MILITARY STANDARD

STANDARD GENERAL REQUIREMENTS FOR SAFE DESIGN AND OPERATION OF PRESSURIZED MISSILE AND SPACE SYSTEMS

TO ALL HOLDERS OF MIL-STD-1522A (USAF)

1. THE FOLLOWING PAGES OF MIL-STD-1522A HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
7	21 December 1984	7	28 May 1984
8	28 May 1984	(Reprinted without Change)	
9	21 December 1984	9	28 May 1984
10	28 May 1984	(Reprinted without Change)	
33	21 December 1984	33	28 May 1984
34	28 May 1984	(Reprinted without Change)	
39	21 December 1984	39	28 May 1984
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2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-1522A (USAF) will verify that page changes indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodian:
Air Force - 19

Preparing Activity:
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3.19 FITTINGS - Fittings are local elements of a pressurized system utilized to connect lines, components and/or vessels within the system.

3.20 FLAW - A flaw is a local discontinuity in a structural material , such as a scratch, notch, crack or void.

3.21 FRACTURE CONTROL - Fracture control is a set of policies and procedures involving the application of analysis and design methodology, manufacturing technology and operating procedures to prevent structural failure due to the initiation of and/or propagation of flaws or crack-like deflects during fabrication, testing, and service life.

3.22 FRACTURE MECHANICS - Fracture mechanics is an engineering concept used to predict flaw-growth and fracture behavior of materials and structures containing cracks or crack-like flaws.

3.23 FRACTURE TOUGHNESS (K_{Ic}) - Fracture toughness is a material characteristic which reflects flaw tolerance and resistance to fracture and is equal to the value of the stress intensity factor at flaw instability. Fracture toughness is dependant on the environment, geometry and loading rate.

3.24 HAZARD - An existing or potential condition that can result in an accident.

3.25 HYDROGEN EMBRITTLEMENT - Hydrogen embrittlement is a mechanical- environmental failure process that results from the initial presence or absorption of excessive amounts of hydrogen in metals, usually in combination with residual or applied tensile stresses.

3.26 INITIAL FLAW - An initial flaw is a flaw in a structural material before the application of load or environment

3.27 LEAK-BEFORE-BURST (LBB) - A fracture mechanics design concept in which it is shown that any initial flaw will grow through the wall of a pressure vessel and cause leakage rather than burst (catastrophic failure).

3.28 LIMIT LOAD - The limit load is the maximum anticipated load, or combination of loads, which a structure may be expected to experience during the performance of specified missions in specified environments. Since the actual loads that are experienced in service are in part random in nature, statistical methods for predicting limit loads are employed wherever appropriate.

3.29 LINES - Lines are tubular elements of a pressurized system provided as a means for transferring fluids between components of the system. Included in this definition are flex hoses.

3.30 LOAD SPECTRUM - The load spectrum on a structure is a representation of the cumulative static and dynamic loadings anticipated for the structure under all expected operating environments.

3.31 MARGIN OF SAFETY - The margin of safety of a structure is the increment by which the allowable load (or stress) exceeds the applied load (or stress), for a specific design condition, expressed as a fraction of the applied load (or stress).

$$\text{Margin of Safety} = \frac{\text{ALLOWABLE LOAD (OR STRESS)}}{\text{APPLIED LOAD (OR STRESS)}} - 1$$

3.32 MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP) - The maximum pressure at which a component can continuously operate based on allowable stress values and functional capabilities. MAWP is synonymous with MDOP (Maximum Design Operating Pressure) or "Rated Pressure".

3.33 MAXIMUM OPERATING PRESSURE (MOP) (MEOP) - The maximum pressure at which the system or component actually operates in a particular application. MOP is synonymous with MEOP (Maximum Expected Operating Pressure) or maximum working pressure. MOP includes the effects of temperature, transient peaks, vehicle acceleration, and relief valve tolerance.

3.34 PRESSURE CYCLE - A pressure cycle is a pressure increase greater than the threshold pressure (P_{TH}) followed by a pressure decrease greater than the P_{TH} unless otherwise specified.

3.35 PRESSURE VESSEL A pressure vessel is a component of a pressurized system designed primarily as a container that stores pressurized fluids and:

(1) Contains stored energy of 14,240 foot-pounds (19,310 joules) or greater based on adiabatic expansion of a perfect gas, Figure 1; Table I; or

(2) Contains a gas or liquid which will create a mishap (accident) if released; or

(3) Will experience a design limit pressure greater than 100 psi.

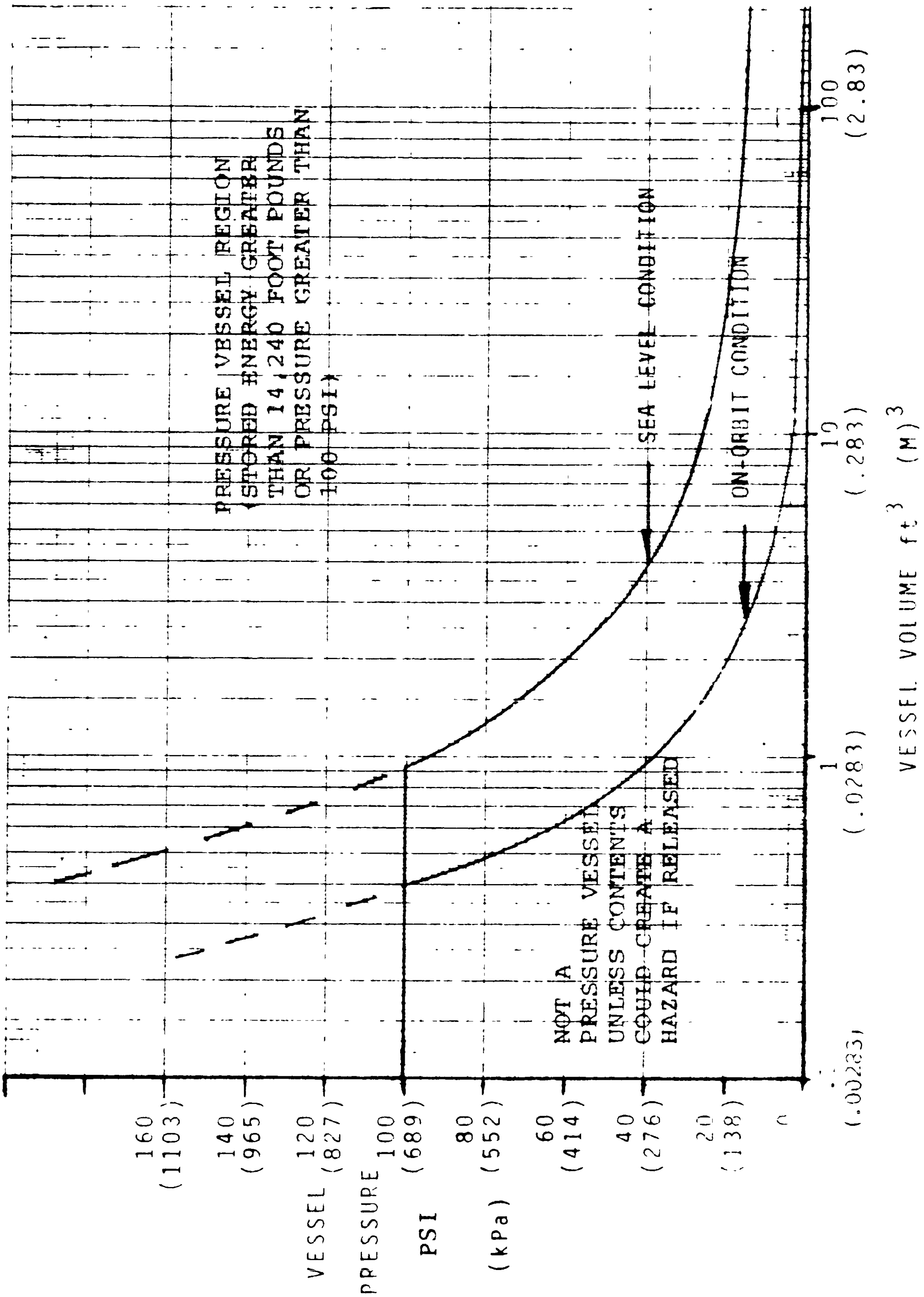

FIGURE 1. Total Energy Contained in a Pressure Vessel

Supersedes Page 9 of 28 May 1984

TABLE I. Stored Energy in Pressure Vessel

PRESSURE VESSEL PRESSURE	ENERGY EQUIVALENT PER CUBIC FOOT OF PRESSURE VESSEL
PSIA	ft lbs
20	606
30	1991
40	3582
50	5313
60	7148
70	9066
80	11051
90	13093
100	15184
200	37849
300	62376
400	87968
500	114286
600	141146
700	168433
800	196070
900	224001
1000	252185
2000	543111
3000	843691
4000	1149784
5000	1459636
6000	1772296
7000	2087167
8000	2403851
9000	2722059
10000	3041575
20000	6283809
30000	9576045

NOTE: To obtain the pressure vessel equivalent, multiply the energy equivalent per cubic foot by the vessel volume in cubic feet.

5.1.2.2 Safe-life Demonstration Requirements. In addition to the stress analysis conducted in accordance with the requirements of Section 4.2.5, safe-life analysis of each pressure vessel covering the maximum expected operating loads and environments, shall be performed under the assumption of pre-existing initial flaws or cracks in the vessel. In particular, the analysis shall show that the pressure vessel with flaws placed in the most unfavorable orientation with respect to the applied stress and material properties, of sizes defined by the acceptance proof test or NDI and acted upon by the spectra of maximum expected operating loads and environments, will meet the safe-life requirements of Section 4.4. Nominal values of fracture toughness and flaw-growth rate data associated with each alloy system, temper, product form, thermal and chemical environments, and loading spectra shall be used along with a life factor of four on specified service life in all safe-life analyses.

Pressure vessels which experience sustained stress shall also show that the corresponding applied stress intensity (K_I) during operation is less than the threshold stress intensity (K_{TH}) in the appropriate environment

$$K_{TH} > K_I$$

The safe-life analysis shall be included in the stress analysis of Section 4.2.5. In particular, the fracture mechanics data, loading spectra and environments, flaw-growth model, initial flaw sizes, proof factors, strength and other input data, analysis assumptions, rationales, methods, references, summary of significant results, shall be clearly presented.

Testing of structure under fracture control in lieu of safe-life analysis is an acceptable alternative, provided that, in addition to following a quality assurance program (Section 4.6) for each flight article, a qualification test program is implemented on pre-flawed specimens representative of the structure design. These flaws shall not be less than the flaw sizes established by the acceptance proof test or the selected NDI method(s). Safe-life requirements of Section 4.4 are considered demonstrated when the pre-flawed test specimens successfully sustain the limit loads and pressures in the expected operating environments for the specified test duration without rupture.

5.1.2.3 Qualification Test Requirements. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design. The test fixtures, support structures, and methods of environmental application shall not include erroneous test conditions. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 4.2.5. The instrumentation shall provide sufficient data to ensure proper application of the accept/reject criteria, which shall be established prior to test. The sequences, combinations, levels, and duration of loads, pressure and environments shall demonstrate that design requirements have been met.

Qualification testing shall include life cycle testing, random vibration testing, and burst testing. The following delineates the required tests:

a. Pressure Testing

Required qualification pressure testing levels are shown in Table II. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. if limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition (e.g., destabilizing load with constant minimum internal pressure, or maximum additive load with constant maximum expected operating pressure). Qualification test procedure shall be approved by the procuring agency and the appropriate launch or test range approval authority.

b. Random Vibration

Random vibration qualification testing shall be performed per requirements of MIL-STD-1540 unless it can be shown the vibration requirement is enveloped by other qualification testing performed.

5.1.2.4 Acceptance Test Requirements. The acceptance test requirements for pressure vessels which exhibit brittle fracture, or hazardous LBB, failure mode are identical to those with ductile fracture failure mode as defined in Section 5.1.1.4 except that the test level shall be that defined by the fracture

TABLE III. Systems Safety Factors

	PROOF	DESIGN BURST	
		AVE	GSE
Lines and fittings dia < 1.5 in.	1.5	4.0	4.0
dia ≥ 1.5 in.	1.5	2.5	4.0
Fluid Return Sections	1.5	3.0	4.0
Fluid Return Hose	1.5	5.0	4.0
Other Components (Except Pressure Vessels)	1.5	2.5	4.0

Components subject to low or negative pressures shall be evaluated at 2.5 times maximum external pressure expected during service life.

5.3.2 Safe-Life Analysis Requirements. Not required.

5.3.3 Qualification Test Requirements. Not required on lines and fittings. Internal/ external pressure testing shall be conducted on all other components to demonstrate no failure at the design burst pressure.

5.3.4 Acceptance Test Requirements. Acceptance test requirements shall be satisfied by completion of leak and/or proof test requirements for the assembled pressurized system as dictated by the applicable range safety documentation. and or procuring agency, requirements.

5.3.5 Re-Certification Test Requirements. Re-certification of lines, fittings and components shall be as delineated in Section 5.3.5 as applied to the refurbished systems.

Supersedes Page 39 of 28 May 1984

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