating:	
					1) 130 ± 5	2 - 3
					2) 160 ± 5	4 - 6
	T7	Two stage heating:				
		1) 505 ± 5	4 - 6	-	-	-
		2) 515 ± 5	4 - 8	Water 80 - 100	230 ± 5	3 - 5

Contd., Table B.1

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature, °C.	Holding Time, hours	Cooling medium Temperature, °C	Heating Temperature, °C.	Holding Time, hours
АК5М4 (АК5М4)	Т6	490 ± 10	5 - 7	Water 20 - 100	170 ± 10	5 - 7
АК5М7 (АК5М7)	Т1	-	-	-	180 ± 10	1 - 5
	Т6	490 ± 10	5 - 7	Water 20 - 100	185 ± 5	1 - 2
АК8М3 (АК8М3)	Т6	500 ± 10	5 - 7	Water 20 - 100	180 ± 10	5 - 10
АК8М3ч (ВАЛ8)	Т4	Three stage heating:				
		1) 490 ± 5	4 - 6	-	-	-
		2) 500 ± 5	4 - 6	-	-	-
		3) 510 ± 5	4 - 6	Water 20 - 100	-	-
	Т5	510 ± 5	4 - 6	Water 20 - 100	160 ± 5	6 - 12
АК9М2 (АК9М2)	Т6	515 ± 5	5 - 7	Water 20 - 100	200 ± 5	1 - 2
АК12ММгН (АЛ30)	Т6	520 ± 5	4 - 6	Water 20 - 100	180 ± 5	6 - 8
	Т1	-	-	-	190 ± 10	6 - 12
	Т6	520 ± 5	1.5 - 6	Water 20 - 70	180 ± 5 or 200 ± 5	12 - 16 or 6 -8
АК12М2МгН (АЛ25)	Т1	-	-	-	210 ± 10	10 - 12
АК5 (АЛ19)	Т4	545^{+3}_{-5}	10 - 12	Water 20 - 100	-	-
АК5 (АЛ19)	Т4	Two stage heating:				
		1) 530 ± 5	5 - 9	-	-	-
		2) 545 ± 3	5 - 9	Water 20 –100	-	-
	Т5	545^{+3}_{-5}	10 - 12	Water 20 - 100	175 ± 5	3 - 6
		Two stage heating:				
		1) 530 ± 5	5 - 9	-	-	-
		2) 545^{+3}_{-5}	5 - 9	Water 20 - 100	175 ± 5	3 - 6
	Т7	545^{+3}_{-5}	10 - 12	Water 80 - 100	250 ± 10	3 - 10
	Т7	Two stage heating:				
		1) 530 ± 5	5 - 9	-	-	-

Contd., Table 5.1

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature, °C.	Holding Time hours	Cooling medium Temperature, °C	Heating Temperature, °C.	Holding Time hours
АМ5 (АЛ19)	Т7	2) 545^{+3}_{-5}	5 - 9	Water 80 - 100	250 ± 10	3 - 10
АМ4.5Кд (ВАЛ10)	Т4	545^{+3}_{-5}	10 - 14	Water 20 - 100	-	-
		Two stage heating:				
		1) 535±5	5 - 9	-	-	-
		2) 545^{+3}_{-5}	5 - 9	Water 20 - 100	-	-
	Т5	545^{+3}_{-5}	10 - 14	Water 20 - 100	155 ± 5	3 - 8
	Т5	Two stage heating:				
		1) 535±5	5 - 9	Water 20 - 100	155 ± 5	3 - 8
		2) 545^{+3}_{-5}	5 - 9	-	-	-
	Т6	545^{+3}_{-5}	10 - 14	Water 20 - 100	170 ± 5	6 - 10
	Т6	Two stage heating:				
		1) 535±5	5 - 9	-	-	-
		2) 545^{+3}_{-5}	5 - 9	Water 20 - 100	170 ± 5	6 - 10
	Т7	545^{+3}_{-5}	10 - 14	Water 80 - 100	250 ± 5	3 - 10
	Т7	Two stage heating:				
		1) 545 ± 5	5-9	-	-	-
АМ4.5Кл (ВАЛ10)		2) 545^{+3}_{-5}	5-9	Water 80-100	250 ± 5	3 - 10
АМг6 (АЛ23)	Т4	430 ± 10	20	Water100 or oil 20	-	-
АМг6лч (АЛ23-1)	Т4	430 ± 10	20	Water100 or oil 20	-	-
АМг10 (АЛ27)	Т4	430 ± 10	20	Water 100	-	-

Contd., Table 5.1

Alloy Grade	Heat treatment process	Hardening			Ageing	
		Heating Temperature °C.	Holding Time hours	Cooling medium Temperature, °C	Heating Temperature, °C	Holding Time hours
АК7Ц9 (АЛ11)	Т2	300 ± 10	2 - 4	-	-	-
АЦ4Мг (АЛ24)	Т5	580 ± 5	4 - 6	Water 100	120 ± 5	8 - 10
АМг11 (АЛ22)	Т4	425 ± 5	15 - 20	Water100 or oil 40 - 50	-	-
АК9с	Т1	-	-	-	175 ± 5	5 - 17
	Т6	535 ± 5	2 - 6	Water 20 - 100	175 ± 5	10 - 15

Note:

1. Two stage heating mode for hardening of alloys АК5М (АЛ5), АМ5 (АЛ19), АК8М (АЛ32), АМ4.5Кд (ВАЛ10) is recommended for massive sections in parts (above 40 mm) to avoid overheating.
2. For reducing the internal stress in large parts having complex design, it is recommended to carry out hardening in water at temperature 80 - 100°C.
3. If required to achieve more higher (by 10 - 15%) strength for parts made of alloys АК9ч (АЛ4), АК9пч (АЛ9-1), it is permitted to increase the heating temperature for hardening upto (545 ± 5)°C, certainly with compulsory reduction of content of iron upto 0.1 - 0.2% and manganese upto 0.25 - 0.35% for alloy АЛ4.
4. Receipt of optimum mechanical properties for alloys АК9пч (АЛ4-1) (mode Т5) is ensured by maintaining the time gap between the hardening and the ageing for a period of 1 - 3 hours.

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17 1321

Keywords: Alloys, Grade, Ingot, Casting, Impurity, Mass fraction, Refined alloy, Quantity, Chemical composition, Billet.