

ENGINEERING MATERIAL SPECIFICATION

Material Name	Specification Number
GRAY CAST IRON, CYLINDER LINERS, THIN WALL	WSE-M1A320-A1
GRAY CAST IRON, CYLINDER LINERS, (10 mm or thicker)	WSE-M1A320-A2
GRAY CAST IRON, CYLINDER LINERS	WSE-M1A320-A3
GRAY CAST IRON, CYLINDER LINERS, HIGH DURABILITY	WSE-M1A320-A4

1. SCOPE

The materials defined by these specifications are gray cast iron with controlled hardness and microstructure to achieve optimum cylinder bore functional characteristics.

2. APPLICATION

These specifications were released originally for materials used as cylinder liners in aluminum blocks. The A4 material was added for long-term durability and improved oil consumption.

3. REQUIREMENTS

Material specification requirements are to be used for initial qualification of materials.

3.1 STANDARD REQUIREMENTS FOR PRODUCTION MATERIALS

Material suppliers and part producers must conform to the Company's Standard Requirements For Production Materials (WSS-M99P1111-A).

3.2 CHEMICAL COMPOSITION (Weight Percent)

	A1	A2	A3	A4
Carbon (total)	3.00 - 3.70	2.80 - 3.60	3.00 - 3.50	3.00 - 3.50
Carbon Equivalent	4.45 max	---	4.40 max	4.40 max
Silicon	1.80 - 2.80	1.80 - 2.50	2.00 - 2.80	2.00 - 2.80
Manganese	0.50 - 0.90	0.50 - 0.90	0.50 - 1.00	0.50 - 1.00
Phosphorus	0.25 max	0.25 max	0.10 - 0.40	0.10 - 0.40
Sulfur	0.15 max	0.15 max	0.12 max	0.12 max
Chromium	0.15 - 0.40	0.20 - 0.50	0.10 - 0.40	0.10 - 0.40
Copper + Nickel*	0.30 - 1.00	0.50 - 1.50	---	0.20 - 1.50
Tin	---	---	0.15 max	0.15 max

Date	Action	Revisions
2002 07 23	Revised	Updated and renumbered
2002 01 31	Revised	Added A4, renumbered & updated R. Thomas
1991 05 08	NE01E10127076	Released J. Webster

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Carbon Equivalent = Total Carbon + 1/3 Silicon

- * Nickel may be substituted for copper or visa versa to the extent that the total nickel plus copper equals specified amount.

Specific composition limits and foundry practice to meet performance and manufacturing requirements will form part of an agreed Control Plan for individual components.

3.3 HARDNESS

ASTM E 10/ISO 6506, P/D2 Ratio = 30:1;
ASTM E 18/ISO 6507)

As cast Brinell hardness test location is on the OD at least 25 mm from the skirt end of the casting. Finished hardness and location shall be taken as shown on Engineering Drawing or Control Plan.

	A1	A2	A3/A4
As cast	179-248 HB	212-293 HB	205-273 HB
Finished*	179-248 HB 85-99 HRB	200-285 HB 93 HRB-30 HRC 210-300 HV	205-273 HB 94-104 HRB

*Average of three readings.

3.4 MICROSTRUCTURE (average over a minimum of 10 adjacent fields at 100X magnification) (ASTM A 247/ASTM E 562)

Evaluate microstructure at any position greater than 2 mm from finished outer diameter. The graphite structure at the wear surface of a finished liner at a point approximately 25 mm from the flange end shall consist as defined in the following.

Form VII flake graphite as follows:

	A1	A2	A3	A4
Type A, % min (size)	50 (4-6)	50 (4-6)	Permissible	50 (4-7)
Type B, % max (size)	50 (4-6)	50 (4-6)	75 (6-8)	
Type D&E, max (size)	10		75 (6-8)	25 (4-8)

The graphite morphology, size and matrix microstructure content may be measured by estimation, comparison to available industry charts, or by quantitative methods (ASTM E 562 or approved image analysis techniques). In case of dispute, the quantitative metallurgical method will be the umpire method.