



**Ayande Roshan Maghate Alyazhy
(ARMA)**

Instruction and checklist for
Quality Control of Steel Ball

Prepared by	Checked by	Approved by	revision	Date
A. Hosseini	E. Hossein zadeh	h. Golbafian	00	30-July-2019

Contents

Purpose	3
Scope	3
Definitions	3
Supply chain identification.....	3
Parameters to be evaluated	3
Inspection procedure	4
Sampling and analysis procedure	4
Confirmation criteria.....	6
Quality confirmation	8
Test instruments calibration	8
Quality Control Checklist	9
Compensation Quality Control Checklist	10
Non Conformity Report	11
Instruments Calibration Certificate	12

Purpose

This procedure is about the inspection instruction of grinding balls over its whole supply chain from the billet production up to packing of the balls.

Scope

This instruction does not cover the quality control of the supply chain of the ball production. Process control factors like proper temperature of the quenching and its duration, rods temperature at the moment of entering to the dies and tempering condition are not covered in this instruction.

Inspection at each stage must be confirmed prior to moving the product toward next one.

This instruction is to approve 25ton product in each order, so the numbers mentioned for sampling are based on this assumption.

Definitions

Product: refer to steel balls

Company: refer to ARMA Company

QC: quality control

Supply chain identification

The stages included in this supply chain are:

1. Billet production
2. Rod manufacturing
3. Ball manufacturing
4. Packing of balls

Parameters to be evaluated

Main parameters to be assessed are as below:

1. Chemical analysis
2. Dimensional tolerance
3. appearance
4. Surface and volumetric hardness
5. Packing

Inspection procedure

In the foundry the billet's chemical composition is analyzed, subject to the confirmation of the chemical composition, they will be transferred to the rod manufacturing factory. After receiving the billets in the rod manufacturing factory chemical composition of the billets will be checked again, and subsequent to the approval of their chemical composition, the process of rod manufacturing will be commenced. The former quality scrutiny is called first control, and the latter is second control.

In the rod manufacturing factory, produced rods will be checked for their dimensional tolerances and appearance, which shall be within their acceptable limits. This scrutiny will be performed in the ball production plant once more and any probable defective rods will be removed from ball production line. The former quality scrutiny is called first control, and the latter is second control.

Produced grinding balls will be controlled as follows:

Appearance of all the balls will be checked just after exiting the quenching pool and prior to entering to the tempering furnace, this is called appearance first checking. After finishing the process of tempering and while the balls are being pushed out of the furnace, required samples will be randomly opted by the QC expert of the company. Subsequent to cooling down to ambient temperature, surface hardness of the balls will be measured. If surface hardness found to be in the acceptable limits, some balls will be randomly chosen from them and prepared for volumetric hardness test. Selected balls will be cut into two hemispheres and volumetric hardness will be measured on one half. The other half will be sent to metallography laboratory if the volumetric hardness of the ball passes its criteria. The second checking of appearance will be performed in the time of storing and precedent to packing.

Finally, drums weights will be measured, their shapes will be checked to be defects free and all the approved ones will be locked.

At this point, the results of the inspection will be delivered to the customer and subject to his confirmation; the process of loading the drums over the truck will be triggered.

Sampling and analysis procedure

- Chemical analysis:

One sample from each melting ladle in foundry plant will be taken by QC expert of the foundry and analyzed with optical emission spectrometer (OES). At the hot-rolling factory the billets will be validated for their chemical composition by one sample for each ladle number, taken by QC expert of the company.

- Appearance of the rods:

All the rods will be checked to be in accordance with DIN1013, twice. These analyses will be performed by QC expert of the company in rod manufacturing company and by QC expert of the grinding ball factory and under supervision of the QC expert of the company in the ball manufacturing company. Defective rods will be removed, if any.

- Appearance of the balls:

Appearance of all the balls will be checked in its first quality control by the QC expert of the company in the grinding ball factory and on the conveyer from quenching pool to the tempering furnace. All the defective balls will be removed.

Second appearance checking of the balls will be performed after the balls stored and their temperature got cooled down. 5 balls from one ton balls will be randomly selected and fully inspected.

- Dimensional tolerances:

One ball from one ton ball, totally cooled down, will be randomly selected and its diameter will be measured using calipers in three different directions. Balls shall not be oval and its diameter shall be in the acceptable limits.

- Surface hardness:

After discharging the balls from tempering furnace, 1 ball out of one ton balls will be randomly selected (totally 25 balls for each truck), and their surface hardness will be measured by QC expert of the company using hardness tester based on Rockwell method available at the ball manufacturing factory. This measurement will be carried out after balls temperature reaches ambient temperature. This hardness will be measured three times and the average of these numbers will be introduced as the surface hardness of the ball.

- Volumetric hardness:

If the surface hardness of the ball is acceptable, two balls out of those 25 balls approved in surface hardness analysis, will be selected and their volumetric hardness will be measured and calculated. This will be performed with hardness tester located in the ball manufacturing factory.

Finally, one sample out of 4 samples used in volumetric analysis will be selected and sent to an external laboratory.

- Metallography:

The hemisphere not used for volumetric hardness analysis will be sent for metallography and the percentage of martensitic and austenitic structure will be evaluated.

- Packing:

Each drum should contain 960±20kg of the balls. They shall not have any gross deformation on the body and the ends. The head could be easily removed and locked. They shall be in accordance with the promised color, and without any Logo. All the drums must be locked after getting approved by the QC expert of the company.

Confirmation criteria

- 1- Chemical composition:

Material designation	%C		%Cr		%Mn		%P	%S	%Si	%Cu
	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Max.	Max.	Max.
70Cr2	0.65	0.80	0.50	0.70	0.70	0.90	0.04	0.04	0.35	0.30

- 2- Surface hardness:

58-62 HRC for 70Cr2 analysis

For any other chemical composition shall be finalized.

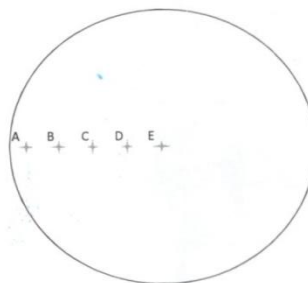
- 3- Volumetric hardness:

57-61 HRC for 70Cr2 analysis

For any other chemical composition shall be finalized.

Volumetric hardness will be calculated as bellow:

Selected balls will be cut into two hemispheres. Hardness will be measured on five point equally distributed on a radius of the cross sectional area of one the hemispheres. The weighted average of these five hardness numbers will be calculated, using coefficients mentioned in the below picture, and introduced as volumetric hardness.



Hardness Average Volume:
 $0.289A + 0.437B + 0.203C + 0.063D + 0.009E$

- 4- Dimensional tolerances:

Ball's diameter (mm)	Dimensional
----------------------	-------------

from	To (and including)	limits
25	60	+2/-1
60	90	+3/-2
90	125	+4/-3

5- Balls appearance:

Maximum acceptable depth of the permitted defects on the surface of the balls shall not be more than 2% of the ball diameter. Each ball shall not have more than one defect which must be in the acceptable limits. Nipples and burrs must be eliminated. Balls shall not have more than one rib as a defect on its surface. Cracks are not acceptable.

6- Rods appearance:

Dimensional limits of the diameters of the rods shall be as follow:

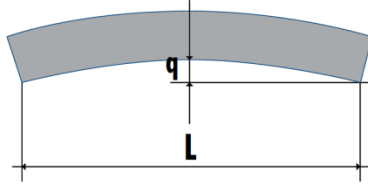
Rod diameter (mm)		Dimensional limits
from	To (and including)	
20	25	±0.5
25	35	±0.6
35	50	±0.8
50	80	±1.0
80	100	±1.3
100	120	±1.5
120	160	±2.0

The difference between the largest and smallest diameter measured in the same cross-sectional plane, shall not exceed 80% of the permissible total variations for diameter according to above table.

Maximum allowable deviation from straightness of the rods shall be within limits mentioned in the below table:

Rod diameter (mm)		Permissible variation from straightness (q)
from	To (and including)	
---	25	Not defined
25	80	0.004.L
80	200	0.0025.L

L: total length of rod



Any circumferential and longitudinal rids and cracks on a rod are not acceptable.

Quality confirmation

Each party of the product, containing approximately 25 ton balls carried by one truck, will be approved if and only if all the aforementioned criteria pass.

If some balls offend the allowable limits, twice as many of those offender balls will be selected and tests will be repeated. If all the newly selected balls pass the tests the whole party will be accepted. In case, some balls could not pass the confirmation criteria in the second analysis, but having a reasonable deviation, the whole party will be approved subject to the confirmation of the end user, informed with a written letter.

Test instruments calibration

Test instruments used in this instruction are: optical emission spectrometer (OES), hardness tester, caliper and weighting scale. Each of these devices for incumbent's subcontractor shall be checked to be calibrated each six month. For any new subcontractor its devices shall be calibrated prior to assigning any contract.

	ARMA co.	Quality Control Checklist	Document no.:	QA/AR/16
			Rev:	00
			Date:	22-09-2019

Order number:	Party number:	Responsibles:
---------------	---------------	---------------

Chemical Analysis									
Material:	%C (....-....)	%Cr (....-....)	%Mn (....-....)	%P (....)	%Cu (....)	%S (....)	%Si (....)	Pass criteria?	QC approval
Ladle no.:	Control1:							<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> App <input type="checkbox"/> Rej
	Control2:							<input type="checkbox"/> Yes <input type="checkbox"/> No	
Ladle no.:	Control1:							<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> App <input type="checkbox"/> Rej
	Control2:							<input type="checkbox"/> Yes <input type="checkbox"/> No	
Ladle no.:	Control1:							<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> App <input type="checkbox"/> Rej
	Control2:							<input type="checkbox"/> Yes <input type="checkbox"/> No	

Rods Appearance						
Unacceptable Defects:	Ribs on surface	Oval shape	Out of straightness	Diameter out of tolerance limits	Lengths out of agreed limits	QC approval
Control 1:	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> App <input type="checkbox"/> Rej
Control2:	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> have <input type="checkbox"/> don't have	<input type="checkbox"/> App <input type="checkbox"/> Rej

Balls Appearance		
Control 1 (after quenching pool):	Criteria: maximum 0.5% defective ball may pass.	QC approval
Control2 (after tempering furnace):		<input type="checkbox"/> App <input type="checkbox"/> Rej

Dimensional tolerances													
Ball number:	1	2	3	4	5	6	7	8	9	10	11	12	Criteria:
App(✓) or Rej(x)												-.....
Ball number:	13	14	15	16	17	18	19	20	21	22	23	24	QC approval
App(✓) or Rej(x)													<input type="checkbox"/> App <input type="checkbox"/> Rej

Surface Hardness													
Ball number	1	2	3	4	5	6	7	8	9	10	11	12	Criteria:
Hardness number													58-62 HRC
Ball number	13	14	15	16	17	18	19	20	21	22	23	24	QC approval
Hardness number													<input type="checkbox"/> App <input type="checkbox"/> Rej

Volumetric Hardness							
Measured spot	center	First quarter	Middle of radius	Third quarter	Near surface	Calculated Volumetric hardness	Criteria:
coefficients	0.009	0.063	0.203	0.436	0.289		
Ball no.:							QC approval
Ball no.:							<input type="checkbox"/> App <input type="checkbox"/> Rej

Drums weight													
Drum no.	1	2	3	4	5	6	7	8	9	10	11	12	13
weight													
Drum no.	14	15	16	17	18	19	20	21	22	23	24	25	QC approval
weight													<input type="checkbox"/> App <input type="checkbox"/> Rej

Drums status			
Appearance:	Criteria: even one drum with gross defects shall not exist.	QC approval	<input type="checkbox"/> App <input type="checkbox"/> Rej
Being locked:	Criteria: even one drum which is not locked yet shall not exist.	QC approval	<input type="checkbox"/> App <input type="checkbox"/> Rej

Is the quality of the balls approved? <input type="checkbox"/> Yes <input type="checkbox"/> No	Shall the ball loaded over trucks? <input type="checkbox"/> Yes <input type="checkbox"/> No
QC manager sign	CEO sign



ARMA co.

Compensation Quality Control Checklist

Document no.:	QA/AR/17
Rev:	00
Date:	22-09-2019

Order number:	Party number:	Responsibles:
---------------	---------------	---------------

Balls Appearance

Compensation control:	Criteria: even one defective ball shall not exist.	QC approval	<input type="checkbox"/> App <input type="checkbox"/> Rej
-----------------------	--	-------------	---

Dimensional tolerances

Ball number	1	2	3	4	5	6	7	8	9	10	11	12	13
App(✓) or Rej(x)													
Ball number	14	15	16	17	18	19	20	21	22	23	24	25	26
App(✓) or Rej(x)													
Ball number	27	28	29	30	31	32	33	34	35	36	37	38	39
App(✓) or Rej(x)													
Ball number	40	41	42	43	44	45	46	47	48	Criteria: all the diameters shall be within ...-....			QC approval
App(✓) or Rej(x)													<input type="checkbox"/> App <input type="checkbox"/> Rej

Surface Hardness

Ball number	1	2	3	4	5	6	7	8	9	10	11	12	13
Hardness number													
Ball number	14	15	16	17	18	19	20	21	22	23	24	25	26
Hardness number													
Ball number	27	28	29	30	31	32	33	34	35	36	37	38	39
Hardness number													
Ball number	40	41	42	43	44	45	46	47	48	Criteria: all hardness numbers shall be within 58 to 62 HRC			QC approval
Hardness number													<input type="checkbox"/> App <input type="checkbox"/> Rej

Volumetric Hardness

Measured spot coefficients	center	First quarter	Middle of radius	Third quarter	Near surface	Calculated Volumetric hardness	Criteria: all the volumetric hardness numbers shall be within 57 to 61 HRC.
	0.009	0.063	0.203	0.436	0.289		
Ball no.:							QC approval <input type="checkbox"/> App <input type="checkbox"/> Rej
Ball no.:							
Ball no.:							
Ball no.:							

Is the quality of the compensated balls approved? Yes No

QC manager sign



ARMA co.

Non Conformity Report

Document no.:

QA/AR/18

Rev:

00

Date:

22-09-2019


Order number:

Party number:

date:

Row	Issue	Solution
1		
2		
3		
4		
5		
6		
7		

Notes:

	ARMA co.	Instruments Calibration Certificate	Document no.:	QA/AR/19
			Rev:	00
			Date:	22-09-2019
Date:		Supervisor:		
Supplier name:		Supplier product: <input type="checkbox"/> billet <input type="checkbox"/> ball		
Equipment at Foundry factory:				
Do results of the optical emission spectrometer (OES) available at the foundry match with the reference data?			<input type="checkbox"/> Yes	<input type="checkbox"/> No
Ball manufacturing factory:				
Does the result of testing on the test block of hardness tester available at ball manufacturing factory match with the reference data?			<input type="checkbox"/> Yes	<input type="checkbox"/> No
Have the weighting scale available at ball manufacturing factory, taken the calibration certification in the recent six month?			<input type="checkbox"/> Yes	<input type="checkbox"/> No
Have the caliper available at ball manufacturing factory, taken the calibration certificate in the recent six month?			<input type="checkbox"/> Yes	<input type="checkbox"/> No