

INCH-POUND

MIL-DTL-32495A  
26 November 2018  
SUPERSEDING  
MIL-DTL-32495  
w/Amendment 2  
23 August 2015

## DETAIL SPECIFICATION

### POWDERS FOR COLD SPRAY DEPOSITION

This specification is approved for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers requirements intended for use in the procurement of powders used to produce deposits utilizing a cold spray materials deposition process for the purpose of parts repair, coatings, or fabrication of near-net shaped parts. Cold spray is a process whereby metal powder particles are utilized to form a deposit by means of ballistic impingement upon a substrate in order to produce thin coatings, thick deposits, or near-net shaped parts. This cold spray process is explained in the manufacturing process standard MIL-STD-3021, "Materials Deposition, Cold Spray". The base document of MIL-DTL-32495 contained requirements for Aluminum powders only. This new Revision (A) expands the list of powders to include additional materials beyond aluminum.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Specifications & Standards Office, Attn: RDRL-WMM-C, Aberdeen Proving Ground, MD 21005-5069. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil/>.

AMSC N/A

AREA MFFP

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

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1.2 Classification. The powders are of the following Group, Class, Alloy, and Type, as specified (see Table I and 6.2). Note: For type designated powders, additional conformance testing is required to ensure adequate mechanical properties in the as deposited state. This is not an all-inclusive list. Hazardous materials including lead, beryllium, and cadmium while sprayable are not encouraged for usage.

1.2.1 Group I. Group I contains iron and steel-based alloys powders.

1.2.1.1 Class A. Class A consists of un-alloyed iron powders.

1.2.1.2 Class B. Class B consists of plain carbon steels powders.

1.2.1.2.1 Alloy 1. Alloy 1 consists of 1008 plain carbon steel (UNS G10080).

1.2.1.2 Class C. Class C consists of Low Alloy steels powders.

1.2.1.3.1 Alloy 1. Alloy 1 consists of Low Alloy steels / 4340 (UNS G43400).

1.2.1.3 Class D. Class D consists of High alloy and stainless steels powders.

1.2.1.4.1 Alloy 1. Alloy 1 consists of High alloy steels / 304 (UNS S30400).

1.2.1.4.2 Alloy 2. Alloy 2 consists of High alloy steels / 316 (UNS S31600).

1.2.1.4.3 Alloy 3. Alloy 3 consists of High alloy steels / 13-8 Mo (UNS S13800).

1.2.1.4.4 Alloy 4. Alloy 4 consists of High alloy steels / 15-5 PH (UNS S15500).

1.2.1.4.5 Alloy 5. Alloy 5 consists of High alloy steels / 17-4 PH (UNS S17400).

1.2.1.4.6 Alloy 6. Alloy 6 consists of High alloy steels / AM-355 (UNS S35500).

1.2.1.4.7 Alloy 7. Alloy 7 consists of Incoloy A-286 (A286) alloy (UNS S66286).

1.2.1.4 Class E. Class E consists of Tool steels powders.

1.2.1.4 Class F. Class F consists of non-steel iron alloy powders.

1.2.2 Group II. Group II contains aluminum and aluminum-based alloys powders.

1.2.2.1 Class A. Class B consists of 1000 series and pure aluminum powders.

1.2.2.1.1 Alloy 1. Alloy 1 consists of aluminum alloy 1199

1.2.2.2 Class B. Class C consists of 2000 series aluminum powders.

1.2.2.2.1 Alloy 1. Alloy 1 consists of aluminum alloy 2024 (UNS A92024)

1.2.2.2.1.1 Type a. Type a consists of high criticality aluminum alloy 2024.

1.2.2.3 Class C. Class D consists of 3000 series aluminum powders.

1.2.2.3.1 Alloy 1. Alloy 1 consists of aluminum alloy 3003 (UNS A93003).

1.2.2.4 Class D. Class E consists of 4000 series aluminum powders.

1.2.2.4.1 Alloy 1. Alloy 1 consists of aluminum alloy 4047 (UNS A94047).

1.2.2.5 Class E. Class F consists of 5000 series aluminum powders.

1.2.2.5.1 Alloy 1. Alloy 1 consists of aluminum alloy 5056 (UNS A95056).

1.2.2.5.1.1 Type a. Type a consists of high criticality aluminum 5056.

1.2.2.5.2 Alloy 2. Alloy 2 consists of aluminum alloy 5083 (UNS A95083).

1.2.2.6 Class F. Class G consists of 6000 series aluminum powders.

1.2.2.6.1 Alloy 1. Alloy 1 consists of aluminum alloy 6061 (UNS A96061).

1.2.2.6.1.1 Type a. Type a consists of high criticality aluminum alloy 6061.

1.2.2.7 Class G. Class H consists of 7000 series aluminum powders.

1.2.2.7.1 Alloy 1. Alloy 1 consists of aluminum alloy 7050 (UNS A97050).

1.2.2.7.2 Alloy 2. Alloy 2 consists of aluminum alloy 7075 (UNS A97075).

1.2.2.7.2.1 Type a. Type a consists of high criticality aluminum alloy 7075.

1.2.2.8 Class H. Class J consists of 8000 series aluminum powders.

1.2.3 Group III. Group III contains copper and copper-based alloys powders.

1.2.3.1 Class A. Class A consists of un-alloyed copper powders (>99% Cu).

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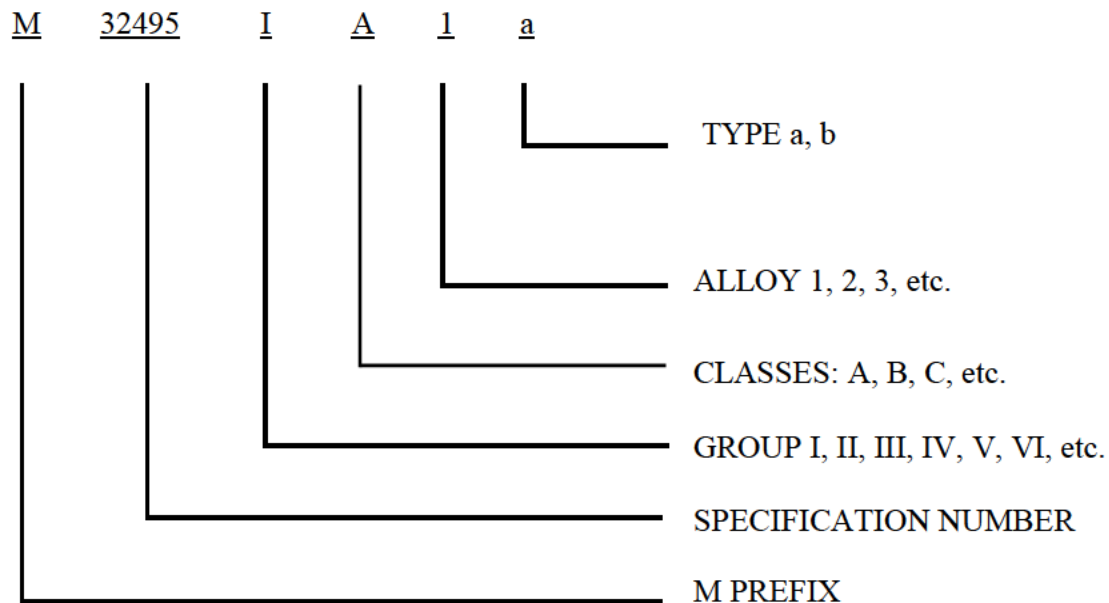
- 1.2.3.2 Class B. Class B consists of bronze alloy powders.
  - 1.2.3.2.1 Alloy 1. Alloy 1 consists of Cu 9Sn-2Zn copper-tin-zinc bronze alloy.
- 1.2.3.3 Class C. Class C consists of brass alloy powders.
  - 1.2.3.3.1 Alloy 1. Alloy 1 consists of Cartridge Brass alloy powder (UNS C26000).
- 1.2.4 Group IV. Group IV contains magnesium and magnesium-based alloys powders.
  - 1.2.4.1 Class A. Class A consists of un-alloyed magnesium powders.
  - 1.2.4.2 Class B. Class B consists of magnesium alloy powders.
- 1.2.5 Group V. Group V contains zinc and zinc-based alloys powders.
  - 1.2.5.1 Class A. Class A consists of un-alloyed zinc powders.
  - 1.2.5.2 Class B. Class B consists of zinc alloy powders.
- 1.2.6 Group VI. Group VI contains silver and silver-based alloys powders.
  - 1.2.6.1 Class A. Class A consists of un-alloyed silver powders.
  - 1.2.6.2 Class B. Class B consists of silver alloy powders.
- 1.2.7 Group VII. Group VII contains gold and gold-based alloys powders.
  - 1.2.7.1 Class A. Class A consists of un-alloyed gold powders.
  - 1.2.7.2 Class B. Class B consists of gold alloy powders.
- 1.2.8 Group VIII. Group VIII contains tin and tin-based alloys powders.
  - 1.2.8.1 Class A. Class A consists of un-alloyed tin powders.
  - 1.2.8.2 Class B. Class B consists of tin alloy powders.
- 1.2.9 Group IX. Group IX contains cobalt and cobalt-based alloys powders.
  - 1.2.9.1 Class A. Class A consists of un-alloyed cobalt powders.
  - 1.2.9.2 Class B. Class B consists of cobalt alloy powders.
- 1.2.10 Group X. Group X contains zirconium and zirconium-based alloys powders.
  - 1.2.10.1 Class A. Class A consists of un-alloyed zirconium powders.
  - 1.2.10.2 Class B. Class B consists of zirconium alloy powders.
- 1.2.11 Group XI. Group XI contains nickel and nickel-based alloys powders.
  - 1.2.11.1 Class A. Class A consists of un-alloyed nickel powders.
  - 1.2.11.2 Class B. Class B consists of iron, nickel, Co alloy powders.
  - 1.2.11.3 Class C. Class C consists of nickel Cr/Fe/Mo alloy powders.
    - 1.2.11.3.1 Alloy 1. Alloy 1 consists of Inconel 625 alloy (UNS N06625).
    - 1.2.11.3.2 Alloy 2. Alloy 2 consists of Inconel 718 alloy (UNS N07718).
  - 1.2.11.4 Class D. Class D consists of nickel / copper alloy powders.
  - 1.2.11.5 Class E. Class E consists of nickel / Mo alloy powders.
  - 1.2.11.6 Class F. Class F consists of other nickel alloy powders.
- 1.2.12 Group XII. Group XII contains refractory metals powders.
  - 1.2.12.1 Class A. Class A consists of un-alloyed niobium powders.
  - 1.2.12.2 Class B. Class B consists of niobium alloy powders.
  - 1.2.12.3 Class C. Class C consists of un-alloyed molybdenum powders.
  - 1.2.12.4 Class D. Class D consists of molybdenum alloy powders.

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- 1.2.12.5 Class E. Class E consists of un-alloyed tantalum powders (UNS R05200).
- 1.2.12.6 Class F. Class F consists of tantalum alloy powders.
  - 1.2.12.6.1 Alloy 1. Alloy 1 consists of 10W-Ta alloy (UNS R05255).
- 1.2.12.7 Class G. Class G consists of un-alloyed tungsten powders.
- 1.2.12.8 Class H. Class H consists of tungsten alloy powders.
- 1.2.12.9 Class J. Class J consists of un-alloyed rhenium powders.
- 1.2.12.10 Class K. Class K consists of rhenium alloy powders.
- 1.2.13 Group XIII. Group XIII contains platinum group metals alloy powders.
  - 1.2.13.1 Class A. Class A consists of un-alloyed platinum powders.
  - 1.2.13.2 Class B. Class B consists of platinum alloy powders.
  - 1.2.13.3 Class C. Class C consists of un-alloyed palladium powders.
  - 1.2.13.4 Class D. Class D consists of palladium alloy powders.
  - 1.2.13.5 Class E. Class E consists of un-alloyed iridium powders.
  - 1.2.13.6 Class F. Class F consists of iridium alloy powders.
  - 1.2.13.7 Class G. Class G consists of un-alloyed rhodium powders.
  - 1.2.13.8 Class H. Class H consists of rhodium alloy powders.
  - 1.2.13.9 Class J. Class J consists of un-alloyed osmium powders.
  - 1.2.13.10 Class K. Class K consists of osmium alloy powders.
  - 1.2.13.11 Class L. Class L consists of un-alloyed ruthenium powders.
  - 1.2.13.12 Class M. Class M consists of ruthenium alloy powders.
- 1.2.14 Group XIV. Group XIV contains titanium and titanium-based alloy powders.
  - 1.2.14.1 Class A. Class A consists of un-alloyed titanium powders.
    - 1.2.14.1.1 Alloy 1. Alloy 1 consists of ASTM Grade 1 titanium (UNS R50250).
    - 1.2.14.1.2 Alloy 2. Alloy 2 consists of ASTM Grade 2 titanium (UNS R50400).
    - 1.2.14.1.3 Alloy 3. Alloy 3 consists of ASTM Grade 3 titanium (UNS R50550).
    - 1.2.14.1.4 Alloy 4. Alloy 4 consists of ASTM Grade 4 titanium (UNS R50700).
  - 1.2.14.2 Class B. Class B consists of Alpha/Near Alpha titanium alloy powders.
  - 1.2.14.3 Class C. Class C consists of Alpha/Beta titanium alloy powders.
    - 1.2.14.3.1 Alloy 1. Alloy 1 consists of ASTM Grade 5 (Ti-6Al-4V) titanium powders (UNS R56400).
    - 1.2.14.3.2 Alloy 2. Alloy 2 consists of ASTM Grade 23 (Ti-6Al-4V) titanium powders (UNS R56407).
  - 1.2.14.4 Class D. Class D consists of Beta/Near Beta titanium alloy powders.
- 1.2.15 Group XV. Group XV contains chromium powders.
  - 1.2.15.1 Class A. Class A consists of un-alloyed chromium powders.
  - 1.2.15.2 Class B. Class B consists of chromium alloy powders.
- 1.2.16 Group XVI. Group XVI contains Lithium powders.
  - 1.2.16.1 Class A. Class A consists of pure Lithium powders.
- 1.2.17 Group XVII. Group XVII contains Rare Earth powders.
  - 1.2.17.1 Class A. Class A consists of 48% Mischmetal powders.
- 1.2.18 Group XVIII. Group XVIII contains Metal Matrix Composite powders.
  - 1.2.18.1 Class A. Class A consists of Carbide Based Blends alloy powders.

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- 1.2.18.1.1 Alloy 1. Alloy 1 consists of chrome-carbide nickel (CrC-Ni) blend.
- 1.2.18.1.2 Alloy 2. Alloy 2 consists of chrome-carbide nickel-chromium (CrC-NiCr) blend.
- 1.2.18.1.3 Alloy 3. Alloy 3 consists of WC-Co alloy blend.
- 1.2.18.2 Class B. Class B consists of Al<sub>2</sub>O<sub>3</sub> Blended alloy powders.
- 1.2.18.2.1 Alloy 4. Alloy 3 consists of Al-Al<sub>2</sub>O<sub>3</sub> alloy blend.
- 1.2.19 Group XIX. Group XIX contains amorphous and high entropy alloy powders.
- 1.2.19.1 Class A. Class A consists of amorphous alloy powders.
- 1.2.19.2 Class B. Class B consists of high entropy alloy powders.
- 1.2.20 Group XX. Group XX contains of powders not defined in Groups I-XIX.
- 1.2.20.1 Class A. Class A consists of metallic based powders.
- 1.2.20.2 Class B. Class B consists of ceramic based powders.
- 1.2.20.3 Class C. Class C consists of polymer based powders.
- 1.2.20.4 Class D. Class D consists of composite based powders.
- 1.3 Part or Identifying Number (PIN). PINs to be used for powders acquired by this specification are created as follows:



## 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

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TABLE I. Powders

PARAGRAPH #	GROUP	CLASS	ALLOY	TYPE	DESCRIPTION
1.2.1.1	I	A	1	N/A	Un-alloyed Iron
1.2.1.2.1	I	B	1	N/A	1008 Plain Carbon Steel
1.2.1.3.1	I	C	1	N/A	Alloy Steel 4340
1.2.1.4.1	I	D	1	N/A	High Alloy Steel 304
1.2.1.4.2	I	D	2	N/A	High Alloy Steel 316
1.2.1.4.3	I	D	3	N/A	High Alloy Steel 13-8 Mo
1.2.1.4.4	I	D	4	N/A	High Alloy Steel 15-5 PH
1.2.1.4.5	I	D	5	N/A	High Alloy Steel 17-4 PH
1.2.1.4.6	I	D	6	N/A	High Alloy Steel AM-355
1.2.1.4.7	I	D	7	N/A	Incoloy A-286 (A286) Alloy
1.2.1.5	I	E	1	N/A	Tool Steel Alloy
1.2.1.6	I	F	TBD	N/A	Nonsteel Iron Alloy
1.2.2.1.1	II	A	1	N/A	1199 Aluminum
1.2.2.2.1	II	B	1	N/A	2024 Aluminum
1.2.2.2.1.1	II	B	1	a	High criticality 2024 Aluminum
1.2.2.3.1	II	C	1	N/A	3003 Aluminum
1.2.2.4.1	II	D	1	N/A	4047 Aluminum
1.2.2.5.1	II	E	1	N/A	5056 Aluminum
1.2.2.5.1.1	II	E	1	a	High criticality 5056 Aluminum
1.2.2.5.2	II	E	2	N/A	5083 Aluminum
1.2.2.6.1	II	F	1	N/A	6061 Aluminum
1.2.2.6.1.1	II	F	1	a	High criticality 6061 Aluminum
1.2.2.7.1	II	G	1	N/A	7050 Aluminum
1.2.2.7.2	II	G	2	N/A	7075 Aluminum
1.2.2.7.2.1	II	G	2	a	High criticality 7075 Aluminum
1.2.2.9	II	H	TBD	N/A	8000 Series Aluminum
1.2.3.1	III	A	TBD	N/A	Un-alloyed Copper
1.2.3.2.1	III	B	1	N/A	Cu 9Sn-2Zn Bronze Alloy
1.2.3.3.1	III	C	1	N/A	Cartridge Brass Alloy
1.2.4.1	IV	A	TBD	N/A	Un-alloyed Magnesium
1.2.4.2	IV	B	TBD	N/A	Magnesium Alloy
1.2.5.1	V	A	TBD	N/A	Un-alloyed Zinc
1.2.5.2	V	B	TBD	N/A	Zinc Alloy
1.2.6.1	VI	A	TBD	N/A	Un-alloyed Silver
1.2.6.2	VI	B	TBD	N/A	Silver Alloy
1.2.7.1	VII	A	1	N/A	Un-alloyed Gold
1.2.7.2	VII	B	TBD	N/A	Gold Alloy
1.2.8.1	VIII	A	1	N/A	Un-alloyed Tin
1.2.8.2	VIII	B	TBD	N/A	Tin Alloy
1.2.9.1	IX	A	1	N/A	Un-alloyed Cobalt
1.2.9.2	IX	B	TBD	N/A	Silver Cobalt
1.2.10.1	X	A	1	N/A	Un-alloyed Zirconium
1.2.10.2	X	B	TBD	N/A	Zirconium Alloy

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TABLE I. Powders - Continued.

PARAGRAPH #	GROUP	CLASS	ALLOY	TYPE	DESCRIPTION
1.2.11.1	XI	A	1	N/A	Un-alloyed Nickel
1.2.11.2	XI	B	TBD	N/A	Iron, Nickel, Co Alloy
1.2.11.3	XI	C	TBD	N/A	Nickel Cr/Fe/Mo Alloy
1.2.11.3.1	XI	C	1	N/A	Nickel-base alloy (Inconel 625)
1.2.11.3.2	XI	C	2	N/A	Nickel-base alloy (Inconel 718)
1.2.11.4	XI	D	TBD	N/A	Nickel / Copper
1.2.11.5	XI	E	TBD	N/A	Nickel / Mo
1.2.11.6	XI	G	TBD	N/A	Other Nickel Alloy
1.2.12.1	XII	A	1	N/A	Un-alloyed Niobium
1.2.12.2	XII	B	TBD	N/A	Niobium Alloy
1.2.12.3	XII	C	1	N/A	Un-alloyed Molybdenum
1.2.12.4	XII	D	TBD	N/A	Molybdenum Alloy
1.2.12.5	XII	E	1	N/A	Un-alloyed Tantalum (R05200)
1.2.12.6.1	XII	F	1	N/A	10W-Ta Alloy Powder (R05255)
1.2.12.7	XII	G	1	N/A	Un-alloyed Tungsten
1.2.12.8	XII	H	1	N/A	WC-Co Alloy
1.2.12.9	XII	J	1	N/A	Un-alloyed Rhenium
1.2.13.1	XIII	A	1	N/A	Un-alloyed Platinum
1.2.13.2	XIII	B	TBD	N/A	Platinum Alloy
1.2.13.3	XIII	C	1	N/A	Un-alloyed Palladium
1.2.13.4	XIII	D	TBD	N/A	Palladium Alloy
1.2.13.5	XIII	E	1	N/A	Un-alloyed Iridium
1.2.13.6	XIII	F	TBD	N/A	Iridium Alloy
1.2.13.7	XIII	G	1	N/A	Un-alloyed Rhodium
1.2.13.8	XIII	H	TBD	N/A	Rhodium Alloy
1.2.13.9	XIII	J	1	N/A	Un-alloyed Osmium
1.2.13.10	XIII	K	TBD	N/A	Osmium Alloy
1.2.13.11	XIII	L	1	N/A	Un-alloyed Ruthenium
1.2.13.12	XIII	M	TBD	N/A	Ruthenium Alloy
1.2.14.1.1	XIV	A	1	N/A	ASTM Grade 1 Titanium
1.2.14.1.2	XIV	A	2	N/A	ASTM Grade 2 Titanium
1.2.14.1.3	XIV	A	3	N/A	ASTM Grade 3 Titanium
1.2.14.1.4	XIV	A	4	N/A	ASTM Grade 4 Titanium
1.2.14.2	XIV	B	TBD	N/A	Alpha/Near Alpha Titanium Alloys
1.2.14.3.1	XIV	C	1	N/A	ASTM Grade 5 (Ti-6Al-4V) Titanium
1.2.14.3.2	XIV	C	2	N/A	ASTM Grade 23 (Ti-6Al-4V) Titanium
1.2.14.4	XIV	D	TBD	N/A	Beta/Near Beta Titanium Alloy
1.2.15.1	XV	A	1	N/A	Un-alloyed Chromium
1.2.15.2	XV	B	TBD	N/A	Chromium Alloy
1.2.17.1	XVII	A	TBD	N/A	Mischmetal Powder (48%)



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TABLE I. Powders - Continued.

PARAGRAPH #	GROUP	CLASS	ALLOY	TYPE	DESCRIPTION
1.2.18.1.1	XVIII	A	1	N/A	Chrome-Carbide Nickel (CrC-Ni) Blend
1.2.18.1.2	XVIII	A	2	N/A	Chrome-Carbide Nickel-Chromium Blend
1.2.18.1.3	XVIII	A	3	N/A	WC-Co Alloy Blend
1.2.18.2.1	XVIII	B	1	N/A	Al <sub>2</sub> O <sub>3</sub> -Al Alloy Blend
1.2.19.1	XIX	A	TBD	N/A	Amorphous Alloy
1.2.19.2	XIX	B	TBD	N/A	High Entropy Alloy
1.2.20.1	XX	A	TBD	N/A	Metallic Powders
1.2.20.2	XX	B	TBD	N/A	Ceramic Powders
1.2.20.3	XX	C	TBD	N/A	Polymer Powders
1.2.20.4	XX	D	TBD	N/A	Composite Powders

N/A – Not Applicable

TBD – To Be Determined

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of this document are those cited in the solicitation or contract (see 6.2).

## FEDERAL STANDARDS

FED-STD-123 - Marking for Shipment (Civil Agencies)

## DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129 - Military Marking for Shipment and Storage

MIL-STD-3021 - Materials Deposition, Cold Spray

(Copies of these documents are available online at <https://quicksearch.dla.mil/>.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

## DoD SHELF-LIFE MANAGEMENT

DoD 4140.27-M - Shelf-life Management Manual.

Copies of this document are available online at: <https://www.shelflife.hq.dla.mil/>.



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## CODE OF FEDERAL REGULATIONS (CFR)

40 CFR 63	-	National Emission Standards for Hazardous Air Pollutants for Source Categories
40 CFR 261	-	Identification and Listing of Hazardous Waste
40 CFR 401.15	-	Protection of Environment (Toxic pollutants)

(Copies of this document are available online at <https://www.ecfr.gov/>).

2.3 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B215	-	Standard Practices for Sampling Metal Powders
ASTM B822	-	Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering
ASTM E3	-	Standard Guide for Preparation of Metallographic Specimens
ASTM E8/E8M	-	Standard Test Methods for Tension Testing of Metallic Materials
ASTM E92	-	Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
ASTM E384	-	Test Method for Microindentation Hardness of Materials
ASTM E1004	-	Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy Current) Method
ASTM E1019	-	Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
ASTM E1131	-	Standard Test Method for Compositional Analysis by Thermogravimetry
ASTM E2109	-	Standard Test Methods for Determining Area Percentage Porosity in Thermal Sprayed Coating
ASTM E2546	-	Standard Practice for Instrumented Indentation Testing
ASTM E3061	-	Standard Test Method for Analysis of Aluminum and Aluminum Alloys by Inductively Coupled Plasma Atomic Emission Spectrometry (Performance Based Method)

(Copies of these documents are available from <https://www.astm.org>)

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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 484 - Standard for Combustible Metals

(Copies of this document are available from <http://www.nfpa.org/>)

THE ALUMINUM ASSOCIATION

Teal Sheets - International Alloy Designations and  
Chemical Composition Limits for  
Wrought Aluminum and Wrought Aluminum  
Alloys

(Copies of this document are available from <https://www.aluminum.org/teal-sheets>)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 3. REQUIREMENTS

#### 3.1 Qualification.

3.1.1 Qualification (Initial). The powders furnished under this specification shall be a product which has been tested by a Certified Testing Agency (see 4.2.2) and has passed the qualification tests specified herein and has been approved for listing by the Cognizant Engineering Authority (CEA) (see 3.1.3) and shall be listed on the applicable Qualified Products Database (QPD) by the Preparing Activity (PA) (see 3.1.4, 4.2 and 6.3) before contract award. Any change in the chemical formulation, the material, the equipment, the process, or the procedure in manufacturing the powder that affects the powders morphology, chemical composition, material condition, and/or contaminant level shall necessitate its being qualified again. The powders supplied under contract shall be identical, within manufacturing tolerances, to the powders receiving qualification. Any powder that does not conform to all the qualification tests specified herein shall be removed from the QPD.

3.1.2 Retention of qualification. To retain qualification approval of powders listed on the Qualified Products Database (QPD), the manufacturer shall be required to verify by certification to the CEA that its powder(s) comply with the requirements of this specification. Unless otherwise specified by the CEA or PA (see 6.2), the time of periodic verification by certification shall be in two-year intervals from the date of original qualification (see 4.3). The certification action is initiated by the Preparing Activity.

3.1.3 Cognizant Engineering Authorities. The CEA (see 6.5.1) assumes all responsibility for assuring that all required testing and subsequent evaluation of any powders submitted to the PA for listing under this specification are completed and pass all requirements specified herein, and also meet any additional performance criteria specific to their intended application.

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3.1.4 Preparing Activity. The activity responsible for qualified products database (QPD) listing is the Specifications & Standards Office (S&SO), [ARMY-MR], Material & Manufacturing Science Division, Army Research Laboratory located at Aberdeen Proving Ground, MD, 21005-5069. Upon receiving written documentation from the applicable CEA (see 3.1.3) that the specific powder has passed all qualification tests specified herein, and has been approved for listing, the PA shall update the QPD.

3.2. Material. The powders that are supplied under this specification shall be as specified herein. Powders not specified shall be selected by the contractor and shall be subjected to all the provisions of this specification and meet the requirements cited in 3.2.1 thru 3.2.8 of this specification. A qualified product shall be considered acceptable when a certified test report(s) showing that the material conforms to all the requirements of this specification (3.2.1 thru 3.2.8) has been received by the CEA (see 3.1.3).

3.2.1 Chemical composition. The chemical composition of the powders shall be the same as that of the sample furnished for qualification testing within the tolerances allowed in this specification. Any change in the formulation of a qualified powder that affects the powders morphology, chemical composition, material condition, and/or contaminant level shall require requalification. A certified composition shall be forwarded to the applicable CEA (see 3.1.3). The chemical composition of the powders, excluding oxygen, shall be of the following percentages by weight (wt.) from tables IIa through IIh when determined in accordance with 4.6.1 (See the list below of tables for each powder). If the chemical composition of the powder does not fall under any listed alloy (for example, Group XX powders do not have chemical compositions listed), the CEA shall provide the chemical composition requirements and recommend a Group, Class, and Alloy listing.

POWDERS	TABLE NUMBER
Steel – Group I	Table IIa
Aluminum – Group II	Table IIb
Copper – Group III	Table IIc
Magnesium – Group IV Zinc – Group V Silver – Group VI Gold – Group VII	Table IId
Tin – Group VIII Cobalt – Group IX Zirconium – Group X	Table IIe
Nickel – Group XI	Table II f
Refractory Metals – Group XII	Table IIg
Platinum Group Metals – Group XIII	Table IIh
Titanium – Group XIV	Table IIj
Chromium – Group XV Lithium – Group XVI Rare Earth – Group XVII	Table IIk
Metal Matrix Composites – Group XVIII	Table II m

3.2.2 Prohibited materials. Unless otherwise specified in the contract or purchase order (see 6.2) the chemical composition of the powders shall not contain any hazardous ingredients as defined

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in 40 CFR 261, toxic pollutants as defined in 40 CFR 401.15, nor hazardous air pollutants as defined in 40 CFR 63.

3.2.3 Non-metallic impurities. For all classes, the total moisture, volatiles (loss on ignition), and other non-metallic impurities, such as oxygen content, shall be specified in the contract or purchase order (see 6.2) as measured in accordance with 4.6.2.1 and 4.6.2.2, unless otherwise specified by the contract or purchase order (see 6.2).

3.2.4 Particle size distribution. The particle size distribution for all powders shall be made available to the applicable CEA and the PA (see 3.1.3) as measured in accordance with 4.6.3 or as specified in the contract or purchase order (see 6.2). The particle size distribution shall fall within 10% of the originally qualified distribution for D10, D50, and D90 values in order to fulfill conformance requirements.

3.2.5 Additives. Any additives to the powder to enhance its sprayability or performance shall be subject to and controlled by this specification, and maintained under the same guidelines for re-qualification if changes are made by the vendor to the type or quantity of additive, even when the additives are not retained in the final coating.

TABLE IIa. Chemical Composition of Group I Powders (wt. %).

ELEMENT	Class A	Class B	Class C	Class D	
	Alloy 1	Alloy 1	Alloy 1	Alloy 1	Alloy 2
	Un-alloyed Iron	1008 Steel	4340 Steel	304 Stainless Steel	316 Stainless Steel
Carbon (C)	--	0.10	0.37-0.43	0.08 max	0.08 max
Chromium (Cr)	--	--	0.70-0.90	18.00-20.00	16.00-18.00
Nickel (Ni)	--	--	1.65-2.00	8.00-12.00	10.00-14.00
Molybdenum (Mo)	--	--	0.20-0.30	--	2.00-3.00
Manganese (Mn)	--	0.30-0.50	0.60-0.80	1.0 max	2.0 max
Silicon (Si)	--	--	0.15-0.30	0.75 max	0.75 max
Nitrogen (N)	--	--	--	0.10 max	0.10 max
Phosphorus	--	0.030	0.035 max	0.045 max	0.045 max
Sulfur (S)	--	0.050	0.040 max	0.03 max	0.03 max
Other, max total	0.1	--	--	--	--
Iron (Fe)	Balance	Balance	Balance	Balance	Balance

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TABLE IIa. Chemical Composition of Group I Powders (wt. %) - Continued.

ELEMENT	Class D				
	Alloy 3	Alloy 4	Alloy 5	Alloy 6	Alloy 7
	13-8 Stainless Steel	15-5 Stainless Steel	17-4 Stainless Steel	AM 355	A-286
Carbon (C)	0.05 max	0.07 max	0.07 max	0.10-0.15	0.08
Chromium (Cr)	12.25-13.25	14.00-15.50	15.00-17.5	15.00-16.00	13.50-16.00
Nickel (Ni)	7.5-8.5	3.50-5.50	3.00-5.00	4.00-5.00	24.00-27.00
Molybdenum	2.00-2.50	--	--	2.50-3.25	1.00-1.50
Manganese (Mn)	0.1 max	1.0 max	1.2 max	0.50-1.25	2.00 max
Silicon (Si)	0.1 max	1.0 max	1.0 max	0.50 max	1.0 max
Nitrogen (N)	0.01 max	--	--	0.07-0.13	--
Phosphorus	0.01 max	0.040 max	0.040 max	0.040 max	0.025 max
Sulfur (S)	0.008 max	0.030 max	0.030 max	0.030 max	0.025 max
Titanium (Ti)	--	--	--	--	1.90-2.35
Aluminum (Al)	0.90-1.35	--	--	--	0.35 max
Vanadium (V)	--	--	--	--	0.10-0.50
Copper (Cu)	--	2.50-4.50	3.0-5.0	--	--
Boron (B)	--	--	--	--	0.003-0.010
Nb + Ta total	--	0.15-0.45	0.15-0.45	--	--
Iron (Fe)	Balance	Balance	Balance	Balance	Balance

TABLE IIb. Chemical Composition of Group II Powders (wt. %).

ELEMENT	Class A	Class B	Class C	Class D
	Alloy 1	Alloy 1	Alloy 1	Alloy 1
	Aluminum Alloy 1199 (High Purity)	Aluminum alloy 2024	Aluminum alloy 3003	Aluminum alloy 4047
Chromium (Cr)	--	0.1 max	--	--
Copper (Cu)	0.006 max	3.8 - 4.9	0.05-0.20	0.30
Iron (Fe)	0.006 max	0.5 max	0.7	0.8
Magnesium (Mg)	0.006	1.2 - 1.8	--	0.10
Manganese (Mn)	0.002 max	0.3 - 0.9	1.0-1.5	0.15
Zinc (Zn)	0.006	0.25 max	0.10	0.20
Silicon (Si)	0.006 max	0.5 max	0.6	11.0-13.0
Titanium (Ti)	0.002 max	0.15 max	--	--
Zirconium (Zr)	--	--	--	--
Gallium (Ga)	0.005 max	--	--	--
Vanadium (V)	0.005 max	--	--	--
Other, max. Each	0.002 max	0.05 max	0.05 max	0.05 max
Other, max. Total	--	0.15 max	0.15 max	0.15 max
Aluminum (Al)	99.99 min	Balance	Balance	Balance

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TABLE IIb. Chemical Composition of Group II Powders (wt. %) - Continued.

ELEMENT	Class E		Class F	Class G	
	Alloy 1	Alloy 2	Alloy 1	Alloy 1	Alloy 2
	Aluminum alloy 5056	Aluminum alloy 5083	Aluminum alloy 6061	Aluminum alloy 7050	Aluminum alloy 7075
Chromium (Cr)	0.05 - 0.20	0.05-0.25	0.04 – 0.35	0.04 max	--
Copper (Cu)	0.10 max	0.10 max	0.15 – 0.40	2.0-2.6	1.2 – 2.0
Iron (Fe)	0.40 max	0.40 max	0.70 max	0.15 max	0.50 max
Magnesium (Mg)	4.5 -5.6	4.0-4.9	0.8 – 1.2	1.9-2.6	2.1 – 2.9
Manganese (Mn)	0.05 - 0.20	0.4-1.0	0.15 max.	0.10 max	0.30 max
Zinc (Zn)	0.10 max	0.25 mx	0.25 max.	5.7-6.7	5.1 – 6.1
Silicon (Si)	0.30 max	0.40 max	0.40 – 0.80	0.12 max	0.40 max
Titanium (Ti)	--	0.15 max	0.15 max.	0.06 max	0.20 max
Zirconium (Zr)	--	--	--	0.08-0.15	--
Other, max. Each	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max
Other, max. Total	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max
Aluminum (Al)	Balance	Balance	Balance	Balance	Balance

TABLE IIc. Chemical Composition of Group III Powders (wt. %).

ELEMENT	CLASS A	CLASS B	CLASS C
	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed copper	9Sn-2Zn Bronze alloy	Cartridge Brass alloy
Niobium (Nb)	--	--	--
Copper (Cu)	99.4 min	88.8 - 89.2	68.5-71.5
Nickel (Ni)	--	--	--
Carbon (C)	--	--	--
Tantalum (Ta)	--	--	--
Iron (Fe)	--	--	0.050
Zinc (Zn)	0.05 max	1.9 – 2.1	28.5
Tin (Sn)	0.15 max	8.9 – 9.1	--
Silicon (Si)	--	--	--
Aluminum (Al)	0.01 max	--	--
Lead (Pb)	0.04 max	--	0.070
Other max. each	0.08	--	--
Other max. total	0.35	0.1	--

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TABLE IId. Chemical Composition of Group IV-VII Pure Powders (wt. %).

ELEMENT	Group IV	Group V	Group VI	Group VII
	Class A	Class A	Class A	Class A
	Alloy 1	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed magnesium (ASTM B92 Grade 9980B)	Un-alloyed zinc	Un-alloyed silver	Un-alloyed gold
Manganese (Mn)	0.0-0.1	--	--	--
Zinc (Zn)	--	99.9 min	--	--
Nickel (Ni)	0.0-0.005	--	--	--
Tin (Sn)	0.0-0.01	--	--	--
Lead (Pb)	0.0-0.01	--	--	--
Copper (Cu)	0.0-0.02	--	--	--
Silver (Ag)	--	--	99.9 min	--
Gold	--	--	--	99.9 min
Zirconium (Zr)	--	--	--	--
Magnesium (Mg)	Balance	--	--	--
Other max. total	--	0.1	0.1	0.1

TABLE Iie. Chemical Composition of Group VIII-X Pure Powders (wt. %).

ELEMENT	Group VIII	Group IX	Group X
	Class A	Class A	Class A
	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed tin	Un-alloyed cobalt	Un-alloyed zirconium
Cobalt (Co)	--	99.9 min	--
Tin (Sn)	99.9 min	--	--
Zirconium (Zr)	--	--	99.9 min
Magnesium (Mg)	--	99.9 min	--
Other max. total	0.1	0.1	0.1



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TABLE II f. Chemical Composition of Group XI Nickel and Nickel Alloys Powders (wt. %).

ELEMENT	Group XI		
	Class A (WT. %)	Class C (WT. %)	
	Alloy 1	Alloy 1	Alloy 2
	Un-alloyed Nickel	Nickel-base alloy (Inconel 625)	Nickel-base alloy (Inconel 718)
Chromium (Cr)	--	20.0 - 23.0	17.0 – 21.0
Copper (Cu)	--	--	0.30 max
Iron (Fe)	--	5.0 max	Balance
Manganese (Mn)	--	0.50 max	0.35 max
Silicon (Si)	--	0.50 max	0.35 max
Nickel (Ni)	99.9 min	58.0 min	--
Molybdenum (Mo)	--	8.0 – 10.0	2.80 – 3.30
Sulfur (S)	--	0.015 max	0.015 max
Phosphorous (P)	--	0.015 max	0.015 max
Carbon (C)	--	0.10 Max	0.08 max
Niobium (Nb) + Tantalum (Ta)	--	3.15 – 4.15	4.75 – 5.50
Aluminum (Al)	--	0.40 max	0.20 – 0.80
Titanium (Ti)	--	0.40 max	0.65 – 1.15
Nickel (Ni) + Cobalt (Co)	--	--	50.0 – 55.0
Cobalt (Co)	--	1.00 max	1.00 max
Boron (B)	--	--	0.006 max
Other max. each	--	--	--
Other max. total	0.1	--	--

TABLE II g. Chemical Composition of Group XII Refractory Metal Powders (wt. %).

ELEMENT	Class A	Class C	Class E
	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed Niobium	Un-alloyed Molybdenum	Un-alloyed Tantalum
Tungsten (W)	--	--	0.0500 max
Carbon (C)	--	--	0.0100 max
Oxygen (O)	--	--	0.0150 max
Nitrogen (N)	--	--	0.0100 max
Hydrogen (H)	--	--	0.0015 max
Niobium (Nb)	99.9 min	--	0.1000 max
Molybdenum (Mo)	--	99.9 min	0.0200 max
Iron (Fe)	--	--	0.0100 max
Cobalt (Co)	--	--	--
Chromium (Cr)	--	--	--
Silicon (Si)	--	--	0.0050 max
Titanium (Ti)	--	--	0.0100 max
Tantalum (Ta)	--	--	Balance
Rhenium (Re)	--	--	--
Other max. total	0.1	0.1	--

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TABLE IIg. Chemical Composition of Group XII Refractory Metal Powders (wt. %) - Continued.

ELEMENT	Class F	Class G	Class J
	Alloy 1	Alloy 1	Alloy 1
	10W-Ta Alloy	Un-alloyed Tungsten	Un-alloyed Rhenium
Tungsten (W)	9.0-11.0	99.9 min	--
Carbon (C)	0.0100 max	--	--
Oxygen (O)	0.0150 max	--	--
Nitrogen (N)	0.0020 max	--	--
Hydrogen (H)	0.0015 max	--	--
Niobium (Nb)	0.1000 max	--	--
Molybdenum (Mo)	0.0200 max	--	--
Iron (Fe)	0.0100 max	--	--
Cobalt (Co)	--	--	--
Chromium (Cr)	--	--	--
Silicon (Si)	0.0050 max	--	--
Titanium (Ti)	0.0100 max	--	--
Tantalum (Ta)	Balance	--	--
Rhenium (Re)	--	--	99.9 min
Other max. total	0.0010	0.1	0.1

TABLE IIh. Chemical Composition of Group XIII Platinum Group Metal Powders (wt. %).

ELEMENT	Class A	Class C	Class E	Class G	Class J
	Alloy 1	Alloy 1	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed Platinum	Un-alloyed Palladium	Un-alloyed Iridium	Un-alloyed Rhodium	Un-alloyed Ruthenium
Platinum (Pt)	99.9 min	--	--	--	--
Palladium (Pd)	--	99.9 min	--	--	--
Iridium (Ir)	--	--	99.9 min	--	--
Rhodium (Rh)	--	--	--	99.9 min	--
Osmium (Os)	--	--	--	--	99.9 min
Other max. total	0.1 max	0.1 max	0.1 max	0.1 max	0.1 max

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TABLE IIj. Chemical Composition of Group XIV Titanium Powders (wt. %).

ELEMENT	Class A				Class C	
	Alloy 1	Alloy 2	Alloy 3	Alloy 4	Alloy 1	Alloy 2
	ASTM Grade 1 Titanium	ASTM Grade 2 Titanium	ASTM Grade 3 Titanium	ASTM Grade 4 Titanium	ASTM Grade 5 Titanium	ASTM Grade 23 Titanium
Carbon (C)	0.100 max	0.100 max	0.100 max	0.100 max	0.08 max	0.08 max
Hydrogen (H)	0.015 max	0.015 max	0.015 max	0.015 max	0.015 max	0.0125 max
Iron (Fe)	0.200 max	0.300 max	0.300 max	0.500 max	0.40 max	0.25 max
Nitrogen (N)	0.030 max	0.030 max	0.050 max	0.050 max	0.05 max	0.030 max
Oxygen (O)	0.180 max	0.250 max	0.350 max	0.400 max	0.20 max	0.13 max
Aluminum (Al)	--	--	--	--	5.50-6.75	5.50-6.50
Vanadium (V)	--	--	--	--	3.50-4.50	3.50-4.50
Other (max ea.)	--	--	--	--	0.10	0.10
Other total	0.300 max	0.300 max	0.300 max	0.300 max	0.400 max	0.400 max
Titanium (Ti)	99.175 min	98.885 min	98.885 min	98.635 min	Balance	Balance

TABLE IIk. Chemical Composition of Group XV-XVII Powders (wt. %).

ELEMENT	Group XIV	Group XVI	Group XVII
	Class A	Class A	Class A
	Alloy 1	Alloy 1	Alloy 1
	Un-alloyed chromium	Un-alloyed lithium	Mischmetal (48%)
Lithium (Li)	--	99.9 min	--
Cerium (Ce)	--	--	48.0 min
Lanthanum (La)	--	--	25.0-33.0
Neodymium (Nd)	--	--	11.0-15.0
Praseodymium (Pr)	--	--	4.0-7.0
Total Rare Earths	--	--	98.0 min
Iron (Fe)	--	--	0.5 max
Silicon (Si)	--	--	0.2 max
Magnesium (Mg)	--	--	0.5 max
Sulfur (S)	--	--	0.02 max
Phosphorus (P)	99.9 min	--	0.01 max
Other max. total	0.1	0.1	--

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TABLE IIm. Chemical Composition of Group XVIII Powders (wt. %).

ELEMENT	Group XVIII		
	Class A		
	Alloy 1	Alloy 2	Alloy 3
	Chrome-carbide nickel (CrC-Ni)	Chrome-carbide nickel-chromium (CrC-NiCr) blended powder	WC-10 Co alloy
Chromium (Cr)	TBD	>75.0	3.00-5.00
Tungsten (W)	--	--	Balance
Carbon (C)	TBD	1.0-5.0	5.00-6.00
Oxygen (O)	--	--	0.20 max
Nickel	TBD	5.0-20.0	--
Iron (Fe)	--	--	0.20 max
Cobalt (Co)	--	--	9.00-11.00
Other max. total	--	--	--

3.2.6 Quality. All powders, as received by the purchaser, shall be thoroughly blended, dry, and free from foreign materials, clumps (agglomerates) and individual particles no larger than 500 microns as determined in accordance with 4.6.4.

3.2.6.1 Images of powders. Images of powders that have met nominal spray requirements can be found in Section 6.4 and serve as a suggestion/recommendation/guide for what "acceptable powders" look like. Images of the powder shall be taken and forwarded to the CEA and the PA for identification purposes and for future verifications of powder morphology to subsequent acquisitions under the same National Stock Number (NSN).

3.2.6.2 Hardness of powders. Powder hardness tests may be specified by the contract and applicable CEA (see 3.1.3), in order to verify the material microstructural state of a given powder, prior to consolidation, per either ASTM E384 or ASTM E2546.

3.2.7 Sprayability. The sprayability of the powders shall be demonstrated by the acceptance of the following requirements (3.2.7.1 thru 3.2.7.1.2) in accordance with 4.6.5. The applicable CEA shall specify all the operating parameters including the working gas that shall be used in the creation of the metallographic coupon. A cold spray control sheet (see MIL-STD-3021; Figure 3) shall be prepared and be submitted with each batch of sprayed coupons or test specimens and shall be forwarded to the applicable CEA (see 3.1.3).

3.2.7.1 Metallographic coupons. A metallographic coupon shall be made in accordance with the procedures listed in MIL-STD-3021 or in accordance with the contract or purchase order (see 6.2). The powder vendor shall use AA6061-T6 as a substrate or another material specified in the contract or purchase order (see 6.2 and 4.6.5.1). The thickness of the deposit shall be a minimum of 0.015 inch. Alternate substrate materials used for qualification requirements shall receive prior approval by the applicable CEA (see 3.1.3).

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3.2.7.1.1 Visual inspection. In accordance with MIL-STD-3021 detailed requirements, the metallographic coupon shall be visually inspected to verify a surface free from spalling, chipping, flaking, surface pitting, and cracking and other objectionable imperfections.

3.2.7.1.2 Microscopic examination. A microscopic examination of the cold spray deposit in the as-polished condition (no etchant) of a specimen cut perpendicular to the deposit surface shall not reveal any cracks, or porosity. The sample shall be prepared according to ASTM E3. The first examination of the deposit for cracks and porosity shall be done at 40x to present a gross overview of the deposit. A second examination for excessive porosity shall be taken at a magnification that allows resolution of the voids and porosity. Excessive porosity shall be defined according to the procedures outlined in ASTM E2109. It is important to label each micrograph file with a scale bar, such as a 50 um bar in the lower right corner to provide a scale to the examiner.

3.2.8 Additional requirements for Type designated powders only. Type designated powders, also referred to as “high criticality powders”, that are designated for use in critical applications may require further verifications to ensure the pedigree of the powder as it pertains to its performance in critical end use applications. Type designation will be tied to a set of property requirements as below (3.2.8.1 through 3.2.8.3). A new set of requirements for a powder of a given Group, Class, Alloy combination shall necessitate a new type listing for that Group, Class, Alloy combination.

3.2.8.1 Tension test specimens. A block of material sufficient to extract five (5) tension test specimens shall be made in accordance with the procedures listed in MIL-STD-3021 utilizing the appropriate cold spray equipment and processing procedures. Five (5) tensile bars shall be made from the block produced in accordance with the dimensions specified in ASTM E8/E8M for a Sub-Size Specimen. Samples shall be 0.125-0.150 inches thick with a minimum of 0.025 inches removed from the sprayed surface and a minimum of 0.010 inches removed from the face bonded to the substrate onto which the deposit is sprayed. The powder vendors shall specify all the operating parameters including the working gas that shall be used in the creation of the tension test specimens. A cold spray control sheet (see Appendix A) shall be prepared and be submitted with each sprayed specimen and forwarded to the applicable CEA (see 3.1.3)

3.2.8.1.1 Tensile properties. Unless otherwise specified in the contract or order (see 6.2), the tensile properties of the test specimen shall meet the minimum tensile properties listed in Table III when tested in accordance with 4.6.6.

3.2.8.2 Non-Destructive Inspection. Non-destructive test methods may be specified by the contract and applicable CEA (see 3.1.3), including, but not limited to electrical conductivity testing of the cold spray deposit, per ASTM E1004, for reference and later use in a production quality control program.

3.2.8.3. Hardness test specimens. Using specimens made in accordance with the procedures listed in MIL-STD-3021 utilizing the appropriate cold spray equipment and processing procedures, as specified by the contract requirements and/or applicable CEA (see 3.1.3), hardness testing may be required in accordance with ASTM E92 or ASTM E384 to verify cold spray deposition property conformance. The hardness testing shall be performed on the sample samples used for metallographic and other mechanical testing, or generated with the same operating parameters used to create the other specimens.

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TABLE III. Minimum mechanical properties of type designated powders.

<b>GROUP /Material</b>	<b>CLASS</b>	<b>ALLOY</b>	<b>TYPE</b>	<b>Tensile Strength, ksi</b>	<b>Yield Strength, 0.2% Offset, ksi</b>	<b>Elongation percent</b>
II AA 2024	C	1	a	49	35	3
II AA 5056	F	1	a	52	38	7
II AA 6061	G	1	a	40	32	3
II AA 7075	H	2	a	52	35	3

3.2.9 Manufacturing Process. The manufacturing processes for the production of the powders shall be as specified in the contract or purchase order (see 6.2) and shall produce a powder that meets or exceeds the requirements of 3.2.1 thru 3.2.7.1.1 and 3.2.9.

3.2.10 Shelf Life. This specification covers items where the assignment of a Federal shelf-life code is a consideration. Specific shelf-life requirements which depends on the level of packaging (see 5.1) shall be specified in the contract or purchase order (see 6.2) and shall be forwarded to the CEA. All paperwork associated with shelf life shall be maintained by each CEA (see 3.1.3). This paperwork should include, as a minimum, shelf-life code, shelf-life package markings in accordance with MIL-STD-129 or FED-STD-123, preparation of a materiel quality storage standard for type II (extendible) shelf-life items, and a minimum of 85 percent shelf-life remaining at time of receipt by the Government. These and other requirements, if necessary, are in DoD 4140.27-M, Shelf-life Management Manual. The shelf-life codes are in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from DoD 4140.27-M, or the designated shelf-life Points of Contact (POC). The POC should be contacted in the following order:

- (1) The Inventory Control Points that manage the item and
- (2) The DoD Service and Agency administrators for the DoD Shelf-Life Program.

Appropriate POCs for the DoD Shelf-Life Program can be contacted through the DoD Shelf-Life Management website: <https://www.shelflife.hq.dla.mil/>.

#### 4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

- (a.) Qualification inspection (see 4.2).
- (b.) Conformance inspection (see 4.4).

4.2 Qualification inspection. Qualification inspection shall consist of all inspections and tests specified in Table IV. Failure of any test shall be cause for rejection.

4.2.1 Qualification samples. The initial qualification samples shall be forwarded to the certified testing agency for testing and the results shall be forwarded to the CEA (see 3.1.3) for maintaining, and upon successful test results, shall be submitted to the PA for inclusion into the QPD. The

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powder shall be furnished in containers of the class, type, and grade to be used in filling contract orders. Samples shall be identified as specified in 6.3.2.1.

**4.2.2 Test reports.** The CEA shall forward to the PA all test reports generated from an ISO 9000/IEC 17025, National Aerospace and Defense Contractors Accreditation Program (NADCAP), and/or National Voluntary Laboratory Accreditation Program (NVLAP) Certified Test Agency (see 6.5.2) showing that the powder conforms to all the requirements of the specification (see 6.3.2) for the specific Service specified in the contract or purchase order (see 6.2) along with a copy of the contract or purchase order. The CEA may use their own ISO 9000/IEC 17025, NACAP, or NVLAP certified facility or any other facilities certified to ISO 9000/IEC 17025, NACAP, or NVLAP for confirming all requirements.

TABLE IV. Test methods.

REQUIREMENTS		TEST METHOD	REFERENCE PARAGRAPH	TESTING	
				QUALIFICATION	CONFORMANCE
Chemical composition (3.2.1)		ASTM E3061	4.6.1	X	X
Prohibited materials (3.2.2)		40 CFR 261, 40 CFR 401.15, and 40 CFR 63		X	X
Non-metallic impurities (3.2.3)		ASTM E1131	4.6.2.1	X	
Oxygen content (3.2.3)		ASTM E1019	4.6.2.2	X	--
Particle size distribution (3.2.4)		ASTM B822	4.6.3	X	X
Quality (3.2.6)		Visual inspection or as specified in contract or purchase order	4.6.4	X	--
Sprayability (3.2.7)	Metallographic coupon (3.2.7.1)	Visual Inspection	4.6.5.1	X	--
		Porosity ASTM E3 ASTM E2109		X	--
Tension test specimens (3.2.8) Type designated powders only.		MIL-STD-3021 and ASTM E8/E8M		X	X
Mechanical properties (3.2.8.1) “Type designated” only.	Tensile properties (3.2.8.1.1)	ASTM E8/E8M	4.6.6 & Table IV	X	X
Manufacturing Process (3.2.9)		--	3.2.1 thru 3.2.7.1.2 and 3.2.9	X	--

**4.3 Retention qualification.** To ensure compliance with all the requirements of this specification the manufacturer shall complete DD Form 1718 (Certification of Qualified Products) for each



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plant location and certify that the statements listed on the DD Form 1718 are true. Unless otherwise specified by the applicable CEA (see 3.1.3) or Preparing Activity the time of periodic verification by certification shall be in two-year intervals from the date of original qualification (see 3.1.2 and 6.2).

**4.4 Conformance inspection.** Conformance inspection shall be conducted on a per batch basis and consist of the satisfaction of all of the requirements identified as conformance in Table IV. Conformance test results from each batch shall be included with each procurement action. If during conformance testing a sample fails any of the above acceptance tests, that test needs to be repeated until two successive batches meet the requirement of the specification.

**4.4.1 Batch.** A batch of powder shall be defined as the amount produced of the same composition or composition blend, the same particle size distribution shall be  $\pm 10\%$  of the value submitted for qualification acceptance, and the same condition and manufactured at the same time from the same basic materials by the same manufacturing process, and submitted for vendor's inspection at the same time. The powder can be classified as either a general use powder with no "Type" designation, or can have a "Type" designation.

**4.4.2 Sampling.** Test samples shall be taken from the master batch in accordance with ASTM B215, Practice B. Sufficient powder shall be taken from each inspection unit to perform at least three (3) evaluations for each test.

**4.5 QPD qualification testing and extension evaluation program.** The powder sample shall meet all requirements of this specification. Although conforming to requirements, it may not pass particle size distribution (that is, subsequent particle size distributions are not within  $\pm 10\%$  of the measured value for the D10, D50, and D90), since it is not a passing criterion in qualifying in the QPD under this specification. This shall be determined on a case by case basis and formalized prior to evaluating through Test Service Agreements. Particle size distribution may be included as an additional requirement if specified in the contract or purchase order (see 6.2).

**4.6 Test methods.**

**4.6.1 Chemical composition.** Samples for chemical analysis (see 3.2.1) shall be prepared and tested in accordance with ASTM E3061, or by one of the following methods; Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES) or Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) or as specified in the contract or purchase order (see 6.2).

**4.6.2 Non-metallic impurities.**

**4.6.2.1 Moisture and volatiles.** The weight percent (wt. %) of the non-metallic impurities moisture and volatiles (see 3.2.3) shall be measured by the thermogravimetric method in accordance with ASTM E1131. For this test only inert gas purge shall be used, and the maximum temperature shall be 500° C.

**4.6.2.2 Oxygen content.** Oxygen content (see 3.2.3) shall be determined by inert gas fusion, as described in ASTM E1019 or as specified in the contract or purchase order (see 6.2).

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4.6.3 Particle size distribution. Powder (see 3.2.4) shall be tested in accordance with ASTM B822 (light scattering) or as specified in the contract or purchase order (see 6.2).

4.6.4 Quality. The requirements specified in 3.2.6 shall be determined by visual inspection or as specified in the contract or purchase order (see 6.2).

4.6.4.1 Images of powders. Images of the powder (see 3.2.6.1) shall be taken and forwarded to the CEA and the PA for as specified by the CEA in the contract or purchase order.

4.6.4.2 Hardness of powders. Hardness of powder (see 3.2.6.2) shall be tested in accordance with either ASTM E384 or ASTM E2546 or as specified in contract of purchase order (see 6.2)

4.6.5 Sprayability.

4.6.5.1 Metallographic coupon. A metallographic coupon (see 3.2.7.1) shall be sprayed and tested in accordance with a visual inspection (see 3.2.7.1.1) for a surface free from spalling, chipping, flaking, and cracking and other objectionable imperfections and a microscopic examination (see 3.2.7.1.2) for porosity.

4.6.6 Tensile properties. For type designated powders or as specified in the contract, tension test specimens (see 3.2.8.1) shall be prepared and tested in accordance with ASTM E8/E8M.

## 5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging and packing requirements shall be as specified in the contract or order (see 6.2) according to the following:

1. Powder shall be packaged within an inert atmosphere and sealed into electrically conductive individual bags in an inert environment. When required bags should have an adapter to enable transfer into a powder feeder without exposure to ambient conditions. The individual bags shall be in turn packaged within a metal container of sufficient quality to preserve the integrity of the contents against normal and expected hazards of transportation. Desiccant packets shall be placed in the metal container to minimize moisture. The individual bags shall be of sufficient quality to maintain the inert atmosphere and protect the powder from external factors such as moisture or oxygen until opened for use. This is considered the preferred form of packaging.

2. Powder shall be contained within electrically conductive plastic bags that shall be in turn packaged within a metal container of sufficient quality to preserve the integrity of the contents against normal and expected hazards of transportation and a seal sufficient to prevent exposure of the contents to the outside environment. Desiccant packets shall be placed outside the plastic bags in the metal container to absorb any moisture that may permeate through the packaging and keep the powder dry and free-flowing. This is considered a good form of packaging and is preferable to option 3.

3. Powder shall be contained within electrically conductive plastic bags that shall be in turn packaged within a plastic container of sufficient quality to preserve the integrity of the contents

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against normal and expected hazards of transportation and a seal sufficient to prevent exposure of the contents to the outside environment. This is an acceptable form of packaging.

However, if no requirements are specified in the contract or purchase order the packing of the powder shall be sealed within an inert atmosphere in electrically conductive plastic bags in accordance with NFPA 484 (Sec. 12.4.1.4 - 12.4.1.6). The bags shall in turn be packaged within containers of sufficient quality to preserve the integrity of the contents against the normal and expected hazards of transportation. When packaging of materiel components is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

## 6. NOTES

(This section contains information of a general or explanatory nature that may be helpful but is not mandatory.)

6.1 Intended use. The powders specified herein are intended to be used with the cold spray process as specified in MIL-STD-3021, entitled: "Materials Deposition, Cold Spray". This standard (MIL-STD-3021) establishes the manufacturing controls for powders that are utilized for the cold spray process for repairing, coating, and the fabrication of near net shape components, such as, Additive Manufacturing purposes. Cold spray is a low-temperature, solid state consolidation process, whereby metal or combinations of metallic and non-metallic particles are injected into a high-velocity gas stream and are directed upon a suitable substrate where they impact and consolidate to form a coating or near-net shape components, without melting. This specification (MIL-DTL-32495A) outlines the requirements for chemical composition, sprayability (see 3.2.5.2), overall quality, and conformance requirements for particle size distribution for powders that are utilized by the cold spray process to; (1) produce coatings on metallic and/or nonmetallic substrates including but not limited to steel, aluminum, ceramics and polymers, (2) produce deposits for dimensional restoration on metallic and/or nonmetallic substrates, or (3) produce near net shaped parts.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- (a.) Title, number and date of this specification.
- (b.) Specify Group, Class, Alloy and Type, of powders, CEA (see 6.3.1), and specific service (see 1.2 and 4.2.2).
- (c.) If issues of documents are different (see 2.2.1, 2.2.2, and 2.3).
- (d.) If the time of periodic verification is different (see 3.1.2 and 4.3).
- (e.) If the chemical composition of the powders cannot contain hazardous ingredients, and/or toxic pollutants, and/or hazardous air pollutants (see 3.2.2).
- (f.) The total moisture, volatiles (loss on ignition), and oxygen content, if required (see 3.2.3).

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- (g.) If the type of measuring is different than that specified in 4.6.2.1 or 4.6.2.2 (see 3.2.3).
- (h.) Particle size distribution if different from within 10% of the measured value and/or method to use in determining particle size distribution (see 3.2.4 and 4.6.3).
- (i.) The dimensions for the metallographic coupon (see 3.2.7.1).
- (j.) An alternate substrate material for the metallographic test (see 3.2.7.1).
- (k.) If the minimum tensile properties are different (see 3.2.8.1.1).
- (l.) Process to use for the manufacturing of the powders (see 3.2.9).
- (m.) Specify shelf life requirements (see 3.2.10) in accordance with the specified level of packaging (see 5.1 and 6.2(u)).
- (n.) The Service, if applicable (see 4.2.2).
- (o.) If particle size distribution should be added as a requirement (see 4.5).
- (p.) If the testing and preparation for chemical analysis is different (see 4.6.1).
- (q.) If the determination of the oxygen content is different (see 4.6.2.2).
- (r.) If the method for determining quality is different (see 4.6.4).
- (s.) Packaging and packing requirements if different (see 5.1).
- (t.) Specify any additional requirements (see 6.3.2).

**6.3 Qualification and Conformance.** With respect to products requiring qualification, awards should be made only for products that are, at the time of award of contract, qualified for inclusion in Qualified Products Database QPL-32495, whether or not such products have actually been so listed by that date. The attention of contractors is called to this requirement and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products and the samples for the qualified products database (QPD) testing (see 4.2) and for the conformance program (see 4.4) should be submitted to the CEA (see 3.1.3), as a submission package of paperwork, powder samples, and panels / coupons. Conformance test reports from each batch (see 4.4.1) should be included with all packaged orders.

**6.3.1 Applicable Cognizant Engineering Authorities.** Government agencies seeking to serve as a CEA should send a request to the PA, namely, Army-MR. Nongovernment entities may also be granted CEA status however they must first be fully vetted by a procuring activity or other government agency to be approved and granted CEA eligibility. As noted under (3.1.3) and similar for all other CEAs, nongovernment CEAs should assume full responsibility for assuring that all required testing and subsequent evaluation of any powders submitted to the PA for listing under this specification are completed and pass all requirements specified herein, and also meet any additional performance criteria specific to their intended application. Powder vendors seeking product listings within the QPL/QPD but with no specific sponsoring CEA (they are selling to another Industry/Company) requesting their powders may use the default CEA, namely, the Army. The Industry/Company may either contract with the Army CEA via a Test Service Agreement (TSA) or alternatively contract using certified testing agencies to satisfy all the requirements listed in this specification. All certified test results must be forwarded to the Army CEA and PA. As new entities are granted approval(s) and added as CEA(s), administrative notices should be posted to the Assist Quicksearch website < <https://quicksearch.dla.mil> > to reflect the updated status.

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6.3.1.1 Government CEAs.

6.3.1.1.1 U.S. Army Research Laboratory. ARL Center for Cold Spray, Material & Manufacturing Science Division, Army Research Laboratory located at Aberdeen Proving Ground, MD, 21005-5069.

6.3.1.2 Nongovernment and Industry CEAs.

TBD

6.3.2 Storage stability, inspection, and other information. In addition to the qualification test samples, the CEA or PA will request the manufacturer to submit to the CEA or PA: a certified test report from an ISO 9000/IEC 17025, NACAP, or NVLAP certified laboratory showing that the powder conforms to all the requirements of the specification (see 4.2.2). Considering the application, the contract should be aware of the following:

- (a.) Studies have shown that powders can be sensitive to environmental factors such as oxygen and moisture that drive oxidation and hydrolyzing which can adversely affect the sprayability of powders and the deposit quality. Extra caution should be taken to avoid unnecessary exposure of the powder to the atmosphere.
- (b.) Shelf-life of the powders can vary from powder to powder as well as the storage environment. The shelf-life of powders are also shortened once the seal to the container is broken. While proper packaging practices significantly help to maintain the quality of powders, it is recommended that powders in excess of 1 year age be re-evaluated for quality prior to use in any critical applications.
- (c.) It is recommended that the contract keep in mind the end-use of the powder and require packaging sizes based on the anticipated use. Packaging in appropriately sized containers should minimize unnecessary environmental exposure of any powder that is in excess of the intended use.
- (d.) The CEA or PA may use their own ISO 9000/IEC 17025, NACAP, or NVLAP certified facility or any other facilities certified to ISO 9000/IEC 17025, NACAP, or NVLAP for qualification under all requirements, for additional requirements specified in the contract or purchase order (see 6.2), or by the CEA. All certified paperwork should be forwarded to the CEA. CEA, in turn, should incorporate all certified paperwork and forward it to the PA for QPD inclusion.

6.3.2.1 Qualification inspection sample identification. Qualification inspection samples are to be forwarded to the CEA, designated in the letter of authorization (see 6.3) and identified as follows:

QUALIFICATION TEST SAMPLES

Specification MIL-DTL-32495

Group I to XIV; Class A, B, C, D, E.; Alloy 1, 2, 3. ; Type a or b (as applicable)

POWDERS FOR COLD SPRAY DEPOSITION



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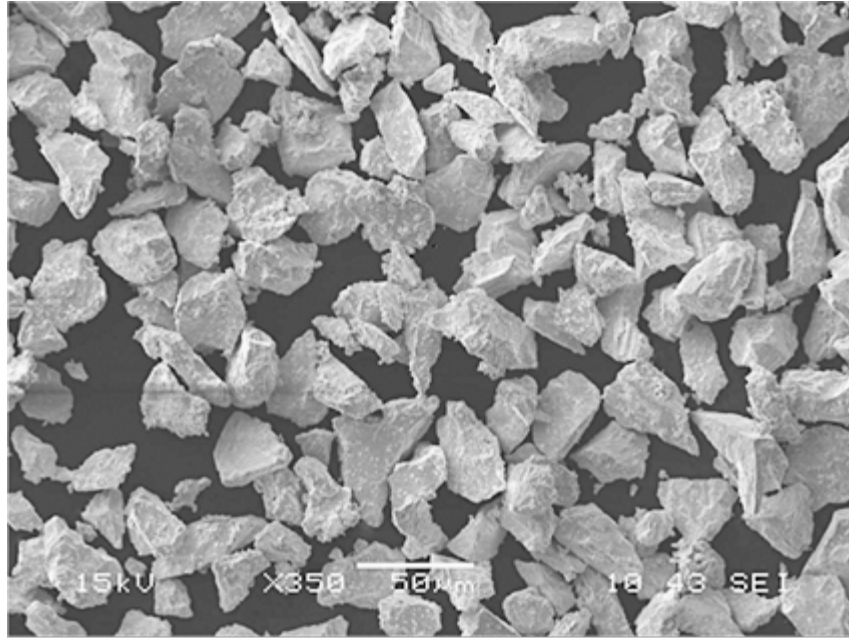
Manufacturer's name and product number

Submitted by (name and date) for evaluation in accordance with authorization  
(reference authorizing letter)

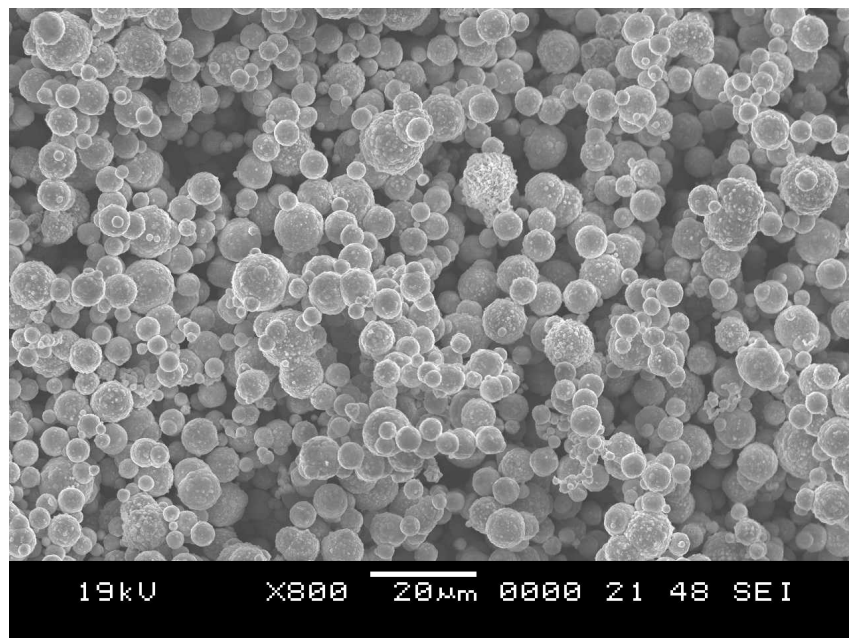
6.4 Images of powders. The following are image based examples of powders.

6.4.1 Examples of “Acceptable” and “Desirable” Powders.

6.4.1.1 Angular Tantalum Powder (Acceptable).

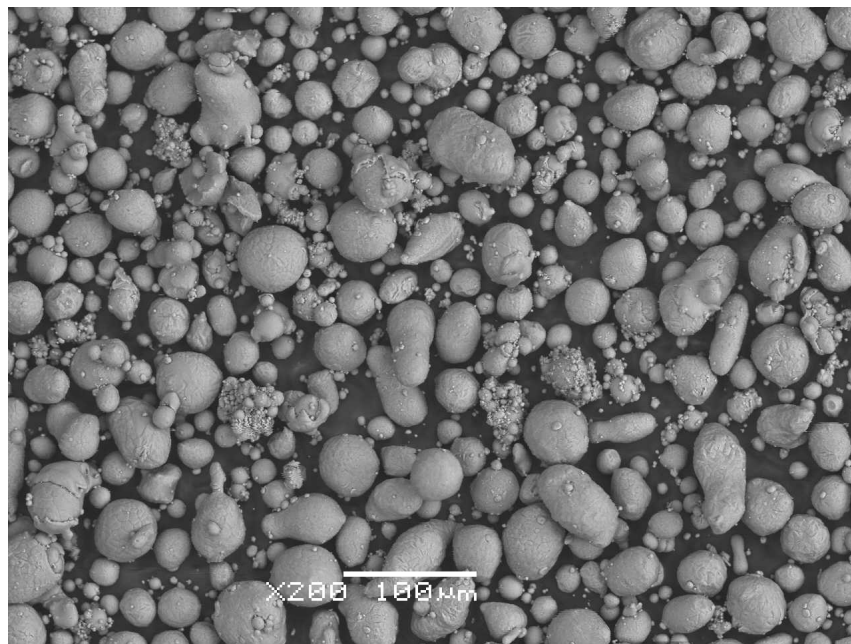


6.4.1.2 Spherical Nickel Powder (Acceptable).

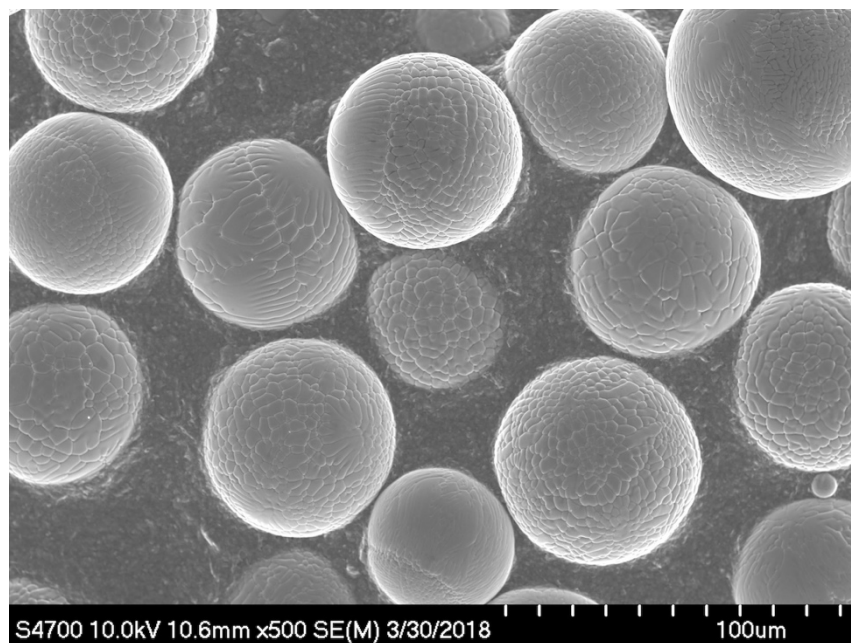


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6.4.1.3 Spherical Copper Powder (Desirable).



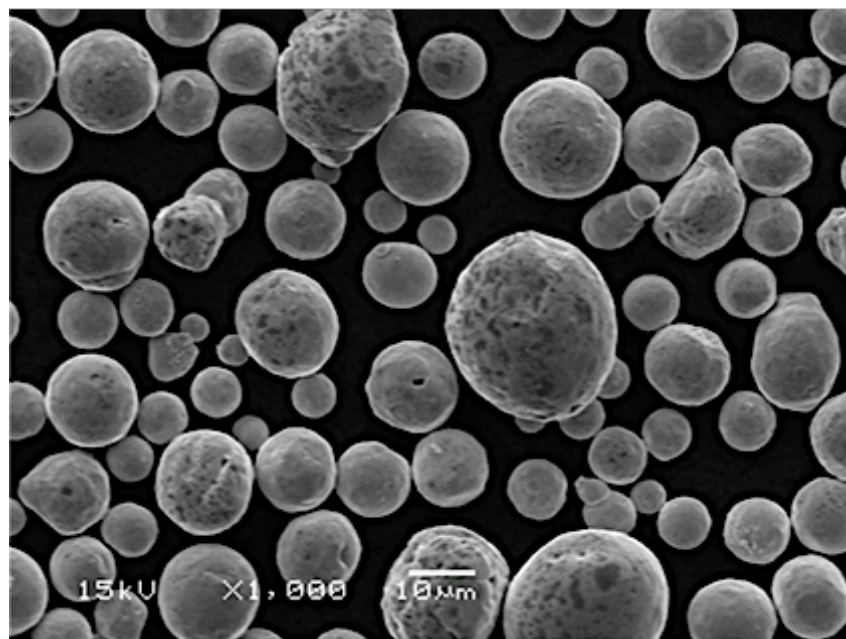
6.4.1.4 Spherical Al 6061 Powder (Desirable).





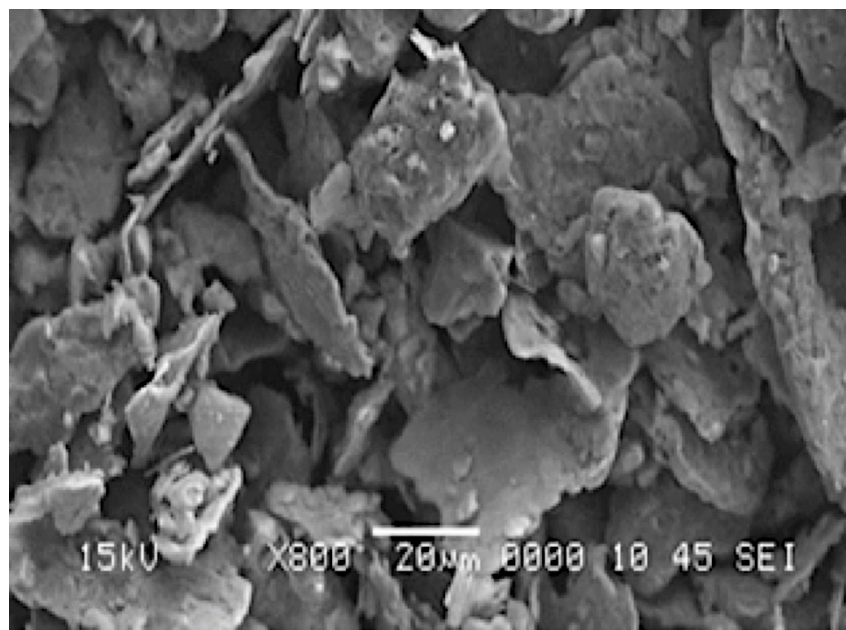
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6.4.1.5 Aggregate Aluminum Powder (Desirable).



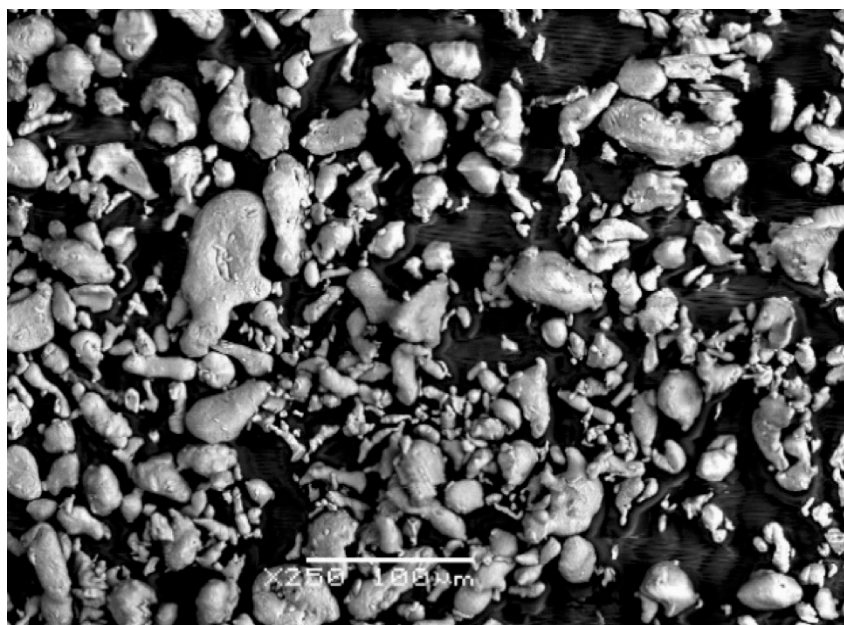
6.4.2 Examples of “Undesirable” powders.

6.4.2.1 Flake Aluminum Powder (Undesirable).

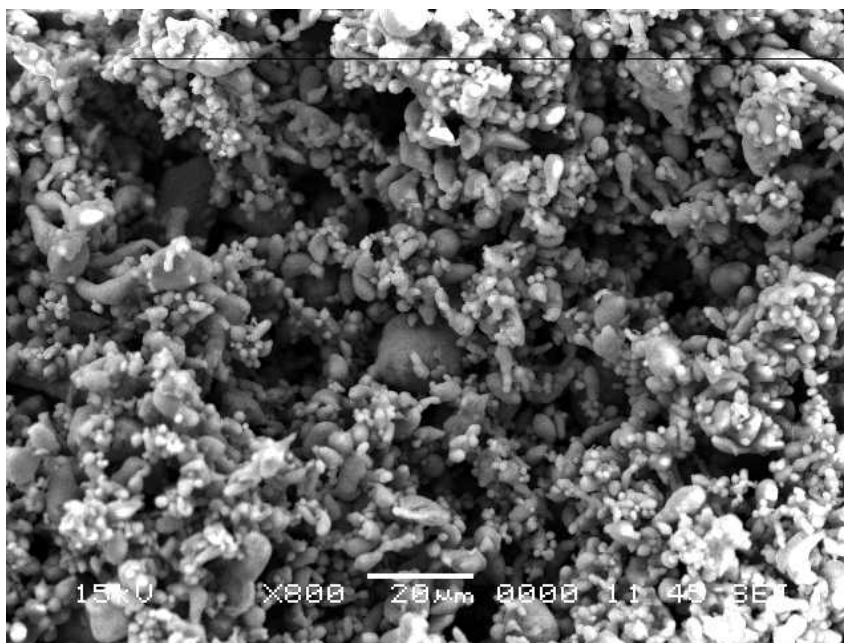


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#### 6.4.2.2 Acicular Powders (Undesirable).



#### 6.4.2.3 Agglomerated Powder (Undesirable).



### 6.5 Definitions.

6.5.1 Cognizant Engineering Authority (CEA). Responsible for the technical adequacy and performance of the product for the end use.

6.5.2 Certified Testing Agency. An ISO 9000/IEC 17025, National Aerospace and Defense Contractors Accreditation Program (NADCAP), and/or National Voluntary Laboratory

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Accreditation Program (NVLAP) certified laboratory suitable for performing qualification and conformance tests needed to qualify or maintain powders on the QPL and/or satisfy contracts or purchase orders.

6.5.3 Preparing Activity (PA). The DoD activity or the civilian agency responsible for the preparation, coordination, issuance, and maintenance of standardization documents. The preparing activity for a document can be identified through the ASSIST.

6.5.4 Qualification. A process in advance of and independent of an acquisition by which a manufacturer's capabilities, or a manufacturer's or distributor's products are examined, tested, and approved to be in conformance with specification requirements, and subsequent approval for or listing of products on a qualified products list (QPL) or manufacturers on a qualified manufacturers list (QML).

6.5.5 Type designated powder. The term 'type designated powder' is any powder that is subject to additional qualification and conformance requirements as determined in section 3.2.8 due to the high criticality nature of the intended application. These powders should be referred to as high criticality powders.

6.6 Submission Package. This section lists the package of documents that is required to be prepared by the powder manufacturer or their representative and submitted to the CEA. Appendix A contains copies of these documents. The submission package should also contain a completed Cold Spray Control Sheet from MIL-STD-3021. The following documents are part of the submission package.

- (1) Cover Sheet/Check List
- (2) Safety Data Sheet (SDS)
- (3) Technical Data Sheet
- (4) Certified Test Report
- (5) Process/Control Sheet
- (6) Non-Disclosure Agreement -- (Not for testing, but for confidential information handling)

6.7 Subject term (key word) listing.

Adhesion	Kinetic metallization
Cohesion	Kinetic spraying
Cold gas dynamic spray	Laser diffraction
High velocity powder deposition	Particles
Impaction process	Propelling gas
Kinetic energy	Thermal spray

6.8 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

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POWDERS FOR COLD SPRAY DEPOSITION

A.1 SCOPE

A.1.1 This appendix covers the package of documents that is required to be submitted by the powder manufacturer (see 6.6) for QPL/QPD listing. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

1. Cover Sheet/Check List
2. Safety Data Sheet (SDS)
3. Technical Data Sheet
4. Certified Test Report
5. Process/Control Sheet
6. Non-Disclosure Agreement --- (Not for testing, but for confidential information handling)

**1. Cover Sheet / Check list:**

COMPANY & POC	SERVICE	MATERIAL	GROUP	CLASS	ALLOY	TYPE
REQUIREMENT						COMPLETED
Chemical composition (3.2.1)						
Prohibited materials (3.2.2)						N/A
Non-metallic impurities (3.2.3)						
Oxygen content (3.2.3)						
Particle size distribution (3.2.4)						
Quality (3.2.6)						
Images of Powders ( 3.2.6.1)						
Hardness of Powders (3.2.6.2)						
Sprayability (3.2.7)						
Metallographic coupon (3.2.7.1)						
Tension test specimens (3.2.8.1) Type designated only.						
Tensile properties (3.2.8.1.1) Type designated only						
Non-Destructive Inspection (3.2.8.2) Type designated only.						
Hardness Test Specimens (3.2.8.3) Type designated only.						
Manufacturing Process (3.2.9)						
Shelf life (3.2.10)						
Additional requirements:						

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APPENDIX A**2. Safety Data Sheet (SDS):****1) MATERIAL IDENTIFICATION****2) COMPOSITION/DATA ON COMPONENTS****3) HAZARDS IDENTIFICATION****4) FIRST AID MEASURES****5) FIRE FIGHTING MEASURES****6) ACCIDENTAL RELEASE MEASURES****7) HANDLING AND STORAGE****8) EXPOSURE CONTROLS AND PERSONAL PROTECTION****9) PHYSICAL AND CHEMICAL PROPERTIES****10) STABILITY AND REACTIVITY DATA****11) TOXICOLOGICAL INFORMATION****12) ECOLOGICAL INFORMATION****13) DISPOSAL CONSIDERATIONS****14) TRANSPORT INFORMATION****15) OTHER REGULATORY INFORMATION****16) OTHER INFORMATION**

MSDS reviewed: DATE
---------------------

Notice to reader: The information is furnished without warranty, expressed or implied, except that it is accurate to the best knowledge of COMPANY Inc. The data on this sheet relates only to the specific material designated herein. The data is not a quality specification. COMPANY Inc. does not assume legal responsibility for use of or reliance on this information. Suitably of use of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, COMPANY Inc. cannot guarantee that these are the only hazards that exist.

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**3. Technical Data Sheet:**

- 1) Date and Company's Product**
- 2) Product Description**
- 3) Typical Physical and Application Properties**
- 4) Standard Package Sizes and Coverage**
- 5) Available Product Configurations**
- 6) Surface Preparation**
- 7) Patents if applicable**
- 8) Typical Application Technique**
- 9) Spray Application**
- 10) Dry/Cure Time**
- 11) Health and Safety Precaution**
- 12) Storage**
- 13) Contact for Additional Information**
- 14) Technical Information**
- 15) Product Use**
- 16) Warranty, Limited Remedy, and Disclaimer**
- 17) Limitation of Liability**

**4. Certified Test Report:**

- 1) Date, Company's Product and Description**
- 2) Accreditations and Certifications (with any additional quality system standards)**
- 3) Test**
- 4) Specification's Section and Paragraph**
- 5) Requirement**
- 6) Result**
- 7) Approved Signature**



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APPENDIX A

## 5. Process/Control Sheet:

Vendor:		
Specific Service: Army   Air Force   Navy   Other (Circle one)		
Cold Spray System:	Model #:	
Nozzle Type/Material:	Nozzle Throat Diameter, Exit Diameter & Length:	
<b>SAMPLE PREPARATION</b>		
Substrate Material Type:		
Heat Treat Condition :		
Surface Preparation (grit blast, scotch rite, solvent clean, etc.):		
<b>COATING POWDER</b>		
Powder Material:	Powder Mean Diameter:	Material Lot # :
Powder Supplier:		
Powder material specification:		
<b>COATING DATA</b>		
Main Gas Type:	Temperature (Deg. C):	
Main Gas Pressure (MPa):		
Nozzle to Work Distance (mm):		
Deposition Angle:		
Notes:		
Hand-Held Gun: YES   NO		Robotically Manipulated Gun: YES   NO
Traverse rate (mm/s):	Increment (mm):	
Deposition Thickness as Sprayed:	Number of Passes:	
Notes:		
Vendor POC Information:		
Vendor Approval:		



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## APPENDIX A

**6. Non-Disclosure Agreement:**

This Non-disclosure Agreement between ARL/WMRD and the Powder Manufacturer is limited to the confidential handling of information in the form of Certified Test Reports. ARL/WMRD personnel shall maintain the original copies of all submitted Test Reports in a file marked with the Official Name of the Powder Manufacturer's Company; the POC of the Company; Their phone number, Cell phone number, Fax number, and Email address; Title of the POC; Address including city & state & zip code; Name of the Powder being evaluated, the Class, Type, & Grade; and the Date.

The following sheet of paper shall be adhered to the file folder that contains all the Certified Test Reports that the Company has provided. Additionally, the file folder shall contain a Coversheet/Check List, Safety Data Sheet (SDS), Technical Data Sheet, and a Process/Control Sheet. Finally, this file folder shall contain all the Test Results from all the required tests listed in the specification, MIL-DTL-XXXX for Qualification Acceptance (that are available to maintain the QPL/QPD). A new file folder shall be prepared to contain all Conformance testing results including the subsequent Certified Test Reports for each Conformance requirement specified in the Specification. All data representing failed outcomes shall be mark in 'RED'.

## MIL-DTL-32495A

### CONCLUDING MATERIAL

#### Custodians:

Army – MR

Navy - AS

Air Force - 20

#### Preparing Activity:

Army – MR

(Project MFFP-2019-001)

#### Review activities:

Army – AV, CR, PT

Navy - EC, MC, SH

Air Force - 19

DLA – DH, GS8

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.dla.mil/>.