AEROSPACE INFORMATION REPORT

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Superseding AIR1082B

Fluid-System-Component Specification Preparation Criteria

RATIONALE

The document as written does not represent a safety or health issue which per document rules disallow cancellation. The value of an updated AIR1082B would be limited because ARP4754 was recently updated and offers guidance on specifying fuel system and equipment and MIL-STD-461e already offers guidance on specification format and production. This document will, therefore, be stabilized.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE AE-5A Aerospace Fuel, Inerting and Lubrication System Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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FOREWORD

This document has been adapted from the Aerospace Fluid Component Designers' Handbook (Report RPL-TDR-64-25, Revision D) prepared by TRW Systems, Redondo Beach, CA under contract to the Air Force Rocket Propulsion Laboratory, Edwards AFB, CA.

TABLE OF CONTENTS

1. SCOPE:

The importance of adequate component procurement specifications to the success of a hardware development program cannot be overemphasized. Specifications which are too stringent can be as detrimental as specifications which are too lax. Performance specifications must not only identify all of the component requirements, but they must also include sufficient quality assurance provisions so that compliance can be verified. It should be understood that in almost every case specifications for components will ultimately become part of a BINDING, WRITTEN CONTRACT (PO).

The purpose of this document is to describe types of specifications, provide guidance for the preparation of fluid component specifications, and identify documents commonly referenced in fluid component specifications.

2. APPLICABLE DOCUMENTS:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

Many of the documents commonly cited in fluid-system component specifications may be found in the following documents:

AIR737 Aerospace Hydraulic and Pneumatic Specifications and Standards
AIR1174 Index of Starting System Specifications and Standards
AIR1408 Aerospace Fuel System Specifications and Standards

It should be noted that the writer should use diligence in seeking other applicable documents. The supplier should make certain that he/she is not requiring anything that would infringe on any existing patents.

2.2 DOD Publications:

Department of Defense specifications, standards, etc. may be found in the Department of Defense, Index of Specifications and Standards. Part I is an alphabetical listing, and Part II is a numerical listing. The Index of Specifications and Standards may be obtained from:

Commanding Officer
Naval Publications and Forms Center
Attention: NPFC 3064
5801 Tabor Avenue
Philadelphia, PA 19120

3. TYPES OF SPECIFICATIONS:

Fluid component specifications can be categorized according to one of the following three basic types:

a. Performance
b. Manufacturing
c. Proprietary

3. (Continued):

Each type is described here and discussed in detail in the subsequent paragraphs.

a. Performance Specification: Identifies the constraining parameters, details the required performance, and specifies the tests needed to verify conformance of the product to performance requirements.

b. Manufacturing Specification: Identifies the complete design including materials, processes, tolerances, dimensions, and configuration in sufficient detail for any qualified manufacturer to produce the product.

c. Proprietary Specification: Identifies the exact make, model, or part number and allows no latitude for deviation for the specified product(s).

3.1 Performance Specification:

A performance specification is a clear and accurate description of the design, construction, and performance requirements of a product with provisions for determining compliance with the specification. A performance specification is written as the basis for procurement of an end product which will completely fulfill all specified requirements.

To accomplish this objective, a performance specification must provide complete answers to the following questions:

a. What is the product?

b. What physical, mechanical, or chemical constraints are imposed on the product?

c. What must the product accomplish?

d. In what environment must it function, and within what limits?

e. What tests and inspections will prove compliance with the requirements?

f. How is the product to be finished, marked, cleaned, packaged, etc.

g. What documentation is required?

h. What are the life and reliability requirements and how is compliance to be demonstrated?

i. What are the maintenance requirements?

j. What safety devices and features are required?

A well-written specification will answer each of the questions clearly. If any question is not answered, it is possible that something has been overlooked, and trouble may be experienced during procurement and application of the product.

3.1 (Continued):

Many component problems in aerospace procurement can be traced to performance and test specifications which either lack important information or are based on unrealistically stringent requirements. Specifications which do not define component requirements can result in components failing to meet the intended function.

Alternately, unnecessarily stringent or conservative specifications will require excessively long and expensive development programs which can result in overdesigned products.

Unreasonably severe functional requirements such as response times, leakage rates, regulation bands, and unrealistic environmental requirements often result in excessive costs, long delivery times, and unreliable systems. Therefore, a performance specification must consider all the requirements of the component for its intended function, and it should avoid imposing severe performance or environmental margins which could compromise the end result.

3.2 Manufacturing Specification:

A manufacturing specification is a document containing enough detailed information to produce the end product described without requiring any additional design work. This specification contains the necessary design details, materials, manufacturing methods, and processes necessary to produce the product.

This type of specification is often used to obtain competitive procurement of a well-seasoned design and when properly prepared and administered can produce a competitive procurement of a very complex product at a minimum cost.

Particular care should be taken to prevent inclusion of performance specifications and tests in a manufacturing specification. Such a combination of performance and manufacturing specifications may be unenforceable because, if the specified design and manufacturing data do not produce a product with the specified performance, the specification is obviously in conflict within its own sections.

3.3 Proprietary Specification:

The proprietary specification specifies the required product by make, model, and manufacturer's part or catalog number. This type of specification is the easiest means of delineating the required product and helps to assure that the specific product desired will be furnished. The proprietary specification should never include the words "or equal" or similar phraseology because the burden of proof of equality is on the purchaser. If the words "or equal" or similar phraseology are required by government regulations, then a performance specification should be used with clearly defined tests and inspections to verify equality. Paragraph 6.5 discusses the "or equal" clause. When performance and test requirements are included, the specification is no longer a proprietary specification but becomes a performance specification. The writer should be sure that there are no requirements that infringe on existing patents.

4. SPECIFICATION FORMAT:

The format of a specification should be as simple as possible and arranged in such a manner that information of a specific type may be readily located and referenced. MIL-STD-490 presents the general format which is widely used both in government and in industrial specifications. The major sections of a specification are listed below in the commonly accepted sequence.

a. Scope
b. Applicable documents
c. Requirements
d. Quality assurance provisions
e. Preparation for delivery
f. Notes

The level of detail under each heading is dependent on the complexity of the product and the type of specification (proprietary, manufacturing, or performance). Since the proprietary specification usually requires only the part number to define an item, the standard format contains sections that may not be required (e.g., "Scope", "Applicable Documents"). The use of section headings is still suggested so that quality assurance and preparation for delivery requirements are more easily recognized.

The manufacturing and performance types of specifications will need all sections of the standard format and will contain considerable detail in each section.

5. SPECIFICATION CONTENT:

The contents of each of the six standard specification sections are discussed in the following paragraphs. The major topics which should be included in each section may be found in Table 1.

TABLE 1 - Specification Content

Section 1 - Scope

a. Brief statement of coverage
b. Brief description of the product
c. Type or class of product

Section 2 - Applicable Documents

a. Referenced specifications
b. Referenced standards
c. Referenced drawings
d. Referenced exhibits
e. Referenced publications

Section 3 - Requirements

3.1 Operational Requirements (This is what the product shall do):

a. Service life
b. Leakage rate
c. Flow rate
d. Pressure loss
e. Cleanability
f. Electrical power requirements
g. Hydraulic power requirements
h. Other

3.2 Operational and Environmental Conditions (These are the conditions during which the product shall meet the operational requirements):

a. Cycles
b. Operating fluid(s)
c. Operating pressure
d. Proof pressure
e. Burst pressure
f. Operating temperature
g. Contamination of the fluid(s)
h. Storage conditions
i. Lubrication
j. Thermal shock
k. Acoustical noise
l. Vibration
m. Shock
n. Acceleration
o. Humidity
p. Fungus
q. Salt spray
r. Fuel resistance and extreme environment
s. Electrical bonding
t. Explosion proof
u. Electromagnetic interference (EMI)
v. Other

3.3 Construction Requirements (How the product is to be built):

a. Envelope
b. Weight
c. Installation
d. Materials
e. Castings
f. Welding
g. Brazing

TABLE 1 (Continued)

h. Joining methods
i. Threaded connections
j. Thread inserts
k. Self-locking fasteners
l. Screw and bolt length
m. Retaining rings
n. Electrical connections
o. Stress concentrations
p. Finishes
q. Identification and markings
r. Nameplate
s. Other markings
t. Maintainability
u. Standardization
v. Interchangeability
w. Design change control
x. Other

NOTE: Requirements in the above paragraphs may be either deleted or expanded as required by the detail specification. For example, materials are seldom specified in a model specification.

Section 4 - Quality Assurance Provisions

a. Test methods and procedures to support the requirements stated in Section 3, including the criteria for success:

Development
Design verification
Qualification
Production
Acceptance

b. Sampling requirements and procedures
c. Examinations and inspections
d. Failure analysis reports

Section 5 - Preparation for Delivery

a. Cleaning
b. Painting
c. Packaging
d. Preserving
e. Marking
f. Identification

Section 6 - Notes

a. Safety
b. Intended use
c. Drawing and data requirements
d. Test reports
e. Ordering data
f. Maintenance data requirements
g. Special tools
h. Symbols
i. Definitions
j. Miscellaneous

5.1 Scope (Section 1):

The scope section may be brief if describing the uses of a simple product, or it might be rather lengthy if the subject product is very complex.

5.2 Applicable Documents (Section 2):

The proper use and application of referenced documents are two of the most difficult aspects of specification preparation. The specification writer is often unable to investigate thoroughly the contents and applicabilities of the referenced documents. As a result, the extent of applicabilities of the referenced documents should be defined in the specification, and, in the worst cases, the reference documents may appear only in Section 2. The writer should assure that there is no infringement on existing patents.

Several rules which should be followed in the preparation of the applicable-documents section are:

a. List only those documents that are actually referenced in the specification text.

b. In the specification text, indicate the pertinent portions of the applicable document.

c. Specify the date of issue or the data of applicability of the referenced document. For example, the words "latest issue" are not enforceable and should not be used because a supplier can only bid on a definable set of specifications of a specific date. The date of invitation to bid is commonly used as the date of applicability. In some procurements, an earlier issue of the referenced document may be desired and thus specified to utilize desirable features of an earlier document.

d. Review the referenced documents to assure that they are actually applicable.

5.3 Requirements (Section 3):

"Requirements" should be the focal point of the specification with all other sections supporting this key section. It should contain a complete description of the performance, design, construction, and other characteristics required of the product. The performance requirements of a performance specification should be clearly stated in this section with care being taken to insure that the full range of operating conditions are specified. The remainder of the specification should be tailored to assure that the item is tested, inspected, packaged, and documented to assure this performance. Test requirements may be stated along with limiting parameters, but the detailed test procedures to implement the test requirements should be included under "Quality Assurance Provisions" (Section 4).

5.3 (Continued):

The inclusion of all critical performance parameters in the requirements section is of utmost importance in the preparation of a performance specification. As an aid in the preparation of performance requirements, Table 1 lists typical fluid component performance parameters indicating the types of products to which they usually apply.

The requirements section of a performance specification should define each operating parameter under which the product being specified must perform. This definition should include the operating environment as well as the interaction of the product with the system in which it is to be used. Performance requirements should include the number of operating cycles required for the product.

In addition to steady-state factors, the performance requirements should include dynamic and transient conditions. Other applicable factors such as thermal interaction and contamination should be clearly defined.

The ideal performance specification contains the actual required upper and lower performance limits of a product. In a new field involving research and development, the performance margins might not be well defined. Under these circumstances, a safety factor may have to be applied to certain performance parameters to help to assure a successful piece of hardware. Safety factors should be selected with great care to assure a reliable end product as a minimum requirement and still stay within the limits of practicability. Another precaution when assigning safety factors is to assure that the safety factor is applied only once. In large programs involving many persons, groups, and agencies, there have been instances of each taking an additional safety factor which compounds the original and valid requirement.

After the performance requirements have been specified, a cross-check should be made with the test requirements to assure the compatibility of the two sections. A performance requirement is meaningful only if a means of testing the performance can be accomplished. Therefore, a test should be provided for each performance requirement, and each test requirement should relate to one or more performance requirements.

5.4 Quality Assurance Provisions (Section 4):

This section should include all test methods, test procedures, and inspections necessary to support the "requirements" section of the specification. (Testing provisions are normally applicable to a performance specification.)

Plans/requirements for testing should be defined in sufficient detail so that the supplier can prepare a valid test procedure. Usually the supplier produces detailed test procedures from these plans/requirements; there may be some cases where it is sensible for the detailed procedures to be defined in Section 4.

5.4.1 Types of Tests: There are three basic reasons for testing a product. To determine:

a. The capabilities of the product

b. The influence of the environment on the capabilities of the product

c. The useful life of the product

The tests used to make these determinations are called:

a. Functional tests (performance)
b. Environmental tests
c. Reliability tests (life and limit)
d. Development tests
e. Design verification tests
f. Prequalification tests
g. Qualification tests
h. Preproduction, pilot-model, pilot-lot tests
i. Production acceptance tests
j. Production monitoring tests
k. System integration tests
l. Explosion proof and safety
m. Electromagnetic interference (EMI)
n. Other environmental

The extent of testing is usually a compromise between:

a. The testing necessary to assure adequate reliability
b. The time, money, and facilities available to perform the tests

For example, this tradeoff is very difficult to make if the product is to be used in space vacuum and zero gravity because of the costs associated with environmental simulation.

5.4.1.1 Functional Tests: Functional tests are conducted to measure the operating parameters of a product; they measure such characteristics as:

a. Flow rate
b. Pressure loss
c. Strength (proof pressure or burst pressure)
d. Internal leakage rate
e. External leakage rate
f. Flow rate and pressure regulation
g. Response times
h. Power requirements
i. Repeatability
j. Contamination tolerance

5.4.1.2 Environmental Tests: Environmental tests are specified to simulate the most severe nonoperating or operating conditions anticipated for the product. Compatibility of a product with the operating environment is usually determined by testing during separate environments (e.g., vibration, low temperature, altitude). The effects of combined environments operating simultaneously is an important consideration and should be evaluated as part of an environmental test program. As combined environmental testing is very expensive, complete environmental simulation is not always practical. Tests must be carefully devised to provide the best simulation within the confines of budget and schedule. Typical exposures included in environmental test specifications are apt to be:

a. Extreme temperature
b. Humidity
c. Salt spray
d. Sand and dust
e. Altitude (vacuum)
f. Mechanical shock
g. Thermal shock
h. Vibration
i. Acceleration
j. Acoustic noise
k. Chemical compatibility
l. Radiation
m. Fungus
n. Icing

5.4.1.3 Reliability Tests: Reliability tests are conducted to determine the probability that a product will fulfill the intended function. Products that are cyclic in operation are usually tested for a number of operating cycles until failure occurs, and products that operate continuously are usually tested to determine the mean-time-to-failure. Cyclic tests can usually be repeated with sufficient frequency to simulate the operating cyclic life in a reasonably short test period. On the other hand, continuous life tests may be difficult to simulate, particularly on products with thousands of hours in normal service.

Limit testing, or performance margin testing, will determine the margin of safe operation over and above the design requirements. Limit tests are conducted by progressively increasing the severity of a test parameter (e.g., temperature) until the product fails. The margin of safe operation over the design requirements is a measure of the functional reliability of the product. Limit tests should not be confused with limit load tests performed to verify structural integrity to withstand a design limit load without failure. The corresponding limit test for a structural element is the ultimate load test in which the element is loaded to failure.

5.4.1.4 Development Tests: These tests are performed on prototype hardware to check the design parameters during the development process. Development tests should be used to measure such factors as flow-path areas, pressure loss, sizing of devices for power-drain, functional operation, and all other requirements necessary to produce a complete set of engineering drawings which will describe a product which meets the specification requirements. The model used for such tests is usually "breadboard", "boiler plate", or "engineering model" that has been produced specifically for these tests. The tests should provide data required to finalize a new design or to optimize an existing design to comply with new requirements. Adjustments, rework, repair, and retest are normal functions during development tests. The specification should require that all activities, adjustments, and repairs be accurately recorded during testing. Reasons for repair and detailed descriptions of all repairs and adjustments should be documented for future correlation for the production device.

5.4.1.5 Design Verification Tests: These tests should be conducted on prototype hardware prior to the release of production drawings and fabrication of production hardware. Design verification tests are to prove that a device will meet all functional and the most critical environmental requirements. Design verification tests on products allow system tests to be started with maximum assurance that products have the proven capability to perform the system function prior to performing time-consuming life or reliability tests.

5.4.1.6 Prequalification Tests: Prequalification tests (also called design-approval tests, preliminary flight-rating tests, and flight-certification tests) are conducted on production hardware prior to flight-testing to determine whether the product fabricated by production tooling and techniques will perform as well as when fabricated as a prototype. These tests should include all functional and environmental requirements and some life-cycle tests. These must prove at this point that the production hardware is able to meet all of the required parameters for at least the length of time required by the flight-test program. Special "stress-to-failure" tests are sometimes included as part of prequalification testing. These tests, which can be destructive, are designed to prove margins of safety over minimum design requirements.

5.4.1.7 Qualification Tests: Qualification tests are normally formal demonstrations (in contrast to evaluations) using production hardware and are the final test requirements for the product. The distinction between formal qualification tests is that this test is used to demonstrate rather than to evaluate the product. These tests should consist of all the steps taken in prequalification tests including the following.

a. The product tested should be randomly-selected production hardware made entirely with the manufacturer's production tooling and processes.

b. The number of specimens tested should be adequate to prove that the devices are statistically capable of meeting the reliability requirements.