STATE STANDARD OF UKRAINE

STEEL MILLING BALLS FOR BALL MILLS

Specifications

DSTU 8538-2015

Official publication

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PREFACE

1. The standard was DEVELOPED and INTRODUCED by Ukrainian Scientific and Technical Center of Metallurgical Industry «Energostal», TK 2 “A long products, rolled section stock and special profiles”.

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2. The standard was APPROVED and IMPLEMENTED by the Order No. 197 of SE “UkrNDNC” dated December 18st, 2015, enters into force 01.07.2016.

3. The standard was implemented for DSTU 3499-97 replacement.

CONTENT

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GRINDING STEEL BALLS FOR BALL MILLS
Specifications

Date of validity: 2016 -07 – 01

1. FIELD OF APPLICATION

This standard applies to steel grinding balls produced by rolling, forging, stamping and used for raw materials and materials grinding in ball mills.

2. NORMATIVE REFERENCES

This standard contains references to the following normative documents:

The Law of Ukraine "On Environment Protection"

The Law of Ukraine "On Occupational Safety"

The Law of Ukraine "On Atmospheric Air Protection"

The Law of Ukraine "On Waste"

The Law of Ukraine "On ensuring sanitary and epidemiological welfare for population"

DSTU 2841-94 (GOST 27809-95) The cast iron and steel. Spectrographic analysis method

DSTU 3273-95 The industrial enterprises safety. General terms and conditions

DSTU 3058-95 (GOST 7566-94) The metal products. Acceptance, labeling, packaging, transportation and storage

DSTU 3910-99 (GOST 17.9.1.1-99) The nature protection. Waste management. Waste classification. The procedure for naming wastes according to the genetic principle and assigning them to classification categories

DSTU 3953-2000 (GOST 5950-2000, IDT) The rods, hubs and coils of tool alloyed steel. General specifications

DSTU 7237:2011 Labor safety standards system. Electrical safety. General requirements and nomenclature of protection types

DSTU 7749:2015 Carbon steel and unalloyed cast iron. General requirements for analysis methods

DSTU 7750:2015 Carbon steel and unalloyed cast iron. Total carbon and graphite determination methods

DSTU 7751:2015 Carbon steel and unalloyed cast iron. Sulfur determination methods

DSTU 7752:2015 Carbon steel and unalloyed cast iron. Phosphorus determination methods

DSTU 7753:2015 Carbon steel and unalloyed cast iron. Silicon determination methods

DSTU 7754:2015 Carbon steel and unalloyed cast iron. Manganese determination methods

DSTU 7756:2015 Carbon steel and unalloyed cast iron. Chromium determination methods

DSTU 7757:2015 Carbon steel and unalloyed cast iron. Copper determination methods

DSTU 7758:2015 Carbon steel and unalloyed cast iron. Nickel determination methods

DSTU 7760:2015 Carbon steel and unalloyed cast iron. Vanadium determination methods

Official publication

DSTU GOST 12.2.061-2009. SSBT. Industrial equipment. General safety requirements for workplaces

DSTU GOST 166:2009 (ISO 3599-76) Calipers. Technical specifications

GOST 12.1.003-83 SSBT. Noise. General safety requirements

GOST 12.1.004-91 SSBT. Fire safety. General requirements

GOST 12.1.005-88 SSBT. General sanitary and hygienic requirements for the air of working area

GOST 12.1.029-80 SSBT. Noise protection means and methods. Classification

GOST 12.1.030-81 SSBT. Electrical safety. Protective grounding, nulling

GOST 12.2.003-91 SSBT. Industrial equipment. General safety requirements

GOST 12.2.007.0-75 SSBT. Electrotechnical products. General safety requirements

GOST 12.2.017-93 Forging and pressing equipment. General safety requirements

GOST 12.2.094-83 SSBT. Rolling equipment. General safety requirements

GOST 12.2.131-92 SSBT. Forging machines. Safety requirements

GOST 12.3.002-75 SSBT. Manufacturing processes. General safety requirements

GOST 12.3.009-76 SSBT. Cargo handling works. General safety requirements

GOST 12.3.026-81 SSBT. Forge-and-press works. Safety requirements

GOST 12.4.010-75 SSBT. Individual protection means. Special gloves. Technical specifications

GOST 12.4.013-85 SSBT. Protective glasses. General specifications.

GOST 12.4.128-83 SSBT. Protective helmets. General technical requirements.

GOST 17.0.0.01-76 The standards system in the environmental protection field and the natural resources improvement. The main provisions.

GOST 17.1.3.13-86 Nature Conservancy. Hydrosphere. General requirements for the surface waters protection against pollution.

GOST 17.2.3.02-78 Nature Conservancy. Atmosphere. Rules for establishment the allowable emissions of harmful substances by industrial enterprises.

GOST 9012-59 (ISO 410-82, ISO 6506-81) Metals. Hardness measuring by Brinell method

GOST 9013-59 (ISO 6508-86) Metals. Hardness measuring by Rockwell method

GOST 14192-96 Cargoes marking.

GOST 14959-79 Carbon and alloy spring steel rolled products. Technical specifications.

GOST 15150-69 Machines, devices and other technical products. Execution for various climatic regions. Categories, operating conditions, storage and transportation in terms of impact environmental climatic factors.

GOST 18895-97 Steel. The photoelectric spectral analysis method.

GOST 27574-87 Women's suits for against general industrial pollution and mechanical effects protection. Technical specifications.

GOST 27575-87 Man's suits for against general industrial pollution and mechanical effects protection. Technical specifications.

GOST 28033-89 Steel. X-ray fluorescence analysis method

3. TERMS AND DEFINITIONS

The terms used in this standard and their labeled concepts definitions given below

3.1 The ball mill

The device with a rotating drum filled by grinding balls and shredded material for materials crushing.

3.2 The grinding balls

Products with ball form for material crushing in ball mills by abrasion, impact and crushing.

3.3 The conditional ball diameter

Ball diameter rounded to standard values.

3.4 The nominal ball diameter

The limit deviations determined relative to this ball diameter.

3.5 Limit diameter deviation

The difference between limit and nominal diameter.

3.6 The volumetric hardness

Calculated hardness index, generalizes its value in the ball volume.

4. CLASSIFICATION AND SYMBOLS

4.1 The balls subdivided into hardness groups:

1 - balls with normal surface hardness;

2 - balls with increased surface hardness;

3 - balls with high surface hardness;

4 - balls with high surface hardness and normalized hardness at 0,5 R depth;

5 - balls with high surface hardness and normalized volumetric hardness.

4.2 Examples of balls symbols

The 60 mm balls with increased surface hardness and 2-nd hardness group:

Balls 60 - 2 DSTU 3499:

The 80 mm balls with high surface hardness and normalized volumetric hardness and 5-th hardness group :

Balls 80 - 5 DSTU 3499:

5. TECHNICAL REQUIREMENTS

5.1 Key characteristics

5.1.1 The balls must be produced in accordance with requirements of this standard.

5.1.2 The balls dimensions and marginal deviations have given at Table 1.

5.1.3 The balls calculation parameters have given in Annex A.

Table 1

In millimeters

Conditional diameter	Nominal diameter	Limit deviations to nominal diameter
15 20 25	15 20 25	± 1,0
30 35 40 45	31,5 36,5 41,5 46,5	± 2,0
50 55 60 65 70 80	52,0 57,0 62,0 68,0 73,0 83,0	± 3,0
90 100	94,0 104,0	± 4,0
110 120	114,0 125,0	± 5,0

5.1.4 The balls hardness after heat treatment must comply with the standards set out in Table 2.

Table 2

Conditional diameter, mm	The balls hardness groups						
	1	2	3	4		5	
	Hardness, HRC/HB, not less						
	Balls surface				At 1/2 R depth	Surface	Volumetric
from 15 to 45 incl.	45/415	49/461	55/534	55/534	45/415	61/601	57/555
from 50 to 70 incl.	43/401	48/453	53/514	53/514	43/401	60/590	53/514
from 80 to 100 incl.	39/341	42/375	52/495	52/495	40/352	58/567	48/453
from 110 to 120 incl.	35/302	38/331	50/477	50/477	35/302	56/545	43/401

Note 1. The volumetric hardness norm of balls is facultative by 01.01.2017.
Note 2. Rationing upper limit the balls hardness is permissible by agreement between producer and consumer.
Note 3. The manufacturer and consumer should use one determination method during the hardness control.

5.1.5 The balls produced of steel with the carbon content and carbon equivalents should correspond to the values in Table 3.

Table 3

Conditional diameter, mm	The balls hardness group	Carbon content	Carbon equivalents
		%, no less	
from 15 to 55 incl.	1,2	0,40	0,50
	3	0,60	0,70
	4,5		0,75
from 60 to 70 incl.	1,2	0,50	0,70
	3,4	0,60	0,75
	5		0,80
from 80 to 120 incl.	1,2	0,50	0,70
	3,4	0,60	0,75
	5		0,80
Note 1. Grinding balls the 1-st and 2-nd hardness groups production is permissible without taking into account the carbon equivalents requirements. **Note 2.** 60mm grinding balls the 1-st and 2-nd hardness groups production is permissible with carbon content not less than 0,4%.			

5.1.6 The steel grinding balls production is permissible in accordance with DSTU 3953 (GOST 5950) and GOST 14959.

5.1.7 The balls surface shall not contain cracks and defects that output the balls size to marginal deviations.

5.1.8 The grinding balls the 4-th and 5-th hardness group may be supplied with impact resistance control by agreement between the manufacturer and consumer. Impact resistance control provides according to the manufacturer's methodology.

5.2 Marking

5.2.1 The grinding balls don't mark.

5.2.2 Transport markings should be providing in accordance with GOST 14192.

5.3 Packaging

5.3.1 The 40mm grinding balls or grinding balls with bigger diameter supply without packing in bulk.

5.3.2 The grinding balls with diameter smaller than 40 mm or the grinding balls with any diameter, by agreement between the manufacturer and consumer, supply in packaging materials - a metal containers, a big-bags, a wooden boxes or other packaging in accordance with current normative document.

6. SAFETY REQUIREMENTS

6.1 The safety work during the grinding balls production should comply in accordance with the Law of Ukraine "On Occupational Safety and Health" and the requirements to DSTU GOST 12.2.061, GOST 12.2.003, GOST 12.2.017, GOST 12.2.094, GOST 12.2.131, GOST 12.3.002, GOST 12.3.026, GOST 12.4.013 and the safety rules at the grinding balls production enterprises.
6.2 Fire safety should comply in accordance with GOST 12.1.004.
6.3 Personnel protection against electric shock should comply with the requirements to DSTU 7237, GOST 12.1.030, GOST 12.2.007.0.
6.4 Employees should be in special clothing and use personal protective equipment during grinding balls production in accordance with GOST 12.4.010, GOST 12.4.013, GOST 12.4.128, GOST 27574, GOST 27575.
6.5 Sanitary and hygienic requirements to the working area air during the grinding balls production must comply to GOST 12.1.005 for the moderate intensity work category.
6.6 The noise level at workplaces should not exceed the norms established by GOST 12.1.003 and other valid normative documents, approved in the established order.
Necessary to use individual protection means of hearing aids in accordance with GOST 12.1.029 in case of occurrence the mechanical origin noise in the workplace during grinding balls production by the rolling, forging or punching method.
6.7 Cargo handling works should comply to requirements of GOST 12.3.009.

7. ENVIRONMENT PROTECTION REQUIREMENTS

7.1 Environmental protection ensure in accordance with the Law of Ukraine "On Environmental Protection", the Law of Ukraine "On Air Protection", the Law of Ukraine "On ensuring sanitary and epidemiological welfare for population" and the requirements of GOST 17.0.0.01.
The technological process of grinding balls production should not additionally contaminate the atmosphere, surface water and soil above the norms provided by GOST 17.1.3.13 and GOST 17.2.3.02 and other valid normative documents, approved in the established order.
Grinding balls are fire dangerous, explosive and radiation dangerous products.
7.2 The industrial waste utilization provides in accordance with the Law of Ukraine "On Waste" and DSTU 3910 (GOST 17.9.1.1).

8. ACCEPTANCE RULES

8.1 The grinding balls accept and delivery by batches.
8.1.1 The controlled batch should contain the grinding balls with the same size, hardness group and its mass must not exceed 150 tons.

8.1.2 The supplying batch may contain the several controlled batches of grinding balls with the same size and hardness group.

8.1.3 The grinding balls batch must be accompanied by the quality document and contains:

- the producer name and trademark;
- the products conditional designation;
- the batch number;
- the weight of shipped batch ;
- the hardness tests results of grinding balls;
- the service stamp about product quality control.

8.1.4 If the supplying batch consists of several controlled batches, the accompanying document indicates the minimum hardness value obtained during balls test from controlled batches.

8.2 Controlling the size, quality and surface hardness provide on ten balls selected from at least five different batch locations.

Acceptable no more than 10% of grinding balls with the dimensions and surface quality that don't respond to this standard requirements.

In the case of unsatisfactory tests results receiving for at least one indicator, then need to perform a repeated test at double number the grinding balls selected from the same batch.

The repeated test results extend to the entire batch.

In the case of unsatisfactory repeated tests results receiving for the grinding balls hardness, the entire batch refers to the group corresponds the obtained results of hardness control.

In the case of unsatisfactory repeated tests results receiving for the grinding balls size and quality on surface, need to re-sort the batch and present it for new inspection again.

8.3 Two balls from each batch need to select for hardness measure at 1/2 radius depth of grinding balls the 4-th hardness group and the volumetric hardness determination of grinding balls the 5-th hardness group.

In the case of unsatisfactory tests results receiving for at least one ball, then need to perform a second test at double balls number selected from the same batch.

In the case of unsatisfactory repeated tests results receiving, the batch refers to the lower hardness group.

8.4 The chemical steel composition determines by the float analysis results or during the inspection control of billet supplied by other enterprises. The chemical steel composition doesn't determine on grinding balls.

8.5 The grinding balls quantity for tests and acceptance rules determine according to the producer's methodology, in the case of impact resistance test.

9. CONTROL METHODS

9.1 The grinding balls dimensions control by calliper in accordance with DSTU GOST 166 or other instrument providing the necessary accuracy.

9.2 The grinding balls surface quality controls visually without the magnifying devices use.

9.3 The grinding balls hardness determines by the Rockwell method according to GOST 9013 or by the Brinell method according to GOST 9012.

9.3.1 The grinding balls surface hardness determines at two diametrically opposed platforms.

9.3.1.1 Four measurements perform at each platform of grinding balls for the hardness determination by Rockwell method.

The first three measurements perform at the vertices of imaginary equilateral triangle with a side length from 5 to 8 mm. These measurements are tentative and the results don't record in test report.

The fourth measurement is a final, it is performs in the center of the triangle. The final measurement result records in test report.

9.3.1.2 One measurement performs at each platform of grinding balls for the hardness determination by Brinell method. This result records in test report.

9.3.1.3 The grinding balls surface hardness from the batch determines as the arithmetic average of final measurements results of all control grinding balls. This value enters the quality document.

9.3.2 The steel grinding balls hardness at 1/2 radius depth determines at one flat surface area prepared in accordance to GOST 9012 and GOST 9013 requirements by removing the ball metal to the required depth.

Four hardness measures perform in the central part of the platform by the Rockwell method. The minimum and the maximum hardness values ignore, and the grinding ball hardness defined as arithmetic average value of the other two dimensions. The measurement result records in test report.

One hardness measure performs in the central part of the platform by the Brinell method.

The steel grinding balls hardness at 1/2 radius depth determines as arithmetic average value of hardness the control grinding balls.

9.3.2.1 Permissible the hardness determination on the templates cut perpendicular to the technological "band", so that the controlled template surface passes through the grinding ball central part. The templates surface prepares in accordance with the requirements GOST 9012 and GOST 9013. The grinding ball cutting technology excludes its heating higher than 100 ºC to avoid distortion the hardness measurements results.

Four hardness measurements on two mutually perpendicular lines performs at 1/2 radius depth. The minimum and the maximum hardness values ignore, and the grinding balls hardness defined as arithmetic average value the other two dimensions.

9.3.3 The volumetric hardness determines in two mutually perpendicular directions at templates, cut in accordance with the requirements point **9.3.2.1.**

Volumetric hardness (VH) calculated by formula:

$$\mathbf{VH = 0{,}289\ T_{surf} + 0{,}436\ T_{0,25} + 0{,}203 T_{0,5} + 0{,}063 T_{0,75} + 0{,}009\ T_c} \quad [1]$$

where $\mathbf{T_{surf}}$, $\mathbf{T_{0,25}}$, $\mathbf{T_{0,5}}$, $\mathbf{T_{0,75}}$, $\mathbf{T_c}$ the hardness values the hardness values at ball surface, at a distance from the grinding ball surface in the radius parts and at ball center.

The volumetric hardness determines as arithmetic average value of volumetric hardness the control grinding balls.

9.4 The control of the steel chemical composition provide in accordance with GOST 18895, DSTU 7749, DSTU 7750, DSTU 7751, DSTU 7752, DSTU 7753, DSTU 7754, DSTU 7756, DSTU 7757, DSTU 7758, DSTU 7760, GOST 27809, GOST 28033 or by other methods ensure the necessary accuracy.

9.4.1 The steel carbon equivalent of C_{eq} calculates in percentage by the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Si}{24} + \frac{Cr}{5} + \frac{Ni + Cu}{40} + \frac{V}{14}, \qquad [2]$$

where C, Mn, Si, Cr, Ni, Cu, V - mass fraction of carbon, manganese, silicon, chromium, nickel, copper and vanadium.

9.5 The grinding balls impact resistance test provide according to the producer's methodology.

10. TRANSPORTATION AND STORAGE

10.1 The grinding balls transports by all transport types in accordance with the current cargo transportation rules.

10.2 The grinding balls blend by different sizes and hardness groups is not allowed during transportation.

10.3 The grinding balls transportation and storage provide according to DSTU 3058 (GOST 7566), in part of the environment climatic factors action - in accordance with GOST 15150.

APPENDIX A
(informative)

THE CALCULATING PARAMETERS OF GRINDING BALLS

Table A.1

Conditional diameter of grinding ball , mm	The calculating nominal parameters			
	Surface area, cm^2	Volume, cm^3	Mass, kg	Grinding balls quantity in one ton, pc
15	7,06	1,76	0,014	71428
20	12,56	4,18	0,033	30300
25	19,52	8,18	0,064	15625
30	31,15	16,40	0,128	7812
35	41,83	25,40	0,199	5025
40	54,00	37,40	0,294	3401
45	67,90	52,60	0,413	2421
50	84,90	74,00	0,580	1724
55	102,00	96,90	0,761	1314
60	120,70	125,00	0,980	1020
65	145,20	164,50	1,291	774
70	167,33	204,00	1,600	625
80	216,31	299,00	2,350	425
90	277,45	435,00	3,410	293
100	339,60	589,00	4,620	216
110	408,00	776,00	6,090	164
120	490,60	1023,00	8,030	124

Note 1. The calculation of grinding balls surface area and grinding balls volume performed by nominal diameters.

The steel density is 7.85 g/cm^3 during grinding balls mass calculation.

Code UCND 77.140.99

Key words: the carbon equivalent, the hardness group, the diameter, the grinding balls, the volumetric hardness, the dimensions, the steel, the hardness

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