

ENGINEERING SPECIFICATION

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| Hyster-Yale Group, Inc. | Document Control Number: |
| Title: PEARLITIC DUCTILE IRON | HC-84 |
| Page 1 of 4 Document Author: Caitlin Toohey | Effective Date: 01-Mar-2017 Revision No. 2017-03 |

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1.0 OBJECTIVE

This specification is established to provide a nodular (spheroidal) cast iron material with mechanical properties approximately equivalent to alloy steel castings for use when welding is not a requirement in fabrication.

2.0 CITED

See [Master Index](#) or attached [Annex](#) for a complete list of Citing & Cited Documents.

3.0 REQUIREMENTS

| Mechanical Properties*, minimum | Separately Cast Test Bars or Test Bars Taken from Specified Location on the Drawing | Casting (Test Bar Location Not Specified) |
|---------------------------------|---|---|
| Tensile Strength | 80 ksi (552 MPa) | 80 ksi (552 MPa) |
| Yield Strength, 0.2% offset | 55 ksi (379 MPa) | 55 ksi (379 MPa) |
| Elongation in 2 inches, % | 6 | 4 |
| Hardness, HB | 179-255 (4.5-3.8 BID) | 179-255 (4.5-3.8 BID) |

* Tensile test requirements apply to separately cast test bars and test bars taken from the casting. Castings with sections insufficient for tensile testing will be judged by microstructure, hardness and separately cast test bar certification.

Test Bar Certification

Prototype castings, pilot production, and samples from new sources or pattern changes will require separately cast test bar certification for correlation with casting properties. The supplier, upon Hyster-Yale Group's request, shall be able to supply records showing conformance to HC-84 for any lot shipped.

Microstructural Characteristics

Graphite: 80% of ASTM A247 Types I and II
Matrix: Ferritic-Pearlitic (30% minimum pearlite)

Massive carbides are not to exceed 1% of the matrix and continuous intercellular carbide networks are not permitted at 500X magnification.

Chemical Composition

It is the supplier's responsibility to control carbon equivalent, alloy content, cooling rate, etc., to the extent necessary to provide machinable castings meeting the mechanical and microstructural requirements of this specification. A typical base composition may be found in SAE J434, but with the following restrictions:

Sulfur $\leq 0.02\%$
Phosphorous $\leq 0.08\%$

The supplier shall submit the proposed composition at the time of quotation.

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Heat Treatment

As cast providing mechanical properties can be met.

Quality

Linear imperfections such as cracks and hot tears are not acceptable. Shrinkage, gas pockets, inclusions, etc., may be cause for rejection, depending upon the effect they may have on reliability, customer acceptance and/or machinability. This is a decision which must be agreed upon by Hyster-Yale Group and the supplier.

Chilled surfaces or edges are not permitted. The casting surface must be free of mold or core sand and any surface conditions that may detract from machinability or usability.

Repair of Imperfections

Weld repair of castings is not permitted.

4.0 ENGINEERING INFORMATION (Not Part of Requirements)Engineering

This material is primarily intended to offer better strength and wear resistance than HC-40, while maintaining machinability. Typical applications would include crossheads, pedals, motor mounts, cages, bearing carriers, yokes, and hubs. It should not be used in welded or brazed fabrications. As a general rule, it should not be specified for sections less than 0.375 inch (10 mm), due to its ability to form massive carbides. If less thickness is required in certain areas of the design, foundry review is suggested in order to determine their ability to cast the section free of massive carbides. This is especially true for pads and appendages (on brake pedals, for example). Thus ductile irons do exhibit some section sensitivity, but not in the nature of gray irons. In addition, certain solidification conditions and centerline segregation can reduce the ductility properties of the iron; therefore, the sections from which test bars will provide dynamically meaningful values are limited. In all cases specimens should be taken as near to the surface as possible. Mechanical property requirements in the casting on the preceding page have been appropriately adjusted for such conditions.

| Mechanical Properties for Design | Undesignated Locations |
|----------------------------------|------------------------|
| Tensile Strength | 80,000 psi |
| Yield Strength, 0.2% offset | 55,000 psi |
| Elongation, % in 2 inches | 4 |
| Hardness | 179-255 HB |
| Fatigue Limit (notched) | 23,000 psi |

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| Fatigue Limit (unnotched) | 39,000 psi |
| Impact Resistance, Charpy (V-notched) | 3.6 ft-lb |
| Impact Resistance, Charpy (unnotched) | 7.1 ft-lb |
| Modulus of Elasticity | 25 x 10 ⁶ psi |
| Proportional Limit | 36,000 psi |
| Poisson's Ratio | 0.28 |

Prototype castings will generally have tensile bars machined from them. All test bars shall be prepared and tested in accordance with ASTM E8. Correlation of separately cast test bar results with those from the actual castings should begin at this time.

Method of Specifying

HC-84 and indicate the location of hardness testing and/or test bars.

(Tensile test bar locations should be noted if strength or ductility is required in specific stress locations.)

Manufacturing

Hardness inspection of incoming castings to a planned quality level should be performed consistent with product classification and supplier performance. Audits confirming correlation of separately cast test bars with those from actual castings may be a part of the inspection program.

Note: On existing drawings which call for HC-84 and require subsequent selective hardening use ASTM A536: Grade 100-70-03 at 241-302 HB.

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Annex

ASTM A247, Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings

ASTM A536, Standard Specification for Ductile Iron Castings

ASTM E8, Standard Test Methods for Tension Testing of Metallic Materials

EN 1563, Spheroidal Graphite Cast Irons

HC-40, Ferritic-Pearlitic Ductile Iron

SAE J434, Automotive Ductile (Nodular) Iron Castings