MIL-STD-982
14 March 1986

MILITARY STANDARD

CEMENTED CARBIDES, METAL CUTTING TOOL GRADES

(GOVERNMENT GRADING SYSTEM, INTENDED USES AND PHYSICAL PROPERTIES)

AMSC N/A
FSC 3455

DEPARTMENT OF DEFENSE
Washington, DC 20301

Cemented Carbides, Metal Cutting Tool Grades, (Government Grading System, Intended Uses and Physical Properties).

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, and deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Industrial Plant Equipment Center, Attn: DIPEC-SSG, Memphis, Tennessee 38114-5297, by using the self addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

Common machine tool grades of cemented carbide products are graded and marketed under a commercial "C" grading system (Grades C-1 through C-8) or under a grading system established by the International Organization for Standardization "ISO Standard 513" (various P, M, and K grades). Both of these systems define the various grades of carbides by intended use only and neither system defines the various grades by their physical properties.

Without knowing the physical properties of the various commercial grades of carbides, the Government is in the untenable position of not being able to test and evaluate tooling for conformance with the requirements of the grade being purchased, and of not being able to reject tooling suspected to be of substandard quality.

Since a commercial standard that defines the physical properties of each carbide grade is unavailable, this standard establishes eight Government grades of carbides (designated as Grades X-1 through X-8) that are intended to parallel the eight common commercial grades of carbides (Grades C-1 through C-8) that are used in the manufacture of metal cutting tools, tool bits, blanks, and tool bit inserts. This standard also states typical machining application data for each Government grade and states physical properties for each grade.

This standard is intended to serve as an interim standard until such time that a recognized non-Government standards writing organization promulgates an acceptable industry standard that provides a sound basis for acceptance or rejection of cemented carbide products.

CONTENTS

1. SCOPE

1.1 General coverage. This standard establishes a Government grading system, interchangeability data with commercial grades, intended uses, and physical properties ranges for eight common grades of cemented carbides used in the manufacture of metal cutting tools, tool bits, blanks and inserts. The Government grading system described herein covers cemented carbides similar, or equal, to those known in the industry as grades C-1, C-2, C-3, C-4, C-5, C-6, C-7, and C-8. This standard is intended to cover carbides used for metal cutting tool applications only and does not cover carbides used for drawing, stamping and swaging dies, gauges, jig bushings, centers, rolls, knives, shear-blades, and similar non-machining applications.

1.2 New grades of cemented carbides. This standard is not intended to cover the more recently developed cemented carbide products such as coated cemented titanium carbide, ceramic, ceramet, or submicron carbides and is not intended to restrict or inhibit commercial development or Government purchase of the newer grades of carbide products. If a Government agency requires and can justify purchase and use of the newer grades of carbide tooling, they should purchase the needed tooling in accordance with the procurement regulations of their agency.

1.3 Classification. This standard covers cemented carbide products of the following Government grades. The Government grade required for specific procurements will be stated in the invitation for bids of request for proposals, and in the contract or order. Descriptions of the various grades are stated in tables I, II, and III herein.

Grade X-1
Grade X-2
Grade X-3
Grade X-4
Grade X-5
Grade X-6
Grade X-7
Grade X-8

2. REFERENCED DOCUMENTS

2.1 Other publications. The following documents form a part of this standard 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. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 294 - Standard Method for Hardness Testing of Cemented Carbides.

ASTM B 311 - Standard Test Method for Density of Cemented Carbides.

ASTM B 406 - Standard Test Method for Transverse Rupture Strength of Cemented Carbides.

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

(Nongovernment standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.2 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Density. The mass of a unit volume of an unimpregnated powder metallurgy part, usually expressed as grams per cubic centimeter.

3.2 Hardness. The value obtained by testing a sintered material with standard indentation hardness equipment, usually expressed as Rockwell A.

3.3 Transverse rupture strength. The stress, calculated from the flexure formula, required to break a specimen as a simple beam supported near the ends and applying the load midway between the center lines of the supports, usually expressed as pounds per square inch.

4. GENERAL REQUIREMENTS

4.1 Use of this standard. This standard is not intended to be used alone, but is intended to be cited as a reference document in other Government procurement documents such as military and federal specifications, commercial item descriptions, and agency purchase descriptions used for purchase of carbide cutting tools, tool bits, blanks, and inserts. This standard is intended to provide acceptance or rejection criteria for procurement documents which reference this standard. In addition, table II is intended to assist Government machine tool users in selecting the proper Government grade for their particular machining application.

5. DETAILED REQUIREMENTS

5.1 Interchangeability with commercial grades. The Government grades covered herein are intended to be similar, or equal, to the commercial "C" grades shown in table I.

TABLE I. Cross reference chart.

Government grade	Similar, or equal, commercial "C" grade
X-1	C-1
X-2	C-2
X-3	C-3
X-4	C-4
X-5	C-5
X-6	C-6
X-7	C-7
X-8	C-8

5.2 Intended uses of the various carbide grades. Table II states intended uses and typical machining operations for the various "X" grades covered herein. Although grades X-1 thru X-4, inclusive, are intended primarily for machining cast iron workpieces, and although grades X-5 thru X-8, inclusive, are intended primarily for machining steel workpieces, these grades are also used for other machining applications. Some of the most common secondary applications are also included in table II. In table II, "Typical Machining Operations" and "Typical Materials" are shown in the approximate order of decreasing frequency of usage, that is, most frequent applications are listed first followed by the less frequent usage. Table II is intended to assist machine tool users in selecting a proper grade of carbide for a particular machining operation, but due to the many variable factors involved in machining operations, users are cautioned to use table II only as a guide to tentative tool grade selection. Final selection of the proper carbide grade should be accomplished by actual field testing of the recommended grade under actual machining conditions.

TABLE II. Intended uses, typical machining application.

Government grade	*Typical machining operations	*Typical materials	Typical cuts		Additional conditions
			Cutting speed	Tool feed	
X-1	Heavy duty roughing cuts by turning, milling, drilling, shaping, and planing under unfavorable machining conditions	Gray cast iron, metal that generates short chips, non-ferrous metal, stainless steel, non-metallic material	Low	Coarse	Applications producing tool shock; interrupted cuts, out-of-round workpieces, heavily scaled castings and forgings, materials having non-uniform hardness, machining operations generating large chip cross sections
X-2	Roughing and general purpose machining by turning, milling, shaping, planing, boring, threading, and drilling	Gray cast iron, non-ferrous metals, titanium metal, stainless steel, high temperature steel alloys, monel, bronze alloys, brasses	Medium	Medium	Machining operations generating medium size chip cross sections
X-3	Semi-finishing and finishing cuts by turning, milling, boring, and broaching	Gray cast iron, malleable iron and nodular iron that generates short chips, hardened steel, silicon aluminum alloys, titanium metals, stainless steels, plastics, hard rubber, fiberglass	Medium to high	Medium to fine	Machining operations generating medium to fine chip cross sections
X-4	Finishing cuts, precise dimension control, and best surface finishes by turning, boring, and milling	Gray iron castings and chilled castings, high silicon aluminum alloys, hardened steel, highly abrasive plastics, phenolic laminates, ceramics	High	Fine	Machining operations generating fine chip cross sections
X-5	Heavy duty roughing cuts by turning, boring, milling, shaping, and planing under unfavorable machining conditions	Carbon and alloy steel, steel castings with sand inclusions, malleable iron that generates relatively long chips	Medium to low	Medium to coarse	Applications producing tool shock; interrupted cuts, out-of-round workpieces, steel castings and forgings with heavy scale, operations generating large chip cross sections
X-6	Roughing and general purpose machining by turning, boring, milling, shaping, and planing	Carbon and alloy steels, steel castings, stainless steels, malleable iron that generates relatively long chips	Medium	Medium	Machining operations generating medium size chip cross sections
X-7	Semi-finishing and finishing cuts by turning, milling, threading, and boring	Carbon and alloy steels, steel castings, stainless steels, malleable and nodular iron that generate relatively long chips	Medium to high	Medium to fine	Machining operations generating medium to fine chip cross sections
X-8	Fine finishing cuts, fine surface finishes, and precise dimensional control by turning and boring. Precise threading by high speed, single point threading machines	Carbon and alloy steels, steel castings	High	Fine	Machining operations generating fine chip cross sections

*Note: "Typical machining operations" and "Typical materials" are listed in the approximate order of decreasing frequency of usage with most frequent applications listed first followed by less frequent applications.

5.2.1 Safety hazard warning. Although cemented carbide products are formulated, manufactured, and treated to withstand high cutting loads and, in some grades, shock loads, these materials are inherently "low ductility" materials that might be susceptible to breakage or fragmentation when overstressed or subjected to severe impact loads. When field testing cemented carbide tooling, especially for new, untried applications producing high tool stresses or high impact loading, adequate safety measures, as prescribed by the using agency's safety regulations, shall be taken to protect operating personnel and bystanders from possible tool breakage or fragmentation hazards.

5.3 Method of manufacture and chemical composition. Each grade of cemented carbide covered herein shall be produced by powder metallurgy manufacturing techniques and shall consist essentially (but not necessarily 100%) of titanium carbide, tantalum carbide, tungsten carbide, a matrix or binder of cobalt, nickel or nickel-molybdenum and any other chemical element or compound used in the manufacturer's standard commercial product. The exact method of manufacture and the exact percentage of each chemical element or compound shall be at the manufacturer's discretion provided that the product meets the intended use and physical properties requirements stated in tables II and III herein.

5.4 Physical properties. The physical properties of carbide products offered for sale to the Government shall be determined by testing random samples drawn from the same production lot as the products being offered or by testing special test samples made from the identical powder formulation and using the identical sintering process that will be used in manufacture of the products offered for sale to the Government. In either event, the sampling plan, sample size, acceptable quality level (AQL), and all other pertinent quality assurance parameters shall be such as to assure that all products offered shall conform to the requirements of 5.4.1, 5.4.2, 5.4.3, and table III.

5.4.1 Hardness. The carbide product shall be capable of meeting the hardness requirements of table III when tested in accordance with the test methods of ASTM B 294.

5.4.2 Density. The carbide product shall be capable of meeting the density requirements of table III when tested in accordance with the test methods of ASTM B 311.

5.4.3 Transverse rupture strength. The carbide product shall be capable of meeting the transverse rupture strength requirements of table III when tested in accordance with the test methods of ASTM B 406. This test requires the use of a specially made test sample, not the actual product being purchased. This test can increase the cost of the item and could also be accomplished by requiring documentation and traceability of the manufacturer's test data.

TABLE III. Physical properties.

Government grade designation	Hardness, (Rockwell A)	Density, (grams per cubic centimeter)	Transverse rupture strength, minimum, (1,000 pounds per square inch)
X-1	89.0 to 91.6	14.0 to 15.1	265
X-2	91.2 to 92.5	14.6 to 15.1	220
X-3	91.6 to 93.2	14.7 to 15.2	200
X-4	92.4 to 93.6	14.9 to 15.5	195
X-5	90.0 to 92.0	11.8 to 14.4	220
X-6	90.7 to 92.5	11.6 to 13.5	170
X-7	91.0 to 92.9	10.3 to 13.0	160
X-8	92.1 to 94.3	10.0 to 12.1	140

6. NOTES

6.1 Subject term (key word) listing.

Carbide
Cemented carbides
Coated titanium
Density
Ductility
Hardness
Submicron
Transverse rupture strength

Custodians:
Army - AL
Navy - SH
Air Force - 99

Review activities:
Air Force - 84
DLA - GS, DH

User activities:
Navy - MC

Preparing activity:
DLA - IP

(Project 3455-0101)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER MIL-STD 982

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ 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)*

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