

MIL-C-62624(AT)
29 March 1988
SUPERSEDING
(see 6.4)

MILITARY SPECIFICATION

CASTINGS, INVESTMENT, COBALT BASE ALLOY

This specification is approved for use within the US Army Tank-Automotive Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the chemical, and mechanical properties, and inspection requirements for cobalt base alloy investment castings commercially known as L-605, Haynes 25, WF-11 or Unitemp L605.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Standards. The following standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Tank-Automotive Command, ATTN: AMSTA-GDS, Warren, MI 48397-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.
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AMSC N/A

AREA MECA

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MIL-C-62624(AT)

STANDARDS
MILITARY

- | | |
|---------------|--|
| MIL-STD-105 | - Sampling Procedures and Tables for Inspection by Attributes. |
| MIL-STD-45662 | - Calibration Systems Requirements. |

(Copies of standards required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

- | | |
|----------|---|
| AMS 2269 | - Chemical Check Analysis Limits - Wrought Nickel Alloys and Cobalt Alloys. |
| AS 478 | - Identification Marking Methods. |

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Avenue, Warrendale, PA 15096.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- | | |
|-----------|--|
| ASTM E8 | - Tension Testing of Metallic Materials. |
| ASTM E139 | - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials. |

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA, 19103.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

MIL-C-62624(AT)

3. REQUIREMENTS

3.1 First article. Unless otherwise specified (see 6.2), the contractor shall furnish samples (castings and specimens) which shall be subjected to first article inspection (see 4.4). First article inspection samples, properly marked with identifying information shall be representative of the units to be furnished to the Government. All subsequent castings delivered to the Government shall conform to these samples in all of their pertinent physical and performance attributes.

3.2 Character or quality.

3.2.1 Condition. Unless otherwise specified (see 6.2), castings shall be delivered in the solution heat treated condition, clean and free of investment and core materials. Cleaning shall be performed by sandblasting or other methods approved by the procuring activity (see 4.6.1).

3.2.2 Quality. Castings shall meet all the requirements of the specification and be uniform in quality and condition, sound and free from foreign materials, internal and external imperfections in excess of those permitted by this specification or detrimental to the fabrication or performance of parts (see 4.6.6).

3.3 Chemical and mechanical properties. Heat treated cast and machined test specimens shall meet the following properties requirements.

3.3.1 Chemical composition. The chemical composition shall conform to the percentages by weight of each element as specified in table I (see 4.6.3).

TABLE I. Chemical composition.

Element	Percentage by weight	
	minimum	maximum
Carbon	--	0.15
Manganese	1.00	2.00
Silicon	--	1.00
Phosphorus	--	0.040
Sulfur	--	0.030
Chromium	19.00	21.00
Tungsten	14.00	16.00
Nickel	9.00	11.00
Iron	--	3.00
Cobalt	Remainder	

3.3.1.1 Composition variations. Composition variations shall meet the requirements of AMS 2269, except the check analysis limits for tungsten shall be 0.10 percent (%) under minimum and over maximum, and iron 0.10% over maximum (see 4.6.3.1).

MIL-C-62624(AT)

3.3.2 Tensile properties. The tensile properties of the castings shall be as follows (see 4.6.4):

- a. Ultimate tensile strength: Not less than 80,000 pounds per square inch (psi) [552 Megapascals (MPa)].
- b. Yield strength at 0.2% offset: Not less than 52,000 psi (359 MPa).
- c. Elongation in 4 diameters (D): Not less than 10%.
- d. Reduction of area: Not less than 10%.

3.3.3 Stress rupture. Stress rupture properties shall be as follows (see 4.6.5):

- a. Specimens shall not rupture in less than 24 hours when maintained at 1500 ± 3 degrees Fahrenheit ($^{\circ}\text{F}$) [816 ± 2 degrees Celsius ($^{\circ}\text{C}$)] while an axial load of 24,000 psi (165.5 MPa) is continuously applied.
- b. After 48 hours, the load shall be increased by 5000 psi (34.5 MPa) every 24 hours until failure occurs in the specimen.
- c. The elongation after rupture, measured at room temperature, shall not be less than 10% (in 3 to 4D). If the time exceeds 48 hours, the elongation shall be not less than 6%.

3.3.4 Grain size. Unless otherwise specified on the engineering drawing, the grain size (see 6.3.3) shall conform to the requirements specified herein. The casting shall be 100% macroetched by methods and procedures mutually agreed upon between the procuring activity and supplier. The grain size shall be generally equiaxed and uniform throughout the entire part and shall not exceed 0.187 inch [4.75 millimeter (mm)] in any direction (see 4.6.6.1).

3.3.5 Surface oxides. Surface oxides shall be permitted provided the depth of penetration does not exceed 0.0010 inch (0.025 mm). Isolated areas of this condition are permitted to a depth of 0.0020 inch (0.050 mm). Castings with excessive penetration may be chemically or mechanically cleaned provided engineering drawing tolerances can be maintained (see 4.6.7).

3.3.6 Recycled, virgin and reclaimed materials. There are no requirements for the exclusive use of virgin materials. The use of recycled or reclaimed (recovered) materials is acceptable provided that all other requirements of this specification are met (see 4.6.1 and 6.3.1).

3.4 Casting.

3.4.1 Master heat. Castings shall be produced from remelted master heat metal or directly from a master heat (see 6.3.4).

MIL-C-62624(AT)

3.4.2 Casting control. The establishment of the refining, pouring, and mold temperature shall be accomplished after determining what is necessary for satisfactory mold filling, soundness, grain size control and mechanical properties (see 4.6.1).

3.4.3 Heat treatment. The castings shall be solution heat treated as follows:

- a. Heat parts to $2100 \pm 25^{\circ}\text{F}$ ($1149 \pm 14^{\circ}\text{C}$).
- b. Hold at heat for 30 to 60 minutes.
- c. Water quench or rapid air cool.

3.5 Identification and marking. Unless otherwise specified on the drawing, each casting shall be marked in accordance with AS 478, method 6A or 30, as follows (see 4.6.2):

- a. Each casting shall contain the drawing number and revision letter, casting lot number and the casting supplier's identification (trademark, symbol, etc.). The symbols shall be marked in the location specified on the drawing using marking Method 6A.
- b. Castings acceptable by fluorescent penetrant, radiographic, and grain size inspection shall be identified using an approved symbol and marking method 30.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform or witness any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

MIL-C-62624(AT)

4.1.2 Inspection equipment. Unless otherwise specified in the contract (see 6.2), the contractor is responsible for the provision and maintenance of all inspection equipment necessary to assure that supplies and services conform to contract requirements. Inspection equipment must be capable of repetitive measurements to an accuracy of 10% of the measurement tolerance. Calibration of inspection equipment shall be in accordance with MIL-STD-45662.

4.1.2.1 Inspection conditions. Unless otherwise specified (see 6.2), all inspections shall be conducted under the following conditions:

- a. Air temperature $73 \pm 18^{\circ}\text{F}$ ($23 \pm 10^{\circ}\text{C}$)
- b. Barometric pressure $28.5 (+2, -3)$ inches mercury
[725 (+50, -75) mm mercury]
- c. Relative humidity $50 \pm 30\%$

4.2 Test specimens.

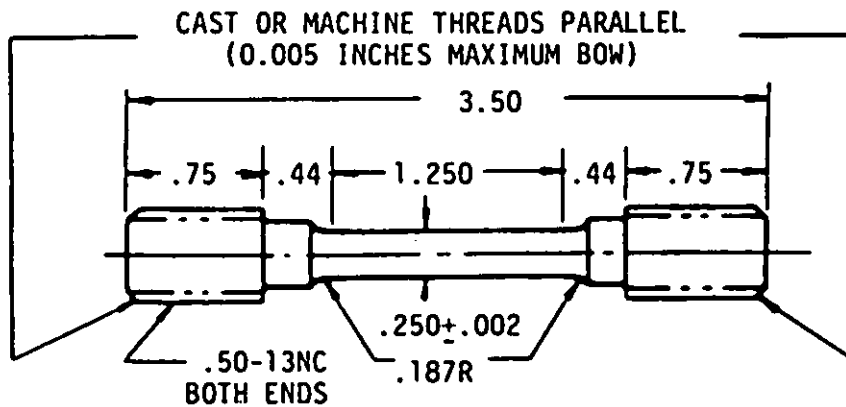
4.2.1 Cast specimens. Cast specimens representing a master heat of metal shall be cast using a fixed process to provide a physically sound bar. The casting procedure used shall be available for review by the procuring activity and shall not be changed without first notifying the procuring activity. The specimen dimensions shall be in accordance with figure 1.

4.2.2 Specimen marking. The test specimens shall be permanently marked with the master heat number and specimen casting process identification.

4.2.3 Machined specimens. The specimens shall be machined to the size shown in figure 1 or other approved size from castings heat treated in accordance with 3.4.3 or may be machined from the locations and to the sizes specified on the applicable processing specification or drawings.

4.2.4 Chemical analysis specimens. Unless otherwise specified (see 6.2), two chemical analysis specimens removed from each master heat of metal shall be of any convenient size, shape, and form agreed to by the procuring activity and the supplier. The minimum recommended dimensions for a typical specimen are 1 x 1 x 1/4 inch (25.4 x 25.4 x 6.4 mm).

MIL-C-62624(AT)

FIGURE 1. Tensile specimen.**4.3 Classification of inspections:**

- a. First article inspection (see 4.4).
- b. Quality conformance inspections (see 4.5).
 1. Examination (see 4.5.2).
 2. Acceptance tests (see 4.5.3).

4.4 First article inspection. The Government shall select a sufficient number of samples (specimens and castings) (see 6.2) produced under the production contract for first article inspection. First article samples shall be inspected as specified in table II. Approval of the first article sample by the Government shall not relieve the contractor of his obligation to supply castings that are fully representative of those inspected as a first article sample. Any changes or deviation of the production units from the first article sample shall be subject to the approval of the contracting officer.

MIL-C-62624(AT)

TABLE II. Classification of inspections.

Title	Requirement	Inspection	First article	Quality conformance		
				Examination	Acceptance tests	
					Specimens	Castings
Certification	3.2.1, 3.3.6 and 3.4.2	4.6.1	X			
Defects (see table III)	3.5	4.6.2	X	X		
Quality	3.2.2	4.6.6	X			X
Chemical composition	3.3.1	4.6.3	X		X	
Composition variations	3.3.1.1	4.6.3.1	X		X	
Tensile properties	3.3.2	4.6.4	X		X	
Stress rupture	3.3.3	4.6.5	X		X	
Grain size	3.3.4	4.6.6.1	X			X
Surface oxides	3.3.5	4.6.7	X			X

4.4.1 First article inspection failure. Deficiencies found during, or as a result of, first article inspection shall be cause for rejection of the first article sample until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiency. Any deficiency found during, or as a result of, first article inspection, shall be evidence that all items already produced prior to completion of the first article inspection are similarly deficient unless contrary evidence satisfactory to the contracting officer is furnished by the contractor. Such deficiencies on all items shall be corrected by the contractor. The Government will not accept products until first article inspection is completed to the satisfaction of the Government.

4.5 Quality conformance inspections.

4.5.1 Sampling.

4.5.1.1 Lot formation. Unless otherwise specified (see 6.2), an inspection lot shall consist of all specimens and castings with the same part number and revision letter poured from one master heat of metal using the same casting process parameters and the same type of preheat and casting furnace.

4.5.1.2 Sampling for examination.

4.5.1.2.1 Castings. Castings for examination shall be selected in accordance with general inspection level II of MIL-STD-105.

MIL-C-62624(AT)

4.5.1.3 Sampling for acceptance tests.

4.5.1.3.1 Specimens. Test specimens selected for acceptance test shall be heat treated (see 3.4.3) separately cast or machined from castings (see 4.2.1 and 4.2.3) shall be tested to verify conformance to 3.3.2 and 3.3.3 and the chemical analysis specimen (see 4.2.4) shall be tested to verify conformance to 3.3.1. In addition all other requirements of 3.3 shall be met. If the master heat of metal is acceptable, the master heat may be used for any nonrotating configuration without further testing or approvals.

4.5.2 Examination.

4.5.2.1 Acceptable quality level. Each sample selected in accordance with 4.5.1.2.1 shall be examined to determine conformance to the following acceptable quality levels (AQL) on the basis of % defective:

<u>Classification</u>	<u>AQL</u>
Minor	2.5

4.5.2.2 Classification of defects. For examination purposes, defects shall be classified as listed in table III.

TABLE III. Classification of defects.

<u>Category</u>	<u>Defect</u>	<u>Method of examination</u>
Critical	None	Visual
Major	None	
Minor 201	AQL 2.5% Defective Marking, improper (see 3.5).	

4.5.3 Acceptance tests.

4.5.3.1 Specimens. Each specimen selected in accordance with 4.5.1.3.1 shall be subjected to the acceptance tests as specified in table II.

4.5.3.1.1 Failure. Failure of any specimen to pass any of the specified acceptance tests shall be cause for rejection of the master heat represented.

4.5.3.2 Castings. Each casting shall be subjected to the acceptance tests specified in table II.

4.5.3.2.1 Failure. Failure of any casting to pass any of the specified acceptance tests (except as specified in 4.5.3.2.2) shall be cause for rejection of the failed casting.

MIL-C-62624(AT)

4.5.3.2.2 Rework. Castings not meeting the visual and fluorescent penetrant inspection requirements may be reworked by blending in accordance with the applicable engineering specifications. Plugging, welding or other methods of repair shall not be employed in rework. All reworked castings shall be subjected to the acceptance tests specified in table II.

4.6 Methods of inspection.

4.6.1 Certification. Conformance to 3.2.1, 3.3.6 and 3.4.2 shall be determined by inspection of contractor records providing proof or certification that the condition, control and materials conform to requirements. Applicable records shall include drawings, specifications, design data, receiving inspection records, processing and quality control standards, vendor catalogs and certifications, industry standards, test reports, and rating data.

4.6.2 Defects. Conformance to 3.5 shall be determined by a visual examination for the defects listed in table III.

4.6.3 Chemical composition. To determine conformance to 3.3.1, the chemical analysis specimens shall be analyzed.

4.6.3.1 Composition variations. To determine conformance to 3.3.1.1, the chemical analysis specimen shall be analyzed in accordance with AMS 2269.

4.6.4 Tensile properties. To determine conformance to 3.3.2, the test specimens shall be prepared and tested in accordance with ASTM E8.

4.6.5 Stress rupture. To determine conformance to 3.3.3, the test specimens shall be tested in accordance with ASTM E139.

4.6.5.1 Retest. If any tensile or stress rupture specimen fails to meet the specified requirements, the disposition of the product shall be as follows:

- a. Four additional specimens shall be obtained and tested.
- b. The test results of all the test specimens (initial specimens plus 4 retest specimens) shall be averaged and the average shall not be less than the minimum acceptance requirement for the failed property.
- c. There shall not be more than two failed test specimens from a combination of the initial and retest specimens.
- d. For tensile specimens, each of the tensile properties (ultimate, yield, elongation) shall be averaged and counted in the retest.
- e. The requirements of 4.2 shall apply to all retest data.

MIL-C-62624(AT)

4.6.6 Quality. To determine conformance to 3.2.2, visual, fluorescent penetrant and radiographic inspections shall be performed on the product in accordance with the requirements specified on the applicable processing specification and the drawing.

4.6.6.1 Grain size. To determine conformance to 3.3.4, each casting shall be 100% macroetched by methods and procedures mutually agreed upon between the procuring activity and the supplier and examined for grain size.

4.6.7 Surface oxides. To determine conformance to 3.3.5, the test specimens shall be tested and shall meet the specified requirements.

5. PACKAGING

5.1 Preservation, packaging, packing, and marking. Preservation, packaging, packing, and marking for the desired level of protection shall be in accordance with the applicable packaging requirements specified by the contracting authority (see 6.2).

6. NOTES

6.1 Intended use. This material is primarily for parts requiring strength at high temperature up to 1500°F (816°C) and oxidation resistance up to 2000°F (1093°C).

6.2 Ordering data. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. If first article samples are not required (see 3.1).
- c. If condition of castings shall be other than as specified (see 3.2.1).
- d. If responsibility for inspection shall be other than as specified (see 4.1).
- e. If responsibility for inspection equipment shall be other than as specified (see 4.1.2).
- f. If inspection conditions shall be other than as specified (see 4.1.2.1).
- g. If chemical analysis sample size shall be other than as specified (see 4.2.4).
- h. If first article inspection is not required (see 4.4).
- i. If an inspection lot shall be other than as specified (see 4.5.1.1).
- j. Selection of applicable level and packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Recovered materials. "Recovered materials" means materials that have been collected or recovered from solid waste (see 6.3.2).

MIL-C-62624(AT)

6.3.2 Solid waste. "Solid waste" means (a) any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and (b) other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. It does not include solid or dissolved material in domestic sewage, or solid or dissolved material in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the Clean Water Act, (33 U.S.C. 1342 et seq.), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.) (Source: Federal Acquisition Regulations, section 23.402).

6.3.3 Grain size. The measurements made to determine grain size are made on the surface of the casting. The dimensional limitations specified herein are defining grain structure as a surface phenomena. Internal grain size is excluded from the requirements specified in 3.5.1. However, it is expected a grain occurring on an edge will be measured on both faces.

6.3.4 Master heat. A master heat is previously refined metal of a single furnace charge. Gates, sprues, risers, and rejected castings shall only be used in preparation of a master heat; they shall not be remelted directly, without refining, for pouring of castings. Metal in the form of shot from more than one master heat may be uniformly blended to form a master heat lot.

6.3.5 Casting lot. Unless otherwise specified in the applicable process specifications, a casting lot is a group of castings with the same part number and revision letter poured from one master heat of metal using the same casting process parameters and the same type of preheat and casting furnace.

6.4 Supersession data. This military specification supersedes AVCO Lycoming specification number M3504C, dated 26 April 1982.

6.5 Subject term (key word) listing.

Cobalt base alloy investment castings
Investment castings, cobalt base alloy
Investment castings, L605
Investment castings, WF-11

Custodian:
Army - AT

Preparing activity:
Army - AT

(Project MECA-A402)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL*(See Instructions – Reverse Side)*

1. DOCUMENT NUMBER		2. DOCUMENT TITLE	
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION (Mark one)	
b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR	
		<input type="checkbox"/> USER	
		<input type="checkbox"/> MANUFACTURER	
		<input type="checkbox"/> OTHER (Specify): _____	
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
6. REMARKS			
7a. NAME OF SUBMITTER (Last, First, MI) – Optional		b. WORK TELEPHONE NUMBER (Include Area Code) – Optional	
c. MAILING ADDRESS (Street, City, State, ZIP Code) – Optional		8. DATE OF SUBMISSION (YYMMDD)	