

INCH-POUND

MIL-DTL-46077G
28 September 2006
SUPERSEDING
MIL-DTL-46077F
29 December 1998

DETAIL SPECIFICATION

ARMOR PLATE, TITANIUM ALLOY, WELDABLE

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

1. SCOPE

1.1 Scope. This specification covers a weldable wrought titanium alloy structural armor plate in nominal thicknesses from 0.125 - 4.0 inch, inclusive. Ballistic data requirements for nominal thicknesses of 0.125 to 0.249 inch, inclusive are not available for this Revision.

1.2 Classification. Wrought titanium alloy armor should be of the following classes as specified (see 6.2).

1.2.1 Class 1. Class 1 is equivalent to material specified by previous revisions of MIL-A-46077, which is an Extra Low Interstitial (ELI) grade.

1.2.2 Class 2. Class 2 is equivalent to material specified by MIL-T-9046J, AB-1 composition.

1.2.3 Class 3. Class 3 permits a higher oxygen level which would be suitable for applications where maximum ductility and toughness are not necessary, such as appliqué.

1.2.4 Class 4. Class 4 permits Al, V, & Fe compositions different from the conventional Ti-6Al-4V alloy.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials Applications Branch, Specifications and Standards Office, Attn: AMSRD-ARL-WM-MC, Aberdeen Proving Ground, MD 21005-5069 or emailed to rsquilla@arl.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil/>.

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 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, 4, or 5 of this specification, whether or not they are listed.

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 these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

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

(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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.

U.S. ARMY TEST AND EVALUATION COMMAND (USATECOM)

TOP 2-2-710 - Ballistic Tests of Armor Materials
ITOP 4-2-805 - Projectile Velocity and Time of Flight Measurements

(Application for copies should be addressed to the Defense Technical Information Center, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218.)

2.3 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal should apply.

American Society for Quality Control (ASQC)

ASQ Z1.4 - Procedures, Sampling and Tables for Inspection by Attributes
(DoD Adopted)

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(Copies of this document are available from www.asq.org or American Society for Quality Control, 600 Plankinton Avenue, Milwaukee, WI 53203.)

ASME INTERNATIONAL

- SAE-AMS 2249 - Chemical Check Analysis Limits - Titanium and Titanium Alloys (DoD Adopted)
- SAE-ARP 982 - Wrought Titanium Alloy Products, Minimizing Stress Corrosion Cracking in (DoD Adopted)

(Copies of this document are available from www.asme.org or ASME International, Three Park Avenue, New York, NY 10016-5990)

ASTM INTERNATIONAL

- ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip (DoD Adopted)
- ASTM E8 - Standard Test Methods for Tension Testing of Metallic Materials, (DoD Adopted)
- ASTM E120 - Chemical Analysis of Titanium and Titanium-Base Alloys (DoD Adopted)
- ASTM E539 - Standard Test Method for X-Ray Emission Spectrometric Analysis of 6Al-4V Titanium Alloy
- ASTM E1409 - Standard Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
- ASTM E1447 - Standard Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

2.4 Order of precedence. 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 First article. When specified (see 6.2), the contractor shall furnish a sample or samples for first article inspection and approval. The contractor shall comply with this requirement at the

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time of his first order or contract and at any time that the supplier has not furnished wrought armor in the applicable thickness range under this specification within a period of 18 months (see 4.4).

3.2 Chemical composition.

3.2.1 Class compositions. The chemical composition of the plates shall be as specified in Table 1 for classes 1, 2 and 3. If no class is specified on the contract, drawing or order, Class 1 shall be supplied. Chemical composition variances shall meet the requirements of SAE AMS 2249.

Table 1. Chemical Composition - Percent by Weight

Class	Al	V	C	O	N	H ¹	Fe	Ti	Other ³	
									Each	Total
1	5.50 - 6.50	3.50 - 4.50	0.04 max	0.14 max	0.02 max	0.0125 max	0.25 max	Rem ²	0.10 max	0.40 max
2	5.50 - 6.75	3.50 - 4.50	0.08 max	0.20 max	0.05 max	0.0150 max	0.30 max	Rem ²	0.10 max	0.40 max
3	5.50 - 6.75	3.50 - 4.50	0.08 max	0.30 max	0.05 max	0.0150 max	0.30 max	Rem ²	0.10 max	0.40 max
4			0.08 max	0.30 max	0.05 max	0.0150 max		Rem ²		

¹ Hydrogen shall be determined on each lot of the product as shipped.

² Titanium is determined by differences.

³ Other elements need not be analyzed nor reported unless otherwise specified.

3.2.1.1 Class 4.

3.2.1.1.1 Class 4 composition. Upon approval of the procuring activity, an alternate composition of titanium alloy may be authorized. In addition to the solute composition limits specified in Table 1, suppliers must submit to the procuring activity established limits for each intentionally added element as well as maximum limits for others.

3.2.1.1.2 Class 4 density. The density shall be 0.158 through 0.165 pounds per cubic inch. Density may be calculated based on chemical composition range established.

3.3 Mechanical properties. Plate shall meet the minimum mechanical properties of Table 2 in both the longitudinal and transverse directions after final heat treatment (See 4.6.1.2 and 4.6.2.2). After temperature exposure and cooling, a minimum of 0.001 inch shall be removed from all surfaces of the sample prior to testing. Sufficient material shall be removed so as to insure compliance of the sample with the requirements of 3.9.

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Table 2. Minimum Mechanical Properties

Class	Yield Strength 0.2% Offset (psi)	Tensile Strength (psi)	Elongation (%)
1	110,000	120,000	10
2	110,000	120,000	6
3	110,000	120,000	6
4	110,000	120,000	6

3.4 Ballistic requirements. The minimum protection ballistic limits (BL(P)) of the test plate shall be in accordance with the values shown in Tables 3 through 8. No through cracks greater than 2.5 inch in length on any plate surface are permitted after ballistic testing. When a complete penetration can not be obtained for any class of armor material, the following rule shall be in effect until a new ballistic acceptance round can be developed and utilized. When the ballistic velocities of four (4) partial penetrations are above the minimum ballistic requirement for the specific thickness, the material shall be certified as acceptable with a V_{50} (which obviously can not be explicitly determined) above the minimum requirement.

Table 3. Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).Firing Obliquity: TBD²Projectile: TBD²

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
0.110	TBD ²	0.170	TBD	0.230	TBD
0.115	TBD	0.175	TBD	0.235	TBD
0.120	TBD	0.180	TBD	0.240	TBD
0.125 ¹	TBD	0.185	TBD	0.245	TBD
0.130	TBD	0.190	TBD	0.249 ³	TBD
0.135	TBD	0.195	TBD	0.250	TBD
0.140	TBD	0.200	TBD	0.255	TBD
0.145	TBD	0.205	TBD	0.260	TBD
0.150	TBD	0.210	TBD	0.270	TBD
0.155	TBD	0.215	TBD	0.275	TBD
0.160	TBD	0.220	TBD	0.280	TBD
0.165	TBD	0.225	TBD	0.285	TBD

¹ Specification requirements begin with this ordered thickness.

² TBD – To be determined.

³ Specification requirements end with this ordered thickness (See Table 4).

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Table 4. Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: Caliber .30 AP M2

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
0.240	1116	0.385	1715	0.530	2158
0.245	1142	0.390	1732	0.535	2171
0.250 ¹	1167	0.395	1749	0.540	2185
0.255	1192	0.400	1766	0.545	2199
0.260	1216	0.405	1783	0.550	2212
0.265	1239	0.410	1799	0.555	2225
0.270	1263	0.415	1815	0.560	2239
0.275	1286	0.420	1832	0.565	2252
0.280	1308	0.425	1848	0.570	2265
0.285	1330	0.430	1864	0.575	2278
0.290	1352	0.435	1879	0.580	2291
0.295	1373	0.440	1895	0.585	2304
0.300	1394	0.445	1910	0.590	2317
0.305	1415	0.450	1926	0.595	2330
0.310	1436	0.455	1941	0.600	2342
0.315	1456	0.460	1956	0.605	2355
0.320	1476	0.465	1971	0.610	2368
0.325	1496	0.470	1986	0.614 ²	2378
0.330	1515	0.475	2001	0.615	2380
0.335	1534	0.480	2016	0.620	2393
0.340	1553	0.485	2031	0.625	2405
0.345	1572	0.490	2045	0.630	2417
0.350	1591	0.495	2059	0.635	2430
0.355	1609	0.500	2074	0.640	2442
0.360	1627	0.505	2088	0.645	2454
0.365	1645	0.510	2102	0.650	2466
0.370	1663	0.515	2116	0.655	2478
0.375	1681	0.520	2130	0.660	2490
0.380	1698	0.525	2144	0.665	2502

¹ Specification requirements begin with this ordered thickness.

² Specification requirements end with this ordered thickness (See Table 5).

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Table 5. Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm FSP

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
0.595	1866	0.745	2229	0.895	2745
0.600	1875	0.750	2244	0.900	2763
0.605	1885	0.755	2260	0.905	2781
0.610	1894	0.760	2276	0.910	2799
0.615 ¹	1904	0.765	2292	0.915	2817
0.620	1913	0.770	2308	0.920	2836
0.625	1922	0.775	2324	0.925	2854
0.630	1932	0.780	2341	0.930	2872
0.635	1942	0.785	2357	0.935	2890
0.640	1952	0.790	2374	0.940	2908
0.645	1963	0.795	2391	0.945	2927
0.650	1973	0.800	2408	0.950	2945
0.655	1985	0.805	2425	0.955	2963
0.660	1996	0.810	2442	0.960	2981
0.665	2008	0.815	2459	0.965	2999
0.670	2020	0.820	2477	0.970	3017
0.675	2032	0.825	2494	0.975	3035
0.680	2045	0.830	2512	0.980	3053
0.685	2057	0.835	2529	0.985	3071
0.690	2070	0.840	2547	0.990	3089
0.695	2084	0.845	2565	0.995	3107
0.700	2097	0.850	2582	1.000	3124
0.705	2111	0.855	2600	1.005	3142
0.710	2125	0.860	2618	1.010	3160
0.715	2139	0.865	2636	1.015	3177
0.720	2154	0.870	2654	1.020	3195
0.725	2168	0.875	2672	1.025	3212
0.730	2183	0.880	2690	1.030	3230
0.735	2198	0.885	2708	1.035	3247
0.740	2213	0.890	2727	1.040	3264

¹ Specification requirements begin with this ordered thickness.

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Table 5. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm FSP

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
1.045	3281	1.195	3752	1.345	4123
1.050	3299	1.200	3766	1.350	4134
1.055	3316	1.205	3780	1.355	4145
1.060	3332	1.210	3794	1.360	4155
1.065	3349	1.215	3808	1.365	4166
1.070	3366	1.220	3821	1.370	4176
1.075	3383	1.225	3835	1.375	4186
1.080	3399	1.230	3848	1.380	4196
1.085	3416	1.235	3861	1.385	4207
1.090	3432	1.240	3874	1.390	4217
1.095	3448	1.245	3887	1.395	4227
1.100	3465	1.250	3900	1.400	4236
1.105	3481	1.255	3913	1.405	4246
1.110	3497	1.260	3926	1.410	4256
1.115	3513	1.265	3938	1.415	4266
1.120	3528	1.270	3950	1.420	4275
1.125	3544	1.275	3963	1.425	4285
1.130	3560	1.280	3975	1.430	4294
1.135	3575	1.285	3987	1.435	4304
1.140	3591	1.290	3999	1.440	4313
1.145	3606	1.295	4011	1.445	4322
1.150	3621	1.300	4022	1.450	4331
1.155	3636	1.305	4034	1.455	4341
1.160	3651	1.310	4046	1.460	4350
1.165	3666	1.315	4057	1.465	4359
1.170	3681	1.320	4068	1.470	4368
1.175	3695	1.325	4080	1.475	4377
1.180	3710	1.330	4091	1.480	4386
1.185	3724	1.335	4102	1.485	4395
1.190	3738	1.340	4113	1.490	4404

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Table 5. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm FSP

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
1.495	4413	1.550	4511	1.600	4601
1.500	4422	1.555	4520	1.605	4610
1.505	4431	1.560	4529	1.610	4619
1.510	4440	1.565	4538	1.615	4628
1.515	4449	1.570	4547	1.620	4637
1.520	4458	1.574 ²	4554	1.625	4646
1.525	4466	1.575	4556	1.630	4655
1.530	4475	1.580	4565	1.635	4664
1.535	4484	1.585	4574	1.640	4673
1.540	4493	1.590	4583	1.645	4682
1.545	4502	1.595	4592	1.650	4691

² Specification requirements end with this ordered thickness (See Table 6).

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Table 6. Minimum Required V₅₀ Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 14.5-mm API B32

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
1.565	2679	1.695	2836	1.825	2986
1.570	2685	1.700	2842	1.830	2991
1.575 ¹	2691	1.705	2848	1.835	2997
1.580	2697	1.710	2854	1.840	3002
1.585	2704	1.715	2860	1.845	3008
1.590	2710	1.720	2866	1.850	3013
1.595	2716	1.725	2871	1.855	3019
1.600	2722	1.730	2877	1.860	3024
1.605	2728	1.735	2883	1.865	3030
1.610	2734	1.740	2889	1.870	3036
1.615	2740	1.745	2895	1.875	3041
1.620	2746	1.750	2900	1.880	3047
1.625	2753	1.755	2906	1.885	3052
1.630	2759	1.760	2912	1.890	3057
1.635	2765	1.765	2918	1.895	3063
1.640	2771	1.770	2923	1.900	3068
1.645	2777	1.775	2929	1.905	3074
1.650	2783	1.780	2935	1.910	3079
1.655	2789	1.785	2940	1.915	3085
1.660	2795	1.790	2946	1.920	3090
1.665	2801	1.795	2952	1.925	3096
1.670	2807	1.800	2957	1.930	3101
1.675	2813	1.805	2963	1.935	3106
1.680	2818	1.810	2969	1.940	3112
1.685	2824	1.815	2974	1.945	3117
1.690	2830	1.820	2980	1.949 ²	3121

¹ Specification requirements begin with this ordered thickness.

² Specification requirements end with this ordered thickness (See Table 7).

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Table 6. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 14.5-mm API B32

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
1.950	3122	1.980	3154	2.010	3186
1.955	3128	1.985	3160	2.015	3191
1.960	3133	1.990	3165	2.020	3197
1.965	3138	1.995	3170	2.025	4003
1.970	3144	2.000	3176	2.030	4008
1.975	3149	2.005	3181	2.035	4013

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Table 7. Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm API-T M602

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
1.935	2330	2.080	2462	2.225	2593
1.940	2334	2.085	2466	2.230	2598
1.945	2339	2.090	2471	2.235	2602
1.950 ¹	2343	2.095	2475	2.240	2607
1.955	2348	2.100	2480	2.245	2611
1.960	2352	2.105	2485	2.250	2616
1.965	2357	2.110	2490	2.255	2620
1.970	2361	2.115	2494	2.260	2625
1.975	2365	2.120	2499	2.265	2629
1.980	2370	2.125	2503	2.270	2634
1.985	2375	2.130	2508	2.275	2638
1.990	2380	2.135	2512	2.280	2643
1.995	2384	2.140	2517	2.285	2647
2.000	2389	2.145	2521	2.290	2652
2.005	2393	2.150	2526	2.295	2656
2.010	2398	2.155	2530	2.300	2661
2.015	2402	2.160	2535	2.305	2665
2.020	2407	2.165	2539	2.310	2670
2.025	2411	2.170	2544	2.315	2674
2.030	2416	2.175	2548	2.320	2679
2.035	2421	2.180	2553	2.325	2683
2.040	2426	2.185	2557	2.330	2687
2.045	2430	2.190	2562	2.335	2691
2.050	2435	2.195	2566	2.340	2696
2.055	2439	2.200	2571	2.345	2700
2.060	2444	2.205	2575	2.350	2705
2.065	2448	2.210	2580	2.355	2709
2.070	2453	2.215	2584	2.360	2714
2.075	2457	2.220	2589	2.365	2718

¹ Specification requirements begin with this ordered thickness.

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Table 7. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm API-T M602

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
2.370	2723	2.520	2854	2.670	2983
2.375	2727	2.525	2858	2.675	2987
2.380	2732	2.530	2863	2.680	2992
2.385	2736	2.535	2867	2.685	2996
2.390	2740	2.540	2872	2.690	3000
2.395	2744	2.545	2876	2.695	3004
2.400	2749	2.550	2880	2.700	3009
2.405	2753	2.555	2884	2.705	3013
2.410	2758	2.560	2889	2.710	3017
2.415	2762	2.565	2893	2.715	3021
2.420	2767	2.570	2898	2.720	3026
2.425	2771	2.575	2902	2.725	3030
2.430	2776	2.580	2906	2.730	3034
2.435	2780	2.585	2910	2.735	3038
2.440	2784	2.590	2915	2.740	3043
2.445	2788	2.595	2919	2.745	3047
2.450	2793	2.600	2923	2.750	3051
2.455	2797	2.605	2927	2.755	3055
2.460	2802	2.610	2932	2.760	3060
2.465	2806	2.615	2936	2.765	3064
2.470	2811	2.620	2941	2.770	3068
2.475	2815	2.625	2945	2.775	3072
2.480	2819	2.630	2949	2.780	3077
2.485	2823	2.635	2953	2.785	3081
2.490	2828	2.640	2958	2.790	3085
2.495	2832	2.645	2962	2.795	3089
2.500	2837	2.650	2966	2.800	3093
2.505	2841	2.655	2970	2.805	3097
2.510	2846	2.660	2975	2.810	3102
2.515	2850	2.665	2979	2.815	3106

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Table 7. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm API-T M602

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
2.820	3110	2.965	3230	3.110	3349
2.825	3114	2.970	3235	3.115	3353
2.830	3119	2.975	3239	3.120	3357
2.835	3123	2.980	3243	3.125	3361
2.840	3127	2.985	3247	3.130	3365
2.845	3131	2.990	3251	3.135	3369
2.850	3135	2.995	3255	3.140	3373
2.855	3139	3.000	3259	3.145	3377
2.860	3144	3.005	3263	3.150	3381
2.865	3148	3.010	3267	3.155	3385
2.870	3152	3.015	3271	3.160	3389
2.875	3156	3.020	3276	3.165	3393
2.880	3160	3.025	3280	3.170	3397
2.885	3164	3.030	3284	3.175	3401
2.890	3169	3.035	3288	3.180	3405
2.895	3173	3.040	3292	3.185	3409
2.900	3177	3.045	3296	3.190	3413
2.905	3181	3.050	3300	3.195	3417
2.910	3185	3.055	3304	3.200	3421
2.915	3189	3.060	3308	3.205	3425
2.920	3193	3.065	3312	3.210	3429
2.925	3197	3.070	3316	3.215	3433
2.930	3202	3.075	3320	3.220	3437
2.935	3206	3.080	3325	3.225	3441
2.940	3210	3.085	3329	3.230	3445
2.945	3214	3.090	3333	3.235	3449
2.950	3218	3.095	3337	3.240	3453
2.955	3222	3.100	3341	3.245	3457
2.960	3226	3.105	3345	3.249 ²	3460

² Specification requirements end with this ordered thickness (See Table 8).

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Table 7. (cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 20-mm API-T M602

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
3.250	3461	3.280	3485	3.310	3509
3.255	3465	3.285	3489	3.315	3513
3.260	3469	3.290	3493	3.320	3517
3.265	3473	3.295	3497	3.325	3521
3.270	3477	3.300	3501	3.330	3525
3.275	3481	3.305	3505	3.335	3529

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Table 8. Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 30-mm APDS

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
3.235	3491	3.380	3606	3.525	3722
3.240	3495	3.385	3610	3.530	3726
3.245	3499	3.390	3614	3.535	3730
3.250 ¹	3503	3.395	3618	3.540	3734
3.255	3507	3.400	3622	3.545	3738
3.260	3511	3.405	3626	3.550	3742
3.265	3514	3.410	3630	3.555	3746
3.270	3518	3.415	3634	3.560	3750
3.275	3522	3.420	3638	3.565	3754
3.280	3526	3.425	3642	3.570	3758
3.285	3530	3.430	3646	3.575	3762
3.290	3534	3.435	3650	3.580	3766
3.295	3538	3.440	3654	3.585	3770
3.300	3542	3.445	3658	3.590	3774
3.305	3546	3.450	3662	3.595	3778
3.310	3550	3.455	3666	3.600	3782
3.315	3554	3.460	3670	3.605	3786
3.320	3558	3.465	3674	3.610	3790
3.325	3562	3.470	3678	3.615	3794
3.330	3566	3.475	3682	3.620	3798
3.335	3570	3.480	3686	3.625	3802
3.340	3574	3.485	3690	3.630	3806
3.345	3578	3.490	3694	3.635	3810
3.350	3582	3.495	3698	3.640	3814
3.355	3586	3.500	3702	3.645	3818
3.360	3590	3.505	3706	3.650	3822
3.365	3594	3.510	3710	3.655	3826
3.370	3598	3.515	3714	3.660	3830
3.375	3602	3.520	3718	3.665	3834

¹ Specification requirements begin with this ordered thickness.

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Table 8. (Cont.) Minimum Required V_{50} Ballistic Limits (Protection Criteria) (BL(P)).
 Firing Obliquity: 0° Projectile: 30-mm APDS

Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)	Thickness (in)	Required BL(P) (fps)
3.670	3838	3.820	3957	3.970	4077
3.675	3842	3.825	3961	3.975	4081
3.680	3846	3.830	3965	3.980	4085
3.685	3850	3.835	3969	3.985	4089
3.690	3854	3.840	3973	3.990	4093
3.695	3858	3.845	3977	3.995	4097
3.700	3861	3.850	3981	4.000 ²	4101
3.705	3865	3.855	3985	4.005	4105
3.710	3869	3.860	3989	4.010	4109
3.715	3873	3.865	3993	4.015	4113
3.720	3877	3.870	3997	4.020	4117
3.725	3881	3.875	4001	4.025	4121
3.730	3885	3.880	4005	4.030	4125
3.735	3889	3.885	4009	4.035	4129
3.740	3893	3.890	4013	4.040	4133
3.745	3897	3.895	4017	4.045	4137
3.750	3901	3.900	4021	4.050	4141
3.755	3905	3.905	4025	4.055	4145
3.760	3909	3.910	4029	4.060	4149
3.765	3913	3.915	4033	4.065	4153
3.770	3917	3.920	4037	4.070	4157
3.775	3921	3.925	4041	4.075	4161
3.780	3925	3.930	4045	4.080	4165
3.785	3929	3.935	4049	4.085	4169
3.790	3933	3.940	4053	4.090	4173
3.795	3937	3.945	4057	4.095	4177
3.800	3941	3.950	4061	4.100	4181
3.805	3945	3.955	4065	4.105	4185
3.810	3949	3.960	4069	4.110	4189
3.815	3953	3.965	4073	4.115	4193

² Specification requirements end with this ordered thickness.

Note: The values above the specification requirements end points are for interpolation of BL(P) requirements for plates received with a plus tolerance on the nominal thickness.

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3.5 Dimensional tolerances.

3.5.1 Length, width, and thickness. Length and width tolerances shall be as agreed upon by purchaser and vendor. The plus and minus tolerances on plate thickness shall be as specified in Table 9.

Table 9. Plate Thickness Tolerances

Thickness Range (inch)	Tolerance (inch) ¹
0.125 to 0.249	TBD ²
0.250 to 0.374	+ 0.045
0.375 to 0.749	+0.055
0.750 to 0.999	+0.060
1.000 to 1.999	+0.070
2.000 to 2.999	+0.085
3.000 to 4.000	+0.100

¹ The entire range has a minus tolerance of 0.010 inch.

² To be determined.

3.5.2 Straightness. Plates shall be of such straightness that the maximum edgewise curvature (depth of arc) shall not exceed 1/8 inch for any 5 ft section along its length.

3.5.3 Flatness. Flatness tolerances across the plate width shall conform to Table 10.

Table 10. Flatness Tolerances for Plate

Plate Thickness (inch)	Maximum Permissible Variation in Flatness (inch)								
	Plate Width (inch)								
	Up to 48, incl.	48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 144, excl.	144 and over
0.125 to 0.249	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
0.250 to 0.374	11/16	3/4	15/16	1-1/8	1-3/8	1-7/16	1-9/16	1-7/8	--
0.375 to 0.499	1/2	9/16	11/16	3/4	15/16	1-1/8	1-1/4	1-7/16	1-3/4
0.500 to 0.749	1/2	9/16	5/8	5/8	13/16	1-1/8	1-1/8	1-1/8	1-3/8
0.750 to 0.999	1/2	9/16	5/8	5/8	3/4	13/16	15/16	1	1-1/8
1.000 to 1.499	1/2	9/16	9/16	9/16	11/16	11/16	11/16	3/4	1
1.500 to 4.000	3/16	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8

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3.6 Marking for identification. Unless otherwise specified in the contract or order that MIL-STD-129 or any other markings shall be used (see 6.2), each plate shall be marked on one face with the manufacturer's name or trademark, the basic number and revision letter of this specification, the composition, the nominal plate thickness, and the lot number. Each plate shall be marked in lengthwise rows of characters recurring at intervals not greater than 3 feet, the rows being spaced not more than 6 inches apart and alternately staggered. The characters shall be not less than 3/8 inch in height and shall be applied using a suitable marking fluid whose residue shall contain not more than traces of halogen-bearing compounds and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the plate material or its performance and shall be sufficiently stable to withstand normal handling.

3.6.1 Marking of ballistic test plates. Each ballistic test plate shall be marked with a plate identification code (see 3.6) and the letters 'PRE' if a first article test plate and 'ACC' if an acceptance test plate. When practicable, the marking shall be an impression stamped on the horizontal edge face of the ballistic test plates.

3.7 Heat treatment. Product shall be heat treated within prescribed temperature, time, and atmospheric condition ranges established during first article testing or commonly approved production runs.

3.7.1 Reheating. Unless otherwise approved by the procuring activity (see 6.2), after the final heat treatment, material shall not be reheated or processed above the final annealing, stress relieving, or aging temperatures or to a temperature that is 100° F below the beta transus, whichever is less. If plates are retreated above these limiting temperatures, they shall be so recorded and completely re-tested as a separate lot.

3.8 Ballistic test plate information. For each lot of titanium alloy armor plate a properly completed Titanium Armor Test Data Form (see Figure 1) shall be submitted with each ballistic test plate that represents that particular processing lot.

3.9 Finish. Unless otherwise specified (see 6.2), plate shall have a surface finish in accordance with ASTM A480 after surface preparation (if necessary). Product shall be free of surface contamination by oxygen (alpha case), hydrogen, carbon, nitrogen, or other such harmful contaminants. The producer shall be permitted to remove minor surface imperfections by spot grinding if such grinding does not reduce the thickness of the material below the minimum permitted by the tolerance for the thickness ordered.

3.10 Workmanship. The material produced under this specification shall be uniform in quality and condition, and free from harmful alloy segregation and surface contamination by oxygen, nitrogen, or other contaminant and foreign material. The plate shall be clean, sound, smooth and free of defects detrimental to fabricability or serviceability such as hard spots, laminations, inclusions, pits, folds, seams, grind marks, and cracks.

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REQUEST FOR BALLISTIC TEST OF TITANIUM ARMOR											
FIRING RECORD:						DATE:					
Plate MANUFACTURER / PRODUCER:						PRIME CONTRACTOR:					
Name:						Name:					
Address:						Address:					
POC:						POC:					
Phone No:						Phone No:					
Fax No:						Fax No:					
SPECIFICATION: MIL-DTL-46077						REVISION: G			AMENDMENT:		
CONTRACT NO:						TECOM PROJECT NO:					
DCAS REGION:						BALLISTIC TEST CONTRACT NO:					
TEST ITEM IDENTIFICATION:											
Lot No.			Plate No.			Ordered Thickness			Alloy and Temper		
PURPOSE: ___ Acceptance ___ First Article ___ Development											
SAMPLE: ___ Primary ___ Retest (Firing Record No. of Failed Sample _____)											
CHEMICAL ANALYSIS:											
Al	V	Fe	O	C	N	H	Si				Ti
											Rem
MECHANICAL PROPERTIES:											
UTS (psi):				0.2% YS (psi):				Elongation (%):			
BALLISTIC TEST RESULTS:											
Test	Projectile	Obl. (deg)	Actual Thickness (in)	Required V ₅₀ (fps)	Actual V ₅₀ (fps)	Pass/ Fail	Notes				
LOTS REPRESENTED BY:				Reduced Testing				Audit Testing			
Lot [met] [failed to meet] the ballistic requirements of specification MIL-DTL-46077G.											
Government Representative				Date		Supplier Representative				Date	

Figure 1. Titanium Armor Test Data Form

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4. VERIFICATION

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

- a. First article inspection (see 4.4).
- b. Conformance inspection (see 4.5).

4.2 Ballistic testing facility. Unless otherwise specified in the contract or purchase order (see 6.2), the ballistic test plates shall be forwarded to the Commander, USA ATC, ATTN: CSTE-DTC-AT-SL-V, Building 358, 400 Colleran Road, APG, MD 21005-5059 for ballistic testing for first article or lot acceptance.

4.3 Lot. A lot shall consist of all plates of the same declared chemistry, the same nominal thickness from the same heat, processed together as a unit. All plates in a lot shall receive the same final heat treatment within standard parameters, but not necessarily at the same time.

4.4 First article inspection. First article inspection, except as otherwise indicated in this specification, shall utilize the same requirements and test methods as the production acceptance inspection shown in 4.5.

4.5 Conformance inspection. Conformance inspection or production acceptance inspection shall include the examination of 4.7 and the tests of 4.8.

4.6 Sampling.

4.6.1 For first article inspection.

4.6.1.1 Chemical analysis. A sample for chemical analysis shall be taken from each heat.

4.6.1.2 Mechanical properties. At least two tension test specimens shall be taken from each lot. The location and type of specimens shall be as specified in 4.6.2.2.2 and 4.6.2.2.3.

4.6.1.3 Ballistic test samples. Two plates, of the thickness specified on the contract, shall be submitted to a Government approved facility for ballistic tests. One sample shall be taken from the first plate fabricated and one from the last plate fabricated in the initial lot produced. When only one plate is fabricated, the samples shall be taken from opposite ends of the plate. The required ballistic testing plate dimensions are listed in Table 11. When more than one thickness is involved, first article approval may be obtained for each of the size ranges listed in Table 11 by submission of plates for one specified thickness within each range. All ballistic tests shall be conducted at zero degrees obliquity with the test projectile specified in Table 11 for each ordered thickness.

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4.6.2 For conformance inspection.

4.6.2.1 For chemical analysis. A sample sufficient to perform the analysis required to determine compliance with 3.2 shall be selected from each lot.

4.6.2.2 For mechanical properties (See 3.3).

4.6.2.2.1 Number of samples. Two random samples shall be taken from each lot. If a lot consists of only one plate, only one sample shall be selected. At least one tension test specimen shall be made from each sample.

Table 11. Ballistic Test Plate Sizes and Corresponding Test Projectiles for First Article and Acceptance Testing

Thickness Ranges (inches)	Minimum Size (inches)	Ballistic Test Projectile	Table for Ballistic Acceptance
0.125 to 0.250, excl	12 x 12	TBD ¹	Table 7
0.250 to 0.615, excl	12 x 12	Cal. .30 AP M2	Table 8
0.615 to 1.575, excl	18 x 12	20-mm FSP	Table 9
1.575 to 1.950, excl	18 x 12	14.5-mm API B32	Table 10
1.950 to 3.250, excl	18 x 12	20-mm API-T M602	Table 11
3.250 to 4.000	24 x 12	30-mm APDS	Table 12

¹ Ballistic acceptance requirements have not yet been determined.

4.6.2.2.2 Types of test specimens. Tension test specimens shall conform to the largest obtainable round cross-section specimen shown in ASTM E8.

4.6.2.2.3 Location of test specimens. Transverse test specimens shall be taken from the plate perpendicular to the primary rolling direction with the central longitudinal axis midway between the top and bottom surfaces of the plate. Longitudinal specimens shall be prepared in such a manner that the longitudinal axis of the specimen is parallel to the principal rolling direction of the sample with the central longitudinal axis midway between the top and bottom surfaces of the plate.

4.6.2.3 For ballistic testing. According to the thickness of the plate represented (ordered plate thickness) one plate, 12 inch by 12 inch for thicknesses less than 0.615 inch or 18 inch by 12 inch for thicknesses 0.615 inch to 3.249 inch or 24 inch by 12 inch for thicknesses 3.250 inch and greater shall be selected from every lot of material of the same thickness. In the event of reduced testing (see 4.8.4), multiple lots represented by a single acceptance ballistic test shall have been manufactured using the same heat treatment and other processing within standard mill parameters of a fixed process.

4.7 Examination.

4.7.1 Visual. Each piece in each lot shall be visually examined for compliance with the requirements for workmanship (see 3.9) and marking for identification (see 3.6).

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4.7.2 Dimensions. All plates shall be subject to inspection for compliance with the dimensional and tolerance requirements (see 3.5).

4.8 Tests (first article and quality conformance).

4.8.1 Chemical composition. Conformance with the chemical composition requirements shall be determined either by heat or lot analysis using ASTM E539 X-ray emission spectrometric method for aluminum, vanadium and iron. Oxygen shall be analyzed by the inert gas fusion technique specified in ASTM E1409. Hydrogen shall be analyzed by the inert gas fusion thermal conductivity method specified in ASTM E1447 and shall be determined on each lot as shipped. Carbon and nitrogen shall be determined using ASTM E120. Other analytical methods may be used with the written approval of the acquiring activity. In case of a dispute, the results of chemical analysis by the ASTM E120 method shall be used as the basis for acceptance or rejection.

4.8.2 Mechanical properties. Conformance to the mechanical property requirements shall be determined by testing at least two specimens (one longitudinal and one transverse) in the condition ordered from each sample selected in accordance with 4.6.2.2. Tension tests shall be accomplished in accordance with the following provisions.

4.8.2.1 Tension specimen configuration. The tension specimens shall conform to the following configuration in accordance with ASTM E8:

- a. For product thickness up to 0.375 inch, standard "sheet-type" rectangular cross-section tension specimens shall be used.
- b. For product thickness equal to or greater than 0.375 inch, standard round cross-section tension specimens with a 0.250 inch diameter minimum reduced test section shall be used.

4.8.2.2 Tension specimen preparation. Unless the lot consists of only one unit, not more than one specimen per grain direction per test condition shall be taken from each sample. Longitudinal specimens shall be prepared in such a manner that the longitudinal axis of the specimen is parallel to the principal rolling direction of the sample. Transverse specimens shall be prepared in such a manner that the longitudinal axis of the specimen is perpendicular to the principal rolling direction and the thickness direction of the sample.

4.8.2.3 Tension test method. Tension tests shall be accomplished in accordance with ASTM E8, except that the strain rate shall be limited to 0.003 to 0.007 inch/inch per minute for the measurement of the yield strength: after that it is to be increased so as to produce tensile failure in approximately one additional minute. In case of dispute, the results of referee tension tests performed on a tensile machine having a strain pacer and using a strain rate of 0.005 inch/inch per minute through the yield strength and a minimum crosshead speed of 0.10 inch per minute when the yield strength has been exceeded shall govern.

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4.8.3 Ballistic tests. Plate thickness as determined by the ballistic test agency shall be used to determine the required protection ballistic limit for that plate and shall be taken as the average of 4 thickness measurements read to the nearest 0.001 inch and the average thickness reported to the nearest 0.005 inch. At least one measurement shall be taken near each edge of the plate at a distance of at least 1 inch from the edge. The V_{50} ballistic tests shall be performed in accordance with USATECOM Ballistic Tests of Armors, TOP 2-2-710 and Projectile Velocity and Time of Flight Measurements, ITOP 4-2-805.

4.8.3.1 Cracking. No through cracks greater than 2.5 inch in length on any plate surface are acceptable after ballistic testing.

4.8.4 Reduced testing for acceptance. Upon the approval of the procuring activity (see 6.2), reduction in the amount of testing per ASQ Z1.4 may be authorized provided the results on consecutive lots indicate that a uniform product meeting the requirements is being produced. Reduction in testing shall only be considered if steady production exists as determined by the procuring activity. Testing for a given plate thickness shall return to standard (non-reduced testing) conditions of one plate per lot, whenever a ballistic test plate fails to meet ballistic requirements.

4.8.4.1 First level reduced testing. Testing frequency may be reduced, upon approval by a responsible authority, to one ballistic test plate for every three lots of material of the same thickness providing the preceding five ballistic test plates for that thickness have met ballistic requirements.

4.8.4.2 Second level reduced testing. Testing frequency may be further reduced, upon approval by a responsible authority, to one ballistic test plate for every five lots of material of the same thickness providing the preceding ten ballistic test plates of that thickness have met ballistic requirements.

4.9 Rejection.

4.9.1 First article. Failure of the first article samples to meet any of the testing and inspection requirements of this specification indicates failure of the process to produce acceptable product.

4.9.2 Retests. Resubmission of first article samples shall not be made until the contractor has demonstrated that he has made necessary corrections in processing the material to the satisfaction of the procuring activity.

4.9.3 Quality conformance.

4.9.3.1 Examination. A lot shall be subject to rejection for failure to meet the visual and dimensional requirements of 4.7.

4.9.3.2 Tests. A lot shall be subject to rejection for failure to meet any of the test requirements of 4.8.

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4.9.3.3 Retests. At the discretion of the producer, a rejected lot may be retested as specified below.

4.9.3.3.1 Non-ballistic retests. All failed sample units from the original sample shall be excluded from the retest lot. Four new sample units shall be taken and tested in accordance with 4.8.2, as applicable. Failure of any retest specimen to meet the applicable property requirements shall be cause for rejection of the entire lot and no further retesting shall be permitted.

4.9.3.3.2 Non-ballistic retest lot. If the retest lot is accepted, the producer may, at his discretion, retest each sample unit which shows failure at one end only. Units which show failure at both ends shall not be retested and shall be rejected. Each sample unit acceptable for retesting of mechanical properties shall be retested as follows: Two test specimens shall be taken from the failed end in either or both directions, longitudinal and transverse, which showed unacceptable mechanical properties, and these specimens shall be tested in accordance with 4.8.2. If any retest shows that the mechanical properties do not conform to the requirements of Table 2 then the parent unit may be cut back at the failed end and further retested until either: (a) both ends show acceptable properties, or (b) the length of the material remaining in the parent unit is less than the minimum specified length in the acquisition documents, whichever comes first. Acceptance or rejection of the parent unit shall then be made as appropriate.

4.9.3.3.3 Ballistic retests. In the event of failure of any one or all of the ballistic test plates, the failed lot(s) may be reprocessed and two plates submitted for retest from each reprocessed lot. If a failure then occurs, the lot shall be permanently rejected.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel components are 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 armor specified herein is intended for use on combat vehicles. Class 1 is equivalent to material specified by previous revisions of MIL-A-46077, which is an Extra

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Low Interstitial (ELI) grade. Class 2 is equivalent to material specified by MIL-T-9046J, AB-1 composition. Class 3 permits a higher oxygen level which would be suitable for applications where maximum ductility and toughness are not necessary, such as appliqué. Class 4 permits compositions different from the conventional Ti-6Al-4V alloy and should be used as appliqué armor only. A weldability study should be conducted prior to any welding of Class 4 armor.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. Product form size (thickness, width, and length) and quantity.
- c. Specify classification, composition and heat treat condition (annealed) (see 1.2).
- d. When first article sample is required (see 3.1).
- e. If markings for identification are specified (see 3.6).
- f. If reheating is allowed (see 3.7).
- g. If surface finish is specified (see 3.9).
- h. Name of inspection agency when inspection should be performed by other than the contractor (see 4.1).
- i. If contractor's facility is not allowed for performing inspection (see 4.1).
- j. If another Government ballistic testing facility is selected by the procuring activity (see 4.2).
- k. If reduced testing is allowed (see 4.8.4).
- l. Packaging requirements (see 5.1).

6.3 Marking. Suggested wording to be included in the contract or purchase order "Marking for shipment and storage should be in accordance with MIL-STD-129".

6.4 Stress corrosion. Certain processing procedures and service conditions may cause these titanium alloy products to be subject to stress corrosion cracking. ARP 982C recommends practices to minimize the susceptibility to such stress corrosion cracking.

6.5 Annealing Temperature. It has been found that an annealing temperature of 1650°F provides optimum ballistic properties for Class 1 material. Reference: *Effect of Annealing Temperature on the Ballistic Limit Velocity of Ti-6Al-4V ELI*, Matthew Burkins and William Love, Proceedings of the 16th International Symposium on Ballistics, San Francisco, CA 23-27 September 1996.

6.6 Definitions.

6.6.1 Plate. A flat rolled product of 0.125 inch or over in thickness and over 12 inches in length with the width at least five times the thickness.

6.6.2 Capability. The words "shall be capable of" are used herein to indicate characteristics or properties required in the product but for which testing of each lot is not required. However, if such testing is performed, products not conforming to the requirements of this specification should be subject to rejection.

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6.6.3 Weldable. For the purposes of this specification, a plate is defined as "weldable" if it has a composition within the limits of its class.

6.6.4 Fair impact. A fair impact is an impact resulting from the striking of the test plate by a projectile in normal flight (no yawing or tumbling) and separated from another impact or the edge of the plate, hole, crack, or spalled area by an undisturbed area of at least one caliber.

6.6.5 Witness plate. A witness plate is normally a 0.014 in thick sheet of 5052 H36 aluminum alloy (or a 0.020 in-thick sheet of 2024-T3) aluminum alloy placed 6 in behind and parallel to the test plate or other ballistic sample.

6.6.6 Complete penetration, protection, CP(P). A protection complete penetration is a penetration in which the projectile or one or more fragments of a projectile or plate passes beyond the back of the test plate and perforates the witness plate.

6.6.7 Partial penetration, protection, PP(P). A partial penetration is any impact that is not a complete penetration.

6.6.8 V₅₀ protection ballistic limit, BL(P). A BL(P) consists of an equal number of complete and partial penetrations attained by the up- and down-firing method. All BL(P)s should be computed using the highest partial penetration velocities and the lowest complete penetration velocities. Table 12 delineates the order of priority.

Table 12. Ballistic Limits (Protection Criteria)

No. of Rounds in BL(P)	Maximum Allowable Velocity Spread (fps)	Maximum No. of Rounds To Be Used
4	60	12 ¹
6	90	12
10	125 ²	as required

¹ Firing should continue until either a 4-round or 6-round BL(P) has been attained, whichever comes first in the firing order. If these occur simultaneously the 6-round BL(P) should be reported. If, after 12 rounds have been fired and neither a 4 or 6 round BL(P) has been determined, then firing should continue until a 10-round BL(P), having a maximum velocity spread of 125 fps, has been determined.

² In the event that a high partial penetration velocity occurs which is more than 125 fps above the low complete penetration velocity, then the ballistic limit should consist of the 5 highest partial penetration velocities and the 5 lowest complete penetration velocities. The maximum velocity spread

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should be kept as small as possible without deviating from the normal up-and-down method of firing.

6.6.8.1 Recomputed BL(P). In the event that after following the above procedures the BL(P) is less than 25 fps above the minimum required BL(P), and a gap (high partial penetration velocity less than the low complete penetration velocity) of 25 fps or more exists in the velocities used to compute the BL(P), then one or more rounds should be fired to reduce the gap to less than 25 fps. The BL(P) should then be recomputed as before using the highest partial velocities and the lowest complete penetration velocities. The recomputed BL(P) should be the one reported on the firing record.

6.7 Ownership of ballistic test plates. First article and test plates that comply with the requirements of this specification are considered as part of the lot of titanium armor they represent, and ownership of them passes to the Government upon acceptance. Test plates that fail to comply with the requirements of this specification are considered as part of the lot they represent and remain the property of the producer just as does the rejectable lot they represent.

6.8 Relationship of mechanical properties to ballistic requirements. The minimum mechanical properties specified may not assure titanium armor plate meeting the specified ballistic requirements.

6.9 Plate tolerances. Titanium alloy plate is normally specified to tolerances established for corrosion-resisting steel plate as specified in the applicable sections of ASTM A480 for thickness, width, length, camber, and flatness.

6.10 Metric units. When metric divisions are required, units for inch, foot, foot-pounds, feet per second, and pounds per square inch may be converted to the metric equivalent by multiplying them by the following conversion factors:

English	Multiply by	Equals	Metric SI unit
inch	0.0254	=	meter (m)
foot	0.3048	=	meter (m)
pound	0.4536	=	kilogram (kg)
foot-lb	1.3558	=	joule (j)
feet/sec	0.3048	=	meter per second (m/s)
pounds/sq. inch	0.00689	=	megapascal (MPa)

6.11 Subject term (key word) listing.

Armor	14.5-mm API	Extra Low Interstitial (ELI) grade
Armor plate	20-mm FSP	Stress Corrosion Cracking
Ballistic limit	20-mm API-T M602	Titanium
caliber .30 AP	30-mm APDS	Vehicles

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6.12 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.

CONCLUDING MATERIAL

Custodians:

Army – MR
Navy – OS
Air Force – 11

Preparing activity:

Army – MR
(Project 9535-2005-005)

Review activities:

Army – AT, AV, TE, MI
Navy – AS
Air Force – 03, 16, 84, 99
DLA – IS

Agent:

DLA – GS

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 <http://assist.daps.dla.mil/>.