METRIC
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PERFORMANCE SPECIFICATION

PROPELLANT, HYDROGEN

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

Comments, suggestions, or questions on this document should be addressed to HQ AFPET/AFTT, 2430 C Street, Bldg 70, Area B, Wright-Patterson AFB, OH 45433-7632 or e-mailed to AFPET.AFTT@wpafb.af.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.

AMSC N/A FSC 9135

1. SCOPE

1.1 Scope. This specification covers the requirements for two types of hydrogen.

1.2 Classification. The hydrogen will be of the following types as specified (see 6.2).

1.2.1 Types. The types of hydrogen are as follows:

Type I - Gaseous

Type II - Liquid

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 Non-government publications. The following documents 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)

ASTM INTERNATIONAL

ASTM E 29	Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM F 307	Standard Practice for Sampling Pressurized Gas for Gas Analysis
ASTM F 310	Standard Practice for Sampling Cryogenic Aerospace Fluids

(Copies of these documents are available online at http://www.astm.org or the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken PA 19428-2959)

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-5.3	Commodity Specification for Hydrogen

(Copies of this document are available online at http://www.cganet.com or from the Compressed Gas Association, Inc., 4221 Walney Road, 5th floor, Chantilly, VA 20151-2923)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), 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 Grade requirements. The purity and impurity concentrations shall conform to the limits of Table I when tested in accordance with the applicable test method also specified in Table I. Other limits and tests may be specified by the procuring activity (see 6.2).

TABLE I. Limits for hydrogen.

		Test Method
Purity, % by vol, min	99.995	4.4.2
Parahydrogen % by vol, min [1]	95.0	4.4.1
Impurities, ppm by vol, max	50	4.4.2
Nitrogen, water vapor, and total hydrocarbons	9.0	4.4.2
Oxygen and argon	1.0	4.4.2
Helium	39.0	4.4.2
Carbon monoxide and carbon dioxide	1.0	4.4.2

Notes
1. Applies to Type II only.

3.2 Limiting values. The following applies to all specified limits in this specification: For purposes of determining conformance with these requirements, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand digit used in expressing the specification limit according to the rounding-off method of ASTM E 29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.

3.3 Filter. A filter with no more than a 10-micrometer nominal and 40-micrometer absolute rating shall be installed between the manufacturer's plant system and the manifold used to fill the gas or liquid containers for delivery.

3.4 Filled containers (Type I only).

3.4.1 Pressure. The container filling pressure shall not differ from that required by the contact by more than 1% at 70°F when tested as specified in 4.5.1. In no case shall the filling pressure exceed the rated service pressure of the container. The pressure-temperature table in section 6 may be used.

3.4.2 Leakage. Cylinders shall not leak when tested according to 4.5.2.

4. VERIFICATION

4.1 Points of inspection (see 6.2). Unless otherwise specified, acceptance tests shall be conducted at the site of filling prior to shipment or departure.

4.2 Conformance inspection. Quality conformance tests shall consist of the following:

a. Individual tests (Type I only)..... 4.2.1

b. Sampling tests 4.2.2

c. In-stream test (Type II only) 4.2.3

4.2.1 Individual tests (Type I only). Each container shall be subjected to the following tests as described under 4.5:

a. Filling pressure 4.5.1

b. Leakage 4.5.2

4.2.2 Sampling test. The number of hydrogen containers shall be selected in accordance with Table II and subjected to the tests required by Table I except for the parahydrogen test.

4.2.3 In-stream test. Liquid hydrogen shall be tested by an in-stream analyzer as described in 4.4.1.

TABLE II. Sampling for test.

Number of containers in lot	Number of containers to be sampled
1	1
2 – 40	2
41 – 70	3
71 – over	4

4.2.4 Lot. A lot shall consist of one of the following:

a. Type I. For gas cylinders, a lot is defined as all of the hydrogen supplied in one or more container(s) filled from a single manifold at the same time. The first and last cylinders filled within a given lot are typically sampled. Other samples may be selected at random as required.

b. Type I. Gas containers that are interconnected by a single manifold that equalizes the pressure across all the containers shall be considered as one lot for the purpose of this specification.

c. Type II. Each filled container shall constitute a lot.

4.2.4.1 Sample. Each sample shall be of sufficient size to conduct all the quality conformance tests as specified herein. Unless otherwise specified, the quality conformance tests shall be performed on each required sample (see 6.2). When required, an equivalent sample shall be forwarded to a laboratory designated by the procuring activity for testing.

4.2.4.2 Sampling methods. Each sample taken for analysis shall be representative of the entire contents of the container being sampled. All apparatus used shall be made of suitable materials. Unless otherwise specified in the acquisition requirements (see 6.2), sampling shall be accomplished by one of the following methods.

a. Type I, gaseous hydrogen may be sampled in accordance with ASTM F 307 and Type II, liquid hydrogen may be sampled in accordance with ASTM F 310. It is critical that the sampling port be clean and free of contaminants.

b. Connect the shipping container being sampled directly to the analytical equipment using suitable pressure regulation as required to prevent over-pressurization of the equipment.

4.2.5 Non-bulk Containers. Non bulk containers are defined as containers with a water capacity of 400 liters, or less. The number of non-bulk containers Type I (gaseous) or Type II (liquid) hydrogen will be in accordance with Table II. Containers to be sampled may be selected at random.

4.2.6 Bulk Containers. Bulk containers are defined as having a water capacity in excess of 400 liters. Each bulk container filled with Type I (gaseous) and Type II (liquid) hydrogen constitutes a lot and shall be sampled.

4.2.6.1 Continuous service (see 6.4.1). Unless otherwise specified by the procuring activity, the following sample option for hydrogen shall be used for storage and transport tanks engaged in continuous hydrogen service (see 6.2). Contractor shall sample the contents of each transport tank engaged in continuous hydrogen service at least once every seven days at uniform intervals of time. Samples shall be taken from the filled transport tanks. Contractor shall sample the contents of each transport tank when entering continuous service and when the transport tank has remained empty for a period greater than 24 hours. When empty, all ports and vents shall remain closed to the atmosphere. While in continuous service, compliance with quality conformance tests specified herein shall be determined by sampling the filling point storage tank after each addition or, in case of continuous production, at established intervals not less frequent than once every 24 hours. When a storage tank is being filled during a change of duty shift, sampling shall be performed after filling.

4.3 Rejection. When any sample tested in accordance with 4.4 fails to conform to the requirements specified herein, the entire lot represented by the sample shall be rejected.

4.4 Analytical procedures. Unless otherwise specified, samples shall be analyzed according to the procedures described below (see 6.2). Calibration gas standards may be required to calibrate (zero and span) analytical instruments used to determine the purity and impurity contents of the hydrogen. The accuracy of the calibration gas standards is to be traceable to the National Institute of Standards and Technology (NIST).

4.4.1 Parahydrogen. Parahydrogen shall be determined by thermal conductivity type in-stream analyzers installed in the manufacturer's plant system. Analyzers shall be calibrated integrally by the appropriate use of temperature-controlled catalyst beds.

4.4.2 Gaseous purity and gaseous impurities. Methods shall be selected from those of CGA G-5.3.

4.5 Containers of Type I hydrogen.

4.5.1 Filling pressure. Containers shall be tested for proper filling pressure by attaching a calibrated Bourdon-tube gauge or equivalent to the valve outlet and by attaching either a thermocouple or thermometer to the container wall. The gauge shall have scale divisions not greater than 100 kPa (15 psi). If a thermometer is used, tape or putty shall be applied to the bulb to protect it from extraneous temperatures. Putty shall not be applied between the bulb and the container wall. The thermometer shall have scale divisions not greater than 1°C (2°F). The container shall be stabilized to ambient temperature. Then the valve shall be opened and the internal pressure observed on the gauge.

4.5.2 Leakage. Each Type I hydrogen container shall be tested for leaks at the neck threads, stem packing, and safety device of the valve with leak-detection fluid. Valve seat leakage shall be tested after filling has been completed. This shall be done by applying the leak-detection fluid sparingly across the outlet of the valve. Only leak-detection fluid that leaves no residue shall be used on the outlet.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (6.2). When packaging of materiel 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 propellant covered by this specification is intended for use as a fuel in rocket engines and other space applications.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Type of hydrogen required (see 1.2).

c. When other limits or tests are required (see 3.1).

d. When a variation in the points of inspection is required (see 4.1).

e. When a variation of the quality conformance tests to be performed on a sample is required (see 4.2.4.1).

f. When a variation to the sampling method is required (see 4.2.4.2).

g. When a variation to the continuous service option is required (see 4.2.6.1).

h. When a variation of the analytical procedures is required (see 4.4).

i. Packaging requirements (see 5.1 and 6.3).

6.3 Packaging requirements. Guidance for cylinders may be found in the following documents:

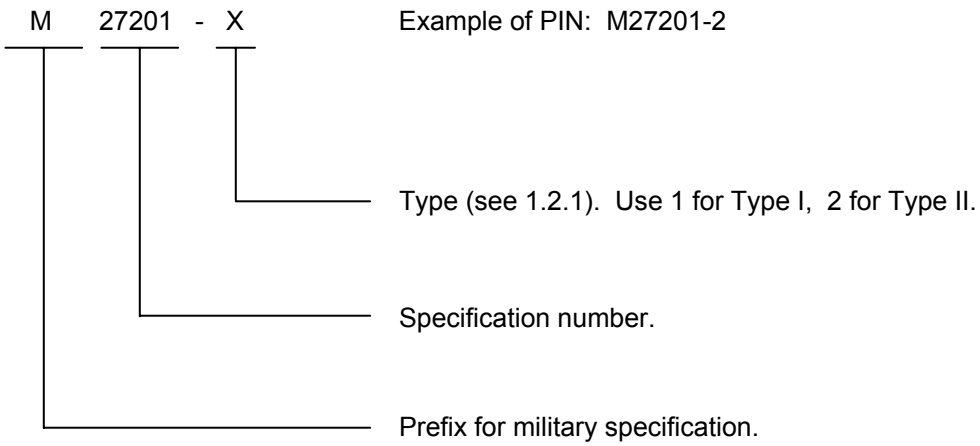
a. RR-C-901	Cylinders, Compressed Gas: Seamless Shatterproof, High Pressure DOT 3AA Steel, and 3AL Aluminum
b. MIL-DTL-2/29	Valve, Cylinder, Gas, Hydrogen Outlet 350
c. MIL-STD-101	Color Code for Pipelines and for Compressed Gas Cylinders
d. MIL-STD-1411	Inspection and Maintenance of Compressed Gas Cylinders
e. 49 CFR 171 – 199	Code of Federal Regulations

6.4 Definitions.

6.4.1 Continuous service. Continuous service applies to continuous deliveries under Government contract of hydrogen complying with the quality conformance tests specified herein.

6.4.2 In-stream analyzer. An analyzer with its sensor in the product stream or which receives samples directly from the product stream.

6.5 Part or identifying number. The PINs to be used for hydrogen acquired to this specification are created as follows:



6.6 Subject term (key word) listing.

Aerospace
Cryogenic
Cylinders
Hydrogen
Propellant
Rocket engines

6.7 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.

6.8 Temperature-pressure relation. Table III has been derived using the values of NBS (now NIST) Technical Note 1079 and the relations for thermal expansion and cylinder stretch of Bureau of Mines publication IC 8367.

TABLE III. Pressure-temperature conversion.

Temperature (°F)	Service pressure (psig)					
	1800	2000	2015	2200	2265	2400
-40	1419	1576	1587	1733	1783	1889
-38	1426	1583	1594	1741	1792	1898
-36	1433	1591	1602	1750	1801	1908
-34	1440	1599	1610	1758	1809	1917
-32	1447	1606	1618	1767	1818	1926
-30	1454	1614	1626	1775	1827	1936
-28	1461	1622	1633	1784	1836	1945
-26	1468	1630	1641	1792	1844	1954
-24	1474	1637	1649	1801	1853	1963
-22	1481	1645	1657	1809	1862	1973
-20	1488	1653	1665	1818	1871	1982
-18	1495	1660	1672	1826	1879	1991
-16	1502	1668	1680	1835	1888	2001
-14	1509	1676	1688	1843	1897	2010
-12	1516	1684	1696	1852	1906	2019
-10	1523	1691	1703	1860	1914	2028
-8	1530	1699	1711	1869	1923	2038
-6	1537	1707	1719	1877	1932	2047
-4	1544	1714	1727	1886	1941	2056
-2	1551	1722	1735	1894	1949	2066
0	1557	1730	1742	1903	1958	2075
2	1564	1738	1750	1911	1967	2084
4	1571	1745	1758	1920	1976	2093
6	1578	1753	1766	1928	1985	2103
8	1585	1761	1774	1937	1993	2112
10	1592	1768	1781	1945	2002	2121
12	1599	1776	1789	1954	2011	2131
14	1606	1784	1797	1962	2020	2140
16	1613	1792	1805	1971	2028	2149
18	1620	1799	1813	1979	2037	2159
20	1627	1807	1820	1988	2046	2168
22	1634	1815	1828	1996	2055	2177
04	1640	1822	1836	2005	2063	2186
26	1647	1830	1844	2013	2072	2196
28	1654	1838	1851	2022	2081	2205
30	1661	1846	1859	2030	2090	2214
32	1668	1853	1867	2039	2098	2224
34	1675	1861	1875	2047	2107	2233
36	1682	1869	1883	2056	2116	2242
38	1689	1876	1890	2064	2125	2251
40	1696	1884	1898	2072	2134	2261
42	1703	1892	1906	2081	2142	2270
44	1710	1900	1914	2089	2151	2279

TABLE III. Pressure-temperature conversion - Continued.

Temperature (°F)	Service pressure (psig)					
	1800	2000	2015	2200	2265	2400
46	1717	1907	1922	2098	2160	2289
48	1723	1915	1929	2106	2169	2298
50	1730	1923	1937	2115	2177	2307
52	1737	1930	1945	2123	2186	2316
54	1744	1938	1953	2132	2195	2326
56	1751	1946	1961	2140	2204	2335
58	1758	1954	1968	2149	2212	2344
60	1765	1961	1976	2157	2221	2354
62	1772	1969	1984	2166	2230	2363
64	1779	1977	1992	2174	2239	2372
66	1786	1984	1999	2183	2247	2381
68	1793	1992	2007	2191	2256	2391
70	1800	2000	2015	2200	2265	2400
72	1806	2008	2023	2208	2274	2409
74	1813	2015	2031	2217	2283	2419
76	1820	2023	2038	2225	2291	2428
78	1827	2031	2046	2234	2300	2437
80	1834	2038	2054	2242	2309	2447
82	1841	2046	2062	2251	2318	2456
84	1848	2054	2070	2259	2326	2465
86	1855	2062	2077	2268	2335	2474
88	1862	2069	2085	2276	2344	2484
90	1869	2077	2093	2285	2353	2493
92	1876	2085	2101	2293	2361	2502
94	1883	2092	2108	2302	2370	2512
96	1889	2100	2116	2310	2379	2521
98	1896	2108	2124	2319	2388	2530
100	1903	2116	2132	2327	2396	2539
102	1910	2123	2140	2336	2405	2549
104	1917	2131	2147	2344	2414	2558
106	1924	2139	2155	2353	2423	2567
108	1931	2146	2163	2361	2432	2577
110	1938	2154	2171	2370	2440	2586
112	1945	2162	2179	2378	2449	2595
114	1952	2170	2186	2387	2458	2604
116	1959	2177	2194	2395	2467	2614
118	1966	2185	2202	2404	2475	2623
120	1972	2193	2210	2412	2484	2632
122	1979	2200	2218	2421	2493	2642
124	1986	2208	2225	2429	2502	2651
126	1993	2216	2233	2438	2510	2660
128	2000	2224	2241	2446	2519	2670
130	2007	2231	2249	2455	2528	2679

CONCLUDING MATERIAL

Custodians:
Army – MI
Navy – AS
Air Force – 68
DLA – PS

Preparing activity:
Air Force – 68
(Project 9135-2005-006)

Review activities:
Air Force – 19

Civil Agency:
NASA – NA

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