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Cold Spray Powder Specification Implementation

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Worcester Polytechnic Institute, Worcester, Massachusetts

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U.S. Army Research Laboratory

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ENDORSING

MIL-DTL-32495A
12 August 2014
27 August 2014
27 August 2014
27 August 2014
27 August 2014
27 August 2014
27 August 2014

DETAIL DESCRIPTION

ACQUISITION HISTORY

1. NAME

2. DATE

3. REVISION

4. AUTHORITY

5. COMMENTS

6. APPROVED BY

7. DATE

8. COMMENTS

9. COMMENTS

10. COMMENTS

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Specification History


- Accompanies MIL-STD-3021
- Created 12 May 2014
- Amendment 1, 26 SEP 2014
- Amendment 2, 23 AUG 2015
- Revision A, forthcoming

Acquisition Path

- Specification (QPL & NSNs)
- System Engineering Drawing
- Contracts for acquisition
- Full Transition

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Specification Term Guide

- PIN – Part Identifying Number
- NSN – National Stock Number
- QPL/QPD – Qualified Products List / Qualified Products Database
- CEA – Cognizant Engineering Authority
- PA – Preparing Activity
- Qualification – The process by which a powder is added to the QPL/QPD
- Conformance – The process by which the quality of the powder is ensured for future contracts

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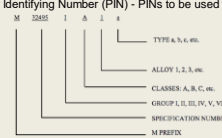
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MIL-DTL-32495 Revision Goals

MIL-DTL-32495A Goals

- Expand specification to include many other powders beyond aluminum and its alloys
- Designate Part or Identifying Number (PIN) - PINs to be used for powders acquired by this specification



- Define powder quality for acceptance including contaminants, shelf life, and storage practices
- Include sample images to define quality of spray with examples to reject
- Establish Qualified Products List (QPL) document – Prior requirement was First Article.
- QPL & QPD will include products with assigned National Stock Numbers (NSNs)

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UNCLASSIFIED **RDECOM** MIL-DTL-32495 - Cognizant Engineering Authority **ARL**

The ARL Advanced Materials & Processes Team (Cold Spray Team) and the other service labs may appoint **Cognizant Engineering Authorities (CEAs)** to determine if new powders will meet their Services' minimum acceptance criteria necessary for inclusion within the companion QPL document. The ARL Specifications & Standards Office (Army-MR) shall approve CEAs designated by each Service (Army, Navy, Air Force, etc.).

When the CEA has determined that a powder satisfactorily fulfills the compulsory criteria of MIL-DTL-32495 the powder and its qualification data are submitted to the Preparing Activity (PA), the ARL Specifications and Standards Office, for final review, assignment of a new NSN and inclusion into the QPL/QPD document.

Mr. William Lum of the ARL Specifications and Standards Office manages QPL/QPD and NSN assignment activities.

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UNCLASSIFIED **RDECOM** MIL-DTL-32495A Additions **ARL**

Group I contains iron and steel-based alloys powders

1	2	13	14	15	16	17	18
H 1088							Hc 14025
Li 940							B 4
Be 900322							C 12011
Na 127080							N 14087
Mg 24305							O 15999
							P 18998
							S 20180
							Al 24305
							Si 35286
							P 36154
							S 37433
							Cr 43700
							Mn 44700
							Fe 49123
							Ni 54521
							Cu 56378
							Zn 72436
							Ga 75287
							As 76204
							Se 76394
							Br 79904
							K 81
							Ca 82
							Sc 91
							Ti 94
							V 99
							Cr 100
							Mn 101
							Fe 102
							Ni 103
							Cu 104
							Zn 105
							Ga 106
							As 107
							Se 108
							Br 109
							K 110
							Ca 111
							Sc 112
							Ti 113
							V 114
							Cr 115
							Mn 116
							Fe 117
							Ni 118
							Cu 119
							Zn 120
							Ga 121
							As 122
							Se 123
							Br 124
							K 125
							Ca 126
							Sc 127
							Ti 128
							V 129
							Cr 130
							Mn 131
							Fe 132
							Ni 133
							Cu 134
							Zn 135
							Ga 136
							As 137
							Se 138
							Br 139
							K 140
							Ca 141
							Sc 142
							Ti 143
							V 144
							Cr 145
							Mn 146
							Fe 147
							Ni 148
							Cu 149
							Zn 150
							Ga 151
							As 152
							Se 153
							Br 154
							K 155
							Ca 156
							Sc 157
							Ti 158
							V 159
							Cr 160
							Mn 161
							Fe 162
							Ni 163
							Cu 164
							Zn 165
							Ga 166
							As 167
							Se 168
							Br 169
							K 170
							Ca 171
							Sc 172
							Ti 173
							V 174
							Cr 175
							Mn 176
							Fe 177
							Ni 178
							Cu 179
							Zn 180
							Ga 181
							As 182
							Se 183
							Br 184
							K 185
							Ca 186
							Sc 187
							Ti 188
							V 189
							Cr 190
							Mn 191
							Fe 192
							Ni 193
							Cu 194
							Zn 195
							Ga 196
							As 197
							Se 198
							Br 199
							K 200
							Ca 201
							Sc 202
							Ti 203
							V 204
							Cr 205
							Mn 206
							Fe 207
							Ni 208
							Cu 209
							Zn 210
							Ga 211
							As 212
							Se 213
							Br 214
							K 215
							Ca 216
							Sc 217
							Ti 218
							V 219
							Cr 220
							Mn 221
							Fe 222
							Ni 223
							Cu 224
							Zn 225
							Ga 226
							As 227
							Se 228
							Br 229
							K 230
							Ca 231
							Sc 232
							Ti 233
							V 234
							Cr 235
							Mn 236
							Fe 237
							Ni 238
							Cu 239
							Zn 240
							Ga 241
							As 242
							Se 243
							Br 244
							K 245
							Ca 246
							Sc 247
							Ti 248
							V 249
							Cr 250
							Mn 251
							Fe 252
							Ni 253
							Cu 254
							Zn 255
							Ga 256
							As 257
							Se 258
							Br 259
							K 260
							Ca 261
							Sc 262
							Ti 263
							V 264
							Cr 265
							Mn 266
							Fe 267
							Ni 268
							Cu 269
							Zn 270
							Ga 271
							As 272
							Se 273
							Br 274
							K 275
							Ca 276
							Sc 277
							Ti 278
							V 279
							Cr 280
							Mn 281
							Fe 282
							Ni 283
							Cu 284
							Zn 285
							Ga 286
							As 287
							Se 288
							Br 289
							K 290
							Ca 291
							Sc 292
							Ti 293
							V 294
							Cr 295
							Mn 296
							Fe 297
							Ni 298
							Cu 299
							Zn 300
							Ga 301
							As 302
							Se 303
							Br 304
							K 305
							Ca 306
							Sc 307
							Ti 308
							V 309
							Cr 310
							Mn 311
							Fe 312
							Ni 313
							Cu 314
							Zn 315
							Ga 316
							As 317
							Se 318
							Br 319
							K 320
							Ca 321
							Sc 322
							Ti 323
							V 324
							Cr 325
							Mn 326
							Fe 327
							Ni 328
							Cu 329
							Zn 330
							Ga 331
							As 332
							Se 333
							Br 334
							K 335
							Ca 336
							Sc 337
							Ti 338
							V 339
							Cr 340
							Mn 341
							Fe 342

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U.S. ARMY RDECOM MIL-DTL-32495A Additions **ARL**

1	2											13	14	15	16	17	18
H	He											B	C	N	O	F	Ne
Li	Be											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Fr	Ra	# Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Group VIII contains tin and tin-based alloys powders

Classes
 Class A: un-alloyed tin powder.
 Class B: tin alloy powder.

* Lanthanide series
 # Actinide series

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U.S. ARMY RDECOM MIL-DTL-32495A Additions **ARL**

1	2											13	14	15	16	17	18
H	He											B	C	N	O	F	Ne
Li	Be											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Fr	Ra	# Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Group IX contains cobalt and cobalt-based alloys powders

Classes
 Class A: un-alloyed cobalt powder.
 Class B: cobalt alloy powder.

* Lanthanide series
 # Actinide series

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U.S. ARMY RDECOM MIL-DTL-32495A Additions **ARL**

1	2											13	14	15	16	17	18
H	He											B	C	N	O	F	Ne
Li	Be											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Fr	Ra	# Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Group X contains zirconium, and zirconium-based alloys powders

Classes
 Class A: un-alloyed zirconium powder.
 Class B: zirconium alloy powder.

* Lanthanide series
 # Actinide series

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U.S. ARMY RDECOM MIL-DTL-32495A Additions **ARL**

1	2											13	14	15	16	17	18
H	He											B	C	N	O	F	Ne
Li	Be											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Fr	Ra	# Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Group XI contains nickel and nickel-based alloys powders

Classes
 Class A: un-alloyed nickel powder.
 Class B: iron, nickel, Co alloy powder.
 Class C: nickel Cr/Fe/Mo alloy powder (Inconel®625, Inconel®718)
 Class D: nickel / Cu alloy powder.
 Class E: nickel / Mo alloy powder.
 Class F: other nickel alloy powder.

* Lanthanide series
 # Actinide series

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MIL-DTL-32495A Additions

Group XVI contains lithium, and lithium-based alloys powders

Classes
 Class A: unalloyed lithium powder.
 Class B: lithium alloy powder.

1	2											13	14	15	16	17	18	
H	Li	Be											B	C	N	O	F	Ne
1.008	6.941	9.0122											10.811	12.011	14.007	15.999	18.998	20.180
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
39.098	40.078	44.956	47.883	50.942	51.996	54.938	55.845	58.933	58.933	63.546	63.546	69.723	72.630	74.922	78.971	79.904	83.798	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.87	112.41	114.82	118.710	121.76	127.60	131.29	131.29	
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	
Cs	Ba	* HF	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
132.91	137.33	171.03	180.95	186.21	186.21	190.23	192.22	193.22	197.04	200.59	204.38	207.2	208.98	208.98	210.99	222.02		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	
Fr	Ra	#	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fh	Mc	Lr	Ts	Og	
171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	

* Lanthanide series
 # Actinide series

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MIL-DTL-32495A Additions

Group XVII contains Rare Earth powders

Classes
 Class A: 48% mischmetal powder.
 Class B: lithium alloy powder.

1	2											13	14	15	16	17	18	
H	Li	Be											B	C	N	O	F	Ne
1.008	6.941	9.0122											10.811	12.011	14.007	15.999	18.998	20.180
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
39.098	40.078	44.956	47.883	50.942	51.996	54.938	55.845	58.933	58.933	63.546	63.546	69.723	72.630	74.922	78.971	79.904	83.798	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.87	112.41	114.82	118.710	121.76	127.60	131.29	131.29	
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	
Cs	Ba	* HF	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
132.91	137.33	171.03	180.95	186.21	186.21	190.23	192.22	193.22	197.04	200.59	204.38	207.2	208.98	208.98	210.99	222.02		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	
Fr	Ra	#	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fh	Mc	Lr	Ts	Og	
171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	

* Lanthanide series
 # Actinide series

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MIL-DTL-32495A Additions

Group XVIII contains Metal Matrix Composite powders

Classes
 Class A: Carbide Based Beryllium alloy powder. (C-CM blend, C-CM blend)

1	2											13	14	15	16	17	18	
H	Li	Be											B	C	N	O	F	Ne
1.008	6.941	9.0122											10.811	12.011	14.007	15.999	18.998	20.180
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
39.098	40.078	44.956	47.883	50.942	51.996	54.938	55.845	58.933	58.933	63.546	63.546	69.723	72.630	74.922	78.971	79.904	83.798	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.87	112.41	114.82	118.710	121.76	127.60	131.29	131.29	
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	
Cs	Ba	* HF	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
132.91	137.33	171.03	180.95	186.21	186.21	190.23	192.22	193.22	197.04	200.59	204.38	207.2	208.98	208.98	210.99	222.02		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	
Fr	Ra	#	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fh	Mc	Lr	Ts	Og	
171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	

* Lanthanide series
 # Actinide series

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MIL-DTL-32495A Additions

Group XIX amorphous and high entropy alloy based powders

Classes
 Class A: Amorphous alloy powder.
 Class B: High entropy alloy powder.

1	2											13	14	15	16	17	18	
H	Li	Be											B	C	N	O	F	Ne
1.008	6.941	9.0122											10.811	12.011	14.007	15.999	18.998	20.180
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
39.098	40.078	44.956	47.883	50.942	51.996	54.938	55.845	58.933	58.933	63.546	63.546	69.723	72.630	74.922	78.971	79.904	83.798	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.87	112.41	114.82	118.710	121.76	127.60	131.29	131.29	
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	
Cs	Ba	* HF	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
132.91	137.33	171.03	180.95	186.21	186.21	190.23	192.22	193.22	197.04	200.59	204.38	207.2	208.98	208.98	210.99	222.02		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	
Fr	Ra	#	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fh	Mc	Lr	Ts	Og	
171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	171.03	

* Lanthanide series
 # Actinide series

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Questions

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