1. SCOPE

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

1.1 TYPES

This specification covers ferrous casting materials used for stamping dies. These materials include: G2500/NAAMS, G3500/NAAMS, D4512/NAAMS, D5506/NAAMS, D6510/NAAMS, SOO30/NAAMS, S0050A/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)
G3500/NAAMS: Alloyed Gray Cast Iron (surface hardenable)
D4512/NAAMS: Non-Alloyed Ferritic Ductile Iron (not surface hardenable)
D5506/NAAMS: Alloyed Pearlitic Ductile Iron (surface hardenable)
D6510/NAAMS: Refined Alloyed Pearlitic Ductile Iron (surface hardenable)
S0030/NAAMS: Non-Alloyed Steel (not surface hardenable)
S0050A/NAAMS: Alloyed Steel (surface hardenable)
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 safety 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.

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 taken 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, example 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.](image-url)
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 microstructures 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 steels 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 on page 3. 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 block 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 A 781.

Sample preparation and subsequent testing shall be in accordance with ASTM E 8 for Iron and ASTM A 370 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.

---

**FIGURE 2 CAST ON KEEL BLOCK**

*Special Note:* Both legs can be cut from the keel block and used for tensile test bars.
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.

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 on page 6. Composition shall be measured as described in Section 2.1 on page 3.

3.3 MICROSTRUCTURE

The microstructure requirements are given in Tables 2a and 2b on page 7. Microstructures are to be determined as described in Sections 2.2 on page 3 and 3.1.

3.4 MECHANICAL PROPERTIES

The mechanical properties are given in Table 3 on page 8. Casting hardness shall be measured as described in Section 2.3 on page 4. Strength and elongation shall be measured as described in Section 2.4 on page 5.

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.
### TABLE 1
Composition Requirements (Weight Percent)*

<table>
<thead>
<tr>
<th>Material #NAAMS</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Cu</th>
<th>V</th>
<th>S max.</th>
<th>P max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2500</td>
<td>2.9-3.5</td>
<td>1.9-2.3</td>
<td>0.5-0.9</td>
<td>0.25 max.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>G3500</td>
<td>2.8-3.2</td>
<td>1.5-2.2</td>
<td>07-1.0</td>
<td>0.35-0.50</td>
<td>0.35-0.50</td>
<td></td>
<td></td>
<td>0.7 max.</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>D4512</td>
<td>3.25-3.75</td>
<td>2.25-2.60</td>
<td>0.2-0.5</td>
<td>0.25 max.</td>
<td></td>
<td>0.5-1.0</td>
<td></td>
<td>0.015</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>D5506</td>
<td>3.0-3.8</td>
<td>2.0-2.6</td>
<td>0.5-1.0</td>
<td>0.25 max.</td>
<td>0.35-0.50</td>
<td>0.5-1.0</td>
<td>0.3 - 0.7</td>
<td>0.015</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>D6510**</td>
<td>3.0-3.7</td>
<td>2.0-2.4</td>
<td>0.3-0.6</td>
<td>0.15 max.</td>
<td>0.35-0.50</td>
<td>0.5-1.0</td>
<td>0.4 - 0.7</td>
<td>0.015</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>S0030</td>
<td>0.20-0.30</td>
<td>0.20-0.30</td>
<td>0.5-0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>0.045</td>
</tr>
<tr>
<td>S0050A</td>
<td>0.4-0.5</td>
<td>0.4-0.5</td>
<td>0.9-1.2</td>
<td>0.8-1.1</td>
<td>0.35-0.50</td>
<td></td>
<td></td>
<td>0.15 max.</td>
<td>0.5</td>
<td>0.045</td>
</tr>
<tr>
<td>TS7</td>
<td>0.45-0.55</td>
<td>0.45-0.55</td>
<td>0.2-0.8</td>
<td>3.00-3.50</td>
<td>1.30-1.80</td>
<td></td>
<td></td>
<td>0.20 - 0.30</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>

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

** Magnesium composition for D6510 IS 0.040 - 0.050.
### TABLE 2a
Cast Iron Microstructure Specifications

<table>
<thead>
<tr>
<th>Material #NAAMS</th>
<th>Graphite Type</th>
<th>Flake Size or Nodule Count</th>
<th>Nodularity min.</th>
<th>Pearlite*</th>
<th>Ferrite*</th>
<th>Carbide* max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2500</td>
<td>Type A</td>
<td>4 - 6</td>
<td>N / A</td>
<td>50% min.</td>
<td>45% min.</td>
<td>5%</td>
</tr>
<tr>
<td>G3500</td>
<td>Type A</td>
<td>4 - 6</td>
<td>N / A</td>
<td>87% min.</td>
<td>10% max.</td>
<td>3%</td>
</tr>
<tr>
<td>D4512</td>
<td>I &amp; II</td>
<td>50/mm² min.</td>
<td>85%</td>
<td>10% max.</td>
<td>87% min.</td>
<td>3%</td>
</tr>
<tr>
<td>D5506</td>
<td>I &amp; II</td>
<td>50/mm² min.</td>
<td>85%</td>
<td>85% min.</td>
<td>10% max.</td>
<td>3%</td>
</tr>
<tr>
<td>D6510</td>
<td>I &amp; II</td>
<td>100/mm² min.</td>
<td>90%</td>
<td>70 - 80%</td>
<td>20 - 30%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

*Note that the peralite, 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 on page 5. Actual casting microstructure may vary as previously described in Section 1.2 on page 2.*

### TABLE 2b
Steel Microstructure Specifications (annealed)

<table>
<thead>
<tr>
<th>Material #NAAMS</th>
<th>Grain Size</th>
<th>Microstructure</th>
<th>% Carbide</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0030</td>
<td>Not Specified</td>
<td>Homogenous mixture of ferrite and pearlite</td>
<td>2% max.</td>
<td>No Dendritic Structure</td>
</tr>
<tr>
<td>S0050A</td>
<td>#5 or finer</td>
<td>Homogenous mixture of ferrite and pearlite</td>
<td>5% max.</td>
<td>No Dendritic Structure</td>
</tr>
<tr>
<td>TS7</td>
<td>Not Specified</td>
<td>Homogenous mixture of ferrite and pearlite</td>
<td>Not Specified</td>
<td>No Dendritic Structure</td>
</tr>
</tbody>
</table>
STAMPING DIE CASTING MATERIALS

GENERAL INFORMATION

TABLE 3
Mechanical Property Requirements As Shipped From Foundry

<table>
<thead>
<tr>
<th>Material #NAAMS</th>
<th>Brinell Hardness Number</th>
<th>Test Bar Minimum Tensile Strength MPa*</th>
<th>Test Bar Minimum Yield Strength MPa*</th>
<th>Test Bar Minimum Elongation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2500</td>
<td>163 - 212</td>
<td>205</td>
<td>N / A</td>
<td>N / A</td>
</tr>
<tr>
<td>G3500</td>
<td>197 - 241</td>
<td>310</td>
<td>N / A</td>
<td>N / A</td>
</tr>
<tr>
<td>D4512</td>
<td>143 - 190</td>
<td>415</td>
<td>310</td>
<td>12%</td>
</tr>
<tr>
<td>D5506</td>
<td>190 - 241</td>
<td>550</td>
<td>380</td>
<td>6%</td>
</tr>
<tr>
<td>D6510</td>
<td>200 - 248</td>
<td>585</td>
<td>380</td>
<td>6%</td>
</tr>
<tr>
<td>S0030</td>
<td>120 - 170</td>
<td>450</td>
<td>240</td>
<td>24%</td>
</tr>
<tr>
<td>S0050A</td>
<td>170 - 229</td>
<td>585</td>
<td>310</td>
<td>16%</td>
</tr>
<tr>
<td>TS7</td>
<td>187 - 223</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
</tr>
</tbody>
</table>

* To convert to ksi multiply MPa by 0.15

1. SCOPE
   This specification encompasses criteria for stamping dies cast materials delivered in the roughcast condition.

3.5 SURFACE QUALITY
   All as-cast surfaces shall meet specified criteria for discontinuities. Acceptance criteria shall be based on ASTM A 802 for steel and ASTM A 934 for iron. Acceptance levels utilize SCRATA (Steel Casting Research And Trade Association) graded reference comparators. Acceptance levels shall be as follows:

   CATEGORY
   (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 supplier's responsibility to assure that harnesses and microstructures, for all cast materials, conform to those specified in Table 2a, 2b on page 7 and 3.

5. IDENTIFICATION

Each casting shall be identified with the NAAMS material number as listed in Section 1.4 on page 2.

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 on page 6. However, since microstructure and mechanical properties are the primary requirements for this specification, as stated in Section 3.1 on page 6, 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 Table 2a and 2b on page 7. The microstructure shall be determined as described in Section 2.2 on pages 3 & 4, and Section 3.1 on page 6.

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 on page 8. Hardness shall be measured as described in Section 2.3 on page 4.
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 on page 8. Mechanical properties shall be measured as described in Section 2.4 on page 5.

6.5 SURFACE QUALITY

The purchaser reserves the right to reject any casting that exhibits a surface discontinuity as described and referenced in Section 3.5 on page 8.

7. ORIGIN

This standard was originated by the Auto/Steel Partnership’s NAAMS Die Materials Subcommittee, November, 2002.