NS 1.0
Nobles Specification
Technical and Quality Requirements for Castings

1. Scope

The scope of this specification is to define the technical and quality requirements of casting to be used by Nobles Worldwide in the production of military products. The primary focus of this specification is aluminum castings but may be applied to steel and alloy castings as well. This specification establishes nondestructive testing methods, sampling frequency, and acceptance criteria for the production and inspection of metal castings.

2. Referenced Documents

SAE AMS 2175	Castings, Classification and Inspection of
SAE AMS A 21180	Aluminum Alloy Castings, High Strength
SAE AMS QQ-A-591	Aluminum Alloy Die Castings
SAE AMS 4291	Aluminum Alloy, Die Castings 8.5Si – 3.5 Cu (A380.0-F) As Cast
SAE AMS 4289	Aluminum Alloy Castings 7.0Si – 0.55Mg – 0.12Ti (F357.0-T6) Solution Heat Treated (Beryllium-Free A357-T6)
SAE AMS 4288	Aluminum Alloy Castings 7.0Si – 0.58Mg – 0.15Ti (E357.0-T6) Solution Heat Treated (Beryllium-Free D357-T6)
SAE AMS 4260	Aluminum Alloy, Investment Castings, 7.0Si – 0.32Mg (356.0-T6), Solution and Precipitation Heat Treated
SAE AMS 2771	Heat Treatment of Aluminum Alloy Castings
SAE AMS 2759	Heat Treatment of Steel Parts, General Requirements
ASTM A 27/A 27M	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A 148/A 148M	Standard Specification for Steel Castings, High Strength, for Structural Purposes
ASTM A 781/A 781M	Standard Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use
ASTM A 370	Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM B 85/B 85M	Standard Specification for Aluminum-Alloy Die Castings
ASTM B 26/B 26M	Standard Specification for Aluminum-Alloy Sand Castings

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ASTM B 557/B 557M	Test Methods for Tension Testing Wrought and Cast Aluminum and Magnesium Alloy Products
ASTM D 3951	Practice for Commercial Packaging
ASTM E 1417/E 1417M	Standard Practice for Liquid Penetrant Testing
ASTM E 1444/E 1444M	Standard Practice for Magnetic Particle Testing
ASTM E 1742/E 1742M	Standard Practice for Radiographic Examination
ASTM E 2973	Standard Digital Reference Images for Inspection of Aluminum and Magnesium Die Castings
ASTM E 505	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Die Castings
ASTM E 2422	Standard Digital Reference Images for Inspection of Aluminum Castings
ASTM E 155	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings
ASTM A 903/A903M	Standard Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
ASTM A 609/A 609M	Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
MIL-STD-1907	Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts, and Weldments
ASME B 46.1	Surface Texture (Surface Roughness, Waviness, and Lay)

3. Definitions – (Ref.: American Foundry Society)
   3.1. Casting Quality Test Methods

   Inspection and testing of castings encompasses five main categories: casting finishing, dimensional accuracy, mechanical properties, chemical composition and casting soundness. The following examples are used for definition of these quality characteristics, these are simply a few of those that could be used:

SAE AMS 2175	Castings, Classification and Inspection of
SAE AMS 4289	Aluminum Alloy Castings 7.0Si – 0.55Mg – 0.12Ti (F357.0-T6) Solution Heat Treated (Beryllium-Free A357-T6)
SAE AMS QQ-A-591	Aluminum Alloy Die Castings
ASTM B 85/B 85M	Standard Specification for Aluminum-Alloy Die Castings

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ASTM B 26/B 26M	Standard Specification for Aluminum-Alloy Sand Castings

3.2. Casting Finish

The surface finish of a metal casting can be influenced by the type of pattern or molding sand, mold coating, and method of cleaning. So far, instrumentation for measuring surface roughness has not provided a useful evaluation, so it is performed largely through simple visual comparison using a series of test panels with increasing surface roughness. Please refer to the following specification for further detail of the definitions of surface texture:

ASME B 46.1	Surface Texture (Surface Roughness, Waviness, and Lay)

3.3. Dimensional Accuracy

Variation in the dimensions of a casting can be the result of mold cavity expansion caused by the heat and head pressure of molten metal, the contraction of the metal as it cools and heat treatment. These expansions and contractions are predicted by the patternmaker who will compensate for the variations in the pattern's design. For large volumes of castings, casting facilities may measure the critical dimensions of the castings more often to check for possible drift, particularly drift due to pattern wear. If a casting requires tight tolerances that are critical to the part's application, those tolerances should be specified.

Nobles Worldwide should check how their casting supplier would verify the dimensions of the parts they produce. The accuracy of the measuring tools is just as important as the dimensional accuracy of the castings. In some instances, the gauges or fixtures needed to routinely check the dimension should be supplied to the casting facility by Nobles.

The dimensions of each casting will vary slightly, so castings are specified by setting a range of values that the dimensions can fall within. The range between the lower tolerance limit and upper tolerance limit can be set by the design drawing, but the narrower the range, the more difficult to produce and test and therefore more costly the casting will be.

3.4. Mechanical Properties

Mechanical testing gives an evaluation of the metal and the casting to determine whether the properties are in compliance with the specified mechanical requirements. Following are common mechanical tests used in metal casting facilities.

3.4.1. Hardness testing—the most commonly used procedure for mechanical property testing, it provides a numerical value and is nondestructive. Hardness values generally relate to an alloy's machinability and wear resistance. The Brinell hardness test uses a 10-mm diameter carbide ball to indent a 3,000-kg load. The impressions are large enough to provide a dependable average hardness. Rockwell hardness tests make smaller indented impressions, which also can be satisfactory if the median of several values is used.

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3.4.2. Tensile and impact testing—conducted on test specimens of standardized dimensions, the two most common types are tensile and Charpy impact. Tensile testing provides ultimate tensile strength, yield strength, elongation and reduction of area data. Charpy impact testing determines the amount of energy absorbed during fracture and is used to gauge ductility and strength.

3.4.3. Service load testing—usually conducted on the entire casting to evaluate its properties, it can be conducted in a number of ways. Castings that must carry a structural load can have a load applied in a fixture while the deflection and the load is measured. Pressure-containing parts can be hydraulically tested to a proof load or destruction. Rotating parts can be spin tested. These types of tests check the soundness of the casting, as well as its properties.

3.5. Chemical Composition

The chemical composition of an alloy has a significant bearing on its performance properties. Chemical composition can be further affected by minor alloying elements added to the material. Casting alloys are typically specified accorded to ASTM, SAE and AMS alloy specifications. Depending on how susceptible an alloy is to variation of its chemical composition, chemical analysis may be required to verify the proper composition is present to achieve a certain set of properties.

Chemical analysis often involves a sample of molten metal poured in to a special mold and evaluated by spectrographic atomic absorption or x-ray fluorescence analysis. Many metal casting facilities check the chemical composition of the alloys they are pouring throughout the course of a day, so melt shop personnel can make required adjustments to the alloy composition as needed.

3.6. Casting Soundness

The performance of metal components can be notably affected by internal and surface defects that cannot be detected through the regular course of visual inspection. Several nondestructive methods can be employed to inspect castings for these “invisible” flaws. Nondestructive tests determine the integrity of a casting without causing physical damage, so once it passes the tests, it can be used for its intended application. Below is a detailed list of nondestructive tests.

3.6.1. Non-destructive Testing Methods

Non-destructive testing gives the metal casting facility the capability of assuring the quality of a casting without destroying it. A metal casting facility may have internal standards regarding nondestructive testing, but it is up to the customer to specify specific tests or frequency of testing. While various methods of nondestructive testing exist to measure mechanical properties, chemical composition, casting soundness or maximum service loads, a single test that encompasses all these factors does not exist. A combination

of nondestructive methods may be required to document the soundness and quality of a casting. The most common methods available are described below. The specification,

SAE AMS 2175 Castings, Classification and Inspection of

defines the classification and grades of castings for military use and the acceptance criteria for each. Nobles documentation should specify this for each casting.

3.6.2. Visual Inspection

Visual inspection is based on the use of the human eye to identify surface defects, improper filling and molding errors. Casting defects that can be detected via visual inspection include sand holes, excessively rough surface, surface shrinkage, blowholes, misruns, cold shuts, and surface dross or slag.

3.6.3. Dimensional Inspection

To ensure a part meets dimensional requirements, such as tolerances, a metal casting facility can check the dimensional accuracy of a part manually or with a coordinate measuring machine (CMM). Checking the dimensional accuracy of a part helps guarantee the Nobles will not have to perform further costly machining on a part to meet the specified dimensions.

CMM has improved the speed and accuracy of measuring casting dimensions, and computerization has made it repetitive and able to be used as a statistical tool.

3.6.4. Dye Penetrant and Fluorescent Powder Testing

For tiny cracks, pores or other surface glitches that are hard to detect by the human eye, dye penetrant testing is used for both ferrous and nonferrous materials. In this method, a colored dye solution is applied to the surface of the casting. The dye, which is suspended in penetrating oil, will find its way into the surface defects. When a special developer is applied, the defects are clearly indicated.

A similar method involves fluorescent powder suspended in penetrating oil. Again, the solution penetrates the defects, so when the casting is dusted or sprayed drying powder, the solution is drawn from the defect and glows under an ultraviolet light where defects have occurred. Fluorescent powder testing only detects surface cracks and flaws but is more effective and economical than radiographic testing.

In general, dye-penetrant techniques identify defects on the surface of the casting and do not detect internal porosity or shrinkage that is not open to the surface. But it can detect rounded indications for porosity or gas on the casting surface. Examples of specifications that call for or define these tests are:

ASTM E 1417/E 1417M Standard Practice for Liquid Penetrant Testing

ASTM A 903/A903M	Standard Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
MIL-STD-1907	Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts, and Weldments

3.6.5. Magnetic Particle Inspection

Magnetic particle inspection is quick, inexpensive and sensitive to defects, particularly shallow (0.003 in.) surface cracks and other lineal indications.

It detects small cracks on or near the surface of ferrous alloys that can be magnetized (any ferrous alloy except austenitic material). A high-amperage, low-voltage current is passed through the casting, which establishes a magnetic field.

Cracks and defects have magnetic properties different from those of the surrounding material, so their presence will interrupt the magnetic field, causing distortion. Small magnetic particles show the path of the flux line that spreads out in order to detour around the distortion, thereby indicating the shape and position of the crack or void. Examples of specifications that call for or define these tests are:

ASTM E 1444/E 1444M	Standard Practice for Magnetic Particle Testing
ASTM A 903/A903M	Standard Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
MIL-STD-1907	Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts, and Weldments

3.6.6. Ultrasonic Testing

Internal defects that are detected by radiography may also be detected by sound. In casting inspection, ultrasonic testing uses high frequency acoustic energy that is transmitted into a casting. Because ultrasonic testing allows investigation of the cross-sectional area of a casting, it is considered to be a volumetric inspection method.

The high frequency acoustic energy travels through the casting until it hits the opposite surface or an interface or defect. The interface or defect reflects portions of the energy, which are collected in a receiving unit and displayed for the analyst to view. The pattern of the energy deflection can indicate the location and size of an internal defect, as well as wall thickness and the nodule count of ductile iron.

Ultrasonic testing requires a high level of knowledge and experience for an accurate interpretation of the results, which will affect the cost added to the part for the inspection.

3.6.7. Radiographic Inspection

Another method used to detect internal defects is radiographic inspection. In this method, a casting is exposed to radiation from an x-ray tube. The casting absorbs part of the

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radiation, and the remaining portion of the radiation exposes the radiographic film. Dense material withstands the radiation penetration, so the film is exposed to a lesser degree in those areas, giving the film a lighter appearance. Less dense materials allow more penetration and correlates to darker areas on the film. Any hole, crack or inclusion that is less dense than the casting alloy is revealed as a dark area.

When done correctly, radiographic inspection is the best nondestructive method for detecting internal defects, such as shrinkage and inclusions, and the radiograph serves as a permanent record of the casting quality that can be reviewed by multiple personnel. Casting thickness and density will limit the range of inspection possible, depending on the energy level of the radiation.

Radiographic inspection also can be performed without film. Instead, the x-ray image is viewed on a video screen. Computerized axial tomography (CAT scanning) also is being used to develop 3-D computer imagery to inspect a casting's soundness. Examples of specifications that call for or define these tests are:

ASTM E 1742/E 1742M	Standard Practice for Radiographic Examination
ASTM E 2973	Standard Digital Reference Images for Inspection of Aluminum and Magnesium Die Castings
ASTM E 505	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Die Castings
ASTM E 2422	Standard Digital Reference Images for Inspection of Aluminum Castings
ASTM E 155	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings

3.6.8. Eddy Current Inspection

The eddy current inspection method is applied to the detection of cracks at or near the surface. An electrically charged coil carrying an alternate current causes an eddy current to flow in any nearby metal. The eddy current may react on the coil to produce substantial changes in its reactivity and resistance, and that reaction is used to pinpoint small cracks or defects.

Eddy current inspection is accurate for the detection of small flaws or material changes that may not be detected with other inspection methods, and the discontinuities in the casting will give an immediate response on the monitoring equipment. However, it requires a vast amount of knowledge and experience to properly interpret the results, which will affect the added cost to the part. The test only can be used with electrically conductive materials.

3.6.9. Pressure Leak Testing

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When a casting is specified to be pressure tight or leak-proof, it is often tested by sealing openings in the casting and pressurizing it with air, inert gas or water.

When water, or hydrostatic, pressure is used, water seeping through the casting wall indicates leaks. If air or gas pressure is used, the pressurized casting is put into a tank of clear water. The appearance of bubbles indicates the air has penetrated through the casting wall and a leak is present.

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4. Technical Requirements
   4.1. Controls on Casting Processes – All Castings
      4.1.1. All castings shall have a specification called out for control of the casting process, alloy chemistry, heat treatment, testing, quality requirements, and mechanical properties as applicable or this document.
      4.1.2. Sample castings from a new or reworked pattern or mold and the casting procedure shall be approved by Nobles before castings for production use are supplied, unless such approval is waived by Nobles in writing.
      4.1.3. Details of the process control shall be available for Nobles' review/audit at the foundry facility.
      4.1.4. Castings shall be produced under radiographic control. This control shall consist of 100% radiographic inspection of castings until process control factors have been established to ensure production of acceptable castings. Unless otherwise specified in the purchase order continued radiographic inspection of production castings shall be performed at a frequency determined by the supplier to ensure continued maintenance of internal quality. Radiographic inspection shall be conducted in accordance with ASTM E 1742, unless otherwise specified or approved by Nobles in writing.
      4.1.5. Supplier shall establish, for production of sample castings of each part number, parameters for the process control factors which produce acceptable castings; these shall constitute the approved casting procedure and shall be used for producing production castings. Supplier shall also establish control factors for producing separately cast tensile specimens, but these control factors need not be identical to those used for production of castings. If necessary to make any change in parameters for the process control factors, supplier shall submit for reapproval a statement of the proposed changes in processing and, when requested, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.
      4.1.6. Control factors for producing castings and separately cast tensile specimens include, but are not limited to, the following. Supplier's procedures shall identify tolerances, ranges, and/or control limits, as applicable:
         4.1.6.1. Type of melting furnace
         4.1.6.2. Furnace atmosphere
         4.1.6.3. Alloy additions, fluxing, deoxidation, gas removal, and grain refining procedures
         4.1.6.4. Gating and risering practice
         4.1.6.5. Location and number of knockout pins, as applicable
         4.1.6.6. Mold composition and molding practice
         4.1.6.7. Mold temperature and tolerances, as applicable
         4.1.6.8. Core composition and fabrication method, when applicable
         4.1.6.9. Metal pouring or injection temperature and pressure
         4.1.6.10. Solidification and cooling procedures

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4.1.6.11. Solution heat treat and precipitation hardening parameters
4.1.6.12. Straightening procedures
4.1.6.13. Cleaning procedures
4.1.6.14. Methods of inspection
4.1.6.15. Inspection sampling plan for any and all inspections
4.1.6.16. Shop Traveler describing sequence of processing, inspection, and testing

4.1.7. Any of the process control factors for which parameters are considered proprietary by the supplier may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.2. Alloy Chemistry Composition – All Castings

4.2.1. The alloy of the casting shall be specified on the drawing or purchase order.

4.2.2. The composition shall be measured as percentages by weight as determined by wet chemical methods in accordance with ASTM E 34, by spectrochemical methods in accordance with ASTM E 227, ASTM E 607, ASTM E 1251, or by other analytical method approved by Nobles. One chemical analysis specimen will be cast from each melt after the last melt addition and shall be tested to qualify the melt. The method for control of any subsequent additions prior to the pouring shall be documented as a control factor. Spectrochemical sample shall be prepared in accordance with ASTM E 716.

4.2.3. Certification of alloy chemistry composition shall be provided for each material lot. The material lot is defined below.

4.2.4. The acceptance criteria for the chemistry shall be defined by the controlling specification called for on the drawing, purchase order, or the defaults specified below in this document.

4.3. Heat Treatment – All Castings

4.3.1. Heat treatment shall be controlled by the specification called for in the drawing, purchase order, or controlling specification.

4.3.2. If a controlling specification is not provided, the default for the heat treatment of aluminum castings shall be SAE AMS 2771.

4.3.3. If a controlling specification is not provided, the default for the heat treatment of steel castings shall be SAE AMS 2759.

4.4. Mechanical Properties – All Castings

4.4.1. Mechanical properties may or may not be a critical characteristic for a casting design.

4.4.2. When required by the drawing or purchase order, mechanical properties testing will be performed based on lot definition and the controlling specification.

4.4.3. Tensile test coupons may be machined from castings, integrally cast, or separately cast and must conform to the properties of the controlling specification or the defaults called for in this document as applicable.

4.4.4. If not otherwise specified, samples and test methods for tensile testing of aluminum castings shall be in accordance with ASTM B 557/B 557M.

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4.4.5. If not otherwise specified, test methods for tensile testing of steel castings shall be in accordance with ASTM A 370 Test Methods and Definitions for Mechanical Testing of Steel Products.

4.5. Lot definition – All Castings

4.5.1. For castings other than die castings, a lot shall consist of all of the cleaned castings poured from the same heat or melt. When castings consist of alloys which require heat treatment, the lot shall consist of all castings from the same melt or heat which have been heat treated in the same furnace charge, or if heat treated in a continuous furnace, all castings from the same melt or heat that are discharged from the furnace during a 4-hour period.

4.5.2. For die castings a lot shall consist of the production from each die or compound die on each machine for each 24 hour period for the first week of normal operation and the production for each 48 hour period thereafter of normal operation. Any significant change in the machine, composition, die, or continuity of operation shall be considered the start of a new lot. Die castings inspected by this method shall be so marked or handled during the finishing operations as not to lose their identity.

4.6. Workmanship, Finish, and Appearance – All Castings

4.6.1. The finished castings shall be uniform in composition and free of blowholes, cracks, shrinks, and other discontinuities except as designated and agreed upon as acceptable by Nobles Worldwide.

4.6.2. The surface finish of the castings shall meet the criteria of the drawing or purchase order or as designated below. These are defined in ASME B 46.1 Surface Texture (Surface Roughness, Waviness, and Lay):

4.6.2.1. If not otherwise specified, the default surface finish for sand castings shall have a surface roughness (Ra) of 500 Microinches or 12.5 Micrometers maximum.

4.6.2.2. Die castings shall have a default surface roughness of 125 Microinches or 3.2 Micrometers maximum.

4.6.2.3. Permanent mold and investment castings shall have a default surface roughness of 125 Microinches or 3.2 Micrometers maximum.

4.6.3. The appearance of castings is critical to Nobles Worldwide products. Castings must be uniform in appearance and texture to provide the product the acceptable final appearance or finish. Trimming and sanding of flash, tooling marks, and other surface imperfections shall be uniform and not exceed dimensional limits or surface finish requirements.

4.7. Repair of Castings – All Castings

4.7.1. Any repair of castings shall be approved by Nobles Worldwide in writing.

4.7.2. Repair procedures shall be submitted and approved in writing by Nobles prior to any repairs being done. Nobles may approve a foundry repair procedure for any or all castings at Nobles discretion.

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4.7.3. Weld repair shall be done by qualified welders approved by Nobles and/or the welding procedures previously approved.

4.7.4. Areas of the casting that have been repaired by welding shall be marked to indicate the full heat affected zone until approved for use.

4.7.5. Repaired castings shall meet the original requirements for internal and surface soundness of the casting unless otherwise approved.

4.7.6. Repaired castings shall have heat treatment done after repairs are complete and the casting must meet the original requirements unless otherwise approved.

4.8. Legacy Castings by Alloy and/or Type

4.8.1. If not specifically defined on the drawing the following shall apply:

4.8.1.1. Aluminum Alloy 357-T6, Beryllium-Free, Sand, Permanent Mold, or Investment Castings

Dimensional requirements shall be in accordance with the technical documentation (drawings and or models) provided by Nobles.

Chemical composition shall comply with the following, tested in accordance with ASTM E 34.

Element	Minimum	Maximum
Silicon	6.50	7.50
Iron	0	0.10
Copper	0	0.20
Manganese	0	0.10
Magnesium	0.40	0.70
Zinc	0	0.10
Titanium	0.04	0.20
Beryllium	0	0.002
Other Elements	0	0.05
Other Element Total	0	0.15
Aluminum	Remainder	
Alloy requirements are stated as percent, test results may be rounded in accordance with the rounding-off method of ASTM E 29		

The temper of the castings shall be T6 condition.

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Heat treatment shall be in accordance with SAE AMS 2771.

Mechanical properties shall be per the tables below; determined in accordance with ASTM B 557 / B 557M. Reports of testing and test methods shall be supplied and certification of the results is required.

Tensile test coupons may be machined from castings, integrally cast, or separately cast and must conform to the properties of tables below as applicable.

Minimum Tensile Properties for Specimens Cut from Castings	
Property	Value
Tensile Strength	38.0 ksi (262 MPa)
Yield Strength at 2% Offset	30.0 ksi (207 MPa)
Elongation in 4D	2%
Minimum Tensile Properties for Integrally Cast Specimens and Separately Cast Specimens	
Property	Value
Tensile Strength	41.0 ksi (283 MPa)
Yield Strength at 2% Offset	32.0 ksi (221 MPa)
Elongation in 4D	3%

After the foundry process is approved by Nobles, inspection per AMS-2175 Class 2 Grade C except penetrant inspect a sample of 10% of the production lot with 0% defect criteria, visually inspect castings for surface porosity 100% to Grade C criteria unless otherwise specified in the purchase order or technical requirements. Notify Nobles if any defects are identified for disposition of the lot.

Certifications shall be provided for results of all testing and inspection performed.

Castings shall be identified on the packaging to identify part number, revision, description, material heat lot(s), certifications, and reports supplied with the castings.

Commercial packaging shall be used unless otherwise specified.

4.8.1.2. Aluminum Alloy 380 Die Castings

Dimensional requirements shall be in accordance with the technical documentation (drawings and or models) provided by Nobles. Sampling of dimensional requirements shall be agreed on by Nobles in writing for each part number.

Alloy ANSI 380; Chemical composition shall be in accordance with the table below and chemical analysis reports, certifications are required.

Element	Minimum	Maximum
Silicon	7.50	9.50
Iron	0	2.00
Copper	3.00	4.00
Manganese	0	0.50
Magnesium	0	0.10
Nickel	0	0.50
Zinc	0	3.0
Tin	0	0.35
Beryllium	0	0.002
Other Element Total	0	0.50
Aluminum	Remainder	
Alloy requirements are stated as percent, test results may be rounded in accordance with the rounding-off method of ASTM E 29		

Inspection and acceptance criteria for soundness shall be agreed upon prior to production. Acceptance criteria shall be based on AMS 2175 Class 2 Grade C for radiographic and visual inspection after foundry controls are approved.

Foundry controls as listed above are required. Nobles shall approve the procedure and the allowed variation of the parameters listed for each part number. Radiographic, liquid penetrant and other quality standards shall be agreed upon by Nobles and the supplier. When acceptance standards are not specified for radiographic inspection, the requirements of the table below shall apply, utilizing the reference radiographs of ASTM E 505. Radiographic inspection shall be conducted in accordance with ASTM E 1742 / E 1742M unless otherwise specified in the purchase order.

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Category of Discontinuity	Maximum Acceptable Level of Discontinuity 1/8 inch (3.2 mm) Reference Radiograph	Maximum Acceptable Level of Discontinuity 5/8 inch (15.9 mm) Reference Radiograph
Applicable Casting Section Thickness	Up to 3/8 inch (9.5 mm), inclusive	Over 3/8 inch (9.5 mm) to 1 inch (25.4 mm), inclusive (1)
Category A (Porosity)	#2	#2
Category B (Cold Fill)	#2	#3 per 1/8 inch (3.2 mm) Reference Radiograph
Category C (Shrinkage)	N/A	#2
Category D (Foreign Material)	Not greater than reference radiograph	Not greater than reference radiograph
(1) Standards for thicker casting sections shall be agreed upon between Nobles and the supplier		

Repair of casting shall not be done without written approval, a written repair procedure, and inspection acceptance criteria specifically agreed to by Nobles in writing.

When specified in the purchase order mechanical properties shall be tested in accordance with ASTM B 557 test methods once per lot and meet the requirements as follows:

Minimum Tensile Properties for Specimens Cut from Castings	
Property	Value
Tensile Strength	46.0 ksi (320 MPa)
Yield Strength at 2% Offset	23.0 ksi (160 MPa)
Elongation in 2 inches, %	2.5%

Whenever possible a whole die-casting shall be used for tensile testing or a sample machined out of a casting. If this is not possible, Nobles must agree to the properties tests to be performed, the acceptance criteria, and the sampling.

Castings shall be identified on the packaging to identify part number, revision, description, lot(s), certifications, and reports supplied with the castings.

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Commercial packaging shall be used unless otherwise specified.

If approved by Nobles ASTM B85/B85M Standard Specification for Aluminum-Alloy Die Castings or SAE AMS 4291 Aluminum Alloy, Die Castings 8.5Si – 3.5 Cu (A380.0-F) As Cast may be used as alternatives to this document. Foundry controls and inspection acceptance criteria are still required.

4.8.2. Other Legacy Castings

4.8.2.1. All castings shall have a specification called out for control of the casting process, alloy chemistry, heat treatment, testing, quality requirements, and mechanical properties as applicable or this document.

4.8.2.2. Unless otherwise specified in the purchase order sections 4.1 to 4.7 above apply to all castings

4.8.2.3. If there is no traceable supersession of specifications Nobles Engineering, Director of Operations, and Quality Assurance Manager shall agree on a controlling specification and acceptance criteria.

5. Quality Assurance Provisions

5.1. It is the responsibility of the supplier to perform and comply with appropriate inspections as necessary and in the proper sequence during processing to assure freedom from harmful discontinuities in the final product. The intent of inspections during processing is to detect discontinuities that would be detrimental to the final product at the earliest stage in processing so as to minimize the cost of rejected or scrapped castings. The sequence for penetrant, magnetic particle and radiographic inspections shall be as specified in ASTM E 1417, ASTM E 1444, ASTM E 1742, respectfully, or as otherwise specified by Nobles Worldwide Engineering.

5.2. Chemical requirements shall be compliant with the specification called for in the drawing, purchase order, or this document. Sampling of the chemistry will be based on the lot definition or as defined by the specification.

5.3. Dimensional first articles inspection reports shall be supplied for all new tools and new processes. New first article reports shall be done if there is any significant change to the casting process, tooling, or equipment.

5.4. Inspection of Castings

Unless otherwise specified on the drawing or purchase order castings shall be assigned a Class and Grade in accordance with SAE AMS 2175. Specific areas of castings can have different requirements based on the application of the casting. If not specifically called out on the drawing the default will be inspection per Class 2, Grade C.

5.5. Inspection of Die Castings

Unless specified on the drawing or purchase order inspection and general quality requirements of all die cast parts shall have a definition of quality for internal soundness agreed to by Nobles Worldwide and documented through reference radiographs, photographs of sectioned parts, or specific sectioned parts retained as a quality samples

with equivalent samples at the supplier and Nobles. A sampling plan for production shall be part of the definition and based on material lot as defined above.

5.6. Inspection Sampling Plans

5.6.1. Sampling plans shall be specified or approved by Nobles Worldwide Engineering or Quality Assurance in writing. Unless otherwise specified, castings other than die castings, shall be 100% nondestructively inspected in accordance with SAE AMS 2175.

5.6.2. Die castings shall be sampled as specified in the Nobles Worldwide approved definition of internal soundness. If no definition is specified, radiographic or sectioning sampling will be done according to the following table:

Number of die castings in lot	Sample number of die castings	Acceptable number of defective die castings, maximum
1-5	All	0
6 - 100	6	0
101 – 500	7	0
501 – 2000	17	1
2001 – 6000	27	2
Over 6000	39	3

6. Packaging, Shipping, and Handling

Unless otherwise specified in the purchase order all castings will be packaged and labeled to identify the lot uniquely and to maintain the identity of the lot. Labels shall be protected from damage in shipment and not damaged by water.

The packaging shall provide adequate protection of the castings during normal handling and transportation. Castings susceptible to bending or warpage shall be individually protected by boxes or dividers. Packages shall be less than 70 pounds for a single person lift or palletized for handling with forklift and other equipment.

Unless otherwise specified, ASTM D 3951 Practice for Commercial Packaging shall apply.

7. Ordering Information

Purchase orders for castings from Nobles shall contain the following information, if there is any missing information or questions the supplier must seek clarification prior to starting work:

7.1. Part number and Revision of part being procured with a drawing

7.2. Quantity to be delivered and schedule of delivery
7.3. Title, identification, and revision of this specification or title, identification, and revision of the specification controlling foundry practices, quality requirements, alloy chemistry, and other requirements
7.4. Alloy of the casting
7.5. Certification requirements
7.6. First article requirements as applicable
7.7. Material properties requirements if not specified elsewhere
7.8. Testing requirements if not specified elsewhere
7.9. Soundness standards and sampling if not specified elsewhere
7.10. Packaging requirements if not specified elsewhere
7.11. Special instructions or requirements

8. Notes / Revision History

Revision Level	Date	Description	Approved/By
A	2017-12-12	Initial Release	Steve Thieman

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