

INDEX FOR STAMPING DIES CAST MATERIALS

| PAGE | DATE | DESCRIPTION |
|------------------------|-------------|--|
| D-1 | 02/12/14 | Index For Stamping Dies Cast Materials |
| D-2 | 02/03/15 | General Information |
| D-3 | 06/02/03 | General Information |
| D-4 | 06/02/03 | General Information |
| D-5 | 06/02/03 | General Information |
| D-6 | 06/02/03 | General Information |
| D-7 | 02/03/15 | General Information |
| D-8 | 02/03/15 | General Information |
| D-9 | 02/03/15 | General Information |
| D-10 | 06/03/10 | General Information, Material Cross Reference |
| D-11 | 08/01/11 | Non-Alloyed Gray Cast Iron (G2500/NAAMS) |
| D-11.1 | 02/03/15 | Low-Alloyed Gray Cast Iron (G25HP/NAAMS) |
| D-12 | 02/03/15 | Alloyed Gray Cast Iron (G3500/NAAMS) |
| D-13 | 02/03/15 | Non-Alloyed Ferritic Ductile Iron (D4512/NAAMS) |
| D-14 | 10/29/07 | Pearlitic Ductile Iron (D5506/NAAMS) (Discontinued) |
| D-15 | 02/03/15 | Refined Pearlitic Ductile Iron (D6510/NAAMS) |
| D-16 | 08/01/11 | Non-Alloyed Steel (S0030/NAAMS) |
| D-17 | 02/12/14 | Alloyed Steel (S0050A/NAAMS) |
| D-18 | 08/01/11 | Medium Shock/MediumWear Resistant Tool Steel (TA2/NAAMS) |
| D-19 | 08/01/11 | High Wear/Low Shock Resistant Tool Steel (TD2/NAAMS) |
| D-20 | 08/01/11 | High Shock/Low Wear Resistant Tool Steel (TS7/NAAMS) |
| D-21 | 08/01/11 | Alloyed Steel (S7140/NAAMS) |
| D-22 | 08/01/11 | Alloyed Steel (S2333/NAAMS) |
| D-23 | 02/03/15 | Refined Pearlitic Ductile Iron (D7003/NAAMS) |

GENERAL INFORMATION

GLOBAL STANDARD COMPONENTS



Stamping

04/14/15

1. SCOPE

This specification encompasses criteria for stamping dies cast materials delivered in the rough-cast condition.

1.1 TYPES

This specification covers ferrous casting materials used for stamping dies. These materials include: G2500/NAAMS, G25HP/NAAMS, G3500/NAAMS, D4512/NAAMS, D5506/NAAMS, D6510/NAAMS, D7003/NAAMS, S0030/NAAMS, S0050A/NAAMS, S7140/NAAMS, S2333/NAAMS, TA2/NAAMS, TD2/NAAMS, and TS7/NAAMS. This specification does not include or cover wrought materials.

1.2 PROPERTIES

The properties of all castings are sensitive to section size, particularly the properties of gray and ductile irons. Since the cooling rate varies with thickness, the microstructure and properties will vary with thickness as well. Therefore, all properties must be referenced to specific test methods and test sample locations.

1.3 APPLICATIONS

The application of these materials is automotive stamping dies.

1.4 MATERIAL DESCRIPTIONS

Brief descriptions are listed below for the materials covered in this specification.

- G2500/NAAMS: Non-Alloyed Gray Cast Iron (not surface hardenable)
- G25HP NAAMS: High Pearlite Low-Alloyed Gray Cast Iron
- G3500/NAAMS: Alloyed Gray Cast Iron (surface hardenable)
- D4512/NAAMS: Non-Alloyed Ferritic Ductile Iron (not surface hardenable)
- D6510/NAAMS: Refined Alloyed Pearlitic Ductile Iron (surface hardenable)
- D7003/NAAMS: Refined Alloyed Pearlitic Ductile Iron (surface hardenable)
- S0030/NAAMS: Non-Alloyed Steel (not surface hardenable)
- S0050A/NAAMS: Alloyed Steel (surface hardenable)
- S2333/NAAMS: Alloyed Steel (surface or through hardenable)
- S7140/NAAMS: Alloyed Steel (surface hardenable)
- TA2/NAAMS: Medium Shock/Medium Wear Resistant Tool Steel
- TD2/NAAMS: High Wear/Low Shock Resistant Tool Steel
- TS7/NAAMS: High Shock/Low Wear Resistant Tool Steel

The prefix on each alloy designation indicates the type of alloy as listed below.

- G Gray Iron
- D Ductile (Nodular) Iron
- S Steel
- T Tool Steel

1.5 SAFETY-HAZARDOUS MATERIALS

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials or procedures, this specification does not address those hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials or process and to take any necessary precautionary measures to ensure the health and safety of all personnel involved.

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2. TEST PROCEDURES

2.1 COMPOSITION

Chemical analysis of cast iron shall be made from chilled samples only. Cast iron chemical analysis shall be determined according to appropriate Standard Test Methods included in Volumes 03.05 and 03.06 of the Annual Book of ASTM Standards. The preferred method for carbon and sulfur determination is according to ASTM E 1019. If alloys are added by inoculation, after taking the chilled sample, calculated recovery amounts shall be noted and added to the analysis. Chemistry checks for steel shall be determined by emission spectroscopy or wet method for all elements according to ASTM A751.

2.2 MICROSTRUCTURE

2.2.1 CAST IRON

The microstructure for cast iron, except for G2500/NAAMS, shall be determined using the casting coupon shown in Figure 1. This coupon may be attached to the casting on or close to a working surface, or may be located on a representative section of the casting.

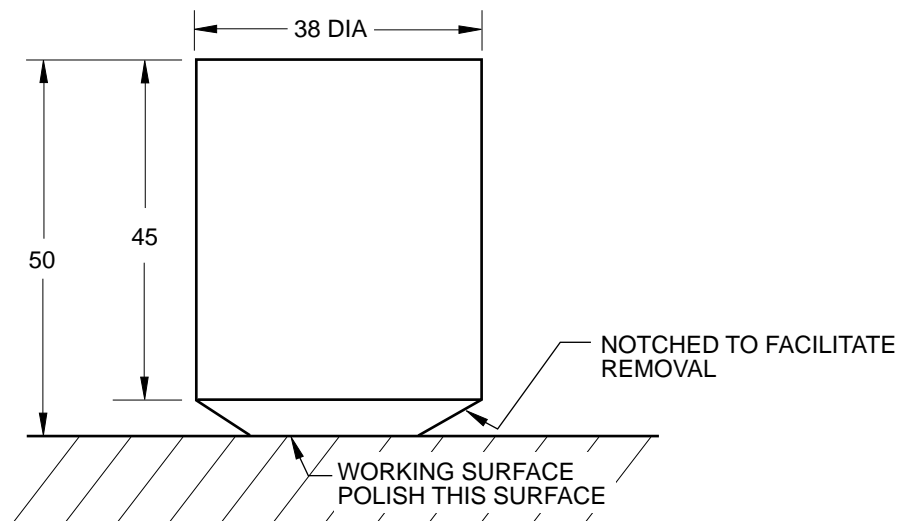


Figure 1 Typical Casting coupon showing location of surface for microstructure analysis.

The microstructure shall be determined in the center of the smaller diameter cross-section.

If required, the microstructure for G2500/NAAMS can be checked using a small representative section from the casting.

Metallographic preparation shall be done according to ASTM E 3. The graphite characteristics shall be determined by ASTM A 247. The matrix microstructure shall be evaluated by quantitative image analysis. If such equipment is unavailable, it is acceptable to use a visual comparison with the Gray Iron or Ductile Iron Microstructures Rating Chart at 100x. These charts are available in poster form from the AFS (American Foundry Society, Inc).

2.2.2 CAST STEEL

Microstructures of steel castings may be determined from small samples taken on or close to the working surface of the die.

Grain size is to be determined according to ASTM E 112.

2.3 HARDNESS

Hardness shall be measured on the casting or on the working surface of the coupon shown in Figure 1. The surface to be checked shall be flat and free of any porosity, inclusions, and decarburization. A minimum of 3.0 mm is to be ground or machined from the casting surface prior to hardness checking. Care must be taken not to burn the surface and cause hairline crack.

All hardness measuring equipment shall be checked using standard blocks and/or calibrated according to the manufacturer's recommended procedures prior to making any hardness checks.

The Brinell hardness test is the preferred method for as-cast samples, performed according to ASTM specification E 10 or E 110 at a load of 3000 kg.

The Rockwell hardness test is the preferred method for hardened samples, performed according to ASTM specification E 18 or E 118.

Electronic rebound type testers providing a digital readout in Brinell are acceptable. A minimum of three (3) hardness measurements shall be made for each area checked.

If there is any discrepancy or question of conformance, the Brinell or Rockwell test, as described above, shall be the arbiter.

2.4 TENSILE TESTING

Standard tensile testing may be done to determine tensile strength, yield strength, and elongation.

Samples for gray iron shall come from a separately cast type C test bar in accordance with ASTM A 48.

Samples for ductile iron shall come from 75 mm Y blocks in accordance with ASTM A 536. As an alternative, samples for ductile iron may come from "cast on" 25 mm keel blocks per Figure 2. Samples for steel shall come from keel blocks in accordance with ASTM A781.

Sample preparation and subsequent testing shall be in accordance with ASTM E8 for Iron and ASTM A370 for Steel.

The presence of porosity, shrink, inclusions, or other discontinuities within the fracture area invalidates the test, and the data must be discarded.

The viewing of such discontinuities shall be done without the use of any magnifying device.

GENERAL INFORMATION

SPECIAL NOTE:
BOTH LEGS CAN BE CUT FROM
THE KEEL BLOCK AND USED
FOR TENSILE TEST BARS

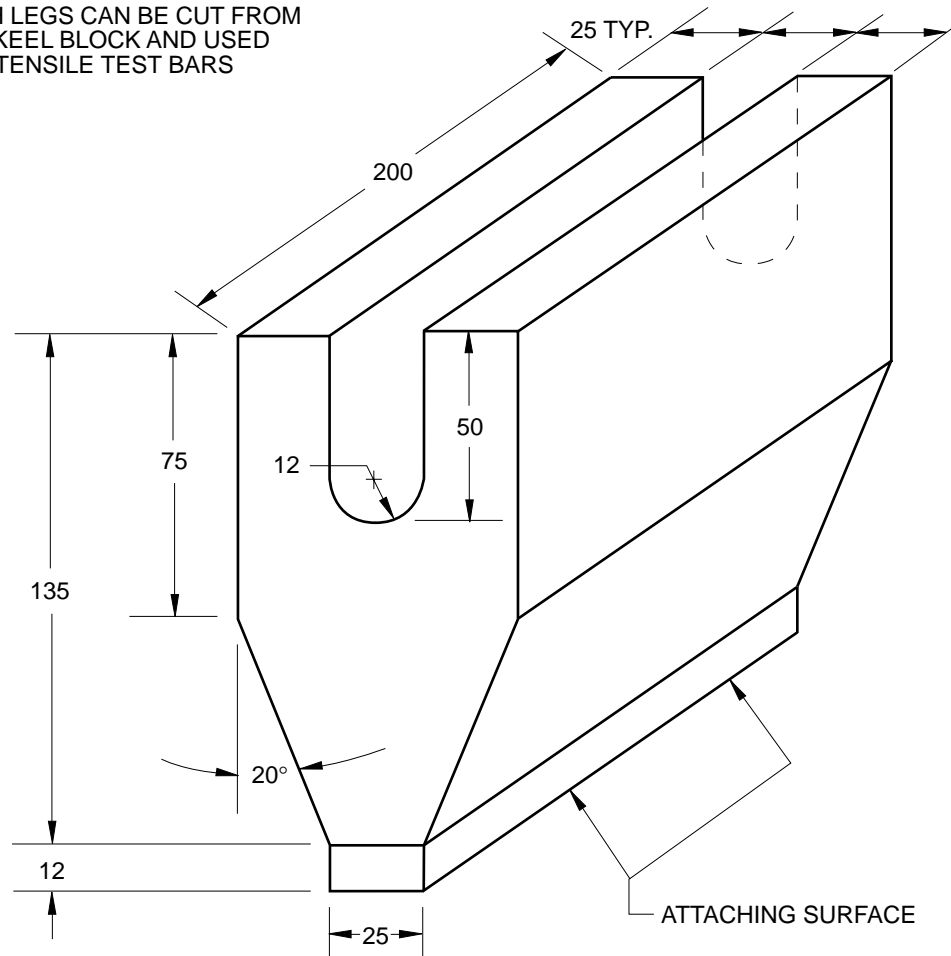


Figure 2 Cast-On Keel Block

3. MECHANICAL PROPERTIES

3.1 GENERAL

The microstructure and mechanical properties, specifically hardness and strength, are the primary requirements for grading and classifying the castings in this specification.

Samples shall be retained by the foundry for 5 years to enable analysis of microstructure and mechanical properties when required. All mechanical properties shall meet or exceed the minimum product requirements.

3.2 COMPOSITION

The composition ranges are given in Table 1. Composition shall be measured as described in Section 2.1.

3.3 MICROSTRUCTURE

The microstructure requirements are given in Tables 2a and 2b. Microstructures are to be determined as described in Sections 2.2 and 3.1.

3.4 MECHANICAL PROPERTIES

The mechanical properties are given in Table 3.

Casting hardness shall be measured as described in Section 2.3.

Strength and elongation shall be measured as described in Section 2.4.

Note: the tensile properties are from the type C test bar, Y block, or keel block only. Sections taken from the die itself may not meet the specification for tensile properties due to variations caused by changes in section thickness.

GENERAL INFORMATION

Table 1
 Composition Requirements (Weight Percent)*

| Material #/NAAMS | C | Si | Mn | Cr | Mo | Ni | Cu | V | Mg | S (max) | P (max) |
|------------------|-----------|-----------|-----------|-----------|-----------|---------|----------|-----------|-------------|---------|---------|
| G2500 | 2.9-3.5 | 1.9-2.3 | 0.5-0.9 | 0.25 max | | | | | | 0.20 | 0.20 |
| G25HP | 3.0-3.4 | 1.7-2.3 | 0.5-1.0 | 0.60 max | | | 0.8 max | | | 0.12 | 0.12 |
| G3500 | 2.8-3.2 | 1.5-2.2 | 0.7-1.0 | 0.35-0.50 | 0.35-0.50 | | 0.7 max | | | 0.15 | 0.15 |
| D4512 | 3.25-3.75 | 2.25-2.60 | 0.2-0.5 | 0.25 max | | 0.5-1.0 | | | | 0.015 | 0.080 |
| D6510 | 3.0-3.8 | 2.0-2.4 | 0.3-0.6 | 0.12 max | 0.35-0.50 | 0.5-1.5 | 0.35-1.0 | | 0.040-0.060 | 0.012 | 0.05 |
| D7003 | 3.0-3.8 | 2.0-2.4 | 0.4-0.8 | 0.12 max | 0.4-0.6 | 0.8-1.2 | 0.8-1.2 | | 0.030-0.065 | 0.02 | 0.05 |
| S0030 | 0.20-0.30 | 0.3-0.5 | 0.5-0.7 | | | | | | | 0.05 | 0.045 |
| S0050A | 0.4-0.5 | 0.2-0.5 | 0.9-1.2 | 0.8-1.1 | 0.35-0.50 | | | 0.15 max | | 0.05 | 0.045 |
| S2333 | 0.56-0.64 | 0.20-0.50 | 0.70-0.90 | 4.30-4.70 | 0.40-0.60 | | | 0.20-0.30 | | 0.035 | 0.035 |
| S7140 | 0.45-0.50 | 0.40-0.80 | 0.80-1.00 | 1.30-1.70 | | | | | | 0.035 | 0.035 |
| TA2 | 0.85-1.05 | 0.25-0.40 | 0.5-0.7 | 4.75-5.25 | 0.95-1.2 | | | 0.2-0.4 | | 0.03 | 0.03 |
| TD2 | 1.4-1.6 | 1.50 max | 1.00 max | 11.0-13.0 | 0.70-1.20 | | | 1.00 max | | 0.03 | 0.03 |
| TS7 | 0.45-0.55 | 0.20-1.00 | 0.20-0.80 | 3.00-3.50 | 1.30-1.80 | | | 0.20-0.30 | | 0.03 | 0.03 |

*Trace amounts shall be limited to standard practice, so that there are no detrimental microstructure or mechanical property effects.

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GENERAL INFORMATION

Table 2a
 Cast Iron Microstructure Specifications - (100X)

| Material #/NAAMS | Graphite Type | Flake Size or Nodule Count | Nodularity (min) | Pearlite* | Ferrite* | Carbide* (max) |
|------------------|---------------|----------------------------|------------------|-----------|----------|----------------|
| G2500 | Type A | 4-6 | n/a | 50% min | 45% max | 5% |
| G25HP | Type A | 4-7 | n/a | 75% min | 10% max | 5% |
| G3500 | Type A | 4-6 | n/a | 87% min | 10% max | 3% |
| D4512 | I & II | 50/mm ² min | 85% | 10% max | 87% min | 3% |
| D6510 | I & II | 100/mm ² min | 90% | 70-90% | 10-30% | 0.5% |
| D7003 | I & II | 50/mm ² min | 85% min | 80-100% | 0-15% | 5% max |

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* Note that the pearlite, ferrite, and carbide contents add up to 100% for the matrix microstructure. Microstructure results are for approved test bars as specified in Section 2.4. Actual casting microstructure may vary as previously described in Section 1.2.

Table 2b
 Steel Microstructure Specifications (annealed)

| Material #/NAAMS | ASTM Grain Size | Microstructure (100x) | % Carbide | Other |
|------------------|-----------------|---|---------------|------------------------|
| S0030 | Not Specified | Homogenous mixture of ferrite and pearlite | 3% max | No dendritic structure |
| S0050A | #5 or finer | Homogenous mixture of pearlite and ferrite | 5% max | |
| S7140 | #5 or finer | Homogenous mixture of pearlite and ferrite and no dendritic structure | 5% max | |
| S2333 | #5 or finer | Homogenous mixture of pearlite and ferrite and no dendritic structure | 5% max | |
| TA2 | Not Specified | Homogenous mixture of pearlite and ferrite | Not Specified | |
| TD2 | Not Specified | Homogenous mixture of pearlite and ferrite | Not Specified | |
| TS7 | Not Specified | Homogenous mixture of pearlite and ferrite | Not Specified | |

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GENERAL INFORMATION

GLOBAL STANDARD COMPONENTS



Stamping

02/03/15

Table 3
Mechanical Property Requirements As Shipped From Foundry

| Material #/NAAMS | Brinell Hardness Number | Test Bar Minimum Tensile Strength (MPa)* | Test Bar Minimum Yield Strength (MPa)* | Test Bar Minimum Elongation (%) |
|------------------|-------------------------|--|--|---------------------------------|
| G2500 | 163 - 212 | 205 | N/A | N/A |
| G25HP | 175 - 235 | 280 | N/A | N/A |
| G3500 | 197 - 241 | 310 | N/A | N/A |
| D4512 | 143 - 190 | 415 | 310 | 12 |
| D6510 | 190 - 248 | 570 | 350 | 4 |
| D7003 | 190 - 300 | 700 | 420 | 2 |
| S0030 | 120 - 170 | 450 | 240 | 24 |
| S0050A | 170 - 229 | 585 | 310 | 16 |
| S2333 | 190 - 230 | 700 | 330 | 7 |
| S7140 | 190 - 230 | 600 | 450 | 10 |
| TA2 | 201 - 229 | Not specified | Not specified | Not specified |
| TD2 | 217 - 255 | Not specified | Not specified | Not specified |
| TS7 | 187 - 223 | Not specified | Not specified | Not specified |

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* To convert to ksi multiply MPa by 0.145

3.5 SURFACE QUALITY

All as-cast surfaces shall meet specified criteria for discontinuities. Acceptance criteria shall be based on ASTM A802 for steel and ASTM A834 for iron. Acceptance levels utilize SCRATA (Steel Casting Research And Trade Association) graded reference comparators. Acceptance levels shall be as follows:

| Category | Plate No. |
|--|-----------|
| (A) Surface Texture (cold shuts, cracks, sand burn in) | [A3] |
| (B) Nonmetallic Inclusions | [B4] |
| (C) Gas Porosity | [C3] |
| (D) Fusion Discontinuities | [D2] |
| (E) Expansion Discontinuities (scabs) | [E3] |
| (G) Metal Removal Marks – Thermal (riser/gates) | [G3] |
| (H) Metal Removal Marks – Mechanical | [H4] |
| (J) Weld | [J3] |

4. HEAT TREATMENT

It is mandatory that all castings requiring furnace stress relief and annealing be processed as specified for each individual alloy.

It is the suppliers responsibility to assure that hardnesses and microstructures, for all cast materials, conform to those specified in Tables 2a, 2b, and 3.

5. IDENTIFICATION
Each casting shall be identified with the NAAMS material number as listed in Section 1.4.
6. INSPECTION AND REJECTION
The purchaser reserves the right to sample incoming shipments, even though it is the responsibility of the supplier to meet the requirements without dependence upon the purchaser's inspection. Frequency of testing is to be agreed upon between the purchaser and the supplier.
 - 6.1 COMPOSITION
The purchaser reserves the right to reject any casting if the value of any element falls outside the limits listed in Table 1. However, since microstructure and mechanical properties are the primary requirements for this specification, as stated in Section 3.1, their conformance shall be a consideration in any out-of-specification situation.
 - 6.2 MICROSTRUCTURE
The purchaser reserves the right to reject any casting if the microstructure does not meet the requirements listed in Tables 2a and 2b.
The microstructure shall be determined as described in Sections 2.2 and 3.1.
 - 6.3 HARDNESS
For large casting with multiple hardness checks, the purchaser reserves the right to reject any casting if more than 20% of the hardness measurements taken fall outside the hardness limits listed in Table 3. Hardness shall be measured as described in Section 2.3.
 - 6.4 MECHANICAL PROPERTIES
The purchaser reserves the right to reject any casting, if the tensile sample representative of the casting exhibits a tensile strength, yield strength, or elongation below the values listed in Table 3. Mechanical properties shall be measured as described in Section 2.4.
 - 6.5 SURFACE QUALITY
The purchaser reserves the right to reject a casting that exhibits a surface discontinuity as described and referenced in Section 3.5
7. ORIGIN
This standard was originated by the Auto/Steel Partnership's NAAMS Die Materials Subcommittee, November, 2002.

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NON-ALLOYED GRAY CAST IRON (G2500/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

1. MECHANICAL PROPERTIES

Hardness: 163-212 HBW
Minimum Tensile Strength: 205 MPa

2. MICROSTRUCTURE (100X)

| | | | |
|-------------|----------------|-----------|---------|
| Flake Type: | Type A 70% min | Pearlite: | 50% min |
| Flake Size: | 4-6 | Ferrite: | 45% max |
| | | Carbide: | 5% max |

3. COMPOSITION (in weight %)*

| | | | |
|----------------|---------|----------------|----------|
| Carbon (C) | 2.9-3.5 | Chromium (Cr) | 0.25 max |
| Silicon (Si) | 1.9-2.3 | Sulfur (S) | 0.20 max |
| Manganese (Mn) | 0.5-0.9 | Phosphorus (P) | 0.20 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

No heat treatment required for G2500/NAAMS castings.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

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LOW-ALLOYED GRAY CAST IRON (G25HP/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

02/03/15

1. MECHANICAL PROPERTIES

Hardness: 175-235 HBW
Minimum Tensile Strength: 280 MPa

2. MICROSTRUCTURE (100X)

Pearlite: 75% min
Carbide: 5% max

3. COMPOSITION (in weight %)*

| | | | |
|----------------|------------|----------------|-----------|
| Carbon (C) | 3.0-3.4 | Copper (CU) | 0.8 max † |
| Silicon (Si) | 1.7-2.3 | Sulfur (S) | 0.12 max |
| Manganese (Mn) | 0.5-1.0 | Phosphorus (P) | 0.12 max |
| Chromium (Cr) | 0.60 max † | | |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

† Chromium and Copper amounts are to be adjusted by foundry so all sizes of castings can meet the hardness required.

4. HEAT TREATMENT

Castings shall be left in the mold until they have cooled to approximately 260°C or less.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

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ALLOYED GRAY CAST IRON (G3500/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

02/03/15

1. MECHANICAL PROPERTIES (Stress-Relieved)

Hardness: 197-241 HBW
Minimum Tensile Strength: 310 MPa

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2. MICROSTRUCTURE (100X)

| | | | |
|-------------|---------------|-----------|---------|
| Flake Type: | Type A 80%min | Pearlite: | 87% min |
| Flake Size: | 4-6 | Ferrite: | 10% max |
| | | Carbide: | 3% max |

3. COMPOSITION (in weight %)*

| | | | |
|----------------|-----------|-----------------|-----------|
| Carbon (C) | 2.8-3.2 | Molybdenum (Mo) | 0.35-0.50 |
| Silicon (Si) | 1.5-2.2 | Copper (Cu) | 0.7 max |
| Manganese (Mn) | 0.7-1.0 | Sulfur (S) | 0.15 max |
| Chromium (Cr) | 0.35-0.50 | Phosphorus (P) | 0.15 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings shall be left in the mold until they have cooled to approximately 260°C or less.

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5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

NON-ALLOYED FERRITIC DUCTILE IRON (D4512/NAAMS) TM

GLOBAL STANDARD COMPONENTS



Stamping

02/03/15

1. MECHANICAL PROPERTIES (Subcritical Annealed)

| | |
|---------------------------|-------------|
| Hardness: | 143-190 HBW |
| Minimum Tensile Strength: | 415 MPa |
| Minimum Yield Strength: | 310 MPa |
| Minimum Elongation: | 12% |

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2. MICROSTRUCTURE (100X)

| | | | |
|---------------|------------------------|-----------|---------|
| Nodule Type: | I & II | Pearlite: | 10% max |
| Nodule Count: | 50/mm ² min | Ferrite: | 87% min |
| Nodularity: | 85% min | Carbide: | 3% max |

3. COMPOSITION (in weight %)*

| | | | |
|----------------|-----------|----------------|-----------|
| Carbon (C) | 3.25-3.75 | Chromium (Cr) | 0.25 max |
| Silicon (Si) | 2.25-2.60 | Sulfur (S) | 0.015 max |
| Manganese (Mn) | 0.2-0.5 | Phosphorus (P) | 0.080 max |
| Nickel (Ni) | 0.5-1.0 | | |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings shall be left in the mold until they have cooled to approximately 260°C or less.

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5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

PEARLITIC DUCTILE IRON (D5506/NAAMS)

1. MECHANICAL PROPERTIES (Stress Relieved)

| | |
|---------------------------|-------------|
| Hardness: | 190-241 BHN |
| Minimum Tensile Strength: | 550 MPa |
| Minimum Yield Strength: | 380 MPa |
| Minimum Elongation: | 6% |

2. MICROSTRUCTURE (100X)

| | | | |
|---------------|------------------------|-----------|---------|
| Nodule Type: | I & II | Pearlite: | 87% min |
| Nodule Count: | 50/mm ² min | Ferrite: | 10% max |
| Nodularity: | 85% min | Carbide: | 3% max |

3. COMPOSITION (in weight %)*

| | | | |
|-----------------|-----------|----------------|----------------------|
| Carbon (C) | 3.0-3.8 | Copper (Cu) | 0.3-0.7 (optional)** |
| Silicon (Si) | 2.0-2.6 | Chromium (Cr) | 0.25 max |
| Manganese (Mn) | 0.5-1.0 | Sulfur (S) | 0.005 max |
| Molybdenum (Mo) | 0.35-0.50 | Phosphorus (P) | 0.08 max |
| Nickel (Ni) | 0.5-1.0 | | |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical properties effects.

**The addition of copper promotes pearlite formation. It is typically added for large castings or castings with large section thicknesses.

4. HEAT TREATMENT

All D5506/NAAMS castings shall be furnace stress relieved by holding at 565-595C for a minimum of one hour per 25 mm of section thickness using the maximum section thickness. Castings shall be cooled at a maximum rate of 55°C per hour to 260C or lower followed by cooling in still air.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

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REFINED PEARLITIC DUCTILE IRON (D6510/NAAMS)

GLOBAL STANDARD COMPONENTS

TM **NAAMS**



Stamping

02/03/15

1. MECHANICAL PROPERTIES (Stress Relieved)

| | |
|--|-------------|
| Hardness: | 190-248 HBW |
| Minimum Tensile Strength: | 570 MPa |
| Minimum Yield Strength: | 350 MPa |
| Minimum Room Temperature Charpy ISO 148-1 2 mm U-notch (root radius 1 mm) with a depth of 2 mm | 3 Joules |
| Minimum Elongation: | 4 % |

2. MICROSTRUCTURE (100X)

| | | | |
|---------------|-------------------------|-----------|----------|
| Nodule Type: | I & II | Ferrite: | 10-30% |
| Nodule Count: | 100/mm ² min | Pearlite: | 70-90% |
| Nodularity: | 90% min | Carbide: | 0.5% max |

This specification requires bull's-eye nodule structure.

3. COMPOSITION (in weight %)**

| | | | |
|-----------------|-----------|----------------|-------------|
| Carbon (C) | 3.0-3.8 | Copper (Cu) | 0.35-1.0 |
| Silicon (Si) | 2.0-2.4 | Chromium (Cr) | 0.12 max |
| Manganese (Mn) | 0.3-0.6 | Sulfur (S) | 0.02 max |
| Molybdenum (Mo) | 0.35-0.50 | Phosphorus (P) | 0.05 max |
| Nickel (Ni) | 0.5-1.5 | Magnesium (Mg) | 0.040-0.060 |

** Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings shall be left in the mold until they have cooled to approximately 260°C or less.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

B

F

A

E

C

D

G

NON-ALLOYED STEEL (S0030/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

1. MECHANICAL PROPERTIES (Annealed)

| | |
|---------------------------|-------------|
| Hardness: | 120-170 HBW |
| Minimum Tensile Strength: | 450 MPa |
| Minimum Yield Strength: | 240 MPa |
| Minimum Elongation: | 24 % |

2. MICROSTRUCTURE (100X)

Homogenous mixture of ferrite and pearlite and no dendritic structure
Carbide: 3 % max

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|-----------|-----------------|-----------|
| Carbon (C): | 0.20-0.30 | Sulfur (S): | 0.05 max |
| Silicon (Si): | 0.3-0.5 | Phosphorus (P): | 0.045 max |
| Manganese (Mn): | 0.5-0.7 | | |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

All S0030/NAAMS castings shall be annealed by heating to 860-895°C and holding for a minimum of one hour plus one hour per 25 mm of section thickness (using the maximum section thickness). Castings shall be furnace cooled to 600°C at a rate not to exceed 45°C per hour then air cooled to room temperature.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

A

ALLOYED STEEL (S0050A/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

02/12/14

1. MECHANICAL PROPERTIES (Annealed)

| | |
|---------------------------|-------------|
| Hardness: | 170-229 HBW |
| Minimum Tensile Strength: | 585 MPa |
| Minimum Yield Strength: | 310 MPa |
| Minimum Elongation : | 16% |

A

2. MICROSTRUCTURE (100X)

Homogenous mixture of pearlite and ferrite and no dendritic structure,

| | |
|-----------------|-------------|
| ASTM grain size | #5 or finer |
| Carbide: | 5 % max |

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|---------|------------------|-----------|
| Carbon (C): | 0.4-0.5 | Molybdenum (Mo): | 0.35-0.50 |
| Silicon (Si): | 0.2-0.5 | Vanadium (V): | 0.15 max |
| Manganese (Mn): | 0.9-1.2 | Sulfur (S): | 0.05 max |
| Chromium (Cr): | 0.8-1.1 | Phosphorus (P): | 0.045 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

All S0050A/NAAMS castings shall be annealed by heating to 872-925°C and holding for a minimum of one hour plus one hour per 25 mm of section thickness using maximum section thickness. Castings shall be furnace cooled to 560°C at a rate not to exceed 45°C per hour, then air cooled at room temperature.

B

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

MEDIUM SHOCK /MEDIUM WEAR RESISTANT TOOL STEEL (TA2/NAAMS)

GLOBAL STANDARD COMPONENTS

TM **NAAMS**



Stamping

08/01/11

1. MECHANICAL PROPERTIES (Annealed)
Hardness: 201-229 HBW

2. MICROSTRUCTURE (100X)
Homogenous mixture of pearlite and ferrite and no dendritic structure.

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|-----------|------------------|-----------|
| Carbon (C): | 0.85-1.05 | Molybdenum (Mo): | 0.95-1.20 |
| Silicon (Si): | 0.25-0.40 | Vanadium (V): | 0.2-0.4 |
| Manganese (Mn): | 0.5-0.7 | Sulfur (S): | 0.03 max |
| Chromium (Cr): | 4.75-5.25 | Phosphorus (P): | 0.03 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental micro-structure or mechanical property effects.

4. HEAT TREATMENT
All TA2/NAAMS castings shall be annealed by heating slowly and uniformly to 845-870°C and holding for a minimum of one hour plus one hour per 25 mm of section thickness using the maximum section thickness. Castings shall be cooled at a maximum rate of 35°C per hour to 540°C then air cooled to room temperature.

5. SURFACE QUALITY
All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION
For any deviation from the above designations refer to General Information Section 6.

A

HIGH WEAR /LOW SHOCK RESISTANCE TOOL STEEL (TD2/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

1. MECHANICAL PROPERTIES (Annealed)

Hardness: 217-255 HBW

2. MICROSTRUCTURE (100X)

Homogenous mixture of pearlite and ferrite and no dendritic structure.

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|-----------|------------------|-----------|
| Carbon (C): | 1.4-1.6 | Molybdenum (Mo): | 0.70-1.20 |
| Silicon (Si): | 1.50 max | Vanadium (V): | 1.00 max |
| Manganese (Mn): | 1.00 max | Sulfur (S): | 0.03 max |
| Chromium (Cr): | 11.0-13.0 | Phosphorus (P): | 0.03 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

All TD2/NAAMS castings shall be annealed by heating slowly and uniformly to 870-900°C and holding for a minimum of one hour plus one hour per 25 mm of section thickness using the maximum section thickness. Castings shall be cooled at a maximum rate of 35°C per hour to 540°C then air cooled to room temperature.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

A

HIGH SHOCK /LOW WEAR RESISTANCE TOOL STEEL (TS7/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

A

1. MECHANICAL PROPERTIES (Annealed)

Hardness: 187-223 HBW

2. MICROSTRUCTURE (100X)

Homogenous mixture of pearlite and ferrite and no dendritic structure.

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|-----------|------------------|-----------|
| Carbon (C): | 0.45-0.55 | Molybdenum (Mo): | 1.30-1.80 |
| Silicon (Si): | 0.20-1.00 | Vanadium (V): | 0.20-0.30 |
| Manganese (Mn): | 0.20-0.80 | Sulfur (S): | 0.03 max |
| Chromium (Cr): | 3.00-3.50 | Phosphorus (P): | 0.03 max |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

All TS7/NAAMS castings shall be annealed by heating uniformly to 815-845°C and holding for a minimum of one hour plus one hour per 25 mm of section thickness using the maximum section thickness. Castings shall be cooled at a maximum rate of 35°C per hour to 540°C then air cooled to room temperature.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

ALLOYED STEEL (S7140/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

1. MECHANICAL PROPERTIES (Annealed)

| | |
|---------------------------|-------------|
| Hardness: | 190-230 HBW |
| Minimum Tensile Strength: | 600 MPa |
| Minimum Yield Strength: | 450 MPa |
| Minimum Elongation : | 10 % |

2. MICROSTRUCTURE (100X)

Homogenous mixture of pearlite and ferrite and no dendritic structure,

| | |
|-----------------|-------------|
| ASTM grain size | #5 or finer |
| Carbide: | 5 % max |

3. COMPOSITION (in weight percent)*

| | | | |
|-----------------|-----------|----------------|-----------|
| Carbon (C): | 0.45-0.50 | Sulphur (S) | 0.035 Max |
| Silicon (Si): | 0.40-0.80 | Phosphorus (P) | 0.035 Max |
| Manganese (Mn): | 0.80-1.00 | | |
| Chromium (Cr): | 1.30-1.70 | | |

* Trace amounts shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings can be delivered annealed or pre-hardened condition per instructions of the purchaser. Pre-hardened casting are typically used for trim steels weighing 20 kg or less.

Annealed: Heat to 840-880°C and hold for a minimum of one hour plus one hour per 25mm of section thickness using maximum section thickness. Castings shall be furnace cooled to 560°C at a rate not to exceed 45°C per hour, then air cooled at room temperature.

Pre-Hardened: Heat to 840-880°C and hold 25 minutes at temperature. Quench with a cooling speed of 15°C per minute. Temper tool as soon as temperature reaches 50-70°C. Temper twice at 560-600°C. Final hardness should be 29-36 Rc.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designations refer to General Information Section 6.

A

ALLOYED STEEL (S2333/NAAMS)

GLOBAL STANDARD COMPONENTS



Stamping

08/01/11

1. MECHANICAL PROPERTIES (Annealed)

| | |
|--------------------------|-------------|
| Maximum Hardness: | 190-230 HBW |
| Minimum Tensile Strength | 700 MPa |
| Minimum Yield Strength | 330 MPa |
| Minimum Elongation | 7 % |

2. MICROSTRUCTURE (100X)

Homogenous mixture of pearlite and ferrite and no dendritic structure

| | |
|-----------------|-------------|
| ASTM grain size | #5 or finer |
| Carbide | 5 % max |

3. COMPOSITION (in weight percent)*

| | | | |
|----------------|-----------|-----------------|-----------|
| Carbon (C) | 0.56-0.64 | Molybdenum (Mo) | 0.40-0.60 |
| Silicon (Si) | 0.20-0.50 | Vanadium (V) | 0.20-0.30 |
| Manganese (Mn) | 0.70-0.90 | Sulphur (S) | 0.035 Max |
| Chromium (Cr) | 4.30-4.70 | Phosphorus (P) | 0.035 Max |

* Trace amounts of tramp elements shall be limited to standard practice so that there are no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings can be delivered in the annealed or pre-hardened condition per instructions of the purchaser. Pre-hardened castings are typically used for trim steels weighing 20 kg or less

Annealed: Heat to 840-880C and hold for a minimum of one hour plus one hour per 25 mm of section thickness using the maximum section thickness. Castings shall be furnace cooled to 770 C at a rate not to exceed 20 C per hour, continue cooling in furnace until 650C at a rate not to exceed 10C/hr, then air cooled at room temperature.

Pre-Hardened: Pre-heat to 600-750 C and hold for one hour. Heat to 950-970C and hold for a minimum of one hour plus one hour per 25 mm of section thickness using the maximum section thickness. Air quench with a cooling speed of 15 C per minute. Temper tool as soon as temperature reaches 50-70C. Temper twice at approximately 675C. Minimum holding time at temperature is 2 hours. Temper twice. Adjust tempering temperature as necessary to reach final hardness. Final hardness should be 280-340 HBW.

5. CLEANLINESS

Metallic Inclusions per ASTM E45A*

| | | | |
|--------------|---------|--------------|---------|
| Type A Thin | 1.5 Max | Type C Thin | 1.5 Max |
| Type A Heavy | 1.5 Max | Type C Heavy | 1.5 Max |
| Type B Thin | 1.5 Max | Type D Thin | 1.5 Max |
| Type B Heavy | 1.5 Max | Type D Heavy | 1.5 Max |

Sum of all metallic inclusions of all types is not to exceed 5.0

% Porosity and Oxide per ASTM E1245 is not to exceed 0.20

* ASTM E45A is adapted for use here despite the absence of reduction through work.

6. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

7. INSPECTION AND REJECTION

For any deviation from the above designation refer to General Information Section 6.

REFINED PEARLITIC DUCTILE IRON (D7003/NAAMS)

GLOBAL STANDARD COMPONENTS

TM **NAAMS**



Stamping

02/03/15

1. MECHANICAL PROPERTIES

| | |
|---------------------------|-------------|
| Maximum Hardness: | 190-300 HBW |
| Minimum Tensile Strength: | 700 MPa |
| Minimum Yield Strength: | 420 MPa |
| Minimum Elongation: | 2% |

2. MICROSTRUCTURE (100X)

| | | | |
|---------------|------------------------|-----------|---------|
| Nodule Type: | I & II | Pearlite: | 80-100% |
| Nodule Count: | 50/mm ² min | Ferrite: | 0-15% |
| Nodularity: | 85% min | Carbide: | 5% max |

3. COMPOSITION (in weight %)

| | | | |
|-----------------|---------|----------------|-------------|
| Carbon (C) | 3.0-3.8 | Copper (Cu) | 0.8-1.2 |
| Silicon (Si) | 2.0-2.4 | Chromium (Cr) | 0.12 Max |
| Manganese (Mn) | 0.4-0.8 | Sulphur (S) | 0.02 Max |
| Molybdenum (Mo) | 0.4-0.6 | Phosphorus (P) | 0.05 Max |
| Nickel (Ni) | 0.8-1.2 | Magnesium (Mg) | 0.030-0.065 |

** Trace amounts shall be limited to standard practice so there is no detrimental microstructure or mechanical property effects.

4. HEAT TREATMENT

Castings shall be left in the mold until they have cooled to approximately 260°C or less.

5. SURFACE QUALITY

All castings must be free of any rejectable surface defects, as described in General Information Section 3.5.

6. INSPECTION AND REJECTION

For any deviation from the above designation refer to General Information Section 6.