NASA Technical Memorandum 106589

NASA Lewis Propulsion Systems Laboratory Test Article Systems Criteria

Ronald H. Soeder
Lewis Research Center
Cleveland, Ohio

July 1994

National Aeronautics and
Space Administration

CONTENTS

NASA LEWIS PROPULSION SYSTEMS LABORATORY

TEST ARTICLE SYSTEMS CRITERIA

Ronald H. Soeder
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

1.0 SUMMARY

This report describes criteria for the design, analysis, and documentation of test article systems submitted for testing in the Propulsion Systems Laboratory at NASA Lewis Research Center. The functions of the facility manager, project engineer, operations engineer, research engineer, design engineer, and facility electrical engineer are defined. Customer-furnished test article systems and in-house test article systems are discussed. The format for test planning meetings, prerun safety meetings, and test article criteria review are outlined. A discussion of the allowable stresses on a test article system is presented, and the format for a test article systems report is described. This report is required for each test article system tested in the Propulsion Systems Laboratory. The engineers responsible for developing this document are noted, as is the timetable for the delivery of this report to the project engineer.

2.0 INTRODUCTION

This report contains the criteria for the design, analysis, and documentation of test articles and engines submitted for testing in the NASA Lewis Propulsion Systems Laboratory (PSL). This facility is managed and operated by the Aeropropulsion Facilities and Experiments Division (AFED). Information more specific than that contained in this report is presented in the Propulsion Systems Laboratory Customer Guide Manual (ref. 1). Customers wishing to test articles in the PSL should contact the facility manager for information and availability.

3.0 BACKGROUND INFORMATION

3.1 Terminology

Test article systems Test article systems are assemblies intended for testing in the PSL. They include articles such as cold pipes, freejets, core engines, turbine engines, high Mach number engines, and hypersonic direct-connect rigs. Test article systems do not include test article support equipment that is a permanent part of the PSL facility, or items that are not critical to the structural integrity of the test article system and whose failure will not result in damage to the PSL. Such noncritical items may include gear boxes, motors, actuators, and such. Instrumentation rakes that are placed upstream or inside of a test article are considered auxiliary equipment and are subject to the criteria discussed in section 4.11.

Customers wishing to submit test article systems for testing in the PSL facility should follow the procedure outlined in appendix A and explained herein.

PSL facility manager The PSL facility manager is responsible for scheduling and overseeing the operation of the PSL. Customers should contact the facility manager, as instructed in appendix B, at least one year in advance of the desired testing date. The facility manager presents the request to the AFED

Chief for final approval. If a conflict exists between the information presented herein and that presented in reference 1, the customer should contact the facility manager and the PSL project engineer to resolve the problem.

PSL project engineer The PSL project engineer is responsible for planning and managing the test program, for specifying any required facility modifications, and for insuring the safe operation of the test. The PSL project engineer also assists the facility manager in interpreting the testing requirements set forth herein.

PSL facility engineer The PSL facility engineer is responsible for reviewing all drawings of the test article and support systems and for properly installing the test article or engine and ancillary equipment in the facility test section.

PSL operations engineer The PSL operations engineer, also known as the test conductor, is in charge of the safe operation of the facility and the test article or engine during a run. The test conductor insures that all prerun checks have been completed (this includes facility setup procedures and test article or engine operational procedures). The test conductor is also responsible for the safe shutdown of the test article and the facility. The test conductor takes charge during any emergency situation, regardless of whether it arises from the operation of the test article system or facility, and instructs all facility personnel, research engineers, the PSL project engineer, and all civilians in the facility control room.

Research engineer The research engineer, or customer, may be from NASA Lewis, another NASA center, another U.S. Government agency, or a private corporation. The research engineer is responsible for defining the test matrix and instrumentation requirements for the test program as well as for specifying the computing requirements, both during and after the test. The computing requirements, such as data reduction schemes and desired forms of output, are outlined in a separate document and delivered to the application programmers in the Research Analysis Center (RAC). Research engineers from NASA Lewis share the responsibilities of test article design and fabrication with the PSL project engineer. Research engineers from other NASA centers, Government agencies, or private corporations are assigned a Lewis research engineer to serve as a contact between themselves and NASA Lewis. The Lewis research engineer is responsible for obtaining the required test matrix as well as the test article stress and load calculations from the customer. The Lewis research engineer may collaborate with others from the Lewis Engineering Directorate to verify the integrity of the test article before allowing it into the facility. The Lewis research engineer is also responsible for obtaining from the customer the test article instrumentation requirements list for the PSL electrical engineer and a computer requirements package for RAC application programmers, if their services are required to perform data reduction activities.

Test article design engineer The test article design engineer is responsible for designing the test article, for preparing the engineering drawings, and for supervising the fabrication of the test article. The test article design engineer informs the research engineer and the PSL project engineer of the progress made on test article development, usually on a monthly basis, and consults with them as necessary.

PSL electrical engineer The PSL electrical engineer is responsible for reviewing and installing all test article system electronics, wiring, and connections required for the desired testing. The PSL electrical engineer is also responsible for reviewing and installing all test-article-system and facility instrumentation specified by the research engineer and the PSL project engineer.

Customer-furnished test article system Customers from outside the Lewis Research Center must supply adequate documentation to substantiate the structural integrity of the test article and ancillary systems and their ability to withstand the required loads. This documentation is presented for review to the assigned Lewis research engineer and the PSL project engineer. Customers from the Lewis Research Center submit their test article structural integrity documentation to the PSL project engineer. The PSL project engineer may require the assistance of engineers from the Engineering Directorate to verify test article integrity.

In-house-furnished test article system An in-house-furnished test article system is one designed and fabricated with NASA Lewis review and manufacturing control.

Critical component A critical component is one critical to the structural integrity of the test article. Overloading or overstressing such a component may lead to failure, which may cause the loss of the test-article system and damage to the PSL.

Critical speed The critical speed of a rotating system corresponds to the speed of a resonant frequency of the test article system.

Test planning meetings A series of test planning meetings will be held at NASA Lewis to discuss the test plan, instrumentation, facility hardware, and data requirements. The number of test planning meetings held will usually depend on the test complexity. The attendees will be the customer, the facility manager, appropriate PSL branch chiefs, key PSL personnel, and the PSL project engineer. The first test planning meeting should be set up as far in advance as practical, at least 1 year prior to the requested test time.

Prerun safety meeting The PSL project engineer will prepare a Safety Permit Request that describes the test. This document will discuss the safety aspects of the test as well as the test objectives, run schedule, instrumentation, hardware, and so on. It is sent to the facility manager who forwards it to the Center's Environmental Compliance Office and the appropriate Area Safety Committee for their review and approval. The Safety Permit Request should be written and available for review at least 2 months before the scheduled test.

3.2 Test Article Criteria Implementation

The facility manager has the responsibility and the authority to implement the criteria in this report. The facility manager may elect to seek assistance from the PSL project engineer and the research engineer. The research engineer and the PSL project engineer share the responsibility of insuring that the test article system design and fabrication meet the criteria of this report. Any deviations in these criteria must be approved by following the deviation procedure outlined in section 6.

3.3 Test Article Criteria Review

Test article system reviews take place through test planning meetings held at regularly scheduled intervals during the test article buildup and installation phase of the program. The PSL project engineer schedules these meetings and notifies the attendees. During the test article buildup and testing phase, it may also be necessary to have engineering review meetings to discuss problems with the test article. These meetings are not scheduled on a regular basis, but are held as required during the program. The PSL project engineer will schedule these meetings and contact the attendees.

4.0 DESIGN AND ANALYSIS

4.1 General Guidelines

4.1.1 Design loads.–The test article design loads are supplied by the test article design engineer and must be consistent with safe operating limits in the PSL (ref. 1). The design loads shall be a part of the test article systems report as described in section 5.1.

4.1.2 Documentation.–The research engineer should present the PSL project engineer with documentation consisting of the following information (when applicable): aerodynamic and thermal loads for the test conditions, test article configurations, design life-cycle requirements, inertia driving forces, frequencies for steady-state and transient testing, and other items deemed necessary. This information should be included as part of the test article systems criteria report as defined in section 5.1 and should be submitted at least 2 months prior to testing.

4.2 Materials Standards

The research engineer is responsible for proving that the test article will withstand the loads and stresses produced during testing. Resources available from the following organizations, such as handbooks, standards, and suggested guidelines, should be used to select appropriate materials for the fabrication of test articles and support structures:

(1) American Institute for Steel Construction (AISC)

(2) American National Standards Institute (ANSI)

(3) American Society of Mechanical Engineers (ASME)

(4) American Society for Testing and Materials (ASTM)

(5) American Welding Society (AWS)

(6) National Institute of Standards and Technology (NIST)

(7) Society of Automotive Engineers (SAE)

(8) American Society for Nondestructive Testing (ASNT)

In addition, the following codes and handbooks should be used:

(1) National Electric Code (NEC)

(2) Aerospace Structural Metals Handbook, from the Department of Defense

(3) Military Handbook #5, from the Department of Defense

(4) ASME Boiler and Pressure Vessel Code, Sections VIII and IX

(5) Department of Transportation Regulations for test articles and systems with elevated pressures

4.3 Materials Selection

4.3.1 Standards.–Materials shall be selected by using mechanical properties obtained from experimental measurements or the latest values published in the codes and handbooks referenced in section 4.2.

4.3.2 Materials adjustments.–All materials properties, design criteria, and allowable stresses must be adjusted for test temperature, pressure, and other environmental effects that may be present during testing.

4.3.3 Materials properties verification.–Materials used for critical components that are subject to special, nonstandard processing must have their post-fabrication properties verified experimentally at test temperature. Appropriate verification techniques, such as tensile tests, will be developed by the PSL project engineer and the research engineer after consultation with members of the Structural Systems Division.

4.3.4 Galling.–Materials used in the test article and auxiliary systems must be selected to resist galling and galvanic corrosion.

4.4 Structural Analysis

4.4.1 Stress analysis.–A stress analysis is required as part of the test article systems report described in section 5.1. The test article systems report must be a complete and comprehensive stand-alone document. It should include the following:

(1) The results of a stress analysis, showing that allowable stresses are not exceeded for the worst-case loads

(2) A sketch of each analyzed section of the test article, showing the forces and moments acting on that particular section (This shall be prepared by the design engineer, who shall annotate the sketches with approximations, assumptions, test article section properties, and the materials properties used.)

(3) A list of all general equations used (before numerical values have been substituted in) and their sources

(4) Analysis of test article sections in sufficient numbers to permit determination of allowable shear, axial load, bending, and torsion of structural members, thereby making it easier to locate the critical sections of the test article

(5) Evidence to demonstrate that the test article, the mounting points, and the restraints are statically and dynamically stable within the test article operating envelope

(6) If finite-element analysis is used, the computer-generated plots of simulated models, tables, or graphical summaries, and the name of the code used (Finite-element models must be validated with either closed-form approximations or other techniques that provide a high level of confidence.)

4.4.2 Thermal analysis.–Sufficient test article analysis shall be performed to examine thermal stresses and distortions for both steady-state and transient conditions.

4.4.3 Fatigue analysis.–A fatigue analysis shall be performed on those test article components subject to cyclic loadings and for which fatigue is a credible failure mode. The fatigue analysis is performed assuming that no flaws or cracks exist in the structure.

4.4.4 Design life.–The test article design engineer shall specify the design life requirements to be used in the fatigue analysis for test article system components. If the design life requirement is not well defined, the following approximation should be used: estimate the number of times a test article system component will experience maximum, steady-state load conditions (i.e., the number of peak load cycles) during the test life and multiply by three.

4.5 Mechanical Connections

4.5.1 Structural joints.–All counterbores, spot faces, and countersinks in the test article and other support structures must be properly aligned so that no bending is applied to the fasteners during torquing.

The minimum safety factor for heat-treated, hardened bolts used for clamping a test article, support system, and auxiliary equipment will be the more conservative of either 4.0 based on yield stress, or 5.0 based on ultimate stress. A discussion of the allowable loads on bolts used to fasten a flat-faced joint is presented in reference 2.

Shear loads should be redistributed through the use of keys, pins, and shoulders. Provision should be made that the keys and pins are properly retained during torquing and vibration.

All welded joints should be designed in accordance with the American Welding Society (AWS) structural codes (i.e., AWS D1.1, Steel; AWS D1.2, Aluminum; and AWS D1.3, Sheet Steel). All critical joints, those whose failure could cause loss of or damage to the test article and support structures or damage to the PSL, must be radiographed according to the guidelines set forth in the applicable AWS code. Other nondestructive testing (NDT) methods may be used if they satisfy the AWS codes and are approved by the PSL project engineer. Weld disposition for the NDT shall be as specified in section 6 of the AWS codes.

4.5.2 Fasteners.–Structural bolted or screwed connections in critical locations must be fitted with positive mechanical locks, such as locking inserts, self-locking nuts, or safety wiring. All threaded fasteners shall be designed with a thread engagement providing a strength equivalent of 1.33 times the bolt preload.

4.6 Test Article Specifications

The test articles that are tested in the PSL are, for the most part, flight hardware such as turbojet or turbofan engines. The test article specifications shall meet the criteria presented in the military specification manual, MIL-E-5007D (ref. 3).

Occasionally, the attachment of the test article to the PSL support superstructure may create a test article loading that could lead to a fatigue failure. In this particular case, the test article design engineer and the research engineer should redesign the mounting assembly to avoid the effects of localized stress concentration. This redesign should be discussed with the PSL project engineer and the PSL facility engineer.

The test article may be a high-Mach-number or hypersonic test rig that creates a complex flow and imposes a well-defined stress profile on the test article. The test article design engineer may determine that closed-form solutions and estimates of materials properties found in standard strength-of-material textbooks are insufficient to accurately estimate the stress levels created in the test article during testing. In this circumstance, a more in-depth analysis, with state-of-the-art structural analysis codes employing finite-element or finite-difference techniques, is required to insure that allowable stress levels are not exceeded during testing. Circumstances that require a more advanced analysis should be agreed upon by the test article design engineer, the research engineer, and the PSL project engineer.

4.7 Test Article Stability

Test article system stability in relation to the facility mounting superstructure must be verified by analyzing the rigid-body motion about the principal axes of the test article system. In addition, aeroelastic stability must be verified by analyzing the test article system flexibility in the pitch, yaw, and roll planes.

4.7.1 Model dynamics.–A test article that is to be dynamically tested shall be analyzed to verify that the mountings and restraints are structurally adequate and dynamically stable. As the energy of the test article is increased during testing, the energy transmitted to the mountings and restraints should not increase. In cases where specialized dynamic testing of a test article is to occur (e.g., testing for fan or compressor blade flutter, or compressor rotating stall), the instrumentation requirements and test article operation should be addressed in the test article stability report as described in section 5.1.4.

4.7.2 Test article system buckling.–The allowable compressive stress/load in test article support columns and shrouds, calculated with the proper slenderness ratio, shall not exceed one-half of the critical buckling stress/load.

4.8 Pressure Systems

4.8.1 Test article support pressure systems.–Any pressurized system used in the test article, support system, or test equipment that exceeds an operating pressure of 15 psig, such as hydraulic and pneumatic actuators, shall be designed, fabricated, inspected, tested, and installed in accordance with the specifications outlined in the ASME Boiler and Pressure Vessel Code, the ANSI codes of the ASME, or the Department of Transportation regulations. Pressure vessels are defined as all shells, chambers, tanks or components that transmit gas with pressures in excess of 15 psig. Pressure vessels shall be welded in accordance with the ASME Boiler and Pressure Vessel Code.

All pressurized systems must be tested at operating pressures (proof tested) before being delivered to the PSL. The research engineer must provide the PSL project engineer with documentation of the volume capacity, temperature range, working pressure, and the proof-test pressure for each component. It is suggested that all components of a pressure system be stored in a clean, dry, and sealed condition after proof testing and prior to delivery to PSL.

4.8.2 Pressure-relief devices.–Pressure-relief devices may be required in a hydraulic, hydrostatic, or pneumatic system, but not necessarily in the test article. If the system is not rated for the pressure emanating from the pressure source, these devices should be capable of relieving the overpressure by discharging sufficient flow from the pressure source under the conditions causing the malfunction.

4.8.3 Pressure piping systems.–All test article and support system piping shall be designed, fabricated, inspected, tested, and installed in accordance with the latest edition of the ANSI/ASME Standard Piping Code. Powered test articles have internal piping that falls under this code. Pressure vessels that are constructed from standard pipe fittings and standard flanges are also considered pressure piping and must obey the ANSI/ASME Standard Piping Code.

Pressure piping shall be welded by using the procedures outlined in the ASME Boiler and Pressure Vessel Code plus the ANSI/ASME Standard Piping Code B 31.3. The welding of all test article and support system pressure vessels and pipes must adhere to the safety guidelines outlined in chapter 7 (Process System Safety) of the NASA Lewis Safety Manual (ref. 4).

All service lines running into or out of a test article should be properly tagged to identify the working pressure, flow direction, and the fluid or gas being carried.

4.9 Thrust Measurement Systems

Both single-axis and multiaxis thrust measurement stands are available in the PSL test cells. A single-axis thrust measurement stand is described in references 1 and 5, and the six-component Ormond thrust stands are discussed in reference 1.

4.10 Rotating Systems

The requirements set forth in this section apply to turbine engines or test articles that contain rotating parts.

4.10.1 Rotating model system analysis.–Before a rotating test article or turbine engine can be tested in the PSL, the research engineer must provide the PSL project engineer with a vibration study in the form of a Campbell diagram, which shows possible resonance points for test articles with rotating parts.

4.10.2 Containment shield.–The containment shield that surrounds the test article rotating equipment must be designed to contain the energy equivalent of a trirotor burst of turbine discs during failure in an overspeed condition.

4.10.3 Prerun testing of rotating test articles.–Demonstration testing of rotating test article systems is required prior to PSL entry. These tests should be performed at the test article manufacturer's location, if possible, and shall demonstrate the safe operation over all operational speed ranges and up to a 10-percent overspeed for rotor systems such as fan or compressor rigs. A lower overspeed condition may be agreed upon by the research engineer and the PSL project engineer in consideration of aeromechanical stability.

4.10.4 Inspection.–All components of a rotating test article system (including blades, drive shafts, bearings, and hubs) shall be thoroughly inspected at the time of manufacture and assembly and may be inspected periodically during testing at the PSL. The guidelines and instructions provided by the test article manufacturer shall be followed.

4.11 Nondestructive Testing of Instrumentation Rakes

If instrumentation rakes are to be placed inside or upstream of a core engine, turbine engine, high-Mach-number engine, or hypersonic direct-connect rig, their design must be rigorously demonstrated, thereby preventing failure during testing. It is paramount that rake failures be prevented so that severe damage to the test article and the PSL is avoided. A procedure in use at NASA Lewis calls for the manufacture and rigorous testing of a prototype for each rake design. This prototype rake is subjected to shock and vibration testing. A vibration and shock test schedule includes sinusoidal sweeps, dwells, random vibrations, and shock tests. The sinusoidal sweep schedule for flight-type rakes is presented in table III of reference 6. A discussion of fatigue testing for the evaluation of jet-engine probes is presented in reference 7. The test schedule for prototype and flight-type rakes must be approved by the PSL project engineer and the PSL facility engineer. The research engineer can obtain the current test schedule for prototype and flight-type rakes from the PSL project engineer.

4.12 Electrical Equipment and Components

The flow environment in the test sections of the PSL requires that only qualified hardware, equipment, and material (i.e., conforming to the National Electrical Code (NEC)) be used. All pressure transducers, strain gauges, vibration pickups, and other low-voltage devices should have each set of wires shielded. Customer-supplied control panels and associated wiring running to the facility control room, and connectors located at control boxes or at the test article exterior must conform to the NEC and be accompanied by electrical wiring diagrams. The details of wiring customer-supplied electrical equipment should be discussed with the PSL project engineer and the PSL electrical engineer at one of the test planning meetings.

4.13 General Periodic In-Service Inspection

All test article system critical components that are loaded shall be inspected periodically, at time intervals agreed upon by the research engineer and the PSL project engineer. These inspections may include thrust measurements systems, test article suspension points required to guard against fatigue failure, and the like. The periodic inspection requirements should be documented and included in the Test Article Systems Report as described in section 5.1.

5.0 DOCUMENTATION

5.1 Test Article Systems Report

A test article systems report is required for all test article systems that are to be tested in the PSL. The test article systems report will be submitted to the PSL project engineer by the research engineer at least 2 months prior to entry of the test article into the PSL. The content of this report will be established by the PSL project engineer, and will be based on the guidelines given in the following sections.

<u>5.1.1 Test article system drawings</u>.–The report shall contain drawings of the configuration of the test article system to be tested, and when applicable, assembly drawings, installation drawings, electrical sketches, and wiring diagrams.

<u>5.1.2 Test article design load calculations</u>.–The design load calculations shall take into account test article specifications and requirements. Derived loads shall consider aerodynamic, mechanical, and thermal effects. Life-cycle requirements shall also be specified if fatigue failure is possible.

<u>5.1.3 Test article stress report</u>.–This report shall contain a summary of all the safety factors used in test article engineering calculations. References shall be given for general equation sets, terms, and computer program codes. Any assumptions that are used in the development of equation sets shall be properly noted. This report should also specify the source and values of material data used to analyze all components that comprise the test article system as well as the fasteners used to secure test article components together. The material data should include standard properties and properties adjusted for operating pressure, temperature, or other environmental effects.

Stress calculations shall be supplemented by sketches of test article sections that show the appropriate forces and moments acting. An adequate number of test article system sections must be analyzed to insure that critical sections have been identified. Detailed shear and moment diagrams for the test article system shall be presented as well as a stress analysis for a worst case scenario in loading.

A structural joint analysis for the test article system components shall be performed if appropriate. This analysis shall consider bolted, welded, brazed and bonded joints. A test article system component analysis shall also be performed for pressurized systems, hydrostatic systems, and specialized test article systems that are subjected to fatigue and thermal effects.

5.1.4 Test article stability report.–When the test article contains rotating parts and the test program is dynamic, specialized situations such as blade flutter and rotating stall dynamics must be documented. The customer should discuss this requirement with the facility manager and the PSL project engineer at one of the test planning meetings.

5.1.5 Test article report.–The research engineer may be required to provide the PSL project engineer with a test report containing general information about the test article or specific components that comprise the test article system. The PSL project engineer will initiate this request. General information may consist of a certification of materials composition (as documented by the supplier), specification of material properties, information on test article loads, and documentation of static and dynamic balancing and test article demonstration runup tests as described in section 4.10.3.

5.1.6 Hazards analysis report.–It may be necessary to develop a hazards analysis report for a test article installed in the PSL. The decision to develop this analysis should be made at the first test planning meeting, which is held at least 1 year in advance of the actual PSL test time. The PSL project engineer will decide if such an analysis is required and what the content should be. This report can discuss damage to the test article and the facility if a test article failure occurs due to stress, thermal effects, fatigue, instrumentation malfunction, facility power loss, and such. The development of this report, if required, will be a joint effort between the PSL project engineer and the research engineer.

5.2 Assembly, Installation, and Configuration Change Procedures

5.2.1 General considerations.–The change procedure for test article system assembly, installation and configuration should be established as early as possible, preferably at the first test planning meeting. The format for this procedure should be agreed upon by the research engineer and the PSL project engineer by the time the test article is delivered to the PSL facility for buildup and installation.

Typical procedures and drawings should contain sequential assembly steps, torque values, alignment criteria, and other instructions necessary to assemble, install, and check the test article and associated hardware.

5.2.2 Test article delivery schedule.–Most of the experiments in PSL are unique and complex; therefore, the test article buildup time in the PSL test sections varies greatly. The research engineer should ask the facility manager for an appropriate arrival schedule for the test article and any auxiliary equipment that is customer-supplied.

6.0 DEVIATIONS

When a deviation from the requirements set forth in this manual is considered necessary by the research engineer, a written request must be submitted to the facility manager and the PSL project engineer. Approval or denial of the request will be documented by the PSL project engineer and retained in the AFED facility files.

6.1 Deviation Requests

The research engineer is responsible for drafting a deviation request. It shall be submitted to the PSL project engineer, who will forward it to the PSL facility manager. The PSL project engineer, with the concurrence of the facility manager, will be responsible for obtaining an evaluation of the request from the proper NASA Lewis authority. The facility manager and the PSL project engineer may request the assistance of the AFED Chief, appropriate AFED branch chiefs, the Center's Environmental Compliance Office, members of the appropriate Area Safety Committee, or other NASA Lewis committees or organizational groups, if necessary.

The deviation request must contain the following information:

(1) Identification of the component or test article system under consideration

(2) The test plan requirement that makes necessary a deviation in the standard operation of the facility or test article

(3) The reason why a test plan requirement cannot be achieved under normal operating procedures

(4) Technical support information that a deviation from normal facility test article system operation is acceptable

6.2 Approval Authority

In instances where failure of a customer's test article could result in minor damage to the facility, the facility manager and the PSL project engineer are required to seek the approval of AFED management before a deviation in test procedures is permitted. The customer and AFED management must reach agreement on liability for the test article and the PSL facility before testing can begin; therefore, the NASA Lewis chief counsel will be notified.

7.0 APPENDIX A

SECURING TEST TIME IN THE PSL

The following steps summarize the procedure used to secure test time in the PSL:

(1) The customer contacts the PSL facility manager at least 1 year prior to the test (more advanced notice is usually required).

(2) The PSL facility manager and appropriate PSL personnel review the request.

(3) The customer submits a formal letter of request to the Director of Aeronautics at NASA Lewis (for non-NASA requesters only).

(4) If the project is accepted, a test agreement is prepared and signed (for non-NASA requesters only). The test agreement outlines the legal responsibilities of NASA Lewis and the PSL customer during the time that the project is at the PSL. The customer is required to sign the test agreement and return it to NASA Lewis. The type of test agreements depends on the type of program in which the customer participates.

(a) NASA test program

(b) NASA/industry cooperative program (i.e., a nonreimbursable Space Act agreement)

(c) Another U.S. Government agency program (i.e., a reimbursable or nonreimbursable interagency agreement)

(d) Industry proprietary or noncooperative program (i.e., a reimbursable Space Act agreement)

8.0 APPENDIX B

CONTACT PERSON

The facility manager is the key contact person at the PSL facility. Mail correspondence can be addressed as follows:

NASA Lewis Research Center
Attn: PSL Facility Manager, M.S. 6-8
21000 Brookpark Road
Cleveland, Ohio 44135

The name of the PSL facility manager can be obtained by calling the NASA switchboard operator at (216) 433-4000 and asking for the name of the PSL facility manager.

9.0 REFERENCES

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1994	Technical Memorandum

4. TITLE AND SUBTITLE

NASA Lewis Propulsion Systems Laboratory Test Article Systems Criteria

5. FUNDING NUMBERS

WU–505–62–84

6. AUTHOR(S)

Ronald H. Soeder

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135–3191

8. PERFORMING ORGANIZATION REPORT NUMBER

E–8856

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Washington, D.C. 20546–0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NASA TM–106589

11. SUPPLEMENTARY NOTES

Responsible person, Ronald H. Soeder, organization code 2830, (216) 433–5713.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Restrict from public web access based on NASA Internet Publishing Content Guidelines, November 15, 2001.

Unclassified - Unlimited
Subject Category 09
This publication is available from the NASA Center for AeroSpace Information, 301–621–0390.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

This report describes criteria for the design, analysis, and documentation of test article systems submitted for testing in the Propulsion Systems Laboratory at NASA Lewis Research Center. The functions of the facility manager, project engineer, operations engineer, research engineer, design engineer, and facility electrical engineer are defined. Customer-furnished test article systems and in-house test article systems are discussed. The format for test planning meetings, prerun safety meetings, and test article criteria review are outlined. A discussion of the allowable stresses on a test article system is presented, and the format for a test article systems report is described. This report is required for each test article system tested in the Propulsion Systems Laboratory. The engineers responsible for developing this document are noted, as is the timetable for the delivery of this report to the project engineer.

14. SUBJECT TERMS

Testing full scale turbine engines; Testing in a propulsion system laboratory

15. NUMBER OF PAGES 18

16. PRICE CODE A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	