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DEPARTMENT OF DEFENSE

HANDBOOK

AIRCRAFT/STORES COMPATIBILITY: SYSTEMS ENGINEERING DATA REQUIREMENTS AND TEST PROCEDURES

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FOREWORD

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2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASC/ENSI, 2530 Loop Road West, Bldg 560, Wright-Patterson AFB OH 45433-7101, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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CONTENTS

PARAGRAPH PAGE

1. SCOPE 1
1.1 Scope. 1
1.2 Purpose. 1
1.3 Application. 1
1.3.1 Applying the handbook. 1
1.3.2 Applying appendix tests and engineering data requirements. 2
1.3.3 Application guidance. 2
1.3.4 Method of reference. 2
2. APPLICABLE DOCUMENTS 2
2.1 General. 2
2.2 Government documents. 5
2.2.1 Specifications, standards, and handbooks. 5
2.2.2 Other Government documents, drawings, and publications. 7
2.3 Non-Government publications. 10
2.4 Order of precedence. 11
3. DEFINITIONS 12
3.1 Standardization of terminology. 12
3.1.1 Aircraft. 12
3.1.2 Aircraft-stores compatibility. 12
3.1.3 Aircraft-store. 12
3.1.4 All-up-round (AUR). 12
3.1.5 Ballistics. 13
3.1.5.1 Free-stream ballistics. 13
3.1.5.2 Separation effects. 13
3.1.5.3 Ballistics accuracy evaluation and verification. 13
3.1.5.4 Ballistic trajectory. 13
3.1.6 Carriage. 13
3.1.6.1 Symmetrical carriage. 13
3.1.6.2 Asymmetrical carriage. 13
3.1.6.3 Conformal (or tangential) carriage. 14
3.1.6.4 Multiple carriage. 14
3.1.6.5 Single carriage. 14
3.1.6.6 Tandem carriage. 14
3.1.7 Authorized download. 14
3.1.8 Compatibility engineering data package (CEDP). 14
3.1.9 Circular error probable (CEP). 14
3.1.10 Agencies. 14
3.1.10.1 Certification agency. 14
3.1.10.2 Compatibility agency. 14
3.1.11 Certification of a store or airworthiness qualification (for Army). 15
3.1.12 Critical conditions. 15
3.1.13 Developmental test and evaluation (DT&E). 15
3.1.14 Dispersion. 15
3.1.14.1 Aircraft dispersion. 15
3.1.14.2 Ballistic dispersion. 15
3.1.14.3 System dispersion. 15
3.1.15 Electromagnetic compatibility (EMC). 15

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Check the source to verify that this is the current version before use.

CONTENTS

PARAGRAPH PAGE

3.1.15.1 Electromagnetic environment effects (E^3). 16
3.1.15.2 Electromagnetic interference (EMI). 16
3.1.16 Employment. 16
3.1.16.1 Release. 16
3.1.16.2 Launch. 16
3.1.16.3 Fire. 16
3.1.16.4 Dispense. 16
3.1.17 Failure mode. 16
3.1.18 Flight clearance/clearance recommendation. 16
3.1.19 Free flight (of a store). 17
3.1.19.1 g-jump. 17
3.1.20 Hung store or hangfire (for Army). 17
3.1.21 Interval. 17
3.1.22 Mean point of impact (MPI). 17
3.1.23 Mixed load. 17
3.1.24 Operating limitation. 17
3.1.25 Operational test and evaluation (OT&E). 17
3.1.26 Range bias. 17
3.1.27 Safe escape/safe arming. 18
3.1.28 Separation. 18
3.1.28.1 Safe separation. 18
3.1.28.2 Acceptable separation. 18
3.1.28.3 Pairs. 18
3.1.28.4 Ripple (or train). 18
3.1.28.5 Salvo. 18
3.1.28.6 Multiple. 18
3.1.28.7 Quantity. 18
3.1.28.8 Selective jettison. 19
3.1.28.9 Emergency jettison. 19
3.1.29 Submunition. 19
3.1.30 Suspension equipment. 19
3.1.31 Technical manuals. 19
4. GENERAL REQUIREMENTS 20
4.1 Compatibility assessment/analyses. 20
4.1.1 General. 20
4.1.2 Data required. 20
4.1.3 Physical compatibility review. 20
4.1.3.1 Review objective. 21
4.1.3.2 Physical deficiency. 22
4.1.4 Engineering analyses. 22
4.1.4.1 General. 22
4.1.4.2 Structural analysis. 22
4.1.4.3 Aerodynamic analysis. 23
4.1.4.4 Aeroelastic analyses. 25
4.1.4.5 Separation analysis. 26
4.1.4.6 Environmental analysis. 28
4.1.4.7 Store propulsion analysis. 30

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Check the source to verify that this is the current version before use.

CONTENTS

PARAGRAPH PAGE

4.1.4.8 Shipboard suitability analysis. 31
4.1.4.9 Target acquisition analysis for guided weapons. 32
4.1.4.10 Gun gas analysis. 33
4.1.4.11 Thermal analysis. 34
4.1.4.12 Ballistic analysis. 36
4.1.4.13 Safe escape analysis. 38
4.1.4.14 Electromagnetic analysis. 38
4.1.5 Results of engineering analyses. 44
4.1.5.1 Determination. 44
4.2 Test requirements and planning. 44
4.2.1 General. 44
4.2.2 Types of testing. 45
4.2.3 Mission requirements. 45
4.2.4 Test sequence. 45
4.2.5 Data acquisition. 46
4.2.6 Test planning. 46
4.2.6.1 Explosive safety. 46
4.3 Completion of compatibility analyses. 46
4.3.1 Determinations. 46
4.3.2 Certification recommendation. 46
4.3.3 Responsibilities. 46
4.4 Certification documentation reports. 47
4.4.1 General. 47
4.4.2 Report types. 47
4.4.2.1 Data report. 47
4.4.2.2 Final report. 47
4.4.2.3 Compatibility report or airworthiness qualification report (for the Army). 48
5. DETAILED REQUIREMENTS 48
5.1 General. 48
5.2 Test structure. 48
5.3 Certification approval. 50
6. NOTES 50
6.1 Intended use. 50
6.2 Tailoring guidance. 51
6.2.1 Tailoring for 1.3.1 provision. 51
6.3 Subject term (key word) listing. 51
6.4 International standardization agreements. 52

TABLE

TABLE A-I. Wind tunnel instrumentation requirements. 72
TABLE A-II. Recommended number of test frequencies. 98
TABLE B-I. Store mass, physical and operational characteristics. 159
TABLE B-II. Aircraft configuration characteristics. 160
TABLE B-III. Release test – aircraft flight condition data. 161
TABLE B-IV. Ballistic data definitions. 184
TABLE B-V. Ballistic data title page format. 186
TABLE B-VI. Ballistic data printout format. 187

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CONTENTS

TABLE PAGE

TABLE B-VII. Data for OFP ballistic evaluation and verification tests. 190

FIGURE

FIGURE 1. Certification process. 3
FIGURE 2. Certification process timeline. 4
FIGURE A-1 Thermal test philosophy. 104
FIGURE A-2. Ground test facility philosophy-wind tunnel. 106

APPENDIX

A Ground test procedures 53

B Flight test procedures 118

C Aircraft/stores compatibility engineering data package 194

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1. SCOPE

1.1 Scope.

This handbook applies to all agencies within the DoD and industry involved with determining the extent of compatibility between military aircraft and aircraft stores. It applies to every activity of the system life cycle involving aircraft and/or stores including: development, manufacturing, deployment, operations, support, training and disposal. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

1.2 Purpose.

This handbook provides uniform guidance requirements for establishing the extent of compatibility between an aircraft, specific stores, and suspension equipment and guidance to justify the airworthiness of stores for use on an aircraft. This handbook defines all the engineering data package requirements and provides standard test methodology, test instrumentation and data to be obtained from each test to establish the extent of aircraft/stores compatibility. By this standardization, responsible agencies may then be assured that a test run by any agency to this handbook will provide the same data they would require, thereby facilitating the transfer of data between agencies and eliminating the unnecessary duplication of tests. Figure 1 provides an outline for the certification process and figure 2 provides a generic timeline for the activities that are expected to take place during a certification project.

1.3 Application.

1.3.1 Applying the handbook.

The process of approving the use of any store on an aircraft involves determining the extent of compatibility which exists, evaluating this data against established compatibility criteria and the aircraft/stores capability being sought via the extant operational requirement, obtaining any additional data which may be needed to complete the evaluation, documenting the results, and issuing the appropriate technical manual changes which outline the aircraft/stores configurations and operating limits, and conditions for the store's use on the specific aircraft. Compatibility must be evaluated between the aircraft, store suspension equipment, the store, and combinations thereof. The factors influencing compatibility are highly interrelated and must be approached with regard to an integrated overall system. There are four separate compatibility situations which must be considered when certification of a store on an aircraft is required. Each of these situations requires a separate approach. No single procedure or test method can be used in every case. It is up to the cognizant test approval authority or certification agency to select the specific methods appropriate for each particular store certification situation. The four situations are:

a. Adding inventory-stores (and/or stores configurations/flight envelopes not previously authorized) to the authorized stores list of inventory aircraft.

b. Adding inventory-stores (and/or stores configurations) to the authorized stores list of modified or new aircraft.

c. Adding new or modified stores (and/or stores configurations) to the authorized stores list of modified or new aircraft.

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d. Adding new or modified stores (and/or stores configurations) to the authorized stores list of inventory aircraft.

Sections 4 and 5, the Test Procedures of appendices A and B, along with the compatibility engineering data package requirements of appendix C should be selectively tailored and applied to satisfy these situations.

1.3.2 Applying appendix tests and engineering data requirements.

The ground and flight tests, and the compatibility engineering data package requirements of appendices A, B and C respectively, should be selectively applied in DoD procurements, requests for proposals, and statement of work for the development, test, production, and deployment of aircraft and/or stores systems and equipment.

1.3.3 Application guidance.

Application guidance and rationale for selecting the tests and data requirements of appendices A, B, and C to fit the needs of a particular aircraft/stores compatibility effort are included in section 4.

1.3.4 Method of reference.

This document is a handbook, not a specification or statement of work, therefore when the intent is to require the tests of this handbook as contractual requirements, the task to be performed must be stated in the contract and reference to specific tests in this handbook should be provided for guidance. Particular attention should be made to the referencing of tests, for example citing the need for “MIL-HDBK-1763, Test 140” includes the conduct of all subordinate Tests, that is, this would include the conduct of Test 141, Test 142, Test 143, and Test 144.

2. APPLICABLE DOCUMENTS

2.1 General.

The documents listed below are not necessarily all of the documents referenced herein, but are the ones that are needed in order to fully understand the information provided by this handbook.

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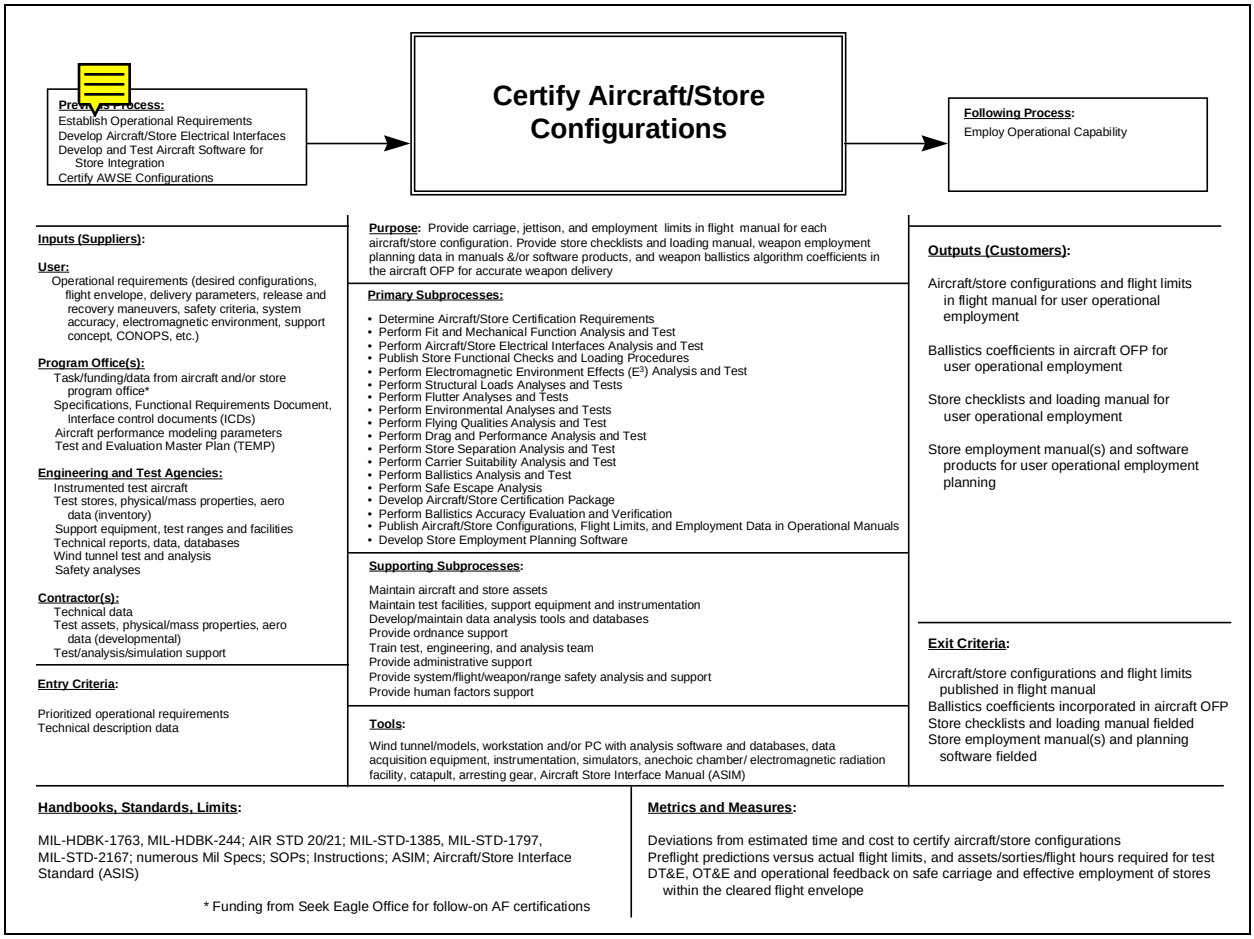


FIGURE 1. Certification process.

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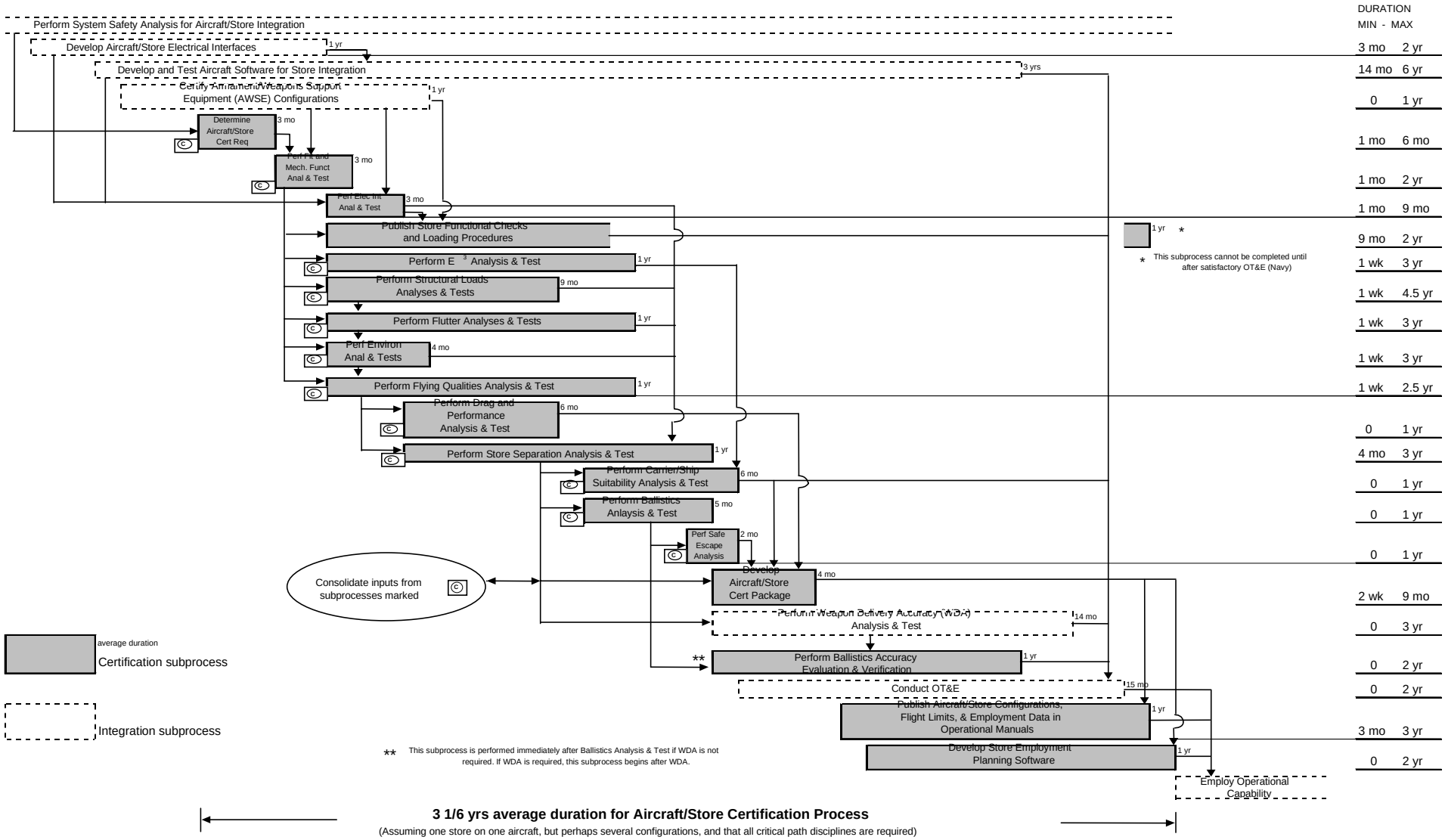


FIGURE 2. Certification process timeline.

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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 listed in the latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-E-5400	Electronic Equipment, Aerospace, General Specification For (Inactive for New Design)
MIL-T-5422	Testing, Environmental, Airborne Electronic and Associated Equipment (Canceled) (Not referenced, use for guidance)
MIL-E-6051	EMC/EMI Electromagnetic Compatibility Requirements, System (Canceled) (Not referenced, use for guidance)
MIL-T-7743	Testing, Store Suspension and Release Equipment, General Specification For
MIL-H-8501	Helicopter Flying and Ground Qualities, General Requirements For (Canceled) (Not referenced, use for guidance)
MIL-A-8591	Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase); General Design Criteria For
MIL-I-8670	Installation of Fixed Guns and Associated Equipment in Naval Aircraft (Not referenced, use for guidance)
MIL-I-8671	Installation of Droppable Stores and Associated Release Systems (Not referenced, use for guidance)
MIL-I-8672	Installation and Test of Aircraft Pyrotechnic Equipment in Aircraft, General Specification For (Canceled) (Not referenced, use for guidance)
MIL-T-8673	Installation and Test of Aircraft Flexible Weapons System (Canceled) (Not referenced, use for guidance)
MIL-I-8677	Installation of Armament Control Systems and Associated Equipment in Naval Aircraft (Canceled) (Not referenced, use for guidance)
MIL-T-8679	Test Requirements, Ground, Helicopter (Canceled)
MIL-S-8698	Structural Design Requirements, Helicopters (Not referenced, use for guidance)

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MIL-D-8708	Demonstration: Aircraft Weapon System, General Specification For
MIL-F-8785	Flying Qualities of Piloted Airplanes (Inactive for New Design)
MIL-A-8860	Airplane Strength and Rigidity, General Specification For
MIL-A-8861	Airplane Strength and Rigidity Flight Loads
MIL-A-8863	Airplane Strength and Rigidity Ground Loads for Navy Acquired Airplanes
MIL-A-8865	Airplane Strength and Rigidity, Miscellaneous Loads (Not referenced, use for guidance)
MIL-A-8866	Airplane Strength and Rigidity Reliability Requirements, Repeated Loads, Fatigue and Damage Tolerance
MIL-A-8867	Airplane Strength and Rigidity Ground Tests
MIL-A-8868	Airplane Strength and Rigidity Data and Reports
MIL-A-8869	Aircraft Strength and Rigidity, Nuclear Weapons Effects (Not referenced, use for guidance)
MIL-A-8870	Airplane Strength and Rigidity, Vibration, Flutter, and Divergence
MIL-PRF-9977	Manuals, Technical and Checklists; Munitions/Weapons Loading Procedures, Nonnuclear and Nuclear and Packages, Standard Data: Munitions Loading Procedures, Nonnuclear (Not referenced, use for guidance)
MIL-D-18243	Demonstration of Airborne Target and Missile Systems, General Specification For (Inactive for New Design) (Not referenced, use for guidance)
MIL-D-23222	Demonstration Requirements for Helicopters
MIL-I-23659	Initiators, Electrical, General Design Specification For
MIL-B-81006	Bombs, Free Fall, Demonstration of Dispersion Requirements for
AFGS-87221	Aircraft Structures, General Specification for

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-210	Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment
MIL-STD-331	Fuze and Fuze Components, Environmental and Performance Tests for
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility

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MIL-STD-462	Measurement of Electromagnetic Interference Characteristics, Test Method Standard For
MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-498	Software Development and Documentation
MIL-STD-810	Test Method Standard for Environmental Engineering Considerations and Laboratory Test
MIL-STD-831	Test Reports, Preparation of
MIL-STD-882	System Safety Program Requirements
MIL-STD-1289	Airborne Stores Ground Fit and Compatibility, Requirements For (Canceled)
MIL-STD-1385	Preclusion of Ordnance Hazards in Electromagnetic Fields, General Requirements for (Canceled)
MIL-STD-1512	Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods
MIL-STD-1670	Environmental Criteria and Guidelines for Air-Launched Weapons
MIL-STD-1760	Interface Standard for Aircraft/Store Electrical Interconnection System
MIL-STD-1795	Lightning Protection of Aerospace Vehicles and Hardware
MIL-STD-1818	Electromagnetic Effects Requirements for Systems
MIL-STD-2105	Hazard Assessment Tests for Non-Nuclear Munitions
MIL-STD-2167	Defense System Software Development (Canceled)
MIL-STD-38784	Standard Practice for Manuals, Technical: General Style and Format Requirements

HANDBOOKS

MIL-HDBK-235-1	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems
MIL-HDBK-244	Guide to Aircraft/Stores Compatibility
MIL-HDBK-1797	Flying Qualities of Piloted Aircraft

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the DoDSSP, Bldg 4D, 700 Robbins Ave., 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.

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PUBLICATIONS

DoDD 4650.1	Management and Use of the Radio Frequency Spectrum
DoDI 6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers
NACSEM 5112	NONSTOP Evaluation Techniques
NSTISSAM TEMPEST/1-92	Compromising Emanations Laboratory Test Requirements, Electromagnetics (U)
NTIA	Manual of Regulations and Procedures for Federal Radio Frequency Management
JMEM 61A1-3-7	Air-to-Surface Special Application, Test Procedures

AIR FORCE

AFI 63-104	The SEEK EAGLE Program
AFI 91-107	Design, Evaluation, Troubleshooting and Maintenance Criteria for Nuclear Weapon Systems
TO 11N-50-7	Aircraft Compatibility Control Drawings
DH 1-4	Electromagnetic Compatibility (Not referenced, use for guidance)
DH 2-5	Armament (Not referenced, use for guidance)
AFR 122-10	Nuclear Weapon Systems Safety Design and Evaluation Criteria (Not referenced, use for guidance)
AFSCR 80-33	Class II Modification of Aerospace Vehicles (Not referenced, use for guidance)

ARMY

ADS-27	Requirements for Aeronautical Standard Rotorcraft Vibration Specification, Modeling and Testing
ADS-37A-RPF	Aeronautical Design Standard, Electromagnetic Environmental Effects (E^3) Management, Design and Test Requirements
AMCP 706-203	Engineering Design Handbook Helicopter Engineering, Part Three Qualification Assurance
AMCP 706-235	Hardening Weapons Systems Against RF Energy, Handbook (Not referenced, use for guidance)
AR 70-38	Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions (Not referenced, use for guidance)

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AR 70-39	Criteria for Air Transport and Airdrop of Material (Not referenced, use for guidance)
AR 70-44	DoD Engineering for Transportability (OPNAVINST 4600.222B/AFR 80-18/MCO 4610.14C/DLAR 4500.25) (Not referenced, use for guidance)

NAVY

NAVAL AIR SYSTEMS COMMAND

AR-56	Structural Design Requirements for Helicopters (Not referenced, use for guidance)
AR-89	Structural Ground Test Requirements
NAVAIRINST 3710.7	NATOPS, General Flight and Operating Instructions (Not referenced, use for guidance)
NAVAIRINST 5100.7	NAVAIRSYSCOM Safety Programs for Explosive Ordnance, Laser Systems and Lithium Batteries (Not referenced, use for guidance)
Volume 1	Fixed Wing Aircraft
Volume 2	Rotary Wing Aircraft
NAVAIRINST 13034.1	Flight Clearance Policy for Manned Air Vehicles
NAVAIRINST 13100.14	Aircraft/Stores Integration Process
SD-24	General Specification or Design and Construction of Aircraft Weapon System
Volume 1	Fixed Wing Aircraft
Volume 2	Rotary Wing Aircraft
SD-8706	Design Examinations, Engineering, Aircraft Weapon System, General Specification For
SWCP 50-7	Major Assembly Release

NAVAL ORDNANCE SYSTEMS COMMAND

NAVSEA OP 3565	Electromagnetic Radiation Hazards (Hazards to Ordnance) Vol II, 6th Edition
NAVWEPS OD 30393	Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance (Not referenced, use for guidance)
NAVWEPS 51-35-501	Technical Manual, Conducting Carrier Suitability Tests of Fixed Wing Aircraft (Not referenced, use for guidance)

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(Copies of the NTIA Manual are available from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh PA 15250-7954. Copies of DoD documents are available from the DoDSSP, Bldg 4D, 700 Robbins Ave., Philadelphia PA 19111-5094. Copies of the NACSEM and NSTISSAM documents are available only through the procuring activity. Copies of Air Force Technical Orders are available from OC-ALC/MMEDT, Tinker AFB OK 73145-5990. Copies of NAVSEA documents are available from Commanding Officer, Naval Surface Warfare Center, Port Hueneme Division, Naval Sea Data Support Activity (Code 5700), Department of the Navy, Port Hueneme CA 93043-4301. Copies of the Joint Munitions Effectiveness Manual (JMEM) are available from JTCG/ME Publications Manager, OC-ALC/TILUB, 7851 2nd St., Ste 206, Tinker AFB OK 73145-9160.)

2.3 Non-Government publications.

The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the latest issue of the DoDISS, and supplement thereto.

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

AAP-6	NATO Glossary of Terms and Definitions for Military Use (Not referenced, use for guidance)
AOP-12	
Volume 1	Aircraft Stores Interface Manual (ASIM)
Volume 2	Stores Characteristics
Volume 3	Suspension Equipment
STANAG 3300	Standardized Aircraft Armament Terminology (Not referenced, use for guidance)
STANAG 3441AA	Design of Aircraft Stores (Not referenced, use for guidance)
STANAG 3556AA	Aircraft Store Ejector Cartridges (Not referenced, use for guidance)
STANAG 3558AA	Location of Electrical Connectors for Aircraft Stores (Not referenced, use for guidance)
STANAG 3575AA	Aircraft Stores Ejector Racks (Not referenced, use for guidance)
STANAG 3605AA	Compatibility of Arming Units and Expendable Aircraft Stores (Not referenced, use for guidance)
STANAG 3859 AA	Standardized Data List for Interoperability Studies and Certification of Aircraft (Not referenced, use for guidance)

AIR STANDARDIZATION COORDINATING COMMITTEE (ASCC)

AIR STANDARDS	
AIR STD 20/9	Design Safety Principles for Aircraft Stores Fuzing (Not referenced, use for guidance)
AIR STD 20/10	Ejector Release Units for Aircraft Stores

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AIR STD 20/12	Aircraft Store Ejector Cartridges
AIR STD 20/13	Design of Aircraft Stores
AIR STD 20/14	Location of Electrical Connectors for Aircraft Stores
AIR STD 20/15	Suspension Lugs for 1000 Pound Class and 2000 to 5000 Pound Class Stores
AIR STD 20/17	Mechanical Connection Between Stores and Suspension Equipment for the Arming and Associated Functions of Stores
AIR STD 20/18	Environmental Test Methods for Aircraft Stores Suspension
AIR STD 20/19	Non-eject Release Units for Aircraft Stores
AIR STD 20/20	Standardized Data List for Interoperability Studies and Certification of Aircraft Stores (Not referenced, use for guidance)
AIR STD 20/21	Ground Fit and Compatibility Criteria for Aircraft Stores
AIR STD 20/22	Aircraft Store Electrical Interconnection System (Not referenced, use for guidance)
AIR STD 20/23	Safety Design Requirements for Airborne Dispenser Weapons (Not referenced, use for guidance)
AIR STD 20/24	20 mm x102 Ammunition for Aircraft Guns
ADVISORY/INFORMATION PUBLICATIONS	
ADV PUB 20/25	Interoperability of Stores with Aircraft (Not referenced, use for guidance)
ADV PUB 20/26	Aircraft/Stores Interface Manual (ASIM)
ADV PUB 20/30	Hazards of Electromagnetic Radiation to Ordnance and Electromagnetic Compatibility / Electromagnetic Interference for Aircraft/Stores

(Copies of NATO Standardization Agreements are available from the Commander, Naval Air Systems Command, ATTN: NATO Standadization, Patuxent River MD 20670-5400.

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.

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3. DEFINITIONS

3.1 Standardization of terminology.

It has been learned through experience, that one of the biggest problems in the field of aircraft-stores compatibility is the inability to properly communicate to others problems or implications of areas of concern. This is caused, primarily, by a lack of awareness and a commonly understood language. The following standardized definitions are provided to assist in the breaking down of this communications barrier. These definitions should be used to the maximum extent possible by all involved in the aircraft/stores compatibility field.

3.1.1 Aircraft.

Any vehicle designed to be supported by air, being borne up either by the dynamic action of the air upon the surfaces of the vehicle, or by its own buoyancy. The term includes fixed and movable wing airplanes, helicopters, gliders, and airships, but excludes air-launched missiles, target drones, and flying bombs.

3.1.2 Aircraft-stores compatibility.

The ability of an aircraft, stores, stores management systems, and related suspension equipment to coexist without unacceptable effects of one of the aerodynamic, structural, electrical, or functional characteristics of the others under all flight and ground conditions expected to be experienced by the aircraft-store combination. A particular store may be compatible with an aircraft in a specific configuration, although not necessarily so with all pylons (or stations) under all conditions.

3.1.3 Aircraft-store.

Any device intended for internal or external carriage and mounted on aircraft suspension and release equipment, whether or not the item is intended to be separated in flight from the aircraft. Aircraft-stores are classified in two categories as follows:

a. Expendable store. An aircraft store normally separated from the aircraft in flight such as a missile, rocket, bomb, nuclear weapon, mine, torpedo, pyrotechnic device, sonobuoy, signal underwater sound device, or other similar items.

b. Non-expendable store. An aircraft-store which is not normally separated from the aircraft in flight such as a fuel tank, electronics or gun pod, suspension rack or tow target.

3.1.4 All-up-round (AUR).

Any store which is completely assembled, both mechanically and electrically, and ready for installation on or in an aircraft for purposes of carriage and employment on a specific mission. An AUR has all mission-necessary sub-assemblies (such as guidance and control units, fins, fairings, and fuzes), associated hardware, and electrical cables installed and serviceable, as well as necessary pre-flight safety devices and any adaptation equipment which is normally fixed to store. An AUR does not include items of suspension equipment (such as bomb racks or missile rails), externally mounted electrical cables which attach the store to the suspension equipment or other items which are not separated with the store.

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3.1.5 Ballistics.

The science that deals with the motion, behavior, appearance, or modification of missiles or other vehicles acted upon by propellants, wind, gravity, temperature, or any other modifying substance, condition, or force.

3.1.5.1 Free-stream ballistics.

A model of the weapon flight path from the time the weapon reaches steady state flight after release from the aircraft.

3.1.5.2 Separation effects.

A model of the weapon motion from the moment it is released until oscillations caused by the aircraft flowfield are dampened. They are currently modeled as a function of release variables such as Mach number, normal acceleration, angle of attack, and dynamic pressure. These coefficients will be used to compensate for separation effects and may be incorporated into the ballistic tables and/or into a separation effects algorithm in the aircraft ballistic operational flight program (OFP). The coefficients used in the separation effect algorithm may result in aircraft velocity adjustments used in the air-to-surface trajectory calculations or may incorporate changes in the mode of trajectory calculation.

3.1.5.3 Ballistics accuracy evaluation and verification.

Flight testing process through which the accuracy of the ballistic portion of the aircraft OFP is determined.

3.1.5.4 Ballistic trajectory.

The trajectory traced after the propulsive force is terminated and the body is acted upon only by gravity and aerodynamic drag.

3.1.6 Carriage.

The conveying of a store by an aircraft under all flight and ground conditions including taxi, take-off, and landing. The store may be located either external or internal to the aircraft. Carriage should include time in flight up to the point of complete separation of the store from the aircraft.

3.1.6.1 Symmetrical carriage.

An arrangement (loading) of identical stores on either side of a dividing line or plane (usually the longitudinal axis) as related to a given aircraft, suspension equipment, or weapons bay.

3.1.6.2 Asymmetrical carriage.

This term applies to the carriage of stores which can be unlike in shape, physical properties, or number with reference to the plane of symmetry.[1]

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[1] **‘Asymmetrical’ applies to the arrangement or loading, of stores on an aircraft or suspension equipment and ‘unsymmetrical’ applies to an aircraft maneuver wherein the aerodynamic loading is unequally distributed on each side of the plane of symmetry of the aircraft, as in a roll.**

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3.1.6.3 Conformal (or tangential) carriage.

The concept of packaging stores to conform as closely as practical to the external aircraft lines to reduce drag and obtain the best overall aerodynamic shape. Stores are generally carried in arrays, mounted tangentially to some portion of the aircraft, usually the bottom of the fuselage. It includes those arrangements made possible by weapon shapes configured for this purpose.

3.1.6.4 Multiple carriage.

Carriage of more than one store on any given piece of suspension equipment, such as bombs carried on a triple ejector rack (TER) or multiple ejector rack (MER).

3.1.6.5 Single carriage.

Carriage of only one store on any given station or pylon.

3.1.6.6 Tandem carriage.

Carriage of more than one store on any given piece of suspension equipment such that one store is behind the other.

3.1.7 Authorized download.

Any configuration that results from the downloading of weapons in the normal employment sequence from a configuration authorized in the aircraft Flight/Tactical Manual and can also be authorized for flight.

3.1.8 Compatibility engineering data package (CEDP).

A CEDP for a store is the primary data package used by the USAF to ensure that stores are physically, mechanically, electromagnetically, environmentally, structurally, and aerodynamically compatible with aircraft systems, so that supporting technical orders can be written.

3.1.9 Circular error probable (CEP).

A measure of accuracy whose value is equal to the radius of a circle centered on the target or mean point of impact and contains 50 percent of the population impact points. CEP is measured in the normal plane for aircraft level and dive deliveries and in the ground plane for loft deliveries and is usually given in mils.

3.1.10 Agencies.

3.1.10.1 Certification agency.

The service office or organization having the responsibility for issuing the technical manuals, and changes thereto, which constitute store certification (e.g., NAVAIR, aircraft System Program Office (SPO), System Program Manager (SPM), or Army Aviation and Missile Command).

3.1.10.2 Compatibility agency.

An office or organization which provides engineering and compatibility support to the certification agency.

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3.1.11 Certification of a store or airworthiness qualification (for Army).

The determination of the extent of specific store/aircraft compatibility and the formal publication of all information necessary for appropriate employment of a store on a specified aircraft (aircraft series) in the applicable technical manuals and flight operation manuals (or interim supplements or revisions thereto). For the Army, the term used is the airworthiness qualification of the store.

3.1.12 Critical conditions.

A combination of pertinent operational parameters expected to be encountered by an aircraft, store, or combinations thereof; upon which the design or operational limits of the aircraft, stores, or portions thereof are based.

3.1.13 Developmental test and evaluation (DT&E).

That test and evaluation (T&E) conducted throughout various phases of the acquisition process to ensure the acquisition and fielding of an effective and supportable system by assisting in the engineering design and development and verifying attainment of technical performance specifications, objectives, and supportability. It includes components, subsystems, preplanned product improvement changes, hardware-software integration and related software, as well as qualification and production acceptance testing. T&E of compatibility and interoperability with existing or planned equipment and systems is emphasized.

3.1.14 Dispersion.

A scattered pattern of hits around the mean point of impact of bombs and projectiles dropped or fired under identical conditions.

3.1.14.1 Aircraft dispersion.

Refers to the errors contributing to the ballistic error budget such as sensor errors, on-board avionics errors, timing delays, fire control, or variation in rack ejection forces**.**

3.1.14.2 Ballistic dispersion.

Weapon-to-weapon variation in the free-stream ballistic flight path which is attributed to manufacturing tolerances such as mass and physical properties, and accidental misalignments occurring during assembly and handling of the weapon.

3.1.14.3 System dispersion.

The total dispersion due to the weapon and aircraft.

3.1.15 Electromagnetic compatibility (EMC).

The capability of electrical and electronic systems, equipment, and devices to operate in their intended electromagnetic environment within a defined margin of safety, and at design levels of performance, without suffering or causing unacceptable degradation as a result of electromagnetic interference.

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3.1.15.1 Electromagnetic environment effects (E^3).

The impact of electromagnetic environment upon the operational capability of electronic or electrical systems, equipment, or devices. It encompasses all electromagnetic disciplines, including electromagnetic compatibility; electromagnetic interference; electromagnetic vulnerability; electromagnetic pulse; electronic countermeasures; hazard of electromagnetic radiation to ordnance and volatile materials; and natural phenomena effects of lightning and precipitation static (p-static).

3.1.15.2 Electromagnetic interference (EMI).

Any electromagnetic disturbance, whether intentional or not, that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronic or electrical equipment.

3.1.16 Employment.

The use of a store for the purpose and in the manner for which it was designed, such as releasing a bomb, launching a missile, firing a gun, or dispensing a submunition.

3.1.16.1 Release.

The intentional separation of a free-fall store, such as an "iron bomb," from its suspension equipment, for purposes of employment of the store.

3.1.16.2 Launch.

The intentional separation of a self-propelled store; such as a missile, rocket, or target-drone; for purposes of employment of the store.

3.1.16.3 Fire.

The operation of a gun, gun pod, or similar weapon, so as to cause a bullet or projectile to leave through the barrel.

3.1.16.4 Dispense.

The intentional separation from an airborne dispenser of devices, weapons, submunitions, liquids, gases, or other matter, for purposes of employment of the items being dispensed.

3.1.17 Failure mode.

The malfunction of weapon components which must operate normally to ensure acceptable separation, such as autopilot actuation or fin employment.

3.1.18 Flight clearance/clearance recommendation.

An authorization for flight, after appropriate engineering analysis has been made, that an aircraft-store combination would not pose an unacceptable risk for a specific, limited, purpose such as DT&E or initial operation test and evaluation (IOT&E). The flight clearance will specify flight limits and remarks for operation for the loading configuration required on a specific aircraft, or group of aircraft, and will remain valid only for a specified finite period of time for a specific user or group of users.

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3.1.19 Free flight (of a store).

The movement or motion of a store, either powered or unpowered, through the air after separation from an aircraft.

3.1.19.1 g-jump.

The change in normal load factor that results from store release, due to the combined effects of ejection force, dynamic response, and instantaneous aircraft gross weight decrease. The g-jump effect is most apparent when several large stores are released simultaneously or a large number of smaller stores are released with a very small ripple interval. The amount of g-jump can, at times, be large enough to cause overstress of the aircraft or other stores not being released. In dive-toss delivery g-jumps of up to 3.5g (in addition to the maneuver load factor) are not uncommon.

3.1.20 Hung store or hangfire (for Army).

Any store (or stores) which does not separate from the aircraft or launcher when actuated for employment or jettison.

3.1.21 Interval.

The elapsed time between the separation of a store and the separation of the next store. The minimum release interval is the shortest allowable or usable interval between successively released stores that will allow safe separation of the stores from the aircraft.

3.1.22 Mean point of impact (MPI).

A point which has as its range/deflection coordinates the arithmetic mean of the range and deflection coordinates of the impact points.

3.1.23 Mixed load.

The simultaneous carriage or loading of two or more unlike stores on a given aircraft.

3.1.24 Operating limitation.

Flight carriage, employment and jettison envelopes detailing acceptable airspeed, mach, altitude, g, roll rate, wing sweep, speed brake operation, delivery angles, release modes, and minimum release intervals as required for a specified aircraft/stores configuration.

3.1.25 Operational test and evaluation (OT&E).

The field test, under realistic conditions, of any system (or key subsystem) such as weapons, equipment, or munitions for the key purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users; and the evaluation of the results of such tests.

3.1.26 Range bias.

The criteria determined by the user that defines whether the weapon delivery system is biased in range; that is, acceptable long/short weapon impacts about the target.

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3.1.27 Safe escape/safe arming.

Safe escape is the minimum release altitude which will provide the delivery aircraft acceptable protection from weapon fragmentation for detonation at the preplanned point. Safe arming separation is the selection of a minimum safe fuze arm time setting which will provide the delivery aircraft acceptable protection from weapon fragmentation if early detonation should occur.

3.1.28 Separation.

The terminating of all physical contact between a store, or portions thereof, and an aircraft; or between a store, or portions thereof; and suspensions equipment.

3.1.28.1 Safe separation.

The parting of a store(s) from an aircraft without exceeding the design limits of the store or the aircraft or anything carried thereon, and without damage to, contact with, or unacceptable adverse effects on the aircraft, suspension equipment, or other store(s) both released and unreleased.

3.1.28.2 Acceptable separation.

Acceptable store separations are those which meet not only the "safe" separation criteria, but also meet pertinent operational criteria. For instance, guided weapons as a minimum must remain within control limitations consistent with mission effectiveness. Conventional weapons, bombs, should not experience excessive angular excursion which induce ballistic dispersions that adversely affect weapons effectiveness, or bomb-to-bomb collisions.

3.1.28.3 Pairs.

The simultaneous separation of stores from two separate stations on an aircraft.

3.1.28.4 Ripple (or train).

The separation of two or more stores or submunitions one after the other in a given sequence at a specified interval.

3.1.28.5 Salvo.

The simultaneous separation of stores from multiple stations on an aircraft.

3.1.28.6 Multiple.

The number of stores released simultaneously from aircraft store stations.

3.1.28.7 Quantity.

The total number of stores released per pass by an aircraft.

3.1.28.7.1 Ejection.

Separation of a store with the assistance of a force imparted from a device, either external or internal to the store.

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3.1.28.8 Selective jettison.

The intentional separation of stores or suspension equipment, or portions thereof (such as expended rocket pods), no longer required for the performance of the mission in which the aircraft is engaged.

3.1.28.9 Emergency jettison.

The intentional simultaneous, or nearly simultaneous, separation of all stores or suspension equipment from the aircraft in a preset, programmed sequence and normally in the unarmed condition.

3.1.29 Submunition.

Any munition that, to perform its task, separates from a parent munition.

3.1.30 Suspension equipment.

All aircraft devices such as racks, adaptors, missile launchers, pylons, used for carriage, employment and jettison of aircraft stores.

3.1.31 Technical manuals.

These manuals contain the approved data required for the loading, carriage and employment of the store(s). These manuals consist of the following types:

a. Air Force Technical Orders (TOs).

(1) Aircraft - 1 TO - Flight Manual

(2) Aircraft - 2 TO - Aircraft Maintenance Manual

(3) Aircraft - 5 TO - Basic Weight Checklist and Loading Data

(4) Aircraft - 16 TO - Nuclear Weapons Loading Procedures

(5) Aircraft - 25 TO - Nuclear Bombs Delivery Manual

(6) Aircraft - 30 TO - Nuclear Missile Delivery Manual

(7) Aircraft - 33 TO - Nonnuclear Munitions Loading Procedures

(8) Aircraft - 34 TO - Nonnuclear Munitions Delivery Manual

(9) Aircraft - 35 or Similar TO - Nonmunitions Stores Installation and Removal Procedures

(10)Aircraft - 100 TO - Aircraft Modifications

b. Army Technical Manuals (TMs).

(1) TM 55-1520-XXX-XXX - Aircraft Technical Manuals

(2) TM 55-1520-XXX-10 - Operators Manual

(3) TM 55-1520-XXX-23 - Maintenance Manual

(4) TM 55-1520-XXX-23P - Parts Manual

(5) TM 9-XXXX-XXX-XX - Armament Technical Manuals

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c. Navy Technical Manuals.

(1) NAVAIR 01-XXXXX-1 Flight Manuals

(2) NAVAIR 01-XXXXX-1T Tactical Manuals

(3) SWCP 50-7

4. GENERAL REQUIREMENTS

4.1 Compatibility assessment/analyses.

4.1.1 General.

The easiest way to recommend carriage/employment of a store is by analogy on the basis of similarity to a currently authorized store. If the aerodynamic, structural, mass and operational characteristics of the store to be certified are sufficiently similar to those of a store already certified in the desired loading configuration of the designated (or similar) aircraft, it may be possible to authorize the store partly or entirely by analogy. Where certification cannot be justified on the basis of similarity, analyses of existing aircraft and store data must be performed to evaluate compatibility. Such analyses may themselves provide enough information to allow certification, or they may point out the need for additional data to be acquired by the performance of specific tests. The analysis of this additional test data would then form the basis for a certification recommendation.

4.1.2 Data required.

Prior to entering into any aircraft-store certification program, all existing data suitable for compatibility analyses should be reviewed to minimize requirements for additional analyses and testing. Before planning or performing any new tests, a data research should be completed to:

a. Provide a preliminary evaluation of compatibility for each store installation.

b. To assess the sufficiency of existing data.

c. To identify what additional data are needed.

Appendix C contains a detailed list of data which is required to ascertain the extent of compatibility for the aircraft/stores configurations. Information acquired in the research should include data for the aircraft and store together with certification information for similar aircraft-store installations. If sufficient data are acquired in this research, many tasks normally required in a complete certification program will be reduced or eliminated. The data must be organized systematically to permit correlation of data availability and suitability with certification requirements.

4.1.3 Physical compatibility review.

It is important to establish early that the store can be installed satisfactorily at the specified locations, in the desired numbers, with all components interfacing properly. For a preliminary check, three view drawings and descriptions of the installations may be used to evaluate physical compatibility. In order to accomplish the physical compatibility review, store/aircraft interface data must be available. The organization requesting the store certification should submit the following data, if available and applicable, to the certification agency:

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a. Detailed mechanical layout drawings of the aircraft-store/suspension equipment combination showing fit and clearances for each aircraft station involved.

b. Mechanical attachment/mating data, including suspension equipment configuration and dimensions, hook spacing, sway brace (if any) locations and dimensions, weight limits, connector locations, ejector locations and dimensions, arming device locations, lug spacing, attachment geometry, hardback area dimensions and location, fin geometry, and any adaptor geometry.

c. Electrical compatibility data, including power and control requirements, electrical connector data (type, location, pin assignments, current and voltage levels, test/checkout points/ functions) wire sizes and routings, and antenna locations and orientations.

d. Optical compatibility data, including wave length, power levels, connector data, fibber optic sizes and routings, and orientation of any lensed system(s).

4.1.3.1 Review objective.

A review of the data should be made to assure that mechanical, electrical, and electro-optical connections and attachments between the store, suspension equipment and aircraft are compatible. The review objective should include

a. Applicable carriage locations. The applicable carriage locations, on which each type of store can be installed, should be defined by weight, clearance, access requirements, and operational requirements.

b. Suspension method. Review suspension provisions on each type of store to determine single and/or multiple carriage capability. Stores using special launching or suspension equipment should be reviewed for installation compatibility.

c. Alignment. The mounting surface nominal alignment for the basic suspension equipment at the carriage locations should be established considering carriage drag, separation characteristics, accuracy requirements, required look angles for guidance units, and store antennae requirements.

d. Quantity per carriage location. The quantity of each type of store that can be installed on a carriage location in terms of the physical, structural, and functional limitations of each store location should be determined. Consideration should be given to suspension equipment release, aerodynamic, and structural characteristics in locating stores. Store loadings exceeding the design limit for the carriage location should be reviewed by the requesting agency to determine operational viability/desirability. Some configurations of this type may be allowed if additional maneuvering limit restrictions are placed on the aircraft such that the maximum allowable product of load factor times weight (N_zW) is not exceeded.

e. Ground/structure clearance. Adequate clearances between the aircraft structure, the ground, and the installed stores should be determined for each method of store suspension. The criteria for determining the adequacy of store clearance and the test procedures to be used are specified in AIR STD 20/21. ADV PUB 20/26/AOP 12 should be used during the initial review if other aircraft or store drawings are unavailable. If physical compatibility between the store and aircraft cannot be positively ascertained during the analytical review, a fit test must be performed in accordance with Test 101. Any store which does not satisfy the clearance requirements of AIR STD 20/21 should not be analyzed or pursued further unless the deviation has been approved by the certification agency having technical or engineering cognizance on the specific aircraft in question.

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4.1.3.2 Physical deficiency.

Any store installation which does not meet the physical compatibility requirements of AIR STD 20/21 should not be analyzed further until deviation waiver has been approved by the certification agency. Waivers should be granted on a case-by-case basis only. Any discrepancies noted between results of ground fit checks and those predicted by use of the ADV PUB 20/26/AOP 12 review should be documented, and any recommended changes to ADV PUB 20/26/AOP 12 should be forwarded to the agency responsible for those publications through the appropriate service custodian.

4.1.4 Engineering analyses.

4.1.4.1 General.

Where store similarity and physical compatibility reviews do not in themselves provide sufficient basis for certification of the carriage/employment of an aircraft-store, additional analyses described in subsequent paragraphs must be performed (see MIL-HDBK-244, 6.1.5).

4.1.4.2 Structural analysis.

Prior to certification of carriage/employment of an aircraft-store on any aircraft, a thorough analysis of the strength of both the store itself and the store/aircraft/suspension equipment combination must be made. This analysis should consider the structural integrity of the store alone, the structural loading effects of the store on the aircraft and suspension equipment and the effects of the aircraft and suspension equipment on the store. Additionally, an analysis should be performed for all conditions throughout the desired aircraft-store operational envelope, including takeoff (catapult, if applicable), carriage, separation and landing (arrested landing, if applicable) and hangfire (hung, partially released stores, or missile thrust without release from aircraft) loads. The sloshing effect of liquid within external tanks can also cause significant center-of-gravity changes and must be analyzed, especially if baffles are not present. In order to verify the structural integrity of the aircraft-store/suspension equipment, the following data must be reviewed: (NOTE: Not all the data listed below is required in every case. The certification agency should be consulted for the exact requirements. However, in general, for a newly developed store, all the data listed is needed.):

a. Store design strength criteria, including strength envelopes required for carriage (catapult takeoffs and arrested landings, if applicable), employment, and the basis for these envelopes.

b. Inertial, maneuver, dynamic response, jet wake encounter, gust, and aerodynamic loads data for carriage, employment, jettison and store-alone conditions; the source of data (flight test, wind tunnel, or analytical), and rationale for selection of specific data.

c. Store loads analysis detailing how inertial and aerodynamic data are used to determine critical loads acting on the store (including distribution of loads).

d. Store stress and fatigue analyses. Components should be classified as to safety or mission critical. If a finite element analysis is used, then details of what program was used must be presented. If the program used is not a well documented public program, then a run of an example case must be made to validate the procedure.

e. Store aeroelastic analysis.

f. Laboratory structural test data, including results of static, fatigue, thermal, structural vibration and aeroacoustic tests.

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g. Results of aeroelastic ground vibration tests (GVT) using random and/or sinusoidal methods.

h. Any structural flight test data available, including takeoff, landing, and shipboard suitability.

i. Dynamic hangfire load analysis to show aircraft can withstand dynamic hangfire caused by worst thrust of weapon measured on hot day.

4.1.4.3 Aerodynamic analysis.

Adding an external store, or group of stores to an aircraft often has a significant effect on the flying qualities and performance of the carrying aircraft. The DoD requires the use of the MIL-A-8860 series specifications. Airloads due to maneuver and gust requirements are of particular interest in developing the aerodynamic and structural performance of the aircraft. In addition to the obvious weight and center-of-gravity changes, the basic airflow over the aircraft lifting and control surfaces can be significantly altered. Depending on how and where the stores are installed on the aircraft, mutual interference effects can cause an increase in drag much larger than the combined free stream drag of all individual components. Aircraft flight simulation (pilot in- and out-of-the-loop) using wind tunnel "increments" and stability derivatives is a helpful tool in determining real-world effects of the store on aircraft flying qualities. Captive carriage of stores must not degrade the flying qualities of the airplane, in accordance with the practice of aircraft flying qualities specification. A detrimental effect may occur to the aircraft engine if the stores are placed too close to the inlet. The detrimental effects could include compressor surge and/or stall resulting from pressure disturbances coming from the stores. Asymmetric loads can require large deflections of aircraft controls for aerodynamic trim which add significantly to the total drag. This additional trim requirement can also reduce the available control authority below acceptance limits for maneuvering flight and arrested landings. Airloads, temperatures and pressure or density gradients in the captive flow environment can be more than the store will tolerate and still function properly. Therefore, analyses for certification must consider the various ways in which stores change the aerodynamics of the aircraft, and aircraft flowfield, and ways the captive environment affects the store and its separation trajectory. Effects of an internal carriage bay on flying qualities can be significant. Bay doors which open outward can adversely affect lateral-directional stability, and bay door transition effects can cause undesirable transients, particularly for an aircraft which relies on flight controls for basic aircraft stability. The flight control laws must be robust enough to handle any transients. Similarly, if the configuration includes a weapons pallet which will be lowered into the freestream to release weapons, flying qualities with the pallet extended must be investigated. For a highly augmented, relaxed static stability aircraft, stores carriage/jettison/release and weapons bay/pallet aerodynamic effects must be investigated early enough in the development program that the flight control system can be designed to handle those effects, or modified to minimize adverse effects.

4.1.4.3.1 Store airloads effects.

Incremental effects of stores on vehicle aerodynamics, including control effectiveness and variations in center-of-gravity location should be included in analyses of the aircraft flying qualities. The analyses should include takeoff and landing configurations where store effects on high-lift systems may be significant. Where control or lifting surfaces are adjacent to or in the wake of external stores, both the steady state aerodynamics and fluctuating airloads must be evaluated. Heavy loadings of wing-mounted stores decrease roll response by increasing roll inertia. Therefore, control effectiveness of the aircraft with stores must be analyzed to assure

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that adequate control authority is available with all loadings. If the aircraft with stores can reach flight conditions where the flying qualities are unsatisfactory, appropriate restrictions must be imposed.

4.1.4.3.2 Stores loading effects.

Whether due to preflight loading or normal in-flight downloading, asymmetric flight configurations, combined with severe flight conditions, may be the most critical test of flying qualities. This is true even though these configuration/flight condition combinations may be encountered only briefly during a typical sortie. Some store installations which induce large aerodynamic forces and moments may be carried acceptably in a symmetric arrangement and be unacceptable when loaded asymmetrically. Certification analyses must determine that the airplane has sufficient control authority to balance the unsymmetric aerodynamic forces and moments created by all asymmetric loadings and still have adequate stability and control characteristics to perform the required missions including takeoff and landing (particularly with asymmetric loadings in crosswind). If the airplane flight characteristics are unacceptable with specific asymmetric loadings, this information should be included in the certification document so the loading can be avoided even if only briefly encountered during employment. Care should be taken to ensure that if a partial download configuration has a more restrictive carriage envelope than the takeoff configuration, that ripple release modes are properly analyzed to ensure that the maximum release interval is not unsafe, i.e., a ripple release with 100ms interval may be found to be safe but a 600ms interval may cause the download configuration to be unsafe.

4.1.4.3.3 Store drag effects.

External stores affect aircraft performance in three important ways. Aerodynamic drag is normally increased by the added external bodies and the mutual flow interference. The added weight requires more lift of the aircraft which increases the induced drag. Also, aerodynamic trim usually has a drag penalty. Therefore, performance calculations for the various store loadings should be used to assure that adequate takeoff, landing and maneuvering performance is available and to evaluate performance penalties produced by the stores. Asymmetric loadings must be considered for any part of the flight envelope where such loadings are realistic because trim drag can be large.

4.1.4.3.4 Store environmental effects.

Most stores have airload, temperature or other environmental limitations. Aerodynamic interference from the aircraft and adjacent stores normally produces a flow environment more severe than that experienced by the store in free flight. The aerodynamic analysis must provide captive airloads and pressure distributions for the structural and separation analyses presented in 4.1.4.2 and 4.1.4.5. Some stores are sensitive to pressure or temperature gradients, therefore these limits must be defined. Most stores have temperature limitations due to such components as warheads, electronics, fuses, or domes. These limits are often dependent on more than absolute temperature alone and are a function of the time spent at specific temperatures. Since stores spend more time in the aircraft environment than in free flight, captive temperatures must be investigated. The aerodynamic heating analyses must show all weapon components will not be exposed to temperatures outside qualification limits during world-wide operational employment.

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4.1.4.3.5 Store operational effects.

To ensure aircraft safety of flight and to inform the pilot of store effects on aircraft stability and control, aircraft flight manuals (or tactical manuals) should contain either "stability index numbers" or maximum allowable center-of-gravity travel for each store or loading configuration. Effects of stores on aircraft mission performance should be represented in aircraft handbooks by "drag indices." Information should also be provided for restricted flight times at conditions that can exceed the allowable temperature for the store(s). All flight restrictions, which are necessary to avoid unacceptable captive loads, flying qualities and aircraft performance, should be identified.

4.1.4.4 Aeroelastic analyses.

4.1.4.4.1 General.

Acceptable approaches within industry vary considerably. Documentation must be established to record the results of the various analyses and tests associated with each take-off configuration along with the applicable limit speed envelopes and flutter margins of safety. These records should be retained whether a particular take-off configuration is cleared or not as they may be invaluable for evaluation of future configurations. Next, the mission priority and a representative series of derived configurations are defined for each proposed take-off configuration. These derived configurations should reasonably cover the entire range of aircraft and store use including store down-loadings, wing sweep (if applicable), fuel expenditure, and applicable limit speeds. Store down-loadings may need to include not only considerations for standard deployment sequences but also optional deployment, mixed stores, hung stores, and partial store expenditure such as from external tanks, rocket launchers, external gun pods, and various dispensers. Partially filled external tanks may need special attention to determine possible adverse center-of-gravity shifts in climbs and dives or liquid sloshing.

4.1.4.4.2 Inertial similarity comparisons.

Experience has shown that, for a given aircraft with a given set of wing pylons and racks, the inertial characteristics of external stores on the pylons usually (but not always) play a much more dominant role in the aeroelastic stability (except divergence) of the total system than either the stores stiffness or unsteady aerodynamics characteristics. More specifically, configurations for the given aircraft/pylons/racks with nearly similar pylon loadings, expressed in values of center-of-gravity and radius of gyration, usually exhibit nearly similar aeroelastic characteristics. Comparing such values for new configurations with those of previously evaluated configurations may thus provide an exceptionally low-cost method for initial reviewing purposes. There are some severe limitations to this method. First, finding another configuration with enough inertial similarity as well as known aeroelastic characteristics usually requires prior evaluation of a large number of configurations. Secondly, determining the allowable tolerances on similar configurations requires an extensive knowledge of the basic aeroelastic mechanisms involved and their associated sensitivities. Results of inertial parameter trend studies using either more formal analytical or wind tunnel methods may be interpolated to actual stores configurations as needed. Inertial similarity may not be sufficient when multiple ejection racks or bomb rack units (MERs or BRUs), multiple launcher rails, or significantly flexible stores are involved because of the intervening stiffness effects. Likewise, stores with large fin areas, large but lightweight stores, or stores mounted near the wing tips may have significant unsteady aerodynamics characteristics not accounted for when only considering inertial similarity.

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4.1.4.4.3 Computer analyses.

Aeroelastic analyses remain the most flexible approach in evaluating carriage of external stores while retaining reasonable accuracy and economy. This approach also tends to reveal the basic aeroelastic mechanisms and their sensitivities. Such information may be especially important in determining optimum resolution of borderline situations.

4.1.4.4.3.1 Flutter analysis.

Flutter analyses are performed with discrete sets of input modal data and calculated unsteady aerodynamics. The transonic region is usually the most flutter critical region. This modal data, consisting of natural frequencies, associated mode shapes, and generalized modal masses, may be obtained directly from ground vibration tests or calculated. Therefore, a modal analysis, in general, must precede each flutter analysis for each configuration being considered. The input data for the modal analysis consists of idealized distributed lumped masses and discrete stiffness in a geometric array to dynamically represent the complete aircraft-stores system with special emphasis placed on the wings, pylons, racks, and individual stores. Calculated stiffness distributions are especially subject to the results of static load-deflection ground tests and are not sufficiently accurate for use in theoretical vibration analysis. The analytical model must be verified by ground vibration tests. Aircraft with high-gain augmented flight control systems require special analyses to predict possible aeroservoelastic instabilities caused by the interaction of the aeroelastic response with the augmented flight control system. Analytical methods in use today are capable of identifying those configurations which are either good or bad from a flutter standpoint. Many times the analysis identifies the candidate configurations in the marginal area from a flutter standpoint. In these cases, three alternatives exist: (1) do not authorize the store; (2) perform an instrumented aircraft flight test; or (3) change the store loading configuration to another one that will allow positive analytical determination. The aeroelastic analysis is performed concurrently with the structural analysis of 4.1.4.2 and utilizes the data defined in that paragraph.

4.1.4.5 Separation analysis.

One of the most important preflight analyses is that of determining the separation characteristics of a store. Store separation characteristics are important because they affect aircraft safety and weapon delivery accuracy. Also, safety hazards associated with flight testing are increased due to the mass of the stores being released, the uncertainty in the predictions, and the opportunities for inflicting serious aircraft damage because of the relatively large numbers of stores released at or near the boundaries of the acceptable flight envelope. Experience has shown that proper use of predictive methods for store separation will enhance the safety of store delivery and jettison during flight testing and subsequent operational employment. Aircraft-store certification flight test programs can be considerably reduced, both in scope and in cost, by reducing full scale flight tests based on a comprehensive analysis and positive correlation of predictions with the flight test data.

4.1.4.5.1 Method selection.

Predicting accurate store separation trajectories on today's high speed aircraft under the varying conditions of altitude, Mach number, dive angle, load factor, and other factors related to delivery techniques (particularly where multiple carriage of stores is involved), is an extremely difficult task, requiring a skilled and experienced analyst. Several techniques are available for store separation analysis, and these are documented throughout scientific literature. Some are purely analytical in nature, utilizing theoretical aerodynamics and complex mathematical

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manipulation and analyst interpretation. Others utilize wind tunnel testing of small scale models of the store and aircraft, while still others involve a combination of theoretical and wind tunnel data, utilizing a high speed digital computer for data reduction. Wind tunnel test data for store separation may be obtained from one, or a combination of, the following:

a. Captive trajectory. This test uses a strain gauge balance within the separating store to continually measure the forces and moments acting on the store. An on-line computer simulation determines successive positions of the store through its trajectory.

b. Grid data. An instrumented store or pressure probe is used to measure the forces and moments acting on the store in the flowfield through which the store must separate. Trajectories are calculated off-line using this information as inputs to a trajectory program.

c. Dynamic drop. The dynamic drop tests use dynamically scaled models that are physically separated in the wind tunnel. Data can either be photographical or telemetry. (This method is generally limited to simulated level flight releases only.)

d. Carriage loads. In this test forces and moments are measured on the store, with the store or weapon attached to the aircraft in its correct carriage position. These data are used as inputs to trajectory computation programs.

No one technique will suffice for all cases. Rather, the analyst must examine the particular case to be analyzed and select the technique that, in his opinion, offers the most advantages for his particular situation. Most purely theoretical techniques available today suffer severe degradation when applied to transonic store separation, or where multiple carriage is involved. However, recent advances in computational fluid dynamics and semi-empirical techniques provide excellent tools for engineering estimations or for use in conjunction with experimental data. Captive trajectories and dynamic drops are expensive in that they are only for a specific flight condition. Grid data are superior because many flight and store characteristics can be changed while the grid data are used as input for 6 degrees-of-freedom equations or other analytical tools. Wind tunnel testing is cheaper than flight testing when the cost of aircraft flight time, weapons assets, telemetry packages, and photogrammetric analyses are considered. For these reasons, most analysts today employ hybrid methods which reduce costs while retaining wide applicability.

4.1.4.5.2 Existing data review.

As a first step in store separation analysis, all available flight test and predicted data pertaining to the separation characteristics of the store in question, either from the aircraft being examine or others with similar installations, should be accumulated and screened for completeness of flight envelope coverage and for trends. If existing data covers the store's separation characteristics from the proper aircraft throughout the desired flight envelope, delivery conditions (speed, dive angle, load factors, altitude), delivery configuration and mode (single, pair, ripple), little or no additional testing may be required to allow certification. If this is not the case, however, additional data must be obtained in accordance with the method of store separation prediction chosen.

4.1.4.5.3 Separation envelopes.

Store employment covers separating the store from the aircraft in its normal operational mode. It should cover separations at all speeds up to the allowable in level and maneuvering flight, both in the single release mode, and in multiple release (ripple) mode down to the minimum release interval. Particular attention should be given to releases of unpowered stores in high dive angles (60^{o} or greater) at the attendant low g (cosine of the dive angle). Such separations

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can be, and often are, extremely dangerous, particularly for unstable or low density stores. In determining the separation envelope, the review should also consider that some parts of the flight envelope will not require analyses due to a more restrictive dive recovery or safe escape limitation. It should also be kept in mind that proper store employment denotes not only safe separation from the aircraft, but also that the separation be relatively unperturbed so as not to adversely affect delivery accuracy.

4.1.4.5.4 Launch transient analysis.

Analyzing the launch transient phase of store separation is extremely difficult. It generally involves guided stores, such as electro-optical guided bombs, which contain autopilot and guidance systems that are active during store separation to avoid target breaklock or radical store movements caused by release perturbations. If every component functions properly, separation will be completely safe and unperturbed. However, control failure or spurious guidance signals causing abnormal control deflections at release can cause high-energy collisions with the aircraft. Because of these possibilities, a reliability analysis of the store guidance and control system will be performed, and the results of possible failures identified and examined for probability of occurrence and effect on store separation. Although no specific pass-fail criteria can be used in all cases, probabilities of failure of a single component causing an impact on the aircraft should be kept in the realm of 10^{-6}. If this cannot be done, store redesign should be effected prior to flight testing.

4.1.4.5.5 Jettison criteria.

Jettison of a store (or a store/suspension equipment combination) involves the releasing of items from the aircraft during emergencies (emergency jettison) or as normal operation after expenditure of cargo or submunitions (selective jettison). Examples of these would be fuel tanks, gun pods, dispensers and multiple bomb racks complete with some or all of its weapons. The primary concern of any jettison is to separate the item, or items, from the aircraft safely, without collision, because there is no requirement for accurate delivery. This phase of store separation is by far the most dangerous to the releasing aircraft since many items jettisoned are aerodynamically unstable, usually of low density, and their separation behavior is generally erratic and unrepeatable. If at all possible, the jettison envelope of a store should be close to the full authorized carriage flight envelope. Jettisons are, however, commonly limited to level flight (plus and minus a reasonable g tolerance, and sideslip of helicopters). Jettison envelopes that are limited to a single speed, or those that specify a very narrow speed, altitude or dynamic pressure band, should be avoided, if at all possible.

4.1.4.6 Environmental analysis.

The store, suspension equipment and any affected aircraft components should or will be environmentally qualified to limits specified in their respective specifications. These limits could be substantiated by the methods delineated in MIL-STD-810 and in MIL-T-7743 for suspension racks and BRUs for each of the specified environments.

4.1.4.6.1 Store life-span considerations.

The initial environmental analyses should compare the natural and induced environment of the aircraft-store combination(s) in which the store and store suspension and release equipment must operate to that which has been or will be qualified. Of primary importance for these stores and equipment during this initial analysis is the operational or mission life-span. For some

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stores, this life-span could be a one-time flight while with other stores, such as fuel tanks, ECM pods, and air-to-air missiles, the life-span could be greater than the using aircraft.

4.1.4.6.1.1 Store employment impact.

On this initial comparative analysis, qualitative judgments can be used for most of the MIL-STD-810 environments. A few, such as vibration, acoustic/noise, and shock must be analyzed in detail considering the store locations on the candidate aircraft, store mix, mission profiles, number of flights and operational deployment such as desert, arctic or worldwide, and the effect of aircraft gun firing.

4.1.4.6.1.2 Initial determinations.

Results of this initial analysis will prove the preliminary limitations, if any, and determine if there is sufficient environmental data and whether or not additional environmental tests are required.

4.1.4.6.2 Synergistic and mutual interactions effects.

The next step is an analysis of the environmental capability of the aircraft-store suspension equipment wherein the synergistic environmental effects and mutual interactions between onboard systems and the proposed store, store suspension equipment and store carriage locations are considered. It should be cautioned that there may also be some unique environments produced by either the aircraft or the store that could adversely affect the aircraft-store compatibility conditions which need to be considered:

a. The aircraft vents and drains need to be investigated to determine if the material discharged will have an effect on any store which may be placed in the path of the material.

b. During store loading, release or launch, an array of miscellaneous debris could be released and includes such items as arming wire, clips, fibber optic cable, lanyards, frangible nose cones, lens covers, rocket motor plugs, dispenser caps, and ammunition links. Analysis should be made to ensure that this debris will not damage the aircraft, either by ensuring that it does not impact the aircraft, or is not ingested in the engine, or it is designed so that impact or ingestion will not do damage. Every attempt should be made to ensure that all possible debris is retained by the store itself.

c. An analysis of the affects of adjacent gun firing either from an internal gun or gun pod. Gun pod installations require the same analysis as the installation of an internal gun. A high cyclic rate gun creates an extremely hostile environment and all of the adverse by-products of gunfire (muzzle blast, gun gas, vibration and shock) need to be analyzed to determine their effect on the aircraft and adjacent stores.

d. An analysis of the potential damage or detrimental effects from debris kicked up from the flight deck or runway by the nose or main gear wheels. Water, slush, sand, pebbles and stones are the more common debris to be considered. This problem can worsen for aircraft operating from unprepared fields.

e. An analysis of turbulent boundary layer effects, shock wave impingement and flow changes caused by adjacent stores, pylons and aircraft surfaces. For aircraft with bomb bays, the cavity effects of the weapons bays should be analyzed.

f. An analysis of the synergistic effects from combinations of two or more of the following: aerodynamic heating, altitude variations, humidity, shock wave, dynamic pressure, vibration and acoustics.

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g. An analysis of electrical interactions between the store and the store management system as electrical changes-of-state occur at release.

4.1.4.6.3 Acceptance criteria.

Any proposed store or store location for which the analyses predict excessive degradation of store performance or damage to store components/adjacent aircraft equipment should be rejected or limitations imposed to bring the degradation/damage within acceptable limits.

4.1.4.6.3.1 Analyses verification.

Sufficient ground and flight tests should be conducted to verify the validity of the synergistic and interactive environmental analyses.

4.1.4.7 Store propulsion analysis.

There is a need to analyze the effects of gas and other by-products produced by thrust-augmented stores. This analysis is concerned with two major effects of these stores, namely the impingement of the expended gas and suspended foreign material (plume) on the aircraft surfaces or other stores and the ingestion of this plume by the aircraft engines(s). Rockets, air-to-air and air-to-ground missiles are the principle thrust-augmented stores although any store, chaff/flare dispenser or suspension and release device utilizing a system that expends gas or other foreign material during employment of stores should be reviewed for potential impact of the expended by-products. Initially, an analysis or investigation should be made to evaluate the location of these thrust-augmented stores with regard to minimizing the impingement and engine ingestion problems with the reduction of ingestion by the engine(s) having the greater priority. Location or relocation of the stores to attain these goals should be accomplished if at all possible. Aside from the exhaust gas plume of the thrust-augmented stores, other foreign material such as clips, chaff, frangible nose cones and lens coverings can also be expended during operational employment of these stores. The analysis for these foreign materials was addressed in 4.1.4.6.2 and will not be discussed here although the analyses may be accomplished together. Although undesirable, some very limited amounts of chaff and other frangible material may be tolerated by some engines, but must be carefully evaluated by the respective engine authority.

4.1.4.7.1 Engine ingestion.

Primarily this analysis is intended to address the gas plume and any foreign material suspended within this plume. Ideally, aircraft jet engines should not ingest any of these gases or other by-products. However, due to the limitation of store locations on some aircraft, engine(s) ingestion of some of these plume gases will occur under many of the flight conditions desired for the store(s) employment. The engine ingestion analysis must include an estimate of the maximum or most critical amount of gas that would be ingested for those flight conditions under which the store(s) would be employed. The flight conditions, (i.e., speed, altitude and maneuvers that would create these conditions) must be determined by suitable analysis or preferably, empirical data from flight tests on similar installations under similar conditions. The permissible quantity and characteristics of ingested gas is a function of the engine, engine controls and sensors, altitude, ambient air conditions at altitude and aircraft velocity. In conjunction with the quantity of gas that will be ingested, the chemical composition of the gas plume and associated temperature, pressure, density and air dilution, plus any foreign material within the exhaust gases (alumina) and shock waves, must be evaluated for detrimental engine

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affects. Flameout, overspeed and non-self-recoverable surge stalls are detrimental effects that can result if the ingested gas variable are of sufficient severity.

4.1.4.7.1.1 Acceptance criteria.

The ingested gas/smoke should not exceed the ingestion sensitivity limits of the respective engine(s). The sensitivity characteristics and their limits must be or have been determined by previous tests. If not, only qualitative judgments can be made. There are several alternatives, aside from relocation of the stores, that may be acceptable if there are adverse effects, to the engine(s), from gas ingestion. These are:

a. Stall/surge improvement devices (compressor bleed, variable geometry) can be actuated.

b. Engines can be scheduled for continuous ignition.

c. To a limited extent, evasive maneuvers or alterations of the flight path can be accomplished.

d. Engine automatic restart procedures can be incorporated.

e. Employment of the store can be restricted to acceptable engine limits only.

4.1.4.7.2 Gas plume impingement.

After store location has been satisfied with respect to the engine ingestion problems, an analysis must be made of the impingement effects of the gas plume on the aircraft or on other stores. Factors that must be considered for the gas plume are residue build-up and its chemical composition, corrosion, blast overpressure, shock wave, thermal effects and the erosion due to the velocity of the exhaust by-products. In considering these factors, the added effects of the natural environments such as humidity, rain, salt spray and solar heat must also be considered. These factors must be considered synergistically as well as individually.

4.1.4.7.2.1 Acceptance criteria.

Limits must be established on the degree of damage or adverse effects that are acceptable. These will vary from aircraft-to-aircraft, but past knowledge of the effects on similar installations is one of the best guides to acceptability. Blast, thermal or other effects that puncture, deform, separate or otherwise weaken the skin of the aircraft or other stores are unacceptable. Scratches, small dents and erosion may be acceptable to some degree, but this degree must be known. If the damage or adverse effects are unacceptable, heavier or tougher skin, abrasive resistant coverings, paint or other protective measures will be required. Evaluation of pylon wiring and suspension equipment may dictate the need for add-on blast deflectors. This should be specified at the beginning if the analysis indicates adverse effects. Smoke or gas residue also can be acceptable to some degree. For instance, cleaning the aircraft at specific intervals is generally an accepted remedy to prevent residue build-up or corrosion.

4.1.4.8 Shipboard suitability analysis.

If the store to be authorized is intended for use on a Navy aircraft, then a shipboard suitability analysis must be performed. This analysis must consider all effects of shipboard catapulting and arrested landings as well as packaging, underway replenishment, handling, loading, stowage, early service preparation and downloading and explosive safety considerations. The criteria for shipboard suitability are specified in AIR STD 20/21 and SD-24.

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4.1.4.8.1 Ship suitability test (SST).

The SST is conducted only once for each weapon system introduced into the Fleet for operational use. The test involves Navy personnel rather than contractor or government engineers, and is performed in a CV having been modified or altered for the weapon system, subjecting the weapon system to replenishment, at sea (UNREP), decanning, strikedown, stowage, strikeup, assembly, servicing, checkout, and arming operations. Handling operations are checked for simplicity, and for compatibility with the crewmen who will perform them. The test is concerned with readiness of the system for Fleet use by determining if the packaging will protect the component or weapon in transit from the manufacturer to the user and throughout handling at sea; if the package design is optimum for expeditious strikedown and transfer to minimize time required alongside the ammunition ship; if the missile and airborne missile control system can withstand repeated catapult launchings and arrested landings without degradation; if adequate spare parts are available to fill squadron needs; if the weapon, airborne missile control system, and associated aircraft circuitry are ready for use by Fleet personnel without contractor assistance; if the ordnance safety provisions are adequate when the weapon is undergoing below deck handling, loading, and exposure to RF radiation; if the weapon can be safely loaded to the aircraft in adverse weather and in darkness; and if the test equipment can reliably determine combat-readiness of the aircraft and the weapon.

4.1.4.9 Target acquisition analysis for guided weapons.

Installation of a guided weapon on a relatively flexible aeroelastic structure results in dynamic coupling motion between the weapon and the aircraft. The resultant pointing error signals can induce violent corrective movements of the weapon control system which can prevent target acquisition by the weapons target seeker systems.

4.1.4.9.1 Dynamic analysis.

A preliminary dynamic analysis should be performed to determine predicted coupling modes and magnitudes of motion. The effects of these dynamic amplitudes, mode shapes, and frequencies upon the weapon should be determined with as much detail as practical for a preliminary analysis.

4.1.4.9.2 Correlation of inputs.

The predicted mode shapes, amplitudes, and frequencies should be correlated to the vibration input to provide a basis for extrapolation to other dynamic input conditions.

4.1.4.9.3 Data required.

As a minimum, the predicted dynamic displacements of the weapon target seeker head due to aircraft maneuver or gust loads and the resulting weapon pointing error signals should be calculated; the structural resonant frequencies for the combined weapon and aircraft should be calculated, and the target “lock-on” electrical signal for the combined weapon and weapon control system should be analyzed and the electrical resonant frequencies calculated. Data format should be both tabular and graphical providing not only amplitudes and frequencies but also predicted wave forms.

4.1.4.9.4 Data input for analysis.

The following data will be required:

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a. Identification of the weapon to be analyzed, its proposed mounting location, the proposed carriage vehicle, and the proposed carriage/launch flight envelopes.

b. Structural stiffness and mass distribution for the weapon.

c. Structural dynamic mode shapes and frequencies for the weapon when supported at its attachment points by a rigid body.

d. Dynamic displacements and frequencies for the proposed weapon mounting location on the aircraft with a mass duplicating the weapon mounted at the proposed location.

e. Electrical circuit characteristics for the weapon target seeker and weapon control system.

f. Dynamic characteristics of the weapon target seeker head and its servo mechanisms.

4.1.4.9.5 Analysis procedure.

A structural dynamic displacement program compatible with the computer to be used should be prepared and recorded in a recognizable format so that the identical analysis can be duplicated. The weapon structural dynamic characteristics should be fed into the program as fixed constants. The predicted dynamic displacements of the proposed weapon mounting location should be input to the program as independent variables with the resulting dynamic motion of the weapon and its dynamic mode shapes recorded as the dependent variable.

4.1.4.9.5.1 Alignment checks.

The angular alignment of the line between target seeker head and target location relative to the weapon centerline should be calculated as a time dependent variable from the data obtained during the structural dynamic analysis. The angular alignment data should be input as the independent variable to a computer program simulating the weapon target acquisition/weapon control system. The dynamic response of the target seeker head and the target acquisition cockpit display signal should be recorded as the dependent variables. The dependent variable dynamic amplitudes should be compared to the allowable amplitudes for the weapon/weapon control system and the dependent variable resonant frequencies compared with the structural resonance frequencies of the weapon/weapon mounting system combination.

4.1.4.9.6 Acceptance criteria.

Any proposed weapon mounting location for which the analysis indicates the weapon seeker head motion induced by dynamic displacement of the weapon mounting location is divergent in form should be rejected. If the analysis indicates the target acquisition display signal is incompatible with a recognizable “lock-on” display, the proposed weapon mounting location and arrangement should be rejected.

4.1.4.10 Gun gas analysis.

See 4.1.4.6 for an analysis of the effects of the hostile environment generated by gunfire. In addition to this hostile environment, the gunfire also generates large volumes of gun gas. It is generated at a rapid rate and is a direct function of the propellant per round, the firing rate, and the burst length. With the abundant air available in flight, the resulting gas-air mixture becomes flammable and explosive over a broad range. The limits of the explosive mixture when combined in an enclosure are referred to as the lower explosive limit (LEL) and the upper explosive limit (UEL).

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4.1.4.10.1 Ingestion and impingement.

The gun gas emanates from the barrel muzzle and from the breech of the gun during gunfire. Although most of the gas from the muzzle is expended overboard; some, due to the forward velocity of the aircraft, can be rammed back down the barrel(s) or past the forward barrel seal into the gun compartment. The external gun gas, be it from an internal mounted gun or a gun pod, should be analyzed for engine ingestion and impingement on the aircraft the same as the thrust-augmented store gas plume detailed in 4.1.4.7. Although the significant effects of gun blast, gas and smoke are generally confined to the muzzle area, smoke residue may accumulate over other sections of the airframe. Another hazard of the free stream gun gas, as implied above, it its ability to ignite and burn near the aircraft. Although this phenomena is undesirable for several reasons, the effects on engine ingestion are the same as detailed in 4.1.4.7 for plume ingestion except the severity can be greater due to the greater fluctuations in the temperature and pressure transients.

4.1.4.10.2 Explosive effects.

The muzzle and breech gas that enters the gun and ammunition bays of the aircraft or pod must be considered. As previously stated, the gas/air mixture accumulated within the bays can be explosive. The analysis must therefore address the generation, accumulation or pocketing of the gun gas, the ventilation system for the gun and ammunition bays to prevent the gas accumulation and the flight conditions, (i.e., altitude, flight attitude and velocity during gunfire). The ventilation system may consist of a purge and scavenge system or only a scavenge system. The analysis must also consider the design of the gun and ammunition bays with regards to air flow, gun gas flow from the gun bay to the ammunition compartment and a qualitative judgment of potential gas/air mixture pockets.

4.1.4.10.3 Acceptance criteria.

4.1.4.10.3.1 External gun(s).

Acceptance criteria for external gun gas is the same provided for gas plumes from thrust-augmented stores in 4.1.4.7.

4.1.4.10.3.2 Internal gun.

The purpose of the internal gun gas analysis is to assure that gas-air mixtures do not occur between the upper and lower explosive limits. The ventilation system must accomplish this effort with a minimum drag penalty to the aircraft. Acceptance criteria is the nonexistence of any potential explosive gas-air mixture. As a safety feature, the design of the gun and ammunition bays should withstand a 5 psi over-pressure without catastrophic results. Lowered area(s) or a blowout panel(s) are accepted design approaches to limit the bay overpressures. If the gun and ammunition bays do not meet this design criteria, they are not acceptable.

4.1.4.11 Thermal analysis.

4.1.4.11.1 General.

The purpose of the thermal analysis is to determine the critical components of the store, the response of these components to anticipated flight and atmospheric conditions, and finally to prove a means by which parametric sensitivity studies can be made for determining the

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important variables for duplication in subsequent ground and flight test facilities. The results of these analyses provide preliminary data for the full range of flight and atmospheric conditions.

4.1.4.11.2 Data requirements.

a. Store definition.
b. Store component and critical temperatures.
c. Store/aircraft flight regimes and specific atmospheric conditions.
d. Store component temperature range.
e. Store heating distributions.
f. Appropriate analytic model of store.
g. Failure criteria or means of interpreting analytic results.

4.1.4.11.2.1 Store definition.

Adequate definition of the store for which the analysis is to be run should be obtained. This includes hardware and drawings as well as store component material and the properties; density, specific heat, thermal conductivity and emissivity.

4.1.4.11.2.2 Store components and critical temperatures.

A list of store components which have a temperature range likely to be exceeded by flight and atmospheric conditions should be compiled along with the limiting temperature. This list should also include heat generation information on functional components such as electronics packages and thermal batteries.

4.1.4.11.2.3 Store/aircraft flight regimes and specific atmospheric conditions.

Determine the Mach number-altitude profiles which the store will encounter in flight. Due to the wide range of possible profiles, a generalized profile may have to be generated which incorporates the flight condition extremes. A standardized atmosphere should be chosen from MIL-STD-210 which gives climatic extremes. The extremes should be chosen carefully and realistically to avoid undue penalty on the store.

4.1.4.11.2.4 Store component temperature range.

Store component temperature range is set by two values - the initial temperature achieved by the component prior to the flight condition in question and the maximum attainable temperature at the condition in question, (i.e., the adiabatic wall temperature). The initial temperature is determined by the store environment in storage or by the flight environment experienced prior to the flight condition for which the thermal analysis is being performed. Determination of store component temperatures under storage conditions is outlined in MIL-STD-1670. Temperatures experienced in storage can range as high as 150^{o}F. Initial temperature in flight may be determined by thermal analysis or by assuming the flight time is long enough that an equilibrium temperature is established. This temperature is $T_{\text{adiabatic wall}}$ (T_{aw}).

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Adiabatic wall temperature may be computed as follows:

$$T_{aw} = T_{\infty} \ (1+0.2r \ M_{\infty}^{2})$$

where:

r = 0.85 for a laminar boundary layer and 0.90 for a turbulent boundary layer,

T^{∞} = Free-stream temperature, and

M^{∞} = Freestream Mach Number.

4.1.4.11.2.5 Store heating distribution.

Interference-free estimates of store heating distributions may be obtained by generating the inviscid pressure distribution over the body in question through techniques such as the South-Jameson Code or the Method of Characteristics Program. These data are then input to an appropriate boundary-layer program such as Spalding-Chi or BLIMP and a heat-transfer coefficient is generated. Estimates of interference heating due to shock impingement and swaybrace influence should be obtained and included in the analysis if possible. Interference effects will probably have to be evaluated from experimental results since interference flow fields are complex and do not lend themselves to analytical calculations. If experimental data is not available, interference-free predictions should be multiplied by 1.5 to obtain a conservative estimate. A more comprehensive discussion of analytical techniques is provided in MIL-STD-1670 and additional publications to aid in assessing heating distributions are included in the reference section.

4.1.4.11.2.6 Analytical model.

A mathematical heat conduction model of the store should be developed with the complexity of the model suited to the need. It can range from a complex three-dimensional finite element model to a simplified equation. In formulating the analytic model, information concerning store definition, construction, and thermal properties is required (see 4.1.4.11.2.1 and 4.1.4.11.2.2). Critical heat paths should be identified and modeled as well as any internal heat generation and the components which produce the heat.

4.1.4.11.2.7 Failure criteria.

Guidelines for interpreting the analytic results should be formulated so that the end result will be realistic and applicable. The criteria should answer questions such as what is the cause of the limiting temperature of a specific component, is the temperature realistic, how much of the critical component may overheat before the situation is truly critical.

4.1.4.12 Ballistic analysis.

4.1.4.12.1 Store behavior.

Analysis of the ballistic behavior of a store in the presence of separation effects often presents a difficult problem, but one that must be solved if ballistic accuracy requirements are to be met.

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Ballistic analysis in the evaluation of aircraft-store compatibility should be coordinated with the aerodynamic and separation analyses discussed in 4.1.4.3 and 4.1.4.5, respectively.

4.1.4.12.2 Store accuracy.

Ballistic accuracy may be assessed for two store flight regimes. The first is the free-stream ballistics independent of the releasing aircraft and occurs after initial store separation disturbances have decayed. The other is for the entire store flight trajectory and is characteristic of the weapon, the releasing aircraft, the specific aircraft configuration, and the release conditions.

4.1.4.12.3 Ballistics validation.

Undisturbed trajectories may be analyzed to determine both a ballistic drag coefficient compatible with a single point (particle) math model that best represents the ballistic performance of the store and an estimate of the ballistic dispersion in mils (CEP) - in a plane normal to the trajectory. The CEP should be less than an allowable maximum, compatible with an estimate of system accuracy desired for the worst anticipated delivery system. For inventory stores, the JMEM will identify required CEP and how to calculate the CEP from test releases. In many instances, e.g., when evaluating compatibility of an existing store on a new aircraft, ballistics and CEP of the store independent of the aircraft will be known before the compatibility flight tests begin. If this is not the case, it will be necessary to conduct and analyze drops to establish aircraft independent ballistics before any ballistic conclusions can be drawn from the compatibility drops. If such drops are required, MIL-B-81006 should be employed to minimize the number of drops required to demonstrate that dispersion requirements are met.

4.1.4.12.4 Ballistics assessment.

Assessment of ballistic accuracy for the store/aircraft delivery system requires a much larger envelope of release conditions and configurations than is required to establish aircraft independent ballistics. Maximum ballistic CEP values for each weapon/aircraft combination should be assigned based on the probability of target kill envelope desired, overall system accuracy, and the ratio of ballistic error to overall delivery system error (it would be unrealistic to assign a low CEP for an inaccurate delivery system). Free flight drop tests will determine what limitations must be placed on aircraft release envelopes, store loading configurations and other parameters.

4.1.4.12.5 Missile fire control analysis.

An assessment of the missile accuracy should be conducted. The effects of the missile system errors; background clutter; boresighting; installation; and target range, speed and maneuver should be included. The analysis should include the entire missile system static and dynamic error budget and error prediction. The error budget and prediction should address subsystems that interface with the missile system and affect its hardware and software performance.

4.1.4.12.6 Rocket fire control analysis.

An analysis should be conducted to determine the expected rocket system accuracy. The boresight effect and system errors should be included. The analysis should include the entire rocket system error budget and error prediction. The error budget and error prediction should address other subsystems that interact with the rocket system an affect its hardware and software performance.

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4.1.4.12.7 Gun accuracy analysis.

The analysis should address all variables affecting gun system performance such as:

a. System errors:

(1) Ammo dispersion.

(2) Gun pointing error.

(3) Fire control prediction error.

(4) Aircraft position, orientation, speed and acceleration errors.

(5) Any other errors, such as: boresight errors, target track errors, range errors (measured and filtered), state estimate errors including time of flight error, body bending error, etc.

b. Target type, maneuver, and range.

4.1.4.13 Safe escape analysis.

4.1.4.13.1 General.

Safe escape analyses are required on all munition systems which could potentially be hazardous to the aircraft due to munition fragmentation. These analyses will consider munitions functioning within design specifications as well as potential munition failure modes identified by the following: munition SPO/PMA, Non-Nuclear Munitions Safety Board, Weapons Systems Safety Review Board or the operational user. Aircraft delivery profiles for the munitions will also be considered in the analyses. For the USAF, analyses will be conducted in accordance with methodology documented in the Advanced Safe Escape Program (ASEP) Analyst Manual. For the Navy, analyses will be conducted in accordance with methodology documented in the Probability of Aircraft Tactical Hazard (PATH) manuals. The munition fragmentation characteristics will be determined by firings in a static arena test. These area test firings will be conducted in accordance with the JMEM, test procedures for high explosive munitions. For the Army, the analysis is called clearance analysis and should be conducted to show adequate clearance in accordance with AIR STD 20/21 for the worst case within the predicted safe launch envelope.

4.1.4.13.2 Acceptance criteria.

Any potential hazard predicted by the analyses due to munition fragmentation or proposed aircraft/munition configuration will be either rejected or limitations will be imposed. Limitations consist of aircraft delivery conditions (altitude/dive angle/maneuver) necessary to attain safe escape criteria.

4.1.4.14 Electromagnetic analysis.

4.1.4.14.1 General.

The store and suspension system should be analyzed to determine electromagnetic compatibility among all subsystems and equipment within the aircraft system and with the electromagnetic environment (EME) external to the aircraft including p-static and lightning. For the Navy applications, analysis should address all life cycle aspects of the system, including (as applicable) normal in-service operation, checkout, storage, transportation, handling, packaging,

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loading/unloading, and launch and the normal operating procedures associated with each aspect.

4.1.4.14.1.1 Acceptance criteria.

Compliance should be verified by test, analysis, or a combination thereof. Instrumentation installed in store and suspension system components during testing for margins should capture the maximum store and suspension system response and should not adversely affect the normal response characteristics of the component. When environmental simulations below specified levels are used, instrumentation responses may be extrapolated to the full environment for components with linear responses (such as hot bridgewire electrically initiated devices (EIDs)). When the response is below instrumentation sensitivity, the instrumentation sensitivity should be used as the basis for extrapolation. For components with non-linear responses (such as semiconductor bridge EIDs), no extrapolation is permitted.

4.1.4.14.2 Margins.

Margins should be evaluated based on store and suspension system operational performance requirements, tolerances in system hardware, and uncertainties involved in verification of system-level design requirements. Safety critical and mission critical store and suspension system functions should have a margin of at least 6 dB. Ordnance should have a margin of at least 16.5 dB of maximum no-fire stimulus (MNFS) for safety assurances and 6 dB of MNFS for other applications.

4.1.4.14.3 Intra-system electromagnetic compatibility (EMC).

The store and suspension system should be evaluated to ensure electromagnetic compatibility within itself such that aircraft system operational performance requirements are met.

4.1.4.14.3.1 Acceptance criteria.

Compliance should be verified by system level test, analysis, or a combination thereof.

4.1.4.14.4 Intersystem EMC.

The store and suspension system should be evaluated to ensure electromagnetic compatibility with its defined external EME such that the aircraft system operational performance requirements are met. Representative EMEs are provided in MIL-STD-464.

4.1.4.14.4.1 Acceptance criteria.

Compliance should be verified by system, subsystem, and equipment level tests; analysis; or a combination thereof.

4.1.4.14.5 Lightning.

The store and suspension system should be evaluated to ensure that there is no degradation of the aircraft system such that it does not meet its operational performance requirements for both direct and indirect effects of lightning. For Navy applications, ordnance should be evaluated to ensure that it meets operational performance requirements after experiencing a near strike in an exposed condition and a direct strike in a stored condition. For Navy applications, ordnance should be evaluated to ensure that it remains safe during and after experiencing a direct strike in an exposed condition. The lightning levels are providing in MIL-STD-464.

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4.1.4.14.5.1 Acceptance criteria.

Compliance should be verified by system, subsystem, equipment, and component (such as structural coupons and radomes) level tests; analysis; or a combination thereof.

4.1.4.14.6 Electromagnetic pulse (EMP).

The store and suspension system should be evaluated to ensure that it does not degrade the aircraft system such that it does not meet its operational performance requirements after being subjected to the EMP requirement. The EMP levels are provided in MIL-STD-464. This requirement is not applicable unless otherwise specified by the procuring activity.

4.1.4.14.6.1 Acceptance criteria.

Compliance should be verified by system, subsystem, and equipment level tests; analysis; or a combination thereof.

4.1.4.14.7 Subsystems and equipment electromagnetic interference (EMI).

Individual store and suspension subsystems and equipment should be evaluated to ensure they meet interference control requirements (such as the conducted emissions, radiated emissions, conducted susceptibility, and radiated susceptibility requirements of MIL-STD-461) so that the overall aircraft system complies with all applicable requirements of MIL-STD-464.

4.1.4.14.7.1 Acceptance criteria.

Compliance should be verified by tests that are consistent with the individual requirement (such as testing to MIL-STD-462 to verify MIL-STD-461 compliance).

4.1.4.14.7.2 Non-developmental items (NDI) and commercial items.

NDI and commercial store and suspension items should be evaluated to ensure they meet EMI interface control requirements suitable for ensuring that aircraft system operational performance requirements are met.

4.1.4.14.7.2.1 Acceptance criteria.

Compliance should be verified by test, analysis, or a combination thereof.

4.1.4.14.7.3 EM spectrum compatibility.

Store and suspension subsystems and equipment should be evaluated to ensure compliance with the DoD, national, and international regulations for the use of the electromagnetic spectrum. (See NTIA “Manual of Regulations and Procedures for Radio Frequency Management” and DoDD 4650.1.)

4.1.4.14.7.3.1 Acceptance criteria.

Compliance should be verified by test, analysis, or a combination thereof.

4.1.4.14.8 Electrostatic charge control.

The store and suspension system should be evaluated to ensure that they control and dissipate the buildup of electrostatic charges caused by precipitation static (p-static) effects, fluid flow, air

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flow, space and launch vehicle charging, and other charge generating mechanisms to avoid fuel ignition and ordnance hazards, to protect personnel from shock hazards, and to prevent performance degradation or damage to electronics.

4.1.4.14.8.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

4.1.4.14.8.2 Vertical lift and inflight refueling.

The store and suspension system should be evaluated to ensure they meet operational performance requirements when subjected to a 300 kilovolt discharge. This requirement is applicable to vertical lift aircraft, inflight refueling of any aircraft, and systems operated or transported externally by vertical lift aircraft.

4.1.4.14.8.2.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof. The test configuration should include electrostatic discharge in the vertical lift mode and inflight refueling mode from a simulated aircraft capacitance of 1000 picofarad, through a maximum of one ohm resistance. (See MIL-STD-331 for test methodology for verification compliance of ordnance systems.)

4.1.4.14.8.3 Precipitation static (P-static).

The store and suspension system should be evaluated to ensure they control p-static interference to antenna-connected receivers such that system operational performance requirements are met.

4.1.4.14.8.3.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof. P-static protection should be verified by testing that applies charging levels representative of conditions in the operational environment.

4.1.4.14.8.4 Ordnance subsystems.

Ordnance subsystems should be evaluated to ensure that they are not inadvertently initiated or dudded by a 25 kilovolt electrostatic discharge caused by personnel handling.

4.1.4.14.8.4.1 Acceptance criteria.

Compliance should be verified by test, discharging a 500 picofarad capacitor through a 500 ohm resistor to the ordnance subsystem (such as electrical interfaces, enclosures, and handling points). (See MIL-STD-331 for test methodology for verification compliance of ordnance.)

4.1.4.14.9 Electromagnetic radiation hazards (EMRADHAZ).

The store and suspension system design should be evaluated to ensure that they protect personnel, fuels, and ordnance from hazardous effects of electromagnetic radiation.

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4.1.4.14.9.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

4.1.4.14.9.2 Hazards of electromagnetic radiation to personnel (HERP).

The store and suspension system should be evaluated to ensure compliance with current national criteria for the protection of personnel against the effects of electromagnetic radiation. DoD policy is currently found in DoDI 6055.11.

4.1.4.14.9.2.1 Acceptance criteria.

Compliance should be verified by test, analysis, or combination thereof.

4.1.4.14.9.3 Hazards of electromagnetic radiation to fuel (HERF).

The store and suspension system should be evaluated to ensure fuels are not inadvertently ignited by radiated EMEs. The EME includes includes onboard emitters and the external EME specified in MIL-STD-464.

4.1.4.14.9.3.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspection, or a combination thereof.

4.1.4.14.9.4 Hazards of electromagnetic radiation to ordnance (HERO).

Ordnance with electrically initiated devices (EIDs) should be evaluated to ensure that they are not inadvertently activated during, or experience degraded performance characteristics after, exposure to the external radiated EME for either direct RF induced actuation or coupling to the associated firing circuits. EMEs are provided in MIL-STD-464.

4.1.4.14.9.4.1 Acceptance criteria.

Compliance should be verified by system, subsystem, and equipment level tests and analysis. For EME's in the HF band derived from near field conditions, verification by test should use transmitting antennas representative of the types present in the installation.

4.1.4.14.10 Life cycle, E^3 hardness.

For Navy and Army applications, the store and suspension system operational performance and E^3 requirements should be evaluated to ensure they meet these requirements throughout the rated life cycle of the system and includes, but is not limited to, the following: maintenance, repair, surveillance, and corrosion control. For Air Force applications, the aircraft/store and suspension configuration should be evaluated to ensure they meet E^3 requirements throughout the rated life cycle of the system and includes, but is not limited to, the following: maintenance, repair, modification, and corrosion control.

4.1.4.14.10.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof, of system design features. Maintainability, accessibility, and testability, and the ability to detect degradations should be demonstrated.

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4.1.4.14.11 Electrical bonding.

The store and suspension system, subsystem, and equipment should be evaluated to ensure they include the necessary electrical bonding to meet the E^3 requirements of MIL-STD-464.

4.1.4.14.11.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof, for the particular bonding provision.

4.1.4.14.11.2 Antenna installations.

Antennas should be evaluated to ensure they are bonded to obtain required antenna patterns and meet the performance requirements for the antenna.

4.1.4.14.11.2.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

4.1.4.14.11.3 Electrical bonding for control of EMI.

The store and suspension system electrical bonding should be evaluated to ensure they provide electrical continuity across external mechanical interfaces on electrical and electronic equipment, both within the equipment and between the equipment and system structure, for control of E^3 such that the aircraft system operational performance requirements are met. For Navy aircraft and Army aircraft applications, the EMI bonds should have an interface direct current (DC) resistance of 2.5 milliohms or less for each faying interface between the subsystem or equipment enclosure and the system ground reference.

4.1.4.14.11.3.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

4.1.4.14.11.4 Shock and fault protection.

Bonding of all exposed electrically conductive items subject to fault condition potentials should be evaluated to ensure they control shock hazard voltages and allow proper operation of circuit protection devices.

4.1.4.14.11.4.1 Acceptance criteria.

Compliance should be verified by test, analysis, or a combination thereof.

4.1.4.14.12 External grounds.

The store and suspension system and associated subsystems should be evaluated to ensure they provide external grounding provisions to control electrical current flow and static charging for protection of personnel from shock, prevention of inadvertent ignition of ordnance, fuel and flammable vapors, and protection of hardware from damage.

4.1.4.14.12.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

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4.1.4.14.13 TEMPEST.

The store and suspension system should be evaluated to ensure national security information is not compromised by emanations from classified information processing equipment.

4.1.4.14.13.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections or a combination thereof. (See NSTISSAM TEMPEST/1-92 and NACSEM 5112 for testing methodology for verifying compliance with TEMPEST requirements.)

4.1.4.14.14 For Navy applications, emission control (EMCON).

The store and suspension system should be evaluated to ensure unintentional electromagnetic radiated emissions do not exceed -110 dBm/m^2 at one nautical mile in any direction from the system over the frequency range of 500 kHz to 40 GHz.

4.1.4.14.14.1 Acceptance criteria.

Compliance should be verified by test and inspection.

4.1.4.14.15 For Navy applications, electronic protection (EP).

The store and suspension system should be evaluated to ensure intentional and unintentional electromagnetic radiated emissions in excess of the EMCON limits preclude the classification and identification of the system such that system operational performance requirements are met. EP should be activated by a single control function, unless otherwise specified by the procuring activity.

4.1.4.14.15.1 Acceptance criteria.

Compliance should be verified by test, analysis, inspections, or a combination thereof.

4.1.5 Results of engineering analyses.

4.1.5.1 Determination.

Upon completion of the engineering analyses, if the desired degree of aircraft-store compatibility has been determined and acceptable flight operating limitations established, the combination may be certified with no additional effort. In the event compatibility cannot be determined by analysis of the data provided, the requesting activity should be advised as to the additional data, analysis or testing that is required for the determination, the estimated costs of the tests or analyses required, and the approximate time required for completion.

4.2 Test requirements and planning.

4.2.1 General.

Store certification tests are, for the most part, conducted for two reasons. The first is to validate the results of analysis. If the validation can be made early in the test program by favorable comparison of predictions to test results, the test program can often be significantly shortened. The second reason for testing is to provide data where no quantitative prediction can be made. In either case, after the test, the data must be examined, either qualitatively or quantitatively, to

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determine the acceptability of the degree of compatibility exhibited by the aircraft-store configuration being examined. Where there are deficiencies in the existing data, tests are planned to provide experimental data for use in the certification analysis. Ground and flight tests should be planned to provide quantitative data or verify analyses through physical tests at points throughout the desired aircraft-store operational envelope. Test requirements must be explicit and must be prepared in accordance with physical limitations of the aircraft-store combination, insofar as these limitations are known, and must reflect the mission requirements as specified by the using agency. The specific test requirements are dependent upon the required operational conditions and upon previous experience with both the store and the aircraft. Often during testing of aircraft-store configurations, the extreme test conditions must be approached incrementally, and the locus of the test results plotted concurrently. This is particularly critical in determining buffet boundaries and flutter limits.

4.2.2 Types of testing.

Certification testing must include tests to evaluate the aircraft, stores, suspension equipment, and, in some cases, ground handling equipment. These tests are intended to evaluate the total aircraft-stores/suspension equipment combination, not the individual components, except as each component relates to the overall combination. Evaluation of aircraft, except for its ability to carry and employ stores, is not part of this certification procedure. In general, certification testing can include any or all the tests listed in appendices A and B. Where software changes are introduced to the Stores Management Set and Fire Control/Mission Computer, software verification testing should be accomplished before flight test of the store being certified.

4.2.3 Mission requirements.

When determining the extent of testing necessary, the mission requirements for the aircraft-stores/suspension equipment involved should be ascertained from the using agency. To ensure that appropriate testing is provided for, operational objectives such as speed, altitude, and acceleration for carriage, employment, and jettison must be specified. Also, such factors as range, delivery modes, delivery accuracy, loading configurations and mission profile must be identified.

4.2.4 Test sequence.

Both ground test and flight test data are usually necessary for certification. Much of the ground testing must be completed before flight tests begin for reasons of safety and as a means to reduce flight test costs. Modeling flight configurations in wind tunnel tests is particularly useful because simulating flight environment under laboratory conditions in the wind tunnel avoids many risks inherent to flying near operational boundaries. Aerodynamic effects of stores on the aircraft, captive environment for the stores, store separation characteristics, store aerodynamics and flutter tendencies are factors which are generally investigated in a wind tunnel. These data will not completely eliminate the requirement for flight investigations for the aerodynamic parameters; however, the quantity of flight testing is greatly reduced by defining areas of the operational envelope critical to certification. Performance of the tests themselves is usually carried out in a specific sequence. Store fit tests should be performed prior to any flight testing. Captive flight testing should be performed prior to any store employment or jettison testing. Single store separations in level flight should precede any tests in multiple, or ripple modes or in dive angles. Sequential testing of this type is done to maximize the safety of the aircrew and test aircraft.

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4.2.5 Data acquisition.

When the test requirements are identified and the test planning is in progress, it may be determined that certain data are required to satisfy the certification test objectives. These data requirements should be identified early in the test planning process in order to assure that test facilities and capabilities are available at the time of the certification test. In addition to identifying facilities and capabilities, the early identification of data also identifies the data reduction and analysis needed to satisfy the certification requirement.

4.2.6 Test planning.

When it has been ascertained that some certification testing is required, specific tests should be planned. Suggested procedures for performing these tests are delineated in appendixes A and B. Procedures are provided for the types of tests that might be necessary. The specific test program selected for the desired store certification should initially be tests chosen from those given in appendices A and B.

4.2.6.1 Explosive safety.

When the test items contain explosive materials or components, the test must be performed with proper safeguards established for personnel and equipment. Safety procedures and equipment consistent with the hazard level involved must be utilized to provide adequate protection in case of an explosion at any point in the performance of the test.

4.3 Completion of compatibility analyses.

4.3.1 Determinations.

Many aircraft-store compatibility determinations may be accomplished by analogy to another previously certified aircraft-store with no effort other than a similarity survey. If this is not possible, certification may still be accomplished through the analyses discussed in 4.1 through 4.1.5.1. If, after analysis, certification still cannot be accomplished, and tests or further analyses must be performed, the data resulting must be reduced, examined, combined with that previously available, and the total compared with that necessary for store certification. Any analysis that is required for certification should be conducted in the same way as those described previously.

4.3.2 Certification recommendation.

If it is concluded that the store may be certified for operational use, a positive certification recommendation should be made to the certifying agency. It is important that negative recommendations for certification are also properly documented so that, in the future, the tests and analyses need not be repeated if another request for certification is received.

4.3.3 Responsibilities.

Organizational and functional responsibilities in the aircraft-store certification process are delineated for the USAF in AFI 63-104, for the Navy in NAVAIRINST 13034.1, and 13100.14 and for the Army in AMCP 706-203.

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4.4 Certification documentation reports.

4.4.1 General.

Reports are an essential part of any effort. They are often the only tangible results from the effort and they convey the conduct and results of the effort to interested parties. The type, content, and depth of reports are as varied as the number of management, analysis, and test agencies. Hence, the report types presented here are not intended to constrain these varied activities to a few report types but rather are intended only to suggest potential objectives and content of reports to be considered. The program manager will ultimately have to decide whether adequate reports exist to properly document his certification efforts. The requirements for report content, frequency, formality (i.e., letter report or published technical report) and distribution should be mutually agreed upon by all parties involved in the aircraft/stores compatibility effort.

4.4.2 Report types.

For purposes of this document, three basic report types are suggested: data, final, and compatibility (see MIL-STD-831).

4.4.2.1 Data report.

A data report could also be called a facility or test report and contains detailed test plans, description of test articles, facilities, equipment, instrumentation, conditions, procedures and sequences, test results, observations, data, and data accuracy, and conclusions and trends that are obvious from a cursory review of the data. The purpose of the report is to document the test (experiment) and transmit the data to the test requester. The data report should avoid judgments or conclusions about the utility of the data. For example, a structural test report might state that the test item did not fail but should not state that, having successfully passed this test, the item is qualified for some purpose. In a similar vein, the report on a wind tunnel or flight test investigating store separation might note that no store hit the aircraft and all stores pitched nose down, but it should not conclude that safe or satisfactory separation was demonstrated. Data reports usually only address one narrow aspect of the overall certification efforts and should not be depended on to discuss the entire effort. Data reports would receive narrow distribution, primarily to the test requester. Interim reports on test progress may be desired in addition to the final data report. There may also be times when, due to the urgency of the certification effort, it is desirable to issue an informal final report to avoid the long time delay associated with a published report.

4.4.2.2 Final report.

Since very few agencies have the variety of facilities needed to conduct all of the tests discussed in this handbook, it is likely that the certification agency will have to solicit the support of several outside agencies to conduct some of the necessary tests. Each of these facilities will probably only provide a data report addressing, in detail, their specific test. At the completion of all work on a specific store certification, it may be desirable to generate a final or summary report to discuss the requirements for the certification, compile and discuss all the analyses and tests conducted, cite test philosophy, draw conclusions about the operational or engineering suitability of the test results, and specify, in general terms, the certification envelope ultimately recommended. Aspects of specific tests that are of particular interest would be discussed in some detail, but the actual data reports would be presented either as annexes or simply referenced. Correlation between simulations and test results would be presented. The final

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report would be of interest to many management and technical members of the aircraft-stores analysis/test community and should therefore be published and given wide initial tri-service distribution.

4.4.2.3 Compatibility report or airworthiness qualification report (for the Army).

Certification agencies often rely on an aircraft/stores compatibility agency to manage, conduct, and evaluate the analyses and tests conducted in support of their certification requirements. Compatibility reports should be provided by the compatibility agency to the certification agency to summarize and document the analyses, test conducted, the conclusions drawn about the operational suitability of the aircraft-store combination and to recommend, in the format of the flight delivery, and loading manuals, the manner in which the store should be authorized. The compatibility agency in conjunction with the certification agency should maintain a record of all testing, analyses, and rationale used in the certification of all aircraft-store configurations authorized in the flight manual. Also included in this record should be the approved delivery and loading manuals for the store.

5. DETAILED REQUIREMENTS

5.1 General.

The detailed requirements for determining the extent of aircraft/stores compatibility for the specific aircraft/stores combination are presented as test and data requirements in the appendices to the handbook. The ground and flight tests necessary to establish the required operating limitations are located in appendices A and B respectively while the engineering data and supporting analyses requirements are included in appendix C. Each individual test is divided into six parts: Purpose, Data Requirements, Test Preparation, Acceptance Criteria, Test Procedure and Test Reporting. The groupings and order of tests are intended to assist in their application, but it is not intended that the tests or subtests be necessarily accomplished in the sequence provided. The sequence of tests and subtests accomplishment should be tailored to the individual aircraft/stores compatibility program to which they are being applied.

5.2 Test structure.

The tests and factors requiring consideration are:

a. Ground test procedures, appendix A, will include:

(1) Tests 101 and 102, Fit and Function. Store loading configurations, clearances electrical/mechanical interfaces, electrical compatibility, armament weapons support equipment or checkout and loading procedures.

(2) Test 110, Static Ejection. Determine reactive force loads, store velocities, separation characteristics, correct lanyard function and arming control system reliability.

(3) Test 120, Aeroelastic Ground Vibration Test (GVT). Determine frequency, damping and mode shape of the aircraft-store/suspension equipment combination for flutter analyses.

(4) Test 130, Structural Integrity. Verify aircraft-store and suspension equipment structural integrity and compatibility to the most critical flight conditions including those necessary for carrier suitability.

(5) Test 140, Wind Tunnel. Determine effect of aircraft on captive stores, captive stores on aircraft, aeroelastic effects, separation and ballistics for the aircraft-store configuration.

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(6) Test 150, Environmental. Determine the ability of the store configuration(s) to withstand or operate in the vibration, aeroacoustic electromagnetic, temperature and thermal environments.

(7) Test 160, Gun/Rocket/Missile Firing. Quantifies the safety, compatibility and performance requirements of the aircraft gun, rocket or missile systems.

b. Flight test procedures, appendix B, may include:

(1) Test 200, Inflight Loads and Structural Integrity. Inflight instrumented tests used to verify the structural integrity and obtain loads survey data for the store and aircraft-store combinations.

(2) Test 210, Flutter. Inflight instrumented tests used to substantiate that the aircraft with stores is free of any aeroelastic instability and has satisfactory damping characteristics in the defined carriage envelope.

(3) Test 220, Environmental. Determines if the aircraft-store and suspension equipment can withstand the actual flight environment, validate design specification levels and substantiate predicted/test levels for vibration, aeroacoustic and thermal environments.

(4) Test 230, Flying Qualities. Inflight instrumented tests used to demonstrate that the aircraft/stores configuration meets the requirements for the flying qualities of military piloted aircraft.

(5) Test 240, Performance and Drag. Determines any degradation in mission performance caused by the carriage of external stores.

(6) Test 250, Captive Flight Profile (CFP). Verifies the effect of a store configuration on aircraft flying qualities and store structural integrity throughout the required flight envelope, usually performed on uninstrumented aircraft.

(7) Test 260, Carrier Suitability. Verifies store compatibility under actual catapult launches and arrested landings.

(8) Test 270, Employment. Verifies stores separation characteristics under various modes (including failure mode), tactics and conditions, store release and propulsion effects on the aircraft and adjacent stores, electromagnetic interference effects and compatibility with shipboard electromagnetic environment.

(9) Test 280, Jettison. Verifies store jettison modes, configurations and conditions, effects on aircraft and adjacent stores, propulsion effects, functional differences in store between employment and jettison.

(10)Test 290, Ballistics. Determines free-stream ballistic coefficients, evaluates and verifies the aircraft/stores ballistic accuracy.

c. Armament system software changes. One extensive aspect of stores certification is the software changes required to the Stores Management Set and/or Fire Control Computer/Mission Computer for control and release of the store being authorized. These software changes are a necessity for proper interface and function of the store with the aircraft. It is probable that for new aircraft, the software changes will be accomplished by the prime contractor; however, as the aircraft enters service, the Operating Service will make input to any necessary changes. Verification of the acceptability of the changes to OFPs affecting operation of stores will normally be conducted as part of Test 102.

d. Human factors and mission effectiveness. When developing the certification plan for any aircraft-store combination, dedicated mission effectiveness or human factors testing should

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be considered. This includes munition preparation, loading, aircraft checkout, preflight, cockpit weapon switchology, takeoff, ingress, target tracking/acquisition, target engagement, safe escape maneuvers, egress, landing, integrated combat turn capability and downloading. The results of mission effectiveness and human factors considerations should be published as part of any certification report to provide a data base for further development of existing weapons systems as well as new technologies.

The agency requesting store certification should be as specific as possible as to their requirements in each of the areas above to assist the certification agency in establishing the criteria to be used in the certification effort. Through the initial certification request and, if necessary, subsequent follow-ups, the certification agency will determine the appropriate criteria to be applied to the specific store certification program. These criteria will include (but not be limited to) essential and desired aircraft/stores configurations (including any mixed load configurations) and the essential and desired operating limitations such as: carriage speeds and accelerations, dive (or climb) release angle, release modes, speeds, intervals and accelerations, jettison speeds and accelerations, required levels of accuracy, etc., as required for the aircraft/stores combination to be operationally effective.

5.3 Certification approval.

Formal approval for certification of an aircraft-store/suspension equipment configuration is accomplished through publication of operational data in appropriate technical manuals. These are: (see 3.1.31 for types of technical manuals):

a. Navy: NATOPS Flight Manuals and Aircraft Tactical Manuals.

b. Army: Technical Manuals (Operators, Maintenance and Parts).

c. Air Force: Aircraft Technical Orders (-1, -2, -5, -16, -25, -30, , -33, -34, and -35).

d. Publication of Aircraft Compatibility Control Drawing (ACCD) and Major Assembly Release (MAR) in TO 11N-50-7 (USAF) and SWCP 50-7 (USN) includes notification by the Department of Energy (DOE) that a war reserve nuclear weapon is released for use with specific aircraft configurations.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful.)

6.1 Intended use.

This handbook is intended to provide information and the methods used to obtain the data to establish that sufficient compatibility exists between an aircraft, specific stores, and suspension equipment to justify certification for carriage and employment of the stores for use on that aircraft. By this standardization, responsible agencies may then be assured that a test run by any agency will still provide the same data they would require, thereby, facilitating the transfer of data between agencies and eliminating the duplication of tests. This handbook purposely does not address the following:

a. Certain aspects of the safety testing of munitions, such as insensitive munitions, rough handling, storage, accelerated aging, or transportation tests.

b. Tests of basic materials or piece parts, such as transistors, and integrated circuits.

c. Munition effectiveness.

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6.2 Tailoring guidance.

This document attempts to define all the tests which might ever be required to certify a store, and provides standard test methodology, test instrumentation, and data to be obtained from each test. Due to the number of separate compatibility situations which must be considered, no single procedure or test method can be used in every case. It is up to the cognizant test approval authority or certification agency to select and/or tailor the specific methods appropriate for each particular store compatibility situation.

6.2.1 Tailoring for 1.3.1 provision.

When this paragraph is invoked, the following tasks in this standard are required to be performed and are tailored as follows:

a. When aircraft/stores configurations and operating limitations are supplied. The contractor is to provide to the managing activity details of appendices A and B tests (or tests conducted by approved test agencies equivalent to the test(s) herein) identifying the extent of compliance with the configurations and essential and desirable operating limitations required along with a statement as to any non-compliance(s) with the test acceptance criteria, and to provide an aircraft/stores compatibility plan providing details of any necessary tests yet to be accomplished in order to establish the extent of aircraft/stores compatibility for the required operating limitations.

b. When aircraft/stores configurations and operating limitations are not supplied. The contractor is to provide to the managing activity details of appendices A and B tests (or tests conducted by approved test agencies equivalent to the test(s)) identifying the extent of compliance demonstrated on equivalent aircraft, and to provide an aircraft/stores compatibility plan providing details of any necessary tests yet to be accomplished in order to establish the extent of aircraft/stores compatibility to achieve the optimum aircraft/stores capability for the aircraft/stores combination.

c. The contractor is to provide the appendix C compatibility engineering data package (CEDP) for the aircraft/stores configuration identifying, or referring to, configuration controlled documentation supporting the operating limitations provided.

6.3 Subject term (key word) listing.

Aeroacoustics

aeroelastic ground vibration test

aircraft flutter

aircraft loads

aircraft/store certification

armament system software changes

ballistics

captive flight profile

carrier suitability

electromagnetic analysis

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employment

environmental testing

fit and function

flying qualities

jettison

operational flight program

safe escape

static ejection

store mass properties

store separation

structural integrity

vibration and endurance’

wind tunnel

6.4 International standardization agreements.

Certain provisions of this document are the subject of international standardization agreements STANAG 3300, STANAG 3441AA, STANAG 3556AA, STANAG 3558AA, STANAG 3575AA, STANAG 3605AA, STANAG 3859AA. When change notice, revision, or cancellation of this document is proposed which will modify the international agreement concerned, the preparing activity should take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

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APPENDIX A

GROUND TEST PROCEDURES

TEST	SUBJECT	PAGE
100	FIT AND FUNCTION TESTS	54
101	FIT TEST	55
102	FUNCTION TEST	57
110	STATIC EJECTION TEST	59
120	AEROELASTIC GROUND VIBRATION TEST (GVT)	62
130	STRUCTURAL INTEGRITY TESTS	64
131	AIRCRAFT-STORE/SUSPENSION EQUIPMENT STRUCTURAL INTEGRITY GROUND TEST	65
132	CARRIER SUITABILITY TEST	68
140	WIND TUNNEL TESTS	70
141	EFFECTS OF AIRCRAFT ON CAPTIVE STORES/SUSPENSION EQUIPMENT	71
142	EFFECTS OF CAPTIVE STORES/SUSPENSION EQUIPMENT ON AIRCRAFT	75
143	AEROELASTIC EFFECTS TEST	78
144	SEPARATION TESTS	82
150	ENVIRONMENTAL TESTS	89
151	VIBRATION TEST	90
152	AEROACOUSTIC TEST	93
153	HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) TEST	96
154	ELECTROMAGNETIC COMPATIBILITY AND ELECTROMAGNETIC INTERFERENCE (EMC/EMI) TEST	99
155	TEMPERATURE EXTREMES AND THERMAL TESTS	103
160	GUN/ROCKET/MISSILE FIRING TESTS	109
161	GUN FIRING TEST	110
162	ROCKET/MISSILE FIRING TEST	114

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APPENDIX A

100 SERIES TESTS

FIT AND FUNCTION TESTS

100.1 Purpose.

Tests in the 100 series are designed to satisfy the fit and function requirements of establishing the extent of aircraft/stores compatibility. Fit and function testing is an item of major importance in aircraft/store compatibility testing and is a prerequisite to, as well as, an integral part of captive carriage and separation tests. In addition to normal safety-of-flight objectives, generation and verification of assembly, loading, rigging, and checkout procedures are major objectives of fit and function tests. Documentation of configurations and procedures should be maintained for use during tests and to serve as a baseline for smooth transition to operational usage. Test 100 has been divided into two separate tests since fit and function are normally conducted at different times during a development effort. Traditionally, a physically representative store and aircraft hardware will be available for a fit test significantly earlier than operationally suitable software changes to the aircraft and/or stores necessary for a representative function test to be conducted. Notwithstanding this, the tests may be conducted together. Each new aircraft/stores configuration should be evaluated using the following:

a. Fit Test (Test 101). Includes the following aspects of AIR STD 20/21:

(1) Installation tests,

(2) Clearance tests,

(3) Accessibility tests,

(4) Stores reinforced area tests, and

(5) Development of loading procedures and ground handling equipment requirements.

b. Function Test (Test 102). Includes the following aspects of AIR STD 20/21.

(1) Electrical interface tests,

(2) Electrical functional tests for all ground and flight modes of operations including jettison, SMS failure reporting, weapon inhibits and boresight procedures,

(3) Armament control system tests,

(4) Ground test equipment tests, and

(5) Validation and/or verification of loading procedures and tests.

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APPENDIX A

TEST 101

FIT TEST

101.1 Purpose.

Fit tests are the loading on the aircraft of the stores in the configurations which are to be certified. These tests investigate the compatibility of the physical and mechanical interface between the store and the aircraft, and the adequacy of the loading procedures employed. A fit test determines whether sufficient clearance exists between the store and its surroundings to permit the satisfactory loading, servicing, carriage and deployment. It ascertains whether proper store alignment with respect to the aircraft can be accomplished. It also shows whether the required electrical, electromechanical, and optical connections (i.e., lanyards, arming wires, umbilical wires, hoses, fibre optic cable, lanyard retention devices, etc) can be made. It develops procedures so that the store can be loaded onto the aircraft using the proposed ground handling equipment specified as a portion of the tests.

101.2 Data requirements.

Clearances between the store and its surroundings must be verified as sufficient to allow all aspects of the loading procedure to be accomplished, to permit aircraft and munition servicing, and to allow for inflight vibration and deployment. Measurements of store-to-store, store-to-aircraft and store-to-ground clearances are required for all operational settings of movable aircraft parts and for the most severe aircraft attitude, in accordance with AIR STD 20/21. Accessibility and stores reinforced area tests in accordance with AIR STD 20/21 will also be accomplished during this test. Any deviation or modification of the test articles or equipment from the standard or norm must be reported.

101.3 Test preparation.

101.3.1 Test articles.

Representative production aircraft, stores, suspension equipment, electrical umbilical/harnesses, lanyard retention devices and loading equipment must be utilized. Modification peculiarities of any of these items would require verification that the modification does not limit the applicability of the test results to less than all of the articles to be certified.

101.3.2 Test equipment.

Only that equipment which is available to aircraft and armament personnel, or which is being introduced as part of the support equipment of the aircraft/store combination being certified, should be used.

101.3.3 Test instrumentation.

Devices with sufficient accuracy to perform the measurements required by AIR STD 20/21 must be provided.

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101.3.4 Test conditions.

The loading checklist should be prepared in advance of the test. Modifications and exceptions are to be documented in a test report.

101.4 Acceptable criteria.

The test should be judged successful if the store is able to be safely loaded, carried with physical store connections made, deployed and unloaded without interfering with the operation of the aircraft or other stores being carried and, if the test fulfills the requirements of AIR STD 20/21. When critical store to aircraft clearances are found, another fit check utilizing different aircraft and/or stores should be performed to take aircraft and/or store tolerances into account.

101.5 Test procedure.

The test should be performed in accordance with AIR STD 20/21.

101.6 Test reporting.

The test report should detail the extent of physical compatibility established in the test. Aircraft, stores suspension equipment and stores test articles and equipment should be identified by model and serial number and other models of the test articles to which the test results do or do not apply should be identified. This will assist in any post-test review conducted later if problems occur with store fit and function when the configuration is used by operational units. To adequately report some tests, it will also be necessary to include electrical wiring diagrams to clearly define the test aircraft, suspension equipment, and test item configuration(s) actually used. The final loading procedures should be completely detailed. Clearances measured during the test should also be presented and photo-documented, if possible, and comments made as to whether or not they are adequate. Particular attention should be paid to any deviation to the requirements of AIR STD 20/21 and statements made as to the recommendation of waivers and justification thereof.

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APPENDIX A

TEST 102

FUNCTION TEST

102.1 Purpose.

Function testing is an item of major importance in aircraft/store compatibility testing and is a prerequisite to, as well as an integral part of, captive carriage and separation tests. These tests investigate the compatibility of the electrical, electromagnetic and electro-optical, arming control system interface between the store and the aircraft, and the adequacy of the loading procedures employed. It also shows whether the required electrical, electromechanical, and optical connections (i.e., lanyards, arming wires, umbilical wires, hoses, fiber optic cable, etc.) can be made. Electrical functional tests for all ground and flight modes of operations including jettison, SMS failure reporting, weapon inhibits and boresight procedures should be accomplished. It verifies that the store can be loaded onto the aircraft using the loading procedures specified as a portion of the tests.

102.2. Data requirements.

Verification of the efficiency and correctness of the functional checkout and loading procedures using necessary ground test equipment and ground handling equipment will be established. Any deviation or modification of the test articles or equipment from the standard or norm must be reported.

102.3 Test preparation.

102.3.1 Test articles.

Representative production aircraft, stores, suspension equipment and loading equipment must be utilized with requisite OFP for aircraft and stores. Modification peculiarities of any of these items would require verification that the modification does not limit the applicability of the test results to less than all of the articles to be certified.

102.3.2 Test equipment.

Only that equipment which is available to aircraft and armament personnel, or which is being introduced as part of the support equipment of the aircraft/store combination being certified, should be used.

102.3.3 Test instrumentation.

Devices with sufficient accuracy to perform the functional tests required by AIR STD 20/21 must be provided.

102.3.4 Test conditions.

The aircraft preflight checkout and loading procedures/checklists should be prepared in advance of the test. Modifications and exceptions are to be documented in a test report.

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102.4 Acceptable criteria.

The test should be judged successful if the store is able to be safely and efficiently loaded, serviced, powered, carried, preflight and inflight functional checks and modes of operation tested, failure modes correctly transmitted, deployed and unloaded without interfering with the operation of the aircraft or other stores being carried and, if the test fulfills the requirements of AIR STD 20/21.

102.5 Test procedure.

The test should be performed in accordance with AIR STD 20/21.

102.6 Test reporting.

The test report should detail the extent of compatibility established in the test. Aircraft, stores suspension equipment and stores test articles and equipment should be identified by model, OFP used, and serial number and other models of the test articles to which the test results do or do not apply should be identified. This will assist in any post-test review conducted later if problems occur with aircraft/stores function when the configuration is used by operational units. To adequately report some tests, it will also be necessary to include electrical wiring diagrams and Interface Control Documentation used to clearly define the test aircraft, suspension equipment, and stores test item configuration(s) actually used.

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TEST 110

STATIC EJECTION TEST

110.1 Purpose.

The purpose of static ejection tests is to determine the reactive force loads, separation characteristics of stores released from aircraft Ejector Release Units (ERUs), correct lanyard function, and arming control system reliability. Such characteristics will include accelerations, angular velocities, and attitude (pitch, yaw, and roll) of the store as it leaves the influence of the ERU (end of ejector stroke), the reaction loads imparted to the aircraft structure by the ERU, and the dynamics imparted to the store by the ejection mechanism.

110.2 Data requirements.

The following is a list of the primary data which should be recorded during each static ejection test:

a. ERU type and identification (nomenclature and serial number).
b. ERU mounting details.
c. Store(s) type and identification.
d. Store characteristics (weight, cg location, moments of inertia).
e. Ambient conditions (temperature and humidity).
f. ERU characteristics.
g. Pitch or force setting, if used (and orifice size, if used).
h. Ejector position with respect to store cg.
i. Ejector stroke length.
j. Sway brace torque, force.
k. Attitude of store and ERU with respect to horizontal.
l. Hydraulic system pressure (if applicable).
m. Cartridges used.
n. Time/number of firings since last cleaning (if applicable).
o. Ejector power source characteristics and identification.
p. Reaction forces between store and ERU (fore, aft, center, sway braces).
q. Lag time in accordance with MIL-T-7743.
r. During store ejection, the following data should be taken at the store cg.
s. Ejector stroke versus time (all ejectors).
t. Ejection force versus time.
u. Ejection velocity versus time.

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v. Acceleration versus time.

w. Pitch attitude and rate.

x. Yaw attitude and rate.

y. Roll attitude and rate.

z. Dynamic response of mounting rig versus time.

aa. Simulated external air loads applied, if applicable

bb. Photographic record

cc. Remarks on the results of correct lanyard function for armed and jettison/safe releases including reliability and confidence levels achieved.

110.3 Test preparation.

110.3.1 Test article.

The test article and ERU must be representative of store and ejector to be used on the designated aircraft. Test article should meet all the performance and inspection requirements of its governing specification and associated drawings.

110.3.2 Test equipment.

The mounting structure for mounting the test ERU should be of sufficient strength to accept the maximum reaction forces anticipated. It will provide for mounting the ERU in a manner duplicating its normal installation in the aircraft. The rigidity and dynamic response of the rig should be monitored. A completely rigid test rig would be normally used to measure store angular and linear movement but may cause additional reaction loads in the arming control system possibly causing an unrepresentative failure rate. The test equipment should provide for test instrumentation sensors for the monitoring and recording of the data specified in 110.2. The mounting structure should provide clearance for measuring required data for a minimum free fall of the store cg, consistent with store dimension, predicted pitch attitude, and distance required for full arming lanyard operation to be observed, if required. A container filled with sand, water, or other dunnage should be provided to protect personnel. If external loads are to be applied during store separation to simulate airloads, they may be applied by pneumatic rams, hydraulic cylinder or weights. If the launch platform is not sufficiently rigid the static ejection tests may need to be performed with the suspension equipment mounted on the actual launch platform.

110.3.3 Test instrumentation.

The instrumentation should provide for the sensing and recording of the parameters listed in 110.2. Any of several methods may be used, providing sufficient accuracy is attained. For example, oscillograph recordings of the ejection sequence are acceptable with the sequencing initiated by suitable triggering devices. Strain gauges may be used to record the reactive forces between the store and the ERU. Provisions for still and motion picture cameras to photograph the ejection should be provided. Either movie or video cameras may be used for the motion picture photography, provided a frame rate (or apparent frame rate) of at least 400 frames/sec is used.

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110.3.4 Test conditions.

The ERU should be mounted in the same manner and attitude as the installation on the using aircraft, and the direction of store ejection should be the same as it would be on the using aircraft. Controlled temperature and humidity conditions should be considered, but may be discarded if not required. If applicable, external loads may be applied to simulate actual conditions.

110.4 Acceptance criteria.

Static ejection tests should be deemed to be successful if, after completion, the following conditions have been met:

a. Satisfactory operation of instrumentation and recording of data.

b. No damage occurred to the ERU and any associated stores or test equipment.

c. The ERU and any associated stores or test equipment operated properly.

d. Data recorded during the test, plus subsequent data analyses, prove that the required test conditions were met.

110.5 Test procedures.

a. Prior to conducting any static ejection tests, a formal test procedure should be prepared and reviewed by appropriate engineering and ground safety authorities. The procedure should contain a general statement of the purpose and desired results of the tests. The detailed procedures must account for all situations which could affect the safety of personnel involved in the tests and others in the test area where the test will be conducted.

b. The ERU should be mounted to the test stand and mounting fixtures in a way to simulate the actual installation on the aircraft. The tests may involve a number of ERU and store configuration variations (for example, different mixes of ejector cartridges and/or other power sources, different pitch rate or attitude selections, different ejector locations, different store weights and cg, and different modes of ejection such as single or ripple release). A careful record of the configuration being tested must be kept for subsequent correlation of data.

c. Instrumentation to be attached to the ERU, store, and supporting structure should be installed. Stores should be attached to the ERU (with power source not installed or activated) and, if necessary, sway braces adjusted according to specifications. If necessary, the ejectors should be adjusted to rest on the store. The final instrumentation package and connections should be completed with appropriate checkouts. Prior to store loading or any electrical connections, ensure that ERU safety lock is locked and all safety pins (if any) are inserted. Load or activate power source, clear area, make final checks and remove safety pins or locks for firing.

110.6 Test reporting.

The test report should include all the data listed in 110.2. The data variance for each ejection should be provided for any given ERU or day listed numerically. Static conditions that change only periodically should be so listed for the sequence of ejections to which they are applicable. Reasons for or causes of failure in mechanical arming and control systems should be documented.

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TEST 120

AEROELASTIC GROUND VIBRATION TEST (GVT)

120.1 Purpose.

The purpose of the aeroelastic ground vibration test (GVT) is to experimentally determine the frequency, damping, and mode shape of the important modes of the aircraft-store/suspension equipment combination. These data are to be used to help substantiate the theoretical flutter calculations.

120.2 Data requirements.

The data required for each normal mode are the frequency, the mode shape, node line, and the amount of modal damping.

120.3 Test preparation.

120.3.1 Test article.

The aircraft used for ground vibration test should be equipped with all items having appreciable mass, such as engines, tip tanks, guns, and similar items. Stores such as bombs, rockets, ammunition, and other items that may constitute a safety hazard will be simulated with ballast weight. The aircraft should be supported so that the rigid body frequencies of the aircraft on its support will be less than one-half the frequency of the lowest elastic wing or fuselage mode to be excited.

120.3.2 Test equipment.

Low frequency suspension system.

120.3.3 Test instrumentation.

Vibration exciters and their associated electronics; vibration pickups and their associated electronics; applied dynamic force gauges; oscilloscope; digital voltmeter; recording oscillograph; frequency counter; phase meter; spectrum analyzer, computer/workstation with modal test software and X-Y plotter.

120.3.4 Test conditions.

Ambient atmosphere conditions.

120.4 Acceptance criteria.

Normal modes are identified when a 90^{o} phase shift Lissajous figure is shown on the oscilloscope as the excitation frequency passes through the resonant frequency. A Lissajous figure can be created on a oscilloscope using a dynamic load cell and accelerometer as inputs. This figure should be an oval oriented about the vertical and horizontal axes. Orthogonality checks may also be used to indicate acceptable normal modes. For example, the generalized mass matrix obtained from an integrated triple matrix product of the experimental orthonormalized mode shapes and the theoretical mass matrix of the dynamic system should

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have off-diagonal elements less than 10 percent of the unit diagonal inertia terms. In random testing the coherence between the input and response is a measure of the quality of the data and ideally should be unity.

120.5 Test procedure.

Vibration pickups should be placed at suitable locations and amplitude-frequency response curves obtained to determine the natural frequencies. The frequency increments selected should be sufficiently small so that no important resonant peaks are overlooked. Alternate pickup and vibrator locations should be employed as a check since node lines may have passed through the first selected vibrator and pickup locations. For normal mode testing, prior to mapping the mode, a decay record should be taken to determine the purity of the mode, (i.e., when the excitation force is suddenly cutoff, the ensuing decay should be without beats) and to determine the amount of modal damping. Damping will be calculated in the random testing procedure.

a. At each natural frequency, amplitude and phase measurements should be carefully taken at a sufficient number of positions to define the mode of vibration (mode shape) and the node line. The frequency range covered during this test should include all frequencies that may be important with respect to flutter.

b. When the aircraft wing has large control surfaces, consideration should be given to performing tests with the surfaces having normal rotational restraint and with the surface being clamped to the wing.

c. For helicopter ground vibration tests, AR-89 (Navy) or ADS-27 (Army) should be used, as directed by the cognizant certification activity, as general standards concerning ground vibration tests, test conditions, test procedures, data, and test reports. Likewise, for fixed wing aircraft MIL-A-8870 is the document to use for ground vibration tests.

120.6 Test reporting.

The GVT report should contain the following information: plots of the amplitude versus frequency for strategically located vibration pickups; the natural frequency, mode shape, damping and node line location for all modes that are measured along with their theoretical counterparts; orthogonality checks; descriptions and photographs of the air vehicle suspension system, the excitation system, the instrumentation, the procedures and the air vehicle configuration along with mass distributions used for the orthogonality checks.

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APPENDIX A

130 SERIES TESTS

STRUCTURAL INTEGRITY TESTS

130.1 Purpose.

Tests in the 130 series are designed to satisfy the structural integrity portion of the aircraft/stores compatibility including those necessary for carrier suitability.

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APPENDIX A

TEST 131

AIRCRAFT-STORES/SUSPENSION EQUIPMENT STRUCTURAL INTEGRITY GROUND TEST

131.1 Purpose.

The purpose of structural integrity ground testing is to test the aircraft-store suspension equipment combination to the most critical flight conditions to verify store/suspension equipment structural integrity and compatibility. The applicable design conditions called out in the vehicle/aircraft specification requirements to MIL-A-8591 and in MIL-A-8860 (Navy only) should be met. Sufficient strength should be provided to meet the applicable ultimate design conditions.

131.2 Data requirements.

Sufficient data should be measured and recorded to determine:

a. Strains.

b. Deflections.

c. Temperatures.

d. Applied loads.

e. Mechanical integrity of the item(s) under test.

f. Crack growth characteristics of the critical structure (if applicable).

131.3 Test preparation.

Test preparation will contain the following as a minimum. Additional appropriate items may be included.

131.3.1 Test article.

Provide a detailed description of the article to be tested including all items in combination which form the article to be tested, e.g., aircraft pylon, suspension equipment, adapter, and store. The article used for the structural integrity ground testing should be structurally representative of the actual article. The test article may have to include the aircraft structure if the design loads exceed the certified strength of the aircraft structure.

131.3.2 Test equipment.

List test items required to perform the tests such as test stands, stores, adaptors, and type of aircraft/suspension equipment interface to be tested.

131.3.3 Test instrumentation.

A detailed description of all instrumentation (e.g., accelerometers, strain gauges, oscillograph recorders, magnetic tape recorders, cameras), methods of calibration, location of instrumentation and calibration data for each test, including drop tests (landing conditions), should be prepared by the test activity and reviewed and accepted by the certification activity.

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The requirements of MIL-D-8708, AMCP 706-203, or MIL-D-23222, as applicable, should be employed as general standards concerning test instrumentation.

131.3.4 Test conditions.

List all test conditions that must be met to collect the required certification data, such as accelerations (n_z, n_x, n_y), aerodynamic forces, pressure, weight and balance, mass distributions, and crack growth characteristics of the structure (if applicable).

131.4 Acceptance criteria.

131.4.1 Test.

Structural integrity ground testing should be deemed successful if, after test completion, the following conditions have been met:

a. Satisfactory operation of instrumentation and recording of data.

b. All required test conditions were attempted or deleted because of test item failure.

c. All data recorded during the test should indicate that required test conditions were met.

d. If required by the certification authority, completion of fatigue/ durability and damage tolerance testing plus the correlation of all test cracks with analysis to validate by both analysis and test that each local area has met the crack growth criterion for initial flaw size to fracture, including meeting the specified residual strength capability.

131.4.2 Test article.

The test article should successfully pass the test if the following conditions have been met:

a. No damage to, and proper operation of, the store and its associated suspension equipment after testing in accordance with the design requirements, as related to aircraft-stores compatibility and operational safety.

b. No structural failure, as related to aircraft store compatibility, at design ultimate conditions, no plastic deformation at 115% limit loads and no catastrophic failure before 150% limit loads.

131.5 Test procedure.

Prior to performing any tests, a test plan should be prepared, reviewed and accepted by the appropriate engineering authority. The plan should set forth the purpose, desired results, and detailed procedures of the test, including a description of the test setup. The tests should be performed in suitable increments for safety to ensure that catastrophic failure does not occur unexpectedly. A detailed record of the store/suspension equipment being tested should be maintained for subsequent correlation of data. Tests should be performed on the test article to ensure proper mechanical/electrical operation prior to, and after completion of, the tests. The aircraft-store/suspension equipment electrical/mechanical interface should be visually inspected by experienced personnel after each test event is completed. Instrumentation should be checked prior to, and after completion of, the tests to ensure it is working properly. Prior to reconfiguration for a following test, ascertain that all test conditions have been met. Record all data applicable to each test point or condition.

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131.6 Test reporting.

The reports required for this testing should be specified by the certifying authority and should include but not be limited to:

a. Ground test plan

b. Instrumentation report

c. Calibration report

d. Test results

The contents of the above reports for airplanes are specified in MIL-A-8867, and MIL-A-8868, and for helicopters in AR-89 (for Navy) and MIL-T-8679 (for Army).

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TEST 132

CARRIER SUITABILITY TEST

132.1 Purpose.

The purpose of simulated carrier suitability ground testing is to test the store/suspension equipment under the most severe dynamic conditions to verify store structural compatibility compliance with the test conditions depicted in the latest version of MIL-A-8591 and MIL-A-8860 series or to the expected environment, whichever is more critical.

132.2 Data requirements.

Sufficient data should be measured and recorded to determine:

a. Simulated catapult accelerations.

b. Simulated arrestment decelerations.

c. Mechanical integrity of item under test.

d. Applied loads.

e. Strains and deflections.

132.3 Test preparation.

Test preparation will include the following items as a minimum. Other items should be added as appropriate.

132.3.1 Test article.

Provide detailed description of article to be tested. The article used for ground test must be structurally representative of the actual article.

132.3.2 Test equipment.

List of items required to complete tests, e.g., stores, type of rack/launcher interface to be tested.

132.3.3 Test instrumentation.

List all data gathering devices used to collect data to authorize the store and associated suspension equipment, e.g., g accelerations, strain gauges, oscillographs, magnetic tape, and cameras.

132.3.4 Test conditions.

List all test conditions that must be met to collect necessary certification data, e.g., catapult accelerations (g loadings).

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132.4 Acceptance criteria.

Carrier suitability structural test should be considered successful if, after test completion, the following conditions have been met:

a. Satisfactory operation of instrumentation and recording of data.

b. No damage to and proper operation of the store and its associated suspension equipment after testing in accordance with the design intent, as related to aircraft-stores compatibility and safety of operation.

132.5 Test procedure.

Prior to performing any tests, a test plan should be prepared and reviewed by appropriate engineering and ground safety authorities. The test plan should give the purpose and desired results of the tests. The detailed procedures must account for all possible situations that could affect safety, including:

a. The store and suspension equipment to be tested should be mounted on the test fixture and loads applied as calculated using the procedures defined in MIL-A-8591. A detailed record of the configuration storage and type rack/launcher being tested must be kept for subsequent correlation of data. Tests should be performed on the test article to ensure proper mechanical operation prior to and after completion of tests. The store/rack/launcher interface (electrical/mechanical) should be visually inspected by experienced personnel after each test event is completed.

b. Ensure that all instrumentation is working prior to and after the tests. Ensure that all test conditions have been met prior to reconfiguring for the next test. Record all test data applicable to each data point.

132.6 Test reporting.

Final certification of a store/suspension equipment/aircraft combination depends upon adequate reporting of all test data. Correction of malfunctions arising in operational service and future design improvement are more easily accomplished if a complete data file on the certification tests is maintained.

a. The cognizant program office should act as a clearing house for test data and make it available to all using agencies. The program office should have copies available of all test data acquired during certification testing in addition to any significant in-service performance data.

b. To assist the program office in processing any malfunction reports and developing repair procedures, the test certification data should be as complete as possible and should include all test instrumentation records suitably notated for calibration and test number in the formal test report.

c. Test reports should be distributed to all line organization management as well as to contractual program monitors. Test reports should be complete and should follow the format required by the contracting agency. Distribution should be as directed by the contracting agency except that in all cases the test facility should retain one copy of the original test data as a permanent record of the tests.

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APPENDIX A

140 SERIES TESTS

WIND TUNNEL TESTS

140.1 General information.

Many of the aerodynamic and aeroelastic questions relative to aircraft-stores compatibility can be investigated in the wind tunnel to reduce the risk and complexities of flight test. Scaled models of the aircraft and stores are supported on fixed mounting in a controlled airstream under laboratory conditions. Aerodynamic forces and moments are obtained without the inertia loads experienced in flight; data obtained from the wind tunnel provide information of aircraft and store aerodynamics, airloads, flow environment and store separation trajectories. The configuration, instrumentation, speed and attitude options for testing in the wind tunnel permit an evaluation of the aerodynamic and aeroelastic influence of aircraft, stores and suspension equipment on each other. However, test data for scaled models are not sufficient for certification purposes without proper interpretation and some flight test verification. Proper test equipment, spares, instrumentation and technique are essential in obtaining useful data. Preparing for a wind tunnel test encompasses clearly defining a test objective and data requirements, test articles and other test peculiar items, and instrumentation. Pre-test simulations using available analysis techniques should be used to identify needed data points and to minimize the test time required. An important factor to consider is what wind tunnel facility to use for the test. All aspects of test preparation and execution hinges around the sophistication of a wind tunnel facility and its capabilities. Different wind tunnels available to a user vary tremendously in their capabilities (see MIL-HDBK-244). In addition, wind tunnels may be intermittent or continuous flow. Wind tunnels vary in test section size, speed, Reynolds number capability, temperature, pressure and humidity regulation, installation requirements, and data reduction capabilities. Once a wind tunnel facility has been tentatively chosen, the user should contact the facility to ensure that it has the capability to satisfy his test objectives. Depending upon the wind tunnel facility, design and fabrication of a test article could be accomplished at the facility, in-house by the user, or via a contractual effort. If the test article is fabricated by the user, a safety analysis may be required by the tunnel facility prior to use. Many wind tunnels contain impurities that have a "sand-blast" effect upon models. The impurities erode leading edges, making the model geometrically or aerodynamically unsuitable for further testing. These factors should be considered in the selection of materials for the wind tunnel models. Because of Reynolds number effects between the test and full scale conditions, consideration should also be given to the use of trips to fix boundary layer transition on the parent aircraft and store models. The wind tunnel must assure that the test data are of sufficient quality to validate results. This validation should include instrumentation recalibration, data repeatability, model alignment and model integrity. Discussions of the wind tunnel tests needed for certification studies are separated in four categories:

a. Effects of aircraft on captive store(s)

b. Effects of captive stores on aircraft

c. Aeroelastic effects

d. Separation tests

These types of tests are delineated in Tests 141 to 144, respectively.

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TEST 141

EFFECTS OF AIRCRAFT ON CAPTIVE STORES/SUSPENSION EQUIPMENT

141.1 Purpose.

The purpose of this test is to define the aerodynamic influence of the parent aircraft on the store/suspension equipment. The data required are the aerodynamic forces and moments acting on the captive store/suspension equipment as a function of Mach number, aircraft orientation, attitude and configuration characteristics, usually disregarding aeroelastic effects.

141.2 Data requirements.

In addition to the store/suspension equipment force and moment or pressure data desired from this test, general tunnel and model data should be recorded, such as:

a. Mach number.
a. Tunnel static temperature.
b. Tunnel dynamic pressure.
c. Tunnel unit Reynolds number.
d. Model configuration identification.
e. Model attitude.
f. Tunnel porosity.
g. Tunnel dew point.

There are various axis systems which could be used to define these data; however, only the body axis system is in routine use. The axis system to be used should be coordinated among the tunnel facility, the testing agency and the certifying agency.

141.3 Test preparation.

141.3.1 Test article.

The test articles will be an instrumented scale model of the candidate store(s), scale model of the suspension equipment and a scale model of the parent aircraft. The wind tunnel model should represent full scale as close as possible. The smaller the scale, the greater the difficulty in simulating model details. All components must be the same scale. The primary limitation on model/wind tunnel size is the requirement that the complete model (aircraft and store) must have a wind tunnel blockage ratio sufficiently low to minimize wall effects.

141.3.2 Test equipment/instrumentation.

The instrumentation required in the store or suspension equipment depends on the desired test information. The types of instrumentation should be considered depending on the data desired are discussed in table A-I for the following types of tests.

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a. There are generally two methods for measuring captive store loads in a wind tunnel: those with the balance/store combination integrated into the aircraft and dual-sting or captive trajectory system (CTS) method. The first method incorporates a strain gauge balance contained within the store or store/pylon combination. This balance is then mounted directly to the aircraft model. This method provides very accurate configuration simulation for small scale models because no external supports are required for store mounting.

b. The dual-sting technique or CTS is another method to obtain captive loads. This technique uses completely separate stings or struts to support the aircraft and the store. This technique is used primarily to predict store separation trajectories, but can also give representative captive loads. The forces and moments acting on the store in the presence of the aircraft are measured using a strain gauge balance mounted within the store.

c. To conduct any wind tunnel test, it is imperative to contact the wind tunnel facility manager as soon as possible after a test requirement has been determined. Each test facility normally has its own unique instrumentation capabilities and data acquisition systems. Therefore, the engineer must ensure that the facility can accept the instrumentation requirements desired.

TABLE A-I. Wind tunnel instrumentation requirements.

Data type	Instrumentation
Local distributed loadings on store or suspension equipment	Pressure(s) transducers
Net reaction loads	Strain gauge balance(s)1/
Temperatures, aerodynamic heating	Thermocouples, phase change paints, liquid crystals, heat transfer rate gauges, thermographic phosphor
Flow visualization local shocks, flow separation	Oil on surface, smoke (smoke tunnel needed), Schlieren, shadowgraph
Aeroacoustic phenomena	Dynamic response pressure thransducers

1/ One of the prime factors to consider when using strain gauge balances is to ensure that the loads to be experienced in the tunnel are within the range of the force(s) being measured, i.e., the data are not within the error scatter band of the balance.

141.3.3 Test conditions.

Large scale model simulation, is desirable from the standpoint of model detail duplication and Reynolds number simulation. However, the larger the model, the higher the costs associated with fabrication and with tunnel operation. If the model scale is too small, the result may be reduced Reynolds number simulation, i.e., laminar/turbulent flow regions and reduced geometric simulation accuracy. In addition, if testing in the transonic flow regime, extreme care should be used to ensure accuracy of test conditions (i.e., Mach number and angle of attack) as well as repeatability. Local flow phenomenon such as separations and shock formation are very sensitive to flow conditions. Flow visualization is always desirable to verify shock reflection cancellation. Wind tunnel limitations:

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a. A limitation of the carriage load method is the inability to accomplish "rapid" model changes. Moving a store to a new location may also necessitate moving the balance. While these changes can be expensive and inefficient, proper balance wiring (i.e., quick disconnects) can reduce time. Store models are often modified with a slot to allow attachment of the balance to the pylon/aircraft. Despite these limitations, this method does provide the most representative technique to acquire captive load data, particularly if a large number of aircraft pitch/yaw sweeps are required.

b. The CTS technique limitations are primarily its inability to accurately simulate the captive store geometry. Due to the usually small size or scale of the store models to be tested, the external shape of the afterbody is sometimes modified to accommodate the sting support. Physical interference caused by the sting can also limit the configuration which may be tested. In addition, a gap (touchwire gap) is needed between the store and the aircraft to avoid extraneous balance output, thus improperly positioning the store with respect to the aircraft. Although the displacements introduced by the technique are usually small, large errors in captive loads can result, particularly when using small scale models. This method does, however, provide a rapid means to obtain store loads more efficiently when testing many store positions than the carriage load method for a small number of aircraft attitudes.

141.4 Acceptance criteria.

These tests should be deemed to be successful if, after test completion, the following conditions have been met:

a. Model design, construction, and pre-test preparation were done according to test program.

b. Satisfactory operation of instrumentation and data recording equipment.

c. All required test conditions were properly controlled during data recording.

If the agency conducting the wind tunnel test does not provide a quality assurance service, then the test user or sponsor must validate the data.

141.5 Test procedure.

The wind tunnel test should be conducted in a manner to increase the reliability or confidence level of the data obtained. The user should set up the test plan so as to obtain data on a baseline configuration and parametrically build the configuration to the desired configurations and desired envelope. Each configuration should be tested at each Mach number and attitude desired. In addition, photographs of all configurations should be taken for future references and cross checks. A sufficient number of repeat runs should be performed to ensure repeatability of data as well as accuracies.

141.6 Test reporting.

Whether the data are to be tabulated, plotted, or recorded on magnetic tape depends on the user's requirements and capability of the facility in satisfying the user's needs.

141.6.1 Data reports.

The data report should include the data stipulated in 141.2. The data report should also include model scale, definition of the configurations tested, instrumentation accuracy, test repeatability, wind tunnel test conditions, plots or tables of the test data and details of any corrections or

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modifications to the data. If aerodynamic coefficients are derived from the data or combinations of the data, specify the equations used, the sign convention, and the appropriate reference dimensions. The data report should include sufficient detail to completely describe the test and document the accuracy of the data.

141.6.2 Final report.

The final report should include the compatibility conclusions already addressed in the data report. The report must contain the criteria for compatibility conclusions, and the analysis method used to determine the conclusions.

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APPENDIX A

TEST 142

EFFECTS OF CAPTIVE STORES/SUSPENSION EQUIPMENT ON AIRCRAFT

142.1 Purpose.

The purpose of this test is to evaluate the influence of stores/suspension equipment on the aerodynamic characteristics of the aircraft. The user's primary objectives usually involve determining the aircraft performance or stability and control effects due to the addition of store/suspension equipment. These effects can cause the aircraft performance and stability and control characteristics to change due to increases in aircraft total drag, coupled with shifts in aircraft center of gravity and neutral point. The purpose of a performance and stability and control wind tunnel test is to obtain aerodynamic coefficients necessary to estimate performance and stability and control characteristics of an aircraft with carriage of external stores. In addition to basic performance, stability and control, if the aircraft may carry stores during air combat maneuvering (ACM), some more specialized wind tunnel tests such as rotary balance, free spin and other small scale model tests may be required. these tests define flight characteristics of a configuration at high angles of attack, both in and out of controlled flight.

a. To accomplish this, the aircraft aerodynamic forces and moments with and without stores should be measured. In certain instances, pressure distributions on the aircraft surface may be required.

b. When considering weapons bays, the aero-acoustic environment of both the store(s) and the cavity must be considered. Extremely high resonant peaks and high overall turbulence can cause structural fatigue and vibration, as well as avionics malfunctions.

c. If the aircraft is equipped with a main balance, it is possible that data can be obtained for aircraft performance studies at the same time a carriage loads test (see Test 141.3.2a) is being conducted. However, caution should be exercised to ensure that the wiring from the carriage loads balances do not impose unacceptable load on the main balance.

142.2 Data requirements.

The general tunnel data requirements of 141.2 are applicable. However, the data required on the aircraft varies with the type of test performed. Such data may include:

a. Performance parameters.

b. Stability and control.

(1) Static and dynamic parameters at low and high angles of attack in Up/Away and in high lift configurations, both in and out of ground effect.

(2) Rotational parameters.

c. Static and dynamic pressures.

There are various axis systems which may be used to define these coefficients; e.g., body axis, wind axis, stability axis, aeroballistic axis. The axis system to be used should be coordinated among the tunnel facility, the testing agency and the certifying agency.

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142.3 Test preparation.

142.3.1 Test article.

The test article should represent the full scale store, suspension equipment, and aircraft geometric dimensions as closely as possible. It is not necessary to model the mass and inertial properties for a force test. The scale of the test article is very important. The scale of an external store model should match that of the parent aircraft and hardware. The user must also consider if the use of a particular scale might hide important aerodynamic effects of small protuberances. For example, rack swaybraces and other protuberances often cannot be accurately aerodynamically modeled. If the aerodynamic effect of these protuberances are of prime importance, then a larger scale should be used to more accurately reproduce the aerodynamic effects. In addition, the user must ensure that the balances used in the test are of sufficient accuracy in order to distinguish the incremental changes of interest. The test article must also be constructed or modified such that it can readily be attached to the parent model of the aircraft pylons or racks. If a free spin/free flight or drop model test is required, the model will need to be dynamically scaled to model mass and inertia characteristics, since these determine actual aircraft motion.

142.3.2 Test equipment/instrumentation.

The particular wind tunnel facility dictates much of the test equipment required for a force test. There are two general categories of tunnel installations. One method of installation is an internally mounted force and moment balance. The second category is a force and moment balance external to the parent aircraft model. Each category has numerous methods of physically installing the aircraft model in the tunnel. Therefore, it is essential to coordinate with the wind tunnel facility to determine model installation requirements and appropriate test equipment peculiar to the user's force test. If a free-flying model test is required, the model will not have a balance at all, but will be free in one or more degrees of freedom to actually fly in the tunnel. The model may be required to be instrumented. The strain gauge balances, ranging from 1 to 6 components (normal, side and axial forces, and pitch, yaw and roll moments) such that the loads measuring capability is matched to the aircraft wind tunnel loads. The balances vary in physical dimensions, number of components, and loads capability. With the majority of the modern tunnel facilities, the balance is interconnected with a computer for rapid data sampling, recording, and reduction to aerodynamic forces and moments. The test engineer will calibrate the balance and correct for sting deflections and flow angularities. The aero-acoustic environments are usually determined with the aid of high dynamic response pressure transducers. This instrumentation should be located at least in the aft part of the cavity since this location is where the highest overall dynamic pressure levels are experienced. However, for sophisticated weapons with electronics sensitive to high resonant peaks, these data should also be obtained at the sensitive locations on the store model.

142.3.3 Test conditions.

Several sources of error inherent to wind tunnel testing conditions include the effects of Reynolds number, temperature, humidity, tunnel porosity, tunnel impurities, aerodynamic interference from support hardware, aerodynamic hysteresis, scaling effects, non-uniform test section flow, and wall effects. The wind tunnel facility must be able to duplicate, as close as possible, the required test conditions. The user must specify what combination of aircraft-store configurations, Mach number, Reynolds number, angles of attack, sideslip angles, and control surface angles he would like to test.

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142.4 Acceptance criteria.

These tests should be deemed to be successful if, after test completion, the following conditions have been met:

a. Model design, construction, and pre-test preparation were done according to test program.

b. Satisfactory operation of instrumentation and data recording equipment.

c. All required test conditions were properly controlled during data recording.

If the agency conducting the wind tunnel test does not provide a quality assurance service, then the test user or sponsor must validate the data.

142.5 Test procedure.

Wind tunnel testing contains inherent errors. To avoid or reduce the magnitude of the inherent errors in aircraft-store force testing, only incremental coefficients should be used in analyses when possible. Usually, an aircraft baseline configuration is chosen to provide reference aerodynamic coefficients. A typical baseline configuration is the aircraft configuration without the store in question. With this method, the aerodynamic coefficients of the full-up configuration are compared to those of the baseline configuration. This comparison provides incremental coefficients due only to the store in question. The degradations to aircraft performance, stability and control due to carriage of an external store can be calculated with the incremental coefficients. The process of using only incremental coefficients eliminates many of the inherent errors of wind tunnel force tests. When performing pressure tests, static and dynamic, the procedure differs somewhat from force testing in that incremental pressure effects are not measured from a baseline, but the absolute values are used and are frequently compared to the baseline, or stores off configuration, pressure levels. Integrated pressure data can be compared to force data results. For a free-flying test, the objective is typically to obtain aircraft motions, not stability and control derivatives, unless some form of parameter identification (PID) is done on the test data from an appropriately instrumented model. If PID is done, the results will be determination of the coefficients for the configuration, not an increment due to stores.

142.6 Test reporting.

The report should include the data stipulated in paragraph 142.2 and relative portions of 141.6.

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TEST 143

AEROELASTIC EFFECTS TEST

143.1 Purpose.

Wind tunnel tests are performed on dynamically scaled models of the aircraft-with-stores to experimentally determine the airspeed, frequency, and modal shape of potential aeroelastic instabilities caused by the addition of external stores. For this purpose, flexible models of the aircraft-with-stores are used in which the geometric shape, mass and stiffness distributions are dynamically similar to the airplane and scaled to the tunnel's operating conditions. These models, with proper construction and instrumentation, simulate any aeroelastic instabilities, and are known as flutter models. These tests are performed to verify analytical predictions of aeroelastic instabilities such as flutter. For verification tests, the models are usually tested at increasing tunnel speeds until an instability occurs or the tunnel limits are reached. Tests are often performed only up to 1.15 times the limit speeds, unless instability should first occur, in order to reduce the risk of model destruction. Extensive flutter model tests may be conducted in low-speed wind tunnels with reasonable economy and assurance of accurate results especially when compressibility and Mach number effects are known to be insignificant. These models are dynamically scaled so that the lower dynamic pressures and airspeeds experienced in the low-speed tunnel represent proportionally much greater values for the aircraft. When compressibility effects may become important (usually above aircraft Mach numbers of about 0.70), limited verification tests may also be conducted in transonic facilities with flutter models that match aircraft Mach numbers in addition to being scaled for other dynamic aeroelastic properties. However, transonic flutter model testing is an order of magnitude more difficult, time consuming, and more expensive than low-speed testing. Special purpose flutter model tests may be appropriate especially when analytical approaches are lacking. One such type of test is to determine the effect of partially filled fuel tanks on flutter. Another type of test may very efficiently use a remotely controlled variable-inertia flutter model to conduct broad ranging parametric studies of the inertia effects on flutter. Wing tip mounted stores pose special analytical problems which may be resolved by wind tunnel testing. Tests using half-span flutter models may sometimes be used to reduce costs and increase testing efficiency or to avoid the inevitable small structural asymmetries of full-span models. However, half-span models do not simulate fuselage flexibility and, if important, must be investigated in other ways, such as full-span flutter models.

143.2 Data requirements.

a. The test data required may range from that which is very simple to that requiring elaborate instrumentation. Low-speed tunnel tests of flutter models generally require continuous monitoring of:

(1) Tunnel dynamic pressure.

(2) Tunnel speed.

(3) Tunnel temperature.

(4) Tunnel static pressures.

(5) Model wing (and sometimes pylon) bending and torsional strains.

(6) Model wing tip accelerations.

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(7) Store pitch/yaw and roll/lateral accelerations.

(8) Positions of control surfaces (usually for trim).

(9) Model soft-support limits.

b. Other data required may include high-speed motion picture coverage (usually only at the onset of any instabilities), local barometric pressure, and model configuration records. Transonic tunnel tests usually require, in addition, nearly continuous monitoring of:

(1) Mach number.

(2) Fluid purity (if some heavy fluid is used instead of air).

(3) Tunnel stagnation pressure.

(4) Tunnel stagnation temperature.

143.3 Test preparation.

143.3.1 Test article.

Flutter models are designed and constructed according to a rigid set of scale ratios which proportionally relate the model structural dynamics and tunnel flow conditions to the full-scale aircraft and atmospheric conditions. Low-speed flutter models are scaled so that the model-to-airplane non-dimensional ratios of reduced frequency, k, and the surface-to-air density, ρ, are unity. High-speed models (transonic and supersonic) are additionally scaled so that the Mach number ratio is also unity. Because of the manner in which the flutter model is aeroelastically scaled to the airplane, a transonic flutter model can be scaled to aeroelastically simulate the aircraft exactly at only one selected condition of aircraft airspeed and altitude. When an aeroelastic instability occurs in the transonic tunnel that does not coincide with this design condition, analytical corrections are applied to the test results. The dimensional scale ratios are derived from equations resulting from the above non-dimensional ratios as well as beam theory and the choice of geometric and airspeed scale ratios. The geometric scale ratio is usually selected to obtain the largest permissible model for the chosen wind tunnel. The airspeed ratio is selected based on the tunnel's operating limits and the aircraft's limit speeds with ample allowance for margins. The dimensional ratios multiplied by the aircraft's appropriate structural characteristics completely define the model's dynamic structural properties of size, distributed masses and stiffnesses. Properly built models should have natural vibration modes whose shapes closely duplicate those of the aircraft (with similar loadings) and accurately scaled natural frequencies that are at least within five percent of design values for the modes of interest. Flutter models are built of simplified construction to represent the aircraft's over-all structural dynamic characteristics to the degree of accuracy required. Exact structural replicas of the aircraft with every spar, stringer and bulkhead duplicated in miniature are not necessary in most instances. Single spar construction with attached, ballasted sections usually suffices for most flutter models. Some transonic models or models of low aspect-ratio aircraft may require some stressed-skin construction. Stiffness and mass properties of the wing, pylons, and multiple store ejector racks are especially important and require very accurate dynamic representation. The stiffness properties for most stores are so relatively high that they may be considered as being rigid, but their total mass properties must be accurately scaled. The geometric shapes, mass, and attachment stiffnesses of wing tip stores are especially important. In general, the further outboard on the wing the store/pylon/rack combination is, the greater impact it has on flutter speed. Before flutter models are installed in the wind tunnel, they must be thoroughly verified by the following test measurements and then documented:

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a. Load versus deflection to verify the accuracy of stiffness distributions

b. Section weights, centers-of-gravity and mass moments of inertia

c. Natural frequencies; mode shapes; and damping.

Flutter models are literally flown in the wind tunnel on soft support systems and require remotely controlled pitch trim because of the broad range of tunnel speeds over which they are tested. The soft-support system must be flexible enough to keep the highest of the rigid-body frequencies well below the lowest model resonance frequency. Care must also be taken so that the support system does not introduce static directional instabilities. A system to excite the model in the general frequency range of interest during testing may be needed. Sometimes tunnel turbulence is relied upon, but more often eccentric masses (driven by variable-speed motors) or jerk wires are used. The model, including stores, should be designed for rapid configuration changes. Prime interest in flutter model construction is the need to meet specified stiffnesses with light enough structure so that geometric airfoil sections lead ballast, actuators, exciters, instrumentation and other non-structural mass items may be so located as to achieve the specified mass distributions. This must be done with model structure that is usually far less efficient than aircraft structure while the models are tested to much higher (scaled) flow conditions than the full scale aircraft will encounter. These limitations become especially acute with models built for and tested in transonic and supersonic wind tunnels. Building flutter models as large as permissible tends to alleviate these limitations. Likewise, the use of heavy fluids instead of air in transonic wind tunnels allows the models to be much heavier for the same stiffness requirements. Testing external store configurations requires a very large number of tunnel entries for configuration changes. These are performed relatively fast in low-speed tunnels. Tests in high-speed tunnels consume more time because of the time required to recharge blow-down tunnels or the time needed to reclaim the special fluids in continuous flow heavy fluid tunnels.

143.3.2 Test equipment/instrumentation.

Wing root and mid-pan strain gauges are installed relative to the elastic axes to separate wing torsional and vertical bending motions using 4-arm bridge circuits. Wing tip accelerometers are also installed. The pylons are strain-gauged to detect pylon pitch and yaw motions or the stores are equipped with accelerometers for measuring roll, pitch, yaw, and lateral motion. The outputs of these transducers are recorded on strip charts and sometimes magnetic tape along with instantaneous tunnel conditions. Selected strain gauge channels are also displayed on oscilloscopes as Lisajjous figures to display the dynamic coupling of bending and torsion at the onset of an instability. Two or three motion picture cameras are installed to film the occurrence of any aeroelastic instabilities.

143.3.3 Test condition.

Since the model has been designed and scaled around the tunnel operating capabilities, the test conditions will be consistent with the test objectives. Namely, tests will be run with incremental increases in Mach Number if applicable, and velocity and dynamic pressure up to 1.15 times the scaled airplane-with-stores maximum flight envelope. A few select configurations may be run beyond 1.15 to obtain flutter points for correlation with theoretical analyses.

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143.4 Acceptance criteria.

These tests should be deemed to be successful if, after test completion, the following conditions have been met:

a. Model design, construction, and pre-test preparation were done according to test program.

b. Satisfactory operation of instrumentation and data recording equipment.

c. All required test conditions were properly controlled during data recording.

If the agency conducting the wind tunnel test does not provide a quality assurance service, then the test user or sponsor must validate the data.

143.5 Test procedure.

After model installation in the tunnel, a brief vibration test will be performed to ensure proper installation and model condition, and to check instrumentation operation. The various loading configurations are then tunnel tested in a predetermined sequence based on the technical logic involved and best efficiency in changing configurations. For each test, the tunnel speed is slowly increased while the model is periodically excited until an instability occurs or the test or tunnel limits are reached. Because blow-down tunnels have short test times, their tunnel airspeeds and dynamic pressures must be increased at relatively very rapid rates. When an instability occurs, high-speed movie cameras are activated and the tunnel is slowed down as quickly as possible to prevent extensive model damage. During the tests, continuously running oscillographs and oscilloscopes are monitored for signs of an impending instability. When the onset of an instability occurs, the instantaneous tunnel airspeed, dynamic pressure and other tunnel conditions are recorded. Other dynamics information such as flutter frequencies are determined from the oscillograph records. More modern testing methods now being developed should be able to trace model response frequencies and damping in near real time during testing.

143.6 Test reporting.

The report on the flutter model tests results should contain the date and place of tests, the model flutter parameters as compared with similar parameters of the full scale airplane, drawings and photographs of representative models, and of the model support. The report should contain the results of tests used to determine that the model does simulate the airplane. The report should also include the test conditions, the mode and frequency of flutter encountered if flutter occurs, plots of the damping coefficient and frequency versus velocity if transients are measured, plots of the flutter speed and frequency versus the variation in important parameters if a parametric study is performed, and comparisons of test results with the results of theoretical flutter analyses on the model. The method of correcting for compressibility should be included. Plots showing the wind tunnel characteristics and indicating the flutter boundary that must be attained (including the flutter margin) should also be included. All data should be presented in terms of both model parameters and airplane parameters.

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TEST 144

SEPARATION TESTS

144.1 Purpose.

The purpose of store separation testing is to gather sufficient data to assure acceptable separation. This is accomplished through wind tunnel testing and analysis of the resultant data. Aerodynamic data is taken on the store while in the aircraft flow field or in the flow field generated by the aircraft. The analysis is used to establish limit bounds for flight tests, to detect problem areas, and find pre-production fixes. There are two basic methods used to obtain this data: dual support systems and dynamically scaled drop testing. These methods are approximations to full scale flight testing; therefore, the method chosen must fit the specifics that need investigation. Care and experience should be exercised in this selection as the separation motion is strongly configuration and condition dependent.

144.1.1 Dual support method.

Dual support systems are usually referred to as captive trajectory systems (CTS) and are used to gather several types of data. Trajectory data, grid force and moment data, flow angularity data, and pressure data can be obtained by use of the CTS. Both trajectory, and grid force and moment testing require the store model to be mounted on a support system capable of motion relative to the aircraft model. The store model is attached to its sting by a strain gauge balance which senses the static aerodynamic loads action on the store. These loads are used for two distinct purposes: on-line trajectory prediction (CTS or point prediction) and off-line trajectory prediction.

a. On-line trajectory prediction requires direct access to a computer while the wind tunnel provides the flow field which generates the static loads on the store model. The computer is used to sum the total loads on the store (static aerodynamics, dynamic, weight, ejection, thrust) as a function of time, integrate the equations of motion, calculate new positions and attitudes, and either reposition the store or give a manual setting as an option. The process is then repeated for as long as desired or until contact occurs between the store/aircraft, support systems or tunnel boundaries are reached. The grid method consists of acquiring the store loads for various combinations of attitudes and positions while in the aircraft flow field and storing them for later use. These data are accessed by different methods for use in the equations of motion. Some facilities curve fit the entire flow field while others use a combination of free stream (isolated from the aircraft field) and interference loads for the total aerodynamic loads to be used.

b. Flow field data consist of recording the pressure field beneath the aircraft model by using angularity probes positioned at various locations in the aircraft flow field. The pressure data are then used with various schemes to ultimately calculate the static aerodynamic load felt by a store immersed in the pressure field. A combination of free stream (isolated from the aircraft field) and flow angularity data can be used to calculate the total aerodynamic loads for use with equations of motion in an off-line prediction method. If enough pressure taps can be physically located in the store model, then these pressures can be integrated in order to get the static loads on the store. For a finned model this is usually impossible for the customary five and ten percent scale models. However, such data can be obtained on finless symmetric models by locating pressure taps along one meridian. By rolling the model through 360 degrees in small increments and integrating the pressures circumferentially and longitudinally

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the static loads and load distribution can be calculated. This type of data is usually used to check analytical prediction methods.

144.1.2 Dynamically scaled drop method.

The dynamic method consists of releasing (ejecting if required) a dynamically scaled store model in the flow field of an aircraft model to determine the separation trajectory. Although all scaling laws in common use require the exterior geometry to be scaled, various methods are in common use to scale mass, dynamic pressure, moments of inertia, and ejection forces. The three basic methods are light, Froude, and heavy with the first two having various possible modifications to offset some known deficiencies. The path during the separation process of the scaled model is photographically recorded for analysis. The effect of model retrieval systems is compensated for in closed circuit wind tunnels by make-up of the energy loss in the compressors. Dynamically scaled drop method is usually used for stores having large angular displacements after release (such as fuel tanks), and for cases such as ripple and weapons bay releases where dual support testing is not applicable.

144.2 Data requirements.

Data requirements will depend upon the availability of the wind tunnel models for both store and aircraft, and the type of test performed.

144.2.1 Dual support method.

If ejection is required, the ejection characteristics, such as force versus time curves and ejector feet locations, should be supplied. If free stream store data are available, they are helpful in determining the location of the strain gauge balance inside the model. The store trajectory, forces, moments, and tunnel conditions as in paragraph 141.2 are required. Although the process of nondimensionalizing aerodynamic loads to coefficients is relatively standard procedure, to avoid confusion the reference dimensions (area, span, chord) for data reduction should be defined.

a. The store data required to calculate trajectory characteristics include moments of inertia, center-of-mass location, and dynamic stability derivatives. Additional parameters such as thrust and forces due to wind gusts can be expressed as a function of time or position/attitude as required.

b. The test schedule outlining release altitude, aircraft maneuvering conditions, Mach number, and aircraft angle of attack/sideslip is required.

c. In the event the store has devices, such as deployable wings or fins that would change the store's aerodynamic characteristics in the separation phase, approximate data including aerodynamic, inertial and deployment time must be included in the trajectory calculation.

d. A configuration with active controls during separation must have the governing equation for the control feedback. The constants necessary for the particular control system such as lead/lag ratio must also be supplied.

e. In the event that grid type data (force and moment, flow angularity, or pressure data) are desired, the position schedule where data is to be taken relative to the parent aircraft model should be provided. The test schedule outlining release simulation altitude, Mach number, and aircraft angle of attack/sideslip are required.

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144.2.2 Dynamically scaled drop method.

If ejection is required, the ejection characteristics such as force versus time curves and ejector feet locations should be supplied to the tunnel facility. The information necessary to dynamically scale the store model such as mass distribution is also required. The test schedule outlining release simulation altitude, Mach number, and aircraft angle of attack/sideslip is required. The store trajectory derived from photographic data is the end product to be supplied to the user.

144.3 Test preparation.

144.3.1 Test article.

The geometrically scaled aircraft model capable of being supported at the desired angles of attack/sideslip with the necessary pylons, related stores, and racks that will simulate the complete aircraft configuration is required. Various types of straight/bent store model mounting stings are often required.

144.3.1.1 Dual support method.

The geometrically scaled store model capable of containing an internal strain-gauge balance and being supported by an independent support system is required for testing that involves measurement of forces and moments. A flow-field probe is required for flow angularity measurements. A store model with a large number of pressure taps is required, if forces and moments are to be determined from pressure integration.

144.3.1.2 Dynamically scaled drop method.

The numbers of store models required depends on the retrieval system, if any, the model frangibility, and the test schedule. All drop models must be geometrically, mass, and inertially scaled for the given dynamic method. Forced separation, if required, may be simulated using a spring, impulse cartridge, or pneumatic system located properly in the pylon or rack so as to contact the store model correctly.

144.3.2 Test equipment/instrumentation.

144.3.2.1 Test equipment.

The tunnel capability and desired method of testing usually determine which facility can be used to perform the required tests.

144.3.2.1.1 Dual support method.

Since the spatial relationship between the parent aircraft and the store is the important feature being simulated, either the aircraft model can be moved relative to the store model or the store model can be moved relative to the parent aircraft. The latter technique is more common, mainly because the loads on the store are smaller than those on the aircraft and the resultant support mechanism required is less bulky. A remotely controlled separate sting-support system is somewhat unique to captive methods. The system must support the store model at the end of a sting via a strain gauge balance. Such systems are usually capable of up to six-degrees-of-freedom from either manual controlled devices or servo controlled from an on-line computer.

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These systems usually permit three positions (longitudinal, lateral, and vertical) and three attitudes (pitch, sideslip and roll) to be controlled.

144.3.2.1.2 Dynamically scaled drop method.

Test chamber floor protectors and net retrieval systems may be required to prevent damage to the tunnel and reduce the damage to the store models. Special equipment to provide pressure and release functions for ejection may require repeated calibration during testing.

144.3.2.2 Test instrumentation.

144.3.2.2.1 Dual support method.

A load detection system consisting of an internal (to the store) strain gauge balance with a minimum of four (no axial force or roll moment) components is required for force and moment testing. It is desirable that all six components be obtained.

a. Electrical equipment is required to condition the electrical signals from the strain gauge balance. This includes a data acquisition system for filtering, digitizing, and recording for storage.

b. A computer of sufficient capability is required for either the on-line or grid method.

c. For flow field measurements, a system of one or more angularity probes capable of sensing several total pressures and several static pressures is required.

144.3.2.2.2 Dynamically scaled drop method.

Estimates of expected separation speed and trajectories should be made to enable selection of appropriate recording equipment such as a strobe light system with still cameras, a high-speed slotted rotating disk with a camera, high-speed motion picture cameras, or a video tape system should be selected.

144.3.3 Tests conditions.

144.3.3.1 Dual support method.

The aircraft model normally remains at a fixed angle of attack/sideslip for each separation trajectory or for each grid of data. The test Mach number is the same as the full scale Mach number and the aerodynamic loads are nondimensionalized to coefficient form for use at any altitude (dynamic pressure). Aircraft maneuvering such as dive, climb or loft delivery are mathematically simulated by the computer. The store attitudes and positions are determined step-by-step in the on-line mode. The range of attitudes and positions covered for grid must be determined prior to testing. Care must be taken to ensure sufficient coverage. One method to establish the range of coverage is to run some selected on-line trajectories.

144.3.3.2 Dynamically scaled drop method.

The aircraft model normally remains at a fixed angle of attack/sideslip for each given separation trajectory. The Mach number is determined by the scaling law used. The test Mach number is the same as the full scale Mach number for the light, modified light, and heavy methods. However, the Froude and modified Froude method do not normally have the test Mach number the same as the full scale Mach number.

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144.4 Acceptance criteria.

These tests should be deemed to be successful if, after test completion, the following conditions have been met:

a. Model design, construction, and pre-test preparation are done according to test program.

b. Satisfactory operation of instrumentation and data recording equipment.

c. All required test conditions were properly controlled during data recording.

If the agency conducting the wind tunnel test does not provide a quality assurance service, then the test user or sponsor must validate the data.

144.5 Test Procedure.

144.5.1 Dual support method.

In on-line trajectory simulations, the store and aircraft models are sometimes mounted inverted in the tunnel for improved trajectory monitoring and to provide convenient access to the models. After the desired test conditions have been obtained in the wind tunnel and the aircraft angle of attack/sideslip are correctly integrated (as a result of airload deflections) to the correct values, the store model is placed at some reference position. For on-line trajectories, this reference point is either the stored (carry) position or the closest place in the separation trajectory that the complete kinematic conditions are available (e.g., the end of an ejector stroke, the end of trapeze swing, the end of a rail launcher).

a. The wind tunnel serves only to generate loads on the store model at positions and attitudes within the flow field of the aircraft model. The store nondimensionalized static aerodynamic loads plus model weight and loads are fed to a computer to be processed. Since the actual trajectory to be simulated will most likely be at some other pressure altitude than at full scale, the computer is programmed to redimensionalize the force and moment coefficients with the proper lengths, areas, and dynamic pressures. The computer is programmed to sum the complete loads on the store as a function of time. The equations of motion are then integrated in an inertial reference system (usually assumed to be the flat surface of a nonrotating earth). The computer then transforms the movement of both store and aircraft for the given time interval back into the tunnel axis through the use of axes transformation equations. At this point, the store must be repositioned to the prediction point. This process of summing loads, integration of the equations of motion, transformation of movement, and placement of store model is repeated until a sufficient distance from the release point has been traversed or until a collision of the store support system with the aircraft or the wind tunnel walls occur.

b. For grid forces and moments, the reference point described above is some known position and attitude relative to the aircraft model. The flow field generated by the aircraft is then mapped using the store model as the probe. This is accomplished by moving the store through some matrix of position and attitude ranges. The store nondimensionalized static aero-dynamic loads plus store model weight tare loads, are digitized and stored for later use in separation simulations. Some judgment must be used to establish the prospective ranges of positions and attitudes of coverage as the simulations may move out beyond coverage.

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c. The first step during a flow field test is the calibration of the flow field probe(s). The calibration is done throughout the range of test Mach numbers and angles of attack/sideslip to remove any inaccuracies in the actual test that might be caused by the probe. The aircraft model in the desired configuration is then placed in the tunnel and the tunnel is then brought up to the desired test conditions. The flow field probe(s) are then moved to the desired locations and the data recorded.

144.5.2 Dynamically scaled drop method.

After the store model is loaded on the aircraft, the aircraft angle of attack/sideslip are brought to the desired test conditions along with the correctly scaled wind tunnel Mach number (velocity) and density. The photographic coverage is initiated and the release sequence started. After completion of the separation, the tunnel is shut down, and preparations are made for the next drop.

144.6 Test reporting.

144.6.1 Data reports.

In addition to the following specific data reports, the requirements of 141.6.1 will also be met.

144.6.1.1 Dual support method.

As a minimum for on-line trajectories, a tabulated computer printout must be provided. Printout information should include, but not be limited to, aerodynamic forces and moments, position, velocities, accelerations, Mach number, and angular attitudes and rates as a function of time. Some of these may be relative to the inertial reference (usually the flat surface of a nonrotating earth) or relative to the aircraft. Some facilities provide plotted data for selected information during testing. In addition, the output may consist of plots or schematics to assist in data analysis.

a. In a grid test, the store force and moment coefficients (actual and corrected) as a function of position and attitude relative to the aircraft must be provided. Mach number and aircraft attitude also must be provided. In addition, the output may consist of plots or schematics to assist in data analysis.

b. The data reported from flow angularity and pressure testing depends on the degree of sophistication of the equipment involved. The recorded data may include position, Mach number, aircraft angle of attack/sideslip, and manometer or transducer readings which must be converted to pressure. The pressures in the normal/side plane of the angularity probe are used to calculate the normal/side velocity components. The total and static pressures are used to calculate dynamic pressure. These data are given at the various positions along with the Mach number, and aircraft angle of attack/sideslip.

144.6.1.2 Dynamically scaled drop method.

The most condensed form of the photographic record is multiple exposure prints. These photographs may be used to calculate velocities and accelerations if the timing intervals of the multiple exposures is known. As a minimum, run number should be shown on each print. Another record is motion picture prints. The motion picture prints may be used to calculate velocities and acceleration if the film speed is known. As a minimum, run number should be

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shown on each print. If two or more cameras are used, synchronization is required. The output should include plotted data from the photos in the form of store position and attitude.

144.6.2 Final report.

The requirements of 141.6.2 must be met.

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APPENDIX A

150 SERIES TESTS

ENVIRONMENTAL TESTS

150.1 Purpose.

Tests in the 150 series are designed to satisfy the environmental analysis portion of the aircraft/stores compatibility.

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APPENDIX A

TEST 151

VIBRATION TEST

151.1 Purpose.

Vibration ground tests are performed to determine the ability of the store configuration(s) to withstand and operate in the flight vibration environments. Environments covered by these tests include vibration due to external store aeroacoustic environment, general aircraft vibration transmitted to the store, airframe buffet vibration transmitted to the store, and the aeroacoustic environment within open weapons bays.

a. Vibration tests simulate the airframe induced and the higher frequency aeroacoustically induced vibration environment. The tests verify store operation and structural integrity in this environment. In addition, adequacy of component vibration criteria can be verified.

b. Tests 151 and 152 should be combined when possible. Low frequency mechanical (shaker) inputs of the vibration test added to the high frequency acoustic energy of the aeroacoustic test provide the best simulation of the store flight, ground, and aircraft carrier operation (if applicable) vibratory response.

c. Additional vibration ground tests are required to test store/rack/launcher configurations for which vibration test requirements of MIL-T-7743 apply.

151.2 Data requirements.

The test should verify that the store survives and operates satisfactorily in the flight, ground, and aircraft carrier vibration environments. The data required should verify that the test was properly conducted, should document local vibration responses to the store, and should contain the following:

a. A description of the test set-up supplemented by drawings and photographs.

b. A list of the rigid body suspension modes including frequencies and mode shape descriptions.

c. A list of the equipment and instrumentation used in the test.

d. A copy of the test procedure including test levels, durations and tolerances.

e. A copy of the test log.

f. Measurements of the vibration response of the test item at the beginning, end, and at appropriate intervals during each test run. Unless specifically agreed to prior to the test, this data should be in acceleration spectral density in g^2/Hertz versus Hertz units on a log log format.

g. Any additional response measurements made during the test. Measurement times and data formats appropriate to the particular measurement are acceptable, however, the format stated above is recommended for general use. (If possible, all plots should have the same frequency scale and all amplitude scales should be consistent in the linear (plotted) dimension per decade (10db)).

h. Copies of the functional performance check sheets.

i. Include the data required by Test 152A.

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151.3 Test preparation.

MIL-STD-810, Method 514 should be used in interpretation and implementation of the following.

151.3.1 Test article.

The test article should be a full scale functional store.

151.3.2 Test equipment.

The test article should be suspended by a suitable structure in such a manner that rigid body suspension frequencies are as low as possible. Vibration should be input directly to the test article by mechanical shakers.

151.3.3 Test instrumentation.

The test instrumentation should include accelerometers to monitor the primary structural responses of the test article and to control the vibration shakers. Additional instrumentation should be utilized to monitor local responses as needed. Instrumentation should be properly calibrated.

151.3.4 Test conditions.

The test conditions should reproduce the expected service life exposure levels and times. The test conditions specified are the vibratory responses of the store at structural hardpoints within the store. Typically the acceleration levels at the structural nose and tail of the store in the vertical and lateral planes are used to control the test. The test levels should be determined prior to test. Sources of test levels are listed below in order of preference:

a. Measurements of captive flight, ground, and aircraft carrier operation vibration of the test item (see Test 221).

b. Measurements of captive flight vibration of similar stores. Similar stores must have similar inertia, shape and dynamic (mode shapes and frequencies) characteristics.

c. Estimates of environment based on MIL-STD-810, Method 514.4.

151.4 Acceptance criteria.

The test article should function in accordance with the specification(s) during and after the test. In addition the test article should not suffer physical or structural damage during the test.

151.5 Test procedure.

Test procedures to be used for the vibration test are described in, or may be modeled after, MIL-STD-810, Method 514.4. When vibration and aeroacoustic tests (Test 152) are combined, test procedures should be a combination of these procedures and those presented in MIL-STD-810, Method 515.4. The required acoustic environment is applied and resulting vibration responses determined. Sufficient vibration is added to raise test article responses to required levels. In frequency bands where vibration responses meet or exceed required levels no vibration input is required. Acoustic levels should not be lowered when vibration response exceeds the vibration requirements.

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151.6 Test reporting.

The test report should cover the test objectives, test article, instrumentation, procedures, data requirements of 151.2, results and conclusions. Each test failure and anomaly should be discussed along with reasons for failure and proposed design changes to correct the problem(s).

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TEST 152

AEROACOUSTIC TEST

152.1 Purpose.

Acoustic ground tests are performed to determine the ability of the store configuration(s) to withstand and to operate in the flight, ground, and aircraft carrier operations acoustic environments. Internal weapons bays subject stores to intense acoustic fields during periods that bay doors are open. These tests cover weapons bay and external carriage acoustic environments.

a. Acoustic tests simulate the higher frequency portions of the aeroacoustically induced vibration environment. The tests verify store operation and structural integrity in this environment. In addition, adequacy of component vibration criteria can be verified.

b. Tests 151 and 152 should be combined when possible. Low frequency mechanical (shaker) inputs of the vibration test added to the high frequency acoustic energy of the acoustic test provide the best simulation of store flight and ground vibration response.

152.2 Data requirements.

The test should verify that the store survives and operates satisfactorily in the flight and ground aeroacoustic environments. The data required should verify that the test was properly conducted, should document local vibration responses to the store, and should contain the following:

a. A description of the test set-up supplemented by drawings and photographs.

b. A list of the rigid body suspension modes including frequencies and mode shape descriptions.

c. A list of the equipment and instrumentation used in the test.

d. A copy of the test procedure including test levels, durations and tolerances.

e. A copy of the test log.

f. Measurements of the acoustic field surrounding the test item at the beginning, end and at appropriate intervals during each test run. Unless specifically agreed to prior to the test these data should be in 1/3 octave band sound pressure level versus Hertz units on a semi-log format.

g. Any additional response measurements made during the test. Measurement times and data formats appropriate to the particular measurement are acceptable, however, the following is recommended for general use. Acoustic measurements should be as stated above. Vibration levels should be 1/3 octave band rms acceleration versus Hertz units on a log-log format and repeated in narrow band acceleration spectral density in g^2/Hertz versus Hertz on log-log format. (If possible, all plots should have the same frequency scale and all amplitude scales should be consistent in the linear (plotted) dimension per decade (20 dB for sound pressure level (SPL); 10 dB rms for acceleration spectral density (ASD)).

h. Copies of the functional performance check sheets.

i. When applicable include the data required by Test 151.

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152.3 Test preparation.

MIL-STD-810, Method 515.4 should be as guidance in interpretation and implementation of the following.

152.3.1 Test article.

The test article should be a full scale functional store.

152.3.2 Test equipment.

The test article should be suspended in a suitable acoustic test chamber, acoustic wind tunnel, free jet flow facility or other suitable test facility. The test article should be suspended in such a manner that rigid body suspension frequencies are as low as possible.

152.3.3 Test instrumentation.

The test instrumentation should include microphones to monitor the test acoustic fields. Additional instrumentation should be utilized to monitor local vibration responses as needed. Instrumentation should be properly calibrated.

152.3.4 Test conditions.

The test conditions should reproduce the expected service life exposure levels and times. Test conditions are specified as sound pressure spectra at the surface of the test article. For stores with open cavities exposed to airflow the sound pressure within the cavities is also required. The test levels should be determined prior to test. Sources of test levels are listed below in order of preference. (For measurement of captive flight test data, see Test 222.)

152.3.4.1 External carriage.

a. Measurements of captive flight environment of the test item.

b. Measurements of captive flight environments of similar stores. Similar stores must have similar inertia, shape and dimensions.

c. Estimates of environments based on MIL-STD-810, Method 515.4.

152.3.4.2 Internal carriage.

The following should be coordinated with the vibroacoustics engineering staff of the certificating agency.

a. Measurements of the open weapons bay environments of the aircraft.

b. Scaled wind tunnel measurements of open weapons bay environments of the aircraft.

c. Estimates of the open weapons bay environments of the aircraft.

152.4 Acceptance criteria.

The test article should function in accordance with the specification(s) during and after the test. In addition the test article should not suffer physical or structural damage during the test.

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152.5 Test procedure.

Test procedures to be used for the aeroacoustic test are described in or may be modeled after MIL-STD-810, Method 515.4. When vibration (Test 151) and aeroacoustic tests are combined, test procedures should be a combination of these procedures and those presented in MIL-STD-810, Method 514.4. The required acoustic environment is applied and resulting vibration responses determined. Sufficient vibration is added to raise test article responses to required levels. In frequency bands where vibration responses meet or exceed required levels no vibration input is required. Acoustic levels should not be lowered when vibration response exceeds the vibration requirements.

152.6 Test reporting.

The test report should cover the test objectives, test article, instrumentation, procedures, data requirements of 151.2, results and conclusions. Each test failure and anomaly should be discussed along with reasons for failure and proposed design changes to correct the problem(s).

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APPENDIX A

TEST 153

HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) TEST

153.1 Purpose.

HERO tests are designed to measure the level of electromagnetic (EM) energy which can be induced into ordnance circuits and dissipated electrically initiated devices (EIDs). The tests are structured to reproduce the electromagnetic environment normally encountered during the sequence from shipping, handling, loading through to delivery. Army conditions are as specified in ADS 37. The test data is analyzed in context with the evaluation criteria to yield a meaningful assessment of the potential effects of the EM energy. These effects are treated as two categories:

a. Hazards in which spurious initiation of an EED might result in injury to personnel or damage to material; and

b. Reliability degradation in which spurious initiation of an EED might result in dudding or degradation of ordnance.

Adequate design protection for electroexplosive subsystems and EIDs must be verified to ensure safety and system performance. Unless a theoretical assessment positively indicates that the induced stimulus on EID firing lines or in electronic circuits associated with safety critical functions is low enough to assure an acceptable safety margin in the specified EME, a HERO test will be required.

153.2 Data requirements.

Assessment of the immunity of an EID is based upon its no fire threshold. For acceptance, test results must demonstrate that any stimulus induced in an EID circuit in the specified EME will not exceed a given level expressed as a margin in dB below the maximum no fire threshold sensitivity for the subject EID.

The required margins, as specified MIL-STD-464, distinguish between safety (16.5 dB) and other applications (6 dB) and allow for measurement uncertainties, such as test instrumentation, EME levels, system configuration, etc.

A detailed description of the electrical characteristics is required to perform the pre-test analysis and to evaluate the test results. The following characteristics should be available:

a. Maximum no-fire D.C. stimulus of each EED.

b. Radio frequency impedance of each EED.

c. Radio frequency sensitivity of each EED.

d. Launcher and ordnance wiring diagram showing all connector wire paths, switches and EID locations.

e. A detailed description of the prescribed test, handling and loading procedures, including identification of ground support equipment (optional for Air Force).

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153.3 Test preparation.

153.3.1 Test article.

Representative aircraft, stores, suspension equipment and loading equipment (optional for Air Force) must be utilized. Modification of any of these items requires verification that the modification does not limit the applicability of the test results to less than the system configuration to be certified.

153.3.2 Test equipment.

Only equipment that is available to aircraft and armament personnel, high power RF transmitters, high power antennas and a ground plane (simulated carrier deck for Navy and runway for Air Force) should be used. In the HF range, transmitting antennas should be the same type used to produce the service EME.

153.3.3 Test instrumentation.

Methods used to demonstrate compliance HERO requirements necessitate instrumenting the EID and firing circuits using techniques such as thermocouple and fiber optic temperature sensors, RF voltage or current measurement devices, temperature sensitive waxes, or substitution of more sensitive elements. Such instrumentation must not alter the system's inherent (noninstrumented) response characteristics. The instrumentation's sensitivity and response time must be sufficient to capture maximum RF induced responses of the EIDs or firing circuits at specified EMEs.

153.3.4 Test conditions.

The test procedures should be primarily influenced by the need to simulate actual operational conditions. A meaningful set of predicted worst case aircraft generated and external electromagnetic environments (based on MIL-STD-464) should be utilized to lead to test results similar to actual effects produced by existing operational environments. The test EME should simulate the specified EME to the extent necessary to stimulate maximum EID and firing circuit responses. This requires an appropriate representation of the specified EME with respect to frequency, field strength (power density), field polarization and angle of incidence. For radar EMEs, representative pulse widths, pulse repetition frequencies and beam dwell periods should be chosen to maximum system response with due consideration for the response times of EIDs and firing circuits.

153.4 Acceptance criteria.

The maximum no fire threshold is the level at which no more than 0.1% of the devices will fire at a 95% confidence level when a stimulus is applied for a period at least ten times greater than the time constant of the device. The maximum no fire threshold can also be defined in accordance with MIL-I-23659. Furthermore, there must not be any RF induced interference to energized firing circuits that results in an unintentional firing command or stimulus to the EID in the specified EME. Acceptable performance level is defined as the margin in dB below the malfunction or switching threshold for an electronic component or system.

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153.5 Test procedure.

Determination of system resonances is a fundamental aspect of HERO testing. If possible, swept frequency testing is the preferred method of determining resonant frequencies. Mode stirred (reverberation) chambers can be used effectively for creating contained, swept frequency EMEs. Follow on testing at discrete, high level EMEs is recommended to determine actual radiated susceptibility thresholds. In the absence of preliminary swept frequency resonance identification, table A-II provides the recommended minimum number of frequencies for discrete frequency testing. In cases in which the test EME is less than the specified EME, the response of linear devices (such as bridgewire EIDs) can be extrapolated to reflect the response in the higher, specified EME. However, if there is no detected response with the given test EME, the following restriction on extrapolation is necessary: the acceptable EME should not be increased by a factor exceeding the ration of the pass or fail limit to instrumentation sensitivity. The response of nonlinear EIDs (such as semiconductor junction devices and electronic safe and arm devices) should not be extrapolated.

TABLE A-II. Recommended number of test frequencies.

Frequency band (MHz)	Minimum number of test Frequencies per band
0.01-2	10
2-32	20
32-100	20
100-1,000	10
1,000-18,000	20
18,000-40,000	5

153.6 Test reporting.

The test report should cover the test objectives, test article, test instrumentation procedures, data requirements of 153.2, results and conclusions.

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APPENDIX A

TEST 154

ELECTROMAGNETIC COMPATIBILITY AND ELECTROMAGNETIC INTERFERENCE (EMC/EMI) TEST

154.1 Purpose.

EMC/EMI certification tests and analyses are performed to determine the extent of unintentional interaction, if any, between aircraft avionics systems, the aircraft operational environment, and store electronic systems as well as the effect of each store on all other stores in the proposed configuration. The effect of all unintentional interactions on flight safety and mission success must be determined and documented.

154.2 Data requirements.

Generally, the data required for EMC/EMI certification analyses is available in the test data and reports generated for each specific system or equipment during development and qualification testing in accordance with MIL-STD-464, MIL-STD-461, MIL-STD-462 and ADS-37 (for Army). In addition to this data, the following specific information is needed on the avionics and store systems.

154.2.1 Avionics systems.

154.2.1.1 Transmitter.

For each transmitting system/subsystem, identify operating frequencies, average/peak output power, spectral content for each transmission mode, duty cycle, pulse repetition frequency with pulse width. Additionally provide information for each antenna type, pattern with gain levels, location, and orientation.

154.2.1.2 Receiver.

For each receiver system/subsystem, identify operating frequencies, minimum sensitivity, dynamic range, half-power bandwidth, shape factor, and interference rejection circuitry (if applicable). Additionally, provide information for each antenna type, pattern with gain levels, location, and orientation.

154.2.1 Stores.

A detailed operational description is required for each store's electronic systems/subsystems, including a detailed functional description of any store EED firing train (if applicable). Provide store electromagnetic susceptibility thresholds and emission characteristics (e.g., MIL-STD-461 results). Where applicable, the same information that is required for aircraft avionics transmitter and receiver systems is necessary for store transmitter and receiver systems.

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154.3 Test or analysis preparation.

154.3.1 Articles.

Stores containing electronic systems/subsystems and aircraft avionics systems are subject to analysis which may reveal the need for testing. All onboard transmitter systems and external emitters defined by MIL-HDBK-235-1 are viewed as electromagnetic sources. Avionics receivers and all store electronic systems/subsystems are considered to be potential victim receptors.

154.3.2 Support equipment.

Due to the wide range and diverse type of systems which may require testing (guided weapons, ECM pods, designator pods), special support equipment required must be determined on a case-by-case basis. A shielded enclosure or anechoic chamber facility is sometimes required for certification testing. No special equipment is required for analysis.

154.3.3 Test instrumentation.

Instrumentation requirements for electromagnetic interference (EMC/EMI) testing are given in MIL-STD-464, MIL-STD-461 and MIL-STD-462. No special instrumentation is required for analysis.

154.3.4 Test conditions.

Test conditions required for EMC/EMI testing are given in MIL-STD-464, MIL-STD-461, and MIL-STD-462. No special conditions are required for analysis.

154.4 Acceptance criteria.

Tests and analyses demonstrating that no system or subsystem experiences degradation of performance or creates a safety hazard due to the presence of the external environment for any other system or subsystem within the configuration being considered constitute acceptable electromagnetic compatibility. For Army, ADS-37 also includes acceptance criteria.

154.5 Electromagnetic certification procedures.

The procedures which follow are grouped under four general phases: data review, analysis, test, and post-test analysis. These procedures are intended as a guide in formulating a test plan for the specific systems being considered.

154.5.1 Data review.

The objective of this phase is to gain familiarity with the functional aspects of the systems involved and to ascertain that sufficient data is available to do an analysis:

a. Review the technical data on all weapon systems and sources of electromagnetic energy, both onboard and external. The technical data should include transmitter antenna patterns with gain levels, antenna and frequency response, spectral contents power output (peak and average), spurious response, duty cycle, frequency, and modes of operation. Receiver data should include antenna patterns with gain levels, antenna frequency response, receiver sensitivity over the operational frequency band and the bandpass and shape factor of the RF/IF stages. Note any signal conditioning within the bandpass which may inhibit the

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effects of in-band EMI or electronic countermeasures (ECM). Systems data should include locations of all transmitters, receivers, associated cabling, antennas, and system operatives (such as windows and access panels).

b. Review the EMC/EMI test data on all weapon systems. This data is normally generated during system development and qualification testing. Note any documented susceptibilities to EM radiation.

c. Determine the adequacy of available technical data and test results. Data which is not available should be categorized as desirable or essential. Data requirements should be reported to the tasking agency with recommended procedures for obtaining the data.

154.5.2 Analysis.

The objective of the analysis phase is to identify those systems in the host and companion aircraft, existing certified stores and the external environment which electromagnetically interact with the store being certified and to assess the probable degree of interaction. This is achieved by comparing each source of electromagnetic energy (such as transmitter antennas or power cables) aboard the host and companion aircraft, and each previously certified store and the environment defined by MIL-HDBK-235 to all possible victim receptors (such as receiver antennas) of the store being certified. Then the process is reversed to determine the effect of each electromagnetic source on the store being certified on the victim receptors onboard the host aircraft and all other certified stores. Determine the characteristics for each source of electromagnetic energy external to and aboard the host aircraft and previously certified stores. Required characteristics include: main lobe gain and patterns, peak power output, spurious emissions, and signal parameters. This information should be tabulated or shown on a suitable graph. The analysis must also consider the means by which the existing store was previously certified. If the existing store was certified by analysis (not verified by subsequent test), the uncertainties created by certification by similarity are compounded. If the existing store was certified by test, knowledge of past and present test criteria and, where applicable, test electromagnetic environments, must be ascertained to permit an accurate analysis/comparison. This particularly important in those cases where the severity of the external environment has increased significantly over time and extrapolation cannot, due to nonlinear response characteristics of the new store, be used to reliably predict store responses.

154.5.3 Test procedure.

The test phase can cover a broad range of tasks to be performed with varying degrees of accuracy required. In the most simple form, testing may consist of uploading the store configuration on the host aircraft for a flight to verify that no compatibility problem exists. A fully instrumented anechoic chamber or static ground test with external high-power emitters and follow-on instrumented flight tests may be necessary. The amount and type of testing required is a function of the results obtained during the analysis phase. The test approach should be as follows:

a. List the specific data required to accomplish certification, e.g., the RF level in the UHF band at station 2.

b. Determine the type of tests required to obtain the data.

c. Define how each test is to be accomplished, (i.e., the specific store configuration, which systems are to be operated and in what modes or settings, the test equipment to be used, and the data requirements).

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d. With the test personnel, write a test plan which encompasses the information above. Additionally, the test plan should address scheduling, environmental/ecological impact, a hazards analysis with respect to personnel and aircraft safety, and identification of storage handling, and EOD render-safe procedures. All tests plans must be submitted to and approved by the procuring activity.

e. Perform testing as required.

154.5.3.1 Post-test analysis.

The post-test analysis phase consists of going back through the analysis phase with the additional test data. Previous points of ambiguity should be clarified and the necessity of a verification flight test determined. Wide discrepancies between analytic predictions and test results must be investigated and explained. The final action under the post-test analysis phase is formulating a recommendation on certification.

154.6 Test or analysis reporting.

The documentation phase consists of reporting the recommendation on certification. The report should display and interpret the pertinent data which led to the recommendation and should clearly state the configuration for which the recommendation applies. The final report, technical data, and working papers for the project should be forwarded to the tasking agency. If applicable, the final report should clearly state when official waivers are necessary. When waivers are needed, the appropriate agencies will be provided copies of the final report and other pertinent documentation for review and approval.

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TEST 155

TEMPERATURE EXTREMES AND THERMAL TEST

155.1 Purpose.

These thermal tests are for the purpose of determining the compatibility of the test article in the thermal environment of captive carriage including flight, ground and, when applicable, aircraft carrier operations. Thermal-structure testing is covered in Test 120. Aerodynamic heating, ambient temperature variations and other thermal sources can alter or modify the functioning characteristics or cause carriage limitations on the store/suspension equipment being investigated. Thermal test conditions as determined in the analysis requirements, see 5.1.4.11, may be used if captive carriage conditions are not available.

155.2 Data requirements.

The data required should include the imposed thermal environment, the thermal response, temperature time histories of critical components and the functioning characteristics during and after the tests.

155.3 Test preparation.

155.3.1 Test article.

The article tested should be physically and thermally representative of the proposed store. Insofar as possible, explosive or hazardous materials should be simulated by non-explosive or nonhazardous materials having similar physical and thermal properties. The effects of differences in thermal properties of the test article and the actual article should be analyzed and documented in the final report.

155.3.2 Test equipment.

The test equipment should consist of those heating or cooling facilities required to simulate the thermal environment. These facilities may include, but not be limited to, hot or cold gas flow sources, environmental test chambers, radiant heat sources, conductive thermal sources as well as the necessary instrumentation to verify the test conditions. Two types of ground test facilities which are available for thermal tests are radiant heat facilities and wind tunnels. The limitations of the test equipment are:

a. Test chamber temperatures should be controlled to skin temperature (not air temperature).

b. Use caution with temperature chambers to establish the correct thermal gradients in the test item.

c. It is possible to have high airflow rates in an environmental test chamber. This is an important consideration when testing components which are in a confined (still air) environment when assembled. The convection process will be very difficult to simulate correctly.

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155.3.2.1 Radiant heat facilities.

a. Capabilities:

(1) Capability of testing full scale flight hardware and providing operational certification.

(2) High productivity at low cost.

(3) Duplication of temperature, heat transfer rate and store component thermal response.

(4) Capability of simulating flight-trajectories in real time.

b. Limitations:

(1) Component initial temperature and heat transfer rate distribution must be known beforehand.

(2) Heating is simulated by radiation instead of air friction.

c. Data obtained from the radiant heat facility are in the form of component thermal responses, i.e., temperature versus time. Thermal philosophy is presented on figure A-1.

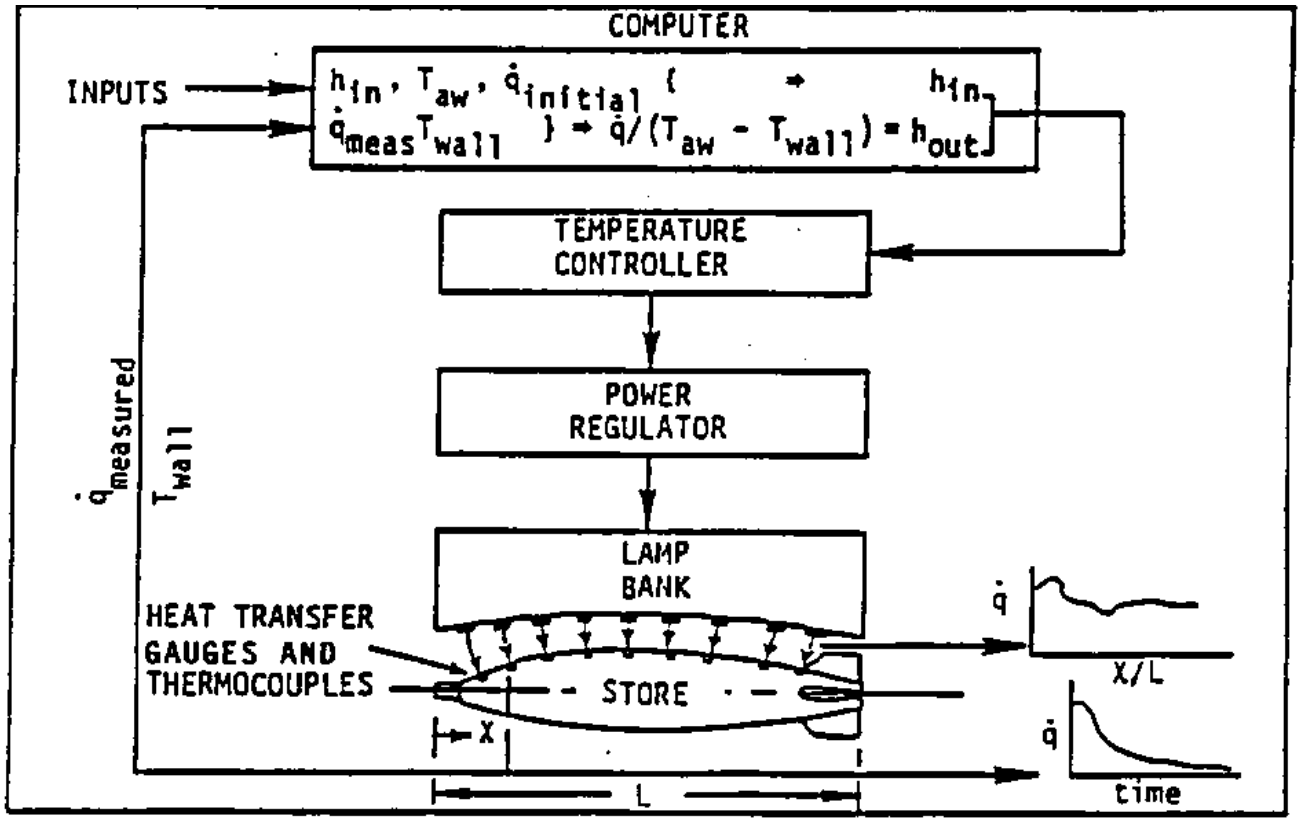


FIGURE A-1 Thermal test philosophy.

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155.3.2.2 Wind tunnels.

a. Capabilities:

(1) Duplication of complex flow fields which are not amenable to analytical

(2) High productivity at low cost.

(3) Capability of testing full scale flight hardware and providing operational certification. This capability is dependent on facility size and as the test article size becomes too large, scaled models, or truncated nose sections may be needed.

b. Limitations:

(1) Duplication of flight conditions are frequently not possible, and aerodynamic scaling laws must be used to extrapolate the data to flight conditions.

(2) Scaled models or truncated nose sections are necessary in most cases.

(3) Boundary layer transition (laminar to turbulent) location and extent cannot be determined in the usual wind tunnel test. A "quiet" wind tunnel or, preferably, flight tests are required for this purpose.

(4) The wind tunnel flow field with no model installed in the test section should have been recently calibrated.

155.3.2.2.1 Types of data.

Data obtained from the wind tunnel depends on the type model used. Full scale or partial full scale models lend themselves to internal component thermal response testing while scaled models yield only heating rate distribution data since the internal geometry is generally not simulated. The data obtained from the wind tunnel apply at the tunnel conditions. Consequently, the appropriate scaling law is required to extrapolate these data to flight conditions. Test philosophy and the extrapolation technique are summarized on figure A-2.

155.3.2.2.2 Planning.

It is important that a pre-test meeting be held, prior to any hardware fabrication, to discuss the test and test requirements with representatives of the candidate facilities. This is to ensure that the test variables can be adequately duplicated and the test requirements met. Also, much expertise concerning model, model size, measurement techniques, program planning, analytical capabilities as well as on hand experimental data can be obtained which leads to time and cost savings in the overall program.

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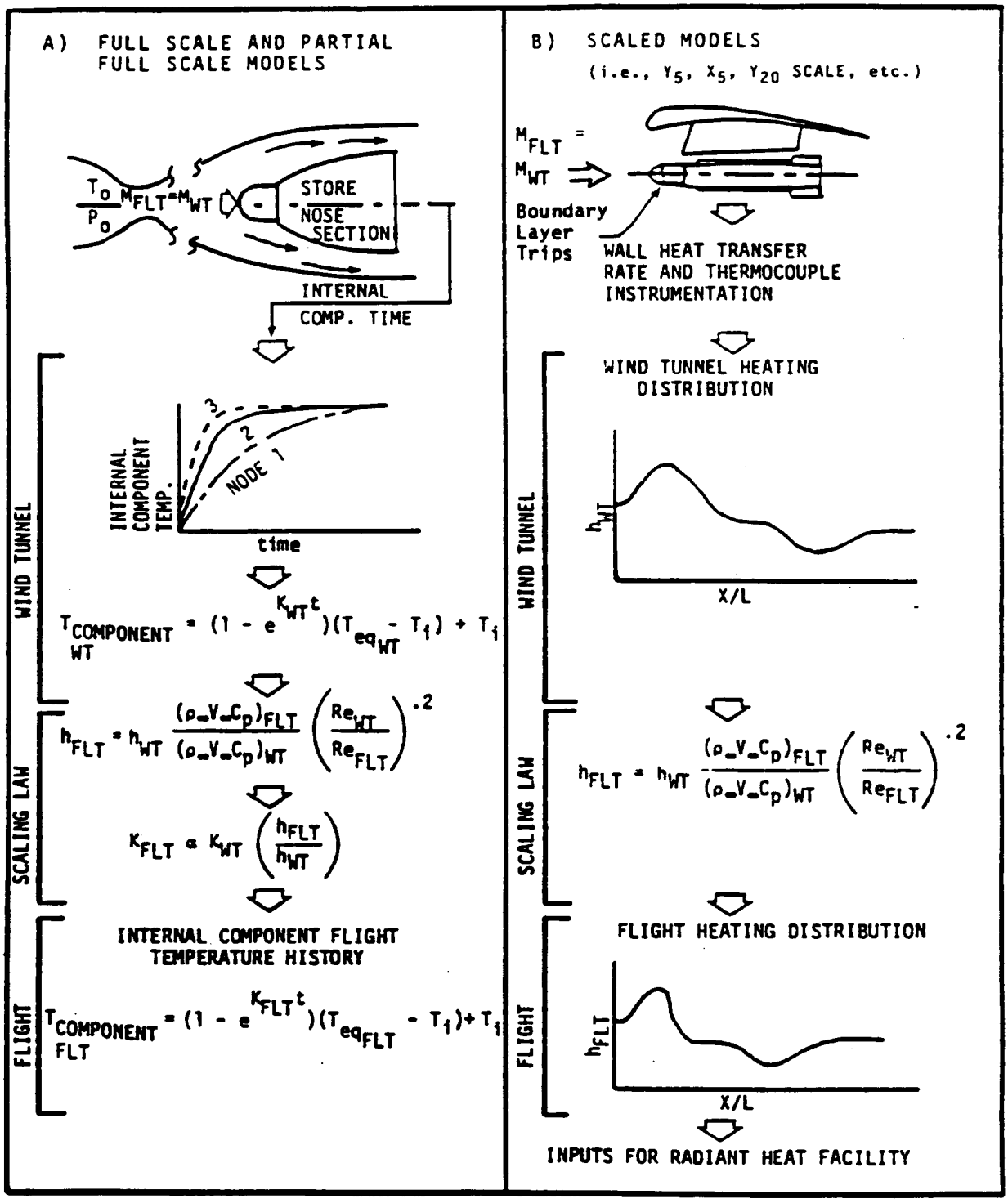


FIGURE A-2. Ground test facility philosophy-wind tunnel.

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155.3.3 Test instrumentation.

The test instrumentation should consist of heat transfer rate gauges, thermocouples, thermistors, and the necessary instrumentation to monitor those parameters which relate the functioning of the test article. The instrumentation should be of the type that could record the data in a manner as to provide for post-test analyses. Additional instrumentation may be utilized to monitor various data during the course of the test. The specific test instruments should be calibrated (and the calibration documented) both before and after the tests.

a. The test facility should be monitored and controlled using instrumentation as required so as to determine real time conditions of the test article.

b. For the wind tunnel, phase change and thermographic phosphor paints should be considered as they yield data in areas difficult to instrument as well as overall surface mapping.

155.3.3 Test conditions.

The test conditions for temperature extremes and thermal test should reproduce the expected thermal conditions as developed from the thermal analyses, applicable specifications of known conditions, e.g., previously determined flight test data, measured temperature exposures or data sources. Test article exposure to temperatures established as soak conditions should be of a duration so as to ensure that stable conditions are realized.

155.4 Acceptance criteria.

The test article should function in accordance with its specification(s), up to and including the most critical conditions, during the test. (Test in this context may include the period of exposure to the specified environment as well as the immediate time period after return to ambient conditions.)

155.5 Test procedure.

A detailed test procedure should be prepared and should be submitted to the cognizant program monitor for approval prior to start of testing.

a. The test article should be placed in the test facility and all instrumentation circuits checked for continuity and calibration.

b. The test instrumentation should be turned on and provided sufficient time to stabilize.

c. The specified test environment should be applied using the heaters, coolers or the test facility.

d. If the store electrical/mechanical components of the test article are intended to operate while the store is subjected to the specified environment, the electrical/mechanical components of the test article should likewise be operated during imposition of the specified test environment.

e. Upon completion of the specified test condition, the test instrumentation and heaters/coolers should be turned off.

f. The test article should be permitted to stabilize at ambient conditions before removal from the test setup.

g. The test article should be carefully examined for indications of structural/mechanical/electrical/functional damage due to the environmental test conducted.

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h. All evidence of damage should be photographed and documented for subsequent transmittal to the procuring agency in either special or routine program reports.

i. The test article disposition should be as specified by the procuring agency.

155.6 Test reporting.

The test report should cover the test objectives, test article, instrumentation, procedures, results and conclusions. The data report and the final report form a part of the test report. See 5.4 for the contents of these reports. Submitted reports should be in accordance with specific guidance provided by the certification agency.

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APPENDIX A

160 SERIES TESTS

GUN/ROCKET/MISSILE FIRING TESTS

160.1 Purpose.

The following approach to qualification of a new gun/rocket/missile system installation assumes that both the store and the aircraft are in development. Thus, if either or both are inventory items, much of the initial effort may have already been done. The qualification of the store installation should be conducted in stairstep fashion to build confidence for each succeeding step. If the installation has a large number of unknowns, or is considerably different from previous installations, consideration should be given to conducting a test with a partial aircraft. Only the portion of the aircraft directly affected by the store system (e.g., muzzle blast or plume impingement) will be necessary. This can provide data early in the development cycle before an aircraft is ground tested. Aircraft ground testing would follow to evaluate such things as: fire control, clearances, operation of related doors, recoil loads, blast overpressure levels, dispersion, temperature distribution, vibration, acoustics, gas concentration, store performance on aircraft power and accuracy. Once system integrity has been established, flight testing can be conducted to qualify the weapon system throughout its flight envelope.

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APPENDIX A

TEST 161

GUN FIRING TEST

161.1 Purpose.

The integration and qualification of a gun or gun system with an air vehicle for operational use must be accomplished without unnecessary risks to life and material. As such, ground gun firing tests are conducted to determine, verify, evaluate and authorize the safety, compatibility and performance requirements of the gun system with the air vehicle prior to flight tests. The gunfire induced environments and their effects that must be considered during the ground tests are:

a. Muzzle blast and overpressures.

b. Effectiveness of muzzle and blast deflectors.

c. Recoil, counter recoil, and loads.

d. Vibration and acoustic frequencies and amplitudes.

e. Effectiveness of the ventilation/purge system to prevent accumulation and pocketing of explosive gun gas mixtures.

f. Gun gas impingement and residue build-up on the air vehicle surfaces: including effects of all particulates which exit the muzzle due to combustion, rotating band wear, projectile wear, barrel wear, etc.

g. Proper operation of the gun system in various attitudes and g loadings simulating actual flight conditions.

h. Evaluation of the accuracy of the gun.

i. Evaluation of the performance parameters of the total gun system and its associated components, i.e., gun, drive, ammunition feed and storage system, spent case/unfired round storage or ejection system, including safe separation of the spent cases away from the aircraft.

j. Evaluation of other aircraft systems that are exposed or affected by the gun fire environment.

k. Evaluate bullet clearance from rotor blades and other surfaces in accordance with AIR STD 20/21.

161.2 Data requirements.

Sufficient test data should be generated and recorded to ascertain that the gun system is safe and compatible with the air vehicle and meets vehicle specification and safety of flight requirements. The following data should be collected and recorded in order to meet the specified acceptable criteria:

a. The measurement and mapping of the blast overpressures where the muzzle blast and projectile shock wave impinge the aircraft/skin structure, including aircraft mission sensors. Test sensors should be located from approximately 12 inches aft of the muzzle, thence forward and to the sides of the line of flight of the projectile. Note that the location where the muzzle blast hits the fuselage and/or adjacent stores is a function of aircraft velocity. Therefore, a

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ground test will produce very different shock and vibration response in adjacent stores than would be seen in flight tests.

b. Vibration and acoustic levels in the air vehicle compartments, adjacent and forward of the gun muzzle should be taken. Special attention should be given to recording the levels where avionic equipment is located.

c. Vibration levels at the gun/air vehicle mountings.

d. Measurement of loads and their time histories at the gun/air vehicle mountings.

e. Measurement of strain levels of supporting aircraft structure.

f. Measurement of loads at the gas/blast deflector/air vehicle or gun mountings.

g. Measurement of blast/gas deflector erosion. This may also have to be qualitative.

h. Photographic (movie and still) coverage of installation, gun gas emanating pattern and gun flash.

i. Measurement of gun gas concentrations in selected areas of the gun bay cockpit area, ammunition storage bay and any bay where the accumulation of gun gas could occur. Measurements are to be made at varying times during and after gun fire bursts.

j. Measurement of gun system drive power requirements (electric/hydraulic/pneumatic).

k. Measurement of gun accuracy, i.e., as installed in the air vehicle mock structure.

l. Gun and ammunition bay temperature and temperature rise during gunfire bursts.

m. Gun fire rate and time to rate as installed in the system (includes complete feed system).

n. Records of gun system malfunctions and their causes.

o. Records of all maintenance actions.

p. Qualitative data on access to the gun system, loading and downloading, and ease of boresighting.

161.3 Test preparation.

161.3.1 Test article.

The test article should consist of the gun system installed in the air vehicle or in a dummy air vehicle section that is representative of the actual air vehicle installation. If a dummy air vehicle section is used, it should include all items of equipment that are installed in the like places of the air vehicle. Exceptions should be documented and approved by the procuring agency. The stiffness and response characteristics of the dummy air vehicle section, if used, should be the same as the air vehicle. Practice rounds of ammunition should be used for actual firing. The gun system should include the gun, gun drive, ammunition storage and feed system, and gun system functional control unit(s).

161.3.2 Test equipment.

Test equipment should consist of those items required for safe operation of the test article during ground testing. Required equipment may include external power supplies (hydraulic, pneumatic, electric), appropriate ground support equipment (multimeter, aircraft jacks,

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maintenance stands), fire extinguishing equipment and harmonization boards. In general, test equipment required will be peculiar to each test article to be evaluated.

161.3.3 Test instrumentation.

Test instrumentation may include but is not limited to:

a. Strain gauges.

b. Force, pressure, temperature, vibration, and acoustic transducers.

c. Voltage, current, and time monitors.

d. Accelerometers.

e. Motion picture cameras.

f. Electronic projectile scoring devices.

g. Witness panels.

h. Flow measuring devices.

i. Magnetic pick-ups.

j. Velocity screens.

All measurements should be recorded on a suitable recording device.

161.3.4 Test conditions.

When the test items contain explosive materials or components, the test must be performed with proper safeguards established for personnel and equipment. Safety procedures and equipment consistent with the hazard level involved must be utilized to provide adequate protection in case of an explosion at any point in the performance of the test. These requirements apply to every test of this handbook when the test item contains explosive components or materials. Unless otherwise prescribed in the detailed test procedure, all measurements and tests should be performed at ambient temperature, pressure and relative humidity. If a choice of geographical test sites is available or if conditions must be controlled in order to obtain reproducible results, atmospheric conditions approximating the operational environment of the test article should be used to the extent practical. Actual test conditions should be recorded during the test.

161.3.5 Test facility.

The test facility should be such that the flight of the projectile fired from the gun system will not result in impact of the projectile off the test range due to ricochet and subsequent erratic flight path or any other unplanned event.

161.4 Acceptance criteria.

A gun system ground firing test should be considered successful if, after test completion, the following conditions have been met:

a. Satisfactory operation of instrumentation and recording data.

b. Proper operation of the gun system in accordance with the design intent as related to aircraft/gun system compatibility and safety of operation.

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c. All data recorded during the test should indicate operation of the gun system in accordance with applicable system and component design specifications. Temporary interruption and/or perturbation of any aircraft system vital to aircraft flight safety, instrumentation, or crew life support systems should not result from gun firing operation.

161.5 Test procedure.

Ground firing tests of aircraft gun systems should be conducted in accordance with a test procedure adhering to the intent and objectives of the following sequence. Each step of the test procedure must be successfully completed and noted by the test director before the next step can be undertaken. A daily test log should be a permanent part of the test record so that the source of any malfunction occurring during the test can be more readily located and corrected.

a. Prepare the test aircraft for ground gun firing in accordance with the appropriate aircraft technical order instructions. This preparation is to include boresighting of the aircraft and may also include jacking, leveling, and tie-down of the aircraft as well as attachment of auxiliary power unit.

b. Perform instrumentation checkout and fire the gun system for functional checkout during this task. The length and number of bursts required are to be determined by the test engineer.

c. After ensuring that the gun is clear, locate a target downrange from the gun muzzle. Cardboard, electronic, or other appropriate targets may be utilized. If electronic targeting is used, install a cardboard target approximately one (1) foot downrange of the electronic target for verification of electronic data. Other targets may be located further downrange as required.

d. Insert a borescope or other suitable boresight device in the gun muzzle and mark its aimpoint on the witness panel. For multibarrel guns, repeat for each barrel that can be indexed into its firing position. Record the coordinates of the barrel aimpoint relative to a reference point. These data are to be used to compare aimpoint and projectile impact locations.

e. Install other downrange targets as required. If electronic targeting is utilized, determine the relationship between the electronic and coordinate systems so the mean point of impact (MPI), dispersion, and aim point error data can be correlated.

f. Load the gun systems and begin firings for data in accordance with the specified firing schedule. Install a new witness panel after each burst, and position each panel so that the original reference coordinates are duplicated. If an electronic target is utilized, the witness panel need not be replaced after every burst, and the replacement interval will be at the discretion of the test engineer.

g. Repeat steps b. through e. for each day's firings. Actions in step a. need only be repeated as necessary, i.e., if the aircraft has been moved and the gun system removed from the aircraft.

161.6 Test reporting.

Final certification of an aircraft gun system installation depends upon adequate reporting of all test data. Test certification data should be complete and should include copies of original test instrumentation records, suitably annotated for calibration, and test number as well as the formal test report. Test reports should be prepared in the format specified by the contracting agency. Distribution should be as directed by the contracting agency except that, in all cases, the test facility should retain one copy of the original test data as a permanent record of the test.

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APPENDIX A

TEST 162

ROCKET/MISSILE FIRING TEST

162.1 Purpose.

Aircraft rockets/missiles and associated launching equipment are ground tested and evaluated to verify safe operating characteristics, establish compatibility with the aircraft, and to establish baseline data prior to flight tests. In addition, ground tests:

a. Provide data on the operation of the rocket/missile launchers and associated intervalometers.

b. Determine rocket/missile plume blast, pressure profile, thrust/impulse, exhaust chemical content, and temperature distribution characteristics.

c. Determine structural effects upon launching aircraft.

d. Determine effects of a rocket/missile/launching equipment malfunction on the launching aircraft. For this test, malfunctions are limited to those which are considered probable during the operational life of the item or those that have historically been problems with the particular item being tested.

e. Measure the trajectory and attitude changes of the munitions during initial trajectory.

f. Measure clearance between the trajectory and the aircraft surfaces and the rotor blades.

g. Assess the effect of firing the rockets in ripple mode of the engine performance.

162.2 Data requirements.

Sufficient test data should be measured and recorded to evaluate:

a. Safety:

(1) Interlock on safety pins.

(2) Electromagnetic compatibility.

(3) Radiation hazard.

(4) Minimum fire interval.

(5) Suitability of controls.

(6) Debris hazard.

b. Fit.

c. Functional compatibility.

d. Structural integrity.

e. Rocket motor characteristics:

(1) Pressure.

(2) Temperature.

f. Suitability of latching devices.

g. Blast and temperature effects on aircraft structure.

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h. Compatibility with other armament suspension and control equipment.

i. Compatibility with aircraft electrical systems.

j. Reliability.

k. Maintainability.

l. Loading/unloading.

m. Arming/dearming.

n. Compatibility with night vision equipment.

162.3 Test preparation.

162.3.1 Test article.

The aircraft, rocket/missile, warhead, fuse and launching equipment must closely approximate the operational article. Inert warheads may be used, but they must have similar aerodynamic and mass properties. Close similarity of the rocket/missile propulsion section is of prime importance. Any modification or deviations must be documented.

162.3.2 Test equipment.

Rockets/missiles may be ground fired from a static test stand(s) or an aircraft as appropriate. However, use of static test stand(s) may not permit the testing organization to obtain data to satisfy test purposes of 162.1 c and d.

162.3.3 Test instrumentation.

The instrumentation may include but not be limited to: strain gauges; force, pressure, temperature, vibration and acoustic transducers; voltage, current, time monitors, high speed cameras, optical and infrared spectrometers with suitable recording devices. The cognizant service agency should approve all instrumentation used to determine aircraft rocket compatibility.

162.3.4 Test conditions.

When the test item contains explosive materials or components, the test must be performed with proper safeguards established for personnel and equipment. Safety procedures and equipment consistent with the hazard level involved must be utilized to provide adequate protection in case of an explosion at any point in the performance of the test. Unless otherwise prescribed in the detailed test procedure, all measurements and tests should be performed at ambient temperature, pressure and relative humidity. If a choice of geographical test sites is available or if conditions must be controlled in order to obtain reproducible results, atmospheric conditions approximating the operational environment of the test article should be used to the extent practical. Actual test conditions should be recorded during the test.

162.3.5 Test facility.

The test facility should be such that flight of a rocket/missile from the ground based launcher will not result in impact of the projectile off the test range due to ricochet and subsequent erratic flight path, unexpected high energy propulsion systems, or any other unplanned event.

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162.4 Acceptance criteria.

A rocket/missile ground firing test should be considered successful if, after test completion, the following conditions have been met:

a. Satisfactory operation of instrumentation and recording data.

b. No damage to the launching aircraft (either structurally or superficially) that would affect airworthiness or require rework prior to next flight.

c. Proper operation of the rocket(s)/missile(s) and associated launching equipment in accordance with design intent, as related to aircraft-stores compatibility and safety of operation. (This is not intended as a qualification or acceptance test for the individual store(s) or launching equipment.)

d. All data recorded during the tests which indicate that launch of the rocket/missile from the launcher, in a simulated operational environment, will not result in: inadvertent release of any other external stores, unacceptable damage to aircraft structure, launcher, any other external store, or aircraft equipment, inadvertent initiation of any aircraft weapon release system, temporary interruption and/or perturbation of any aircraft system vital to aircraft flight safety and instrumentation or to crew life support systems.

162.5 Test procedure.

Ground firing tests of rockets/missiles should be conducted according to a test procedure adhering to the intent and objectives of the following procedural sequence. The sequence may be varied to suit the particular requirements of the rocket/missile to be fired, but range safety considerations must take precedence over test expediency. Each step must be successfully completed and noted by the test director before the test sequence can be advanced to the next step. A checklist should be a permanent part of the test record so that the source of any malfunction occurring during the test may be more readily located and corrected.

a. The rocket pod, missile launching rail, or missile launcher should be attached to the test stand or the aircraft using the attachment bolts and fittings projected for operational use.

b. All test instrumentation should be installed, warmed up and checked for proper calibration and operation.

c. The rocket/missile launching system should be connected and checked for circuit continuity and for spurious electrical impulses.

d. A release signal should be applied to the launching circuit at the pilot control point, and the signal strength level, wave form, time delay, and command content should be measured at the rocket pod or missile launcher interface.

e. The test instrumentation data collected should be examined for evidence of voltage spikes, "cross talk," and other undesirable phenomena due to the launching impulse.

f. The launching circuit should be grounded and the test range hazard areas cleared of personnel in preparation for loading the rockets/missiles.

g. The rockets/missiles should be loaded into the pod/launch rail or launcher and all mechanical and electrical safety interlocks checked for both fit and function with the test article in place.

h. The umbilical connector to the rocket/missile, if any, should be connected.

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i. The test range hazard areas should again be checked for presence of personnel and if necessary cleared of personnel and extraneous equipment.

j. A Klaxon signal should be sounded to produce a 5-minute warning of impending launch. During this 5-minute period, all test instrumentation and required range facilities should be individually checked for proper function and operation and required pyrotechnics installed. A flashing red light should be activated at the launching point and at all access points to the test range hazard areas to provide a visual warning of impending launch.

k. At the 1-minute before launch time point, the grounding connection on the launching circuit should be removed and a 5-second long siren signal should provide a 1-minute warning.

l. A release impulse should be applied to the launching circuit at the pilot control point and the rocket/missile launched.

m. After a successful launch, the safety officer should inspect the launch area and should query the range observers as to hazardous conditions on the test range. Finding no hazardous conditions, an appropriate all clear signal should be sounded and the red flashing lights extinguished.

n. If the test is the last scheduled test of the day, all test instrumentation should be turned off and otherwise prepared for an inactive standby period until the next test.

o. If additional tests are scheduled, the test procedure should recommence at step d.

p. In the event of a misfire or a failure to launch, the safety officer should announce a misfire and the warning siren should sound a series of 5-second signals at 30 second intervals to provide a clear and audible indication of a hazardous range condition, until the rocket/missile mechanical and electrical safety interlocks have been installed and the rocket/missile unloaded from the pod/launcher.

q. The safety officer should be the only individual authorized to declare an all clear condition.

r. After a misfire, the test article should be carefully checked for launching circuit continuity in a suitable test area. The launch circuit continuity from the pilot control point to the rocket/missile to pod/launcher interface should be carefully checked and test procedure repeated.

s. No further tests of either the rocket/missile type or at the particular test stand should be conducted until the cause of the malfunction has been determined and corrections accomplished.

162.6 Test reporting.

Final certification of a rocket/missile - aircraft combination depends upon adequate reporting of all test data. Correction of malfunctions arising in operational service and future design improvements are more easily accomplished if a complete data file on the certification test is maintained. The test certification data should be complete and should include copies of original test instrumentation records suitably annotated for calibration and test number as well as the formal test report.

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APPENDIX B

FLIGHT TEST PROCEDURES

TEST	SUBJECT	PAGE
200	INFLIGHT LOADS TEST	119
210	FLUTTER TEST	123
220	ENVIRONMENTAL TESTS	127
221	VIBRATION TEST	128
222	AEROACOUSTIC TEST	133
223	THERMAL TEST	137
224	ELECTROMAGNETIC COMPATIBILITY/ELECTROMAGNETIC INTERFERENCE (EMC/EMI) FLIGHT TEST	140
230	FLYING QUALITIES TEST	142
240	PERFORMANCE AND DRAG TESTS	144
250	CAPTIVE FLIGHT PROFIL:E (CFP) TESTS	146
251	HANDLING QUALITIES TEST	148
252	STRUCTURAL INTEGRITY TEST	151
253	ENDURANCE TEST	153
260	CARRIER SUITABILITY TEST	154
270	EMPLOYMENT TESTS	157
271	RELEASE TEST	158
272	LAUNCH TEST OR WEAPONS SURVEY AND DEMONSTRATIONS (FOR THE ARMY)	166
273	GUN FIRING TEST	168
274	DISPENSE TEST	171
280	JETTISON TEST	174
290	BALLISTICS TESTS	177
291	WEAPON FREESTREAM BALLISTICS TEST	179
292	OPERATIONAL FLIGHT PROGRAM (OFP) BALLISTICS EVALUATION TEST	188
293	SEPARATION EFFECTS DERIVATION TEST	191
294	OPERATIONAL FLIGHT PROGRAM (OFP) BALLISTICS VERIFICATION TEST	193

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APPENDIX B

TEST 200

INFLIGHT LOADS TEST

200.1 Purpose.

These tests are to obtain inflight measured data for use in verifying the structural integrity of the store and aircraft-stores combinations. The types of tests that may be performed are set forth with a brief statement of the purpose of each test.

200.1.1 Flight demonstration.

To demonstrate the structural integrity of the aircraft-stores combination for critical loading conditions by performing flights to such conditions without damage to, or failure of either the aircraft, store, or suspension equipment.

200.1.2 Flight loads survey.

To measure inflight loads to substantiate the structural design loads and analyses for critical aircraft-stores loading conditions.

200.1.3 Dynamic response tests.

To measure the elastic response characteristics of the aircraft structure to dynamic loads for substantiating the dynamic loads analysis. The certifying authority will designate the test or tests to be performed.

200.2 Data requirements.

Sufficient test condition parameters should be obtained to validate that the aircraft-stores combination was flown to the critical loading conditions. Such parameters include, but are not limited to, airspeed, altitude, load factors, aircraft angle of attack, aircraft angle of sideslip, and angular rates and accelerations. Loads should be measured to ensure valid comparisons of the flight test results with the appropriate loads criteria, analyses, and design conditions. Such measurements include, but are not limited to, aircraft-store interface loads, shears, bending moments, torsions, stresses, and pressures.

200.3 Test preparation.

200.3.1 Test article.

The structural flight test store and aircraft-store combination should be structurally, inertially, and aerodynamically similar to the design used in the structural analysis and drawings. Configuration, materials, and quality of workmanship should be the same as for the in-service store and aircraft-store combination.

200.3.2 Test instrumentation.

The test instrumentation should be capable of measuring the data necessary to meet the data requirements of 200.2 and should be approved by the procuring agency.

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200.3.2.1 Test conditions parameters.

The measurements obtained from this instrumentation should be used to prove compliance with test requirements. Instrumentation to measure the following parameters should be utilized as applicable.

a. Airspeed and Mach number.

b. Pressure altitude.

c. Normal, lateral, and longitudinal linear acceleration at the center of gravity of the airplane.

d. Roll, pitch, and yaw angular rates and accelerations at the center of gravity.

e. Angle of attack, sideslip, and bank.

f. Aircraft weight, moments of inertia, cross products of inertia, and center of gravity (computed).

g. Stagnation and ambient air temperature.

h. Aircraft configuration (auxiliary lift and drag device positions, landing gear positions, aircraft geometry, stores, engine positions, as applicable).

i. Aircraft sink speed.

j. Landing and taxi ground speed.

k. Landing gear strut positions.

l. Oleo stroke and air pressure.

m. Other measurements specified by the certifying authority.

200.3.2.2 Loads.

Instrumentation should be installed for determination of the loads at the interface of the store pylon with the airframe or the store with the airframe to substantiate the structural flight integrity of the store and aircraft-store combination. Loads measurements should include, but not be limited to, vertical, side, and drag load and pitching, yawing, and rolling moment as applicable. The following instrumentation may be utilized as applicable to measure these loads:

a. Strain gauges.

b. Calibrated strain gauges to measure shear, bending moment, and torsion.

c. Pressure transducers.

d. Accelerometers to measure load factors.

200.3.3 Test conditions.

The test conditions for this test should cover the various operating regimes such as, but not limited to, gross weight, load factor, airspeed, altitude, plus critical loading conditions of the particular store or aircraft/store combination such that the measured loads may be used to correlate with and substantiate the design loads analysis. Conditions selected should be as approved by the certifying authority.

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200.4 Acceptance criteria.

200.4.1 Data.

The instrumentation involved must have calibration tests performed prior to flight. All instrumentation must have a pre-taxi reading made to establish preload after installation of stores. All instrumentation must have a post-flight reading made to establish any calibration drift or redistribution of preloads. All generated data must be in the sensitivity range of the instrumentation. Data rate sampling must be sufficient to ensure no loss of transitory data.

200.4.2 Aircraft/store configuration.

A configuration may be considered certifiable for operational use, from a loads and structures standpoint, when the most critical, or a set of the most critical, loading conditions have been flight demonstrated and the loads and stresses resulting have been shown to be within the design loads and structural envelope of both the store and the aircraft. In addition, any anomalies in the data encountered during the flight test must be investigated and explained prior to recommendation for certification.

200.5 Test procedures.

The testing should be performed in the following three phases:

a. Ground operating loads tests. These tests should include all ground operating conditions required for the particular type of store or aircraft-store combination which are indicated to be critical or near critical by analytical calculations. These tests should be performed after successful completion of the ultimate static tests for all ground loading conditions.

b. Initial phase flight tests to 80 percent limitations. Eighty percent of the design limit load on any primary structural component of the store or aircraft-store should not be exceeded during this phase of the test program.

c. Final phase flight tests to 100% limitation. The final phase flight tests should be performed after completion of the initial phase flight tests, and the ultimate load static tests, and with specific approval of the certifying authority. Build-up maneuvers should be flown as necessary to ensure that 100% design limit loads are not exceeded.

200.6 Test reporting.

The reports required for this testing should be specified by the certifying authority and should include but not be limited to:

a. Flight test plan.

b. Instrumentation report.

c. Calibration report.

d. Initial phase report and loads comparison.

e. Final phase report and loads comparison.

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f. Ground phase report and loads comparison. The contents of these reports are specified in MIL-A-8868. The test report must clearly document the actual parameters attained during the test, highlighting any deficiencies found during the post-flight inspections along with proposed design changes to correct the problem(s).

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APPENDIX B

TEST 210

FLUTTER TEST

210.1 Purpose.

The purpose of the flutter flight test is to substantiate that the aircraft with stores is free of any aeroelastic instability and has satisfactory damping characteristics within the prescribed flight envelope.

210.2 Data requirements.

The test data required are the structural response frequencies of the wings, pylons and stores and the associated response amplitudes and damping along with their changes with increasing dynamic pressure and Mach number. Gradual or sudden decreases in damping, usually with increases in response amplitudes and the coalescing of two response frequencies generally indicate approaching flutter. Other test data required are the configuration logs, aircraft fuel loading and usage, airspeed, altitude, air temperature, and barometric pressure.

210.3 Test preparation.

210.3.1 Test article.

The flutter flight tests must be performed in an instrumented test aircraft which must be representative of, and similar to, those in operational use. It must be equipped with all standard items having appreciable mass and aerodynamic loading. The fuel loading should be such that the most flutter critical loading is attained through usage at about the time the maximum speed at the lowest altitude is reached. Stores, such as bombs, rockets, missiles, should have their warheads replaced by inert ballast for safety. Since many stores have appreciable manufactured mass variations, all flight test stores should be carefully mass ballasted to their design or worst case values in weight, center-of-gravity (cg) location, and pitch, roll and yaw inertias.

210.3.2 Test equipment and instrumentation.

The test aircraft should be equipped with a structural excitation system which can adequately excite the wing and stores modes of interest, unless it can be shown that stick raps and pulses of the flight controls can provide adequate excitation. Stick raps can usually excite structural modes only up to about 8 to 12 Hz for most fighter aircraft, but often this may only be adequate if the lower frequency wing and store modes are involved in the predicted instabilities. Various excitation systems have been used with success such as oscillating tip vanes, rotating or oscillating masses, and excitation through the airplane flight control surfaces programmed through the flight control system. Reliance upon atmospheric turbulence for excitation has been less successful. Dynamics instrumentation includes four-arm bridge strain gauge circuits at the wing roots, mid-span, and on the pylons on both sides of the aircraft. These gauges are oriented to the local elastic axes in order to separate bending and torsional structural motion. Other instrumentation includes store and wing tip accelerometers as well as control surface position indicators. Either a frequency modulated (FM) or pulse code modulated (PCM) telemetry system is needed to transmit the test data signals to the ground for analysis during flight. Sample rates for PCM systems should be at least ten times the highest structural

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resonance frequencies of interest, in order to capture both amplitude and frequency. An onboard magnetic tape recorder is also installed for post flight analysis and as a backup system. The ground station is equipped with oscillograph recorders and oscilloscopes for observing the test data. Newer test methods require a time-series analyzer for near-real-time analysis of the test data using fast-Fourier and Laplace transform algorithm methods. It is essential that a direct radio voice link be established between the test pilot(s) and the dynamics test engineer(s) conducting the test.

210.3.3 Test conditions.

Atmospheric test conditions need to be good flight weather having smooth air free of turbulence (except when turbulence is desired for excitation) and clear visibility. Local storms in the area could cause interference with the telemetry system. Clear visibility of the ground is necessary to fly the required low-altitude diving maneuvers. Flying through temperature inversions in dives should also be avoided as sudden, normally unattainable, large increases in dynamic pressure may occur which could initiate unpredicted flutter.

210.4 Acceptance criteria.

A given take-off configuration will be considered certifiable for operational use, from a flutter standpoint, when the most critical derived down-loading, including hung stores, aircraft configuration has been tested at the prescribed test points. The flight test data should demonstrate this configuration to be free of any aeroelastic instability throughout its appropriate operational flight envelope with no less than three percent structural response total damping (including aeroelastic as well as structural damping) and no predicted occurrence of an aeroelastic instability up to 1.15 limit speeds through extrapolation of the flight test data. In addition, the flight test structural response data must correlate reasonably well with the flutter analyses and/or wind tunnel test results. For aircraft with augmented flight controls, the above criteria must hold both with the augmentation system turned on and off.

210.5 Test procedure.

Flutter flight tests of external stores configurations may initially be conducted simultaneously with other structural integrity flight tests in a gradual expansion of the cleared flight envelope. However, the other structural flight tests are usually only concerned with a few specific loading configurations and thereafter flight tests may be more dedicated to flutter. Generally, only the most critical derived down-loading, including hung stores, configuration needs to be flutter flight tested for a given takeoff configuration. However, that configuration must be tested out to the maximum Mach Number and dynamic pressure at the prescribed limit speeds (but no more) for the aircraft-with-stores. For aircraft with augmented flight controls, the above stores configuration must be flutter flight tested both with the augmentation system on and off (the latter at test speeds for which the unaugmented aircraft can be sagely flown). It is not always necessary to fly with the augmented flight controls both on and off at every test point. For some aircraft/store configurations, this only needs to be done at a few specified points. The tests must be performed in a careful methodical manner to detect the earliest indications of any possible aeroelastic instability. In spite of these precautions and technical advances in testing and analyses, flutter flight testing remains among the most dangerous kinds of flight testing and requires the utmost vigilance and expertise to avoid encountering an actual aeroelastic instability in flight.

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210.5.1 Pre-flutter flight test data.

Before the selected store configuration can be flutter flight tested on a given aircraft, that configuration must be shown by validated flutter analyses and/or wind tunnel flutter model tests to be the most critical configuration derived from the desired takeoff configuration being certified.

210.5.2 Test points.

Flutter flight tests are flown with test data taken at predetermined test points in a prescribed order of ascending criticality. At each test point, defined by Mach number and altitude, the aircraft-with-stores is structurally excited and the test data recording the excitation and structural response is telemetered to the ground station for immediate analysis. The test pilot must not be allowed to proceed to the next test point until granted clearance by the dynamics test engineers from the ground station that it is safe to proceed. The test points are chosen at increasing Mach numbers up to limit speed, usually in 0.05 Mach number increments or less, at constant altitude. Initially, two or three altitudes, tested in descending order, may be chosen but, with experience, only the most critical altitude (usually the lowest possible altitude still permitting safe flight) may need to be flown. For aircraft with augmented flight controls, test data is taken at each test point with the system on and off for speeds at which the unaugmented aircraft can be safely flown. The most critical test points, usually at the highest attainable dynamic pressure, are flown last. These test points can usually be reached only by diving the aircraft from a higher altitude at full throttle and then pulling out of the dive at the prescribed test altitude. These test points are especially dangerous because they have the highest possibility of flutter occurrence while the aircraft has the least favorable attitude for a quick recovery.

210.5.3 Emergency procedures.

Should the onset of flutter occur, the pilot may have no more than two or three seconds (sometimes even less) to take recovery actions before major structural damage or aircraft destruction occurs. Therefore, the most effective emergency procedures for recovery from flutter must be carefully planned in advance and the test pilot briefed before each test flight. Flutter may sometimes be stopped by immediately reducing airspeed to at least that of the last test point. This may be done by simultaneously deploying the speed brakes (if so equipped) and pulling up into a climb. However, a pull-up that is too suddenly applied may impose excessively large g loads on the wing and pylons on top of the very high dynamic loads caused by the wildly oscillating stores and wings. Reducing engine throttle is usually ineffective because the engine response is too slow. For aircraft with variable wing geometry, the wings must be swept to a region previously demonstrated to have no flutter; this would be done in conjunction with the above maneuvers. Jettison of some of the external stores may be used to arrive at a stable condition. This must be carefully planned in advance since store separation characteristics of oscillating stores, especially at high speeds, can also be unpredictable and hazardous. Therefore, the pilot must be intimately familiar with all possible emergency procedures.

210.5.4 Test data analysis.

Immediate but qualitative assessments of the test aircraft's aeroelastic stability can be interpreted from the oscillograph's continuous recordings of the dynamics instrumentation outputs. Lissajous figures on the oscilloscope, portraying bending-torsion strain gauge outputs, can instantly show modal coupling tendencies. New methods using digital computers and time-

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series analysis methods, including Fourier and Laplace transform algorithms, can extract response frequencies and associated dampings from accelerometer outputs within a minute or two after the structure has been excited. Other data reduction methods may also give quick analysis results with an acceptable degree of reliability, providing the test aircraft can be adequately excited. Additionally, a post flight analysis of the tape-recorded flight test data may be performed, at a more leisurely pace with a higher degree of accuracy, if required. Correlation of the flight test data with available flutter analyses and wind tunnel flutter model tests is very important. In particular, frequency and damping trends determined from the flight test data should agree favorably with the pre-flight evaluations in order to properly identify the most critical store combinations. If flutter is actually encountered in flight, the resulting flight test data could be exceptionally valuable in making direct flutter frequency comparisons with analytical and wind tunnel test results. However, because the risks are so great, one should never intentionally seek actual flutter or other aeroelastic instabilities during flutter flight test.

210.6 Test reporting.

The test report should cover the test objectives, test article, instrumentation procedures, data requirements of 210.2, results and conclusions.

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APPENDIX B

220 SERIES TESTS

ENVIRONMENTAL TESTS

220.1 Purpose.

The purpose of the environmental flight tests is to determine if the aircraft-store and suspension equipment can withstand the actual flight environment to validate the design specification levels and to substantiate the predicted/test levels. Environmental flight test of the store and suspension equipment are always performed in the captive carriage mode. This test is accomplished throughout the entire flight envelope to demonstrate that the store and its components will safely and satisfactorily operate. Instrumented aircraft and/or stores are generally used for these tests.

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APPENDIX B

TEST 221

VIBRATION TEST

221.1 Purpose.

Captive flight vibration measurements on a store are made a part of the store certification process for a number of reasons. These reasons include:

a. To determine if the store has been designed and tested to vibration conditions typical of service.

b. To establish test levels for the store.

c. To establish test levels for equipment within the store.

d. d. To investigate changes in vibration environments due to modifications to the aircraft or the store, or to changes in store carriage configurations, tactics, or operational flight envelopes.

Tests 221 and 222 should be combined when possible.

221.1 Data requirements.

Data required includes the measured vibration levels at various locations in the store (and suspension equipment if required). The nature and magnitude of the vibration induced in a store is a sensitive function of the aircraft-store configuration. Therefore, for each flight test, the configuration must be fully documented. The following is based on jet aircraft. Turboprop aircraft and helicopter reports should be the same except that some analyses will be in terms of peak g rather than acceleration spectral density. Note that frequency spectra are always necessary. Measurement of peak g at blade (rotor) passage frequency and a few harmonics are not sufficient. These spectra are continuous with approximately sinusoidal components superimposed on a continuous vibration background. This documentation should include:

a. A description of the test configuration supplemented by drawings and photographs including description of any modification to the aircraft which would affect the airflow around the aircraft and any deviations from standard technical orders procedures for loading/installing stores on the aircraft.

b. Description of store to be flight tested. A list of instrumentation including specific locations and orientations of each sensor supplemented by drawings and photographs should be included.

c. Identification for the flight test conditions at which measurements were made including:

(1) Indicated airspeed.

(2) Mach number.

(3) Altitude.

(4) Ambient temperature.

(5) Angle of attack.

(6) Angle of yaw.

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(7) Normal load factor.

(8) All configuration variations such as speedbrake position, high lift device(s) position, bomb bay door position and firing or ejection of weapons or stores.

d. A list of the data analysis equipment including pertinent technical data.

e. A description of the data analyses including equipment flow charts, technical parameters and data sample selection criteria for each type of analysis.

f. Copies of the reduced data. Each plot should be annotated with sensor identification(s) and flight condition. Reduced data should include:

(1) Samples of time histories (grms versus time) showing analysis sample selections.

(2) Acceleration spectral density plots (g^2/Hz versus Hz) in log log format for steady state analyses.

(3) Time histories (grms, 1/3 Octave band grms, or other appropriate amplitude parameter versus time) of transient events.

(4) Selected frequency domain plots of steady state conditions for comparison to transient event time histories.

(5) 1/3 Octave band acceleration spectral density plots when required for correlation with acoustic data from Test 222.

(6) Other forms as appropriate to a specific test.

(7) All plots should have consistent amplitude scales and frequency domain plots should have the same frequency scale.

221.3 Test preparation.

221.3.1 Test article.

The test article should be a full scale functional store. If not a production store it should be dynamically and aerodynamically similar to the production store (inertia, stiffness, shape, dimensions) and contain a full set of equipment, wiring and plumbing. Experience has shown that dummy store vibration response is significantly different from stores with actual structure, shape and equipment installations. MIL-STD-810, Method 514.4 estimates are more accurate than measurements with dummy stores.

221.3.2 Test equipment.

The test article should be carried on production suspension equipment. If substitute suspension equipment is used, store location relative to the aircraft and other stores must be accurate. Also, low frequency vibration portions of the data will not be accurate and must be disregarded. This applies particularly to airframe buffet induced vibration.

221.3.3 Test instrumentation.

Accelerometers should be mounted on or within the store so that vibration measurements will be directly applicable to derivation or verification of store design criteria. In general this should be as described for control of vibration ground tests of assembled stores in MIL-STD-810,

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Method 514.4. Additional accelerometers and possibly strain gauges should be located to measure critical equipment environments and/or structural response.

221.3.4 Test conditions.

Flight conditions should be chosen to explore the aircraft-store flight envelope. The following are based on jet aircraft. Turboprop aircraft and helicopters vibrations levels follow the same basic patterns except that for helicopters transition from hover to forward flight is normally more severe than takeoff.

221.3.4.1 Takeoff and landing.

The maximum engine generated acoustic noise occurs at maximum thrust and zero ground speed. The maximum difference between exhaust plume and ambient air velocities occurs at this time along with maximum reflections of acoustic energy from the ground back to the aircraft. As the aircraft picks up forward speed acoustic noise drops off rapidly. However, as geometry changes during the takeoff run acoustic reflections often cause local hot spots. Steady state measurements should be made at brake release conditions and transient measurements should be made during the takeoff run and during catapulting. Airfield landings, and arrested landings during aircraft carrier operations, will cause significant shock and vibration loadings. Accelerometer recordings should be made during this portion of the airplane operations.

221.3.4.2 Dynamic pressure and Mach number.

General vibration levels in stores are generally related linearly to dynamic pressure and nonlinearly to Mach number. Sufficient steady state measurement points and slow acceleration and deceleration points should be included to thoroughly define trends of vibration levels and worst case vibration levels within the flight envelope.

221.3.4.3 Maneuvering flight.

Vibration levels vary with maneuver conditions. Measurements should be made during maneuver conditions characteristic of the aircraft-store tactical mission(s) (windup turns, pitch-overs, pull-ups, throttle chops). In addition measurements should be made during any maneuver known to produce high vibration in the airframe.

221.3.4.4 Buffet.

In addition to 221.3.4.2 severe low frequency vibrations occur on some aircraft during buffet. This may be during high angle of attack maneuvers or high speed maneuvers. Sufficient measurements should be made to define store buffet environments.

221.3.4.5 Gunfire.

Sufficient inflight and ground gunfire measurements should be made to define store gunfire environments.

221.4 Acceptance criteria.

The test should be considered successful when:

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a. Sufficient data are recorded to define the vibration environments of the store throughout the flight envelope.

b. Data quality is sufficient to allow accurate analysis/reduction of the measured data to final form.

c. Reduced data of sufficient quality and quantity to meet the stated purposes of the test are provided to the user.

221.5 Test procedure.

221.5.1 Preflight.

a. Define the mission in detail. The vibration aspects of this definition should include test configuration, flight conditions, data record timing and lengths, and applicable telemetry requirements, cautions, decision points and decision responsibilities.

b. Define the aircraft configuration including aircraft modification status, all stores, all store suspension equipment, and any variations in technical order procedures.

c. Identify all instrumentation and verify locations and channel identifications.

d. Assure that the aircraft parameters identified at 221.2c are measured and recorded during vibration measurements.

e. Calibrate all instrumentation from sensor through recording equipment.

f. Verify that recorders are loaded with tape (or equivalent recording medium).

g. Verify that there is no interference between instrumentation, test equipment, store, suspension equipment and airframe.

h. Verify and document, preferably with photographs, aircraft, test equipment, suspension equipment, store configuration. This should include all stores and store suspension equipment.

221.5.2 Flight.

a. Verify and document each test point as it is performed.

b. Call out decision points, make and document decisions.

c. Call out and document all anomalies.

221.5.3 Post flight.

a. Verify and document aircraft, test equipment, suspension equipment, store configuration.

b. Conduct required post flight inspections.

c. Conduct post flight calibrations of instrumentation and record results.

d. Review data for quality and completeness.

e. Reduce data.

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221.6 Test reporting.

The test report should cover the test objectives, test article, instrumentation, procedures, data requirements of 221.2, results and conclusions. Each failure and anomaly should be discussed along with reasons for failure and proposed design changes to correct the problem(s).

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APPENDIX B

TEST 222

AEROACOUSTIC TEST

221.1 Purpose.

Aeroacoustic flight tests are performed to determine the actual flight acoustic environment and to determine the ability of the store configurations to withstand and operate in the flight environment. The flight data is required to validate the acoustic specification levels and/or to substantiate the predicted/test levels. The following are some of the most common needs for flight data:

a. To determine if the store has been designed and tested to aeroacoustic conditions typical of service.

b. To establish test levels for the store.

c. To establish test levels for equipment within the store.

d. To investigate changes in the aircraft's aeroacoustic environments due to modifications to the aircraft or the store, or to changes in store carriage configuration, tactics, or operational flight envelopes.

Tests 221 and 222 should be combined when possible.

222.2 Data requirements.

Data required include the measured aeroacoustic levels at various locations on and in the store and the aircraft along with details of the aircraft, store and store carriage configurations and definition of the flight conditions at which the aeroacoustic data were acquired.

a. A description of the test configuration supplemented by drawings and photographs including description of any modification to the aircraft which would affect the airflow around the aircraft and any deviations from standard technical orders procedures for loading/installing stores on the aircraft.

b. Description of store to be flight tested. A list of instrumentation including specific locations and orientations of each sensor supplemented by drawings and photographs.

c. Identification for the flight test conditions at which measurements were made including:

(1) Indicated airspeed.

(2) Mach number.

(3) Altitude.

(4) Ambient temperature.

(5) Angle of attack.

(6) Angle of yaw.

(7) Normal load factor.

(8) All configuration variations such as speedbrake position, high lift device(s) position, bomb bay door position and firing or ejection of weapons or stores.

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d. A list of the data analysis equipment including pertinent technical data.

e. A description of the data analyses including equipment flow charts, technical parameters and data sample selection criteria for each type of analysis.

f. Copies of the reduced data. Each plot should be annotated with sensor identification(s) and flight condition. Reduced data should include:

(1) Samples of time histories (sound pressure level (SPL) versus time) showing analysis sample selections.

(2) 1/3 octave band SPL versus frequency plots in semi-log format of steady state events.

(3) Time histories (SPL, 1/3 octave band SPL, or other appropriate bandwidths versus time) of transient events.

(4) Other forms as appropriate to specific tests.

(5) All plots should have consistent amplitude scales and frequency domain plots should have the same frequency scale.

222.3 Test preparation.

222.3.1 Test article.

The test article should be a full scale store. If it is not a production store it should be aerodynamically similar to the production store (shape and dimensions). If internal acoustic levels are to be measured then the test article should be a full scale functional store. If not a production store it should be dynamically and aero-dynamically similar to the production store (inertia, stiffness, shape, dimensions) and contain a full set of equipment, wiring and plumbing. Experience has shown that dummy store internal acoustic levels are significantly different from stores with actual structure, shape and equipment installations.

222.3.2 Test equipment.

The test article should be carried on production suspension equipment. If substitute suspension equipment is used, store location relative to the aircraft and other stores must be accurate.

222.3.3 Test instrumentation.

Dynamic pressure transducers should be mounted on and within the store so that measurements will be directly applicable to derivation or verification of store design criteria. In general this should be as described for control of acoustics ground tests of assembled stores in MIL-STD-810, Method 515.4. Additional transducers should be located to measure critical equipment environments and/or structural environments. Selection of transducers and transducer mounts should prevent transducer response to mechanical vibration.

222.3.4 Test conditions.

Flight conditions should be chosen to explore the aircraft-store flight envelope. The following are based on jet aircraft. Turboprop aircraft aeroacoustic levels follow the same basic patterns. Helicopters acoustic levels are generally not high enough to result in significant vibration of equipment and structures.

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222.3.4.1 Take-off.

The maximum engine generated acoustic noise occurs at maximum thrust and zero ground speed. The maximum difference between exhaust plume and ambient air velocities occurs at this time along with maximum reflections of acoustic energy from the ground back to the aircraft and from aircraft carriers' jet blast deflectors (JBD) back to the aircraft. As the aircraft picks up forward speed acoustic noise drops off rapidly. However, as geometry changes during the takeoff run acoustic reflections often cause local hot spots. Measurements should be made from just before brake release through the takeoff run.

222.3.4.2 Dynamic pressure, Mach number.

Aeroacoustic levels of stores are generally related linearly to dynamic pressure and nonlinearly to Mach number. Sufficient steady state measurement points and slow acceleration and deceleration points should be included to thoroughly define trends of aeroacoustic levels and worst case levels within the flight envelope.

222.3.4.3 Maneuvering flight.

Aeroacoustic levels vary with maneuver conditions. Measurements should be made during maneuver conditions characteristic of the aircraft-store tactical mission(s) (windup turns, pitch-overs, pull-ups). In addition measurements should be made during any maneuver known to produce high vibration in the airframe.

222.3.4.4 Gunfire.

Sufficient inflight and ground gunfire measurements should be made to define store gunfire environments.

222.4 Acceptance criteria.

The test should be considered successful when:

a. Sufficient data are recorded to define the aeroacoustic environments of the store throughout the flight envelope.

b. Data quality is sufficient to allow accurate analysis/reduction of the measured data to final form.

c. Reduced data of sufficient quality and quantity to meet the stated purposes of the test are provided to the user.

222.5 Test procedure.

222.5.1 Preflight:

a. Define the mission in detail. The aeroacoustic aspects of this definition should include test configuration, flight conditions, data record timing and lengths, and applicable telemetry requirements, cautions, decision points and decision responsibilities.

b. Define the aircraft configuration including aircraft modification status, all stores, all store suspension equipment, and any variations in technical order procedures.

c. Identify all instrumentation and verify locations and channel identifications.

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d. Assure that the aircraft parameters identified in 222.2c will be measured and recorded during aeroacoustic measurements.

e. Calibrate all instrumentation from sensor through recording equipment.

f. Verify that recorders are loaded with tape (or equivalent recording medium).

g. Verify that there is no interference between instrumentation, test equipment, store, suspension equipment and airframe.

h. Verify and document, preferably with photographs, aircraft, test equipment, suspension equipment, store configuration. This should include all stores and store suspension equipment.

222.5.2 Flight:

a. Verify and document each test point as it is performed.

b. Call out decision points, make and document decisions.

c. Call out and document all anomalies.

222.5.3 Post flight:

a. Verify and document aircraft, test equipment, suspension equipment, store configuration.

b. Conduct required post flight inspections.

c. Conduct post flight calibrations of instrumentation and record results.

d. Review data for quality and completeness.

e. Reduce data.

222.6 Test reporting.

The test report should cover the test objective, test article, instrumentation, procedures, data requirements of 222.2, results and conclusions. Each failure and anomaly should be discussed along with reasons for failure and proposed design changes to correct the problem(s).

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APPENDIX B

TEST 223

THERMAL TEST

223.1 Purpose.

The purpose of the thermal test flight is to determine if the test article/subsystems can withstand the actual thermal environment of flight. Flight test results are also used to correlate with ground test and analytic results to improve/verify theory and test techniques.

223.2 Data requirements.

The data requirements for the thermal environment flight test are as follows:

a. Flight data, Mach number, altitude, angle of attack, time.

b. Ambient conditions external to the aircraft insofar as they can be measured (meteorological data, altitude).

c. Store surface heat transfer rate versus time.

d. Internal component temperature versus time.

e. Store wall temperature versus time.

223.3 Test preparation.

223.3.1 Test article.

a. The article tested should have the same physical and thermal properties as the proposed store insofar as possible. Explosive or hazardous materials should be simulated by non-explosive or nonhazardous materials having similar physical and thermal properties. The effects of differences in thermal properties of the test article and the actual article should be analyzed and documented in the final report.

b. The carrier aircraft should be chosen so as to provide the extreme conditions in the flight envelope, (e.g., Mach number, altitude and adjacent weapons carriage), as well as being compatible with the flight test mission from the data acquisition and instrumentation checkout aspect.

223.3.2 Test equipment.

Photographic equipment for recording test article installation and temperature sensitive paint flow patterns, as well as power supplies and all equipment necessary to provide support for a complete operational check on the store, store instrumentation, and data acquisition system just prior to, and after, flight test is required. If available, a self-contained data recording system should be used so as to eliminate aircraft modification requirements. For an expanded list of data requirements, as well as details on the data recording system and transducers, appendix D of MIL-STD-1670 should be consulted.

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223.3.3 Test instrumentation.

Test article instrumentation should consist of heat transfer rate gauges for monitoring the store external wall heat transfer rate distribution. Thermocouples or thermistors should be used for measuring external wall and internal component temperature.

a. Store wall heat transfer rate gauges and temperature sensors should be located such that representative temperature and heating distributions are obtained. Instrumentation should be of sufficient density for detection of hot and cold spots. Approximate locations can be determined by pre-flight analysis. An adequate distribution of internal component temperature measuring devices (such as thermocouples or thermistors) should be located in and around the critical components, i.e., those with temperature restrictions.

b. Phase change paint is also advantageous in flight test use for providing a means of obtaining flow field visualization information. The paints, which melt and flow at predetermined temperatures, can be photographed after the flight test to give a permanent record of the store flow field.

c. Temperature sensitive tape can also be used to determine approximate temperature extremes on components out of the direct airflow.

223.3.4 Test conditions.

Test points (Mach number, altitude, ambient temperature) should be chosen within the flight envelope which yield representative and extreme conditions on the test article. In addition, adjacent store configurations may be chosen to determine possible interference heating.

223.4 Acceptance criteria.

The recorded data should be of sufficient quality that its signal-to-noise ratio gives good confidence to the data quality. The data should be free of distortion and clipping of signals. The test article should perform to its thermal specifications at the most severe flight envelope conditions (both hot and cold, operating and non-operating).

223.5 Test procedure.

223.5.1 Preflight.

The following should be performed prior to flight:

a. Assemble support equipment, according to the pretest report for carrying out the various operational checks required.

b. Identify all store instrumentation.

c. Check continuity of store instrumentation through the data system to ensure proper operation and connection to the data recording system.

d. Inspect temperature sensor installation.

e. Calibrate all sensors. Obtain and record instrumentation scale factors and calibration constants for each sensor.

f. Inspect store/aircraft to ensure the configuration is the same as would be experienced on an actual mission-photographs should be taken of the aircraft-store configuration tested.

g. Run operational check on all systems.

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h. Obtain preflight data - meteorological data for the test date, location, and time of flight test, aircraft type model and Serial Number/Bureau Number, store type and modification number.

i. Prior to flight record preflight zeros, i.e., take several scans of data where heat transfer rates are zero and the temperature sensors are reading ambient.

223.5.2 Flight.

The data recording system need only be on during the test phase.

223.5.3 Post flight.

On completion of the mission when the store/aircraft has had time to return to ambient ground conditions, the following should be performed:

a. Several scans of post-flight zeros should be recorded on the data system.

b. Post-flight calibration should be performed as required.

c. Post-flight calibration scale factors and zeros should be compared with the pretest values for the purpose of detecting any faulty instrumentation that may have developed during flight.

d. Photographs of the installation and paint flow should be taken.

e. All data should be reduced and checked for content and consistency as soon as possible after mission completion.

223.6 Test reporting.

The test report should include the critical component temperature-time history as well as the heat flux and wall temperature distributions. In addition, the report should describe the test setup, hardware, instrumentation and results in tabulated and plotted form.

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APPENDIX B

TEST 224

ELECTROMAGNETIC COMPATIBILITY/ELECTROMAGNETIC INTERFERENCE (EMC/EMI) FLIGHT TEST

224.1 Purpose.

EMC/EMI flight tests are performed to determine the ability of the aircraft/stores configuration to satisfactorily operate inflight and are only conducted when ground testing cannot demonstrate this. The effects of unintentional interaction between aircraft avionics systems and store electronic systems in all proposed configurations is investigated. EMI/EMC ground testing, under Test 154, is normally used for this determination. Flight EMC/EMI testing will only be used if ground testing of certain avionics or store electronics operating modes is not technically possible, or verification of ground test results is required. Such flight testing is normally only required for electronic warfare pods that are programmed to react to threats that cannot be simulated while stationary on the ground or when the presence of the ground interferes with test applicability. The effects of EMI can be very unpredictable. Consequently, EMC/EMI flight testing has the potential to be very dangerous, with EMI induced catastrophic failure of critical flight systems possible. In spite of the technical advances in testing and analysis techniques, EMC/EMI flight testing is potentially among the most dangerous flight testing and requires the utmost vigilance and expertise to avoid encountering catastrophic systems failures in flight.

224.2 Data requirements.

Data requirements for EMC/EMI flight testing are as detailed in Test 154.

224.3 Test preparation.

Coordination with the appropriate safety boards and offices.

224.3.1 Test article.

The aircraft and store used in EMC/EMI testing must be representative of those in operational use and be equipped with all required avionics equipment.

224.3.2 Test equipment and instrumentation.

Test equipment and instrumentation should be determined on a case by case basis. This is due to the wide range of equipment types that may require testing and the objectives of each flight test.

224.3.3 Test conditions.

Test conditions should be such that the required aircraft and stores systems may be operated in all modes of operation. Aircraft flight conditions during this testing should be as benign as possible while still allowing satisfactory testing to occur. Typically this would mean testing at altitude, during cruise conditions. Testing at other points in the flight envelope should only occur if deemed necessary by operational requirements, and only after a suitable risk assessment has been performed.

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224.4 Acceptance criteria.

Acceptable EMC is demonstrated by test results indicating that no system or subsystem experiences degradation of performance or creates a safety hazard due to the presence of other aircraft/stores system or subsystem.

224.5 Test procedure.

EMC/EMI testing of an aircraft store configuration may be conducted simultaneously with other flight testing, if safety of flight implications in the event of failure or the validity of either test will not be compromised. EMC/EMI testing should follow a matrix developed by test personnel to ensure that all systems combinations requiring testing are adequately analyzed.

224.5.1 Test points.

Test points (airspeed, altitude, maneuvers, etc.) should reflect the most benign flight conditions that will allow satisfactory progression of required inflight testing.

224.5.2 Emergency procedures.

Should an electromagnetic incompatibility become apparent during flight testing, the severity of the incompatibility and its effects may range from minor to catastrophic failure of one or more safety of flight critical systems. As such, the most effective emergency procedures for recovery from any such potential failures must be planned in advance and the pilot briefed before each test flight.

224.5.3 Test data analysis.

Immediate qualitative assessment of EMC may be obtained from test pilot comments and review of standard onboard flight data recording systems. Any quantitative assessment of this or any additional data from test specific instrumentation will be carried out on a case by case requirement.

224.6 Test reporting.

The test report should cover the test objectives, test article, any instrumentation used, data requirements of 224.2, results and conclusions. Each failure and anomaly should be discussed along with reasons for failure and proposed changes to correct the problem.

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TEST 230

FLYING QUALITIES TEST

230.1 Purpose.

The flying qualities tests demonstrate that the aircraft meets the requirements for the flying qualities of military piloted aircraft. These tests establish the limit within which the aircraft can be safely operated and ensure that the aircraft meets the goal of its design mission as related to flying qualities with any particular store or stores combination. The results of these tests also provide an accurate description of flight characteristics for inclusion in the aircraft flight manual. Care should be taken in design of this test so that worst case (possibly asymmetric) conditions are considered.

230.2 Data requirements.

Instrumentation should be used to provide or derive the following aircraft parameters and characteristics:

a. Aircraft flight condition - airspeed; Mach number; altitude; weight; center of gravity; normal, lateral and longitudinal accelerations; angular rates and accelerations; moments of inertia; angle of attack; sideslip and bank.

b. Pilot's control positions.

c. Control surface positions.

d. Static and dynamic stability and control derivatives - longitudinal, lateral and directional.

e. Auxiliary devices positions.

f. Control forces.

g. Aircraft performance, such as climb, turn rates, dives.

230.3 Test preparation.

Flying qualities tests should consist of quantitative flight test measurements demonstrating compliance with the particular aircraft design and flying quality specifications which may have been based on MIL-F-8785 or MIL-HDBK-1797. These flying qualities test should be within the boundaries of the operating flight envelope and demonstrating satisfactory flight characteristics within the maximum speed and maneuver envelope of the aircraft for the configuration.

230.3.1 Test article.

The test article should consist of aircraft-stores configurations, which analysis and previously conducted ground tests, including wind tunnel, if applicable, have shown to be critical.

230.3.2 Test equipment.

The equipment should consist of operationally representative, instrumented, aircraft equipped with necessary gauges, accelerometers, telemetry capability, movie cameras and provisions for recording aircraft flight conditions and aircraft flight path and trajectories. If spin testing is required, provisions should be made for a spin recovery system.

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230.3.3 Test instrumentation.

The instrumentation necessary to gather the data presented in 230.2 will be installed, calibrated and checked-out as required. If spin testing is required, provisions should be made for early warning stall devices.

230.3.4 Test conditions.

The conditions stipulated in MIL-D-8708, table IIIB, should apply. The design and test conditions specified in section 4 of MIL-F-8785, or section 5 of MIL-HDBK-1797 should apply. For helicopter test conditions, refer to AMCP 706-203.

230.4 Acceptance criteria.

The selected design points must be sufficient to allow accurate extrapolation to the other conditions at which the requirements apply. When the requirements of MIL-F-8785 or MIL-HDBK-1797 are successfully applied to assure that no limitations on flight safety or on the capability to perform intended missions will result from deficiencies in flying qualities, then the flying qualities tests are acceptable. When the aircraft-stores, combinations are judged acceptable, i.e., meeting the flying qualities requirements presented by the procuring activity, then the tasks are said to be acceptable. The three levels of flying qualities for the three categories of flight phases defined in MIL-F-8785 or MIL-HDBK-1797 should be used for flying qualities test acceptance criteria.

230.5 Test procedure.

The test should be performed to evaluate the aircraft longitudinal, lateral, and directional stability and control at critical flight conditions and configurations for:

a. Taxi and ground handling characteristics.

b. Takeoff characteristics, including crosswind.

c. Climb, cruise, maneuvering, descent characteristics, including effects of speed brake, power, and configuration changes.

d. Subsonic, transonic, supersonic, and hypersonic characteristics (as applicable) including trim and stability changes.

e. Buffet onset and intensity, vibration, stall characteristics, spin and departure characteristics.

f. Low speed characteristics, with and without high lift devices, carrier power approach (PA) characteristics (for carrier type aircraft) including stalls, wave-offs, and crosswind landings.

g. Air-refueling operations.

h. Operationally representative tracking maneuvers.

230.6 Test reporting.

The flying qualities demonstration data report should contain quantitative data and qualitative information, as appropriate, documenting compliance with requirements of MIL-D-8708, SD-8706, and MIL-HDBK-244. Also, spin demonstration data reports, as defined in MIL-D-8708, should be provided.

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APPENDIX B

TEST 240

PERFORMANCE AND DRAG TESTS

240.1 Purpose.

Performance and drag tests are required to determine what, if any, degradation in mission performance is caused by the carriage of external stores. Store loadings selected to be flown should be compatible with the anticipated operational requirements, and should yield a sufficient range of aerodynamic drag in order to be representative of all loadings. Results of these tests should be compared with those analytically derived and those data obtained from wind tunnel tests. In the event that the drag of any tested loading is unusually excessive, alternate, lower drag loadings should be selected, where practical, and tested.

240.2 Data requirements.

In addition to the aircraft flight condition parameters, as listed in Tests 200 and 230, the following data will also be required:

a. Engine fuel flow and rpm to assist in determining aircraft drag levels.

b. Instrumented store(s)/racks to measure installed store drag.

240.3 Test preparation.

240.3.1 Test equipment.

a. Instrumented operationally representative aircraft.

b. Store suspension equipment (pylon, racks).

c. Test stores.

240.3.2 Test instrumentation.

The instrumentation required is identical to that specified in 230.2, except for that added to measure aircraft engine fuel flow, engine rpm, flight path acceleration and store drag. A test aircraft with calibrated and instrumented engines is desirable for drag tests and significantly increases the confidence in the flight test data.

240.4 Acceptance criteria.

The selected test points must be sufficient to allow accurate extrapolation to all conditions at which the store will be carried. The data must be such that a determination of the aircraft performance (acceleration, turn rate, climb rate) with various store loadings can be made throughout the Mach number/altitude envelope. The performance and drag of aircraft-store combinations will be judged acceptable if the system specifications are met with no degradation in mission performance or, if any degradation is indicated, that degradation is determined acceptable by the procuring agency.

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240.5 Test procedures.

Methods for the determination of aircraft performance, while carrying external stores, should be either of (but not necessarily limited to) the following:

a. Determine aircraft performance throughout the entire flight envelope, including take-off, climb, acceleration, stabilized level flight, wind-up deceleration and landing. Data from these maneuvers will yield the performance of the aircraft-stores combination directly, in terms of takeoff and landing distances, rate-of-climb or nautical miles per pound of fuel. This method provides excellent results, but requires extensive flight testing over the entire flight envelope. An adaptation of this method which yields performance less directly, but with considerably less flying, is to limit the testing to only dynamic maneuvers, that is, selected climbs, descents, and ascents-descents. Resulting data from these maneuvers are those used to generate drag polars. Data obtained from these techniques are then compared with that obtained from testing without external stores, and forms the basis from which aircraft performance can be calculated for any store loading.

b. An alternate method is the store drop technique. This involves releasing selected external stores from an instrumented aircraft in stabilized level flight. The resultant horizontal and longitudinal acceleration are then analyzed using data from flight path accelerometers to obtain the increments in drag between the pre- and post-drop aircraft configuration. This technique appears to be considerably more accurate than that involving the measurement of total aircraft performance, but, could be more costly due to expended stores and limitation of only one flight condition per drop. However, improved accuracy derived from this technique might warrant this cost increase, particularly for the determination of the drag of small items and interference drag.

240.6 Test reporting.

Flight test reports should be prepared and should satisfactorily document the results obtained, in the form of quantitative data and qualitative assessments, depending upon the type of goals of the specific flight tests. These reports should be submitted as required by the procuring agency. It is recommended that such test reports be divided into two sections:

a. Pertinent discussion relating to the findings, goals, conclusions and recommendations, and

b. Complete data compilation, including explanations of symbology and terms, presented in an easily understood and translated format.

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APPENDIX B

250 SERIES TESTS

CAPTIVE COMPATIBILITY FLIGHT PROFILE (CFP) TESTS

250.1 Purpose.

Captive compatibility flight profile (CFP) missions are qualitative tests flown to evaluate the effect of a store configuration on aircraft flying qualities and store structural integrity throughout the required flight envelope. Uninstrumented aircraft are generally used for this purpose. There is no set of guidelines for CFPs which covers all situations so engineering judgment is necessary. Further guidance on test technique is provided in MIL-HDBK-244. Each new aircraft store configuration requiring certification should be evaluated using the following:

a. Handling Qualities Test (Test 251). A store, whose shape, mass, inertia properties or configuration are not analogous to another previously certified or tested item on that aircraft, should be flown for handling qualities. Store configurations to be flown to higher limits (airspeed or load factors) than analogous configurations require testing. Large, heavy stores which approach (but are not beyond) known mass, inertial and aerodynamic boundaries for the particular aircraft generally require CFP testing. Store configurations exhibiting characteristics beyond known aircraft limitations should be considered for real time instrumented testing, not qualitative CFP testing. CFP handling qualities testing is not normally applied toward expanding the known flying qualities or design limitations of the aircraft.

b. Structural Integrity Test (Test 252). A store being considered for certification should be flown for structural integrity if no previous flight testing to analogous flight limits has taken place. Previous testing on another aircraft or in a different configuration on the candidate aircraft may be substituted, depending on engineering judgment. In general, one-of-a-kind developmental stores do not require this type of testing unless the store is intended for certification. Inventory stores already verified which undergo significant airframe modification should be tested. If a store is to be certified on numerous aircraft, the aircraft and configuration judged most severe with regard to structural integrity may be chosen for testing and thereby meet test requirements for all aircraft; keeping in mind different aircraft have different severe environments. For instance, some aircraft-store configurations may require engine spillage testing to determine the aerodynamic load effects of transient engine inlet backwash/spillage if the stores are mounted in the vicinity of the inlet or in other vulnerable positions.

c. Endurance Test (Test 253). A store being considered for certification should be flight tested for endurance if no previous flight testing, analogous to the required flight limits has taken place. If lanyard routing is significantly different than previously flown, endurance and vibration may be necessary.

250.2 Test conditions.

Test conditions to investigate the ability of the stores loaded in a specific aircraft-store configuration to withstand the aircraft structural, aeroacoustical, vibrational environment for sustained periods (as would be the case on a combat mission with several in-flight refuelings) are specified in Tests 251, 252 and 253, respectively. A copy of the aircraft head-up display (HUD) video and a copy of the aircraft on-board data tape may be requested for aircraft with these capabilities. The test conditions for these tests should be representative of the appropriate flight envelope. Test conditions should include variations such as gross weight, load factor, airspeed, Mach, altitude, rapid throttle motions simulating throttle chops and critical

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loading conditions of the particular store or aircraft-store combination. To accomplish this part of the test, the specific aircraft-store configuration should be flown for a minimum total time (Test 251 plus Test 252 plus Test 253, or Test 252 plus Test 253) equivalent to the aircraft's mission radius plus 50 percent of the mission time. This would be 150 percent of the mission time on that particular serial number store in that specified store configuration. Of this total time, at least 30 minutes should be obtained in the region of highest vibrational loading during Test 253. For example, the minimum mission time of one hour should be used for fighter type aircraft such as F-15. Note that this does not preclude the certification agency requiring a greater time if it is anticipated that a particular aircraft-store configuration could experience greater mission times due to air-to-air refueling, or if the store is a training item that will encounter repeated flights in-service. During the accumulation of this minimum mission time the test agency should ensure that it is operationally representative. If more than one sortie is required to obtain the total flight time, stores should not be downloaded nor minor discrepancies corrected between sorties. Finally, loading procedures for the stores involved should be verified with detailed procedures identified in the respective test plan to ensure that satisfactory procedures have been developed for the aircraft-store combination.

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APPENDIX B

TEST 251

HANDLING QUALITIES TEST

251.1 Purpose.

The purpose of this test is to evaluate the influence of the stores/suspension equipment on the handling qualities of the aircraft. This test establishes the limits within which the aircraft can be safely operated and ensure that the aircraft meets the goals of its designed mission as related to handling qualities with any particular store or stores combination. The results of these tests also provide an accurate description of flight characteristics for inclusion in the aircraft flight manual.

251.2 Data requirements.

A qualitative assessment of aircraft-store performance will be made by the pilot. A copy of the aircraft HUD video and a copy of the aircraft on-board data tape may be requested for aircraft with these capabilities. Although not specifically required for the handling qualities test any store discrepancies such as arming wire slippage or structural damage will be recorded as specified in 252.2.

251.3 Test preparation.

251.3.1 Test articles.

An aircraft plus the stores and suspension equipment required for the configuration being certified are required. In general the test store and aircraft-store combination should be structurally, inertially, and aerodynamically similar to the design used in the structural analysis and drawings. Configuration, materials, and quality of workmanship should be the same as for the in-service store and aircraft-store combination. Identification of these as representative production items is necessary to ensure the test is representative of the articles to be certified. Inert munitions should be employed with fuzes, booster, arming wires, and lanyards installed. Stores containing electronic/electrical equipment should be capable of being powered during the flight tests. For Test 251 the test item need only be aerodynamically and inertially representative of the store under investigation.

251.3.2 Test equipment.

No specific equipment, beyond the standard aircraft and store support equipment, is required.

251.3.3 Test instrumentation.

No special instrumentation is required. This does not, however, preclude instrumentation to gather flight test data if useful information can be obtained without making the test item nonrepresentative of the production item. Use of the aircraft on-board data recorder to record data for post-flight analysis may be requested.

251.3.4 Test conditions.

As specified in 250.2. Typically, a baseline sortie will also be flown prior to the CFP, using the same aircrew and the same aircraft without the test store. The same profile will be flown to

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establish the "baseline" handling qualities of the aircraft. The test conditions for this test should cover the various operating regimes such as gross weight, load factor, airspeed, altitude plus critical asymmetric configuration. The test should address all phases of ground and flight operations.

251.4 Acceptance criteria.

The test will be considered successful if acceptable handling qualities, as defined by the certifying agency, are observed by a qualified test pilot current in that aircraft. The selected test points must be sufficient to allow accurate extrapolations throughout the flight regime at which the handling quality requirements apply.

It is desirable that no store discrepancies occur during this test. If store discrepancies occur, Tests 252 and 253 should be flown.

251.5 Test procedure.

This test should be performed using individual sorties, as required, to satisfy 250.2 conditions. If this test is being done in conjunction with either Test 252 or 253, the stores should not be unloaded nor should minor discrepancies be corrected between sorties. The particular aircraft control system with the aircraft flying quality specification would be taken into account when deciding which of the following maneuvers should be done with parts, or all, of the control systems on or off (i.e., CAS, SAD, or dampers). The following paragraphs use the term “dampers” for this reference. Adhere to any aircraft flight control related restrictions on this subject if appropriate for the particular flight test. This test should be performed to evaluate the aircraft-store handling qualities by performing the following at selected test points as necessary:

a. Taxi and ground handling characteristics.

b. Take-off characteristics, including crosswind.

c. Climb, cruise, maneuvering descent characteristics, including effectiveness of speed brakes, power, and configuration changes.

d. Subsonic, transonic, supersonic characteristics (as applicable) including trim and stability changes as follows:

(1) Stabilize aircraft at desired airspeed in level flight and trim to fly hands off.

(2) Perform steady state sideslip analysis noting rudder deflection versus sideslip and aileron deflection/stick force (confirm positive static directional stability C_{n_β} (positive number) and positive dihedral effect C_{l_β} (negative number)).

(3) Perform longitudinal dynamic short period motion analysis noting the number of overshoots with pitch dampers off due to an approximate 1 g pitch oscillation by the pilot. Typically, less than seven (7) overshoots is acceptable with dampers off (one (1) or two (2) overshoots with pitch damper engaged). If oscillations continue undamped or increase in amplitude (dynamically neutral or unstable respectively), engage pitch dampers and dampen motion with pilot input. Do not proceed further with test.

(4) Perform lateral-directional dynamic analysis with roll and yaw dampers disengaged noting the motion due to a rudder doublet. Resulting dutch roll motion should be damped. If motion continues undamped or increases in amplitude (dynamically neutral or unstable respectively) engage roll and yaw dampers and dampen motion with pilot input. Do not proceed further with test.

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(5) Investigate aircraft roll performance. With all dampers off build-up to maximum aileron roll rate noting aircraft divergence from flight path. Re-engage dampers.

(6) Investigate aircraft maneuvering stability characteristics (usually during wind-up turn for positive g and symmetrical push-over for negative g) noting the stick force per incremental g up to the maximum g limit. This provides an indication of the degree of dynamic longitudinal maneuvering stability. Investigate aircraft control characteristics throughout the maneuvering envelope to the maximum positive and negative unsymmetric, or rolling, g limit.

(7) If structural integrity (Test 252) needs to be demonstrated at this airspeed, it may be expeditious to perform it now or combine it with Test 251.5d(6).

(8) Evaluate speed stability during acceleration or deceleration to next test point, noting increasing stick force. Do not trim during the acceleration or deceleration.

(9) Repeat steps (1) through (8) at each speed increment. At maximum speed points, a dive may be required to achieve parameters. At these points, a series of control inputs must be made dynamically and the aircraft will not be able to stabilize at precise conditions.

(10) Upon completion of the final test point, or at the highest speed authorized, evaluate trim change induced when speed brake is extended noting change in trim force required to maintain level flight.

e. Investigate buffet onset and intensity, vibration and stall/high angle-of-attack characteristics.

f. Investigate low speed flying characteristics (with and without high lift devices) including stalls, wave-offs, and crosswind landings.

g. Investigate trim changes when lowering gear and flaps, while performing turns, and while approaching stall warning.

h. Air-refueling operations.

i. Operationally representative maneuvers including tracking tasks appropriate to the mission of the aircraft.

251.6 Test reporting.

A test report should be prepared which documents the test results. The test report should document to the certifying agency the flight test limits actually achieved, the test aircraft-store configuration and any discrepancies noted. It is recommended that terms such as "clean or basic aircraft limits (CAL or BAL) were demonstrated" not be used. Instead the actual parameters achieved during the tests such as 700 KIAS/1.40 Mach, –1.00 to +7.33 symmetrical g's, –0.5 to +5.5 unsymmetrical g's should be used, since the value of BAL or CAL may change with improved engines or subsequent aircraft upgrade programs. Flying qualities will be reported using qualitative comments and the Cooper-Harper Rating Scale and/or the Pilot Induced Oscillation Rating Scale where appropriate tasks are defined. The report should document any significant change in aircraft handling qualities from the basic aircraft with respect to any phase of flight or ground operations. Store discrepancies resulting from the test, will be described and illustrated with photographs. The report will include a complete and detailed description of the test articles and sorties flown. Along with any recommendations that could correct any discrepancies identified.

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APPENDIX B

TEST 252

STRUCTURAL INTEGRITY TEST

252.1 Purpose.

The purpose of this test is to verify the structural integrity of the store and aircraft-stores combinations. This test demonstrates the ability of the stores loaded in a specific critical aircraft-store configuration to withstand the aircraft ground and flight operational environment for periods of time longer than a single mission. This test will evaluate preparation, flight and return with all stores still on the aircraft by performing flights to maximum symmetrical and unsymmetrical load factors at the maximum allowable speed without damage to or a failure of either the aircraft, store, or suspension equipment. Engine spillage testing may also be required for some aircraft-store configurations to determine the aerodynamic load effects of transient engine inlet backwash/spillage on stores mounted in the vicinity of the inlet or in other vulnerable positions. The degree of engine spillage is often a function of Mach number and engine spool speed and has been observed through so-called "throttle chop" maneuvers especially in the transonic flight regime. Uninstrumented operationally representative aircraft are generally used for Test 252.

252.2 Data requirements.

Test aircrew should obtain the following data: indicated airspeed, pressure altitude, load factors, aircraft angle of attack, indicated Mach number, aircraft angle of sideslip, angular rates, accelerations, aircraft weight and sink rates, as necessary, to validate the aircraft-stores combination was flown to the critical loading conditions. The test aircrew should also record sufficient data to document the engine spillage test maneuver if required. Any aircraft-store discrepancies such as arming wire slippage or structural damage will be recorded. The use of still photographs is generally used to document store discrepancies. A complete description of the test equipment, including model identification, store physical and electrical characteristics and test configuration, will be made to permit the test to be repeated if required. All store electronic/electrical equipment should be functionally checked prior to the test and after the last mission to ensure the flight does not adversely affect store serviceability. During aircraft preflight, any aircraft-store deficiencies or anomalies must be carefully noted to assist in post-flight review. Typically, any paint loss, scratches or dents on the test aircraft or store should be clearly marked with a china-graph, or similar marker.

252.3 Test preparation.

As specified in 251.3.

252.4 Acceptance criteria.

The test will be considered successful if no major store or aircraft discrepancies are observed throughout the flight envelope. During the test any store discrepancies should be recorded. After each sortie, visually examine the aircraft, suspension equipment, store combination for damage, failure, cracks, looseness or popped rivets. If significant discrepancies occur, discontinue testing and determine if the test should be repeated or discontinued. If lesser discrepancies occur (arming wire slippage, decals coming off), continue with sorties without correction of the discrepancies. After the sorties, examine the configuration both externally and

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internally, as necessary, for evidence of any discrepancies. All critical structural components in the store, aircraft ejector rack, and pylon should be visually inspected and non-destructively inspected as specified by the certifying agency. Conduct all necessary functional checks on the store to verify serviceability before, during, and after the test.

252.5 Test procedure.

This sortie will check the configuration for structural integrity by subjecting the aircraft-store combination to maximum symmetrical and unsymmetrical load factors at maximum allowable airspeed. Occasionally, two envelopes for a particular aircraft/stores combination may be specified to permit higher airspeeds or Mach but at a reduced load factor. In such cases, demonstrate both envelopes. If the handling qualities are an issue it may be necessary to perform Test 251 at the desired airspeed prior to conducting this test. If handling qualities are not an issue, then perform the test as follows:

a. Stabilize aircraft and altitude and ensure dampers are engaged. Roll into turn adding power to maintain airspeed as g is gradually increased to maximum attainable (determined by unacceptable aircraft buffet or munition limit g whichever occurs first). Maintaining nearly a constant bank angle so as not to induce any rolling g, noting the stick force per g.

b. Attain rolling g limits upon completion of maneuvering flight by relaxing the g to the rolling limit and roll the aircraft back to wings level attitude, maintaining maximum roll rate.

c. Perform negative g limit structural integrity demonstration by pushover or inverted turn maneuver.

d. Perform engine spillage test maneuvers, if required.

e. Repeat a through d at each speed increment required.

252.6 Test reporting.

As specified in 251.6.

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APPENDIX B

TEST 253

ENDURANCE TEST

253.1 Purpose.

This test is flown to check the effect of a store loading configuration on the aircraft and store failures induced by the aircraft. Uninstrumented operationally representative aircraft are generally used for this test.

253.2 Data requirements.

As specified in 252.2.

253.3 Test preparation.

As specified in 251.3. The test agency should also ensure that during this test the terrain over which the mission is to be flown provides a vibration environment representative of that to be experienced in-service.

253.4 Acceptance criteria.

As specified in 252.4.

253.5 Test procedure.

This test should be conducted at either 0.9 Mach, the airspeed at which the worst case straight and level vibration occurs, or the maximum allowable airspeed (whichever is the more restrictive) at the lowest practical altitude commensurate with weather and safety considerations (1000 feet above mean sea level as a maximum) for a cumulative total of 50 percent of the total mission radius or approximately 30 minutes. Previous flight testing has demonstrated that the worst case vibration for current in-service aircraft loaded with external stores occurs around 0.9 Mach at the lowest practical altitude. US Army helicopter endurance tests should be performed on an accelerated basis and should consist of a minimum of 300 flight hours. For guidance, refer to AMCP 706-203.

253.6 Test reporting.

As specified in 251.6.

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APPENDIX B

TEST 260

CARRIER SUITABILITY TEST

260.1 Purpose.

The purpose of carrier suitability testing is to test the store under the dynamic conditions of actual catapult launchers and arrested landings to verify store compatibility in accordance with NAVWEPS 51-35-501. Tests are conducted on the aircraft with the highest structural limits of those aircraft from which the store is expected to operate. Tests may be required on various aircraft if indicated by differences of rack/launcher, asymmetry or clearances with catapult/arresting gear/deck hardware. Prior to being tested on the test aircraft, simulated ground tests as described in Test 132 or to the expected environment, whichever is more critical, should have been met.

260.2 Data requirements.

The following data, if applicable, should be measured and/or recorded as a minimum. If strength of aircraft or suspension equipment, or store is marginal, additional measured data will be required:

a. Maximum aircraft cg. longitudinal accelerations/decelerations.

b. Aircraft sinking speed at touchdown (or cable pick-up for free flight arrestments).

c. Aircraft off-center distance at cable engagement.

d. Deck clearances for bridles, shuttles and arresting cables.

e. Aircraft configurations, including asymmetry.

f. Aircraft weight.

g. Aircraft catapult end speed/engaging speed.

h. Aircraft pitch, roll and yaw attitudes at touchdown (or cable pick-up for free flight arrestments).

i. Mechanical, electrical and functional integrity of the system under test after each flight or at the end of the day.

j. Type of jet blast deflector (JBD) and locations of aircraft relative to the JBD when measurements are made.

260.3 Test preparation.

Test preparation will contain the following items as a minimum. Other items should be added as appropriate.

260.3.1 Test article.

Provide detailed description of article to be tested. The article used for flight test should be representative of the articles that are to be delivered to the armed services.

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260.3.2 Test equipment.

List of items required to complete tests.

260.3.3 Test instrumentation.

List all data gathering devices used to collect data to authorize store such as catapult endspeed and sink speed instrumentation, cameras or radar. Test instrumentation should also be capable of measuring loads data necessary to demonstrate adequate strength of aircraft, suspension equipment, or store, if required.

260.3.4 Test conditions.

The following test conditions will be met as a minimum.

a. Catapult launches:

Spot condition	% Limit longitudinal load factor
Symmetrical	100
Off-center (left or right)	100
Yawed, nose gear (left or right)	100
Yawed, main gear (left or right)	100

1. Not applicable to nose tow launch type aircraft.
2. If asymmetric loading of stores is tested, do yawed main gear left and right

b. Arrested landing:

Type landing	%Load longitudinal load factor	Sink speed
On-center	100	Nominal
Off-center (20% left/right)	100	Nominal
High sink	80-100	0.817 aircraft design maximum
5° roll and 5° yaw	80-100	Roll in same direction as yaw and repeated with roll opposite to yaw
In-flight engagement	Nominal	Nominal

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260.4 Acceptance criteria.

A carrier suitability test should be considered successful if, after test completion, the following conditions have been met.

a. Satisfactory operation of instrumentation and recording equipment.

b. No damage to the aircraft and suspension equipment (either structurally or superficially) that would affect airworthiness or require rework prior to next flight.

c. No damage and proper operation of the store and its associated equipment after testing in accordance with the design intent, as related to aircraft-stores compatibility and safety of operation.

d. All data recorded during the test should indicate test conditions were met.

e. No degradation of flying qualities that would affect operation of the aircraft.

260.5 Test procedure.

Prior to conducting any tests, a test plan should be prepared and reviewed by appropriate engineering and flight safety authorities. The test plan should give the purpose and desired results of the tests. The detailed procedures must account for all possible situations that could affect safety of the test airplane or personnel.

a. The store to be tested should be mounted on the most critical armament station. Some tests may involve a number of store configurations. The following is a representative list of variables though not necessarily all inclusive: location of store, ejector cartridge installed/removed, store weight, aircraft asymmetric limits, aircraft structural limits. A detailed record of the configuration being tested must be kept for subsequent correlation of data. Tests should be performed on the test article to ensure proper operation (both electrical and mechanical) prior to, during, and after completion of tests. The store rack/launcher interface (electrical and mechanical) should be visually inspected by experienced personnel after each test event is completed.

b. Ensure that all instrumentation is working prior to and after the tests. Ensure that all test conditions have been met prior to reconfiguring the test aircraft. Record all test data applicable to each data point.

260.6 Test reporting.

Final certification of a store/aircraft combination depends upon adequate reporting of all test data. Correction of malfunctions arising in operational service and future design improvements are more easily accomplished if complete data file on the certification tests is maintained.

a. The program office should act as a clearing house for test data and make it available to all using agencies. The program office should have copies available of all test data acquired during certification testing in addition to any significant in-service performance data.

b. To assist the program office in processing any malfunction reports and developing repair procedures, the test certification data should be as complete as possible and should include all test instrumentation records suitable and notated for calibration and test number in the formal test report.

Distribution should be as directed by the contracting agency except that in all cases the test facility should retain one copy of the original test data as a permanent record of the tests.

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APPENDIX B

270 SERIES TESTS

EMPLOYMENT TESTS

270.1 Purpose.

During these tests, part or all of the stores are released from the aircraft. Even though wind tunnel tests are widely used to predict employment characteristics, flight testing is normally considered mandatory to demonstrate as a minimum, envelope extremes. Many occasions will arise when employment analogies or simulations are not available or sufficient and flight testing is the only available tool to determine safe employment envelopes.

a. Employment, as defined earlier, means to release, launch, fire, or dispense part or all of the selected stores from the aircraft. Employment in many cases is characteristically different from jettison. Jettison is the safe release of stores from the aircraft and is done simply to separate the stores from the aircraft for safety or performance reasons. During employment tests, the store is operated in its normal mode to accomplish an operational objective as opposed to jettison, which is usually accomplished in l g level flight. Employment testing is often accomplished throughout a large part of the aircraft flight envelope to demonstrate that the store or store part will safely and satisfactorily separate from the aircraft. As a side benefit, through a well structured employment test, valuable parametric insight into basic aircraft-store employment characteristics can be obtained.

b. It is easily conceivable that a store will be designed that could dispense as it separates from the aircraft, or otherwise combine more than one of the four types of employment modes. For such cases, several standard tests may have to be combined to properly evaluate safe employment.

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APPENDIX B

TEST 271

RELEASE TEST

271.1 Purpose.

Release tests are performed when, during normal employment, the entire store is released from its suspension equipment. Guided and unguided iron bombs and clusters, fire-bombs, and nuclear weapons are examples of weapons that are normally released during employment. Release tests are performed to demonstrate that the store or the submunitions within a cluster bomb will safely and satisfactorily separate from the aircraft throughout the employment envelope. It is important to understand that a store must not only separate safely from the aircraft, it must also separate without undue disturbance of its ballistic trajectory. It is of little value to the mission if the store, or stores, separate with no safety problem, only to have separation disturbances perturbate the weapon's trajectory to the point that the intended target cannot be hit. A good separation, then is one which is not only safe, but also relatively benign to the weapon trajectory. Missiles and rockets that release, then propel, are discussed under Test 272. Cluster bombs that dispense submunitions after the cluster is released from the aircraft are discussed herein. Dispensers that remain on the aircraft while dispensing submunitions are discussed in Test 274.

271.2 Data requirements.

Data are taken to ensure the stores released are representative of the inventory, to ensure the desired release conditions are demonstrated, to document the store release characteristics, and to allow comparison of flight release motion with that predicted during simulations. Data may be quantitative as measured by film or instrumentation or qualitative as noted by the pilot or chase observer.

a. To ensure the test stores are representative of the inventory, the mass, physical and operational characteristics of the inventory stores must be known and compared to the measured values of the test stores. Stores with measured values outside the tolerances of the inventory should not be used unless it can be determined through analysis or judgment that the out-of-tolerance parameter will not be expected to affect basic separation characteristics. Parameters of interest and their criticality are given in table B-I.

b. To ensure the desired release conditions are achieved, the test engineer must have knowledge of the aircraft configuration and release flight conditions. Aircraft configuration characteristics are listed in table B-II. Aircraft flight conditions at release are outlined in table B-III and are best obtained with instrumented aircraft. However, often an instrumented aircraft is not available and the test engineer must rely on a visual (by crew member) or photographic (HUD or over-the-shoulder camera) record of the flight conditions from aircraft instruments. If a visual record is the only available one, the crew member should be provided with a flight card or form with relabeled spaces to facilitate entry of data. Flight conditions at release may also be determined from tracking information (radar or photographic). To document store release characteristics, it is essential to have onboard or chase high speed motion picture cameras or a video equivalent. It has been demonstrated over and over that the pilot of the release or chase aircraft cannot be expected to reliably visually ascertain store separation characteristics. Onboard cameras may be mounted internally, on adapters to the skin of the aircraft, carried in removable pods, carried on a beam with suspension lugs (i.e., a pod without skin), or on very low-speed (150 MPH or less) aircraft, hand held by a crew member. Cameras must be installed

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in such a way that their presence does not perturb the airflow sufficiently to affect store separation characteristics. "High speed" is defined herein as minimum frame rates of 200 frames per second. Slower frame rates do not sufficiently slow down the motion to allow checking of phenomena such as fin-to-fin contact. Onboard cameras should be lensed and aimed such that separation motion is documented from the pylon/store interface until the store is well clear (approximately 20 feet) of the aircraft. Combinations of side viewing and rear viewing, or side viewing and down viewing cameras may be needed to adequately record separation characteristics including store oscillations, functioning, store-to-store collisions and store passage through aircraft flow and shock fields. Extreme wide-angle or fisheye lenses can provide useful information, but the image is so distorted that linear and angular relationships are usually lost. Video systems can provide an instantaneous review of the release if the video information is telemetered to a ground monitoring system.

TABLE B-I. Store mass, physical and operational characteristics.

Characterisitc	Recommended allowable variation	Criticality
Nomenclature and type including components such as fuze, fin, wing, warhead, percent of allowable payload, payload distribution		Can be critical
Mass or weight	+5%	Usually not critical*
Pitch/yaw moments of inertia	+10%	Usually not critical*
Roll moments of inertia	+10%	Usually not critical*
Center-of-gravity location	+10 mm (+0.5 in)	Usually critical
Length	+5 mm (+0.25 in)	Usually not critical
Diameter	+3 mm (+0.120 in)	Usually not critical
Suspension lug locations	+2 mm (±0.08 in)	Usually critical
Time to fin/control surface/component activation	+50 ms	Usually critical
Sequence of component operation		Usually critical
*Except with guided munitions.		
*For guided missiles the recommended allowable variation in moments of inertia is ±5%; it is usually not critical, but is situation dependent.		

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TABLE B-II. Aircraft configuration characteristics.

1. Aircraft type, designation, model number.
2. Position of external control surfaces (speed brakes, flap settings, gear settings, canards, slats) at release.
3. Location of all additional external stores.
4. Pylons, racks, adapters used.
5. Release mode, interval, and sequence.
6. Routing and installation of wires, lanyards, electrical, pneumatic and fuel connectors.
7. Ejection information (cartridge, orifice combinations, rack settings, ejector foot location, pitch rate, ejection velocity).
8. Preset of lugs, swaybraces.

c. Chase camera coverage is often considered superfluous to onboard coverage, but there are many release situations for which chase coverage is superior. For example, store reactions well below the aircraft (i.e., through a shock wave), store functions such as retarded initiation, motor ignition, store trajectory changes due to long period store oscillations, and store-to-store collisions, crossovers, and drafting may be best documented through chase photography. Chase cameras are usually hand held since it is difficult to keep a hard-mounted camera on the chase aircraft aimed at the store. Chase cameras should be "high speed" in the same sense as onboard cameras. Ideally, for most release tests, the chase pilot should be positioned approximately side-by-side, just slightly aft of, and just slightly below the release aircraft. The photographer should be able to see the store (not hidden by fuel tanks or other stores) and the resulting film should usually depict a pitch plane of the store separating. The chase aircraft should be close enough that the store is easily identifiable in the film but far enough away that other stores released simultaneously may be seen, as well as the aircraft tail area. Variations from test to test may necessitate different chase positions. Also, as single releases are made from one side of the aircraft, then the other, the chase aircraft must also be repositioned to get useful camera coverage. The chase aircraft can also be used to inspect the test aircraft after the release to ensure no aircraft damage has occurred. The chase aircraft crew must be fully briefed by the separations engineer to ensure safety of flight and to ensure that the optimum photo coverage can be obtained.

d. Onboard and chase coverage are often not permissible for releases at high speeds, steep dive angles, or certain maneuvers. For such tests, it may be possible to use a ground camera to document separation characteristics. Ground cameras may also be useful to get store functions, drafting, or store-to-store collisions. In general, however, ground cameras do not provide a close enough view to replace onboard or chase camera coverage.

e. Pilot comments on the response of the aircraft during and after store release provide subjective but valuable information. Comments related to the "feel" of the release (was there a bump), the resulting g-jumps, trim changes, and oscillation, their ease of control, their similarity to other stores and their overall acceptability should be recorded for the final report.

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TABLE B-III. Release test – aircraft flight condition data.

Characteristic	Expected max deviation	Criticality
1. Airspeed	+ 10 kts	Critical
2. Altitude	+ 60 m (± 200 ft)	Not critical
3. Flight path angle (dive or climb)	+ 5°	Not critical except for steep dive
4. Delivery g (normal acceleration)	+ 0.2g	Not critical except below + 0.7g
5. Gross weight	+ 100kg (± 220 lbs)	Not critical
6. Mach number	+ 0.02	Critical
7. Outside air temp	+ 1° C	Not critical
8. Aircraft or rack response at release in flexure, g-jump, roll angle, bump	Pilot record	Critical
9. Angle of attack	+ 0.5°	Critical
10. Angle of sideslip	+ 0.5°	Critical
11. Angle of roll	+ 5.0°	Not critical

NOTES: 1. Many parameters, such as altitude, may vary for ripple release.

2. It is normal practice, during store certification separation tests, to over-test Mach number, dive angle, delivery g, and airspeed to insure that a slight safety margin is incorporated in the aircraft flight manuals. The amount of over-testing on each parameter is determined on a case by case basis, depending on experience and analysis of experimental data. If no data are available, the following over-test values should be used:

Airspeed	10 – 15 KCAS
Mach number	0.05
Dive angle	5 to 10 °
G	0.2 to 0.3

f. To allow comparisons of wind tunnel trajectories, 6 degrees-of-freedom simulations, and flight test results, several experimental techniques are available including telemetry (TM) package data and photogrammetric data. All flight-tested weapons should be marked with targets for photogrammetric measurements, and have their weight, moments of inertia, and cg measured, even if there is no immediate intent to use that data. Weapons tested in a questionable part of the flight test envelope should be equipped with TM packages which provide 3-axis rates, and 3-axis accelerations which can be integrated to obtain x, y, and z displacements as well as pitch, roll, and yaw attitudes. Since the exact requirements of each system vary, it is up to the weapons program engineers to select the systems which are required for the flight test program.

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271.3 Test preparation.

Test preparation consists of several steps (these steps are often combined with preparation for fit, captive flight, other employment, and jettison tests):

a. Establish the desired or predicted release envelope - quite often this might seem as simple as ascertaining operational requirements, but such requirements may be modified to clear all of a similar type of store to a common release envelope or to clear only a simple low cost portion of the operationally desired envelope.

b. Generate a release test plan - test plans should not be formulated until data from previous test and evaluation of the store in question and similar stores are fully reviewed. Then using that knowledge, along with the information gained through available analysis and simulation, a detailed test plan can be formulated. Typically, testing is started from the safest presumed condition (not necessarily the lowest speed) and the release envelope is expanded from there. Expansion may consist of higher dynamic pressure and lower altitudes, higher and lower airspeeds and Mach numbers, higher and lower load factors, increasing dive angles (reducing g), increasing bank angle, reducing release intervals, proceeding from single carriage to multiple carriage, proceeding from single release to multiple release (including salvo), proceeding from preprogrammed or dummy vehicles to vehicles with active guidance systems, proceeding from low drag to high drag, and proceeding from protracted function times to minimum function times. Liquid filled stores may proceed from a non-sloshing dummy to an actual liquid fill. The test plans should include data requirements, range requirements and details on all aspects of configurations and release conditions.

c. Evaluate separation failure modes - In formulating test plans, it is critical to ensure either that store separation with unopened fins or worst case control settings is safe (not necessarily acceptable) or that the likelihood of such a failure or setting is acceptably low (say once every 10,000 releases). If such cannot be determined, then release tests of the store should not be initiated since a control system or fin opening system failure could easily result in a high energy aircraft-store collision.

d. Employ a test agency - Test plans will have to be conveyed to the agency that is desired to actually do the tests. Although the communications will vary widely from agency to agency, the type of information that must be provided usually consists of test objectives, agency responsibilities, resources required, data required, test peculiarities, test authority and funding sources.

271.3.1 Test articles.

Test stores should be identical to inventory stores except, in the interest of flight safety, they should be inert if at all possible. There may be cases where a simulant for the live fill cannot be found (e.g., fuel air explosive (FAE), fire-bombs), and therefore inventory stores with inert fuzes may be used. In cases where a large test program is planned, it may be cost effective to design an inert separation test vehicle (STV) of identical shape and mass properties but without complicated and costly internal mechanisms, electronics, or exotic materials. All test articles should have their critical physical and mass properties checked prior to their use in a flight test situation, and specially painted, if needed, to assist in data reduction. For some guided weapons, it may be desirable to have preprogrammed vehicles or other STVs to eliminate the possibility of, or evaluate the effects of, control system failures or settings.

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271.3.2 Test equipment.

Camera systems and aircraft instrumentation to monitor release conditions and results should be identified, serviced and installed as necessary. Responsible agencies should be identified to monitor and maintain instrumentation and to collect data.

271.3.3 Test instrumentation.

Specific test instrumentation for store release tests can vary considerably, depending on the technique of testing chosen. However, in general, the releasing aircraft should be equipped with onboard movie cameras (usually operating at 200 frames/sec) and some method of determining the aircraft conditions at time of store release (speed, altitude, dive angle, accelerations). The latter can be a cockpit-mounted camera, a pod recording system, or an internally mounted data package. It is frequently desirable to have the weapon rack instrumented also to measure reaction loads, hook opening, or to provide a "stores away" signal.

271.3.4 Test conditions.

Test conditions should be chosen to demonstrate the entire release envelope. Sufficient "build-up" conditions must be included prior to proceeding to critical conditions. Critical test conditions for release may include maximum airspeed (maximum dynamic pressure), maximum Mach number, (or, in some cases, transonic Mach number) minimum or maximum g, minimum release interval, maximum aircraft angle of attack (minimum speed at maximum altitude), release in the transonic regime, release from worst configuration or worst station, release during autorotation or sideslip, or others as specifically related to the test item such as dives or roll angles. Releases should be made at the conditions specified in the test plan. The test plan may state allowable tolerances on release conditions such as suggested in table B-III. Helicopter flight demonstrations should be performed in different flight modes. As a minimum, tests should be demonstrated at the power for level flight and during auto-rotative flight.

271.4 Acceptance criteria.

The store must safely and satisfactorily separate from the aircraft throughout the desired release envelope, or the release envelope must be reduced to that commensurate with safe and satisfactory separation criteria. In addition to separation characteristics of the store, the aircraft response must be evaluated. Responses such as g-jump, trim changes, and aircraft oscillations should not be objectionable. Evaluation of these responses is primarily a subjective judgment the test pilot must make aided by aircraft instruments denoting quantitative values achieved during the test. The criteria for safe and acceptable separation trajectories must include the following:

a. Positive movement away from aircraft: Any store being separated from an aircraft must have positive movement away from the aircraft such that no part of the store will strike the aircraft or adjacent stores. . This includes all reasonable perturbations of nominal store mass and physical properties, ejector rack performance, aircraft flight conditions and store performance Navy requirements). Positive movement should be such that no portion of the item penetrates a predetermined interference boundary of the aircraft including remaining suspension equipment and stores. The interference boundary is defined by a six (6) inch encapsulation of the aircraft (in the immediate area where separation is occurring), the pylon, the ejection rack and any adjacent stores. Portions of the store being inside the boundary are prohibited from further encroachment. Once outside the boundary no part of the store may re-

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enter the boundary. In the vicinity of the aircraft empennage, the boundary is expanded to ten (10) feet minimum. Again, the store must maintain positive movement away from the aircraft. An acceptable separation also requires that the transient store motions do not unacceptably degrade the weapons ability to perform its mission.

b. Store-to-store collision: Store-to-store collision of armed stores resulting from multiple store releases, at any specified interval, is unsafe and totally unacceptable if the collisions occur while the aircraft is still within the lethal range of the ordnance (blast and shrapnel) effects.

271.5 Test procedure.

Test procedures should be contained in the detailed test plan. The plan should relate mandatory release sequences and missions. A number of techniques can be employed to combine tests and hence reduce the number of missions actually flown. For example, the assumption is often made that the airflow on one side of the aircraft is the mirror image of the flow on the opposite side of the aircraft. If loading configuration rules permit, two separate store configurations may be split in half and loaded half each on the two different sides of the aircraft. Since normally the initial release from one configuration must be reviewed before the subsequent release from that configuration, concurrent testing with the two configurations could reduce the number of missions required by half. This type of testing may, under certain circumstances, even be employed with multiple carriage stores. Multiple racks normally have an inherent release sequence which means that a multiple bomb racks load of bombs released from one side of the aircraft is not the mirror image of a multiple bomb racks load of bombs released from the other side. But cases occur where the point of interest may be release of stores from the multiple bomb racks in the presence of some other store or missile. By partially reversing the release sequence of one multiple bomb racks, a mirror image situation can be created. In a pairs release, stores could be released from one wing with the adjacent store present, and from the other wing with the adjacent store absent. With pairs release, the effects of the adjacent store is obvious. In the same manner, if there are two stores for which an analogy is assumed, pairs release can confirm or deny that analogy. When flying asymmetric configurations to reduce the overall number of flights required, attention must be paid to aircraft control surface deflections to achieve or maintain desired aircraft heading. Aircraft conditions may vary due to the asymmetric loading and give erroneous data.

a. Stores with fins that deploy after release (not retarders) should have the fin release wire hardwired to the aircraft to ensure the fins open. An arming solenoid should not be used for this function.

b. A practice that should be avoided is the use of the release or chase aircraft pilot to observe one release and then, based on his observation alone, clear a more rigorous release condition. Store motion is quick and will elude even a trained eye. Use of this procedure is especially dangerous in multiple releases as the observer simply cannot be expected to see what individual stores did for the second or so it takes them to be clear of the aircraft.

c. After each release mission, the amount of data review required will vary depending on the level of difficulty of the next release. It may, in many cases, be adequate to review the film to ensure no anomalies occurred. It may be necessary, however, in some cases to additionally inspect the test aircraft, suspension equipment and adjacent stores for signs of store contact. It may be necessary to have separation motion analytically determined from the film and compare these data to simulations. It may be necessary to test fire the rack or function the stores release system on the ground to isolate interval or ejector problems. It may be necessary to

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review in-flight release conditions in detail to determine if release problems were due to release at other than the desired condition.

d. After any release, it may be that safety of flight dictates a different subsequent release than the one planned. When making such changes, the entire test plan philosophy will probably have to be reviewed to ensure that insertion of a single new mission does not result in a wastefully small step to the originally planned subsequent mission.

e. The test pilot should be familiar with the normal aircraft response to release of stores of similar types. Such a person will be best able to evaluate the acceptability of release transients and verbalize the nature of those transients for subsequent reporting. The pilot should be pre-briefed on what to observe and expect during and after release.

f. Any store released from an aircraft could possibly strike the aircraft, causing physical damage to the aircraft, or aircraft loss; therefore, the test agency should have well thought out contingency plans for such events. Hung store contingency plans should also be prepared. Hazard/Safety Review Boards made up of engineering, operational and safety personnel should review all release tests prior to the first drop. The board should ensure that the authority to release stores (flight clearance) has been provided by a competent agency.

271.6 Test reporting.

Results of release tests should be included in whatever report is provided on the overall certification effort. All release test conditions, aircraft configurations, store, mass properties, reduced data and pilot comments should be formally documented in some form. Whether any or all of these data are provided to the certification agency is up to the specific agencies involved. If the separation tests resulted in information of general technical interest, then a technical report should be prepared. Distribution of this report would be to agencies outside the normal certification channels. Where unusual or complicated separation motion occurred, that should be depicted photographically or through sketches rather than by long, wordy, narratives.

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APPENDIX B

TEST 272

LAUNCH TEST OR WEAPONS SURVEY AND DEMONSTRATIONS (FOR THE ARMY)

272.1 Purpose.

Launch tests are conducted when the store to be employed separates from the aircraft primarily through the propulsion of a motor, rather than gravity or an ejection cartridge. Air-to-air and air-to-ground missiles and rockets are examples. That the store may be released and left to free fall for a short (approximately one second) time prior to motor ignition does not alter the classification. Launch tests are conducted to demonstrate that the store will safely and satisfactorily separate from the aircraft throughout the desired employment envelope. For the Army the term launch test encompasses more than just firing the rocket and the missile for safe separation. It encompassed the series of surveys and demonstration flight tests to evaluate and demonstrate the following:

a. Safe launch envelop for all missiles and rockets.

b. Missile/rocket system accuracy.

c. Boresight retention and accuracy.

d. Time line verification.

e. Safe level of gas concentration in the cockpit.

f. Safe noise level in the cockpit.

g. Engine will not stall and there is no adverse effect on the transmission system due to firing the missile/rockets in all firing modes including salvo mode.

272.2 Data requirements.

Data requirements are essentially as specified in 271.2 with a few additions and exceptions. Onboard cameras that view forward will be needed. Data systems will have to monitor and record, in addition to previously specified parameters, effects of motor thrust, levels of motor thrust, motor ignition times, plume pressure, temperature, and impingement on aircraft engine operation, control responses, external surfaces (corrosion, combustion product build-up), crew support systems (such as oxygen) and crew effects, including toxic gas measurement in the crew station(s).

272.3 Test preparation.

Test preparation consists of the same steps as for Test 271. In addition, when evaluating possible effects on the aircraft engine, there are analytic techniques that can be used to predict flight conditions or motor ignition times that minimize or maximize engine effects. As with some released stores, the effects of separation failure modes, such as autopilot failure or fin opening failures must be considered in formulating the test plan.

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272.3.1 Test articles.

Test articles should be of a similar mass and physical characteristics to the inventory item. The warhead should be replaced with an inert version or, if missile free-flight data are also being measured, the warhead may be replaced with a telemetered or recoverable instrumentation package. Guidance system may be replaced with ballast, with a preprogrammed control system, or the actual system may be needed, depending on test requirements and autopilot logic. Control surface alignment and actuator bias are factors which must be monitored to ensure missile aerodynamic characteristics are correct for the test conditions and represent the actual item.

272.3.2 Test equipment.

Equipment requirements are the same as for Test 271.

272.4 Acceptance criteria.

Criteria are the same as for Test 271. Additionally, unguided, multiple fired rockets should not collide with each other. Also, engine stall or operation transients should not occur.

272.5 Test procedures.

Procedures are the same as for Test 271. After any launch test, where live rocket motors are used, the aircraft should be inspected for blackening, build-up of combustion products, corrosion, pitting and damage from throat seal pieces.

272.6 Test reporting.

Reporting is the same as for Test 271. Pilot comments, instrument changes, and physical degradation due to firing the rocket motors should be included.

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APPENDIX B

TEST 273

GUN FIRING TEST

273.1 Purpose.

Gun firing tests are conducted to determine and evaluate the performance and verify the safety, reliability and maintainability of the aircraft/gun system combination throughout the operational requirements of the aircraft. This evaluation includes: the ammunition handling and loading/unloading methods; equipment and procedures; the installing and removal of the gun system; access for service, maintenance, and safety, and the safety features of the gun system for both ground and airborne operations. For the Army, this test also addresses the following:

a. Gun system accuracy.

b. Gas concentration and noise level in the cockpit.

c. Boresight accuracy and retention.

d. Bullet clearance from rotor blades and from aircraft surface.

273.2 Data requirements.

Factors, characteristics and effects generated by or for the gun system during gunfire that must be determined are specified below. In some cases, the data may be qualitative rather than quantitative and are so indicated.

a. Quantitative determination of gun gas concentrations in the gun and ammunition compartments and any other compartment susceptible to accumulating gun gas will be made at those flight conditions (combinations of speed, altitude, burst length, maneuvers performed) analyzed as being the most critical.

b. Qualitative evaluation by the pilot/crew members of any gun gas concentrations within the cockpit during firing bursts.

c. Engine ingestion of gun gas throughout the flight envelope and resulting temperature spikes, inlet pressure fluctuation or flameouts should be noted. Temperature and pressure fluctuations should be measured and will require corrective measures.

d. Measurement of vibrations and acoustic levels during gunfire within the cockpit and those aircraft compartments in the area of the gun and muzzle blast environment.

e. Blast overpressures and pattern on aircraft skin areas adjacent to the gun muzzle. Measurements should be from approximately twelve inches aft of the muzzle forward. The location where the muzzle blast hits the fuselage and/or adjacent stores should be reported as a function of aircraft velocity.

f. The recoil, counter-recoil and blast loads transmitted to the airframe during gunfire should be measured under varying conditions of inertia, velocity, and altitude. Structural adequacy will be determined from these actual measurements.

g. Qualitative evaluation, including movie pictures, of visibility during both night and day gunfiring. Such factors as flash, flame, smoke or residue to be evaluated for corrective action deemed necessary. None of these are desired although all may not be totally eliminated.

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h. Gun gas residue on aircraft skin and windscreen or canopy. Corrosion effects and visibility determination should be determined.

i. Gun control characteristics should be measured. Time to start and come up to speed after trigger is actuated and time to stop after trigger release will be measured. If applicable, clearing times after gunfire burst, clearing gun jams and reverse gun clearing cycles will be measured.

j. Safety evaluation of the complete gun system will be accomplished throughout the test. Safety features to prevent gunfire during ground operations, takeoff, landing and in flight should also be assessed, as well as the hazards of gun ejecta, including sabot, on the aircraft during normal operation.

k. Although separate reliability and maintainability tests may be employed, the gun system flight test program should log the maintenance actions and record the stoppages and malfunctions and the reason for same, for inclusion into the reliability and maintainability programs.

l. Verify that the aircraft gun system installation imposes no limitation on burst length under any and all flight conditions. If the installation dictates burst limitations, verify that the limiter will function in the event of system control failure.

m. Power required for control and operation of the gun system should be measured. Such characteristics as AC/DC voltage, amps and hydraulic or pneumatic pressures and flow should be measured.

n. Effects of gunfire and length of burst on aircraft stability, control and handling should be qualitatively determined. Inputs to the flight control system to offset these effects should be evaluated.

o. Accuracy and accuracy retention will be determined in conjunction with the gunsight system employed on the aircraft. Both air-to-air and air-to-ground accuracies in accordance with the aircraft system specification requirements will be evaluated. Boresight retention should be evaluated by frequent ground boresightings during the flight test program. Ground gun butt firing prior to and after flight qualification should be conducted to verify gun sight to mean impact point relationship.

p. Aircraft flight conditions including airspeed, altitude, dive angle, angle of attack, normal acceleration, and flight control positions should be recorded during firing.

q. Measurement of noise level in the cockpit.

273.3 Test preparation.

273.3.1 Test article.

The test article should be the final aircraft/gun system configuration. All normal aircraft equipment should be installed in functional condition. The performance characteristic of the installed engine(s) should be established prior to the gun firing test in order to evaluate effects of gun gas ingestion and power extraction. The use of non-representative equipment will jeopardize the results and thus the validity of the qualification program.

273.3.2 Test equipment.

A representative production aircraft configuration and gun system.

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273.3.3 Test conditions.

The gun system should be fired throughout the weapons firing envelope. Primary attention should be directed in the primary use envelope. Firing should be conducted at various engine power settings including idle. Testing should include the maximum allowable burst lengths.

273.3.4 Test instrumentation.

The measurement of physical effects of gunfire on structure and equipment will be accomplished using typical test equipment such as accelerometers, strain gauges, microphones and thermocouples. Maximum structural temperature in less critical structure and equipment will be obtained by temperature sensitive labels or other similar devices. Gun gas concentration in the gun bay should be measured by continuous read-out type instrumentation due to the transient nature of the data. Cockpit air samples should be taken during the periods of highest gas concentration for laboratory evaluation. Accuracy data should be obtained on a scoreable range in conjunction with ground tracking of aircraft to establish the aircraft conditions during firing. Typical flight test instrumentation should be used to establish aircraft flight and engine conditions for tests other than accuracy. Photochase, onboard camera, and the gun sight camera (if desired) should be used to record the effects of gunfire.

273.4 Acceptance criteria.

The system should perform within design limits under all conditions tested and should not adversely affect the aircrew or aircraft.

273.5 Test procedure.

A test plan should be written and approved by the procuring agency. The flight testing should proceed in confidence building steps beginning with basic data on gun gas concentration and cockpit conditions and progressing to more severe conditions throughout the envelope. All aircraft equipment should be operated during gunfire tests and their operation evaluated.

273.6 Test reporting.

The test report should document the test configuration, instrumentation, test condition, quantitative data, and qualitative evaluation.

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APPENDIX B

TEST 274

DISPENSE TEST

274.1 Purpose.

Dispense tests are conducted when, during normal employment, the payload of the store is freely or forcefully admitted into the airstream, but the basic store structure is retained with the aircraft. Submunitions, practice bombs, flares, chaff, liquid and dry agents, smoke, and sensors are examples of items that are normally dispensed from a store. Dispensing can occur forward or sideward, but is most commonly rearward or downward. Dispense tests are conducted to demonstrate that the material released, including its packaging, will safely and satisfactorily separate from the aircraft throughout the desired employment envelope. (NOTE: A cluster consists of a dispenser filled with material. Some clusters are released and open after release; some dispense the material while the dispenser itself remains attached to the aircraft. The latter type only is addressed in this section. The former are discussed under Test 271.)

274.2 Data requirements.

Data requirements for items dispensed may be similar to those in Test 271 if the dispensed item is large. The test agency must ensure that the physical, mass, and functional characteristics are representative of the inventory. For minuscule items such as chaff, or for powders or liquid, the actual material will probably have to be used. The physical characteristics of simulants, such as specific gravity and viscosity must be carefully matched to the actual material being simulated.

a. As with other types of employment tests, it is important to record aircraft flight conditions at dispensing. Dispensing tests may require that the flight condition be maintained for several seconds. Thus, variations in flight altitude or velocity will be noted, as this can distort impact pattern data. For dispensed items such as IR flares, decoys or chaff, it is likely that dispensing tests may occur during maneuvering flight and exact dispensing flight conditions will be difficult to ascertain without an instrumented aircraft.

b. Photographic documentation of dispensed material can pose problems as the material streaming out from behind the aircraft may be difficult to see by the chase photographer. As the material slows down relative to the aircraft, the photographer will have difficulty following it with the camera. Also, as the dispensed material spreads out, the photographer will have difficulty keeping it in frame. Finally, for items forcibly dispensed at high exit velocities, a high camera frame rate may be required to satisfactorily slow down the motion for later analysis. Frame rates in excess of 200 per second may be required to capture such motion, but this shortens the time that film coverage is available.

c. Rearward and downward dispensed materials have been observed to strike or contaminate wing, fuselage, or tail surfaces. It will be desirable to aim cameras to evaluate such events. It may also be necessary to dye or color coat the dispensed items or to put some sort of witness card or coating on areas of potential contamination or impingement to make detection of impact more positive.

d. Dispensers that forcibly eject items downward in varying intervals may excite structural frequencies at or near the natural structural frequencies of the aircraft wing. It may be necessary to instrument the aircraft with accelerometers to monitor wing response during dispensing tests.

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274.3 Test preparation.

The preparation of a dispense test will be similar to Test 271, outlined earlier. During formulation of the test plan, there are additional factors that should be considered when determining how to proceed through envelope demonstration. For submunitions of changing mass or shape, such as flares or chaff, it may be necessary to initiate testing with a dummy of fixed shape and mass and then proceed to the actual item (which ultimately would have to be tested). For dispensers that forcibly downward eject submunitions of a variety of weights, it may be desirable to test the heaviest last since the heavy item will probably generate the highest reaction force and the lowest separation velocity. For rearward dispensed items of various weights, it may be desirable to dispense the lightest last since it is more likely to be perturbed by the airflow about the aircraft, and therefore more likely to strike the aircraft. The test planner should reflect on the effects of a failure of a dispenser ejection system to ensure that such a failure will not cause the item to strike the aircraft.

274.3.1 Test article.

Guidance provided under Test 271 on test items is applicable except that it may be an unnecessary (and monumental) task to verify each and every item dispensed. Also, as noted in 274.2, items may have to be painted, dyed, or color coated to positively detect aircraft impacts or impingement. Extreme care should be taken with dispense test of flares, particularly with pyrophoric type flares which burn instantaneously on contact with oxygen, since tests of inerted items are not normally possible.

274.3.2 Test equipment.

Same as Test 271. Instrumentation may be needed to monitor dispenser reaction loads and/or aircraft structure response.

274.3.3 Test conditions.

Same as Test 271.

274.4 Acceptance criteria.

The items or material dispensed should not strike or narrowly miss (such that a repeat of the test might result in hit) the aircraft. Items with fuzes, explosives, damageable electronics or damageable external shape should not bump into each other. Items that function (deploy chute or retarder) should be in a proper orientation so as not to defeat that function. Dispensed items should not disintegrate or fail structurally. Aircraft responses, in the judgment of the test pilot, should be acceptable.

274.5 Test procedure.

The guidance provided in Test 271 is basically applicable to dispense tests. One special area of concern in dispense tests is the determination of hung or undispensed submunitions. Few aircraft have a competent stores management system to determine if the dispenser has completely expended its payload. Submunitions or items not dispensed can fall out at any time, but a common event is to have items fall from an ejecting dispenser when the aircraft touches down for landing. For safety of flight and landing, it may be desirable to selectively jettison functioned dispensers as soon as permissible although knowledge on dispenser reliability and failure modes may be lost. Jettison may also be desirable since empty dispensers often exhibit

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cavity resonances (acoustic vibrations) that will unduly vibrate the aircraft or slowly destroy the empty dispenser while still on the aircraft (see Test 280.)

274.6 Test reporting.

Same as for Test 271.

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APPENDIX B

TEST 280

JETTISON TEST

280.1 Purpose.

Internal/external stores are jettisoned to rid the aircraft of their weight, drag, or other undesirable characteristics. Virtually any type of store may be jettisoned, but typical examples are fuel tanks and empty dispensers. Jettison may occur in an emergency to improve aircraft survivability or just to avoid the carriage of an item of questionable value and safety. Since the jettison of stores is not always a preplanned event, the speed limits to which a store may be jettisoned should be as wide as possible. Jettison is normally done in straight and level flight, but there are exceptions. Munitions are normally jettisoned safe. Jettison of empty dispensers may be desirable to reduce acoustic vibrations generated by dispenser cavity resonances.

a. There are two modes of jettison: selective and emergency. Selective jettison consists of the elimination of some part of the stores and suspension equipment (excluding pylons). Emergency jettison constitutes the elimination of all stores and suspension equipment (including pylons on some aircraft), usually in a preset sequence. Under each of these cases, there may be an option to release just stores, then failing that, stores and suspension equipment, and, on some aircraft, the pylons. Selection of the options may be made by the pilot or built into the stores management set.

b. Jettison of stores, suspension equipment and, if applicable, pylons, are usually done forcefully. In jettison, missiles may be launched safe, allowed to fall off their launcher, or, on some aircraft, released as a missile/launcher combination. Jettison tests are also conducted to demonstrate that the store and/or suspension equipment and pylon, as applicable, will safely separate from the aircraft throughout the desired jettison envelope.

280.2 Data requirements.

Data are taken to ensure the items released represent the inventory, to ensure the desired jettison conditions are demonstrated, to document the item jettison characteristics, and to allow comparison of flight jettison motion with that predicted during simulation.

a. To ensure the test items represent the inventory, it will be desirable to measure the mass and physical characteristics of the item jettisoned. If this is a single store, proceed as in Test 271. However, if a store/rack, store/pylon, or other configuration of items is to be jettisoned, the mass and physical characteristics of those combinations will be determined. The mass properties of individual pieces may have to be summed to estimate the mass properties of the combination; however, it would be more desirable for actual measurements to be made. The mass and physical properties of table III in Test 271 will be of interest as well as the location of stores on the rack, if a rack jettison is planned. If fuel tanks are jettisoned, it will be desirable to note quantity and location (compartment) of fuel. It will also be desirable to have fuel seepage rate if fuel tends to slowly leak into other compartments of the tank. Finally, some fuel tanks, multiple ejector racks, and pylons have a pivot mechanism of some sort to control initial jettison motion of the item. These pivots can employ various ways of adjusting the amount of rotation or translation allowed before release finally occurs. Details of these adjustments will be critical to the orderly understanding of test results.

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b. Determination of additional data requirements (conditions, characteristics, and comparisons) are as outlined in Test 271 except that the test agency must keep in mind that the requirements pertain to the item jettisoned, not necessarily just the store involved.

280.3 Test preparation.

Preparation is essentially similar to that of Test 271. The desired jettison envelope usually consists of a speed range at 1 g in level flight. The speed range should be as broad as possible, consistent with flight safety, so that the operational pilot is not driven to unreasonable extremes or a single airspeed to jettison. Desirable speed ranges encompass take-off speed through maximum speed for which carriage of the stores is intended. For rotary wing aircraft, jettison should be accomplished during worst case autorotative, sideward and rearward flight.

a. For single carriage stable stores, the employment (release) envelope may be virtually identical in airspeed to the desired jettison envelope. However, jettison is often accomplished at flight conditions where employment is not normally done, such as high altitude, low speed or low altitude, high speed, and hence, even for a single carriage store, the employment tests may not demonstrate the entire envelope desired for jettison. Test plans should reflect these differences.

b. The jettison test plan will probably not include all the variables in Test 271, but consideration must be given to more than speed. Jettison sequence and interval between stations can be a large factor in determining whether jettisoned stores collide below the aircraft. For items of variable cg such as partially loaded dispensers, fuel tanks, and multiple ejector racks with hung stores or partial downloads, a careful analysis will have to be made to select representative cases and avoid testing all possible situations over the speed range.

c. Any store with folding fins that is jettisonable as a store should have its fin release wire hardwired to the aircraft. An arming solenoid should not be used for this function since, during jettison, the arming solenoids will not be activated and the fins will not open, resulting in a potentially dangerous separation.

280.3.1 Test articles.

Normally multiple ejector racks, practice bomb racks, and pylons will be inventory items since small numbers are involved and it would be impractical to develop and procure a "ballasted" version. However, it may be possible to use condemned but structurally sound hardware to minimize lost equipment. Stores used should be selected in accordance with Test 271.

280.3.2 Test equipment.

See Test 271.

280.3.3 Test conditions.

Test conditions should be chosen to demonstrate safe separation throughout the entire jettison envelope. Critical test conditions for jettison may include maximum airspeed (maximum dynamic pressure), maximum Mach number, minimum g, minimum release interval, maximum aircraft angle of attack for which carriage of the stores is intended, jettison during autorotation or sideslip, or others as specifically related to the test item. Test conditions should be held to tolerances as suggested in table B-III, Test 271.

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280.4 Acceptance criteria.

Separation should be safe, but need not be satisfactory. In emergency cases, minor store-to-store or store-to-aircraft contact may be acceptable. For normal, non-emergency cases, however, store-to-aircraft contact is unacceptable. Aircraft response should be noted, but, unless severe, should not prohibit jettison. Items jettisoned may break up or otherwise fail after release as long as such break-up does not threaten the aircraft.

280.5 Test procedure.

Procedures are as discussed in Test 271. Items released in jettison tests often possess center-of-gravity position, aerodynamic shape or other characteristics that would be undesirable from a separation viewpoint. Separation predictions are often incorrect due to an inability to accurately predict aerodynamic or mass characteristics. Therefore, some jettison tests may be considered as high risk. Jettison tests should undergo appropriate safety review and then the degree of risk (low, medium, high) inherent to that test assessed.

280.6 Test reporting.

See Test 271.

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APPENDIX B

290 SERIES TESTS

BALLISTICS TESTS

290.1 Purpose.

An integral part of certification of a weapon for carriage and release from an aircraft is the assurance that the weapon, when employed, will hit the target by providing the user with weapon delivery mission planning data as well as the ballistic and/or in-range/shoot-cue algorithms, respectively, for both ballistic and guided weapons for inclusion in the aircraft operational flight program (OFP). The weapon's accuracy and ballistic/guided flight path must analyzed and release data prepared to provide the aircraft flight crew with weapon release system settings and delivery procedures for various flight conditions. This test defines the data requirements needed for collecting and reducing the weapon test data in order to model the ballistics and/or guidance and control system of the weapon and defines the ballistic accuracy verification process. Each new aircraft-store configuration should be evaluated using the following general guidelines:

a. Weapon Free-stream ballistics Test (Test 291). In instances where baseline aircraft independent ballistics have not been established for the weapon, they are to be determined and modeled. This modeling will include the freestream drag coefficient, dispersion characteristics and event times for the weapon, independent of the aircraft. The data will normally be obtained during weapon DT&E. Every effort should be made to ensure that any data obtained from this test is used to reduce the number of sorties required for later ballistic tests. Therefore, the data requirements and ballistic data reduction for Tests 292, 293, and 294 should be included with the requirements for Test 291. Accurate modeling of the weapon free-stream ballistics is essential since an error in this model could falsely indicate a need to conduct separation effects derivation testing.

b. Aircraft/Weapon Ballistic Accuracy Verification Tests. Due to the extent of the testing required to adequately verify aircraft/weapon ballistic accuracy, the using command should clearly identify to the certifying agency the specific aircraft/weapon configurations requiring verification and OFP optimization in addition to clearly defining the accuracy acceptance criteria. The ballistic accuracy verification process consists of three phases:

(1) Operational Flight Program (OFP) Ballistics Evaluation Test (Test 292): The objective of this test is to evaluate the initial accuracy of the OFP ballistic algorithms. The ballistics of the OFP during this phase should consist of the free-stream ballistics of the weapon. If available, separation effects gathered by analogy with a similar store, or from wind tunnel tests, will be incorporated to the maximum extent possible. The evaluation of the ballistics includes a CEP test and a range bias test. If both CEP and range bias evaluations meet the acceptance criteria, then the ballistic accuracy of the OFP for the particular aircraft/weapon configuration will have been verified and Tests 293 and 294 will not be required. For guided weapons, in-range/shoot cue algorithms and/or release envelopes should be evaluated for inclusion in the aircraft OFP.

(2) Separation Effects Derivation Test (Test 293): The objective of this test is to derive the separation effects coefficients for the preferred aircraft-store configurations. Separation effects models account for the motion of the weapon from the moment it is released until all oscillations caused by the aircraft flowfield are damped. Separation effects are currently modeled as a function of release variables such as Mach number, normal acceleration, angle of

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attack, and dynamic pressure. These coefficients will be used to compensate for separation effects and may be incorporated into the Ballistic Tables and/or into a separation effects algorithm in the aircraft ballistic OFP. The coefficients used in the separation effect algorithm may result in aircraft velocity adjustments used in the air-to-surface trajectory calculations or may cause incorporation of changes in the mode of trajectory calculation. A thorough understanding of the aircraft and the weapon system being tested as well as the intended use of the weapon is paramount in designing a successful test matrix.

(3) OFP Ballistic Verification Test (Test 294): The objective of this test is to verify the ballistic accuracy of the OFP. The ballistics at this point in the process consist of both the freestream drag curves and the derived separation effect coefficients. The ballistic accuracy verification phase is identical to that performed in the OFP ballistic evaluation phase (Test 292). A CEP and range bias evaluation are performed and compared to the acceptance criteria.

In determining the bombing accuracy of an aircraft weapon system, one of the most important decisions that must be made is the number of weapons to be dropped in each configuration. Enough weapons should be dropped to ensure the data obtained is statistically significant. The process of refining the aircraft ballistics OFP can continue until the acceptance criteria is achieved or until the user accepts the results, accepts an aimpoint offset, or cancels the requirement for that configuration.

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APPENDIX B

TEST 291

WEAPON FREESTREAM BALLISTICS TEST

291.1 Purpose.

The purpose of this test is to determine the freestream path from the time the weapon reaches steady state flight until impact and is independent of the aircraft and the delivery mode. The model will include a reference weight, diameter and drag function and will define event times.

291.2 Data requirements.

The following data should be recorded:

a. Onboard, ground and/or photochase aircraft high speed time tagged motion picture cameras or a video equivalent.

b. Time-space-position information (TSPI) on the aircraft and munition by cinetheodolites operating at no less than 20 frames/samples per second, providing the following coverage:

(1) Of the aircraft from a minimum of three (3) seconds before release (T-3) to release (T-0) and from release to as long after release as the aircraft appears on the film of the cinetheodolites tracking the munition.

(2) Of the munition from release (T-0) to cluster/dispenser opening, fuze function, impact, or similar event.

(3) For tests on which munition-aircraft separation throughout the trajectory is required, the aircraft may be tracked by radar or laser with data samples taken from a minimum of three (3) seconds before release (T-3) to munition impact.

c. The time of munition separation from the aircraft is available from the following data sources:

(1) The actual times of separation of the munition from the rack as follows (in order of preference):

(a) Onboard cameras with IRIG time.

(b) By medium speed tracking cameras operating at 96 frames per second or greater with IRIG A time to ± 5 millisecond accuracy with flash instrumentation installed on each store/rack combination to assist in capturing first store motion.

(c) By means of instrumentation installed on racks which either transmit the data to be recorded by ground telemetry systems, or record it by a magnetic tape recorder on the rack with IRIG B time.

(d) By IRIG-correlated ground tracking, including cinetheodolites or high-speed ground cameras without aircraft flash instrumentation to ± 16.7 millisecond accuracy.

(2) Release initiation by the pilot from the aircraft UHF tone, to within 100 millisecond accuracy for standard tones due to transmitter and receiver triggering delays, and to ± 5 milliseconds accuracy for 150 millisecond tones. This tone instrumentation is a less desirable alternate to the telemetry and photographic instrumentation described in 291.2.c(1) above, and will not be used as a primary source of munitions separation time data unless data from other more suitable instrumentation are not available.

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d. Any special event times such as fins opening, chute deployment, munition functioning, and/or impact. These data can be recorded by the instrumentation described in 291.2.c(1)(a) and/or (b). Thirty-five millimeter film will be used to record these data. Color film should also be used to record events where color contrast is an important factor in facilitating the detection and recording of their occurrence; otherwise, black and white film will be used. For events requiring timing accuracies higher than those specified above (i.e., 1 millisecond or higher), 16mm cameras operating at frame rates of 1000 frames per second or higher and with color or black and white film as specified above and IRIG A time may be required.

e. Impact times, velocities, and angles of submunitions or a munition too small to be tracked by cinetheodolites or the tracking cameras as described above. These data may be collected by CZR-1, fixed Milliken, or similar grid cameras, with film and IRIG time.

f. Munition fuze function heights (if required):

(1) For function heights from approximately 500 to 4000 feet, to approximately ± 10 feet accuracy, using cinetheodolites and medium speed tracking cameras (96 frames per second frame rate) and 35mm with IRIG A time and the function point projected vertically to the range surface. This method is used primarily for determining the fuze function heights of clusters or submunition dispensers, the function of which is readily apparent on film due to the size of the test item and the ready detection of its opening on film.

(2) For function heights from approximately 10 to 500 feet, to approximately ± one foot accuracy, using cinetheodolites and 16mm high speed cameras (1000 frames per second frame rate, black and white film and IRIG A time), and a flag of known height at the impact points to be photographed post-impact by the cinetheodolites.

(3) For function heights of four inches up to ten feet, to accuracies of approximately ± six to three inches using 16mm film high speed cameras operating at 2000 to 4000 frames per second with color film and IRIG A time. These cameras are mounted on MK-51 mounts modified to cause these cameras to track in azimuth only. Suitable lenses as necessary to provide the required vertical munition terminal trajectory coverage will be used. Up to two, 2' x 8' x 1/2" colored fuze function height reference panels are located post-impact at the impact points and photographed by these cameras.

(4) If the fuze function is not clearly apparent on the film (i.e., as apparent as in the case of a dispenser), the munition must be modified to provide a clear manifestation of the fuze function either by the installation of instrumentation, such as strobe lights for camera frame munitions drilled to permit the fuze function explosion products to be evidenced outside the munition, or the equivalent.

g. Munition or submunition impact and scoring data:

(1) For a large munition (excluding submunitions), scoring by polar coordinates orientated to the target and to the flight line downrange of the target.

(2) For submunitions and other munitions as released on grids, separated by item types or dispensers from which released, to provide pattern data:

(a) Standard grid coordinate scoring, for either the submunition initial or final impact locations. Scoring by initial impact locations may not be practical if the submunitions do not possess sufficient velocity to dent the grid surface.

(b) Number of items located.

(c) Number of duds.

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h. The following data will be furnished to the analyst:

(1) Aircraft.

(a) Aircraft type (model/version and serial/bureau number).

(b) Aircraft/rack station associated with each pass for weapons that were released.

(c) Complete aircraft loadout.

(2) Weapon data.

(a) Weapon nomenclature (include if live or inert).

(b) Weapon weight, center of gravity (cg), and moments of inertia associated with each pass for weapons that were released.

(c) Fuze type (if applicable).

(d) Fuze time or altitude and RPM setting (if applicable).

(3) Rack data.

(a) Rack type.

(b) Orifice settings.

(c) Cartridge.

(d) Estimated ejection velocity of the store.

i. Meteorological data as follows:

(1) Atmospheric properties data such as temperature, density, wind velocity, and direction are obtained from standard base upper air (Rawinsonde or Rocketsonde) observations.

(2) Wind direction and velocity using a pilot balloon (PIBAL) data. These data are required at altitudes from the surface to 3000 feet at 500-foot increments, and from 3000 feet at 1000-foot increments, to 1000 feet above the release altitude (to a maximum of 15,000 feet), within 30 minutes of the munition release time, in the vicinity of the release area. The PIBAL should be tracked by range cinetheodolites. These cinetheodolites will operate at 10 frames per second, recording data with IRIG time in bursts of approximately five (5) seconds each at one-half minute intervals. The cinetheodolite and PIBAL data will be integrated by the data reduction facility into the final reduced ballistics data printouts and magnetic tape. Printouts of these wind data will also be provided separately to the analyst. For altitudes of over 15,000 feet, the wind data from the standard daily Rawinsonde observations closest in time to the munition release time will be used and integrated into the ballistics data printouts and magnetic tape. For certain tests, special Rawinsonde missions at times closer to the mission time will be scheduled and their data used for this purpose.

291.3 Test preparation.

291.3.1 Test article.

Each munition dropped for ballistics test purposes must possess the exact aerodynamic, geometric, and mass properties of the actual munition (see Test 271, table B-I). The munition may be live, but are generally inert for testing purposes. If the store is a dispensing munition, it must have a live fuze, however, the submunitions may be inert. Painting the munition to

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enhance or facilitate optical tracking may be required. If so, the exact paint scheme should be decided upon in consultation with the test range operators.

291.3.2 Test equipment.

a. Test aircraft with an event recorder to obtain store release information and onboard cameras orientated to view store separation.

b. Photochase aircraft (optional).

c. Meteorological measurement equipment.

d. Optional tracking radar or laser.

291.3.3 Test instrumentation.

a. Cinetheodolite cameras or equivalent.

b. Time correlated ground tracking cameras operating at 96 frames per second or higher.

c. CZR, fixed Milliken, overhead scoring aircraft, or similar grid cameras, as required.

d. Facility to obtain weight, center of gravity, and moments of inertia of test munitions.

291.3.4 Test conditions.

Test conditions to obtain aircraft independent ballistic data normally include several airspeeds and altitudes. Determination of the conditions required for a particular munition should be coordinated with personnel responsible for ballistics for the service having primary recognizance of the weapon. A thorough understanding of the aircraft and a weapon system being tested as well as the intended use of the weapon is paramount in designing a successful test matrix. Test conditions should be contained in the detailed test plan.

291.4 Acceptance criteria.

All data gathered should be compared to the requirements specified above to ensure their usefulness. Data which is obtained outside the specified tolerances should not be used. Every reasonable effort should be made to acquire data to the tolerances specified above. There are times, however, when requirements of an overall test may dictate certain parameters that result in out-of-tolerance data. If this occurs, a determination will be made as to the adequacy of the data to perform the analysis.

291.5..Test procedures.

Prior to any drops, the atmospheric conditions in the vicinity of the test range are to be determined. MIL-B-81006 should be employed to minimize the number of drops required to demonstrate that dispersion requirements are met. The following test procedures should be included in the detailed test plan:

a. The pilot must maintain a stable wings level flight at weapon release.

b. Onboard, ground and/or photochase motion picture coverage should be used to document munition separation events on each air drop.

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c. The test aircrew will record the following aircraft conditions at the time of each munition release event: airspeed, pressure altitude, angle of attack, normal load factor, and, if applicable, wing sweep. The test aircrew should also record their assessment of weapon impact point relative to aim point and some other fixed reference point on the range. (This data can then be used later by data analysts to verify range test data.)

291.6 Test reporting.

291.6.1 General.

Results of the analysis of the test data will be reported as requested by the certifiying agency responsible for the aircraft.

291.6.2 Ballistics data reduction.

All ballistic data should be reduced as follows:

a. Cinetheodolite and radar data:

(1) Printouts in accordance with the appropriate programs, either uncorrected or corrected, for atmospheric conditions. The following data (title page and data format and parameters) are to be obtained from computer programs.

(a) Time phasing and printout intervals:

1 For the aircraft, from three seconds prior to release to two seconds after release (extrapolated from the available TSPI data); or, when aircraft-munition separation data are required, from the radar TSPI to the times of impact, fuze function, cluster opening, or similar events.

2 For the munition, from release to dispenser function, impact, or similar event.

3 Printouts will be at 0.2 second intervals or at other intervals as mutually agreed on by the test project officer and analyst and at specified special event times.

(b) Format (see table B-IV for definitions):

1 Title page should be in accordance with table B-V.

2 Data. Printouts should be in accordance with table B-VI.

(2) In the reduction of smoothed data:

(a) The line of flight (direction of the downrange axis) will be the aircraft track at 0.0 time.

(b) The origin of the coordinate system will be the target. If the origin must be something other than the target, it must be mutually agreed on by the test project officer, range personnel, and, most importantly, the analyst.

b. Munitions event identification. These events may be recorded by cinetheodolites, medium and high speed cameras, recorders installed in the munitions, transmitted to a ground telemetry station from telemetry transmitters installed in the munitions, or similar instrumentations. Examples of these events are fin opening, control surface operations (up, down), cluster or chute start and complete opening, and fuze arm and function, as specified and as available from the data. The TSPI printouts will be annotated to indicate such events on request.

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TABLE B-IV. Ballistic data definitions.

NAME	UNITS	PARAMETER – EQUATION (IF APPLICABLE)
TIME	H M S	TIME OF DAY IN HOURS, MINUTES, SECONDS
T-FREZ	SEC	TIME FROM FREEZE IN SECONDS
X, Y, Z	FEET	X COORDINATE (X IS HORIZ ALONG FLT LINE); Y IS VERTICAL, + UP; Z IS HORIZ 90 DEG CLOCKWISE FROM +X)
		FOR THE NAVY: Y IS HORIZ AND Z IS UP
HT	FEET	HEIGHT ABOVE SEA LEVEL
SR	FEET	SLANT RANGE =SQRT (X**2 = + Y**2 + Z**2)
GR RNG	FEET	GROUND RANGE = SQRT (X**2 + Z**2)
D PP	FEET	DISTANCE IN PROBLEM PLANE = SQRT (X**2 + Y**2)
RN, RE	FEET	RANGE NORTH; RANGE EAST
LAT, LONG	DMS	LATITUDE AND LONGITUDE IN DEGREES, MINUTES, SECONDS
VX	F/S	X VELOCITY – DIRECTION OF A/C
VY	F/S	Y VELOCITY – VERTICAL UP POSITIVE
VZ	F/S	Z VELOCITY – CROSS CLOCKWISE FROM X
VN, VE	F/S	NORTHWARD AND EASTWARD VELOCITY COMPONENTS
VT	F/S	TOTAL VELOCITY = SQRT (VX**2 + VY**2 + VZ**2)
VA	F/S	TOTAL VELOCITY IN AIR MASS = SQRT (VWX**2 + VY**2 + VWZ**2)
VG	F/S	GROUND VELOCITY = SQRT (VX**2 + VZ**2)
VWX	F/S	X VELOCITY WITH RESPECT TO AIR MASS = VX – WX
VWZ	F/S	Z VELOCITY WITH RESPECT TO AIR MASS = VZ – WZ
M	---	MACH NUMBER = VAVS
AX, AY, AZ	F/S/S	X, Y, AND Z ACCELERATION
A	F/S/S	ACCEL MAGNITIDE = SQRT (AX**2 + AY**2 + AZ**2)
LOCALG	F/S/S	VALUE OF GRAVITY FOR EACH SPECIFIC LOCATION
A	G	ACCEL MAGNITUDE = AM/(LOCALG/(1 + HT/RAD)**2)
AN G	G	NORMAL ACCEL = SQRT (VY*AX – VWZ*(AY + G)**2 + (AX*VWZ – AZ*VWX)**2 + (VWX*(AY+G)-VY*AX)**2)/(LOCALG*VA)
AD	F/S/S	ACCEL DUE TO DRAG = (AX*VWX + (AY + G)*VY + AZ*VWZ)/VA

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TABLE B-IV. Ballistic data definitions. - Continued

NAME	UNITS	PARAMETER – EQUATION (IF APPLICABLE)
CD	---	DRAG COEFFICIENT = - 4AD/(PI*Q*GAMMA*G)
WX, WZ	F/S	WIND VELOCITY (X AND Z COMPONENT)
P	I	N HG PRESSURE (INCHES MERCURY) = .029536*P (MILLIBARS)
VS	F/S	SPEED OF SOUND = 1116.89*SORT((T(C) + 273.16)/288.16)
Q	LB/FT2	DYNAMIC PRESSURE = 49.511 * P * M **2
HV	DEGREES	TRACK FROM NORTH = ARCTAN(VZ/VX) + FLT LINE (0 TO 360)
HVA	DEGREES	HEADING FROM NORTH = ARCTAN(VWZ/VWX) + FLT LINE (0 TO 360)
DA GR	DEGREES	DIVE ANGLE = ARCTAN(VY/VG)(-180 TO +180)
DA AIR	DEGREES	DIVE ANGLE = ARCTAN(VY/SQRT (VWX**2 + VW2**2))) (-180 TO + 180)
KD	----	DRAG COEFFICIENT (BALLISTICS) = .3927 * CD
POS ER	FEET	ERROR IN POSITION DUE TO NOISE
GAMMA	FT2/LB	(WEAPON DIAMETER)**2/WEAPON WEIGHT
XA, YA, ZA	FEET	AIRCRAFT X, Y, AND Z COORDINATE OFFSET FROM FILM READING COORDINATES TO SOME OTHER AIRCRAFT REFERENCE POINT
ANGLE OF ROTATION	DEGREES	AXIS TO A/C TRACK AT WEAPON RELEASE IN GROUND PLANE
NO PT SMO	----	NUMBER OF POINTS USED IN SMOOTHING ROUTINE
DEG		DEGREE OF POLYNOMIAL THAT TSPI DATA IS SMOOTHED TO
DOWN RANGE MISS DIST	FT	DIFFERENCE BETWEEN AIMPOINT (AT DESIGNATED REF TO TGT) AND WEAPON IMPACT (REF TO TGT) IN ALONG TRACK
CROSS RANGE MISS DIST	FT	DIFFERENCE BETWEEN AIMPOINT AND WEAPON GROUND IMPACT IN THE CROSS RACK COORDINATES

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c. CZR-1 and Milliken camera data. Submunitions impact velocities and angles and times of individual impacts (correlated to scored impact if possible) will be transmitted to the analyst.

d. Impact data:

(1) For all munitions:

(a) Plots of impact data, specifying the location of each munition (or submunition) of each release. For submunitions, these plots should be the initial and final impact patterns and each item will be identified by dispenser or cluster, and type. Annotate these plots with the line of flight, the release point, and other parameters, and/or information as requested by the test project officer or analyst.

(b) Tabulate the locations of each munition or submunition with respect to the established coordinate system. For submunitions, each item will be identified by dispenser or cluster and type.

(2) For submunitions, compute impact pattern statistical data (MPI, CEP, 80% or 90% ellipses, Sigma X, Sigma Y) and similar parameters as requested by analyst.

TABLE B-V. Ballistic data title page format.

Line 1: TEST NO. DATE MSN NO. PASS NO. A/C/ITEM A/C TYPE/TAIL NO.
Line 2: BLANK
Line 3: ID NO PT SMO DEG
Line 4: INPUT ORIGIN LAT LONG HT FLT LINE
Line 5: XA YA ZA ANGLE OF ROTATION
Line 6: OUTPUT LAT LONG HT FLT LINE
Line 7: T-ZERO SOURCE OF T-ZERO (i.e., aircraft UHF tone, medium speed (96 fps) cameras, cinetheodolites, or aircraft rack instrumentation)
Line 8 GAMMA

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TABLE B-VI. Ballistic data printout format.

PAGE 1	ZULU TIME T-FREZ X Y Z VX VY VZ HT
PAGE 2	T-FREZ VT VA VWX VWZ WX WZ HT POSER
PAGE 3	T-FREZ AN G AD M KD CD DA GR DA AIR HT
PAGE 4	T-FREZ AX AY AZ HV HVA Q HT SR
PAGE 5	DOWN RANGE MISS DISTANCE CROSSRANGE MISS DISTANCE MPI STANDARD DEVIATION CEP

291.6.3 Data base support.

a. Air Force Munition Data Base Support. All Air Force data obtained by modeling the munition (drag coefficient, event times, separation effects coefficients) should be forwarded to: Air Force SEEK EAGLE Office, 207 West D Ave., Eglin AFB FL 32542-5417, for inclusion in their munitions data base.

b. Navy Munition Data Base Support. All Navy data obtained by modeling the munition (drag coefficients, event times, separation effects coefficients, etc.) should be forwarded to: NAWCAD, Code 4.11.2, Mailstop 3, Hangar 201, Patuxent River, MD 20670-1906 for inclusion in their munitions database. Any other documented data from other services are also requested.

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TEST 292

OPERATIONAL FLIGHT PROGRAM (OFP) BALLISTICS EVALUATION TEST

292.1 Purpose.

The purpose of this test is to evaluate the initial weapon ballistic accuracy of the aircraft OFP algorithms. The evaluation of the ballistics also includes a CEP test and a range bias test.

292.2 Data requirements.

Although this test does not require the collection of all the data required for Test 291, this test should obtain all the data required for Test 291 and that required for this test. This data can be used to increase the sample size for Test 291 as well as for Test 293. The data requirements are as specified in 291.2 with additional data as follows:

a. Information obtained from an onboard data acquisition system (such as PDAS) or equivalent printout.

b. Head up display (HUD) video tape.

c. The following data will be furnished to the analyst (Some of this aircraft release condition data will be obtained from the PDAS or equivalent printout and HUD video tape):

(1) Aircraft type (model/version and serial/bureau number).

(2) Aircraft/rack station associated with each pass for weapons that were released.

(3) Complete aircraft loadout.

(4) Aircraft release conditions:

(a) Altitude.

(b) Airspeed and Mach number.

(c) Flight path angle.

(d) Slant range to target.

(e) OFP software version for aircraft and store (very important).

(f) Pilot aimpoint at designation (referenced to target).

(g) g's (load factor).

(h) Angle of attack.

(i) Heading.

d. Estimated elapsed time from firing pulse command to first movement of store.

292.3 Test preparation.

292.3.1 Test article.

As specified in 291.3.1

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292.3.2 Test equipment.

The test equipment specified in 291.3.2 is highly desirable. The test aircraft OFP ballistics during this test should consist of the free-stream ballistics of the weapon. If available, separation effects gathered by analogy with a similar store, or from wind tunnel tests, will be incorporated to the maximum extent possible in the OFP ballistics.

292.3.3 Test instrumentation.

The test instrumentation specified in 291.3.3.a, b and c is desirable while d is essential.

292.3.4 Test conditions.

In general, test conditions will be those dictated by the specific munition loading configurations and delivery envelope required for the aircraft/weapon configuration being evaluated. In each instance, the required loading configurations delivery conditions to be optimized and desired accuracy should be specified by the user through the certification agency. The release conditions should include the extremes of altitude, airspeed, dive or loft angle, and g's in the delivery envelope, and several intermediate conditions.

292.4 Acceptance criteria.

As specified in 291.4. If both CEP and range bias evaluations meet the user specified acceptance criteria, then the ballistic accuracy of the OFP for the particular aircraft/weapon configuration will have been verified and Tests 293 and 294 will not be required. However, if either criteria is not met, it must be determined whether the problem is in the aircraft OFP algorithm, the avionics, or the ballistics. If the problem is within the OFP algorithm or the avionics, it must be determined whether it can be corrected. If it can be corrected, Test 292 may be reflown after the appropriate corrections are made. If the weapon separation effects are suspected to be the significant error source, then Test 293 must be conducted to derive the required separation effects coefficients. If Test 293 and the analysis thereof cannot be achieved in a reasonable time, then the certification agency may consider using the existing OFP and aimpoint offsets determined during the analysis.

292.5 Test procedures.

As specified in 291.5 with the following additions:

a. The test A/C must have a valid boresight and be footprinted to measure any system biases.

b. In-flight system checks must be performed during each mission to ensure that radar ranging, INS drift, and accelerometer errors are all within tolerances.

292.6 Test reporting.

292.6.1 General.

Results of the analysis of the test data will be reported as requested by the certifying agency responsible for the aircraft. If the certifying agency requests aimpoint offsets be supplied for specific delivery conditions then the report should clearly define and show exactly the sign conventions used.

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292.6.2 Ballistics data reduction.

As specified in 291.6.2 with the data shown in table B-VII.

TABLE B-VII. Data for OFP ballistic evaluation and verification tests.

DOWN RANGE MISS DISTANCE
CROSS RANGE MISS DISTANCE
AIRCRAFT RELEASE CONDITIONS:
ALTITUDE (AGL AND MSL)
AIRSPEED AND MACH NUMBER
FLIGHT PATH ANGLE
SLANT RANGE TO TARGET
PILOTS AIMPOINT AT DESIGNATION RELATIVE TO TARGET
G's (LOAD FACTOR)
ANGLE OF ATTACK (OR EQUIVALENT)
HEADING (MAGNETIC AND TRUE)

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APPENDIX B

TEST 293

SEPARATION EFFECTS DERIVATION TEST

293.1 Purpose.

The purpose of this test is to derive the separation effects coefficients for each specific aircraft/store configuration. Separation effects models account for the motion of the weapon from the moment it is released until it clears the turbulent air around the aircraft (i.e. reaches steady state flight). Separation effects should not account for avionic hardware or software deficiencies pressure. Current implementation of Separations effects average the aircraft station to station differences and are currently modeled as a function of release variables such as Mach number, normal acceleration, angle of attack, and dynamic. In the future, computer processing power may permit optimization of configuration and station specific OFPs; if so, then these same techniques will apply.

293.2 Data requirements.

In order to derive the separation effects coefficients for an aircraft/store configuration, stores are dropped and tracked for TSPI in accordance with the data requirement specified in 291.2.

293.3 Test preparation.

293.3.1 Test article.

As specified in 291.3.1.

293.3.2 Test equipment.

As specified in 291.3.2.

293.3.3 Test instrumentation.

As specified in 291.3.3.

293.3.4 Test conditions.

A three by three matrix (low, medium, and high g releases versus low, medium, and high airspeeds) represents the baseline test envelope for defining the separation effect coefficients due to the nonlinearity of the separation effects. The test conditions chosen will depend on the aircraft/weapon configuration, the operational delivery conditions, and the expected shape of the three-dimensional surface. There will likely be circumstances which do not warrant the use of the entire matrix. There are some weapons, for instance, which would never be released under high g conditions. There are also weapons designed to be released under one set of conditions. Obviously, under these circumstances a three by three matrix is unnecessary. The test conditions should be selected with the goal of acquiring enough data to derive the separation coefficients with an acceptable confidence level. Only the flight conditions not flown, or for which acceptable data was not gathered during Test 292 need to be reflown.

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293.4 Acceptance criteria.

As specified in 291.4.

293.5 Test procedures.

As specified in 291.5.

293.6 Test reporting.

As specified in 291.6. The report should also specify the number of weapon releases used to statistically determine coefficients and range bias/aimpoint offsets.

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TEST 294

OPERATIONAL FLIGHT PROGRAM (OFP) BALLISTICS VERIFICATION TEST

294.1 Purpose.

The purpose of this test is to verify the ballistic accuracy of the aircraft OFP ballistic algorithms. The ballistics at this point in the process consist of both the free-stream drag curves and the derived separation effects coefficients. The ballistic accuracy verification phase should be identical to that performed in the OFP ballistic evaluation phase (Test 292). A CEP and bias evaluations are performed and compared to the acceptance criteria.

294.2 Data requirements.

As specified in 292.2.

294.3 Test preparation.

As specified in 292.3.

294.4 Acceptance criteria.

As specified in 292.4. If the criteria specified by certifying agency on behalf of the user command is not met, then the decision for further analysis, rederivation of the separation effect coefficients or modification to the delivery platform (aircraft), must be made versus accepting a less accurate weapon system or rejecting the aircraft/store configuration.

294.5 Test procedures.

Should be identical to that specified in 292.5.

294.6 Test reporting.

As specified in 292.6.

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APPENDIX C

AIRCRAFT/STORES COMPATIBILITY ENGINEERING DATA PACKAGE (CEDP)

C.1. The aircraft/stores compatibility engineering data package (CEDP) consists of a standardized list of reference data essential for determining the extent of aircraft/stores compatibility and forms the source from which service technical publications will be derived. Details of prior testing by recognized agencies relevant to aircraft/stores compatibility disciplines during stores qualification tests such as ground fit and function tests, wind tunnel and environmental tests, ground static ejection rig tests, flight tests such as flutter, load, captive carriage, separation and ballistics tests are included, or preferably referenced (provided the reference is also supplied), in the applicable part. The CEDP should also include conclusions from certification and analyses previously accomplished documenting clearly all aircraft/stores configurations and operating limits for carriage, employment, jettison and accuracy. The CEDP should include analogous aircraft stores, store installation and operational data for similar aircraft/stores installation(s) where certification has already been completed to defined operating limits.

C.2. The aircraft/stores CEDP consists of the following parts for the specific aircraft/stores combination:

a. PART I – FUNCTIONAL DESCRIPTION

b. PART II – FIT AND FUNCTION

c. PART III – STRUCTURAL AND ENVIRONMENTAL

d. PART IV - AEROELASTICITY

e. PART V – CAPTIVE CARRIAGE, FLYING QUALITIES AND PERFORMANCE

f. PART VI – EMPLOYMENT AND JETTISON

g. PART VII – MISSION PLANNING, BALLISTICS, SAFE ESCAPE AND MUNITIONS EFFECTIVENESS

h. PART VIII - PROCEDURES

i. PART IX - SPECIFICATIONS

C.3. Due to the number and variety of different types of aircraft and stores, not all the requirements of this appendix will be applicable to all aircraft/stores configurations or for the operating limits required for carriage, employment, jettison or accuracy. Application should be made to the agency responsible for determining aircraft/stores compatibility, for approval to tailor specific requirements for a particular aircraft and/or stores configuration/operating limit by stating that the requirement is “Not Applicable” and providing supporting rationale.

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APPENDIX C

PART I – FUNCTIONAL DESCRIPTION

C.I.1 General description.

A general description of the aircraft and store is to include function, role, delivery modes and a brief technical description of sufficient detail and quality to be used in maintenance and aircraft Technical Orders. Pictures or schematics are highly desirable to provide sufficient detail to clearly identify the aircraft, the suspension equipment and the store. Where variants or different marks/modification status of munitions or associated equipment exist such as different fuzing configurations, a detailed breakdown of the differences and the reasons for the change is to be provided.

C.I.2 Operational description.

It also includes an operational description and sequences including: safing and arming actions, control surface actuation/deployment, motor performance, submunition employment, autopilot activation, guidance and control activation and anticipated actions by the launch aircraft before and after store separation. Mathematical models and software relating to aircraft/store compatibility should be provided.

C.I.3 Aircraft data.

Aircraft data is to consist of:

a. Operational data. The operational data for the aircraft, suspension and release equipment (including necessary ejector cartridge type(s)), and stores, should consist of:

(1) Identifications of all loading configurations (including mixed loads). Indicate station locations and stores fit for each applicable station. Aircraft/stores configurations should include, as appropriate:

(a) clean/basic aircraft,

(b) aircraft with pylons,

(c) aircraft with pylons and suspension and release equipment, and

(d) aircraft with pylons, suspension and release equipment and stores.

(2) Identification of operational limitations for carriage, employment and jettison (i.e., maximum and minimum velocity/mach, maneuvers, load factors, altitude, wing sweep, speedbrake usage, dive angles, etc) for all identified aircraft/stores configurations.

(3) Desired release sequence (single, ripple, minimum and maximum ripple intervals, jettison) and delivery modes.

(4) Peculiar-to-type-operations. If required, include a section indicating any peculiar-to-type operations (for example, dive brake operation, fuel tank jettison prior to door guns usage, wing sweep setting limits, etc.).

(5) Additional information. If required, include remarks on any additional information needing clarification/attention necessary for inclusion directly in the flight/tactical manual.

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Include all annotations/remarks on the chart, notes on partial/authorized downloads, mirror image loads authorized, orifice settings, ejector cartridge types, etc.

b. Software requirements. Descriptions of software configuration required and complete descriptions of modes (including aircraft checkout, preflight, inflight, failure reporting) and functions used in the stores management system set and fire control/mission computer operational flight program (OFP) to allow for optimal control, release and accuracy of the aircraft/store combination. Details of algorithms used for ballistics and “in-range”/shoot cues are to be provided.

C.I.4 Store data. Store data is to consist of:

a. Operational. Operational description of the store, including event times in sequences such as sub-munition employment, autopilot activation or control surface activation/deployment (including event time rate if applicable).

b. Descriptive data. Descriptive data on each required fuze is to include a brief description and illustration of the fuze. The data is to also include functional type, safety devices, armed/safe indications, type of fuze action arming delays, functioning delays and installation procedures for the store in all required configurations. The data provided should include steps required to check pre-fuzed munitions and install those fuzes that are not authorized to be installed prior to loading the munition.

c. Store functional data. Any special store functional data, such as limiting seeker look angles, boresight/boresight retention tolerances, cooling requirements.

d. Motor performance. Motor performance, including thrust/impulse vs time, exhaust chemical analysis, blast overpressure and temperature distribution.

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PART II – FIT AND FUNCTION

C.II.1 Physical description.

Engineering drawings and documentation to establish external dimensions and location of pertinent parts. These should include data detailing attachment hardware, fluid or electrical connections, all necessary fuze installations, arming wire guides and access covers. Physical description should include details of tests conducted to demonstrate compliance with AIR STD 20/21.

C.II.1.1 Aircraft data.

Aircraft data is to consist of:

a. Drawings. Three-view drawings of stores installed on desired carriage stations and dimensional information showing required clearances between stores, ground and aircraft components (in accordance with the provisions of AIR STD 20/21).

b. Description. Description of suspension and release equipment, including applicable impulse cartridges, ejection velocities, orifices, arming unit type and location, and inspection criteria.

c. Requirements. Any special installation requirements, such as field of view, or servicing and identification of any special equipment required (i.e., non-standard lugs, mechanical adaptors, rocket blast deflectors).

d. Characteristics of radar. Radar cross section characteristics of the store, suspension equipment and aircraft/suspension equipment/store(s) combinations is highly desirable.

C.II.1.2 Store data.

Store data is to consist of:

a. Geometric data. A three view scaled drawing depicting external dimensions of the store in each configuration (i.e., fins folded or retracted and extended, with each authorized fuze and nose plug) showing:

(1) Body diameter (or width and height).

(2) Overall store length for each operational configuration (with fins, fuzes etc).

(3) Fin location, planform and span (extended and folded, if applicable).

(4) Fin angular orientation with respect to lugs/rails.

(5) Lug/rail type, location and spacing.

(6) Length of store from forward attachment point to tip of nose with each authorized fuze and nose plug.

(7) Hardback locations.

(8) Acceptable swaybrace pad and ejector location.

(9) Total wetted area (exposed surface area).

(10)Lifting locations for ground handling equipment to meet.

(11)Allowable tolerances on appropriate dimensions.

(12)Access panel and servicing panel locations.

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b. Materials.

c. Surface finish and markings.

d. Radar cross section data. Data to establish radar cross section of the store.

e. Illustrations. Engineering drawings or photographs (dimensional)[2] (See also note (1)).

f. Arming wire/lanyard routings. All arming wire and lanyard routings and component description such as types of wire should be identified including reliability for armed and jettison/safe releases.

g. Wiring diagrams. Wiring diagrams and illustrated parts breakdown, and details of compliance with MIL-E-5400 or equivalent.

C.II.2 Mass properties.

Includes weights, centers of gravity (cg), pitch, yaw and roll moments of inertia and variations due to manufacturing, or hysteresis (slosh).

C.II.2.1 Aircraft data.

Aircraft data is to consist of the aircraft weights, location of cg in three axes and the cg limits for all aircraft/stores configurations and downloads.

C.II.2.2 Store data.

Store data is to consist of mass properties for each store configuration (including acceptable tolerances) showing:

a. Weight (filled, partially filled and empty, where applicable).

b. Location and tolerance. Location and tolerance of the cg in three axes using the forward lug for longitudinal dimension and the longitudinal center-line for the vertical and lateral dimension (including variation with payload/motor burn, if applicable).

c. Moments of inertia. Moments of inertia in pitch, yaw and roll.

C.II.3 Interface control data.

a. The aircraft/store interface information is to include electrical, optical, hydraulic, pneumatic and fuel interfaces, schematics, connector descriptions and locations, pin functions, electrical loads, aircraft/store software requirements, fluid flow rates and arming wire or lanyard routing. The data is to include the interface control drawings and should reference the contractual aircraft interface control document (ICD).

b. For the store and store management system (SMS) this section should show satisfactory compliance with MIL-HDBK-1763, Test 100, Fit and Function Tests and AIR STD 20/21 for store function and safety with the aircraft SMS, including all modes capable of ground operation. It should show tests conducted to ensure prevention of inadvertent releases and the absence of single point failure modes in the stores release system. It should show compliance with design safety requirements for fuzing AIR STD 20/9, aircraft stores electrical

[2] Level of drawings are to be specified by the certification agency as necessary for aircraft/stores compatibility flight clearances or for certification.

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interconnection system requirements AIR STD 20/22 and MIL-STD-1760, safety design requirements for airborne dispenser weapons AIR STD 20/23, and compliance with MIL-STD-2167

c. This section should show satisfactory compliance with MIL-HDBK-1763, Test 100, AIR STD 20/21, and for ERU mounted stores, the physical arrangement requirements for swaybracing/hardbacks and loading support for physical fit of all MIL-A-8591, appendix A configurations. It should show compliance with the:

(1) Suspension and release equipment (S&RE) store ejector cartridges requirements of AIR STD 20/12;

(2) Location of electrical connectors for aircraft stores requirements of AIR STD 20/14;

(3) Requirements for 1000 lb and 2000 lb class suspension lugs requirements of AIR STD 20/15;

(4) Mechanical connection provisions of AIR STD 20/17, and for non-ejection release units the requirements of AIR STD 20/19;

(5) Physical fit requirements for 20 mm ammunition of AIR STD 20/24;

(6) Location of electrical connectors for dispensers and internal intervalometer type rocket launchers for aircraft in accordance with AIR STD 20/27.

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APPENDIX C

PART III – STRUCTURAL AND ENVIRONMENTAL

C.III.1 Structural analysis.

Stress analysis should be based on loads in accordance with to MIL-A-8591, appendix A unless otherwise specified by the procuring activity. Reaction loads due to store functions are also to be included. Store influence coefficients and an associated mass matrix may be required with certain stores. The aircraft/store structural integrity should specify satisfactory compliance with MIL-HDBK-1763, Test 131 or 132, 4.1.4.2, and the structural and mechanical requirements of MIL-A-8591/AIR STD 20/13 for the store and aircraft suspension equipment, for all identified aircraft/stores configurations, to the limits identified at Part I. Inflight load tests conducted to verify the satisfactory structural integrity of the store and aircraft/stores combinations in accordance with, or need for, *instrumented* MIL-HDBK-1763, Test 200 for all identified aircraft/stores configurations to the limits identified at Part I should be included.

C.III.1.1 Aircraft data.

Aircraft data is to consist of:

a. Allowable loadings. Allowable loadings at each store station, aircraft cg and asymmetric loading limits (weight and distribution) for all authorized configurations.

b. Structural design limits. For all pylons and racks, structural design limits etc as per “store data”.

c. Fatigue. Fatigue analysis and supporting test data appropriate to the aircraft/store configuration.

d. Effect of aircraft on store. Should state satisfactory compliance with MIL-HDBK-1763, Test 141 for all identified aircraft/stores configurations to the limits identified at Part I.

C.III.1.2 Store data.

Store data is to consist of:

a. Structural design limits. Structural design limits in three axes for the store and major components (body, fins, lugs/rails and actuators).

b. Reaction loads. Dispenser reaction loads versus time for each dispenser intervalometer setting.

c. Ejection force and velocities. Maximum permissible ejection forces and velocities.

d. Structural Stiffness. Structural stiffness data for the store and suspension equipment.

e. Fatigue. Fatigue analyses and supporting test results.

C.III.2 Environmental analyses and qualification test data.

Includes all aircraft, suspension equipment and stores tests conducted according to MIL-STD-810 and MIL-T-7743, and static loads tests; discussion of components that are known or thought to be sensitive to high or low temperature, aerodynamic heating, rain, ice, hail, or other

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environmental effects to the extent that safety of flight or mission accomplishment would be compromised.

C.III.2.1 Aircraft data.

Aircraft data is to consist of analyses of onboard SMS related systems as well as data for pylons and racks, as for “store data”. For the aircraft launcher/rack, this includes documentation showing compliance of launcher/rack with MIL-STD-810/AIR STD 20/18, MIL-T-7743, MIL-A-8591/AIR STD 20/10 for all store/rack/launcher/ERUs combinations, for all environmental ground testing for all identified aircraft/stores configurations to the limits of appendix A. Compliance with the requirements of AIR STD 20/19 for non-eject release units should be shown.

C.III.2.2 Store data.

Store data is to consist of:

a. Environmental. Environmental qualification limits (temperature, aeroacoustic, shock, vibration, etc.) including:

(1) Vibration and aeroacoustics. State whether MIL-HDBK-1763, Tests 151 and 152 were required, and should show satisfactory compliance with specified portions of MIL-STD-810/AIR STD 20/10, MIL-STD-1670, and MIL-STD-210, for vibration and aeroacoustics for all identified aircraft/stores configurations to the limits of appendix A including carriage, freeflight and, if required, impact with water/ground/hardened targets. This section should state whether *instrumented* MIL-HDBK-1763, Tests 221 and 222 were required, and whether compliance was achieved with specified portions of MIL-STD-810/AIR STD 20/18, MIL-STD-1670, and MIL-STD-210, for vibration and aeroacoustics of all identified aircraft/stores configurations to the limits identified at Part I.

(2) Thermal. This section should identify any thermal limitations associated with the store, including the warhead, rocket motor electronic components, etc. It should show compliance with MIL-HDBK-1763, Test 155, MIL-STD-1670, and MIL-STD-210 for all identified aircraft/stores configurations to the limits identified at Part I.

b. Explosive Hazard. This section should provide explosive component and hazard data (for components and all-up-round), to include net explosive quantity (NEQ), UN hazard classification codes (HCC) as well as known hazards (radiation, chemical, toxic material, etc) for the all up round and subsections. Rationale supporting the classification(s) is to be provided.

C.III.3 Electromagnetic compatibility and electromagnetic interference data.

This section should include a detailed operational description of each of the aircraft, aircraft suspension equipment *and* the store's electronic systems or subsystems (including all electro-explosive devices) and the test data and reports generated during development and qualification testing in accordance with MIL-STD-461 and MIL-STD-462, and the systems level requirements of MIL-E-6051, MIL-STD-1818, or MIL-STD-464, MIL-STD-1512, MIL-HDBK-1763, Test 154, MIL-HDBK-1763, Test 224 and ADV PUB 20/30 in the environment of MIL-STD-1385 or MIL-STD-464. Note that the “aircraft” EMC/EMI and HERO classification is to

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include results for the aircraft *and* all store suspension pylon/rack combinations. MIL-HDBK-1763, Test 224 test results should identify and document any inflight EMC/EMI tests conducted for aircraft/stores configurations which cannot be tested in accordance with MIL-HDBK-1763, Test 154 (such as ECM pods that require representative external stimuli to radiate). Data required for both aircraft and store consists of:

a. Transmitting. For each transmitting system or subsystem:

(1) Operating Frequencies. Operating frequencies of each mode.

(2) Output Power. Average/peak output power spectral content for each mode of operation.

(3) Duty Cycle. Duty cycle and pulse width (if applicable).

(4) Antenna. Antenna type, location, orientation, frequency response (gain) and radiation pattern on the aircraft.

b. Receiving. For each receiving system or subsystem, identify:

(1) Operating frequencies. Operating frequencies of each mode.

(2) Sensitivity. Minimum sensitivity.

(3) Range. Dynamic range.

(4) Bandwidth. Half-power bandwidth.

(5) Shape. Shape factor.

(6) Rejection. Interference rejection circuitry.

(7) Antenna. Antenna type, location, orientation, frequency response and reception pattern.

(8) Threshold. Maximum no fire threshold.

(9) Impedance. Bridge wire impedance.

C.III.3.1 HERO Classification.

This section should document the HERO Classification (safe, susceptible or unsafe) in accordance with NAVSEA OP 3565 and ADV PUB 20/30 for all aircraft, suspension equipment and stores electro-explosive systems/components, including ejector cartridges and partially assembled stores. For systems classified as HERO-susceptible or HERO-unsafe, operating limitations are to be provided such as maximum power levels and safety distances to be used when the systems are containerized, unpacked and installed in the system. It should show satisfactory compliance with MIL-HDBK-1763, Test 153 and the levels of MIL-STD-1385 or MIL-STD-464 in accordance with the HERO systems test requirements of MIL-E-6051, MIL-STD-1818 or MIL-STD-464, and the subsystem requirements of MIL-STD-461 and MIL-STD-462, for the store, aircraft and aircraft/S&RE/stores combinations. If necessary the HERO classification of the store may need to be specified for the store in approved shipping containers, during stores preparation/loading and when loaded to the aircraft. Rationale supporting the classification(s) is to be provided.

C.III.4 Shipboard requirements.

The shipboard requirements of MIL-HDBK-1763 are to be included, if applicable.

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C.III.4.1 Part III compliance.

Compliance with the requirements of this part may be demonstrated by providing details from prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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PART IV - AEROELASTICITY

C.IV.1 Aeroelastic data.

The aeroelastic data should cover the entire range of aircraft/store configurations, including authorized and failure mode store partial downloads, wing sweeps, required mixed weapon loads, fuel expenditure, and applicable limit speeds. It should identify margins of safety for all configurations and authorized downloads in accordance with MIL-HDBK-1763 wing damping and flutter limit speeds criteria.

C.IV.2 Aeroelastic ground vibration tests.

This section should identify satisfactory compliance with MIL-HDBK-1763, Test 120 aeroelastic GVT to help substantiate the flutter/aeroelastic analysis of all aircraft/stores configurations, their authorized downloads and failure downloads for all identified aircraft/stores configurations to the limits identified in Part I.

C.IV.3 Aeroelastic wind tunnel testing.

This section should identify satisfactory compliance with MIL-HDBK-1763, Test 143 for all identified aircraft/stores configurations to the limits identified in Part I.

C.IV.4 Flight tests.

This section should specify satisfactory compliance with MIL-HDBK-1763, Test 210 for those configurations requiring flutter flight testing to address all identified aircraft/stores configurations to the limits identified in Part I.

C.IV.5 Part IV compliance.

Compliance with the requirements of this part may be demonstrated by providing of details of prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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PART V – CAPTIVE CARRIAGE, FLYING QUALITIES AND PERFORMANCE

C.V.1 Captive carriage, flying qualities and performance data.

This part should include free stream and installed store aerodynamic force and moment coefficients and drag index and/or count of store, suspension equipment, and aircraft/suspension equipment/store combinations. Data should include parameters and assumptions used in its generation.

C.V.1.1 Aircraft data.

Aircraft data is to consist of aircraft performance and flying qualities information (with and without stores and flight control system), in accordance with MIL-F-8785 or MIL-HDBK-1797, including flight envelopes, normal aircraft symmetric and unsymmetrical loads versus all up weight (N_zW), maximum asymmetric carriage limits, weight and balance limitations, thrust and any other restrictions.

C.V.1.2 Store data.

Store data is to consist of:

a. Aerodynamic data. Free stream aerodynamic data (including data uncertainty) showing:

(1) Aerodynamic coefficients and stability derivatives versus angle of attack and sideslip for the applicable Mach numbers.

(2) Location of moment reference point for moment data.

(3) Values of reference area and length used to determine force and moment coefficients.

C.V.1.3 Effect of store on aircraft.

Should specify satisfactory compliance with MIL-HDBK-1763, Test 142 for all identified aircraft/stores configurations to the limits identified in Part I.

C.V.1.4 Reports.

Reports supporting previously demonstrated operational envelopes for analogous carriage (i.e., maximum and minimum velocity/mach, maneuvers, load factors, altitude, wing sweep, speedbrake useage, and dive angles) are to be provided where possible. This should include carriage during all desired release sequence (single, ripple, ripple intervals, jettison) and delivery modes.

C.V.1.5 Quantitative aircraft flying qualities.

This section should identify testing performed to demonstrate that the aircraft/stores configuration will safely and satisfactorily operate throughout the appendix A flight envelope with respect to aircraft handling qualities in accordance with the requirements for the flying qualities of military piloted aircraft specified in MIL-F-8785 or MIL-HDBK-1797. It should identify inflight instrumented handling quality tests conducted to verify the structural integrity of the store and aircraft/store combinations in accordance with *instrumented* MIL-HDBK-1763, Test 230.

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C.V.1.6 Qualitative handling qualities.

This section should identify qualitative tests performed to demonstrate that the aircraft/store configuration will safely and satisfactorily operate throughout the entire flight envelope with respect to handling qualities for all configurations and all authorized and necessary failure downloads. As a minimum, compliance with *qualitative* MIL-HDBK-1763, Test 251 is required, unless a clear analogy basis exists.

C.V.1.7 Maneuver load limitations.

This section should document, for the necessary aircraft/stores combinations, whether all normal aircraft symmetric and unsymmetric loads versus all up weight (i.e., N_zW) limitations for all aircraft/stores configurations and downloads have been analyzed and satisfactorily demonstrated to the limits identified in Part I.

C.V.1.8 Qualitative structural integrity.

This section should identify tests performed to demonstrate that the aircraft/stores configuration will safely and satisfactorily operate throughout the entire Part I A flight envelope with respect to aircraft/stores structural integrity. As a minimum, compliance with the *qualitative* MIL-HDBK-1763, Test 252 is required, unless a clear analogy basis exists.

C.V.1.9 Vibration and endurance.

As a minimum for all aircraft/stores combinations, satisfactory compliance with the *qualitative* MIL-HDBK-1763, Test 253 is required, unless a clear analogy basis exists.

C.V.1.10 Weight and balance.

This section should document whether acceptable aircraft weight and balance implications for all aircraft store configurations and downloads has been analyzed and satisfactorily demonstrated for all identified aircraft/stores configurations to the limits of Part I.

C.V.1.11 Performance and drag.

This section should identify degradation in mission performance caused by the carriage of the stores and should identify drag indexes or counts, and whether they need to be verified in accordance with *instrumented* MIL-HDBK-1763, Test 240.

C.V.1.12 Part V compliance.

Compliance with the requirements of this part may be demonstrated by provision of details of prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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PART VI – EMPLOYMENT AND JETTISON

C.VI.1 Employment and jettison data.

This part should document analyses and testing conducted to establish employment *and* jettison limits for stores, and for rack and/or stores jettison characteristics of all aircraft/stores configurations and release/jettison sequences and release intervals.

C.VI.1.1 Static ejection tests.

Should specify satisfactory compliance with MIL-HDBK-1763, Test 110, including:

a. Reliability and confidence levels attained for ARMED and SAFE releases,

b. Cartridges and ejector unit orifice settings used, and

c. Ejection velocity and pitch rate averages *and* range (if required for Wind Tunnel Tests in accordance with MIL-HDBK-1763, Test 144.)

C.VI.2 Ground.

C.VI.2.1 Effect of aircraft on store.

Should specify satisfactory compliance with MIL-HDBK-1763, Test 144 wind tunnel separation tests for all identified aircraft/stores configurations to the limits identified in Part I.

C.VI.2.2 Gun/missile firing.

Should include any results of gun and rocket firing from the aircraft during ground test. Compatibility with night vision equipment should be addressed. It should show compliance with MIL-HDBK-1763, Test 162. It should also show compliance with the 20 mm external ballistics requirements of AIR STD 20/24, if applicable.

C.VI.3 Flight.

C.VI.3.1 Release/launch/dispenser.

This section should show satisfactory compliance with relevant MIL-HDBK-1763, Test 270 series for all identified aircraft/stores configurations to the limits identified at Part I. It should specify and document which live fire tests have been conducted to determine system effectiveness.

C.VI.3.2 Jettison.

This section should identify the separation tests conducted to derive the recommended store jettison limits (and store/rack jettison limits, if applicable), in compliance with MIL-HDBK-1763, Test 280 for all identified aircraft/stores configurations to the limits identified in Part I.

C.VI.4 Reports.

Reports supporting previously demonstrated operational envelopes for analogous employment and jettison (i.e., maximum and minimum velocity/mach, maneuvers, load factors, altitude, wing

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sweep, speedbrake useage, and dive angles) and release sequence (single, ripple, ripple intervals, jettison) and delivery modes are to be included, if applicable.

C.VI.5 Night vision equipment.

Compatibility with night vision equipment during all required separation modes should be included, if applicable.

C.VI.6 Part VI compliance.

Compliance with the requirements of this part may be demonstrated by provision of details of prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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PART VII – MISSION PLANNING, BALLISTICS, SAFE ESCAPE AND MUNITIONS EFFECTIVENESS

C.VII.1 Mission planning, ballistics, safe escape and effectiveness data.

This part is to cover weapon ballistics, minimum safe release distance/heights, safe escape charts, conversion tables and other charts used in mission planning.

C.VII.2 Mission planning.

C.VII.2.1 Equipment and procedures.

A description of the charts, tables, and assumptions to be used by the aircrew for the employment of the weapon/store configuration should be provided. A description of the planning methods for each type of delivery mode is to be provided along with sample problems and solutions. The description is to cover weapon ballistics, minimum safe release distance/heights, safe escape charts, conversion tables and other charts used in mission planning.

C.VII.2.2 Charts and ballistic tables.

This section is to contain a description for use of safe escape charts, fuze arm time charts, angle of attack charts, sight depression angle charts and airspeed and altimeter position error charts (if applicable), dive recovery charts, conversion tables and tables necessary for planning all types of release/launch/jettison.

C.VII.2.3 Supplementary data.

This should include error analysis, harmonization, static arena trials in accordance with JMEMs, safe escape (including probability of self fragmentation) and fuze arming time data, hazard analysis, safety tables derivation and verification, conversion values for appropriate ballistics equations and automated systems error analysis. Compatibility with night vision equipment should be included, if applicable.

C.VII.3 Ballistics.

This section should provide store coefficient of drag versus mach number (including event timing and tolerances, if applicable) and assumed weapon diameter/mass used for ballistic analysis purposes.

C.VII.3.1 Freestream aerodynamic coefficients.

This section should identify relevant wind tunnel method/tests used to determine store freestream aerodynamic coefficients.

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C.VII.3.2 Ballistics accuracy evaluation/verification.

Accuracy evaluation/verification status and results (CEP, dispersion and range biases) for all aircraft/stores configurations should be included in accordance with MIL-HDBK-1763, Test 290 for all delivery modes and the aircraft OFP used. Algorithms and flowfield separation coefficients should be identified, if used.

C.VII.3.3 Flight testing of stores.

Acceptability of store OFP used during flight testing is to be included. Verification of OFP launch cuing for “in-range” indications should be documented. Interaction with other systems is to documented such as air-to-air missile operation when in air-to-ground mode and a data link pod is in operation. If the acceptable employment envelope is less than the Part I maxima due to OFP limitations, then this should be clearly stated. Acceptability of dash 34 ballistic tables used during flight testing is to be included. If the ballistics accuracy is for an employment envelope less than the limits identified in Part I maxima, then this should be clearly stated.

C.VII.4 Minimum safe release height and safe escape.

C.VII.4.1 Fragmentation envelopes.

This section should specify store fragmentation envelopes determined by analysis and during static arena trials by recognized agencies for the purposes of safe escape analyses.

C.VII.4.2 Analyses of safe escape charts/mission planning tools.

This section is to contain a complete analyses of safe escape charts/mission planning tools (including probability of self fragmentation assumed, modeling and safe escape maneuvers used, and verification/validation used), fuze arm time charts, angle of attack charts, sight depression angle charts and airspeed and altimeter position error charts (if applicable), dive recovery charts, conversion tables and tables necessary for planning all types of release, launch and jettison. Identification of source and acceptability of dash 34 MSRH and safe escape data in accordance with policy requirements for all aircraft delivery conditions, store fuze settings and safe escape maneuvers authorized for all identified aircraft/stores configurations to the limits identified in Part I is to be included. Further guidance is provided in ADV PUB 20/152.

C.VII.5 Munitions effectiveness.

This section should provide results of static arena trials to determine munition effectiveness in accordance with JMEM 61A1-3-7, or equivalent. This should include error analysis, harmonization, static arena tests in accordance with JMEMs, safe and fuze arming time data, hazard analysis, safety tables derivation and verification, conversion values for appropriate ballistics equations and automated systems error analysis.

C.VII.5.1 Part VII compliance.

Compliance with the requirements of this part may be demonstrated by providing of details of prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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APPENDIX C

PART VIII - PROCEDURES

C.VIII.1 Data and tests.

This part includes data and tests, conducted in accordance with MIL-HDBK-1763, Test 100 and AIR STD 20/21, to provide step-by-step procedures, illustrations, verification of need for special tools and safety precautions necessary to employ munitions, including:

C.VIII.1.1 Stores preparation procedures.

Munitions preparation procedures (dash 32 series TOs) for:

a. Safety checks. Safety checks and explosives inspection.

b. Serviceability. Serviceability checks.

c. Fuzing. Fuzing procedures.

d. Inspection. Any other inspection or preparation required before loading munitions.

e. Procedures. Procedures to prepare and dismantle the all up round.

f. Prestorage. Details of any prestorage checks and storage limitation.

C.VIII.1.2 Aircraft/stores loading procedures.

Aircraft stores/munitions loading procedures (dash 33 series TOs) for:

a. Arming wire/lanyards. Authorized arming wire or lanyard installation or routing, including hardware requirements (i.e., swivel and loops or links used, tie-off blocks, adjusters).

b. After loading. Preparation of munitions after loading (i.e., computer control group installation, guidance fins).

c. Inspections. Preloading and postloading inspections.

d. Procedures. Procedures for loading/unloading of the store(s) and suspension equipment and for the arming/safing of a weapon just prior to aircraft taking off and during delays awaiting takeoff. Particular attention to WARNINGS, CAUTIONS and NOTES is to be made.

e. Procedures for safing. Procedures for safing munition if the weapon returns from flight or if takeoff is aborted.

f. Emergency procedures. Emergency ground procedures and specific safety requirements; emergency procedures should be prefaced by a brief explanation of actions to be accomplished by the loading crew in the case of fire or other emergency. This data should contain the withdrawal distances and the time the munition can be expected to function after being enveloped by flames and methodology concerning the manner in which this was obtained (such as by test in accordance with MIL-STD-2105). Emergency procedures should be marked in accordance with the requirements of MIL-STD-38784. The data should provide all specific safety requirements pertaining to the loading and unloading of the munition.

C.VIII.1.3 Munitions description.

(Topic dash 2 series TOs) for:

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a. Leading particulars

b. Description,

c. Operation,

d. Storage life and special requirements for servicing and supply,

e. Fire-fighting withdrawal times and safety distances,

f. Disposal methods,

g. Inspection requirements such as those required for receipt inspection by storage personnel, operating level or intermediate level servicings,

h. Proof requirements, and

i. Safety requirements for all actions required

C.VIII.1.4 Aircrew preflight/inflight/postflight procedures.

Aircrew Tactical Manual/Weapons Delivery Manual (dash 34 or equivalent series TOs) pre-flight and in-flight procedures and mission planning information:

a. Normal aircrew and procedures. This is a description of the complete weapon employment and jettison cycles from preparation to the last functional step in the sequence. The information is to include crew responsibilities (pre-flight, in-flight and post-flight procedures), stores management provisions, target acquisition procedure (if applicable), stores preparations for employment and jettisoning (including pre-employment sequence of events and warm-up time), employment and jettison modes and sequences, including all major events such as store release, ejector firing, rocket firing, first motion, fin deployment (time and proximity) and control surface activation.

b. Emergency aircrew procedures. These procedures are to include emergency release of stores and emergency jettison of stores and suspension equipment certified for a particular aircraft. A fire-fighting criterion is to also be defined.

C.VIII.1.5 Aircraft armament system maintenance/checkout procedures.

Aircraft armament system (aircraft and necessary stores suspension equipment) maintenance and checkout procedures (dash 2-11 series TO) procedures are to be provided. All necessary test equipment is to be identified, including any software requirements for a specific type. Recommended maintenance and checkout periods are to be supplied.

C.VIII.1.6 Procedures format.

All procedures are to be provided in hardcopy and softcopy (Word or Interleaf) unless specified otherwise by the aircraft/stores compatibility agency.

C.VIII.1.7 Part VIII compliance.

Compliance with the requirements of this part may be demonstrated by providing details of prior testing by recognized agencies relevant to each of the aircraft/stores compatibility disciplines.

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APPENDIX C

PART IX - SPECIFICATIONS

Summarize any non-compliances with ratified AIR STDs.

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CONCLUDING MATERIAL

Custodians:

Army – AV

Navy – AS

Air Force - 11

Review activities:

Air Force – 99

Preparing activity:

Air Force – 11

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INSTRUCTIONS

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-HDBK-1763	2. DOCUMENT DATE (YYMMDD) 980615

3. DOCUMENT TITLE
AIRCRAFT/STORES COMPATIBILITY: SYSTEMS ENGINEERING DATA REQUIREMENTS AND TEST PROCEDURES

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (include Zip Code)	d. TELEPHONE (Include Area Code (1) Commercial (2) AUTOVON *(If applicable)*	e. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME ASC/ENSI (AF-11)	b. TELEPHONE (Include Area Code (1) Commercial (937)255-6281	(2) AUTOVON 785-6281
c. ADDRESS *(Include Zip Code)* BLDG 560 2530 LOOP ROAD W WRIGHT-PATTERSON AFB OH 45433-7101	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	

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