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MILITARY HANDBOOK

GUIDE TO AIRCRAFT/STORES COMPATIBILITY

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DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FOREWARD

1. This military handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 53), Lakehurst, NJ 08733-5100, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This handbook was developed by the Department of Defense with the assistance of the Joint Ordnance Commanders Sub Group (JOCG) for aircraft/stores compatibility in accordance with established procedure.

4. This document provides basic guidelines for accomplishing compatibility between military aircraft and airborne stores or weapons. The handbook is not intended to be referenced in purchase specifications except for informational purposes, nor shall it supersede any specification requirements. Every effort has been made to reflect the latest information on aircraft/store compatibility. It is the intent to review this handbook periodically to ensure the completeness and currency.

5. This document is intended to assist engineers in the design and testing of aircraft, suspension and employment equipment, and airborne stores or weapons. It is expected that the engineer using the guidance provided by this handbook will assume the responsibility to determine and apply the latest technology available in each particular area of interest. Major effort has been placed on standardizing the types and methods of testing between the U.S. Air Force, U.S. Army, and U.S. Navy to demonstrate aircraft/store compatibility. Quantitative values provided in this handbook are the best available at this time based on past experience but are to be viewed as recommendations since each design or test effort should be dealt with using full consideration of available information.

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1. SCOPE

1.1 Scope. The handbook is intended to cover all aspects of aircraft/weapons compatibility: mechanical, electrical, structural, aerodynamic, etc. These are dealt with individually as they relate to various elements of the complete system. The material has been organized to present design guidelines for the five general categories of weapon system components: aircraft, suspension equipment, stores, stores management equipment, and ground support equipment. This information deals with compatibility of the components while the system is on the ground, in flight, and during weapon delivery.

1.2 Successful airborne weapon system. A successful airborne weapon system is achieved by proper matching of all components. Integrating the numerous components which make up a complete weapon system into one effective, efficient, maintainable, and reliable operating unit will not produce the desired compatibility unless each element is designed with proper consideration of its relation to all other elements. The complexity of modern airborne weapon systems and the interdependency between components make the task of assuring compatibility difficult. Therefore, definitive guidelines are needed to provide engineering direction for the development of all components. Because some major components are used in more than one weapon system, there must be consistency, versatility and clarity in the guidelines prepared for this purpose. This handbook deals in detail with all individual elements to present guidelines for the design integration of totally compatible systems.

1.3 Detailed engineering data. This handbook does not include detailed engineering data necessary to design specific components of a compatible system. Much of the published material useful in the design process is available through government technical information services. However, there are large quantities of additional technical data and design information located at various government laboratories and contractor facilities. There is no intent to include that material here because of the large volume of data involved. Direct contact with the responsible organizations may be necessary if the design information is needed to apply the compatibility guidelines presented in this handbook.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 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 issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-E-5007	Engines, Aircraft, Turbojet and Turbofan, General Specifications for
MIL-B-5087	Bonding, Electrical and Lightning Protection for Aerospace Systems
MIL-E-6051	Electromagnetic Compatibility Requirements Systems
MIL-H-8501	Helicopter Flying and Ground Qualities, General Requirements for
MIL-A-8591	Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase); General Design Criteria for
MIL-I-8671	Installation of Droppable Stores and Associated Release Systems
MIL-I-8672	Installation and Test of Aircraft Pyrotechnic Equipment in Aircraft, General Specification for
MIL-T-8679	Test Requirements, Ground, Helicopter
MIL-S-8698	Structural Design Requirements, Helicopters
MIL-D-8708	Demonstration Requirements for Airplanes

SPECIFICATIONS - Continued

MILITARY

MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-M-8856	Missiles Guided Strength and Rigidity, General Specification for
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
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	Airplane Strength and Rigidity Nuclear Weapons Effects
MIL-A-8870	Airplane Strength and Rigidity Vibration, Flutter, and Divergence
MIL-F-15733	Filters and Capacitors, Radio Frequency Interference, General Specification for
MIL-T-18847	Tanks Fuel Aircraft, Auxillary External, Design and Installation of
MIL-I-23659	Initiators, Electrical, General Design Specification for
MIL-C-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect
MIL-B-81006	Bombs, Free Fall, Demonstration of Dispersion Requirements for
MIL-D-81303	Design and Evaluation of Cartridges for Stores Suspension Equipment
MIL-F-83300	Flying Qualities of Piloted V/Stol Aircraft
MIL-A-87221	Aircraft Structures, General Specification for

STANDARDS

MILITARY

MIL-STD-129	Marking for Shipping and Storage
MIL-STD-210	Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment
MIL-STD-220	Method of Insertion Loss Measurement
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirement for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-1289	Ground Fit and Compatibility Tests of Airborne Stores, Procedure for
MIL-STD-1316	Fuze Design, Safety Criteria for
MIL-STD-1319	Item Characteristics Affecting Transportability and Packaging and Handling Equipment Design
MIL-STD-1385	Preclusion of Ordnance Hazards in Electromagnetic Fields, General Requirements for
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

STANDARDS - Continued

MILITARY

MIL-STD-1512	Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods
MIL-STD-1553	Digital Time Division Command/Response Multiplex Data Bus
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)(Metric)
MIL-STD-1760	Aircraft/Store Electrical Interconnection System
MIL-STD-1763	Aircraft/Stores Certification Procedures
MIL-STD-2088	Bomb Rack Unit (BRU), Aircraft, General Design Criteria for

HANDBOOKS

MILITARY

MIL-HDBK-235-1	Electromagnetic (Radiated) Enviroment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems
DOD-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) Metric

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents and publications. The following other Government documents and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

OTHER GOVERNMENT DOCUMENTS

CODE OF FEDERAL REGULATIONS

49CFR, Parts 100-177	Transportation
49CFR, Parts 178-199	Transportation

(Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-0001.)

PUBLICATIONS

AIR FORCE

DH 1-4	Design Handbook Electromagnetic Compatibility
DH 2-1	Design Handbook Airframe
DH 2-2	Design Handbook Crew Stations and Passenger Accommodations
DH 2-4	Design Handbook Electronic Warfare (S)
DH 2-5	Design Handbook Armament
AFR 127-100	Explosive Safety Standards
TR 70-131	Aircraft Gunfire Vibration

(Copies of DHs are available from ASD/ENES, Wright Patterson AFB, Ohio 45433-6503. Copies of TRs are available from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22304-6145 and from the National Technical Information Services (NTIS), 5285 Port Royal Road, Springfield, VA 22161-2171. Copies of AFRs are available from the Air Force Publications Distribution Center, Baltimore, MD 21220-2998.)

PUBLICATIONS - Continued

ARMY

AMCP 706-201	Helicopter Engineering, Part One, Preliminary Design
AMCP 706-202	Helicopter Engineering, Part Two, Detail Design
AMCP 706-203	U.S. Army Material Command Engineering Design Handbook, Helicopter Engineering, Qualification Assurance
AMCP 706-235	Hardening Weapons Systems Against RF Energy Handbook
TR RD-TE-87-1	Electromagnetic Environmental Criteria for U.S. Army Missile Systems; EMC, EMR, EMI, EMP, ESD, and Lightning

(Unless otherwise indicated, copies of AMCPs and TRs are available from the National Technical Information Services (NTIS), 5285 Port Royal Road, Springfield, VA 22161-2171. Copies of TRs are also available from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22304-6145.)

NAVAL SEA SYSTEMS COMMAND

OP-4	Ammunition Afloat
OD 30393	Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance (HERO Design Guide)

(Copies of OP-4 and OD 30393 are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

NAVAL AIR SYSTEMS COMMAND (NAVAIR)

SD-24 Volume I	General Specification for Design and Construction of Aircraft Weapon Systems Fixed Wing Aircraft
SD-24 Volume II	General Specification for Design and Construction of Aircraft Weapon Systems Rotary Wing Aircraft
AR-56	Structural Design Requirements for (Helicopters)

(Copies of SD-24 and AR-56 are available from the Naval Air Systems Command, Standardization Section (Code 51122E), Washington, DC 20361-5110.)

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

STANAG 3525 AA	Design Safety Princples and General Design Criteria for Airborne Weapon Fuzing Systems
STANAG 3556 AA	Aircraft Store Ejector Cartridge

PUBLICATIONS - Continued

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

STANAG 3558 AA	Locations for Aircraft Electrical Control Connections for Aircraft Stores
STANAG 3575 AA	Aircraft Stores Ejector Racks
STANAG 3605 AA	Compatibility of Mechanical Fuzing Systems and Arming Devices for Expendable Aircraft Stores
STANAG 3726 AA	Bail (Portal) Lugs for the Suspension of Aircraft Stores
STANAG 3791 AA	Interoperability of NATO Aircraft Stores - AOP-11
STANAG 3837 AA	Aircraft Stores Electrical Interconnection System
STANAG 3842 AA	Rail Launched Missile/Launcher Interface for Aircraft
STANAG 3898 AA	Aircraft/Store Interface Manual (ASIM) - AOP-12
STANAG 3899 AA	Ground Fit and Compatibility Criteria for Aircraft Stores
AGARDograph No. 300 Volume 5	AGARD Flight Test Techniques Series Store Separation Flight Testing
AOP-11	Interoperability of NATO Stores with Fixed Wing Aircraft and Helicopters
AOP-12 Volume 1	Aircraft Stores Interface Manual (ASIM) Aircraft Manual
AOP-12 Volume 2	Aircraft Stores Interface Manual (ASIM) Stores Characteristics
AOP-12 Volume 3	Aircraft Stores Interface Manual (ASIM) Suspension Equipment

AIR STANDARDIZATION COORDINATING COMMITTEE (ASCC)

AIR STD 20/10	Ejector Racks for Conventional Weapons
AIR STD 20/12	Cartridges for Stores Suspension Equipment
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

PUBLICATIONS - Continued

AIR STANDARDIZATION COORDINATING COMMITTEE (ASCC)

AIR STD 20/16	Design Guide to Preclude Hazards of Electromagnetic Radiation to Airborne Weapon Systems
AIR STD 20/17	Mechanical Arming Wire Connections Between Airborne Armament Stores and Associated Suspension Equipment
AIR STD 20/21	Ground Fit and Compatibility Criteria for Aircraft Stores
AIR STD 20/22	Aircraft Store Electrical Interconnection System

(Unless otherwise indicated, copies of STANAGs and AIR STDs are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. AOP-11 and AOP-12 are published by the Pacific Missile Test Center Maintenance Engineering Branch, Code 2021, Point Mugu, CA 93042-5000. Application for microfiche or photocopies of AGARDograph No. 300 Vol. 5, edited by R.K. Bogue, should be made to the National Technical Information Service (NTIS) 5285 Port Royal Road, Springfield, VA 22161-2171.)

2.2 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.

3. DEFINITIONS

3.1 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.

3.2 Aircraft/Store Compatibility. The ability of an aircraft, stores, stores management system, and related suspension equipment to coexist without unacceptable effect of one on the aerodynamic, structural, 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) or under all conditions.

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

(a) Symmetrical carriage. The loading of identical stores and suspension equipment on both sides of the centerline longitudinal axis of the aircraft. Each side is the mirror image of the other for store stations and weapon bays. Loading of similar stores on each side of the aircraft may be considered functionally symmetrical if there is no disparity in aerodynamics or physical properties of the stores.

(b) Asymmetrical carriage. The carriage of stores arranged without symmetry. This term applies to the carriage of the stores unlike in shape, physical properties, or number with reference to the plane of symmetry.

NOTE: The term "asymmetrical" shall apply to the arrangement or loading, of stores on an aircraft or suspension equipment, as contrasted with the term "unsymmetrical," which shall apply 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.

(c) 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.

(d) Multiple carriage. Carriage of more than one store on any given piece of suspension equipment, such as bombs carried on a Triple Ejection Rack (TER) or Multiple Ejection Rack (MER).

(e) Single carriage. Carriage of only one store on any given station or pylon.

3.4 Certification of a Store. 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.

3.5 Critical conditions. A combination of pertinent operational parameters expected to be encountered by an aircraft, store, stores management system, suspension equipment or combinations thereof; upon which the design or operational limits of the aforesaid vehicles, devices, or portions thereof are based.

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

(a) 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.

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

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

(d) 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.

3.7 Free flight (of a store). The movement or motion of a store through the air after separation from an aircraft.

3.8 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.

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

3.10 Interval. The elapsed time between the separation of a store and the separation of the next store.

(a) Minimum interval. The shortest allowable or usable interval between successively released stores that will allow safe separation of the stores from the aircraft.

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

3.12 Separation. The terminating of all physical contact between a store or suspension equipment, or portions thereof, and an aircraft; or between a store, or portions thereof, and suspension equipment. This shall include the parting of items or submunitions from a dispenser.

(a) Safe separation. The parting of a store, submunition, suspension equipment, or portions thereof, 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 stores both released and unreleased.

(b) Acceptable separation. Acceptable store separations are those which meet not only the "safe" separation criteria, but also meet pertinent operational criteria. While a store may pitch, yaw, or roll to any magnitude during separation from the aircraft as the interference boundary is not penetrated or bomb-to-bomb collisions do not occur, such a separation would be unsatisfactory if, for example, the control limitations for a guided weapon were exceeded thereby resulting in an inaccurate weapon. Also, while separation from the aircraft may be safe, angular excursions may be of such a magnitude that variations in predicted ballistic dispersions are generated which cause loss of weapon accuracy. Thus, a successful separation encompasses the total store trajectory commencing with safe separation from the aircraft and terminating with accurate impact on the targets.

(c) Pairs. The simultaneous separation of stores from two separate stations on an aircraft.

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

(e) Salvo. The simultaneous release of two or more stores.

(f) Ejection. The process of forcibly separating an aircraft store from an aircraft to achieve safe separation.

(g) Selective jettison. The intentional separation of selected stores or suspension equipment, or portions thereof (such as expended rocket pods).

(h) 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.

3.13 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 tank (fuel and spray), line-source disseminator, pod (refuelling, thrust augmentation, gun, electronic countermeasures, data link) multiple rack, target, cargo drop container, drone or other similar item.

In the context of MIL-STD-1760, stores are further subdivided into two categories: mission stores and carriage stores. Mission stores are stores which directly support mission of the aircraft and which are not suspension and release equipment. Carriage stores are stores which are also suspension and release equipment. Examples of mission stores include missiles, rockets, bombs, mines, torpedoes, electronic countermeasures (ECM) pods and fuel tanks Examples of carriage stores include multiple ejector racks and rail launchers which attach to parent racks.

(c) All-up store. 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 all-up store 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 the store. An all-up store does not include items of suspension equipment (such as empty 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.

3.14 Submunition. Any munition carried in or dispensed from projectiles, dispensers, or cluster bomb units and intended for employment therefrom. Rockets are not considered as submunitions.

3.15 Suspension and release equipment. All aircraft devices such as racks, adapters, missile launchers, and pylons used for carriage, suspension, employment, and jettison of aircraft stores.

3.16 Aircraft store ejection cartridge. A cartridge used to provide the mechanical force for ejection of an aircraft store from its aircraft store ejector rack.

3.17 Aircraft store ejector rack. Suspension equipment which incorporates a method of forcibly separating the aircraft store from the aircraft at the time of release.

3.18 Aircraft stores management system. That functional aircraft sub-system which monitors and controls aircraft stores and manages all communications between aircraft stores and other aircraft sub-systems and crew.

3.19 Arm. To prepare an explosive device, aircraft store or aircraft weapon system for functioning, usually by removing the safety constraints.

3.20 Fuzing system. A physical system designed to sense a correct release environment, to preclude unintentional initiation of the explosive train, and to cause an item of ammunition or aircraft store to function at the desired position and time.

3.21 Jettison. Deliberate release of an aircraft store from an aircraft to effect aircraft safety or prepare for air combat.

3.22 Sway braces. Mechanical devices designed either as a part of, or as an attachment to, suspension equipment which, when properly positioned on an attached aircraft store, provide store restraint in roll and assist in counteracting side and vertical forces.

4. GENERAL REQUIREMENTS

4.1 Basic design areas. Aircraft/store compatibility difficulties can not realistically be ascribed to any one particular design group or piece of equipment or ordnance. The compatibility problem involves basic design areas that shall be assigned to the aircraft designer, the store suspension equipment designer, stores management system designer, and the store designer. Aircraft/store compatibility problems represent the resolution of mutual design parameters which often cannot be fully solved unless the designer considers the relationship to all areas and applies this overall knowledge to his specific design problem. MIL-STD-1763 establishes standardized procedures for the certification of stores on aircraft, and defines the information and data required to determine aircraft/store compatibility.

4.2 Types of compatibility requirements. Aircraft/store compatibility problems may occur between the aircraft and the suspension equipment, the suspension equipment and the store, the aircraft stores management equipment and the store, the store and the aircraft, or combination thereof. The problems are inter-related and must be approached from an overall system basis. Basically, however, there are four compatibility situations requiring separate solutions by the design engineer. These are:

(a) Type I - Adding inventory stores (or store configurations) not previously certified to the authorized weapons list of inventory aircraft.

(b) Type II - Adding inventory stores (or store configurations) to the authorized weapons list of new or future aircraft.

(c) Type III - Adding new, modified, or future stores (or store configurations) to the authorized weapons list of inventory aircraft.

(d) Type IV - Adding new, modified, or future stores (or stores configurations) to the authorized weapons list of new or future aircraft.

4.2.1 Type I. Type I generally requires the least involvement from design and compatibility engineers. Both the store and the aircraft have already been produced. Ideally, the store and the aircraft are compatible and the only task required is to simply verify and demonstrate compatibility. In other cases, particularly if the store requires an electrical interface with the aircraft, some modification of the aircraft stores management system supporting avionics suite may be required to employ the store. For these cases, the burden of achieving compatibility is primarily placed on the aircraft and SMS designers. This is because the store is already in inventory and changes would not be practical. The Type I condition is one of the drivers that result in periodic updates to the capabilities of inventory aircraft.

4.2.2 Type II. Type II presents a challenge to the aircraft and suspension equipment designers and represents the most complex problems. The stores to be carried on a particular aircraft can, and do, have a profound effect on the specific aircraft design and quite often are the cause of aircraft design trade-off.

4.2.3 Type III. Type III places a large portion of the responsibility and effort for achieving compatibility on the store designer. It is not uncommon to find that the requirement for carriage of a newly developed store on certain specific aircraft has had a major influence on the store design. The aircraft and stores management system (SMS) designers will also have significant efforts in the situation particularly if an electrical interface is required. While it is possible in some cases to design a new store which mimics the electrical interface of an inventory store, most new stores (with electrical interfaces) will require modifications to the aircraft. This modification may be limited to software changes in the aircraft avionics or SMS.

4.2.4 Type IV. Type IV represents the classic case of the absolute necessity of dialogue during the design stages between the aircraft designer, the suspension equipment designer, and the store designer to preclude any aircraft/store compatibility problems occuring at the operational phases. The stores to be carried on a particular aircraft can, and do, have a profound effect on the specific aircraft design and quite often are the cause of aircraft design trade-offs.

4.3 Compatibility at the design stages. Operational experience acquired by all the services has repeatedly demonstrated that airborne weapon system compatibility considerations have not been adequately addressed during the design stages of the aircraft, suspension equipment, store or combinations thereof. Therefore, the primary objective of this section is to emphasize, to the design engineer, those areas that are considered prerequisite and necessary for achieving total weapon system compatibility during the design evolution. The development of the aircraft/weapon interface shall consider not only the equipment already in inventory, but also those projected or proposed for future employment. Elimination of interface compatibility problems encountered in times past by the various services is a mandatory objective.

5. DETAILED REQUIREMENTS

5.1 Aircraft design. The aircraft should be considered first and above all a carrier and deliverer of stores to the specified target location. Therefore, its design, both in general and in detail, should be optimized to successfully achieve that goal.

5.1.1 Store installation criteria. The aircraft's size, aerodynamic configuration and method of weapon carriage should be optimized for the most efficient execution of successive primary missions while carrying the primary mission stores in designated load configurations. The selected method of store carriage, arrangement, and installation should be designed such that the aircraft/store operational envelope and delivery accuracy be maximized, and that mission turn-around time and required interface operation and maintenance effort be minimized.

5.1.1.1 Carriage. Carriage shall be the conveying of a store or suspension equipment by an aircraft under all flight and ground conditions, including taxi, take-off, and landing. Carriage shall include time in flight up to the point of complete separation of the store or suspension equipment from the aircraft. The store or suspension equipment may be located either external or internal to the aircraft. External carriage can be further identified as:

(a) Conventional pylon with racks or launcher carriage.

(b) Semi-submerged carriage.

(c) Conformal carriage.

(d) Internal carriage equipment that is external at release.

5.1.1.1.1 Mission requirements. Mission requirements will set the types and quantities of stores to be carried through given mission profiles, and will, in large measure, establish the speed-altitude envelope and maneuvering capability required of the final design. The requirements of the primary mission will lead to the final airframe size, general arrangement, and primary weapon carriage mode. Notwithstanding this design priority, the carriage provisions for secondary stores carried in secondary mission roles could result in minimum range, endurance, speed and maneuvering agility loss due to the installed secondary stores. Moreover, store arrangement, location, orientation, and spacing should be carefully assessed to minimize aerodynamic loads, separation perturbations due to local aerodynamic interference forces and moments, increases in aircraft signature, and increases in aircraft vulnerability from unnecessary exposure to enemy air defense weapon effects. In no instance should release conditions pursuant to delivery tactics desired for a particular mission be limited by separation characteristics attributable to store carriage provisions. With respect to store carriage, the overriding weighting factors are aircraft performance during store carriage, separation safety and weapon delivery accuracy.

5.1.1.1.2 Selecting carriage location on airframe. Selecting the locations for store carriage involves many parameters for the aircraft designer, such as, but not limited to, the stores effect on the aircraft's:

(a) Performance.

(b) Stability and control for full, partial, and mixed store loadings.

(c) Lifting and control surfaces (primary or secondary).

(d) Engine inlets by disturbance of inlet flow or released to pass in flow field ingested by the engine.

(e) Components or systems, such as inertial, acoustic, electromagnetic, etc.

(f) Boundary layer disturbances on carriage and separation.

(g) Preflight inspection and access panels.

(h) Radar and infra-red cross sections.

(i) Stability and control during store separation.

5.1.1.1.2.1 Performance. The design objective for true aircraft/store compatibility is that aircraft performance must not be appreciably compromised both before and after the store has been released. Quite often, when a new aircraft is being designed, the situation occurs where the service wants the latest technology included in the aircraft design, but at the same time wants to be able to carry and release older weapons. When faced with the situation, the designer has only two basic options. First, the designer could design the aircraft to accept all stores required, both new and old, and meet all the performance and mission requirements. This generally results in a design compromise on the aircraft caused by the older stores, and a resultant aircraft which does not embody all the latest technology. Secondly, the designer could design the aircraft to accept the latest stores design, using the latest, or innovative, carriage techniques without penalizing aircraft performance or mission requirements. In this case the older stores would be carried on a "secondary" basis, allowing whatever penalty in performance or mission these stores cause. The second option is the preferred solution because usually the latest tecnology is embodied in the aircraft and store designs.

5.1.1.1.2.2 Stability and control. The effects of partial as well as mixed store loadings, on the stability and control characteristics of the mission configured aircraft, should be such that the aircraft continues to exhibit stability and control characteristics required by MIL-F-8785, for all physically possible permutations and combinations of those specific stores required by the aircraft's detailed specification.

5.1.1.1.2.3 Lifting and control surfaces. Provision for store carriage and the placement of lifting and control surfaces (primary or secondary) must avoid strong mutual aerodynamic interferences between the stores and the aircraft. The aerodynamic surfaces must be fully effective with or without the presence of stores. In addition, the surfaces must not produce adverse effects on the functioning of the store or its separation trajectory through physical interference or loads pursuant to steady or unsteady aerodynamic pressure or flow fields generated by the surfaces. Airframe external protuberances, fixed or movable, (antennae, fittings, etc.) should not produce degrading effects through like influences. Particular attention should be given to the design of the empennage for aircraft on which stores that are rocket powered or retro-launched are expected to be used.

5.1.1.1.2.4 Engine inlets. Stores carried near engine inlets, or released to pass in the vicinity of the flow field being ingested by the engine are undesirable because of the detrimental effects on engine performance caused by the flow disturbance or exhaust gas ingestion or both.

5.1.1.1.2.5 Airframe functional components and systems. Careful consideration should be given to the environmental effects that airframe functional components and systems produce upon the stores, while operating through their full functional range, during both transport and separation. Here, transport includes both ground and in-flight movement. In particular, the above requires that the impact of airframe component or system operation on stores' spatial, inertial, aerodynamic, thermal, acoustic, electromagnetic and vibrational environments be carefully assessed. For systems utilizing internal bays, consideration shall be given to minimization of the aero-acoustic environment associated with such bays either by bay design or incorporation of suppression techniques. The airframe designer, then, must be well versed in the stores' design criteria and their structural environmental limits and sensitivities.

5.1.1.1.2.6 Boundary layer disturbances or separation. The airframe and stabilizing surfaces are also sensitive to boundary layer disturbances or separation caused by flow interference from the captive store. Vortices, exhaust gases or aerodynamic interactions produced by the store may cause surface loadings, heating, erosion, or vibrations on the airframe which may be detrimental to the local structure. Therefore, the choice of carriage locations must be made to assure that the airframe can be designed to withstand the store loading environment.

5.1.1.1.2.7 Stability and control during store separation. The effects of store separation (such as changes in aircraft loading, aerodynamics, store reaction forces, and locally induced turbulence) shall be considered during the design phase to assure successful performance of the weapon delivery system. For systems utilizing internal weapons bays, the unique aerodynamic interactions between the bay and the store during store separation shall be considered.

5.1.1.1.2.8 Preflight access panels. All pre-flight inspection and servicing access panels and fittings required for operation of the aircraft should be available to maintenance and operating personnel under any store loading condition. Similarly, the detail design of the airframe including its store carriage provisions should in no way impair or make difficult the required servicing of stores while loaded on the aircraft.

5.1.1.2 Separation. Separation is defined as the terminating of all physical contact between a store or suspension equipment, or portions thereof, and an aircraft; or between a store, or portions thereof, and suspension equipment. This shall include the parting of items or submunitions from a dispenser. Store separation studies should be applied to assist in determination of carriage locations, types and number of weapons to be used, required suspension systems, release sequence of stores, minimum time intervals between releases, either single or multiple store releases, avionic requirements, and ground and flight testing requirements. A complete discussion of the store separation, its causes, effects, and solutions may be found in AGARDograph No.300, Vol 5. The following paragraphs cover some, but not all, of the information in the AGARDograph.

5.1.1.2.1 Separation during design phase. During the design phase of an aircraft, the geometry of the design is strongly influenced by the number and types of weapons stipulated for carriage. If one particular type of weapon or the minimum required number of any one weapon, has the greatest impact on the design, that weapon should be evaluated for effect on safe separation so that these studies can aid in the continuation of the design, or give indication that another design approach must be used. As design decisions are made that relate to carriage of stores (such as type, number, and location), separation of these stores should be of vital interest. The aircraft, as a weapon system, must be capable of meeting its performance and flying qualities requirements, and must, in most cases, to achieve its objective, deliver a weapon, either air-to-air or air-to-surface and have that weapon hit the target. An aircraft that can carry numerous types and quantities of weapons at desirable flight conditions, but is then restricted in the release of these stores, may be more vulnerable to enemy attack. It is imperative, therefore, that maximum safe separation envelopes of weapons under realistic flight conditions, compatible with the type aircraft being considered, be analyzed during early design stages. Over the past several years, the services have identified certain stores or types of stores, that almost always cause problems during separation (e.g. lightweight, low-density stores, or stores with folding fins or other surfaces). A list of these stores can be obtained by the designer and their effects studied during early design stages. This way, using a "worst case" scenario, unpleasant "surprises" later on may be minimized or avoided entirely.

5.1.1.2.2 Separation problem areas. One of the areas essential for consideration during aircraft design phases is store separation, both employment and jettison. Store separation problems are not necessarily accidental, many times they are built into the aircraft design. All too often store separation is given cursory attention, being relegated to a minor status in favor of aircraft performance or clean aircraft handling qualities. Such things as high wings, low horizontal tails, close pylon or store spacing, multiple carriage, flexible bomb racks, and low ejector forces are prime contributors to store separation problems. Shallow internal bays, multiple bays, bays in the vicinity of external aircraft protuberances and bays with doors extended into the airstream can also create store separation problems. Of all these, the currently used flexible, multiple bomb racks with single ejector pistons and low actual ejection forces are, without doubt, the principal contributor to separation problems. Bomb racks, with individually controlled, dual ejection pistons and high ejection forces are currently available. Unfortunately, few of today's inventory aircraft can take full advantage of these rack improvements, primarily because thin, flexible aircraft wing structures cannot withstand the higher ejection forces and increased reaction loads. High aircraft wings contribute to store separation problems by causing the store to remain in the perturbated flow field longer allowing the airplane to cause erratic store behavior. High wings and straight, slab-sided aircraft fuselages also cause a flow field which tends to move the stores toward the aircraft centerline below the fuselage. This increases the chances of bomb-to-bomb collisions. Low aircraft horizontal tails present two major problems. One is obvious, they are directly in the path of debris and rearward-dispensed stores. The other fault is not so obvious. Any store which changes shape immediately after release (such as the opening of retarder fins) radically affects the airflow immediately downstream of the store. If this disturbed air passes over the horizontal tail, sudden, radical aircraft pitch or roll oscillations may occur. Balanced against these disadvantages, however, is the contribution of the low tail to superior aircraft control performance at high "g" and high angle of attack. If all the preceeding factors are designed into one aircraft, the probability of serious store separation problems is high. See AGARDograph No. 300, Volume 5, for a more complete discussion of separation problems.

5.1.1.2.3 <u>Separation analysis</u>. Separation of stores from any aircraft without reasonable foreknowledge of their trajectories exposes the pilot and aircraft to unnecessary risk. Safe separation is contingent upon some degree of order and repeatability in the behavior of both the aircraft and stores. These behavioral characteristics are largely predictable prior to flight by analyses based on experimental, theoretical, and empirical methods.

5.1.1.2.3.1 <u>Factors</u>. Several factors, including, but not limited to those stated, form a part of any acceptable store separation analysis and the analysis must demonstrate that these factors are not detrimental to the performance of the aircraft or the employment of its ordnance.

(a) Weapon sequencing - As the design progresses, the separation analyst must consider the proper sequencing of these weapons, either singly or multiply, from their respective carriage stations. The importance of weapon sequencing, as well as the weapon's location on the aircraft, cannot be overemphasized, particularly when assessing store separation and ballistic accuracy of the weapon. Acceptable separation, as well as ground impact points, must be evaluated based on the capability of the armament control system. Mission objectives and versatility in delivery sequence should be a major consideration in establishing the best sequence for weapon delivery.

(b) Minimum time interval - To assure a sufficient number of weapons on target, a minimum time interval for employment of weapons must be determined for single or multiple release modes. Simultaneously, the analyst must ensure that sufficient clearance between weapons is maintained when employed within the minimum time interval so that store-to-store collision does not occur within the lethal envelope of the store. Minimum time interval is also directly related to aircraft exposure time over target whether it amounts to fewer passes or less time on a single pass. For flexible weapons or projectiles of different velocities, it is necessary to consider time intervals between firings or action of interruptors to prevent projectile collision in the proximity of the aircraft.

(c) Correct weapon carriage station - Most present day aircraft are required to include a large variety of stores in their weapons complement to meet their multi-role missions, which generally include several of the following: intercept, combat air patrol, interdiction, close air support, surveillance, early warning and anti-submarine. Coupled with the large variety of weapons required for carriage is the need to have multi-station capability for maximum ordnance. Mating the proper weapon to the correct carriage station requires that store separation anaylysis be performed during early design phases.

(d) Variable store geometry - Since there are many types of ordnance presently available that change geometric characteristics immediately upon employment, the changed geometry must be considered in carriage station selection for satisfactory aircraft/store compatibility.

(e) Ordnance exhaust plumes - Present day aircraft generally carry some ordnance that contain rocket motors, such as 2.75 inch or 5 inch rockets, and air-to-air or air-to-surface missiles. Since the exhaust plumes from rocket motors can cause aircraft engine flame-out or degraded performance, selection of carriage stations for these types or ordnance must include a consideration to provide sufficient distance away from aircraft engine inlets. The effect of rocket exhaust impinging upon nearby aircraft structure such as the horizontal tail should be assessed together with the design of structure to minimize severe erosion and corrosion problems and heavy corrective maintenance time. The effect of metallic particles in the exhaust plume on sensors or other devices in the store itself or adjacent stores is another area which should be assessed. In some cases, the aircraft may fly through the rocket exhaust after the store has been launched. When such conditions occur, the above effects should be considered.

(f) Delivery accuracy - Both the initial store employment trajectory and its subsequent terminal impact are largely dependent upon the magnitude and direction of the net loads acting on the store at the instant of release (i.e. inertial, plus the carriage aerodynamic and interference loads prevailing at the release flight condition). The integrated effect of large drag and normal forces on the store caused by separation transient oscillations results in a trajectory deviation from that which would have developed without the oscillation. The trajectories of unstable or marginally stable stores are more seriously affected in this manner by large and unsymmetrical carriage loads. Thus, the separation trajectories can be unrepeatable or unpredictable. Another factor having a significant effect on the delivery accuracy is the geometry of the store release station. For example, if three stores are carried on a triple ejector rack (TER), with one store ejected vertically and the other two at 45° from the vertical, the store ejected vertically will impact the ground dozens of feet behind the other two, simply because the other two stores are being ejected with a vertical acceleration of 0.707g and the first is ejected at 1.0g. This "g" difference is entirely caused by the the geometry of the TER. To enhance delivery accuracy, it is imperative, therefore, that stores be carried and released in aerodynamic fields of low interference that aid separation. Such flow fields generate low pitching and yawing moments about the store center of gravity, which are desirable for gravity releases. Moreover, sufficiently rigid structure must be made available to the rack, to obviate rack flexure, maximize allowable ejector impulse and make ejector separation impulses applied to the store uniform within the rack capability.

(g) Employment parameters - Of the many possible variables that affect store separation, the following list contains the basic parameters that should be included in any analysis:

(1) Aircraft flight path angle.

(2) Aircraft bank angle.

(3) Aircraft angle of attack.

(4) Aircraft side slip.

(5) Aircraft load factor.

(6) Aircraft mach number.

(7) Altitude.

(8) Aircraft weight.

(9) Variable wing sweep (if pertinent).

(10) Store load configuration and position.

(11) Store aeroballistics characteristics (after separation).

(12) Support structure reactive compliance.

(13) Ejector impulse characteristics.

(14) Release sequence.

(15) Release interval.

(16) Delivery modes.

(17) Aircraft dynamic response to store separation.

(18) Store mass properties.

(19) Aircraft interference flow field characteristics.

(20) Propulsion actuation sequence (missiles).

The above parameters will vary considerably depending upon the type store being considered. For example, employment parameters for actively launched air-to-air missiles will entail extremes of pitch, roll, and maneuver load factor which are neither required nor desired for conventional air-to-ground ballistic stores.

(h) Jettison requirements - Any external or internal store is capable of producing a recognizable hazardous condition to the aircraft while being carried by the aircraft and ideally should be capable of safe separation in an unarmed condition from the aircraft at any Mach-Altitude condition in the carriage envelope. A capability for emergency jettison of all external stores in cases where a rapid decrease in aircraft weight or drag is desired (particularly during take-off and landing operations) must be provided. Emergency jettison is required to be accomplished at least between normal load factors of +1.00 ±.5g's absolute and bank angles and roll rates between ±10° and ±10° per second, respectively, and pitch attitudes between ±10°. Selective jettison, where required, for the purpose of intentional separation of stores or suspension equipment no longer required for the performance of the mission in which the aircraft is engaged, must be capable of being accomplished at least within the load factor, attitude, and angular rate noted above.

(i) Airframe cavities - The airflow within and around airframe cavities such as those generated for semi-submerged stores or bays used for internal carriage should be of such basic character or controlled such that the separation of stores therefrom shall be safe and shall result in minimum dispersion due to separation perturbations. The provisions of (e) should apply equally to stores carried in such cavities.

(j) Aircraft response - Response of the aircraft to store separation is also a vital consideration to the overall weapons system design. The aircraft response will create additional store response, thus, an amplification of the total separation transient can result. Aircraft response is derived from the effects of the ejection sequence, the change to the aerodynamic characteristics of the airplane after store release, and the effect of store induced aerodynamic loads on the aircraft during separation. The latter effect is pronounced when stores of relatively large size are utilized or when stores reach large displacements in attitude during supersonic separation thus producing strong shock waves that impinge on the aircraft.

(k) Arming wires and clips - A detailed analysis should be made of the effect on the aircraft of store arming wires, lanyards, clips, pins, and other debris. There are several ways to install arming wires or lanyards to stores to effect arming of the weapon. The installation method depends on the fuze selected, the position of the bomb rack arming solenoid, whether there is some pilot-operated inflight fuzing option, and whether the wire or lanyard is intended to be dropped with the bomb. In any case, arming wire retaining clips, and pins become debris during store separation. Such debris may become entangled with aircraft control surfaces or imbedded in other structure, or it may be ingested into the aircraft engines causing serious failures. Arming wires routing and securing should be the subject of detailed analysis,since the wires, if broken, can cause a dud bomb or damage the aircraft or suspension equipment by flailing around. Arming wires which become unsecured can cause bombs to become armed while still attached to the aircraft.

(l) Wake effects - The location of stores on the aircraft can result in adverse effects on other aircraft structure. Clusters of stores, store fin wake, and store angle of attack during carriage can affect the wing or tail boundary layer in such a manner as to cause local flow separation. Fin extension during employment can damage adjoining structure. Vibratory loads, such as those resulting from gun fire, can affect local structure.

(m) Shock effects - Oscillating shock waves in the near-sonic flow regime between the store and the pylon, the store and the wing surface, or on surfaces between tandem-carried stores can result in rapid metal fatigue of the structure being impinged upon.

5.1.1.2.3.2 Separation analysis data. Because of the complex flow field about many store installations, analytical methods usually require experimental verification, but they do serve to provide preliminary estimates, and to reduce the experimental studies needed for this purpose. The data required by the separation analyses shall include but not limited to that specified in 5.1.1.2.3.2.1 through 5.1.1.2.3.2.4.

5.1.1.2.3.2.1 Analytically derived data. It has been stated that installed loads and flow fields are best derived from experimental sources. Data on store free-stream aerodynamic characteristics can be derived experimentally or analytically. It is also emphasized that cost savings can be realized by utilization of available data on similar configurations and on data that can be reliably derived from analytical prediction methods. Analytical methods are also extremely useful during predesign and conceptual phases of design in determining trends or preferred locations.

5.1.1.2.3.2.2 Suspension equipment data. Some of the inputs required for a store separation analysis are release system capabilities such as force time histories, induced pitch or yaw rates, ejection velocities as a function of store weight, and ejector stroke length. Normally, this type of data is based on experimental values derived from ground tests such as qualification or developmental tests. In almost all cases, data are gathered for individual rack/cartridge combinations mounted from rigid steel supports. Data are taken for several representative store weights, but rarely includes other than 1g, zero air load conditions. For stores installed on flexible structure, situated in a severe, non-uniform flow, which cause large excursions in loads, data during release under the effect of applied air loads and flexible structures become essential.

5.1.1.2.3.2.3 Experimental data. Store separation analysis must be substantiated by or based upon experimental data, either ground or flight. As developmental wind tunnel tests are planned, time should be allocated to measure the following:

(a) Installed store loads - Initial store response is grossly dependent upon magnitude and direction of the aerodynamic loads acting on the store at the instant of release. Though there are several basic analytical techniques currently available to predict installed store loads, none are available for complex or multiple carriage situations. These data are also used for structural design purposes.

(b) Aircraft interference flow field - Knowledge of the flow environment, including flow angularity and shock patterns at high transonic and supersonic speeds, is essential to a meaningful theoretical store separation analysis. In the absence of flow separation under-wing subsonic flow can be predicted fairly accurately using existing methods for clean wing or single pylon/store installations. Multiple store installations (MER or TER) cause flow fields which are extremely complex and difficult to predict.

5.1.1.2.3.2.4 Six degree of freedom computer analysis. With the advent and extensive use of high speed computers, solutions to complex problems, such as aircraft/store motions, have been made more reliable and useful. It is imperative that the designer utilize the best means available to solve the basic problem of maximum safe separation of the store from the aircraft. Separation analysis is an applied engineering discipline in which the ultimate solution relies on an integrated application of principles from three fundamental fields: mechanics of solids, fluid mechanics and applied mathematics. The absolute or relative position and orientation of one body upon separation from a second are the areas of concern. It differs from a general trajectory analysis only in accounting for the interaction which exists between bodies in proximity to one another, each having a peculiar flow field associated with it. In the presence of an atmosphere, the effect of complex interference air flows plays a dominant role in controlling the initial trajectory of a separated body. Computer simulation derived by a sum of flow field interference and store aerodynamic data (usually data on wind tunnel tests) together with proper initial conditions provides rapid and accurate predictions of separation characteristics. Continuous refinement of the inputs to such a simulation by correlation with wind tunnel and flight test data will ensure that costly and time consuming flight test incremental drops are kept to a minimum. The basic analytical areas necessary for a logical development of the equations and operations involved in a separation analysis are discussed herein. These areas fall into the following categories:

(a) Various frames of reference and their relationships.

(b) Expressions developed for the absolute linear and angular accelerations of a rigid body.

(c) The general dynamic equations.

5.1.1.2.3.2.4.1 Choice of axes system. Depending upon individual preference or familiarity, any one of the following axes systems can be used: earth, body, wind or stability. Each has its peculiar usefulness and can be used provided any necessary transformation of coordinates is readily available, since the experimental and analytical data used in the analysis come in many forms. The general dynamic equations for a rigid body in terms of an axis system fixed to the body at its center of mass relate the summation of the forces and moments about the X, Y, Z axes respectively, to the absolute acceleration of a point-mass in terms of motions observed from a moving frame.

5.1.1.2.3.3 Separation criteria. The criteria for safe and acceptable separation trajectories must include the following:

(a) Positive movement away from aircraft - Any store, submunition, suspension equipment, or combination thereof being separated from an aircraft must have positive movement away from the aircraft. Positive movement, in the form of positive velocities of the item as a whole, should be such that no portion of the item penetrates a predetermined interference boundary of the aircraft and remaining suspension equipment and stores. This interference boundary is defined as that area encompassed by the aircraft or store combination into which the released item cannot transcend or contact. For example, an interference boundary may be defined by a plane which is parallel to the bottom of a pylon. However, low tail surfaces downstream of unpowered stores are particularly vulnerable to store damage and illustrate the need for something more than simple, planar, interference boundaries for some aircraft configurations. With this form of boundary, a given store separation would be satisfactory as long as the path of the store did not result in any portion of the store penetrating the interference boundary during the release trajectory.

(b) Critical parts - Critical parts of the item being separated should not be caused to fail during separation or during the free-fall trajectory. This limitation applies to rigid as well as moving parts such as folding fins, canards, strakes, and wings.

(c) Store exhaust - the exhaust plume of a self-propelled store must not cause structural damage or erosion of any portion of the aircraft or stores or have any adverse effect on engine operation and performance or aircrew environment.

(d) Jettison of rocket propelled stores - Alternate means to jettison rocket propelled stores than firing the rocket motor should be considered. In older technology, the jettison mode had fewer checks than the normal employment mode. Therefore, inadvertent store launches in the jettison mode were more likely to occur than in the normal employment mode. These inadvertent launches, particularly during ground operations, can be catastrophic. Thus in new technology, if jettison of stores by firing of rocket motors is to allow for an application, sufficient safety devices and functions must be provided in the jettison circuits to preclude inadvertent rocket firing due to probable failure in hardware, software or operating/maintenance procedures. For applications where reliability and safety values are not defined, the following is suggested as a guideline. The probability that jettison occur when commanded shall be at least 0.9999. The probability of inadvertent jettison shall not exceed 1×10^{-7} for normal conditions, and 1×10^{-5} when in hostile territory, and 1×10^{-3} when in the attack mode. These values apply over any one hour operating interval throughout the life of the weapon system. The different values for inadvertent jettison reflect that the safety checks are intentionally progressively removed as the weapon system approaches the target.

(e) Store-to-store collision - Store-to-store collision of armed stores resulting from multiple store releases, at any specified interval, is totally unsafe and unacceptable if the stated collisions occur while the aircraft is still within the lethal range of their ordnance (blast and shrapnel) effects.

(f) Detonation - Weapon or fuze detonation must not occur while the aircraft is within lethal range of the weapon.

(g) Aircraft overstress - Release of stores should not cause the aircraft to be overstressed. The release of one or more stores results in a dynamic response or g-jump of the aircraft, the magnitude of which is dependent upon such factors as the number of stores released, interval between stores, ejection force, store weight, and aerodynamic changes to the aircraft as a result of the absence of the store or to the interference flow field generated by the store itself. The aircraft structure must be designed to withstand this dynamic response or suffer a reduction in the maneuvering flight envelope during stores release to the extent that the aircraft limit load factor is not exceeded.

(h) Items specified - The limitations listed in (a) to (h) apply to iron bombs, cannisters, pods, rockets, missiles, guided weapons, towed stores, submunitions, containers, dispensed munitions and suspension equipment.

5.1.2 Store-to-aircraft clearances and fit. One of the first analyses to be made in determining the compatibility of a store with a particular aircraft is that of ensuring that the store will physically fit on the aircraft without interfering with any part of the aircraft, other stores, or the ground. See AOP-11 (STANAG 3791 AA and AIR STD 20/21), AOP-12 (STANAG 3898 AA and AIR STD 20/21), and MIL-STD-1289 (STANAG 3899 AA and AIR STD 20/21) for the appropriate data.

5.1.3 Electrical interface. Many of the latest aircraft weapon release systems are extremely complex and designed to deliver a multitude of different types of weapons. Some of these weapons can be carried singly on a parent rack or on multiple ejector racks attached to parent racks. Many of these stores require electrical connections to the aircraft. When the stores are carried singly, only one harness or adapter is needed to connect it to the aircraft; however, when a multiple rack is used, a harness is needed between the aircraft and rack, and a harness for each weapon to connect it to the multiple rack, may also be required. In all cases, however, electrical connectors are required from the aircraft to multiple racks and launchers. Refer to 5.4 for details on aircraft stores management system design guidelines.

5.1.3.1 Categories. Since the first issue of MIL-STD-1760, there are five major categories of stores and aircraft, with several sub-categories. The five major categories are:

(1) New stores on new aircraft.

(2) Old stores (developed before 1981) on new aircraft.

(3) New stores on old aircraft (developed before 1981).

(4) Old stores on old aircraft that were designed to work together.

(5) Old stores on old aircraft that were not designed to work together.

Each of the stores and aircraft that have started development since 1981 are required to be compliant with the revision of MIL-STD-1760 that was in force when their development started. The compliance with MIL-STD-1760 greatly reduced the difficulty and expense of adapting the electrical interface of any of the new stores to the new aircraft. There will be some cost and difficulty as MIL-STD-1760 is still not complete; however, as long as the new stores and aircraft are held to being required to comply with MIL-STD-1760, this cost and difficulty will be minimized. In addition to the first category, there is the category where there are many of the pre-1981 stores in inventory that are quite useful and would make sense being carried on the newer aircraft. To carry these older stores on the newer aircraft may require an electrical interface, as well as the rest of the interface requirements. Even having one half of the interface (the aircraft side) standardized will simplify the difficulty and somewhat reduce the cost. Similarly, there will be recently developed stores that will be desirable to place on older aircraft. Again, with one side of the electrical interface standardized, the integration task has some reduction in difficulty and cost. The category of pre-1981 stores on pre-1981 aircraft that were designed to work together is not an aircraft/store compatibility issue. The remaining category is the pre-1981 aircraft with pre-1981 stores that were not designed to work together. Even though the aircraft utility would be enhanced if it were compatible with these stores, there will be all the incompatibility problems that existed before MIL-STD-1760 began standardizing these electrical interfaces. This category has the following sub-categories:

(a) Store and aircraft have different connectors.

(b) Store has same connector but the pins have different function assignments, or sex, or polarization.

(c) Store or aircraft does not have the electronics to generate the required signal format

(d) Aircraft does not have a sensor to originate the data required by the store before it can function.

The above sub-categories b, c, and d will be aircraft/store electrical compatibility issues and subcategory b will require different aircraft-to-store adapter(s).

5.1.3.2 <u>Logistics and training</u>. Test sets, checklists, and complex loading manuals result in logistics and training problems. Logistics are affected by the large number of harness and test sets to be kept available. Training is also affected because of the special instructions and checklists for each test set and loading procedure. The introduction of MIL-STD-1760 compliant stores into the inventory will reduce the growth of different types of harnesses and test sets in the short term and gradually reduce the number of different types in the long term.

5.1.3.3 <u>Multiplex circuits</u>. The use of MIL-STD-1760 based interfaces between aircraft and stores will significantly reduce the aircraft wiring harness modifications required to integrate new stores onto the aircraft. The use of multiplex bus based systems in the aircraft SMS and avionics will also contribute to reduction in wiring and other hardware modifications to the aircraft. The use of multiplexed information distribution systems allows changes to aircraft operation by changing the data distributed on the multiplexed wiring channels without changing the hardware associated with the channels.

5.1.3.4 Test circuits. New systems must be designed with extensive Built-in-Test (BIT) capability to reduce the amount of external ground support required to support the checkout and maintenance of the weapon system. Effective implementation of this BIT capability requires active involvement during all phase of the system development process by aircraft, suspension equipment, store, and SMS designers. The exchange of BIT commands and status reporting across the aircraft/store interface will be required and therefore must be considered as part of aircraft/store compatibility. Tests of bridge wires may include applying low level test currents to the bridge wire provided that the test current does not exceed 50 mA or 10% of the minimum no fire current of the electro-explosive device, whichever is less.

5.1.3.5 Electrical connectors. Connectors must be designed to prevent accidental shorting of contacts during mating of the plug and receptacle. The connector must contain positive mating features to prevent any possibility of mismatching. It should contain peripheral grounding fingers that connect the two mating halves of the connector before pin and socket contacts make connection. The connector should also contain provisions for terminating shield braid for EMI protection. The connector mating halves on the aircraft, store and suspension equipment sides of the interface should have socket type contacts and electrical adapter harness connector mating halves should contain pin type contacts. Refer to MIL-STD-1760 for connector requirements. The aircraft SMS should be designed to ensure that the store connectors are not powered until an indication that the interface mated condition exists. Furthermore, the aircraft SMS design should ensure that power is removed from the interface before a store separation at that interface to avoid power arcing and associated equipment damage during disconnect of a powered connector.

5.1.3.6 Pin function assignments. The approach to pin function assignments must first include a pin study to segregate signals into categories which relate the electrical functions and provide the maximum safety and electromagnetic compatibility. The characteristics of every signal in the aircraft/weapon interface should be defined as follows:

(a) Function name.

(b) Signal type - analog, discrete, pulse train, fire (single end or differential).

(c) Signal voltage - AC, DC.

(d) AC signal - volts, amperes, power factor, and phase relationship.

(e) DC signal - volts and amperes.

(f) Susceptibility threshold values.

(g) Grounding.

(1) Power

(2) Signal

(3) For interfaces controlled by MIL-STD-1760, the pin function and assignments for the electrical interface connector are defined in the standard. The characteristics listed above should still be defined for the specific signals applied to the interface lines. For example, if a pulse train is applied to one of the high bandwidth interfaces lines, the characteristics of the pulse train must be documented.

5.1.3.7 Location of electrical disconnects. Store connectors should be located in accordance with MIL-A-8591 (STANAG 3558 AA and AIR STD 20/14) and the keyway oriented as defined in MIL-STD-1760.

5.1.4 Electrical release systems design. The aircraft weapons system should provide two separate and independent release systems for each store or suspension device carried on the aircraft. One system shall be designed as the primary release method and the other as a back-up or secondary method. Dual or redundant circuits may be used in each system for increased reliability. However, the requirement for two separate systems cannot be satisfied by one system with dual circuits. The systems should be mutually exclusive and should be initiated by separate controls. The release systems should be designed such that the failure of any single component in either system will not cause a release, nor prevent a release upon intentional actuation of the other system. The systems should also be designed with the potential for carriage of stores with a specific electrical identity for store type and quantity. See 5.4 for SMS equipment design considerations.

5.1.4.1 Guidelines for armament system safety. To ensure armament system safety, the following guidelines should be followed:

(a) Weapon employment circuits should receive power from sources other than jettison circuits.

(b) Weapon employment circuits should not share wires or connectors with jettison circuits.

(c) A separate, guarded, master armament switch should be provided which provides a positive control of electrical power to all armament circuits.

(d) Circuit breakers should not be used as power switches in armament circuits.

5.1.5 Mechanical interface. The factors to be analyzed and examined, include but are not limited to those below, to determine the mechanical interface problem areas are as follows:

(a) Stores characteristics - The stores functional or operational characteristics, mission objectives, and their integration into the aircraft systems should be examined to better identify all factors associated with a compatible installation of stores onto the aircraft. The attach mechanism, the functional controls, and the store configuration should be known to allow the engineer to perform appropriate trade-off studies to arrive at an optimum employment of the weapon.

(b) Store geometry and attaching hardware location - The store geometry and location of attaching hardware at the aircraft/weapon interface shall be designed to provide interchangeability between various types of aircraft and interservice usage. The designer should consult the Allied Operations Publication (AOP-12) prepared by the Joint Ordnance Commanders Sub Group (JOCG). This manual will prove most useful in revealing possible interference between munitions or stores and the structures, pylons, bomb racks, etc. of the aircraft meant to carry them.

(c) Carriage configuration - The development of the aircraft/weapon interface must take into consideration the type carriage that will be incorporated into the aircraft, such as pylons, bomb bay, semi-submerged, or conformal. Shaping of the aircraft fuselage, control surfaces, and pylons are factors that must be coordinated with the suspension equipment and stores for proper system integration. Each discrete type of carriage must be adequately developed for maximum compatibility with existing and proposed suspension equipment and stores.

(d) Weight distribution - The carriage configuration must be developed with full consideration for store weights distribution on the aircraft such that a full complement of stores or any partial load has minimal effect on the aircraft static margin limits. In addition, the carriage configuration must be developed recognizing that expensive and limited availability stores may need to be returned to the airfield or aircraft if they are unused. The release sequence must also be evaluated to determine that normal release with possible random "hung" store, or stores, does not cause instability of the aircraft. Aircraft response and weapon dispersion effects should be assessed.

(e) Suspension equipment compatibility - The physical characteristics of the suspension equipment must be known to the engineer to allow proper integration of the equipment to the aircraft side of the interface. The physical characteristics consist of the external configuration of the suspension equipment, identifying size, shape, mounting holes or provisions; strength; stiffness; load factors; ejector force range; materials; connection locations; and access requirements. The aircraft interface should be compatible with requirements of MIL-A-8591.

(f) Alignment - The alignment of the suspension equipment in relation to the aircraft armament datum line should be controlled within appropriate tolerances. The alignment is necessary for proper store orientation with the flight path or attitude of the aircraft, and for stores (inventory or proposed) that may have boresight or seeker alignment requirements (see MIL-I-8671).

(g) Store interchangeability - The aircraft/suspension equipment interface should be designed to accept a variety of stores with minimum modification or special adapters to the aircraft. Interchangeability would avoid limiting the weapon carrying capability which reduces overall system effectiveness. Considerations for interchangeability would further enhance usage of interservice equipments.

(h) Fixed/jettisonable - Stores and suspension equipment jettison requirements can be met by separating the store from the suspension equipment, or by separating the suspension equipment with its store(s) from the aircraft structure. The factors to be considered in selecting the separation point are primarily the mission requirements (aircraft performance), complexity of the equipment, and the additional costs of expending the suspension equipment.

(i) Variable geometry aircraft - Where applicable, the aircraft design should provide for pivotal arrangements of wing pylons on variable geometry aircraft. Alignment of the store in relation to the armament datum line is obviously necessary to minimize degradation of performance due to windstream effects, but alignment and clearances must also be maintained within appropriate tolerances at the wing extended position, or any intermediate launch position, to preserve weapon accuracy.

(j) Attachment - The method of attachment of the suspension equipment to the aircraft structure must ensure proper carry-through of the load paths, and be designed for ready access to enable reconfiguring the aircraft and maintenance. Special attention should be given to avoidance of dissimilar metals and corrosion at the connecting interface. Positive locking methods of the attachment should be incorporated to ensure against inadvertent separation of the suspension equipment from the aircraft.

(k) Plumbing and wiring - The suspension equipment and stores requirements for plumbing and wiring interfaces must be determined. The aircraft side of the interface must provide appropriate wiring for release or jettison, weapon environmental and functional control, and arming and fuzing control. The system requirements must also be examined for use of environmental heating or cooling, pneumatics, hydraulics and fuel connections. MIL-STD-1760 defines much of the interface wiring requirements.

(1) Store sensing and identification - Depending on system requirements and aircraft geometry, considerations should be given to store sensing devices to provide positive indication of store present condition on the suspension equipment, particularly in the case of a bomb bay, fuselage or wing centerline station that cannot be observed by the crew inflight. This information is necessary to the pilot to indicate the completion of an attack and to confirm aircraft loading and weapon status. MIL-STD-1760 provides mechanism for automatically determining the identification of a store connected to the aircraft. MIL-STD-1760 also includes a mechanism (interlock interface) for verifying that the store is electrically mated to the aircraft. (This interlock interface, by itself, does not provide a reliable indication that the store has physically separated from the aircraft or is not physically present at the station.)

5.1.5.1 Safety devices. The weapon should be designed to incorporate safety devices that will preclude premature (inadvertent) launch or premature detonation, and ensure positive lock of the attachment of the suspension equipment to the aircraft structure, and the engagement of the stores to the suspension equipment. These safety devices may be broadly classified as inflight and ground type.

5.1.5.1.1 In-flight. The weapon should be designed to incorporate safety devices to preclude premature (inadvertent) launch or premature detonation. The aircraft side of the interface should provide appropriate controls to ensure proper and positive actuation of any safety devices controllable by the aircrew. The system should be designed to ensure that safe separation is accomplished prior to weapon in-flight arming or fuzing.

5.1.5.1.1.1 Interlocks. Mechanical or electrical interlocks should be applied to prevent inadvertent selection and attempted launch/jettison of stores. Interlocks that can prevent store release or jettison should also be incorporated into suspension equipment, bomb bay doors or any movable surface of the aircraft (such as extended landing gear).

5.1.5.1.1.2 Jettison. The interface should be so designed that positive and emergency jettison of all stores can be accomplished in an unarmed condition by the pilot in event of flight emergencies. The stores must be controllable for jettison or launch in an unarmed condition where separation may be necessary in friendly territory.

5.1.5.1.2 Ground. Mechanical devices should be applied at the aircraft/weapon interface to ensure positive lock of the attachment of the suspension equipment to the aircraft structure, and the engagement of the stores to the suspension equipment. Actuation and visual inspection of safety locks or hook open/closed condition must be positive and readily accessible. Provisions should be considered to allow loading or off-loading of stores, and application of any hoisting devices, with minimum exposure of ground personnel to a hazardous situation. Mechanical blocks should be provided for mechanical and electrical actuation to prevent accidental separation or detonation of stores even though other electrical or mechanical functions may have been compromised. (Typically, the application of a safety pin has been used to block hook opening of an ejection rack even if the ejector cartridges are inadvertently fired. Newer suspension and release equipment incorporate an in flight activated safety system.) The mechanical safety device should be located as close as possible to the explosive device, contained entirely within the weapon station without the use of loose or removable hardware, be readily accessible and operable without special tools, and be readily discernible at all times as to a safe or unsafe condition. Electrical or mechanical interlocks should also be incorporated, such as a weight off wheels switch, to prevent undesired electrical signals to the suspension equipment and stores until the aircraft has attained its flight environment. The aircraft electrical system must be designed to provide maximum protection against the hazards of electromagnetic radiation to ordnance (HERO) (see 5.1.8.5.3).

5.1.5.2 Accessibility. The aircraft/weapon interface should be designed with adequate space to allow minimum involvement of personnel and special equipment for the loading and off-loading of stores and to provide adequate clearance for the application of any checkout or special support equipment during these operations.

5.1.5.2.1 Loading or off-loading. The aircraft/weapon interface should be designed with adequate space provisions to allow loading and off-loading of stores with minimum involvement of special equipment and personnel. Consideration should be given to ground clearances such that the suspension equipment and stores can be operable and discernible without the use of special stands for the personnel. Aircraft geometry must be considered to provide for proper application of hoisting devices, loading carts or trucks, and to minimize inter-station interference with a full complement of stores, or a partially loaded configuration. Adequate clearance must be provided for actuation of bomb rack hooks, actuation of safety devices, electrical connector hook-up, positive visual determination of status of installation of stores, adjustment of sway braces, or any other mechanical adjustment required.

5.1.5.2.2 Checkout and preparation. The aircraft/weapon interface should have adequate clearance for the application of any checkout or special support equipment to be used during loading or off-loading operations. The suspension equipment, typically, requires application of electrical connectors for test or release system, weapon functional control, and a stray-voltage check prior to connections to an electroexplosive device. Where cartridge fired racks are employed, access must be provided for installation of cartridges and functioning of appropriate mechanical safety devices. Objectively, the store should be delivered to the aircraft as an "all-up" weapon (any store which is completely assembled, both mechanically and electrically, and ready for installation in or on the aircraft), however, access may be required to the stores when loaded to the aircraft weapon station for fuze installation, actuation, and visual determination of fuze settings, igniter connections, thermal battery status, or any functional control that must be pre-set prior to flight.

5.1.6 Aircraft structure. When designing an aircraft intended to carry or employ stores, the designer should provide adequate strength and rigidity for the total weapon system (aircraft, suspension equipment, and stores) under all conditions of intended and anticipated use. Airplane structural strength and rigidity requirements are specified in MIL-A-8860, MIL-A-8861, MIL-A-8863, and MIL-A-8865 through MIL-A-8870. Helicopter structural strength requirements are specified in MIL-S-8698 for U.S. Army and U.S. Air Force helicopters, and in AR-56 for U.S. Navy helicopters. In complying with these requirements, the designer should provide adequate strength for all possible combinations of required- arriage stores and suspension equipment under all conditions of taxi, field take-off, rough-field and catapult take-offs (if applicable), flight, field-landing, rough-field landing (if applicable), and arrested landings (if applicable). Aircraft structure should be designed so that loads imposed by stores are reacted with the minimum structure (for example, bomb bay supporting structure should be located near store c.g. to minimize moments.) Primary areas of concern are discussed in 5.1.6.1 through 5.1.6.3.

5.1.6.1 Carriage loads. The aircraft should have sufficient strength for the carriage of all specified stores and suspension equipment, in all possible combinations, throughout the carriage envelope of the aircraft or the stores, whichever is more restrictive (see MIL-A-8591). Carriage loads imposed upon the aircraft by stores or suspension equipment include those resulting from aerodynamic and inertia conditions, asymmetric loadings (wing, fuselage, and rack), changes in store center-of-gravity locations, separation conditions (ejection, employment, jettison, and g-jump).

5.1.6.2 Flutter and vibration. The total weapons system should be flutter-free and should meet the flutter and vibration strength and rigidity requirements of MIL-A-8870 for airplanes, (also MIL-A-87221 for U.S. Air Force) or MIL-S-8698 for U.S. Army and U.S. Air Force helicopters, or AR-56 for U.S. Navy helicopters. The requirements are applicable throughout the entire carriage envelope. All possible combinations of required-carriage stores and suspension equipment should be investigated, or analyzed, and critical combinations tested; including all hung-store conditions and combinations.

5.1.6.2.1 Mechanical instability. For helicopters, the total weapon system should be free of mechanical instability and any adverse rotor induced forced vibrations of stores. Design procedures should be in accordance with MIL-A-8591.

5.1.6.3 Landing loads. The aircraft must have sufficient strength to land at normal sink rates with the maximum practicable number of stores and suspension equipment aboard. Landings include field-landings, rough-field landings (if applicable), vertical landings (if applicable), and arrested landings (if applicable). In addition to the obvious U.S. Navy arrested landing requirement, the designer should be aware that arrested landings are normal for U.S. Air Force airplanes under wet field conditions. Therefore, these conditions, with resulting side loads, should be included in the aircraft design. In deriving the maximum practicable number of stores and suspension equipment, the designer should base his determinations upon such conditions as the reluctance of operating personnel to jettison expensive or short-supply stores or suspension equipment, prohibitions against jettisoning nuclear weapons, hung-stores, and store or suspension equipment logistic problems in the fleet and field. Landing loads imposed upon the aircraft by stores/suspension equipment should include all critical conditions such as asymmetric store loadings (wing, fuselage, and rack), and the effects of dynamic response.

5.1.7 Aerodynamics. The purpose of this section is to make the aircraft designer aware that he must consider the impact of the various store arrangements on the aerodynamics of the total system. The following paragraphs highlight the primary areas of consideration and provide some typical problems encountered in aircraft/store compatibility.

5.1.7.1 Flying qualities. The flying qualities requirements of MIL-F-8785, MIL-H-8501, and MIL-F-83300 must be investigated for critical aircraft/store configurations, with both internal and external stores. The effects of stores on the weight, moments of inertia, center-of-gravity positions and aerodynamic characteristics of the airplane should be considered for each applicable mission. When the stores contain expendable loads, the requirements of MIL-F-8785 apply throughout the range of store loadings. Investigation of flying qualities for store combinations should include asymmetric as well as symmetric combinations. The critical store loadings identified in the analyses of 6.1.5 should be flight tested with aircraft suitably instrumented to obtain quantitative flying qualities data.

5.1.7.1.1 Store carriage locations. In the selection of store carriage locations, flying qualities effects due to center-of-gravity, weight, and moments of inertia must be carefully investigated. Generally, aircraft which have stores located such that the resultant aircraft center of gravity is at or near the allowable forward or aft limit, will exhibit greater effects on stability and control characteristics during stores release. Similarly, for aircraft with external wing stores, the greater the spanwise distribution of stores the greater the lateral control problem, for both symmetric and assymmetric store loadings.

5.1.7.1.2 Store carriage and separation aerodynamics. The aerodynamic effects of the stores on the aircraft's flying qualities during carriage and separations must be carefully analyzed for all possible store combinations during the initial aircraft design phases. Some of the more general aerodynamic characteristics affected by stores carriage which should be investigated, but not limited to, are the following:

(a) Stability with external store carriage.

(b) Stability with internal store carriage.

(c) Engine ingestion of missile exhaust gases.

(d) Store release transients.

5.1.7.1.2.1 Stability with external carriage. Location of external stores relative to the wing leading edge and horizontal tail can have a marked effect on longitudinal stability and buffet characteristics. In addition, increasing wing sweep decreases the longitudinal stability with wing mounted external stores. Generally, airplanes with wing sweep greater than 30 degrees show the greatest stability loss with external stores.

5.1.7.1.2.2 Stability with internal carriage. For aircraft designed for internal store carriage, opening of the bomb bay doors, similar panels or trapeze extensions should not excessively degrade the airplane flying qualities. Flying qualities effects such as buffet characteristics, directional stability, and longitudinal stability should be investigated with the bomb bay doors open (both full and to intermediate positions) and operating.

5.1.7.1.2.3 Engine ingestion of missile exhaust. Aircraft engine ingestion of missile exhaust plumes from rocket motors can cause engine flame-out or degraded performance. Often to minimize adverse aircraft engine characteristics due to missile exhaust gas ingestion, engine thrust levels are momentarily reduced during the missile or rocket firing sequence and airplane trim changes may ensue.

5.1.7.2 Optimizing carriage aerodynamics. When designing an aircraft, the effect of store carriage on aircraft performance must be minimized. A great variety of stores is available in many different carriage combinations. For example, certain store combinations can produce an incremental drag equal to or even greater than the basic drag of the clean aircraft, and therefore, it is crucial to consider their effects on aircraft performance.

5.1.7.2.1 Choosing carriage class. The two major classes of store carriage are "internal" and "external". There are important effects of each to be considered in aircraft design, the choice of either or both types depending on mission requirements. An analytical approach backed up by substantial experimental proof will lead to the best store arrangement for a given mission.

5.1.7.2.2 Internal carriage aerodynamics. Internal carriage usually results in a larger fuselage cross-sectional area and larger aircraft take-off weight. However, particularly for larger store loads, the additional drag of the fuselage is often less than that resulting from external store carriage during cruise. The critical design condition (after making the necessary mission cruise performance tradeoffs) is actual store delivery. The design of the cavity shape and method of closure can affect store delivery, aircraft stability and control, and engine-inlet performance.

5.1.7.2.2.1 Weapon bay design. Early incorporation of good aerodynamic design inside the weapon bay is necessary in order to reduce the possibility of having weapon separation problems or weapon buffet problems for weapon bay loadings. If this is not accomplished, the aircraft flight test program may reveal severe problems in separating weapons from the bay which would require a major redesign of the aircraft. Or it may reveal that the vibration-buffet environment to which the weapons in the bay are subjected, exceeds the limits of the weapons or their fuses, requiring major redesign of the weapon or the aircraft. The following should be considered in the design of the weapon bay of all high speed aircraft:

(a) The major problem associated with weapon bay releases at high dynamic pressure and supersonic speeds is the strong vortex inside the weapon bay which can cause pressure changes such that the weapon will not fall or will exhibit undesirable motions within the bay or just below the bay. The vortex can be reduced to an acceptable level by changing the aft bulkhead of the bay from the normal vertical design to a downward-sloping ramp. A similar effect can be accomplished by venting the aft bulkhead (assuming that sufficient venting can be provided).

(b) Spoilers located ahead of the weapon bay can produce favorable effects on the separation characteristics of weapons separated from the bay. Wedges ahead of the bay can improve weapon separation from the aft part of the bay but have unpredictable effect on the separation from the forward part of the bay.

(c) The weapon location in the bay has a very noticeable effect on the weapon separation. The weapons located at the back of the bay will be affected the most since the vortex is strongest at the back of the bay. These weapons will generally undergo large perturbations upon release.

(d) Particular attention should be given the forward part of the weapon bay doors or any other protuberance near the forward part of the bay. At supersonic speeds, the forward part of the weapon bay doors (or any other protuberance) will generate a large shock wave ahead of the doors which will separate the boundary layer on the body and cause it to increase several times in thickness. This thickened boundary layer cannot be maintained over the bay cavity and expands into the bay increasing the turbulence.

(e) The weapon bay doors should be designed that when in the open position, the doors have a minimal effect on the separation of weapons from the bay. The optimal open door position would have the entire door above the lowest part of the bay. If this design cannot be employed, then the leading edge of the door should be pointed to reduce the strength of the bay door shock to keep the shock attached to the doors instead of out ahead of the doors.

(f) All weapons carried in bays should be suspended from devices that are capable of adjusting the ejection velocity and ejection pitch rate. The suspension device should be compatible with the longest lug spacing available for applicable weapons because the longer spacing reduces the problem of bomb vibration in the bay. The suspension device must be designed to adequately take out the rapidly changing side load forces due to the turbulence in the bay.

(g) After an acceptable weapon bay design has been tested and determined to have satisfactory weapon separation characteristics and vibration-buffet levels, it is essential that the weapon bay design not be changed. This includes addition of equipment boxes inside the bay, covering up or restricting vent holes, or adding external protuberances ahead of the weapon bay. If any change is made which might affect the flow inside the weapon bay, a costly program will be required to check the weapon bay for satisfactory separation characteristics and satisfactory weapon vibration-buffet levels.

5.1.7.2.3 External carriage aerodynamics. External carriage involves a more complex store arrangement. The primary benefits are a "clean" and lighter aircraft on the return flight and more potential and flexibility in loading arrangements. The situation is complex because of many considerations which must be made. Two basic types of external store carriage are "single" or "multiple". Two basic approaches are pylon mounted, and conformal (tangent to aircraft surface or partially submerged). The loads on stores and aircraft (and pylons) are not generally additive. In the case of mulitple carriage, the interference effects between stores and the aircraft can exceed store-alone loads and can considerably degrade the performance of the aircraft. The flow environment in the fuselage region is quite different from that in the wing region. Further, adjacent store carriage stations have considerable interactive effect and the interference field can extend from one side of the aircraft to the other. In general, the aerodynamic drag of externally mounted stores is a function of, but not limited to, the following:

(a) Chordwise and spanwise location.

(b) Length of pylon on which the store is mounted (distance to aircraft surface).

(c) Whether wing or fuselage mounted.

(d) Submerged or semi-submerged.

(e) Side-by-side or tandem.

(f) Single or multiple.

(g) Angle of mounting relative to aircraft flow field (pitch and yaw).

(h) Wing sweep angle.

(i) Proximity to high lift devices (deflected or undeflected).

(j) Proximity to other stores.

(k) Other considerations unique to individual aircraft.

These variables are in addition to those due to the shape and size of the particular store being considered.

5.1.7.2.3.1 Wing mounted stores. Variable aircraft geometry, (wings, flaps, slats, speed brakes), is often advantageous and desirable from an aircraft aerodynamic standpoint; however, the impact of store carriage requirements can either force a change in store location, a change in variable geometry philosophy, or an acceptance of system degradation. Wing mounted external stores often cause severe aircraft maneuvering penalties in the form of restricted roll rates or inability to maintain moderate maneuvering g levels. The further outboard the stores are from the aircraft centerline, the more severe these penalties become. Ground clearances can have considerable impact on take-off and landing performance. Each of these items must be considered in turn and then as part of the total system performance.

5.1.7.2.3.2 Pylon design parameters. As an example of some specific design parameters that must be resolved for a particular area, we shall discuss some of these for a pylon design. The pylon design should be as streamlined and as small as possible with few or no openings and protuberances. Optimum alignment based on minimum drag and side forces should be achieved based on the flight envelope. It should be faired to the primary structure to decrease drag effects. The types of store mountings (single, multiple) will have some aerodynamic effect on desired pylon depth, length, and angle into local flow. In addition to these purely aerodynamic considerations, the cg of the store load and ground clearances should be optimized for takeoff, in-flight, and landing performance. Variable geometry aircraft components can lead to physical and aerodynamic interference, particularly in the case of variable sweep wings. Since the overriding consideration in store installation is usually optimum aircraft performance, designers of high speed aircraft are often led to conformally mounted stores (tangent mounting) to eliminate the need for multiple racks and pylons and to place a significant portion of the store in the boundary layer. Further, the aerodynamic effects and signature variations of partially loaded racks or exposed store mounting areas must be considered as these situations occur after weapon delivery. The pylon design should also consider the following electrical areas:

(a) Installation of stores management encoders/decoders.

(b) Installation of AMAC encoders/decoders.

(c) Installation of bomb racks containing an electrically operated in-flight-operable-bomb-lock.

(d) Repairable and replaceable environmental and EME sealed pylon and umbilical adapter cables.

5.1.7.2.4 Drag count (index) system. The large variety of external store loadings permitted on some aircraft, requires a method of data presentation, which can be used to obtain the performance of the aircraft, without requiring an individual chart for every combination of store loadings. This method is referred to as the Drag Count, or Drag Index System. In the Drag Count (Index) System, each external store, such as a bomb or fuel tank, is assigned a drag value that is relative to its installed drag and its location on the aircraft. This number is usually the incremental installed drag (ΔC_D) of the store, multiplied by a constant. The individual drag count numbers for each store are then combined to obtain the total drag count for a given loading. This number is then applied to a chart which defines the performance of an aircraft over a range of drag counts (indices).

5.1.8 Environment. The aircraft and its electronic, electrical, and electro-explosive subsystems associated with store and suspension equipment should be designed to function without degradation under all operating conditions in the natural and induced service environments. The environmental parameters defining the transportation and storage requirements of vibration, time, and temperature exposure must also be clearly defined. Aging of certain materials and the vibration spectrum of shipping and handling can seriously damage equipment that was specifically designed for a narrow operationally defined environment.

5.1.8.1 Store related equipment within aircraft. Equipment associated with a store and located on or within the aircraft should be designed to withstand, and function while being exposed to, the representative operational vibration environments specified in MIL-STD-810, Method 514.3, 515.3, or to actual in-flight measured vibration levels, which ever is the most severe. This equipment should also be designed to withstand transportation and storage environments throughout the life of the aircraft.

5.1.8.2 Aeroacoustic or acoustic. The aircraft/store interface equipment which is exposed to aeroacoustic or acoustic pressure fluctuations should be designed to withstand sonic fatigue. This requirement is usually met by design trade-offs. MIL-A-87221 and handbook AFSC DH 2-1, Design Note 2C7, cover the design of aircraft/store interface equipment from an aeroacoustic standpoint. Power augmented stores sometime present a severe sonic environment to adjacent stores or aircraft structure; the provisions of 5.2.6.3.2 apply to this situation.

5.1.8.3 Thermal. Design consideration must be given to the thermal environment which the aircraft imposes on the store and associated suspension equipment. Most stores contain or consist of combinations of explosives, propellant, fuel, electronic equipment, or special materials which are thermally limited by either a minimum or maximum exposed temperature, or a time-temperature soak condition. Cartridges and firing machanisms within the suspension and release equipment are also thermally limited. It is the responsibility of the aircraft designer to:

(a) Define the most severe thermal environment-field around each store station. This may occur during take-off (for a VTOL or STOL aircraft), carriage, exhaust gas impingement from an adjacent launching store, or similar effect. This information may be used for future store design criteria.

(b) Provide a thermally compatible system for specified stores. This may include such things as providing a thermally controlled weapons bay, store heaters, or a cooling source ducted to each store. Usually, temperatures exceeding 165°F are to be avoided, or will require special design considerations. For detailed information, consult MIL-STD-210 and MIL-STD-810.

5.1.8.4 Nuclear hardening. Nuclear hardening can be defined as the deliberate actions taken to design a system to operate in nuclear weapon environment. Particular attention must be given to the design problems associated with the nuclear environment which may be imposed in the aircraft by a store. Damage to the aircraft's mission-essential subsystems resulting from neutron and gamma radiation caused by close juxtaposition of, or combat damage to, the stores is of particular concern to achieve acceptable nuclear hardness with the minimum impact on the performance of each system. To achieve nuclear hardening the following steps should be taken:

(a) Define the initial estimate of the threat to the system.

(b) Consider various levels of nuclear hardness. Tradeoffs between various levels of hardness, and other characteristics such as weight and cost, must be described in quantitive terms.

(c) The tradeoffs between the level of hardness, cost, performance, reliability, and maintainability should be further refined and final system specifications confirmed.

(d) Sufficient analysis and testing of each system should be accomplished during development to establish the ability of the system to meet the requirements of the hardness specifications.

5.1.8.5 Electromagnetic. Electromagnetic energy generated by radio, radar, and other transmitting equipment in the aircraft, in adjacent aircraft on mobile ground platforms (i.e., trucks, vans, and ships) and at fixed locations both on land and afloat continually impinges upon the aircraft, its stores and suspension equipments, any or all of which may contain electro-explosive devices. This environment varies from airfield to airfield, from checkout and maintenance areas to arming and launching areas, and in flight from areas over friendly forces to areas over hostile forces. The magnitude of the above mentioned electromagnetic environments are defined in MIL-STD-461 with supplementary Navy environments defined in MIL-HDBK-235 -1 and supplementary requirements for Army applications in Army Missile Command TR RD-TE-87-1.

5.1.8.5.1 Design guidance. The aircraft designer should consult the following design guidance documents in relation to protection requirements for electromagnetic energy:

Navy - SD-24
Air Force - AFSC DH 1-4
Army - Handbook AMCP-706-235 Report 18

5.1.8.5.2 Electroexplosive subsystems. Electroexplosive subsystems within the aircraft should be designed to comply with the following:

Navy - MIL-I-23659
MIL-STD-1385
MIL-HDBK-235-1
Design Guide OD 30393

Air Force - MIL-STD-1512
Design Guide AFSC DH 2-5

Army - Handbook AMPC-706-235, Report 18

5.1.8.5.3 Electromagnetic interface. Aircraft electrical and electronics subsystems must be designed to be compatible with the stores and suspension systems associated with the aircraft. These stores and suspension systems must be designed to meet the electromagnetic interface characteristics of MIL-STD-461, MIL-STD-462, as well as applicable sections of MIL-HDBK-235-1 and Army Missile Command TR RD-TE-87-1. Overall electromagnetic compatibility (EMC) is addressed in MIL-E-6051.

5.1.8.5.4 Electrical bonding and lightning protection. Electrical bonding and lightning protection requirements should be in accordance with MIL-B-5087. Special electrostatic protection by grounding is provided by NAVORD OP-4.

5.1.8.5.5 Electrostatic protection. Aircraft shall be designed to minimize generation of static electricity and to prevent static electricity from degrading overall system effectiveness. Special static protective procedures, such as grounding are required for weapons loading and unloading operations. The following design guidance documents should be used:

Navy - OP-4
Air Force - AFR 127-100, DH 1-4
Army - AMCP-706-235 Report 18

In addition, DOD-HDBK-263 and DOD-STD-1686 define electrostatic protection requirements for non-electroexplosive system electrical/electronic equipment. Electrostatic protection requirements for electroexplosive system equipment is defined by MIL-STD-1512.

5.1.8.5.6 Electromagnetic interference filters. Where electromagnetic interference (EMI) filters are shown to be necessary in electrical or electronic subsystems within the aircraft, they should be designed to protect against the specified frequencies and field intensities and evaluated when terminated in the tactical input and output impedances. The filters shall comply with the requirements of MIL-F-15733. Radio frequency (RF) filter characteristics shall be monitored for production purposes in accordance with MIL-STD-220.

5.1.9 Propulsion effects. The effects of the aircraft's propulsion system, particularly VTOL and V/STOL type aircraft, on the stores when installed on the aircraft must be critically analyzed and studied. Likewise, effects on the aircraft engine caused by the carriage and release/launch of stores shall be considered. Some problem areas that must be investigated are shock wave effects, blast effects, engine armament gas ingestion, interference with devices to prevent engine malfunction or sustained loss of power.

5.1.9.1 Rate of pressure and temperature change. The maximum permissible rate of change of inlet total pressure and temperature for the installed engine(s) at any operating condition, without surge, stall, flameout, high fan compressor blade stresses, or any mechanical damage should be as follows:

Rate	Maximum change
30,000°F/sec	550°F
300°F/sec	500°F
300 psi/sec	0.90 psi
70 psi/sec	5.0 psi

If satisfactory engine operation cannot be met with the defined pressure and temperature limits, a reset system is required for all appropriate stores.

5.1.9.2 Engine ingestion of armament gas. The installed engine(s) must operate, without stall, surge, flameout, high fan/compressor blade stresses, or any mechanical damage as a result of gas ingestion. During armament gas ingestion, the applicable rates of pressure and temperature change of 5.1.9.1 should be met, without the use of a reset system. The effect of armament gas ingestion on engine performance throughout the engine operating envelope and in all modes of operation, including engine reset condition, is included in the engine performance card deck.

5.1.9.2.1 Gun gas ingestion. In establishing gun gas ingestion criteria, the number of conditions should be defined and for each condition the engine power setting, the altitude, mach number, allowable quantity and composition of gas ingested and maximum firing duration should be determined. The engine(s) should operate in accordance with 5.1.9.2.

5.1.9.2.2 Rocket gas ingestion. In establishing rocket gas ingestion criteria the following minimum design parameters must be defined and their relationship to the engine in the operating environment determined:

(a) Type of rocket.

(b) Rocket fuel composition.

(c) Rocket plume composition.

(d) Rocket mass flow rates.

(e) Firing duration.

(f) Rocket plume characteristics and chemical composition as a function of distance away from nozzle versus altitude and mach number.

(g) Rocket flight paths for the various loading configurations.

(h) Define the number of conditions and for each condition include the following as the minimum data conditions:

(1) Engine power settings.

(2) Engine altitudes.

(3) Mach numbers.

(4) Ingestion duration.

(5) Allowable quantity of gas ingested.

(6) Allowable composition of gas ingested.

The engines should operate in accordance with 5.1.9.2.

5.1.9.2.3 Infrared flare smoke ingestion. In establishing infrared (IR) flare smoke ingestion criteria, the number of conditions should be defined and for each condition the engine power setting, the altitude, mach number and quantity of smoke ingested should be determined, as well as defining whether an engine reset system is required. The engine should operate in accordance with 5.1.9.2.

5.1.9.2.4 Foreign object damage. The contractor should equip the engine inlet areas with foreign object damage (FOD) protection devices. These devices protect the engines from FOD that may be generated during the release of stores and equipment.

5.1.9.2.5 Chaff ingestion. In establishing the chaff ingestion criteria, the maximum chaff ingestion requirements created by decoys or other aircraft should be defined.

5.1.10 Gunpod installations. For an aircraft to be compatible with an external gunpod the following minimum design criteria should be defined:

(a) The operating environment.

(b) Reactions and functions associated with the gunfire.

(c) Ease of service.

(d) Maintenance criteria.

(e) Installation and removal criteria.

(f) Adjustment for boresighting.

(g) Harmonization (correlating all the components of the gun system under dynamic conditions).

(h) Ammunition loading and unloading criteria.

5.1.10.1 Internal vs. external gunpod installation.

5.1.10.1.1 Advantages. The internal gun installation has several advantages over the external gunpod installation. Some of these are:

(a) It provides a stiffer gun platform.

(b) Increases accuracy.

(c) Produces less drag.

(d) Improves the airplane's performance.

5.1.10.1.2 Disadvantages. The internal gun installations disadvantages over the external gunpod installations are:

(a) Blast pressure affects the skin surface and structure since the gun barrels are closer to the airframe.

(b) Vibration from gun fire loads are transmitted directly into the airframe instead of the store mounting station.

(c) Closer proximity to engine inlets may cause blast pressure and gun gas ingestion problems.

5.1.10.2 Muzzle blast pressure wave. The magnitude of the pressure wave from the gun muzzle during gunfire is a function of gun caliber, chamber pressure and the quantity of propellant per round. To a lesser extent the length of the barrel will also have some effect. The firing rate also has some effect since the rate of its harmonics may coincide with structural natural frequencies. Neglecting some initial air and gun gas effects as the projectile leaves the muzzle, there is a shock wave formed by the projectile and, of more signifigance, a pressure wave formed by the hot, high pressure gases expanding from the muzzle. The magnitude of this pressure wave is a function of the distance from the muzzle, primarily in the forward direction. Only a relatively short distance aft of the muzzle sees this pressure wave. As an example, Figure 1 presents a pressure map of the 20mm M61A1 gun during single shot firing with conditions as specified thereon. Because of the short pulse duration, one millisecond or less for the M61A1, a pressure map for rapid or burst firing may be considered as similar. A pressure map when the barrel is located 24 inches (610mm) away from a flat plate is presented in Figure 3. A comparison of these two figures shows a noticeable decrease in pressure near the muzzle. The latter map is more representative of a gunpod installation. Figures 2 and 4 present pressure maps when a blast diffuser is used on the muzzle. Conditions for each are presented on the respective figures. These do not necessarily represent the optimum and each system should be examined for meeting the specifics of its own installation requirements. Other features of blast deflectors/diffusers are to direct the gun gas in a particular direction, such as away from the engine inlet. Whether a deflector is used or not, the aircraft skin, including access panels and servicing doors, must be designed to withstand the pressure wave generated as well as any abrasive action of the gun gases.

5.1.10.3 Vibration generated at gun muzzle. Vibration generated at the gun muzzle will depend on the firing rate, number of guns and muzzle energy. Muzzle energy is readily available as a parameter and equals $1/2\ mv^2$ where m is the projectile mass and v is the muzzle velocity. Structural vibration is characterized by maximum levels concentrated in front of and near the gun muzzle and coupled with the blast pulses. The levels exhibit a sharply decaying behavior as a function of the distance from the muzzle and can be approximated by an exponential function. Although muzzle deflectors and diffusers may have some effect on attenuating the induced vibration, the extent of the attenuation is considered minimal for any device hard mounted to the airframe. As a general guideline, equipment located within 50 calibers (50 x bore diameter) of the muzzle are subjected to the induced gunfire vibration and should be designed to withstand that environment.

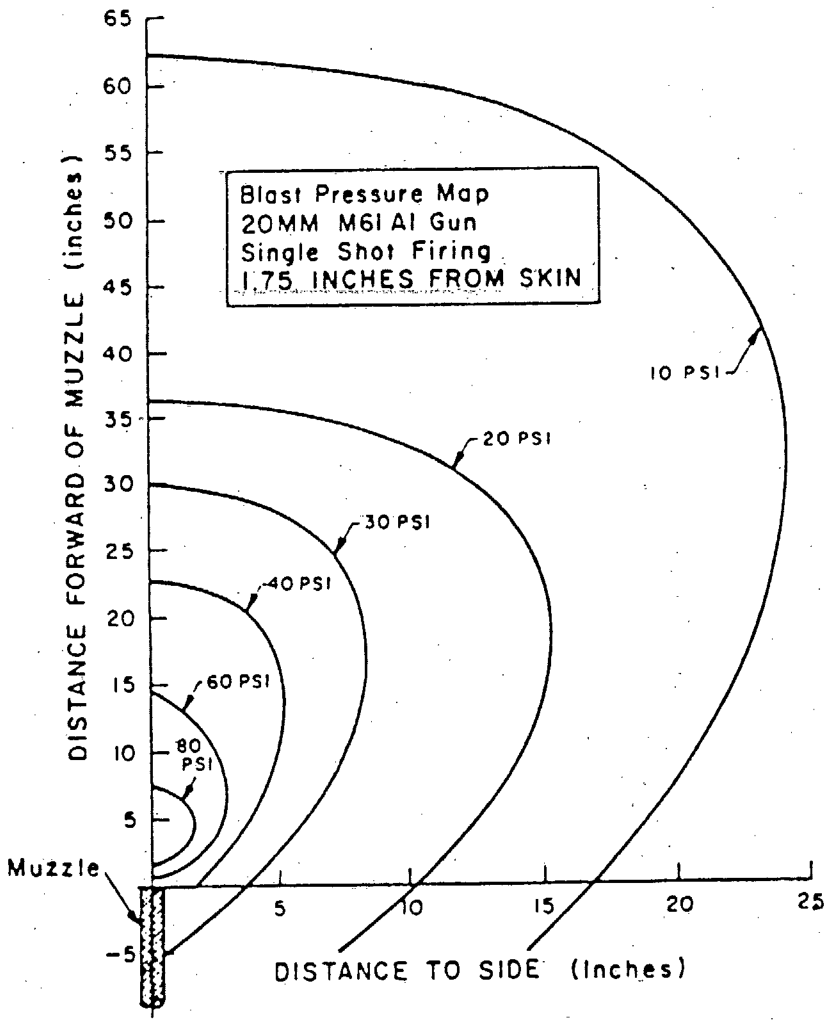

FIGURE 1. No diffuser.

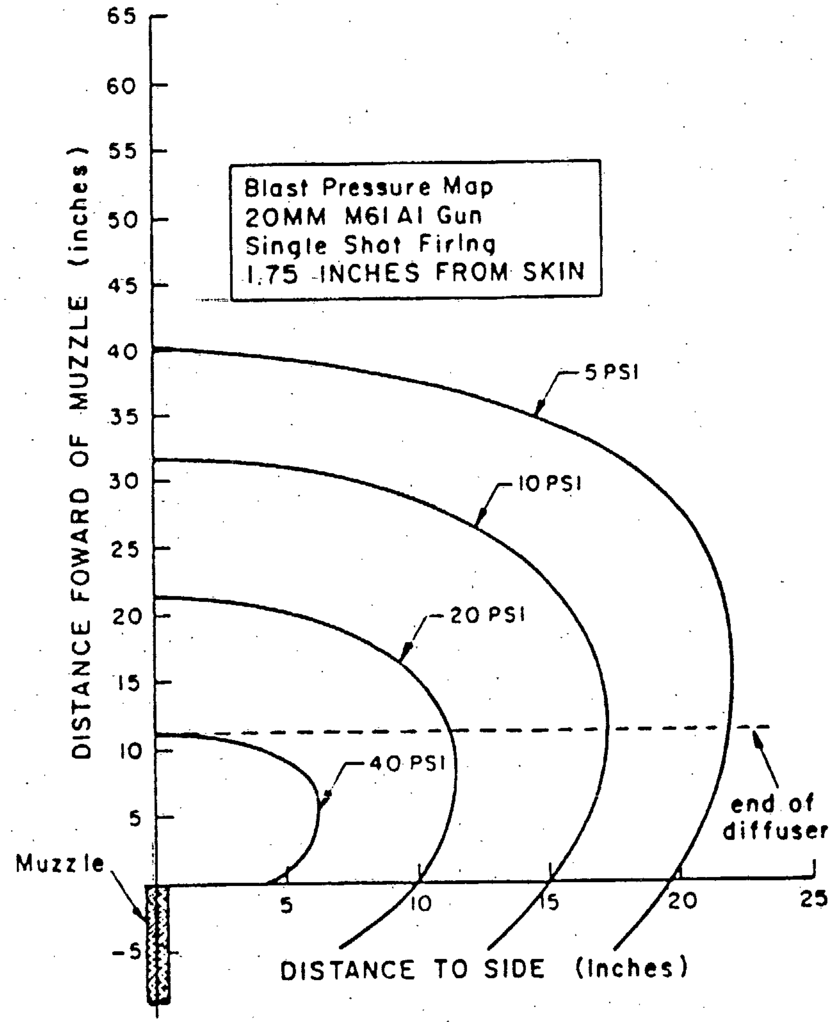

FIGURE 2. With diffuser.

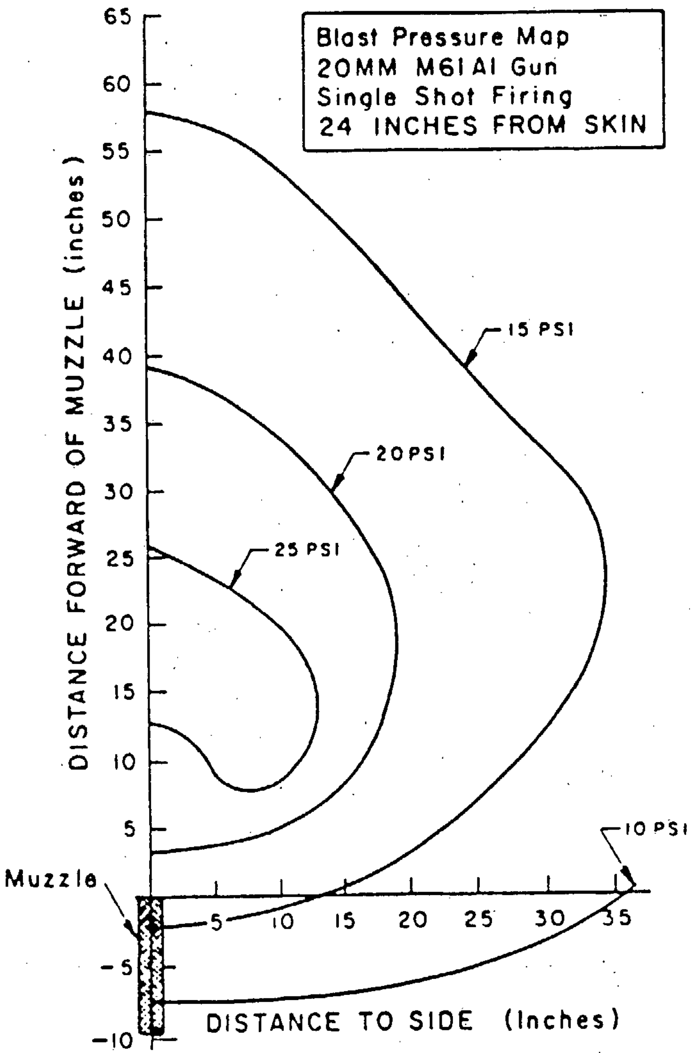

FIGURE 3. No diffuser.

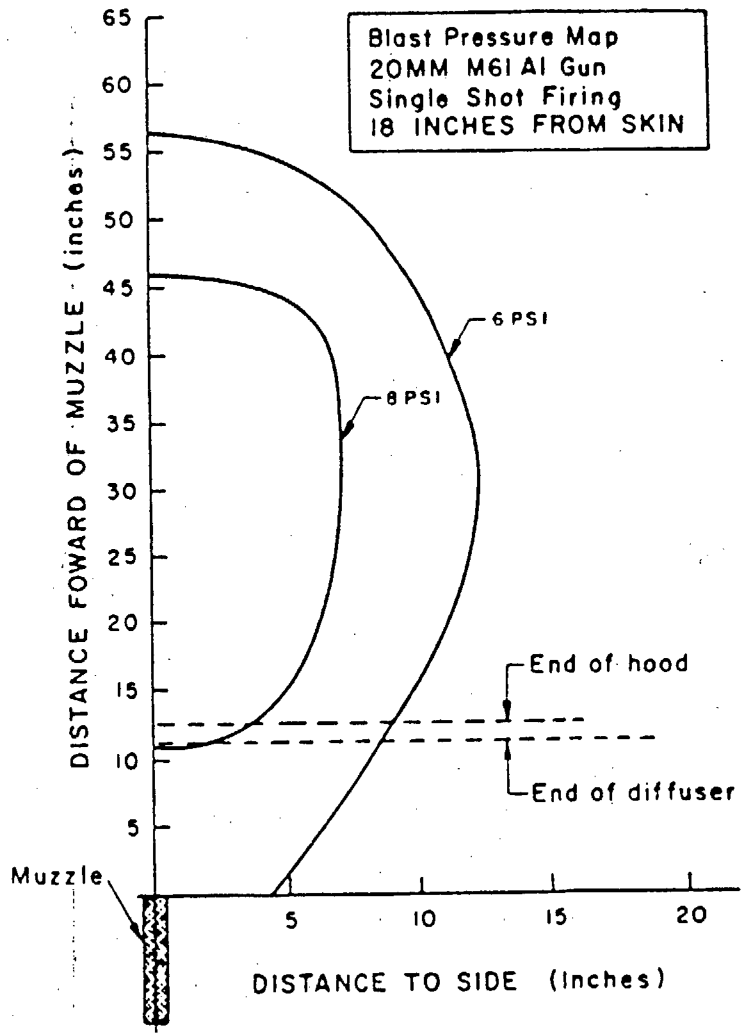

FIGURE 4. With diffuser.

5.1.10.3.1 Aircraft gunfire vibration report. The AFFDL TR-70-131, "Aircraft Gunfire Vibration" report, dated November 1970, is recommended for establishing the rationale and models to be used in estimating gunfire vibration levels. The report investigated pulses relating to three main cases of gunfire:

(a) Constant firing rate.

(b) Variable firing rate (gatling gun).

(c) Unsynchronized, multiple gun arrays, which is characterized by multiple pulse trains randomly phased with each other.

5.1.10.3.1.1 Gunfire report objectives. The AFFDL TR-70-131, "Aircraft Gunfire Vibration" report had two prime objectives. These are:

(a) The development of a prediction rationale for estimating the magnitude and character of gunfire induced vibrations which must be reacted by the aircraft gun installation structure.

(b) The synthesis of a laboratory vibration test procedure which may be used to qualify future equipment.

The test technique developed from this work has been published as Method 519.3 of MIL-STD-810.

5.1.10.4 Vibration at gun mounts. Although normally not as severe, vibration due to gunfire also is transmitted into the airframe at the gun mounts. The intensity of the vibrations at these primary mounting locations generally is further attenuated and is a function of the recoil adapters.

5.1.10.5 Acoustic environment. The acoustic environment produced by gunfire is, like the vibration, of the impulse type with the muzzle being the primary source. There are two major effects of the induced gunfire noise environment that must be considered; namely, human tolerance and sonic aircraft structural fatigue.

5.1.10.5.1 Human tolerance acoustic level. The noise level in the cockpit should not cause pain or any danger to the aircrew's hearing. The damage risk level varies with frequency, duration, and intensity of the noise pulses. Accepted damage-risk criteria are presented in Figure 5. The noise level should also not have any adverse affects on the cockpit instrumentation.

5.1.10.5.2 Aircraft structure sonic fatigue. MIL-A-8870 and MIL-A-87221 require noise surveys on structures where they are estimated to exceed 140 decibles (dB). The relation between muzzle pressure and noise level or sound pressure level (SPL) can be expressed by the following:

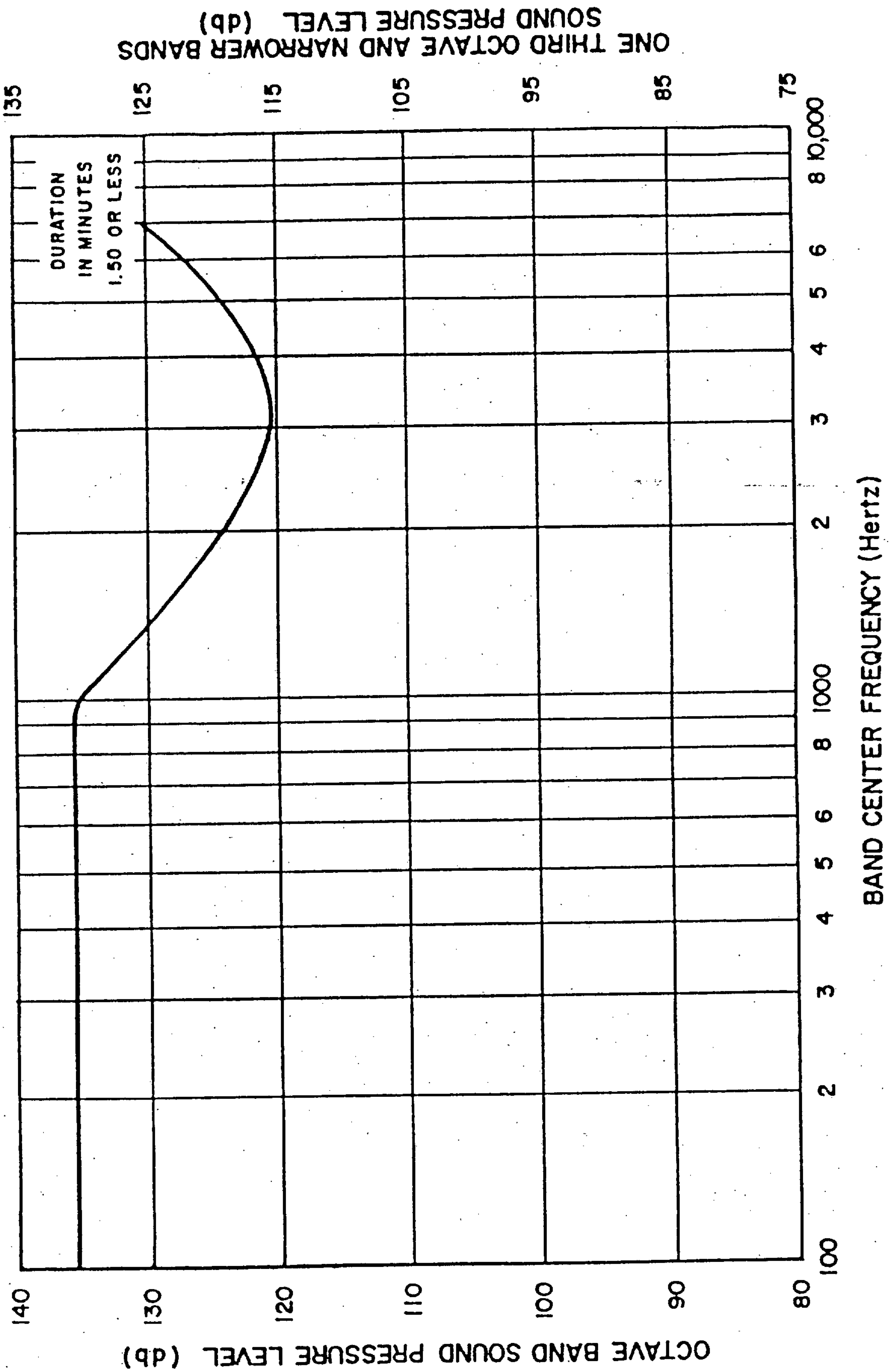

FIGURE 5. Damage-risk contours for one exposure per day to octave (left-hand ordinate) and one-third octave or narrower (right-hand ordinate) bands of noise.

$$dB = 20 \log \frac{P}{P_o}$$

Where: log = logarithm to the base 10
P = muzzle pressure, (psi)
P_o= reference pressure (3×10^{-9} psi) (20.7×10^{-6} Pa)

The 140 dB level is reached at approximately .03 psi, (207 Pa), utilizing the muzzle pressure maps, it is evident that a large area around the gun muzzle and extending a considerable distance in front of the muzzle will be subject to sonic fatigue.

5.1.10.6 Mounting and load characteristics. A gun system may be internally mounted in many different locations and by a variety of ways, all or any of which may be satisfactory for the particular installation. The following factors, but not limited to those listed, must be defined and analyzed in determining a compatible internal gun installation:

(a) The caliber and type of gun being installed.

(b) Number of guns for the installation and firing rate of each.

(c) Location of firing barrel with respect to aircraft and gun center of gravity and gun mounts.

(d) Gun drive system and requirements if externally driven (internal can be gas or recoil operated).

(e) Type of feed system - linked or linkless and power required to operate.

(f) Capacity of ammunition storage system and power required to operate.

(g) Retention or overboard ejection of links and shells or unfired rounds.

(h) Recoil adapters and mounts provided on gun and other components. Determine whether pallet, modular or individual component mount is more appropriate.

(i) Boresight and harmonization (correlating all the components of the gun system under dynamic conditions) requirements.

(j) Access to the gun system for cleaning jams, loading and unloading ammunition and cases/debris, and changing gun barrels.

The mounting of all components, except the gun, generally presents only normal engineering tasks and these will not be discussed.

5.1.10.6.1 Functioning in flight. A very important design criterion for mounting all components of the gun installation is the requirement for the system to function (no jams) while being subjected to any of the conditions attainable in the aircraft flight design envelope and be capable of operation after being subjected to aircraft limit loads (150% design loads).

5.1.10.6.2 Hard mounting of gun. Hard mounting the gun to the airframe will produce loads generated by gunfire that will be transmitted directly into the airframe with minimum attenuation. For a large caliber weapon, these loads can be considerable and, under rapid fire, present high impulse shock loads. A realistic example is a 20mm gun that fires a 1500 grain projectile and generates a breech pressure of 50,000 psi (345MPa). It develops an instantaneous recoil load of over 24,000 pounds (106.8kN) (breech pressure times bore area) and an average force of over 9000 pounds (40kN) for 2.5 ms, 60 inch (1524mm) barrel and 3380 ft/sec (1030 m/s) muzzle velocity).

5.1.10.6.3 Soft mounting (recoil adapters) of gun. Most presently installed gun systems are mounted with recoil adapters, i.e., soft-mounted to reduce the peak loads and smooth out the loads generated during rapid firing. An example of soft-mount guns is the 20mm M61A1 gatling gun mounted in the A-7 aircraft. At 6,000 shots per minute, the average recoil load is 3,420 pounds (15kN) with a maximum peak load of up to 5,000 pounds (22kN) following a misfire. Maximum recoil travel is 0.5 inch (12.7mm). Although the recoil adapters tend to smooth out the pulses during burst firing, there is still a pulsation or "dither" force between shots. For the F-4E 20mm M61A1 installation, this dither force is 600 pounds (2669N). The movement of the gun during this load variation is the dither travel and the mounts, other than at the recoil adapters, must accommodate this travel in the recoil direction. At last round firing or during single shot firing, there will be a counter-recoil force due to the energy built up in the recoil packs. The recoil adapters should be designed to minimize both recoil and dither forces within a permissible recoil travel at the nominal firing rate or rates. Preload forces in both the recoil and counter recoil direction, damping, spring rate, travel, and hysteresis are all variables that can be altered to control the effects of recoil. Dual or multiple rates complicate the optimization of the recoil packs and the rate that will be predominately used shall be the prime influence on the design.

5.1.10.6.4 Recoil loads. The mount or mounts, other than at the recoil adapters, must accept the recoil or counter-recoil movement (longitudinal), the loads generated in the vertical and side directions, and provide the adjustments for boresighting and harmonization. In general, these vertical and side loads are not as large as the recoil loads. They will depend on the location of the gun center of gravity, position of the firing barrel, location of the recoil adapters and muzzle devices that deflect gun gases.

5.1.10.6.5 Gun barrel support. Support of the gun barrel(s) is a feature that should be considered to stabilize barrel whip or deflection, improve accuracy if desired, or when installing muzzle devices that deflect the barrel. These supports should accept the recoil travel and not prevent removal of the barrel(s) with the gun installed.

5.1.10.6.6 Pitch or yaw due to burst firing. Another consideration that should not be overlooked is the pitch or yaw moment that can be induced into the aircraft during burst firing, especially with large caliber weapons. If the caliber and power is of sufficient magnitude to develop large, average, or peak recoil loads and the location of the gun is offset with respect to the aircraft center of gravity, then large moments can be generated and must be compensated for to prevent projectile impact inaccuracies.

5.1.10.6.7 Ammunition depletion C.G. shift. a similar aircraft imbalance must be considered if the complement of ammunition is large and the weight is significant. The ammunition should be located to have acceptable, if not minimal, effects on the movement of the aircraft center of gravity during depletion of the ammunition.

5.1.10.7 Gun system power. Gun systems may be self powered or externally powered. If self powered,the power demands and characteristics will be a function of, and supplied by, the gun system and only the control power will be required of the aircraft. However, if the gun system is externally driven, the aircraft system must supply this drive power as well as the control power. The external drive may be electric, hydraulic, pneumatic, or turbine (SUU - 16 gunpod) powered. For large caliber weapons, this power demand can be significant and presents a definite impact on the aircraft power supply. For instance, the F-4E aircraft 20mm M61A1 gun system is hydraulically driven and requires 29 horsepower (HP) at 6000 shots per minute (SPM), steady state. Of this, 20 HP is required to drive the gun with the remainder required for the feed and storage system.

5.1.10.7.1 Feed and ammunition initiation power. Even in self powered guns with belted ammunition, it is sometimes necessary to provide boosters to move the rounds of ammunition from the storage container to the gun. Where cases and links are dumped overboard, it may be necessary to assure positive separation from the aircraft by an ejection mechanism that would use aircraft power. In addition, some ammunition is electrically initiated and is another power consumer.

5.1.10.8 Feed and storage system. The feed and storage system, belted or linkless, shall be designed to control the rounds of ammunition under all aircraft flight conditions. Of special concern is the operation of the gun and the prevention of jams during high g maneuvers or when flexible gun systems are used. This necessitates adequate support of the feed and, where used, the case return chuting. In addition, there must be sufficient flexibility in the chuting to accommodate the maximum recoil and counter recoil travel, flexible gun system manueverability, and maximum boresight adjustments.

5.1.10.9 Gun gas. The generation of gun gas is a direct function of the propellant charge per round and the firing rate. The approximate products of combustion by volume for ball power, as used in aircraft ammunition, are given in Table I. Solid residues constitute less than one percent. The quantitives will vary depending on the type and chemical composition of the propellant. Carbon monoxide and hydrogen are the constituents that can form air explosive of flammable mixture. The upper (UEL) and lower (LEL) explosive limits in air are given in percent by volume in Table I.

TABLE I. Explosive limits in air.

Constituent	Percent (%) by volume range	Explosive limits percent (%) by volume	
		Lower	Upper
CO	46 - 50	12.5	74.2
H_2	15 - 17	4.0	74.2
CO_2	5 - 8	-	-
N_2	10 - 11	-	-
H_2O	17 - 19	-	-

5.1.10.9.1 Corrosive effect. Gun gases are corrosive and materials on which they impinge or accumulate must be selected, processed, and protected accordingly. Surfaces near and forward of the muzzle are subjected to the erosive effects of these gases due to their high pressure and velocity. Selection of materials used in this area must consider these factors as well as the associated high temperature and vibrations.

5.1.10.9.2 Internal gas accumulation. Most of the gas generated during gunfire is expelled out the muzzle of the gun. However, there is some leakage at the gun breech, some gas is blown back with case extraction and some gas may be blown back by the airstream around the outside of the barrel(s). If empty cases are retained on board the aircraft, they can carry gas back into the storage area. The area around the gun muzzle should be sealed to limit the re-entry of gas around the barrel(s).

5.1.10.9.2.1 Gun compartment and storage area. The gun compartment and the case or link storage area can collect these gases if not adequately ventilated and form an explosive mixture. There are two rationales for design to control gas accumulation and its effects. The government agency procuring the aircraft should be consulted to affirm its respective criteria. One approach is to provide a purge and scavenge system that never permits the gas level or pockets of gas accumulation to reach the lower explosive level. A scavenge system uses ram air to move and diffuse the gases and exhausts the mixture overboard through venting louvers. The louver area must be sufficient to permit the air and gases to exhaust with minimal pressure build-up and the air flow must be controlled to diffuse the gasses and permit no pockets; an electrical interlock must be provided to ensure that scavenge or ram air door has opened prior to firing the gun. As an added precaution, a door or panel in the respective compartment(s) should be designed to act as a "relief valve". That is, it should blow out if an explosion should occur prior to any internal compartment or equipment damage due to overpressure. For any gas leakage at the breech a purge system shall be used to exhaust the gases. In this system, the breech area of the gun is enclosed by a shroud and engine bleed air, a purge valve and a nozzle are used to generate a negative pressure around the gun breech. The bleed air and collected gun gases are exhausted overboard.

5.1.10.9.3 Muzzle gas. The gas leaving the muzzle becomes important only if it reenters the aircraft by sifting in through openings, ram air inlets or by entering the engine(s). Any surface skin areas of the aircraft that are subject to the muzzle gas flow field should be sealed to prevent gas entry or the area should be scavenged as discussed in the preceding paragraph. Ram air inlets should be located to prevent or control any gun gas entry. Gas entering the engine is important not only from its explosive characteristics but also from its inerting characteristics and its severe pressure and temperature gradients. It is obvious that any burning or explosive action could physically damage the engine. All these characteristics can also cause engine stall. One approach is to deflect the gases away from the engine(s) inlet flow field by a deflector or diffuser. These are generllly peculiar to the specific aircraft type and must be designed for that respective installation. The services and aircraft gun manufacturers should be consulted for successful previous designs and current design criteria. Automatic throttling engine bleed or continuous ignition are other approaches to control engine stall. Gas ingestion is further discussed under 5.1.9.2.

5.1.10.9.4 Flash suppression. A gun gas deflector is not the same as a flash suppressor though it may perform the same function. A flash suppressor does not necessarily direct the gun gases, but control the expansion and propagation of the flame. A flash suppressor is warranted if either of the following is required:

(a) Preventing flash blinding the pilot.

(b) Significantly reduce aircraft signature from the ground.

5.1.10.9.5 Temperature effect of gun gas. Another characteristic of the gas exiting the muzzle is its high temperature. Less than half of the energy generated by the burning propellant is consumed in propelling the projectile. It is estimated that over 10 percent of this energy is transferred to the gun in the form of heat. The gun installation should be specifically designed to dissipate the heat and guard against cook-off (spontaneous explosion of the round due to excessive heat input). Aircraft guns are cleared after firing to preclude cook-off. Materials used in the gun installation and in proximity to the gun or spent cases when not ejected overboard should be fireproofed and resistant to penetration of cooked-off ammunition. The manner of installation will have a major impact on length of burst, number of permissible bursts, and ammunition complement. The design criteria for components for compartments and chutes which house ammunition should consider the maximum temperatures attainable under the worst conditions of flight and gunfire. For high speed aircraft, cooling the guns by means other than ram air should be considered for maximum protection and safety of flight.

5.1.10.9.5.1 Example of temperature effect. As an example, after short ground bursts of 60-70 rounds on the 20mm M61 gatling gun, a skin temperature of 600-700°F (316-371° Celsius) was measured at a point 4 inches (101.6mm) forward and 4.25 inches (107.95mm) to the side of the muzzle. At a point 4 inches (101.6mm) farther forward, the temperature was approximately 450°F (2320° Celsius). Aircraft skin temperatures will depend on several factors, i.e., flight conditions, ambient temperature, and skin friction, but this added input from the gun gas should not be overlooked.

5.1.10.9.6 Safety. The installation and operation of a gun system in an aircraft requires special emphasis be placed on safety. The ammunition, the feeding of same to the gun, the firing, the exiting projectile, the generation of gun gases with explosive characteristics, and the loads, vibration, and acoustics resulting from gun firing all present potential safety hazards. Therefore, design precautions of the gun installation features and controls that negate or minimize these potential hazards should be incorporated. Major potential hazards are detailed as follows:

(a) Radiation hazards - Of primary concern where electrically initiated ammunition is used. Design precautions should be taken to shield the electric initiator from all induced radiation sources of sufficient magnitude to generate a fire potential. This includes shielding in the storage container, the feed chuting and, where applicable, the return chuting to the storage container.

(b) Gun gas - The problems of gun gas have been discussed in detail in preceding paragraphs. As a general guideline, gun gas concentrations between the limits of 10.5 and 72 percent in air are explosive. Controls should be incorporated to prevent any accumulation in the aircraft between these limits. Another safety hazard of gun gas is its capability to cause engine flame out due to oxygen starvation. As such, gun gas should be prevented from entering the engine inlet for both its explosive nature and oxygen starvation characteristics.

(c) Cook-off - The hazards of round cook-off are twofold, one being the projectile exiting if cook-off occurs in the breech of the gun and the second being the rupturing of the case and spewing out of burning propellant in the immediate area of cook-off. The latter, does not impart any significant velocity to the projectile, although that possibility should be thoroughly determined. To prevent cook-off in the breech, the gun should be cleared after each burst. To prevent cook-off in the ammunition container and feed chuting, the compartment should be controlled to maintain a temperature below 160°F (71.1° Celsius) (or below the cook-off temperature of the ammunition if higher than this). For low speed aircraft, the use of ram air to cool both the gun and gun system compartment is usually adequate. However, with high speed, high performance aircraft (Mach 1 or above), the value of ram air as a coolant becomes questionable. In any event, the ammunition compartment temperature must be controlled.

(d) Double-feed - This hazard is primarily due to a gun malfunction, although the system installation could be a contributor. A double feed will generally result in rupturing the case of the second round and ejecting burning propellant therefrom. A gun jam will also result and the system should shut down automatically if an external drive system is being used.

(e) Hangfire - Hazards associated with a hangfire are twofold depending on where the hangfire occurs. If the round is still in the breech portion of the gun, the projectile can exit out of the firing position with up to normal muzzle velocity. Portions of the aircraft impacted by the projectile would determine the hazard created. Internally, the gun could be jammed or the case ruptured with resulting ejection of burning propellant and case material. A combination of these hazards could also be the end result.

(f) Tampions - Any gun installation that has the barrels plugged, thus blocking the normal trajectory of the projectile, creates a safety hazard. A readily visible indicator must be attached to these blocking devices to identify their presence and assure their removal prior to flight. In like manner, doors that must be open for normal and safe operation of the gun must be electrically interlocked with the gun controls to prevent firing of the gun in the event they fail to operate.

5.1.11 Cockpit controls, displays, and management. The following paragraphs are condensed from AFSC design Handbook Series 2-0, DH 2-2 Crew Stations and Passenger Accommodations. Design Note 2A10 of the latest edition of DH 2-2 should be referenced prior to any design effort. See 5.4 for stores management system equipment design guidelines.

5.1.11.1 Store management controls. For single place aircraft, locate pilot-operated stores management controls in a separate panel on the left side of the instrument panel and within the general peripheral vision of the pilot.

5.1.11.1.1 Sight controls. Locate the sight rheostat and range sweep potentiometer rocket selector unit, bomb target-wind scale assembly, or similar controls adjacent to the sight.

5.1.11.1.1.1 Manual sight controls. Design this control so that it can be operated by means of a twist grip on the power control for stick-controlled aircraft. On wheel-controlled aircraft, use a range control that consists of a spring-loaded paddle which may be depressed by either the right or left thumb.

5.1.11.1.1.2 Sight electrical caging and radar. Install the sight electrical caging switch on either the power control or the control wheel handgrip.

5.1.11.1.1.3 Radar-out control. Locate the radar-out switch on the control-stick grip or wheel.

5.1.11.1.2 Gun control. The first position of the gun-firing switch should start the gun camera, energize the ammunition booster motors, and operate the gun-bay purge doors or any other pre-fire action required. The second switch position should fire the gun.

5.1.11.1.3 Control of other munitions. Locate the actuating switch for firing or releasing rockets, bombs, torpedoes, or chemical tanks at the right thumb position on the control-stick grip. Where rockets replace guns as the primary armament installation, locate the rocket-firing controls in the position now reserved for gun-firing controls.

5.1.11.1.4 Emergency release of stores. Provide electrical and mechanical means for emergency jettisoning of all internal and external stores.

5.1.11.1.5 Bomb bay door control. Locate the bomb bay switch functionally with the armament controls.

5.1.11.1.6 Missile guidance control. Locate the manual missile guidance control accessible to the pilot's left hand.

5.1.11.1.7 Air-to-air combat mode quick change selection control. On aircraft with multiple armament capabilities, a weapons mode quick change switch should be located on the control stick. This control would immediately place the aircraft in an air-to-air combat configuration.

5.1.11.2 Stores management displays. Weapon selection and status displays should be visible in a pilot's headup configuration. Secondary or confirm displays of weapons and primary displays of other stores should be placed on the stores management controls panel.

5.1.11.2.1 Control panel displays. Displays of all stores should be integrated with the stores management controls.

5.1.11.2.2 Head-up display. Display of selected weapons and status should be visible to the pilot on the head-up display or sighting screen.

5.2 Suspension equipment design. When the missions of the aircraft are known and the weapons have been selected to fulfill those missions, suspension equipment must be selected that can handle the required carriage and release of these weapons. The suspension equipment should meet the requirements of MIL-STD-2088 (STANAG 3842 AA, STANAG 3575 AA, and AIR STD 20/10). The suspension equipment selected, in addition to performing its primary task, will also affect aircraft performance, flying qualities, aeroelastic characteristics, and the size and shape of pylons, adapters, rails, or fairings. It will also affect store sequencing, time interval and delivery accuracy. In addition, consideration should be given to interfacing requirements, such as weapon loading and armament system checkout. For instance, a clip-in pre-loaded, rack offers the advantage of loading and checkout of the rack and stores while

5.1.11.1.1.3 Radar-out control. Locate the radar-out switch on the control-stick grip or wheel.

5.2.1 Shape criteria. The configuration of suspension equipment must be derived and developed from an investigation, weighted evaluation, and application of the criteria given in this handbook and the requirements for the aircraft weapons system as specified in the aircraft detail specification. Specific areas which require concentrated investigation are:

(a) Strength (see 5.2.5).

(b) Location in aircraft structure (wing or bomb bay, effect of variable wing sweep).

(c) Type of stores to be carried (to release free-fall stores, or to launch powered stores, or both).

(d) Drag effects when integrated with aircraft structure.

(e) Maintainability.

(f) Loading and servicing adaptability and access.

(g) Compatibility and adapatability of equipment with current ground support equipment.

(h) Accessibility of all interface connections.

(i) Visibility and accessability of safety feature and check points.

(j) Clearance of stores with adjacent stores or structure when stores are released.

(k) Minimized rack cross-sectional area.

(l) Post-release debris (such as arming wire clips, and bands.

(m) Investigate any possible method of fairing which would streamline the flow field downstream, as it has been found that the flow field downstream of racks and sway braces is very turbulent and has a significant effect on store vibration.

5.2.2 Electrical/mechanical/plumbing interfaces. Configuration and functional requirements must comply with the applicable specifications cited in paragraph 2.1. The design of these interfaces, both at the aircraft and weapon, requires a practical consideration of the operational conditions under which these junctions will be made, serviced, and inspected. Particular attention should be given to:

(a) Accessibility and visibility for inspection and service.

(b) Accommodation for misalignment due to production tolerances.

(c) Standardization with existing hardware.

(d) Elimination of tool requirements or, at least, the use of standard tools for service.

(e) Protection from environmental conditions and contaminants.

(f) Accommodations for safety and storage plugs to protect interface surfaces and openings during service, storage, or inoperational periods.

(g) Protection from weapon and aircraft engine exhaust gas blast.

(h) Electromagnetic environment (EMI, EMP and TEMPEST).

5.2.3 Electrical connector selection. Electrical connector selection for suspension equipment (such as bomb racks and rocket launchers) should be made in accordance with MIL-STD-1760 (STANAG 3837 AA and AIR STD 20/22). In addition, the criteria in 5.1.3.4 and 5.1.3.5 apply to the same extent as they apply to the aircraft side of the interface.

5.2.4 Stepping switches. Older multiple and triple bomb ejector racks, now in wide use by the using activities, utilize electro-mechanical stepping switches for sequential release of stores from a rack. The reaction time required for these electro-mechanical devices to sequentially release stores is frequently too long to obtain the desired bomb spacing at high speeds. New bomb racks, built to sequentially release bombs, use state-of-the-art components such as solid state steppers to obtain faster stepping and closer bomb spacing on the ground and eliminate unwanted electromagnetic interference generated by electro-mechanical stepper solenoids. New multiple bomb racks should provide weapon presence information for each weapon location.

5.2.5 Strength. The suspension equipment structure must have strength, rigidity, and durability sufficient for carriage, employment, and jettison of stores under conditions of MIL-A-8591. The structural adequacy must be maintained throughout the specified operating life for a number of weapon releases and flight hours. If the equipment is to be used on carrier based aircraft, requirements of catapult launch and arrested landing loads will be as specified in MIL-A-8863.

5.2.5.1 Material selection. Material selection and member configurations should be made to obtain maximum strength to weight ratios with consideration to minimize material and manufacturing costs as well as weight. For members subject to cyclic loading or sustained loads under vibratory conditions, specific attention should be given to the selection of materials with high fatigue strength, low notch sensitivity and low susceptibility to stress corrosion. In attaining strength and durability of the suspension/employment equipment, the designer must be aware of the requirements imposed by fracture mechanics as well as conform to requirements within the current production manufacturing technology.

5.2.6 Employment characteristics. Weapon employment from the carriage position on the aircraft should be considered for weapons which are either launched, force ejected, or gravity released. All equipment should be designed to have two modes of release; a primary release mode, and a secondary "back-up" release mode. Gravity release, because of inherent simplicity, should be considered when possible (i.e., low speed aircraft). For high speed aircraft application, some form of powered launch or forced ejection mechanism should generally be used.

(a) Primary ejection shall be by a mechanism (see 4.2.2.5) which shall impart a separation force to the store relative to the aircraft upon command of the appropriate crew member.

(b) Secondary, or back-up, release of the weapon should be a system independent of failure of the primary ejection system and it should be initiated by a separate action.

5.2.6.1 Ejection velocity. In the primary release mode, the mechanism to affect separation of free-fall type weapons should remain in contact with and accelerate the weapon away from the aircraft throughout a minimum distance of 6 inches (152.40 mm) and should impart to the weapon sufficient velocity (in the direction of the velocity vector) and pitch rate to ensure safe separation under the most critical release conditions. There is no fixed ejection velocity that imparted to a store will, in all conditions, ensure safe separation. Rather, the amount of ejection velocity needed will vary from installation to installation. Too much ejection velocity may cause undesirable reaction loads in the aircraft or store structure, while too little may result in unsafe separation. A design goal should be to impart at least 20 ft/sec (6.096 m/sec) to a 500 lb (227.0 Kg) class weapon varying linearly to 14 ft/sec (4.27 m/sec) for a 2000 lb (908.0 Kg) class weapon. The employment equipment should be designed in accordance with MIL-STD-2088 and should include multiple ejector pistons, variable store pitch control, and a means of varying total ejector forces.

5.2.6.2 Ejector piston location. Variation in location of store CG between the carriage points should be accommodated by the primary ejection system by adjustment of weapon carry attitude or by controlled application of store pitch motion applied to the weapon during separation. The ejector pistons should be located so as to interface with the ejection areas specified in MIL-A-8591.

5.2.6.3 Store acceleration requirement. Ejector systems for the release of stores should be designed to effect safe separation of the weapon and aircraft while at the same time minimizing the effects of reaction loads. Safe separation should be attainable throughout the aircraft's maneuvering flight envelope.

5.2.6.3.1 Free fall stores. For the release of free fall stores, the ejection system should be such as to impart the ejection velocities set fourth in 5.2.6.1 while minimizing as much as possible, the store acceleration, and the resultant structural reactions on the store and the aircraft. The ejection force and pressure shall be in accordance with MIL-STD-2088. Some stores may require significantly less force or pressure (see STANAG 3575 AA and AIR STD 20/10). All portions of the store must:

(a) Maintain a velocity away from the aircraft until it is clear.

(b) Not reenter the projected area of all portions of the aircraft in the forward line of flight of the aircraft.

5.2.6.3.2 Power augmented weapons. In the case of power augmented weapons, acceleration of the store forward or down and away from the aircraft must not only effect clearance of the structures, but also minimize effects of the weapon exhaust on the aircraft structure, other weapons, engine inlet and performance, and aircraft flying qualities.

5.2.6.4 Ejector force. The ejector force to the store should be applied to meet the requirements of MIL-STD-2088 (STANAG 3575 AA and AIR STD 20/10).

5.2.6.5 Cartridge firing pin selection. Cartridge breeches of applicable stores suspension equipment should be designed to accept a spring-loaded firing pin (as opposed to a fixed or rigid firing pin). Use of a spring-loaded firing pin assures better electrical contact between the firing pin and the electrode of the cartridge for cartridges that are removed (from breeches) and reinstalled. After repeated removals and installations of cartridges in fixed (rigid) type firing pin breeches, electrical contact cannot be assured, due to progressive enlargement of the indentation in the cartridge electrode with each insertion. This condition is especially prevalent when cartridges are intercharged between different types of racks, dispensers, and launchers. The cartridge firing pins and breeches shall be designed to meet the requirements of MIL-STD-2088, STANAG 3575 AA, and AIR STD 20/10. Firing pin configuration should conform to MIL-STD-2088 and STANAG bulletins.

5.2.7 Cartridges. While the suspension equipment is being considered for particular aircraft/store combinations, thought must be given to any cartridges which may be required to yield the desired ejection forces and velocities and be compatible with the suspension equipment. The same cartridge or cartridge combination in two different racks will not necessarily produce the same forces and velocities. It is necessary, therefore, to consider each piece of suspension equipment separately for proper cartridge selection. Correct cartridge selection will aid release sequence, minimum time interval and deliver accuracy. In addition, cartridges should be safe for use in relatively high electrostatic field and RF environment (see 5.2.11 for specific guidance). Where cartridges are used as the energy source in store suspension equipment, they should conform to the requirements of MIL-D-81303, STANAG 3556 AA, and AIR STD 20/10.

5.2.8 Store/loading and handling. Airborne store suspension equipment must be compatible with a wide range of store weight, sizes, and shapes which seriously complicates the store suspension equipment interface. Store loading must be accomplished safely and efficiently. General guidelines for improving aircraft store suspension, store, and ground handling equipment compatibility include:

(a) Provide good visibility and easy access to switches, controls, safety devices, breech caps for cartridge insertion or removal, arming solenoids, sway braces, hooks, snubbers, various store adjustments, electric fuzing, electrical and fuel tank connectors, but located suitably to avoid damage during the loading cycles.

(b) Provide means and methods for rapid mechanical and electrical checkout of the store suspension equipment to ascertain proper armament system functioning.

(c) Provide suitable switches, controls, and all safety devices.

(d) Provide clear indication of the status of the lock-unlock condition both with and without aircraft electrical power.

(e) Design suspension equipment to minimize tool requirements during the loading and sway bracing operations.

(f) Provide store hoist provision or allow space for hoist adapters.

(g) Minimize mechanical adapter and electrical adapters and safety pin requirements by using existing equipment rather than introducing new special purpose adapters. Special purpose adapters for handling new stores, such as palletized stores, should be designed to interface with existing transport and loading equipment.

(h) Design for minimum interface between suspension equipment fairings, droop openings, and ground handling equipment store loading combinations.

(i) Maximize the hook opening tolerance for the store lug loading so that the exact store X, Y, Z distances and pitch and yaw attitudes are not required.

(j) Consider store ground handling equipment maneuverability including approach directions, maximum cramp angle, maximum lift and height capabilities, and hook lug entry angle during designs.

(k) Allow adequate personnel space for sway bracing store and make any special adjustments that are required when the stores are loaded in the prescribed sequence established by the weapons loading checklists.

(l) Consider the effects of red light night loading operations, and loading in foul weather with protective clothing.

(m) Consider sequence of store loading so that personnel are not exposed by working under previously loaded stores.

(n) Consider the requirements of 6.1.8 so that Hazards of Electromagnetic Radiation (HERO) restrictions are not required during the loading cycle.

5.2.9 Fuzing and arming. Present and future store stations on aircraft, pylons or suspension/launching equipment, despite differences in racks or aircraft, should incorporate standard provisions for integral mechanical, electrical or digital fuze arming functions to control the "SAFE/ARM" condition of stores and fuzes. The arming provision should comply with 5.2.9.1, 5.2.9.2, or 5.2.9.3 as appropriate and comply with the interface requirements of MIL-A-8591. A goal should be to use electrical arming (5.2.9.2) or to pass coded arming commands via the MIL-STD-1760 interface (5.2.9.3) to provide more in-flight arming options than available mechanical arming method of 5.2.9.1.

5.2.9.1 Mechanical arming units. Mechanical arming units shall be of the zero retention force type, allowing zero retention force on the arming wire when the store is released and the arming units are safe or unenergized. An energized arming unit shall retain the arming wire with a force of 400 pounds. The arming units shall meet the requirements as specified in MIL-STD-2088 (STANAG 3605 AA and AIR STD 20/17).

5.2.9.2 Electrical arming units. There should be an interlock function provided between the launcher or bomb rack release linkage and the method of electric or coded pulse transmission whereby,the arming unit must sense correct linkage movement representing properly intended store release, before the electrical pulse is permitted to enter the electric fuze arming unit. Subsequently, separation of the weapon from the suspension should initiate the process of arming, with electric fuze arming intelligence transmitted within 5 inch (12.70 cm) travel, followed by disconnect of the cable from the arming unit. Location of the arming unit should correspond to the geometry outlined in MIL-A-8591 and MIL-STD-2088, either attached to pylon or aircraft structure. Access should be provided vertically to permit the electric fuze arming cable connection to be made by hand after the weapon is mounted on the rack.

5.2.9.3 Digital arming. For new store applications using MIL-STD-1760 and its associated MIL-STD-1553 multiplexed digital data interface, the transfer of arming commands from aircraft to the store should occur through the MIL-STD-1760 interface. The transfer of digitally encoded arming commands can be protected to a high level by the error detection coding methods described in MIL-STD-1760 and through the use of Preset, Verify, Execute (PVE) command and monitor sequences. The use of digital arming provides not only expansion of arming and fuzing options but also allows the aircraft to monitor the arming/fuzing status of the store prior to the store separation.

5.2.10 Conflagration hazards.

5.2.10.1 Existing suspension/employment equipment. In those cases of new aircraft design, which for operational reasons are required by detail specification to employ existing suspension/employment equipment at the aircraft/weapon interface, the probability of such equipment contributing to a conflagration can only be minimized by strict adherence to safety employment procedures presently published for the equipment involved.

5.2.11 Carriage environment. The suspension system and its electrical and electronic subsystem shall be designed to function without degradation under all operating conditions in the natural and induced service environments.

5.2.11.1 Electromagnetic. The suspension system, including test sets, shall be designed to comply with the requirements of MIL-E-6051 and for US Navy MIL-HDBK-235-1 (Electromagnetic Environment Criteria). In addition, the following design guidance documents should be used:

Air Force - AFSC DH 1-4

Navy - SD-24

Army Handbook AMCP-706-235, Report 18

5.2.11.2 Electroexplosive subsystems. Electroexplosive subsystem requirements should be designed to comply with:

Air Force - MIL-STD-1512
Design Guide AFSC DH 2-5

Navy - MIL-STD-1385
Design Guide - OD 30393 and MIL-HDBK-235-1

Army - Handbook AMCP-706-235, Report 18

5.2.11.3 Electromagnetic interference (EMI). When specified, all suspension systems shall comply with the electromagnetic interference requirements of MIL-STD-461 and 462. The minimum methods that should be applied are CE03, CE06, CE07, CS01, CS02, RS02, and RS03. The procuring activity should tailor the EMI requirements to fit the specific environment of the system when known.

5.2.11.4 Electrical bonding and lightning protection. Electrical bonding and lightning protection requirements should be in accordance with MIL-B-5087. Special electrostatic protection by grounding is provided by OP-4.

5.2.11.5 Electrostatic protection. All electrical, electronic, explosive and electromechanical subsystems or equipment should be designed to prevent static electricity from degrading system effectiveness. Special static protective procedures, such as grounding, are required for weapons loading and unloading operators. The following design guidance documents should be used:

Air Force - AFR 127-100, DH 1-4

Navy - OP-4

Army - AMCP-706-235, Report 18

In addition, DOD-HDBK-263 and DOD-STD-1686 defines electrostatic protection requirements for non-electroexplosive system electrical/electronic equipment. Electrostatic protection requirements for electroexplosive system equipment is defined by MIL-STD-1512.

5.2.11.6 Electromagnetic interference filters. Where EMI filters are shown to be necessary, they should be designed to protect against the specified frequencies and field intensities and evaluated when terminated in the tactical input and output impedances. The filters shall comply with MIL-F-15733. RF filter characteristics shall be monitored for production purposes in accordance with MIL-STD-220.

5.2.11.7 Electromagnetic environment. Unless otherwise specified, the electromagnetic environment should be as defined in MIL-STD-461 with supplementary requirements for Navy application defined in MIL-HDBK-235 -1 and supplementary Army applications defined in Army Missile Command TR RD-TE-87-1.

5.2.12 Special purpose launchers and adapters. The design requirements for special purpose launchers and adapters are significantly different from general store suspension equipment. Special purpose launchers and adapters must maintain high availability rates in the absence of maintenance and logistic support and in the presence of a significantly different service environment (infrequent use and increased handling and storage). Suspension equipment used for conventional weapons is frequently exercised in training, but because of the cost of training with missiles, special purpose launchers are infrequently used. For this reason, serious faults are sometimes not discovered and a false sense of high launcher availability results. Another condition, associated with infrequent use, is that the environment of a special launcher is significantly different from that of a conventional suspension rack. A conventional rack spends the majority of its in-service time attached to the aircraft and is, therefore, subjected to approximately the same environment as any other portion of the aircraft. With special purpose launchers, however, the most severe service environment tends to be associated with handling and storage. In the development and evaluation of special purpose launching systems, past experience has tended to show that special purpose launchers:

(a) Will be maintained, spasmodically, by indigenous personnel,

(b) Will not be supported by periodic rework, and

(c) Will be difficult to locate and fix if they are found to be deficient in service.

5.3 Store design. In the design of a new store or in a new application of an existing store, the designer must consider its impact on the total aircraft/store system. Few stores exist which do not result in some degradation of aircraft performance (i.e., its range, speed, altitude, or flying qualities). The most efficient design is one which results in minimum degradation of aircraft performance while meeting the mission objectives of the stores. This is usually done by trade-offs between free flight requirements and aircraft carriage and release requirements. General design criteria for airborne stores and associated suspension equipment are contained in MIL-A-8591. The wide variety of store types, coupled with the diversity of operational requirements, precludes the definition of precise guidelines for their aerodynamic design.

5.3.1 Design parameters. The following store design parameters, but not limited to those stated, must be analyzed, trade-offs determined, definitive designs selected, and finite values chosen for the following:

(a) Store shall be packaged with as high a density factor as possible with respect to its total functional component weight to store volume.

(b) Store carriage external or internal.

(c) Store carriage subsonically or supersonically.

(d) Captive store loads to which the store is subjected.

(e) Delivery techniques.

(f) Release or launch capabilities.

(g) Emergency jettison capabilities.

(h) Environmental effects and requirements.

(i) Electrical interfaces (see MIL-STD-1760).

(j) Mechanical interfaces.

(k) Aerodynamic characteristics.

(l) Aerodynamic interference.

(m) Store design shall provide for the loads and environments encountered in the rapid, automated handling and loading on the aircraft.

(n) Store design shall in no way impair required store or aircraft servicing while loaded on the aircraft.

(o) Store design shall provide for the service life as specified for the particular store.

5.3.2 Release conditions. The release conditions, which must be considered, besides those associated with tactical delivery, are selective and emergency jettison capabilities. Stores may be released either singly, in multiples, in ripples (train), or salvo by being gravity released, ejected, fired, or launched from racks, fuselage or wing mounts, rails or tubes and may be projected downward, forward, or rearward. Appropriate consideration must be given to store aerodynamic stability immediately after release while it is still traversing the complex flow field around the aircraft (Store stability the initial conditions of the store as it begins its own free stream trajectory.) If dispersion is a requirement, the store should be designed in conformance with MIL-B-81006.

5.3.3 Carriage environment. The store designer should assume that the store will be operationally available for 20 years. Therefore, the store design specification should designate the carriage environment expected during this time. This environment should be based on technology forecasts of aircraft performance and operating conditions projected for this time.

5.3.4 Droppable stores. The requirements and testing procedures for droppable store installation and associated release systems are as specified in MIL-I-8671.

5.3.5 Aircraft pyrotechnic equipment. The requirements and testing procedures for installation of aircraft pyrotechnic equipment in piloted aircraft are as specified in MIL-I-8672.

5.3.6 Classes of airborne stores. The design parameters of a store are dictated by its operational and mission requirements. It is convenient, therefore, to list the following classes of airborne stores:

(a) Missiles (powered)

(1) Air-to-air

(2) Air-to-ground

(b) Bombs

(1) Finned (general purpose, penetration mines, torpedoes, and high drag)

(2) Unfinned (napalm)

(3) Guided, free fall

(4) Augmented glide bombs

(c) Dispensers

(1) Bomblet

(2) Rocket

(3) Chemical spray

(4) Gun pods

(5) Photo cassettes

(6) Flare, electronic sensor, or chaff

(d) Special purpose

(1) ECM pods

(2) Camera pods

(3) Cargo/baggage containers

(4) Laser pods

(5) Data link pods

(e) Fuel tanks

(1) Rigid

(2) Collapsible (variable geometry)

(3) Aerial refueling stores

5.3.6.1 Dispensers. Dispensers are a unique class of airborne store, in the sense that they are not normally released from the aircraft to achieve their operational purpose. Instead, they release their payload over the target. Dispensers may be classified into two general classes.

(a) Class 1 - dispensers in this class are carried and released like a bomb but open after release to distribute their payload.

(b) Class 2 - dispensers which release their payload while attached to the aircraft.

5.3.6.1.1 Class 2 dispensers. Dispensers in this category present many unique and critical problems related to aircraft/store compatibility. Some of these problems are:

(a) Release of payload may result in collision or impingement of payload on carrier aircraft.

(b) Portions of the dispenser that are released with the payload (such as rocket package nose cones) may collide with the aircraft.

(c) Depending on its type, the dispenser could change size and shape during the conduct of a mission (rocket packages, for example) so that in an aerodynamic sense, two separate bodies are involved.

5.3.6.1.2 Dispensing operation. Dispensers may be carried as external stores or may be built into the aircraft structure. Every effort should be made to minimize hazards to the aircraft during dispensing operations, including the basic payload dispensed and the amount of dispenser parts released with the payload. Rearward dispensing weapons should be designed so that the area traversed by any item dispensed may be circumscribed by a cone whose apex is at the dispenser and whose half angle does not exceed 10°.

5.3.6.1.3 Dispenser jettison. The jettison of dispenser munitions has proven to be particularly hazardous. Basic aerodynamic design should address the jettison of the store full, partially full or empty, to provide safe separation over a broad speed range. Factors to consider which would minimize jettison problems include:

(a) Hold dispenser shape constant.

(b) Minimize center of gravity travel during dispensing.

(c) Provide dispenser with positive static stability for all weight conditions from full to empty.

5.3.7 Store aerodynamics. The store designer must be aware of the various aerodynamic considerations that need to be made when designing a store intended for carriage on and employment or jettison from aircraft. The aerodynamic characteristics of a store, although in a large measure dictated by mission requirements, should be designed to minimize its effect on the flying qualities, observability, and performance of the aircraft. As such, prior to store design, every effort should be made to determine the various model aircraft intended to carry the store. The flight design envelope of the store should include the maximum and minimum airspeed and Mach number limits of these aircraft, if practical. In the past, the store limit often restricted the maximum speed of the aircraft when carrying the store. It is desirable to carry, employ, and jettison the store to the limits of the aircraft. The aerodynamic characteristics of the store should be documented in report form for the full airspeed/Mach number envelope by wind tunnel tests.

5.3.7.1 Trade offs. An important consideration in the design is to trade off requirements for the store's free flight requirements for those involving carriage on an aircraft. Of the latter, there are a multitude of considerations. Once the usage characteristics have been defined, the specific aerodynamic environmental problems can be pursued.

5.3.7.2 Drag. The drag of a store installed on an aircraft is a function of the type of installation technique employed. Typical installations are:

(a) Single or multiple carriage on external pylon.

(b) Tangential or conformal carriage on fuselage.

(c) Semi-submerged on fuselage.

(d) Internal or bomb bay.

5.3.7.2.1 Free-body drag. Historically, a given store has been carried on several different aircraft and in a wide range of carriage techniques. In general, however, every effort should be expended to maintain minimum free-body drag of the store resulting in the best aircraft/store interface. Operational requirements will affect the general size and shape of the store, but where possible, shape variables including nose shape, after-body shape, frontal area, fin geometry discontinuities, and protuberances should be weighed in consideration of free stream drag.

5.3.7.2.2 Installation factor. To aid interface analysis, store free-body drag data should be available for its intended carriage Mach number range over a reasonable angle-of-attack range. The isolated drag of a store is usually increased due to airplane interference effects between the store and mounting pylon, and the store and the wing or fuselage. The free stream drag of a store in relation to its drag installed on a particular aircraft is referred to as the "installation factor." This installation factor may not be constant at all mounting stations, but may vary from one location to another.

5.3.7.2.3 Supersonic. Supersonic carriage is another area which needs more attention, particularly in acquiring experimental (wind tunnel and flight test) data. All too often aircraft performance is significantly hampered by inadequate consideration of these factors.

5.3.7.3 Stability. The aerodynamic stability of an airborne store is, in general, dictated by its primary operational use. The wide range of store types, and their primary operational uses can pose serious interface problems on a given carrier aircraft. Most conventional stores are designed for subsonic or transonic flight. Because of this, they do not generally have a significant effect on the basic static directional stability of aircraft designed for supersonic flight. Weapons that are specifically designed for supersonic flight, however, usually do affect aircraft directional stability.

5.3.7.3.1 Destabilizing effects. Generally, the carriage of external store(s) on wing or fuselage pylons tends to destabilize the aircraft due to any, or all of the following:

(a) Externally mounted store(s) may have an aerodynamically destabilizing effect on the aircraft resulting from a forward shift of the aircraft neutral point, thus reducing the aircraft static longitudinal stability margin.

(b) The mounting of store(s) on wing or fuselage pylons can have a significant effect on the aft c.g. travel of the aircraft. Moving of the aircraft c.g. aft tends to destabilize the aircraft by reducing the aircraft static longitudinal stability margin.

(c) Externally mounted stores may interfere with airflow in the vicinity of the horizontal tail which in turn can cause a destabilizing effect on the aircraft itself.

(d) High performance aircraft with swept wings tend to be more susceptible to both an aircraft neutral point shift and an aft center of gravity shift due to mounting of stores on wing pylons.

5.3.7.3.2 Stability factors for various store classes. Stability factors for the aerodynamic design of the different classes of stores may be stated as follows:

(a) Guided missiles and guided bombs - The required degree of static stability of a guided weapon is dictated by its maneuvering requirements and launch mode. Powered missiles may require high maneuvering capabilities to intercept a target, and as a result, their static stability may be neutral, or unstable. These missiles usually experience deviations from the expected launch trajectory in pitch, yaw, or roll angles or rates. To assure the safe separation of guided missiles and guided bombs the following design factors should be incorporated into the weapon:

(1) Weapon should have positive static stability at launch.

(2) An artificial weapon stability at launch should be incorporated (for example a pitch, yaw, and roll damper) if the positive static stability cannot be obtained by other means.

(3) Incorporate acceptable control surface deflection at launch.

(b) Unguided rockets - Conventional unguided rockets have relatively low maneuvering requirements or are fired in a boresight mode. For this weapon to be effective, it must have a positive static stability to reduce launch perturbations to a minimum.

(c) Bombs - Bombs are launched in a boresight mode and to be effective must have a positive static stability to reduce launch perturbations to a minimum. Bombs as a class may be further subdivided into finned and unfinned types.

(1) Finned - As a general rule, it is recommended that bombs (general purpose, mines, etc.) possess a positive static longitudinal stability margin of at least one body diameter to provide safe separation. For purposes of this paragraph, static, longitudinal, stability margin is defined as the distance between the bomb center of gravity and its aerodynamic center of pressure. Positive, static stability exists when the center of pressure is aft of the center of gravity. It is noted that bomb areodynamic chracteristics must also provide for repeatable ballistics, and this is generally best achieved by maximizing the dynamic stability of the bomb. However, in some cases this can increase dispersion because of aircraft flow field angularity.

(2) Unfinned - Unfinned bombs, such as napalm, are designed to possess aerodynamic instability for operational reasons. A general design guideline to provide safe separation of this type store is to provide for as dense a body as possible. The ratio of length (ft) to pitching moment of inertia (slug-ft^2) for existing napalm bombs is in the range of .065 to .120. The lower ratio tends to provide improved separation characteristics.

(d) Dispensers - The dispenser is a unique class of airborne store and the Class 2 dispenser, which remains attached to the aircraft after employment of its submunitions, creates particularly troublesome aerodynamic problems.

(1) The dispenser with its submunitions and until its submunitions are employed will undergo large variations in weight, center of gravity, and moments of inertia, which can drastically affect jettison characteristics. Dispensers should be designed so that, during employment of its submunitions, the c.g. movement of the store is held constant or minimized.

(2) Dispensers which, after employment of submunitions, have open tubes or bays can cause severe drag and stability problems on the carrier aircraft. Further, the open tubes or bays whether they be forward, rearward or downward facing, may cause aeroacoustic vibratory effects which can affect the structural integrity of both the store and the aircraft.

(e) Special purpose stores - Special purpose stores are not normally released from the aircraft, except under extreme emergency conditions. Safe separation (jettison) of these stores should, however, be considered in their basic design. The following should be considered:

(1) Low ratio of length to pitch inertia.

(2) Stabilizing fins.

(f) Fuel tanks - Fuel tanks, rigid or collapsible, are not normally released from the aircraft except in emergency conditions. Additionally, a fuel tank design may not necessarily be universally adaptable to a variety of aircraft. From the standpoint of safe separation (jettison), their aerodynamic design can be tailored to specific aircraft and its suspension equipment. An emergency jettison situation can occur at any flight condition, and result from a failure of aircraft equipment or combat urgency.

It is desirable, therefore, that the fuel tank be capable of jettison throughout a broad speed range, and with any amount of fuel quantity from full to empty. Design concepts to be considered include:

(1) Positive static stability - Possibly including center of gravity control.

(2) Controlled release of tank from aircraft (pivots, linkages, etc.) to assure safe jettison.

5.3.8 Analysis of store clearances and fit. One of the first analyses to be made in determining the compatibility of a store with a particular aircraft is that of ensuring that the store will physically fit on the aircraft without interfering with any part of the aircraft, other stores, or the ground. Allowable minimum distances between the store, the aircraft, other stores, and the ground are contained in MIL-STD-1289. This document also contains methods of testing to determine what clearances exist.

5.3.9 Store electrical interface. The configuration and functional requirements for the electrical interface of the store to the suspension equipment employed on the aircraft must comply with the applicable specifications. The design of these interfaces, both at the store and the aircraft, requires a practical consideration of the operational conditions under which these junctions will be made, serviced, and inspected. Particular attention should be given to:

(a) Accessibility and visibility for inspection and service.

(b) Standardization with existing hardware.

(c) Elimination of tool requirements or, at least, the use of standard tools for service.

(d) Protection from environmental conditions and contaminants.

(e) Accommodations for safety and storage plugs to protect interface surfaces and openings during service, storage, or inoperational periods.

(f) Protection from weapon and aircraft engine exhaust gas blast.

(g) Design to the electrical interface standardization provided by MIL-STD-1760 (STANAG 3837 AA and AIR STD 20/22).

5.3.9.1 Store electrical connectors. Connectors must be designed to prevent accidental shorting of contacts during mating of the plug and receptacle. The connector must have positive mating features to prevent any possibility of mismating. It should contain peripheral grounding fingers that connect the two mating halves of the connector before pin and socket contacts make connection. The connector should also contain provisions for connecting shield braid for EMI protection. The connector mating halves on the aircraft, store and suspension equipment sides of the interface should contain socket type contacts and the electrical adapter harness connector mating halves should contain pin type contacts. Refer to MIL-STD-1760 for connector requirements. The store should be designed to allow power to be removed from the interface before separation to avoid power arcing and associated equipment damage during disconnect of a powered connector.

5.3.9.2 Store pin function assignments. The approach to pin function assignments must first include a pin study to segregate signals into categories which first include a pin study to segregate signals into categories which relate the electrical functions and provide the maximum safety and electromagnetic compatibility. The characteristics of every signal in the aircraft/weapon interface should be defined as follows:

(a) Function name

(b) Signal type - analog, discrete, pulse train, fire (single end or differential)

(c) Signal voltage - AC,DC

(d) AC signal - volts, amperes, power factor and phase relationship

(e) DC signal- volts and amperes

(f) Susceptibility threshold values

(g) Grounding

(1) Power.

(2) Signal.

(3) Shield.

For interfaces controlled by MIL-STD-1760, the pin assignments for the electrical interface connector are defined in the standard. The characteristics listed above should still be defined for specific signals applied to the interface lines. For example, if a pulse train is applied to one of the high bandwidth interface lines, the characteristics of the pulse train must be documented.

5.3.9.3 Connector location. Electrical connectors on the store shall be located in accordance with MIL-A-8591 (STANAG 3558 AA and AIR STD 20/14). Where stores are to be installed on pylons, the electrical connections must not extend beyond the contours of the pylon such that additional fairings or pylon modifications would be required. Bail-bar locations shall be chosen to provide easy electrical separation of umbilical connections for all droppable or jettisonable stores.

5.3.9.4 Store power requirements. For new stores, MIL-STD-1760 defines the power requirements of the store at the electrical interface. For non MIL-STD-1760 applications, the following conditions must be considered during store design. All electrical equipment used in the aircraft is required to operate satisfactorily when designed to meet the power requirements of MIL-STD-704, as a minimum. Equipment installed inside a store that is powered directly from the aircraft power sources must consider the additional power characteristic degradation that will occur due to power distribution from the aircraft interface to the power terminals on the store equipment. In addition, MIL-STD-704 requires that AC loads applied to the aircraft power system (including loads applied by the store) must be phase balanced within specified limits. The trend in new store designs, in general, is toward requiring increased power consumption from the aircraft. Large single phase loads imposed by the store on the aircraft power system result in phase unbalance and the phase voltage being out of specification limits. This unbalance caused by a store could effect the performance of other aircraft equipment. As a result, any AC loads exceeding 500 VA, are required to utilize three phase AC power and must be balanced in terms of the load on each phase within the balance limits of MIL-STD-704. Therefore, heaters and power supplies in the store must operate on balanced three phase power instead of single phase AC power as has been used in the past.

5.3.9.5 Connector keyway. The electrical connector keyway orientation on the store must comply with the requirements of MIL-STD-1760. In applications requiring more than one connector on a store, the connector shell and keying shall be selected to preclude interchanging (i.e; mismating) connectors.

5.3.10 Store mechanical interface. The mechanical interface of the store to the suspension equipment and aircraft shall be as specified in MIL-STD-2088, STANAG 3842 AA, STANAG 3575 AA, AIR STD 20/10, MIL-A-8591, and MIL-I-8671. The general configuration of the aircraft and location of its equipment must be known to the store designer in order that he may define the store interfaces for, but not be limited to, the following:

(a) Physical clearances.

(b) Functional requirements.

(c) Operational requirements.

(d) Application of any special support equipment.

(e) Access requirements for installation and checkout.

5.3.10.1 Store mechanical interference. In the design phase particular attention should be directed to the store mechanical interference requirements. This is necessary to assure that the store will have the maximum employment on the largest number of aircraft types, including provisions for interservice usage. If these various store mechanical interface requirements could be categorized, and perhaps standardized for all stores, it would minimize the many problems associated with maintenance and logistics. The designer should consult the Aircraft Stores Interface Manual AOP-12, prepared by the Joint Ordnance Commanders Sub Group (JOCG). This manual will prove most useful in revealing possible interference between munitions or stores and the structures, pylons, bomb racks, etc. of the aircraft meant to carry them.

5.3.10.2 "All-up" delivery to aircraft. The store interface should be designed to be deliverable to the aircraft for loading as an "all-up" round. When an item such as a fuze or sensing element is to be assembled to the store after delivery to the aircraft, it must be verified through test or analysis that this assembly will not degrade the performance of the store. In the case of cluster weapons or multiple store adapters, the stores should be preloaded to the adapters prior to loading to the aircraft. The task associated with loading or off-loading of stores should be kept to an absolute minimum to meet normally imposed turn around time requirements and to simplify the aircraft re-arming procedures.

5.3.10.3 Store lugs. The store/aircraft interface must take into consideration the physical attachment of the store to the aircraft. The primary criterion consists of the store lug geometry and spacing for proper fit to suspension equipment hooks. Not only must the lugs properly mate with the suspension hooks, but they must also carry the store loads induced by the aircraft while operating at the limits of its performance envelope. Objectively, the aircraft performance should not be limited by stores constraints. The general design criteria for store suspending lugs and the store-aircraft interface shall be as specified in MIL-A-8591 (STANAG 3726 AA and AIR STD 20/15).

5.3.10.4 Sway brace compatibility. Adequate structure must be designed into the store for fit compatibility with sway braces, to carry side loads induced into the store, and prevent any movement of the store on the suspension equipment. The sway brace areas shall be as specified in MIL-A-8591.

5.3.10.5 Ejector areas. If the suspension equipment contains an ejector mechanism, the store must contain adequate structure (strongback) to withstand the forces of the ejection pad(s). Consideration must be given to access for actuation of the suspension equipment for opening or closing of the hooks, adjustment and locking of sway braces, adjustment of preload on ejectors, installing or removing of safety pins, and electrical connector access. The ejector area requirements shall be as specified in MIL-A-8591.

5.3.10.6 Weight and center of gravity. The store weight, or combined weights where cluster or multiple stores are suspended from a single station, must be limited so that the load carrying capability of the weakest pylon or suspension equipment under consideration is not exceeded. The center of gravity and mass property distribution must be considered to allow for normal safe separation or emergency jettison from the aircraft. For dispensers, fuel tanks, or any munition that has a variable weight or center of gravity during flight, separation/jettison capabilities must be evaluated for all adverse conditions.

5.3.10.7 Special equipment and services. The aircraft interface should be evaluated for availability and arrangement of special equipment and services that may be required by the store. For example, the availability of any environmental cooling or heating, pneumatic plumbing, and hydraulics, should be examined as well as the type of store fuzing. Obviously, for droppable fuel tank installations, the stations selected should have provisions for fuel connections and quantity gauging.

5.3.11 Store structural requirements. When designing an airborne store, the designer should provide structural strength for carriage, employment, and landing conditions. Structural strength and rigidity requirements for airborne stores are specified in MIL-A-8591; MIL-M-8856, for missiles; and MIL-T-18847, for US Navy external fuel tanks. The design should ensure that the center of gravity of the store be located in the fore-and-aft direction, between the suspension lugs on dual-lug stores, and within two inches of the lug vertical centerline on single lug stores. Design loads should be those expected to be experienced when aboard all aircraft for which the store is designed. If no specific aircraft are designated to carry the store, the store should be designed to the most critical conditions specified in MIL-A-8591, or MIL-M-8856, or MIL-T-18847, as applicable.

5.3.11.1 Store/aircraft structural interface. The designer should obtain the necessary and sufficient basic elastic, aerodynamic, inertia, structural damping, free-play, dynamic, material property, load, temperature, and all other data required to define the store-to-aircraft interface boundary conditions for the store during carriage, employment, and landing conditions.

5.3.11.1.1 Deformation at interface. The cumulative effects of elastic, permanent, or thermal deformations acting singly or together, which result from application of design temperatures, repeated loads and limit loads should not:

(a) Inhibit or degrade the mechanical operation of the store or of the carriage/employment aircraft or suspension equipment.

(b) Adversely affect the store's aerodynamic characteristics or the aerodynamic characteristics of the carriage aircraft or suspension equipment.

(c) Require repair or replacement of parts.

5.3.11.2 Carriage loads imposed on store. The store must have sufficient strength to withstand all the loads imposed upon it during carriage on aircraft. Such loads would include, but not be limited to, aerodynamic loads, inertia loads, separation loads, aircraft to store, store to store, store to suspension equipment interference effects, accelerations in all three planes (including combinations thereof), taxi loads, field take-off loads, rough-field and catapult take-off loads (if applicable), and landing loads. Flight loads should be all those expected to be experienced throughout the entire flight envelopes of all aircraft for which the store is designated for carriage. If no specific aircraft are designated to carry the store, the store should be designed to the most critical flight conditions specified in

MIL-A-8591, MIL-M-8856, or MIL-T-18847, as applicable. Design in-flight accelerations should be as specified in MIL-A-8591. Design conditions should include all possible stores stations, suspension equipment locations, loading conditions (including asymmetric loadings; wing, fuselage, and suspension equipment), and hung-store configurations.

5.3.11.3 Store flutter and vibration. The store design should meet the applicable requirements of MIL-A-8870 for the aircraft carriage envelope as well as the store aerodynamic envelope. The store design should be such that there is no divergence or flutter of the store, its components, or store/rack combination at all speeds up to 1.15 times the highest limit speed of the store or the aircraft/store combination. This design requirement applies for all of the aircraft on which the store is intended to be carried, and for all design ranges of altitudes, maneuvers, loading conditions, and aerodynamic heating effects. An increase of 15 percent in the equivalent air speed at all points on the captive flight limit speed envelope, both at constant Mach number and, alternately, at constant altitude, should not result in flutter or divergence. In addition, the total aerodynamic and structural damping coefficient g for all altitudes and captive flight speeds must be at least 3.0 percent for all vibratory modes. The natural frequencies of any control surface balance weights and attachments should not be less than twice the frequencies of the flutter modes in which the balance weights are effective. Sufficient store fatigue strength should be provided for aeroacoustical loads. The store should be designed to withstand and function while being exposed to the representative operational vibration environments specified in MIL-STD-810, Method 514.3, 515.3, or to actual in-flight measured vibration levels, whichever is the most severe.

5.3.11.4 Store dynamic response. The magnitudes and distributions of loads should include the effects of the dynamic response of the store structure resulting from the transient or sudden application of loads including, but not limited to, those resulting from the separation sequence (employment or jettison), and, in the case of external fuel tanks, fuel-slosh, and fuel-surge.

5.3.11.5 Landing loads imposed on store. The store must have sufficient strength to withstand all loads imposed upon it during field landings, rough field-landings (if applicable) and arrested landings (if the store is intended for use on carrier-based or Short Airfield for Tactical Support (SATS) capable aircraft). Arrested landing accelerations should be as specified in MIL-A-8591. If no specific aircraft are designated to carry the store, it should be assumed that the store will be used on carrier-based and SATS - capable aircraft, unless such use is specifically deleted as a design requirement in an applicable contractual document. Design conditions should include all possible stores stations and suspension equipment locations and loading configurations, including asymmetric loadings (wing, fuselage, and suspension equipment), and hung-store configurations.

5.3.12 Store environment. The store structure and store components should be designed to function without degradation under all operating conditions in the natural and induced service environments. Specifically, the store and its equipment should be designed to withstand and function while being exposed to the representative operational vibration environments specified in MIL-STD-810, Method 514.3, or 515.3, or to actual in-flight measured vibration levels, whichever is the most severe. Obviously poor design practices, such as attaching equipment to thin surfaces or cantilevering equipment, should be avoided. When practicable, external fins should be dynamically damped to reduce the amount of vibration that they feed into the store system. In addition, the design of the store should contain fail-safe features, whenever practicable, as defined in MIL-A-8861 such that if and when fatigue failures occur, they would not cause catastrophic failure of the store.

5.3.12.1 Store aeroacoustic parameters. Sufficient fatigue strength should be provided to withstand oscillatory forces (aeroacoustic) associated with turbulent airflow, boundary layers, wakes, and similar sources, as well as radiated noises from jet effluxes. Consult MIL-A-87221 for detailed guidance. Dispensers which leave cavities open to the airstream after munition packages have been employed, should be designed to withstand the representative acoustic cavity resonance levels of MIL-STD-810, Method 515.3, or actual in-flight measured levels, whichever is more severe.

5.3.12.2 Store thermal environment. Design consideration must be given to the thermal environment which the store will be subjected to while being carried on an aircraft as well as the self-created thermal environment in free flight. It is the responsibility of the store and related suspension equipment designer to:

(a) Define the thermal environment peculiar to the needs of the store and related suspension equipment. This may be expressed as a maximum shock temperature or a time soak temperature.

(b) Define the coolant requirements from the aircraft system necessary to sustain store equipment, if required.

(c) Define the exhaust gas or plume thermal field during firing or launch.

(d) See 5.1.8.3 for additional thermal environment design requirements.

5.3.12.3 Operational vibration. Representative operational vibration environments specified in MIL-STD-810, Method 514.3 or 515.3 must not degrade the store or its ability to function as designed. The design of the store should contain fail-safe features as defined in MIL-A-8861, whenever practicable, so that if fatigue failures occur, they would not cause catastrophic failure of the store.

5.3.12.4 Store electromagnetic criteria. The stores, including test sets, should be designed to comply with the requirements of MIL-E-6051 and for US Navy MIL-HDBK-235-1 (Electromagnetic Environment Criteria). In addition, the following design guidance documents should be used:

Air Force - AFSC DH 1-4
Navy - SD-24
Army - Handbook AMCP-706-235, Report 18

5.3.12.4.1 Store electroexplosive subsystems. Electroexplosive subsystems shall be designed to the requirements as specified in:

Air Force - MIL-STD-1512
- AFSC DH 2-5

Navy - MIL-STD-1385
- MIL-HDBK-235-1
- OD 30393

Army - AMCP-706-235, Report 18

5.3.12.4.2 Store electromagnetic interference. The procuring activity should tailor the EMI requirements to fit the specific environment of the system. When specified, all stores should comply with the requirements of MIL-STD-461 and MIL-STD-462. The minimum methods that should be applied are CE03, CE06, CE07, CS01, CS02, CS06, RE02, RS02, and RS03.

5.3.12.4.3 Store electrical bonding and lightning protection. Electrical bonding and lightning protection requirements should be in accordance with MIL-B-5087. Special electrostatic protection by grounding is provided by OP-4.

5.3.12.4.4 Store engine electrostatic charging. Stores that include means of propulsion and contain antennae or unshielded electronic systems should be designed to minimize generation of static electricity.

5.3.12.4.5 Store electrostatic protection. All electrical, electronic, explosive, and electromechanical subsystems/equipment should be designed to prevent static electricity from degrading system effectiveness. Special static protective procedures, such as grounding, are required for weapons loading and unloading operations. The following design guidance documents should be used:

Air Force - AFM 127-100, DH 1-4
Navy - OP-4
Army - AMCP-706-235, Report 18

In addition, DOD-HDBK-263 and DOD-STD-1686 defines electrostatic protection requirements for non-electroexplosive system electrical/electronic equipment. Electrostatic protection requirements for electroexplosive system equipment is defined by MIL-STD-1512.

5.3.12.4.6 Store EMI filters. Where EMI filters are shown to be necessary, they should be designed to protect against the specified frequencies and field intensities and evaluated when terminated in the tactical input and output impendances. The filters shall comply with MIL-F-15733. RF filter characteristics shall be monitored for production purposes in accordance with MIL-STD-220.

5.3.12.4.7 Store electromagnetic environment. Unless otherwise specified, the electromagnetic environment, should be as defined in MIL-STD-461 with supplementary requirements for Navy applications defined in MIL-HDBK-235-1 and supplementary Army applications defined in Army Missile Command TR RD-TE-87-1.

5.3.13 Loading and handling. The wide variety of store types and wide range of operational uses poses serious store loading and handling problems. The stores must be shipped from the factory to the operational theaters by several modes of transportation. Containers for stores are wooden, metal, foam, etc, and generally are inexpensive because they may be discarded. The transportation modes include truck, railroad, ship, aircraft, and other suitable means. Weapons are stored in enclosed magazines, throughout ships, open areas, and so forth, being exposed to various environmental extremes of weather (rain, snow, dust, mud) and radiation hazards. Stores will be handled during night operations, cold weather and high wind (carrier). No damage to the store, fins or control surfaces, ram air turbines, frangible radomes, exposed electrical connectors or the like can be tolerated if it degrades the functioning of the store.

5.3.13.1 Stores design as a function of AGE and GSE requirements. General design guidelines for stores in relation to the Aerospace Ground Equipment (AGE) and Ground Support Equipment (GSE) requirements are as specified in 5.3.13.1.1 through 5.3.13.1.11.

5.3.13.1.1 Packaging. The various class stores shall be packaged in accordance with MIL-STD-1319 and further detailed specifications from the procurement activity.

5.3.13.1.2 Transportation. The store should be suitable for transportation to the environmental limits defined in MIL-STD-1319.

5.3.13.1.3 Assembly. Assembly of stores is a major problem during intensive operations. The requirement to uncrate various pieces and attach fins, fuzes, arming wires, load dispensers, or ammunition is costly in manpower and time. Every effort should be taken to minimize assembly time by rapid attachment methods without the use of special tools. Minimum package dunnage is also desirable. Where applicable, all-up stores are preferred.

5.3.13.1.4 Cradle area. The cradle area is very critical as stores may be handled with many types and classes of AGE/GSE during transportation and loading. Stores shall be designed in accordance with MIL-A-8591.

5.3.13.1.5 Strongback and sway brace areas. Strongback and sway brace areas shall be designed in accordance with MIL-A-8591.

5.3.13.1.6 Hoist band areas. Many stores are loaded with single point hoists with bands around, or attachment points on the store at or near the center of gravity. Applicable store designs should include strengthened areas for bands or attachment point for hoist. Thin skinned stores, such as fire bombs, are most vulnerable to damage.

5.3.13.1.7 External protuberances. Exposed connectors, safety devices, frangible nose cones, fins and control surfaces, ram air turbines, and so forth, are easily damaged during store handling and loading. The risk of damage should be minimized or proper protection provided.

5.3.13.1.8 Flight line assembly or removal. Stores should be designed to minimize requirements to install or remove parts while maximizing protection or safety devices on the flight line or carrier deck. These objects become foreign object damage potential and missile hazards for high wind conditions in addition to reducing tempo of operations.

5.3.13.1.9 Special tool requirements. Stores shall be designed to use standard tools for assembly, handling, or loading.

5.3.13.1.10 Markings. Suitable markings concerning safety, store type, special handling or loading requirements should be provided. Store shipping containers should be marked in accordance with MIL-STD-129 and 49CFR, Parts 171-179.

5.3.13.1.11 Adapter cables and store suspension requirements. Stores should be designed to perform with existing electrical adapter cables and existing store suspension equipment.

5.3.14 Fuzing and arming. Fuzing as referred to herein, applies to devices located on or in the airborne weapons. Arming equipment, as referred to herein, is part of the aircraft or suspension and launching equipment. Parts involved in fuzing arming, including the weapon, fuze(s), suspension, arming unit(s), interconnecting wires and electrical cables comprise a common, interdependent interface problem, and none of the parts should exercise preferential or exclusive requirements over any other. Notwithstanding possible variations in weapon, fuzes, or aircraft store stations, design goals of the interface should include as much standardization of the geometric, structural, and functional characteristics as possible. The fuzing and arming system, collectively, should provide positive safety on the carrier deck or the ground against weapon arming or functioning, and the status of the safe/arm condition must be plainly evident. Fuzing design safety shall comply with the requirements of MIL-STD-1316 (STANAG 3525 AA and AIR STD 20/15).

5.3.14.1 Fuze and weapon. Present and future weapons which may have different weights, sizes, shapes, fuze types, fuze locations, launching methods or functional characteristics, should incorporate standardized provisions regarding management and initiation of the fuze arming cycle. Such a system should automatically control initiation of the arming cycle and positively prevent completion of the arming cycle until the weapon has separated from the aircraft the specified minimum distance, as dictated by the weapon delivery tactic or mode, and the pertinent safety requirements, or as specified in the appropriate system technical manual.

5.3.14.1.1 Mechanical fuze connections. The arming wire assembly, routing, and attachment arrangement(s) which interconnect the electro-mechanical arming unit(s) on the aircraft or launching equipment and the fuze(s) in the weapon should have a minimum number of configurations. If necessary, by unique requirements of particular weapons, a minimum number of different arming wire arrangements may be acceptable as interim standards only. However, change to the standard configuration should be accomplished at the earliest times by modification to parts of the system as needed.

5.3.14.1.2 Mechanical fuze characteristics. The "SAFE" and "ARMED" condition of the fuze should be controlled by retention or extraction, respectively, of the arming wire from the mechanical part of the fuze which initiates arming or permits the fuze to start such process. Completion of the arming process should not cause detonation or function of the fuze, but a subsequent, specified environmental stimulus will cause an armed fuze to function. Certain forward-launched or propelled weapons having fuzes armed by a specified acceleration history or by rocket motor pressure should include a specified mechanical safety feature to maintain the weapon in an unarmed condition during ground handling and stowage and may, therefore, omit the mechanical arming sequence above. Inadvertent firing of the rocket motor should not result in an armed store. A fuze arming wire extraction force range of 30 to 80 pounds should be provided. A minimum of 30 pounds extraction force (with the wire retained in the fuze) is required to ensure a "SAFE" fuze. To ensure an "ARMED" fuze, an arming wire extraction force of no more than 80 pounds should be required on the fuze. In either instance, a design goal should be to separate the arming wire from the aircraft as a final function, to avoid airframe damage.

5.3.14.1.3 Electrical fuze connections and characteristics. A maximum of one power lead and one ground return wire connection between the aircraft and store should constitute the physical interface if electric fuze(s) are used in the weapon. The weapon connection should be located as specified in MIL-A-8591. Coded fuze control commands should be transmitted, comprising specified various DC voltage levels, or no voltage, and either positive or negative. An RF coded system should not be used. The electric fuze settings for arming time(s) and function time(s) should be transmitted to the weapon after release of the weapon and before a 5-inch separation occurs between launcher and weapon. After transmitting fuze functional information, the cable should disconnect from the aircraft and go with the weapon.

5.3.14.1.4 Digital fuzing. For new store applications using MIL-STD-1760 and its associated MIL-STD-1553 multiplexed digital data interface, the transfer of arming commands from aircraft to the store should occur through the MIL-STD-1760 interface. The transfer of the digitally encoded fuzing commands can be protected to a high level by error detection methods described in MIL-STD-1553 and MIL-STD-1760 and through the use of Preset, Verify, Execute (PVE) command and monitor sequences. The use of digital fuzing not only provides an expansion of arming and fuzing options but also allows the aircraft to monitor the arming/fuzing status of the store prior to store separation. The full acceptance of the arming/fuzing commands can be made conditional (in the store) on the detection of interface disconnect (all address lines revert to logic 1 state with address parity error) plus other environmental sensor(s) within a predefined time receiving the arming/fuzing messages from the aircraft.

5.3.15 Reliability and maintainability. Crucially important characteristics of a store design are its reliability and maintainability. Reliability can be expressed as a probability that the store will perform its intended function for a specified period of time under stated conditions. Maintainability is a characteristic of store design and installation that can also be expressed as the probability that it will be retained in or restored to a specific condition within a given period of time. Such characteristics should be part of the initial design as opposed to modifications.

5.3.15.1 Store system effectiveness. Both reliability and maintainability are parameters of system effectiveness analyses. Where weapon system effectiveness can be defined to be a quantitative measure of the extent to which the system may be expected to achieve a set of specific mission requirements, it is imperative that both store reliability and maintainability requirements be based on system effectiveness requirements and not be arbitrarily set or guessed at. When store reliability and maintainability requirements are related to their effect on the system, future design changes and their reliability and maintainability impact can be evaluated against the effectiveness goal. Based on the effectiveness analyses or model, store reliability and maintainability numbers can be assigned to guide the design.

5.3.16 Mass properties variation. To achieve high quantity production rates economically, liberal store manufacturing tolerances are generally permitted. Unfortunately, these liberal tolerances significantly affect the weight, balance, and moments-of-inertia characteristics of the store. In achieving aircraft/store compatibility, store mass properties are very important from an aircraft structural loads or flutter standpoint. This effect can be critical in the case of smaller aircraft, or aircraft which carry large numbers of stores.

5.3.16.1 Mass properties tolerances. At present, the range of store production mass properties tolerances are not known for existing non-nuclear stores. Mass properties for nuclear stores, on the other hand, are generally well defined. Designers of new stores should incorporate into their design criteria the following production tolerances: weight $\pm 5\%$; center of gravity ± 0.50 inch (± 12.70mm); moments of inertia $\pm 10\%$. A quality control procedure should also be included in production contracts to ensure that these tolerances are not being exceeded.

5.3.17 Conflagration. The continuing development of new propellant and explosive constituents and the emergence of advanced design techniques for protecting weapon motors and warheads from cook-off should be utilized to a maximum in the design of new stores to minimize the stores' sensitivity to external flame or heat and to ensure, upon eventual ignition, that the stores' burning rate is minimized. Store fusing should be failsafe with respect to environmental temperatures above its design limit. New stores may draw upon the aircraft's internal fire-fighting and inerting systems to provide for internal and external store protection from a high temperature environment, or to quench a fire within the store. The developing advanced technology for aircraft fuel system increased survivability and reduction of vulnerability may be exploited in store design to guard against conflagration, either as an initiator or a victim.

5.3.17.1 Store fire protection. If available operational aircraft systems will not suffice, the requirements of the aircraft/weapon system may place the bulk of the separate store fire-protection and fire-fighting system within the aircraft.

5.4 Stores management system. The stores management system (SMS) controls, monitors, and releases the various stores located at the aircraft store stations. The SMS equipment provides the major electrical interface between the aircraft electronic and electrical systems and the stores, and between the aircraft and the suspension and release equipment (S&RE). For applications where mission stores are carried on an aircraft via a carriage store (e.g., a multiple carriage rack), the SMS controls the mission store by issuing commands to the carriage store for transfer to the mission store.

5.4.1 Stores management equipment. Implementation of the SMS functions can be allocated among various aircraft equipment. However, the SMS tends to be implemented with one of two types of system architecture: centralized or distributed.

(a) Centralized - In the centralized system, the SMS typically consists of a central control unit installed in an avionics bay and a set of controls and displays installed in the cockpit. All wiring associated with each of the store stations connect to the central control unit.

(b) Distributed - In the distributed system, the SMS typically consists of the following:

(1) Stores Management Processor installed in the avionic equipment bay.

(2) Remote encoders/decoders installed near the store station.

(3) Control/display panel installed in the cockpit.

(4) Power distribution unit installed near the power bus.

(5) Wideband signal distribution unit installed in the avionics bay.

5.4.2 SMS electrical interfaces. The SMS (as a subsystem) will contain a number of electrical interfaces. A representative list of these interfaces are:

(a) SMS to avionics equipment - This interface should use the multiplex, data mechanism for maximum flexibility and to simplify future upgrades. Some interfaces may exceed the information bandwidth or response time available on the multiplex bus and therefore may require dedicated wiring.

(b) SMS to power system - This interface consists primarily of power wiring to feed electrical energy from the power system to the SMS and its associated equipment. For aircraft that use multiplex based power distribution control systems, a data interface may also be required.

(c) SMS to suspension equipment - This interface tends to consist of dedicated wiring for power locks, arming units, pulsed power for firing electroexplosive devices, and status monitoring of the release equipment.

(d) SMS to control displays - This interface may be multiplex bus or dedicated wiring depending on the controls/displays concept adopted for the aircraft. (See 5.4.4)

(e) SMS to stores - This interface typically consists of seemingly random combinations of dedicated discrete, analog and power wiring for older stores. New stores using MIL-STD-1760 interfaces will simplify the SMS store interface by standardizing the signals in this interface. For these new store applications, the multiplex bus based MIL-STD-1760 provides a flexible command, statusing and data communication link between the SMS and the store. If the distributed SMS concept is selected for a specific aircraft, then the various sub-elements of the SMS will also contain interfaces among themselves. Recent distributed SMS implementations tend to use redundant buses (e.g., MIL-STD-1553) for the bulk of these interfaces.

5.4.2.1 Electrical connectors. Connectors must be designed to prevent accidental shorting of contacts during mating of the plug and receptacle. The connector must contain positive mating features to prevent any possibility of mismating. It should contain peripheral grounding fingers that connect the two mating halves of the connector before pin and socket contacts make contact. The connector should also contain provisions for terminating shield braid for EME protection. The connector mating halves on the aircraft, store and suspension equipment sides of the interface should contain socket-type contacts and the electrical adapter harness connector mating halves should have pin-type contacts. In general, connector selection should be made utilizing MIL-C-38999 Series III or IV with finish W. For MIL-STD-1760 applications, the aircraft station interface (ASI) connector requirements are defined in the standard. The aircraft SMS should be designed to ensure that store station connectors are not powered until an indication that the interface mated condition exists. Furthermore, the aircraft SMS design should ensure that power is removed from the interface before separation at that interface to avoid power arcing and associated equipment damage during disconnect of a powered connector.

5.4.2.2 Pin function assignments. Pin function assignments for all connectors in the SMS should be established after completion of a pin study. This study segregates signals into categories with related electrical functions and provides maximum safety and electromagnetic compatibility. The pin study must include a bent-pin analysis for all signals associated with safety critical functions. The characteristics of every signal in the interfaces should be defined as follows:

(a) Function name.

(b) Signal type - analog, discrete, pulse train, fire pulse (differential fire signals only).

(c) Signal voltage, current, power factor, and phase.

(d) Susceptibility threshold values.

(e) Grounding for power, signal and shield.

(f) Any special characteristics or requirements.

For interfaces controlled by MIL-STD-1760, the pin function and assignments for the ASI connector are defined in the standard. The characteristics listed above should still be defined for specific signals applied to the interface lines. For example, if a pulse train is applied to one of the high bandwidth interface lines, the characteristics of the pulse train must be documented.

5.4.2.3 Location of electrical connectors. The following criteria should be used as a guide to locating the electrical connectors on the SMS equipment:

(a) Maximum protection against EME.

(b) Maximum protection against moisture.

(c) Ease of connecting test equipment and aircraft cables.

5.4.2.4 Electrical input power. The SMS equipment should be designed to operate when energized with aircraft electrical power having the characteristics and limits specified in MIL-STD-704.

5.4.3 SMS mechanical interface. The mechanical interface design should consider the following:

(a) Ease of installation and removal.

(b) Maximum protection from EMI/EMP.

(c) Maximum protection from service environmental conditions.

5.4.4 Controls and displays. The stores management control and display functions must be integrated into the overall man-machine interface concept selected for the crew stations. If this selected concept includes integration of the SMS controls/displays (e.g., multifunction displays), substantial integration between the SMS and the aircraft controls/displays subsystem is required. Human factor aspects (MIL-STD-1472) particularly crew workload, must be considered in selecting the controls/displays concept and in determining the interaction required with the air crew. Extensive automation of stores management functions should be considered to reduce crew workload. The use of dedicated controls and displays for some critical SMS functions (e.g., emergency jettison and backup modes) must be considered.

5.4.5 General design criteria. The following item should be considered during the design of stores management equipment:

(a) The electronic portion of the equipment should be functionally modularized (printed circuit cards should be designed to perform a function: not be designed as a specific weapon controller).

(b) Microprocessor control of the functional electronic cards should be considered so as to minimize changes to aircraft wiring and system hardware.

(c) The design of the equipment should be such that any failure or malfunction within the equipment shall not create a hazardous or catastrophic condition by reason of its failure mode or by the direct effect of such a failure on interfacing equipment. The equipment design shall be that no single failure will result in an erroneous release command to a store.

(d) A failure detection function should be provided to indicate a go-no-go condition of the equipment. This function should include a continuous Built-in-Test (BIT) that is automatically initiated upon application of power to the equipment and should not interfere with any system function or operational mode. In addition, a manually initiated operational test should be provided to detect equipment failures, then isolate, record, report, and identify the failure. Reporting of degraded mode capability (degraded mode assessment), based on current mission stores loading, should be designed into the system to advise the crew of mission capability limitations.

5.5 Helicopter application. Design requirements for stores compatibility on U.S. Army rotary wing aircraft are addressed in AMC Pamphlets AMCP 706-201 Helicopter Engineering, Part One, Preliminary Design, and AMCP 706-202 Helicopter Engineering, Part Two, Detail 202 Helicopter Engineering , Part Two, Detail Design.

6. TESTS AND ANALYSES

6.1 Ground tests. The procuring activity shall approve all test plans, test procedures, and test schedules prior to the conduct of any proposed or actual tests.

6.1.1 Test plan. The test plan shall include test objectives and descriptions of each planned test, including equipment and facilities to be used, performance characteristics and accuracy of test instrumentation and recording devices to be used, and data to be recorded. Reliability criteria and failure definition shall be stated in each applicable test plan. The test program shall include, but not be limited to the minimum demonstration and test regimen herein required. Purchase of costly test equipment, duplicating that available at Government facilities, shall be avoided by utilizing such facilities.

6.1.2 Wind tunnel tests. Wind tunnel tests are necessary to establish aircraft/store compatibility to obtain qualitative and quantitative aerodynamic, aeroelastic, and dynamic data for aircraft and store combinations. Sufficient data is needed for the aircraft alone and for the isolated stores to provide a valid base for evaluating the incremental interference effects from the aircraft to store and where applicable, store to store combinations. Wind tunnel tests are conducted to provide data to supplement or substantiate analysis methods and provide reference information for conducting flight tests. Wind tunnel tests are particularly needed where analytical limits cannot be established or where analysis indicates marginal operational characteristics of the aircraft/store combination under consideration. Thus, wind tunnel tests can be very extensive or can be selective for certain configurations judged to be critical. Data shall be obtained, but not be limited to, the following relationships:

(a) Effects of stores and suspension equipment on the aircraft.

(b) Effects of stores on the suspension equipment.

(c) Effects of suspension equipment on the aircraft.

(d) Effects of aircraft and suspension equipment on the store.

6.1.2.1 Effect of stores on aircraft. Wind tunnel testing shall be conducted with sufficient instrumentation to evaluate, as a minimum, the following aerodynamic effects of stores:

(a) Changes in the drag, stability, and control of the aircraft during store carriage.

(b) Disturbances to the local flow field of the aircraft.

(c) Additional forces and moments imparted to the aircraft through the suspension system.

(d) Changes in the flutter and divergence characteristics of the aircraft.

6.1.2.1.1 Test models. Test models for stores effects on aircraft usually require specially tailored models, equipment, and techniques.

(a) Aircraft aerodynamics and captive store airloads use three dimensional models and acquire data with strain gauge balances, pressure instrumentation, flow visualization techniques, and flow survey rakes.

(b) Flutter and divergence studies require wind tunnel model tests of the aircraft with suspension systems and stores. Model dynamic similarity for important geometric, mass, and elastic parameters is necessary. Model instrumentation, such as accelerometers and strain gauges, are used to obtain test data. An exciter mechanism for the model may be useful.

6.1.2.1.2 Test data. Data from these tests should be obtained at sufficient variations in Reynolds number, Mach number, angle of attack, sideslip, control surface deflection and store loading to represent all reasonable flight conditions. Force, moment, and pressure data should be reduced to coefficient form and presented as functions of the test variables. Flutter and divergence test data should include airplane equivalent velocities, altitude, Mach number, frequencies, damping, modal descriptions, and descriptions of the test configuration including mass and elastic distributions. Since Reynolds number and Mach number effects are often critical to the validity of data, consideration must be given to the needs for matching these test parameters with flight conditions. These considerations are particularly important for transonic speeds and where boundary layer conditions must be simulated.

6.1.2.2 Effect of aircraft on stores. Aerodynamic environment for a captive store frequently involves curvilinear flow induced by either the aircraft, the aircraft and suspension equipment, or the aircraft, suspension equipment, and adjacent stores. Forces and moments acting on the store and its components are normally much different from these which would be encountered in an isolated environment. Wind tunnel testing should be used to evaluate the captive store airloads and to determine trajectory characteristics of the store separating from the aircraft. Where the store is sensitive to environment characteristics such as temperature, pressure (or gradients thereof) or imbedded shock patterns, local flow data are also needed.

6.1.2.2.1 Test models for aircraft effect on stores. These tests entail specifically tailored models, equipment, and techniques. Captive airload tests use three-dimensional models to acquire data with strain gauge balance, pressure instrumentation and flow visualization techniques. Strain gauges may be used in the store mode, in the suspension system, and in the airplane model at the point of attachment. Data on the three force and three moment components are desired for acquiring the imposed airloads. As a minimum, two force components (normal force and side force) plus two moment components (pitching moment and yawing moment) should be attained. The rolling moment component should also be included when testing finned stores. If model size permits, the axial force component should also be included.

6.1.2.2.2 Wind tunnel tests for store separation. Wind tunnel tests for store separation data may be obtained, but not limited to, the following tests:

(a) Dynamic drop - The dynamic drop tests use dynamically scaled store models. Data are recorded photographically. (This type of testing is limited to simulated level flight releases only.)

(b) Captive trajectory - Captive trajectory tests use a strain gauge balance within the separating store to continually measure the forces and moments acting on the store and uses an on-line computer to calculate the store trajectory.

(c) Grid data - Grid data tests use an instrumented store or pressure rake to survey the flow field through which the store must separate.

6.1.2.2.2.1 Wind tunnel test data for store separation. Drop test and captive trajectory data should be adequate for establishing trajectories in the form of store position and attitude. Grid data should provide store forces and moments as functions of store position and attitude for a space grid sufficient to enclose any store trajectory from the release position. Grid pressure rake data should cover the same trajectory region and should be obtained in the form of flow angularity and velocity. Accurate simulation of the ejector time versus load history is a crucial part of these tests.

6.1.2.2.3 Wind tunnel facilities. Some of the wind tunnel test facilities used for investigation of store separation are listed in Table II.

6.1.2.3 Isolated store aerodynamic tests. The purpose of isolated store aerodynamic testing is to determine the free-air" or isolated store aerodynamic characteristics. These tests should cover the range of Mach numbers and, if possible, Reynolds number anticipated for the future operational usage of the store. Angles of attack, sideslip, and bank should be investigated to determine the store's stability characteristics under the most severe conditions. High angles of attack(± 90°) should be considered for finless stores. Missiles and finned stores should be tested to ± 45°. Asymmetric bodies should be tested to ± 90° roll angle and ± 90° yaw angle.

TABLE II. Wind tunnel facilities for store separation.

Test laboratory	Tunnel types	Speed range	Test section size	Test method
NSRDC 1/ (Govt.)	Subsonic (continuous)	10-180 MPH	8' x 10'	Dynamic drop
	Transonic (continuous)	0.3-1.17 Mach	7' x 10'	(1) Captive trajectory (2) Grid (Flow field) (3) Dynamic drop
	Supersonic (intermittent)	0.2-4.5 Mach	18" x 18"	Dynamic drop
AEDC 2/ (Govt.)	Transonic (continuous)	0.1-1.3, 1.6, 2.0 Mach	4' x 4'	(1) Captive trajectory (2) Grid (Flow field) (3) Dynamic drop
	Transonic (continuous)	0.2-1.6 Mach	16' x 16'	Dynamic drop
	Supersonic (continuous)	1.5-4.75 Mach	16' x 16'	Dynamic drop
		1.5-6.0 Mach	40" x 40"	Dynamic drop
CAL 3/ (Private)	Transonic (continuous)	0-1.34 Mach	8' x 8'	Captive trajectory
GD 4/ (Private)	High speed (intermittent)	0.5-2.0 Mach	4' x 4'	(1) Captive trajectory (2) Grid (Flow field) (3) Dynamic drop
LTV 5/ (VSD) (Private)	High speed (intermittent)	0.5-5.0 Mach	4' x 4'	(1) Captive trajectory (2) Dynamic drop
	Low speed (continuous)	40-350 fps	7' x 10'	(1) Captive trajectory (2) Dynamic drop

1/ NSRDC - Naval Ship Research and Development Center
2/ AEDC - Arnold Engineering Development Center
3/ CAL - CALSPAN
4/ GD - General Dynamics (San Diego)
5/ LTV (VSD) - LTV Aerospace Corp., Vought Systems Division

6.1.2.3.1 Store model. Isolated store aerodynamic tests should utilize specifically tailored full-scale stores or stores scaled to the least extent necessary compatible with tunnel requirements, (e.g., interference effects, blockage) to ensure the highest degree of simulation. Isolated store tests also aid in ensuring that subsequent store separation wind tunnel tests (either captive trajectory system or dynamic drop), which employ smaller models, are measuring the appropriate loads.

6.1.2.3.2 Store model capabilities. The store model used in the tests shall have the following minimum capabilities:

(a) Aerodynamic force and moment tests require the use of a 6-component balance. Supplementary information can be obtained through the use of pressure surveys and flow field visualization techniques.

(b) The model should have the capability of being positioned to allow the obtaining of aerodynamic information throughout a wide range of pitch, roll, and yaw angles. Roll angle capability should be up to 90o to obtain the effect on store stability margin.

6.1.3 Store and suspension equipment characteristics tests. Several static and functional tests of the store and suspension equipment combination shall be conducted which will establish some basic store and suspension equipment characteristics prior to operational tests in flight. In some cases, the flight environment will be more severe than for ground tests. However, quantitative results can be obtained under controlled conditions on the ground while comparable data would not be possible or would be much less accurate if taken during flight. The reduced accuracies are a result of compromises in instrumentation and because of the increased number of variables that are inherent to a flight program. The basic objectives of these tests are to evaluate variables affecting compatibility and to confirm those used in predictions of satisfactory system performance.

6.1.3.1 Structural response during multiple store release. Tests to define the structural response during multiple store release are also required to evaluate these effects on store velocity during separation. A test set-up for this purpose should include airframe structure, suspension equipment, store racks and weapons to produce representative structural response during ejector firings. Variations in store loading and release interval should be representative of those for weapon delivery. Ejections of various weight stores should be made singly and in ripple from each rack position. Ripple ejections of stores are required to determine the effect of suspension equipment dynamic response on store ejection velocity. Test data should define time histories of store and rack position and attitude. The data should also provide means for evaluating the impulse imparted to each store during the separation cycle. The test data will include strain measurements of stressed linkages, actuators, frame members, and brackets. This data will be used to evaluate safety factors used in design and to provide a data base for solution of any in-service problems.

6.1.3.2 Ejector performance tests. Tests should be performed to determine ejector performance, including data as to variations in impulse imparted to stores because of differences in rack orifice settings or in production cartridges. These tests should be performed for all types of cartridges, ejectors and racks to be used as part of a weapon system. The data are applicable to other weapon systems, provided there are no large differences in the support structure that will appreciably change the rack flexibility and store dynamics. The ejector performance tests provide the definitive and representative data needed for the analytical procedures used to study store releases. These analytical procedures avoid the need of dynamic response data for a very large number of ground test store drops.

6.1.4 Store tests. The store shall be tested to determine if the design requirements have been achieved. This will be accomplished by static tests, liquid-filled store tests, vibration tests, and acoustic tests as shown in 6.1.4.1 through 6.1.4.4.

6.1.4.1 Store static tests. The store shall be static tested as specified in 6.1.4.1.1 through 6.1.4.4.

6.1.4.1.1 Test fixture. The test specimen should be mounted in a fixture duplicating the normal suspension equipment. The fixture should be capable of reacting any loads applied to the store. Application of loads to the store should be performed in such a way that they will, as closely as possible, duplicate the shear and moment diagrams for the corresponding loading conditions. The fixture should be sufficiently rigid so that there will be no significant deflection on the part of the fixture throughout the test. Sufficient deflection gages should be incorporated in the test instrumentation to define a stiffness matrix for the item being tested to verify the predicted stiffness of the item as used in the aeroelastic analysis.

6.1.4.1.2 Design limit and yield loads. The test specimen should be static tested to its design limit and yield loads (115 percent of design limit load) in each axis. The loads should be applied incrementally until 100 percent of the design load has been reached. Each percent increment should be held for one minute before proceeding to the next percent increment. At the end of the 100 percent load one minute holding period, the load should be relieved to zero and the test specimen inspected for permanent deformation. Permanent deformation after the removal of the 100 percent load constitues a failure of the test. The test specimen should be subjected to a yield load of 115 percent of design limit load for one minute. The 115 percent load should be relieved to zero and the test specimen inspected for deformation. Permanent deformation after removal of the 115 percent load will constitute a failure of the test.

6.1.4.1.3 Design ultimate load. The test specimen should be static tested to its design ultimate load. The load should be applied incrementally until 150 percent of the design limit load has been reached. The test specimen should withstand the design ultimate load without failure although deformation is allowable.

6.1.4.1.4 Failure load. The test specimen should be tested to failure. Failure load of the test specimen is defined as that load at which any part of the primary structure of the test specimen fractures. The loads applied to the specimen at failure should be measured and recorded.

6.1.4.2 Liquid-filled stores tests. Liquid-filled stores shall be tested as specified in 6.1.4.2.1 through 6.1.4.2.3.

6.1.4.2.1 Accelerated loads test. It should be demonstrated that the store filled to the applicable capacity, and its internal components can sustain the dynamic effects of 1.00 times the design inertial limit load at the applicable weights for catapult, arrested landing, and flight conditions without leakage, permanent set or failure. Further, it should be demonstrated that the store, filled to the applicable capacity, and its internal components can sustain the dynamic effects of 1.50 times the design inertial limit loads at the applicable weights for catapult, arrested landing, and flight conditions without fracture or failure.

6.1.4.2.2 Test method. The test method should simulate the dynamic effects of fluid on the store and the internal components during the applicable loading conditions. Ground tests of U.S. Navy external fuel tanks should be in accordance with MIL-T-18847. The proposed test method should be submitted to the procuring agency for approval.

6.1.4.2.3 External protrusions load tests. The external protrusions, such as, but not limited to, fins, tail cones, or fairings shall be subjected to the following design limit loads:

(a) 1.00 times the applicable loads without permanent set, leakage, or structural failure.

(b) 1.50 times the applicable loads without failure.

6.1.4.3 Vibration tests. Vibration tests will be performed as specified in 6.1.4.3.1 through 6.1.4.3.4 and Table III.

6.1.4.3.1 External store configurations. Using information obtained from the final external stores configuration definition and from the parametric analyses, a set of configurations should be developed for ground vibration testing. All required loads of the specified external stores configurations should be considered and a set of the most critical configurations selected for test. To the extent possible, other configurations should be selected for test which will provide data on a range of values of important parameters such as inertia, weight, and center-of-gravity location.

6.1.4.3.2 Pylon influence coefficient. A pylon influence coefficient test should determine the pylon-rack stiffness to be used in flutter analyses and the design of the flutter model pylons.

TABLE III. Vibration test methods.1/

Components to be tested	Simulated vibration environment	Failure definition	Test methods
Store and 2/ associated hardware	Service definition for store	No allowable store or aircraft performance degradation or malfunction	Method 514.3 MIL-STD-810
Stores containing electronic equipment, such as ECM, sensors, etc	Service definition for store	No allowable store or aircraft performance degradation or malfunction with proof that electronics payload has withstood the vibration environment	Method 514.3 MIL-STD-810
Store and associated hardware	Operational 3/ acoustic	No allowable store or aircraft performance degradation or malfunction	Method 515.3 MIL-STD-810
Store and associated hardware	Repetitive firing of guns mounted in, on, or near the aircraft structure	No allowable store or aircraft performance degradation or malfunction	Method 519.3 MIL-STD-810

1/ If actual, in-flight measured vibrations are known and are more severe than those shown in TABLE III then the measured levels shall be used in lieu of those stated for MIL-STD-810.

2/ "Associated hardware" is all accessory equipment that will make the store functionally operational.

3/ See 6.1.4.4 for acoustic testing of areas that have sound pressure levels in excess of 140 dB.

6.1.4.3.3 Jig-mounted pylon ground vibration. A jig-mounted pylon ground vibration test consisting of the pylon, pylon-store interface structure, wing-pylon interface structure, and store(s) shall be performed early in the development phase. This test is necessary to validate the mathematical model and the wind tunnel model being used for the external store flutter clearance effort. This test should accurately determine the frequencies, node lines, mode shapes, and damping ratios of each normal mode of the system.

6.1.4.3.4 Airplane ground vibration. Airplane ground vibration tests with the specified external stores should determine the dynamic characteristics (natural frequencies, mode shapes and damping) of the airplane and, in addition, should investigate the degree of dynamic similarity of the flutter and analytical mathematical models to the actual airplane.

6.1.4.4 Acoustic tests. Stores, mounts and adjacent structures which are exposed to acoustic or aero-acoustic sound pressure levels in excess of 140 dB should be tested in acoustic facilities. During these tests, the operational conditions should be simulated as closely as practicable. These conditions include the acoustic environment, boundary conditions, temperature, and service time. Method 515.3 of MIL-STD-810 titled "Acoustic Noise" should be used as the testing criteria for testing the stores. MIL-A-87221 provides for the acoustic testing of aircraft structures.

6.1.5 Engineering analyses. The engineering analyses typically required to determine store/airplane compatibility should include, but not be limited to, the following:

(a) Operational compatibility.

(b) Store functional limitations.

(c) Carriage limitations.

(d) Separation limitations.

Compatibility involves the establishing of estimated flight envelope limits for carrying, employing and jettisoning of a store or stores configuration intended for tactical employment. Analytical methods, coupled with empirical and experimental data, are used prior to flight test to predict critical areas, conditions, parameters, and to reduce the scope of the test programs, both ground and flight.

6.1.5.1 Engineering analysis parameters. The comprehensive ease of any analysis is to a large degree dependent on the thoroughness and clarity established for the definitions of the parameters utilized. Parameter definitions, including but not limited to those stated, are needed:

(a) Types of stores to be carried.

(b) Mixes of stores in one loading.

(c) Loading symmetry.

(d) Partial loading criteria.

(e) Hung store criteria.

(f) Employment sequencing.

(g) Airplane external and internal configuration baseline prior to the addition of stores.

(h) The specific number of stores or combination of store loadings for which compatibility is required.

(i) Establishment of a basic loading for the store having the maximum tactical priority when different types of stores are carried.

(j) Store characteristics, which shall include, but not be limited to, the following:

(1) General arrangement.

(2) Special installation requirements.

(3) Clearance requirements for moving parts.

(4) Permissible store design factors for:

(aa) Angular displacement.

(bb) Rates and acceleration.

(cc) Weights.

(dd) Center of gravity.

(ee) Moment of inertia.

(5) Flight envelope limits for:

(aa) Carriage.

(bb) Operation.

(cc) Launch.

(dd) Release or jettison.

(6) Carriage acceleration limits.

(7) Aerodynamic data.

(8) Ballistic data.

(9) Mechanical attachment requirements.

(10) Electrical attachment requirements.

(k) Suspension equipment characteristics, which shall include, but not be limited to, the following:

(1) Release mechanics characteristics.

(2) Ejection force time history.

(3) Ejection moment time history.

6.1.5.2 Physical compatibility review. The physical compatibility review shall be as specified in 6.1.5.2.1 through 6.1.5.2.6.

6.1.5.2.1 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. Any suspected incompatibility should be investigated.

6.1.5.2.2 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.

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

6.1.5.2.4 Quantity per carriage location. The quantity of each type of store that can be installed on a carriage location should be determined. This should be the quantity that falls within the physical, structural, and functional limitations of each location, and for each method of store suspension equipment utilized. 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 for tactical desirability. Some configurations of this type may be allowed by the procuring activity if additional maneuvering limit restrictions are placed on the aircraft such that the maximum allowable product of load factor times weight (nW) is not exceeded.

6.1.5.2.5 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 may be found in MIL-STD-1289. Any store installation which does not satisfy the clearance requirements of MIL-STD-1289 should not be analyzed or pursued further unless the deviation has been approved by the agency having technical or engineering cognizance on the specific aircraft in question. In addition to the above requirements, adequate clearance should exist so that runway or carrier pendant cables will not strike the aircraft or installed stores or suspension equipment during cable bounce caused by nose or main gear roll-over.

6.1.5.2.6 Stores configuration. The maximum store configurations which provide maximum quantities of store types desired for the airplane should be defined. This definition includes separation clearance requirements, carriage clearance, and minimum static clearance between adjacent stores as well as hung stores. Derivable store configurations acquired from the maximum stores configuration should be evaluated for compatibility.

6.1.5.3 Store configuration evaluation. The store configuration evaluation shall be as specified in 6.1.5.3.1 through 6.1.5.3.2.

6.1.5.3.1 Operational conditions analysis. A complete, detailed, operational conditions analysis shall be made to predict the operational limitations for carriage and employment of each external or internal stores configuration and for any of their derivable configurations. Where limits cannot be predicted by analyses, the requirements for wind tunnel, structural, and any other ground testing necessary for establishing the analyses parameters shall be clearly defined and their relationship(s) to the analyses precisely established. Operational conditions are defined for the specified airplane/store in the applicable contractural document. Hung store conditions shall be investigated for the total flight envelope and the store operational limits. Hung store investigation is normally made considering any combination of one hung store per aircraft station. For Navy procured airplanes the arrested landing or barricade engagement conditions with the hung store shall be one of the parameters for airplane/store operational conditions.

6.1.5.3.2 Captive carriage analysis. A captive carriage analysis is to be performed and shall include the analyses and reviews as specified in 6.1.5.3.2.1 through 6.1.5.3.2.4.

6.1.5.3.2.1 Weight and CG review. For the weight and CG review, the aircraft weight and the most forward and the most aft center of gravity locations shall be determined. When the aircraft aerodynamic center can be determined by analytical prediction from existing data on similar or related external stores configurations, a comparison of the aircraft aerodynamic center and center of gravity locations shall be made to ascertain that an acceptable static margin exists. For this review, the aircraft internal configurations (electronic countermeasures gear, and armor plate) and the ground rules governing the expending of stores (i.e., store release sequence variations, whether empty rocket launchers, dispensers and spray tanks are jettisoned or retained) should be established. Due to subsequent changes to the aircraft (i.e., ECPS's that add or remove equipment) weights and CG's computed during these analyses may not always be representative of the aircraft. Therefore, it is not intended that this compatibility evaluation of a stores configuration shall eliminate the necessity to use the operational aircraft weight and balance handbook information to assure that a specific aircraft/stores configuration is within allowable weight and CG limits. When the aerodynamic center cannot be analytically determined, the requirement for wind tunnel testing shall be established.

6.1.5.3.2.2 Structural review. For the structural review, the store loading on each carriage station in the stores configuration should be compared with bomb rack and aircraft carriage station allowable strengths. The estimation of the allowable strength should include fatigue and fracture failures modes, as well as the classical static failure mode. A check should be made of the total station store loading against the allowable structural limits. These loads should be obtained by performing an aeroelastic analysis of external store installation to define side force, yawing moment, rolling moment, lift, pitching moment, and drag for the external store installation. The allowable aircraft roll and g limits for each stores configuration should be determined. Where external store loads as determined analytically or from wind tunnel tests may exceed the static strength of bomb racks and/or airplane carriage stations, the allowable limits should be established and an acceptable alternate stores configuration should be defined. For hung store structural considerations, the allowable limit load may be reduced to a lower percentage of failing load as established by tests or analysis. A typical critical yaw condition usually exists when one of six stores carried on a multiple rack is released, thereby creating a five store configuration which is not symmetrical fore and aft. In the case of stores attached to a multiple carriage rack, the following checks, but not limited to those stated, should be made of:

(a) Individual store loads against individual ejector unit allowable structural limits.

(b) The forward and aft cluster loads against beam allowable structural limits.

(c) Any configuration of stores on a multiple carriage rack obtained through normal release or short loading (taking off with a partially filled rack).

(d) Any configuration of hung stores on a multiple carriage rack obtained from a full or partial loading.

6.1.5.3.2.3 Flutter analyses. For the flutter analyses, all applicable stores can be divided into the inertially similar groups (or families) based on weight, pitching radius of gyration, and longitudinal center of gravity location. Provided there is reasonable aerodynamic similarity between stores in any group, all stores in the group should exhibit similar flutter properties. Aircraft/store combination flutter analyses for both the symmetric and asymmetric cases can be performed to cover various ranges of store weight, pitching radius of gyration and longitudinal center of gravity. Charts of the results of these analyses can be used to define critical flutter areas. This review may also be made by comparison with existing data on similar or related stores configurations. For analyses of mechanical instability and rotor-induced forced vibrations of stores, the same approach as described above (grouping stores based on similar mass characteristics) should be used.

6.1.5.3.2.4 Aerodynamic analyses. For aerodynamic analyses, the operational flight envelope capabilities of the aircraft with external stores should be predicted. As a first order approximation, the limits to which each external store has been designed and flown on other aircraft can be compared with the airplane capabilities, and the external stores configurations appropriately limited.

6.1.5.3.3 Employment analyses. Employment analyses shall include, but not be limited to the requirements as specified in 6.1.5.3.3.1 and 6.1.5.3.3.2.

6.1.5.3.3.1 Launch analyses. The missile and rocket launch trajectories and conditions compatible with the aircraft should be predicted by analyses of basic weapon information, such as, but not limited to, the following:

(a) Launch envelope.

(b) Acceleration profile.

(c) Plume characteristics.

(d) Initial control surface positions.

(e) Stabilization requirements.

(f) Aerodynamic loads.

(g) Aircraft flow field characteristics.

(h) Missile flow field characteristics.

(i) Missile characteristics.

Analytical comparison with similarly launched stores can be utilized to ascertain feasible missile launch, and appropriate wind tunnel tests requirements can be established. An evaluation should be conducted to ascertain probable detrimental side effects from heat, blast, and post-launch debris impingement on aircraft components, adjacent racks and stores, and gas ingestion into the engine.

6.1.5.3.3.2 Separation analyses. Appropriate analytical evaluation of existing separation data on the specific or comparable stores should be utilized as initial estimators to predict individual store release and jettison separation characteristics. For emergency jettison conditions, empty and fully loaded multiple carriage racks and partial rack loadings obtainable through the normal rack release sequence should be evaluated. Available bomb ejection cartridge data should be evaluated to obtain appropriate ejection forces at the points of force application. General evaluation can be made as applicable of side effects and possible problem areas associate with store separation, such as: aircraft response resulting from store release, aircraft control surface influence, partially full fuel tank jettison, etc. Where separation envelopes cannot be predicted by the above analyses, the necessary wind tunnel test and flight test requirements should be established. For external stores that spray or dispense munitions or components, a review can be made utilizing existing store data to define possible problem areas. Defining or predicting the separation characteristics of agents, munitions, objects, materials, etc., that may be dispensed, sprayed, or otherwise released from stores carried on the aircraft should be made to determine a safe separation based on available data. Types and bounds can be established for defining various families of stores and the criteria used in selecting a store for a particular family. The family method, properly established, is a valid procedure. Reliance on qualitative data only for analysis or acceptance of only qualitative data from tests, particularly flight, is unrealistic. Quantitative data acquired from approved testing standards should be used in analysis, whenever possible. A variety of techniques may be used to show quantitatively whether the store separation is safe, marginal, or unsafe. Any store that falls near the safe separation boundary should be studied more closely. The detailed trajectories of all conditions could then be used to define the safe envelope.

6.1.5.3.3.3 Minimum release interval. An analytical study should be done using available techniques to assist in evaluating store minimum release intervals. The results can be used as a guide to minimize the flight test program. Sequence of release and hung-store criteria are among the many factors which must be considered when establishing minimum release interval.

6.1.5.3.4 Stores configuration report. The store configurations evaluated should be summarized. This report should include the results of an analyses of the quantitative data derived from ground test programs. This summary should also include recommended flight envelope limits as determined by these analyses and tests prior to flight testing. The recommended flight envelopes should specify the reason for each limit shown.

6.1.6 Fit and function test. Prior to flight testing, all airborne stores should be fit tested on the desired aircraft in accordance with the procedures specified in MIL-STD-1289 (STANAG 3899 AA and AIR STD 20/21). Items which undergo in-flight configuration changes, such as extension of probes, air powered generators, will be cycled through these modes during the fit test.

6.1.7 Aerospace ground equipment (AGE)/ground support equipment (GSE). Analyses and tests shall be performed to demonstrate compatibility of the AGE or GSE with the aircraft, suspension equipment, stores, and store containers to be used in all the environments encountered in all theater of operations. Primary emphasis will be placed on the aircraft weapon compatibility of store handling equipment tests in lieu of the total tests (structural, environmental, and safety) that is required to certify AGE/GSE. General guidelines regarding aircraft weapon compatibility AGE/GSE tests are included in 6.1.7.1 and 6.1.7.2.

6.1.7.1 AGE/GSE analyses. Prior to conducting AGE/GSE tests the following shall be determined:

(a) The cognizant activity should establish safety certification of transporters and loaders with the store(s) undergoing tests.

(b) The cognizant activity should determine the applicable aircraft and stores and establish a loading matrix. They should also establish the AGE/GSE to be used.

(c) From previous fit tests, the maximum single store loading capability and also the various mixed store configurations will be established. For existing aircraft, appropriate Tactical Manuals or drawings should be used to obtain this information.

(d) The difference between maximum height from ground to the top of the store when mounted on loader or transporter, and the minimum height from ground to aircraft/store suspension equipment should indicate critical loads with regard to clearance.

(e) Wheels, gear doors, antennae or other aircraft protrusions should be noted from drawings which restrict approach angles or provide insufficient clearance.

(f) Planned store loadings should be analyzed to ensure adequate personnel and aircraft safety. The requirement for personnel to work under loaded stores during approaches, loading, sway bracing, or normally required operations should be avoided.

(g) Store vertical, lateral, and longitudinal displacement or roll, pitch, and yaw attitude requirements to mate with suspension equipment should be established from drawings and noted. The effects of ship movement about its axis (roll, pitch, and yaw) shall be defined for Navy application.

From the above data, the critical aircraft, store, or AGE/GSE conditions will be established and these critical configurations should be subjected to actual transporting and loading demonstrations.

6.1.7.2 AGE/GSE tests. The AGE/GSE tests are designed to demonstrate that the equipment is suitable for its intended use, whether it be on land for Army or Air Force, or on aircraft carriers for the Navy. Critical configurations established from the analysis of 6.1.7.1 should be subjected to tests. In general these tests should include, but not be limited to, the following:

(a) Clearance tests to demonstrate that adequate store-to-ground/deck and store-to-aircraft clearance exists to maneuver and load stores. Clearance tests will also indicate order of stores to be loaded (generally from inboard to outboard).

(b) Maneuverability tests to determine AGE/GSE aircraft approach patterns, maneuverability, and creep capability in order to preset store in alignment with store suspension equipment for loading operation.

(c) Hoisting tests should be conducted to establish adequacy of coarse and fine controls to position the store in the correct vertical, lateral, longitudinal position at the proper roll, pitch, yaw attitude in order to mate with the store suspension equipment. Coarse controls, together with the transporter creep capability, should provide gross position. Fine controls should be used to mate weapon with aircraft and uneven response may be cause for damage and rejection. Good visibility of stores, store suspension equipment, including hooks, sway braces, release and safety devices, are essential for this operation. Bomb bay loads can provide problems in regard to visibility. Good communication between loading crew members is also essential. Noisy mufflers or other devices may preclude satisfactory communications.

(d) Store and store suspension mating tests should be conducted to verify proper AGE/GSE weapon control and positive store suspension equipment latching. Safety pins or devices to ensure mechanical integrity should be installed and must clearly indicate the status of safe/arm conditions. Adequate clearance for personnel to latch, install safety devices, tighten sway braces, remove AGE/GSE store tie-downs, and make all other adjustments without jeopardizing physical safety is mandatory. Bomb bay installations, or close external parent stations with multiple carriage racks, can have serious problems in this regard.

(e) The capability of the AGE/GSE to download stores should be evaluated. Many stores are carried and returned if the proper target is not encountered. Also, stores which become "hung" through mechanical or electrical armament system malfunctions must be downloaded. The reverse process to uploading should be used to determine compatibility of the AGE/GSE to download stores.

(f) The above conditions should be tested at night under red lighting and also with protective clothing for cold weather operations.

(g) Flight line assembly or removal of parts (wings, fuzes) or protection devices should be evaluated.

(h) Tool requirements and electronic checkout equipment for handling and loading should be evaluated for suitability.

6.1.8 Stores management equipment test. Stores management equipment should be tested to determine if the design requirements have been achieved. These tests should include the following:

(a) Acceptable test on each delivered unit to detect any workmanship or material problems with the equipment. This test should include an operational test under defined cycles of vibration, temperature and failure free hours of burn in.

(b) EMI and environmental qualification tests identified by the procuring service operational environment.

(c) Test, analyze, and fix tests to determine that the equipment meets its reliability requirements.

(d) Software verification and validation tests to determine that the software meets all design requirements.

(e) Laboratory integration tests to determine that the stores management equipment performs properly with the equipment to which it is to be interfaced.

(f) Aircraft ground tests to assure that when installed in the aircraft, the aircraft/SMS interface is properly done.

(g) Aircraft flight tests to determine that the operation and accuracy of weapon release meets its safety of flight and accuracy requirements within the flight envelope.

6.1.9 Electromagnetic compatibility testing. System electronic testing should be in accordance with MIL-E-6051 and for the electromagnetic environments (EME) specified in MIL-STD-461. For Navy applications, additional EME requirements are defined in MIL-HDBK-235-1. For Army applications, additional EME requirements are defined in Army Missile Command TR RD-TE-87-1. An electromagnetic compatibility (EMC) test plan must be prepared as required by MIL-E-6051 and submitted to the procuring activity for approval prior to testing when specified in the contract. See DOD-STD-1686 and DOD-HDBK-263 for electronic equipment electrostatic protection requirements.

6.1.9.1 Electroexplosive subsystem testing. Testing of electroexplosive subsystems and components, shall be in accordance with:

Air Force - MIL-STD-1512

Navy - MIL-STD-1385

6.1.9.2 Electromagnetic interference testing. Tests on electrical, electronic, and electromechanical subsystem/equipment shall be in accordance with MIL-STD-462. Susceptibility tests should use swept CW frequencies and should use swept frequency amplitude modulation from 10 to 10,000 Hz (spot frequency CE tests are prohibited). A test plan should be submitted to the contracting agency and approved prior to the start of testing.

6.1.9.3 Electrical bonding and lightning protection testing. Tests should be performed to demonstrate compliance with MIL-B-5087. A test plan should be submitted to the contracting agency and approved prior to start of testing.

6.1.9.4 Store engine electrostatic charging tests. Tests should be performed to determine the store engine electrostatic charging characteristics for systems that have antennae or unshielded electronic subsystems. A test plan should be submitted to the contracting agency and approved prior to start of testing.

6.1.9.5 Static charge test. Systems and subsystems should be tested for susceptibility to static charge. Susceptibility to helicopter static charge buildup should be evaluated by discharging a 1000 micro Farad capacitor charged to 300,000 volts into the system. Susceptibility to static charge buildup on personnel should be determined by discharging a 500 micro Farad capacitor, charged to 25,000 volts and in series with a 5 kilohm non-inductive resistor, into the system. A static charge test plan should be submitted to the contracting agency and approved prior to start of testing.

6.1.10 Engine ingestion tests. Tests for engine ingestion shall be those as specified in MIL-E-5007. These engine ingestion tests cover armament gas, bird, foreign object damage, ice, sand, atmospheric water, and corrosion susceptibility conditions.

6.2 Flight tests. Flight tests are performed to investigate critical aircraft/store configurations determined from pre-flight analyses and to determine the total airborne weapon system's suitability for operational use.

6.2.1 Captive flight testing. Captive flight tests are performed to investigate flying qualities, performance, flutter and vibration characteristics, structural integrity, aeroacoustic and thermal characteristics, and endurance capability of the aircraft/store configuration. These flight tests are performed to obtain qualitative and quantitative test results, as appropriate.

6.2.1.1 Aircraft flying qualities. The flying qualities requirements of MIL-F-8785, MIL-F-83300 and MIL-H-8501 should be investigated for critical aircraft/store configurations as determined from the analyses of 6.1.5 and buildup flight tests. Tests should be performed with an aircraft suitably instrumented to obtain quantitative flying qualities data. In addition, provisions should be made to configure the test aircraft/store combination to ensure that critical conditions are obtainable during flight. The flying qualities characteristics should be investigated in those areas determined to be critical by performing appropriate test maneuvers in general accordance with those outlined in MIL-D-8708. Pertinent data defining the flying qualities characteristics should be observed and recorded during the test and reported.

6.2.1.2 Structural flight tests. Structural flight testing should be performed to demonstrate the structural integrity of aircraft/suspension equipment/store combinations, when such testing is deemed to be necessary and required by the procuring activity. To reduce expenditures and eliminate needless duplication, only critical combinations of aircraft, suspension equipment and stores should be demonstrated to critical conditions. Maximum use should be made of structural flight test data previously acquired for the aircraft involved when determining critical combinations and critical conditions. The development of structural envelope curves to define safe carriage limits for store/suspension equipment/support structure from existing data is encouraged. Structural flight tests should be performed as specified for:

Air Force - MIL-A-87221

Navy - MIL-D-8708

Army - AMCP 706-203

6.2.1.3 Flight flutter tests. Flight flutter tests must be performed for two very specific conditions. The first condition, as discussed in 6.2.1.3.1, is that for the basic aircraft with its specified representative critical stores as defined in the design and preproduction phases. The second condition, as defined in 6.2.1.3.2, is that for the basic aircraft but with stores not specified nor tested with the aircraft in the design or preproduction phases.

6.2.1.3.1 Basic aircraft with specified stores. Flight flutter tests shall be performed for the basic aircraft with its specified representative critical stores as defined for the design and preproduction phases. These tests should substantiate that the aircraft is free from aeroelastic instabilities for all design variables. Flight flutter testing of stores should be limited, for the most part, to critical store configurations along with non-critical representative and other non-listed configurations in order to substantiate the flutter boundaries established by analyses and wind tunnel tests. Flight flutter tests should be performed up to V_L (the limit speed of the basic configuration specified for structural design) for critical configurations of listed stores and to predicted safe flutter speeds for other loadings. Measurements should be made at the minimum altitude for which the maximum design dynamic pressure can be obtained, and the minimum altitude for which transonic effects can be obtained. Sufficient instrumentation and suitable methods of excitation should be installed and utilized to clearly detect, define, and measure the mode shapes, modal frequencies, and amount of modal damping.

6.2.1.3.2 Basic aircraft with non-specified stores. Flight flutter tests shall be performed to established flutter envelopes for aircraft/store combinations not included in the design and preproduction phases (see 6.2.1.3.1). These tests should substantiate that the airplane/store(s) combination is free from aeroelastic instabilities for all design variables. The store configurations to be tested should be limited, for the most part, to critical store configurations established by analyses and wind tunnel tests. Flight flutter tests should be performed up to V_L for those critical configurations whose predicted minimum flutter speeds are in excess of 1.15 V_L. Those critical configurations whose predicted minimum flutter speeds are below 1.15 V_L may be flight flutter tested up to $V_{flutter}$ divided by 1.15, providing damping values meet established requirements. This latter speed then becomes the restricted speed for the listed takeoff configuration from which the critical configuration was derived if the flight flutter test was successful and no other lesser speed restrictions are encountered. Sufficient instrumentation and suitable methods of excitation should be installed and utilized to clearly detect anticipated modal responses and to measure modal frequencies and damping. Measurements should be made at the minimum altitude for which:

(a) The maximum design dynamic pressure can be obtained.

(b) The maximum Mach number can be obtained.

(c) The greatest transonic effects can be obtained.

6.2.1.4 Flight vibration and aeroacoustic tests. Flight vibration and aeroacoustic measurements should be made in the areas near the stores which are suspected to have either severe flight vibration or aeroacoustic pressure fluctuations, or both conditions. These measurements can be used to determine the ability of the stores, their mounts, and the adjacent structures to:

(a) Resist sonic fatigue failures.

(b) Inhibit equipment malfunctions.

(c) Establish fatigue data criteria.

(d) Establish criteria for the acoustic facility tests.

6.2.1.5 Mechanical instability. Mechanical instability and rotor-induced vibration of stores should be performed in accordance with the test procedures of MIL-T-8679.

6.2.1.6 Performance degradation measurement tests. Flight testing should be performed to determine the degradation in mission performance caused by drag associated with store carriage. A variety of store combinations, selected to be compatible with anticipated mission requirements, should be flown. Results should be compared with those analytically derived under paragraph 5.1.7 and 5.3.12 and those experimentally derived from wind tunnel and flight test (see 6.1.2 and 6.2.1). Methods of determining airplane performance while carrying external stores should be either of the following:

(a) The traditional method of determining airplane performance while carrying external stores is to perform, using an instrumented test aircraft, such maneuvers as takeoffs, climbs, accelerations, stabilized level flight, windup turns, and landings. The data from such maneuvers yield the performance of the aircraft/stores combination directly in terms of takeoff distance, rate-of-climb, and nautical air miles per pound of fuel. This method of testing provides excellent results, but does require considerable flight testing, particularly with aircraft which have a large flight envelope. An adaptation of the traditional method, which yields the desired performance less directly but with considerably less flying, is to restrict the flight to dynamic maneuvers only; that is, selected climbs, descents, accelerations and decelerations. These maneuvers are then used to generate drag polars and engine characteristic data. These data, used in conjunction with similar data obtained from testing without external stores, form the basis from which any desired type of airplane/store performance can be calculated.

(b) An alternative to the above approach is the store drop technique which has been used with considerable success. With this technique, an instrumented aircraft is flown over a suitable drop area in stabilized or quasistabilized flight and the external stores are released. The resultant changes in normal and longitudinal accelerations are analyzed to obtain an increment in drag coefficient between the pre-drop and post-drop data. This technique appears to be considerably more accurate than conventional methods but is more costly since the stores are expended and data are obtained only at one flight condition for each drop. The improved accuracy available from this technique could be very useful for the determination of small drag items, such as the interference drag between stores.

6.2.1.7 Qualitative flight tests. Qualitative flight tests are flown on uninstrumented aircraft to:

(a) Check the store loading configurations on the aircraft flying qualities and store failures induced by the aircraft (6.2.1.7.2).

(b) Investigate the ability of the stores loaded in a specific aircraft/store configuration to withstand the aircraft ground and flight operational environment for periods of time longer than a single mission, including preparation for and return with all stores still on aircraft (6.2.1.7.3).

6.2.1.7.1 Purpose of qualitative flight tests. Generally, captive flight critical conditions are defined by those store loadings which could: cause wing flutter, aircraft stability problems, or maximize loads in the aircraft pylon or wing structure. These conditions are usually derived analytically by grouping stores in terms of those of similar size, weight or moments of inertia. Flight tests with instrumented aircraft are then used, as necessary to verify the analytical predictions (see 6.2.1.1 through 6.2.1.6). These methods all concentrate on the effect of the store on the aircraft and do not completely explore the effect the aircraft being tested may have on the specific store. Often, store structural problems may be evident on only one aircraft type or only in certain loading configurations.

6.2.1.7.2 Store loading configurations. To preclude store failures induced by the aircraft and to make a final qualitative check of the store loading configuration on the aircraft flying qualities, a representative number of combat store loadings should be flown on an uninstrumented aircraft. In addition, certain aircraft/store loading configurations may be judged by the testing agency to be analogous to other loadings of similar stores and, therefore, not require quantitative flight testing. Experience has shown, however, that such analogous configurations should be flown on a spot-check basis prior to release for operational use.

6.2.1.7.3 Store carriage for sustained periods. One of the major purposes of the qualitative flight test is 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. To accomplish this part of the test, the specific aircraft/store configuration should be flown for a total time equivalent to the aircraft's mission radius plus 50% of the mission time. This would be 150% 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, generally a high subsonic speed, at the lowest practicable altitude. If more than one sortie is required to obtain the total flight time, stores should not be downloaded between sorties.

6.2.1.7.4 Examination after each sortie. After each sortie, visually examine the aircraft, suspension equipment, store combination for damage, failure, cracks, looseness, and popped rivets. If significant discrepancies occur on the first sortie (major structural failure, extreme vibration or looseness, aircraft damage, fin bending, rivet popping, etc.), discontinue testing and decide whether to repeat the flight (after applicable correction is performed) or to suspend the test. If lesser discrepancies occur (arming wire slippage), continue with the second sortie without correction of the discrepancies. After the last sortie, examine the configuration both externally and internally (dismantling as necessary) for evidence of any discrepancies. Still photographs are desired if significant discrepancies are found after either flight.

6.2.1.7.5 Aircraft configuration and munitions. The aircraft configuration will be indicated in the appropriate test method. Inert munitions are desired for all captive compatibility flights, with fuzes, boosters and arming wires or lanyards installed.

6.2.1.7.6 Part I/first sortie (structural integrity and handling). The first sortie will be a check of the configuration for structural integrity and degradation of aircraft handling qualities by subjecting the aircraft/munition combination to maximum symmetrical and unsymmetrical load factors at maximum allowable airspeed. A series of increasing values will be employed to reach the maximum load factors and maximum airspeed specified.

6.2.1.7.6.1 Specified envelopes. Occasionally two envelopes for a particular aircraft/munition combination may be specified. The first, or primary, envelope gives the maximum allowable load factor with its corresponding airspeed or Mach limitations. The second, or alternate, envelope permits higher airspeeds or Mach but at a reduced load factor. In such cases, demonstrate both envelopes.

6.2.1.7.6.2 Detailed instructions. The first captive compatibility sortie should be performed as follows:

(a) Stabilize aircraft at desired airspeed in level flight and trim to fly hands off. Do not expend a large amount of time doing this, especially at high thrust settings.

(b) Perform steady state sideslip analysis. Slowly increase rudder deflection (either direction, assuming symmetrical configuration) and apply necessary aileron deflection to maintain straight, level flight. Do not apply full rudder deflection, just enough to obtain necessary data. Note if rudder deflection (force) increases for increasing sideslip. (This is an indication of positive static directional stability $C_{n\beta}$.) Note increasing aileron deflection (stick force) in direction opposite rudder application. (This is an indication of positive dihedral effect $C_{l\beta}$.) Slowly return control surfaces to neutral.

(c) Perform longitudinal dynamic short period motion analysis. Stabilize aircraft on airspeed and altitude (repeat of step 1) and turn pitch damper off. Apply a pitch doublet pilot input by pushing slightly forward and pulling slightly back on control stick then releasing to obtain about ± 1 "g" pitch oscillation. Exercise extreme caution during this imput, especially at high speed, as too large an imput may create an oscillation that could overstress the aircraft. If the first attempt is too small, simply repeat using slightly larger input. After releasing control stick, observe and note the overshoots in pitch oscillation. Less than 7 overshoots is acceptable damping of longitudinal short period dynamic motion (oscillations should damp in 1 or 2 overshoots with pitch damper engaged). If oscillations continue undamped, the aircraft/weapon configuration is apparently neutrally stable dynamically. If oscillations increase in amplitude, reengage pitch damper and quickly dampen motion with pilot inputs. Do no further investigations as the configuration is unsafe (dynamically unstable longitudinally).

(d) Perform lateral-directional dynamics analysis. Stabilize aircraft airspeed and altitude (repeat of step 1) and disengage roll and yaw dampers. With hands off control stick, apply a rudder doublet to induce

Dutch roll motion. Apply just enough rudder to induce motion, do not rapidly apply full rudder. Observe if the resulting motion is damped. If motion continues undamped, the aircraft/weapon configuration is apparently neutrally stable dynamically. If oscillations increase in amplitude, reengage dampers and quickly dampen motion with pilot inputs, aborting mission as the configuration is unsafe (dynamically unstable laterally/directionally).

(e) Investigage aircraft roll performance. Stabilize aircraft airspeed and altitude (repeat of step 1) and disengage all dampers. Perform aileron roll at maximum specified roll rate (limits provided on test mission card) by timing roll through cardinal bank angles (i.e., 90° to 270°). Approach maximum roll rate slowly, repeating point until desired rate is attained. Note aircraft divergence from flight path. Upon completion of roll (either direction if configuration is symmetrical) reengage dampers.

(f) Investigate aircraft maneuvering stability characteristics. Normally, a wind-up turn is performed to obtain an indication of the degree of dynamic longitudinal maneuvering stability that exists for that specific loading, center of gravity position and flight condition. This is attained by measuring the amount of stick force required to pull +1, 2, 3, 4 etc., incremental "g" up to the maximum + "g" limit authorized; or, to put it another way, by measuring the stick force per "g" gradient over the incremental "g" bank authorized. Another purpose for performing the wind-up turn is to determine the positive structural integrity of the configuration, which is accomplished by attaining the maximum positive "g" authorized. Stabilize aircraft airspeed and altitude (repeat of step a) and ensure dampers engaged. Roll into turn adding power required to maintain airspeed (valid evaluation is dependent on maintaining airspeed constant) as "g" is gradually increased to maximum attainable (unacceptable aircraft buffet) or munition limit "g", whichever occurs first. Maintain nearly a constant bank angle so as not to induce rolling "g" on the configuration (bank angle will probably be greater than 90°). Stick (pull) force should continue to increase with increasing "g". However, a lightening of stick (pull) force may occur during the windup turn. This is permissible, provided the local F_s/g gradient doesn't deviate from the average gradient by more than 50 percent during the maneuver (Figure 6). If the stick (pull) force reverses such that it takes totally less pull force to achieve a higher incremental "g" (Figure 7), then "stick reversal" has occurred. Consequently, the aircraft/store configuration should be considered unsafe to fly beyond that "g" limit, at that particular center of gravity, since "stick reversal" can rapidly lead to an aircraft and store overstress condition.

(g) Attain rolling "g" limits upon completion of maneuvering flight by relaxing "g" to rolling limit (limits provided on tests mission card) and roll the aircraft back to wings level attitude, maintaining maximum roll rate. Adjust power to maintain airspeed. This maneuver will generally place the greatest stress on the aircraft/munition combination; thus, the design "g" limits should not be exceeded.

(h) Perform negative "g" limit structural integrity demonstration. Stabilize airspeed and altitude (hands off trim not required) and attain negative "g" limit (limits provided on test mission card) by pushover or inverted turn manuever (120° bank, level reverse turn to attain negative "g"s').

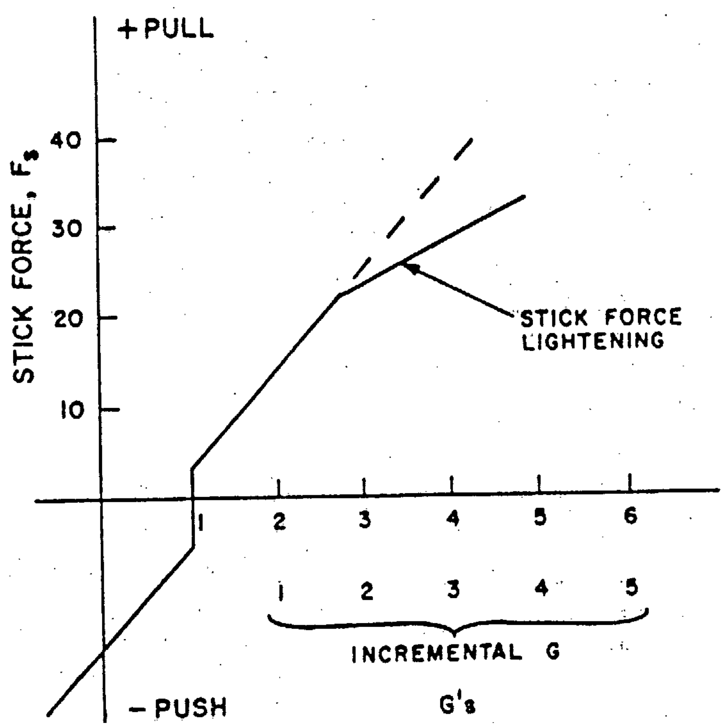

FIGURE 6. Stick force lightening.
(Stick force vs incremental load factor)

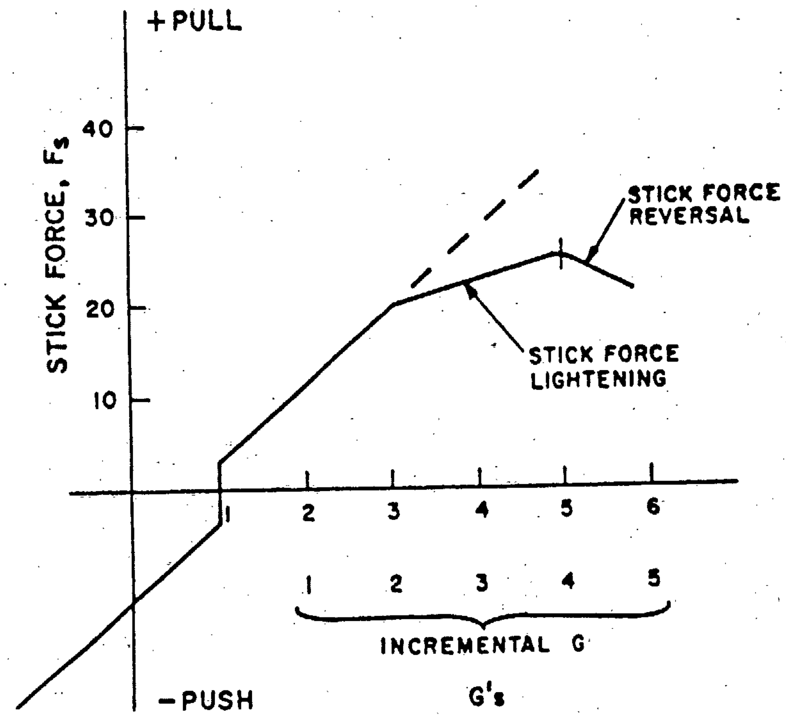

FIGURE 7. Stick force reversal.
(Stick force vs incremental load factor)

(i) Evaluate speed stability during acceleration to next speed increment. Maintain level flight and note that stick force (push) increases slightly as airspeed is increased. Do not trim during the acceleration.

(j) Repeat steps (a) through (i) at each speed increment specified by the test mission card.

(k) Throttle chop testing to evaluate store structural integrity should be performed under certain conditions. This test is necessary to determine the aerodynamic load effects of transient engine inlet backwash/ spillage which occurs during a throttle chop maneuver. The throttle chop maneuver is performed by rapidly shifting the throttle from full MIL power or afterburner to idle while flying near Mach 1 (transonic range Mach .98 to 1.0). Throttle chop maneuver should be performed when the flight clearance envelope will include the transonic regime and stores mounted in positions vulnerable to engine spillage. Generally, wing mounted stores would not be affected given a fuselage engine installation. Stores located small distances laterally or radially from the engine, such as downstream for the engine inlet, are candidates.

(l) Upon completion of final point (step h at maximum airspeed) evaluate trim change induced when speed brake is extended. Extend speed brake noting change in trim force required to maintain level flight. Excessive forces should be reflected in technical report.

(m) Prior to landing, investigate slow speed general flying qualities with aircraft in landing configuration. Investigate trim changes when lowering gear and flaps, while performing turns, and while approaching stall warning. Keep in mind configuration may not normally be landed operationally.

6.2.1.7.7 Part II/second sortie (vibration and endurance). The second sortie shall fly the configuration at 0.90 Mach or the maximum allowable airspeed (whichever is more restrictive) at the lowest practicable altitude commensurate with weather and safety considerations (1000 feet above mean sea level as maximum) for a cumulative total (first and second sortie) of approximately 30 minutes.

6.2.1.7.8 Flying time. Flying time is allocated as follows:

(a) Part I plus Part II total (2 sorties) is 1.50 multiplied by the time equivalent to the aircraft mission radius with a minimum time of 1 hour and 30 minutes. The minimum time of 1 hour and 30 minutes is predicated on fighter type aircraft (F-105 and F-4). For other aircraft types the minimum time may need to be altered.

(b) Part II total of approximately 30 minutes.

6.2.1.7.9 Documentation of flight tests. Documentation of the results of the captive flights should be made. The method of documentation is at the discretion of the testing agency. For standardization purposes, however, a reporting system such as the Cooper-Harper Pilot Opinion Rating System should be used.

6.2.2 Store separation tests.

6.2.2.1 Need for flight test. The behavior of stores separated during employment is influenced by many factors that cannot practically be represented accurately except by flight test. Because there are certain variables unique to individual stores and loadings, the flight test plans must include careful consideration of those parameters which are not realistically accounted for in wind tunnel tests or in analytical predictions of separation characteristics. These parameters may include such items as flow field (i.e; boundary layer-shock wave and multiple release bomb-to-bomb ineraction), ejector impulse, or the operation of store mechanisms. Therefore, inflight separations permit an evaluation of the true effects of local flow mechanisms, "g"-jump, and aircraft maneuver.

6.2.2.2 Flight program. The flight program must include enough testing to demonstrate that stores can be separated safely, without excessive disturbances to the flight path of either the airplane or store. Separations from internal compartments, external pods, store-to-aircraft, or store-to-store impact, and delivery accuracy are characteristics to be evaluated during flight tests. Repeatability should be desmonstrated.

6.2.2.3 Flight test demonstration. The final determination of acceptable store separation is flight test demonstration. Most often, programs are planned to define the maximum safe separation envelope and the most critical release flight conditions. The usual practice is to "walk-around" the envelope, based on maximum permissible carriage speeds, and use "buildups" prior to critical point demonstrations. It may be necessary to add points within the envelope, e.g; intermediate speeds between minimum and maximum speed at a given altitude or intermediate altitudes at a given speed. Such points may be required for verification of analytical interpolations and extrapolations for predicting total trajactory perturbations and effects on store terminal impact point. To keep any program within reasonable cost, the results of a preflight-test analysis should be used to plan the demonstration, such that the first one or two releases, at noncritical points, either show the analysis to be reliable or clearly indicate a revision to analysis technique or input data is warranted. If a revision is needed, the store separation analyst must modify his programs such that his revised analysis results will correlate with demonstration. He should then revise the original flight test plan to reflect the new predicted results. If the analysis is reliable within reasonable tolerances, the flight test program should then be tailored to a minimum, using demonstrations of end or critical points within the predicted envelope.

6.2.2.4 Correlation of predicted with demonstration results. Flight test results, starting with the initial drops, should be compared to the predicted results, provided the flight conditions are identical. If the demonstration condition was different, for whatever reason, from the predicted condition, additional analysis, using the original prediction methods, must be run at the actual flight condition before a valid comparison is made. Continual correlation as the demonstration program progresses must provide at minimum:

(a) Improved data and methods to make the prediction results more reliable and acceptable.

(b) A reduction in the amount of actual flight testing in the program currently underway or some future program of a similar nature.

6.2.2.4.1 Correlation techniques. The correlation techniques can take any one or more of the following approaches:

(a) Revision to the aircraft interference flow field.

(b) Perturbation in the magnitudes or directions of the installed loads.

(c) Change in free stream aerodynamic chracteristics, particularly if large excursions in angle of attack or sideslip are involved.

(d) Reevaluation of the suspension equipment characteristics using forces or velocities as a function of applied loads on the store.

(e) Revision to the inertial characteristics of the store.

6.2.2.5 Employment tests. Employment tests are those specified in 6.2.2.5.1 through 6.2.2.5.5.

6.2.2.5.1 Separation test objectives. Separation tests for weapon employment should be comprehensive enough to satisfy the following objectives:

(a) Perform functional checks of stores, suspension, release ejection mechanisms and controls.

(b) Verify safe and acceptable store separation envelope.

(c) Assess store release effects on aircraft flight characteristics including store exhaust gas ingestion and aircraft dynamic response.

(d) Evaluate the effects of aircraft controls and flight conditions on store trajectory from release to impact and on delivery accuracy. For each of these objectives there will have been prior checks or predictions as to the expected results. This information should be used as a base for measuring the success in meeting design goals. Safe store separation envelopes prepared by the engineering analyses described in 6.1.5 will provide guidance regarding critical flight conditions for individual store loadings and help scope the flight test program. Therefore, the flight program serves the purpose of confirming or correcting these predictions by use of correlation analysis techniques.

6.2.2.5.2 Minimum flight test program. Tests should be accomplished in systematic increments from low risk regions of the flight envelope to the more sensitive conditions which must be investigated to establish safe separation envelopes. A comparison of the separation characteristics, observed during early flights in this build up with those previously predicted for that same flight condition will indicate the feasibility of proceeding to more severe conditions. This procedure should be continued until a safe operational boundary is identified. Consideration must be given that a reasonable, not exorbitant, number of store and flights are planned, so that a minimum flight test program, consistent with reasonable aircraft flight safety results.

6.2.2.5.3 Flight envelope parameters. A satisfactory flight envelope should involve more than achieving safe separation in the sense of avoiding damage to the aircraft or store. Also of importance are factors which may adversely influence the stores trajectory and degrade the delivery accuracy. Therefore, it is important to perform these tests with adequate instrumentation to provide accurate data as to the position and attitude of both the airplane and separating store as a function of time. These data must provide a definition of true space trajectories for both the airplane and store; but more importantly, there must be adequate data for a thorough and accurate definition of the relative position and attitude of the store with respect to the aircraft and its components.

6.2.2.5.4 Store production tolerances relation to flight data. Manufacturing tolerances do permit significant variations in physical characteristics between individual stores of any specific type and this nonuniformity has some effects on the separation behavior. Therefore, consideration must be given to these effects in obtaining the flight data and in establishing satisfactory flight boundaries. Care should be exercised in selecting stores for the separation program, to assure their acceptability as to weight, balance, and external lines (dimensions, and fin alignment). Sufficient store drops should be made to establish separation envelopes and obtain total trajectory perturbation data suitable for any store acceptable within the production tolerances.

6.2.2.5.5. Employment data. Flight test data should include dimensional and balance information for those stores used in the employment program. To make direct correlations possible between analytical results and flight data, the test program should provide flight conditions, flight path, aircraft control positions, ejector impulse, store trajectories, release intervals, and performance evaluations of all operational components to the separation sequence. This would include information as to the effects on separation characteristics of store arming, fuzing, fin or parachute deployment, or separation from pods and cavities.

6.2.2.6 Jettison tests. Compatibility testing for store separation under jettison conditions has the objective of ensuring that the stores, which are jettisoned safely, clear the airplane without any need for considerations of subsequent trajectory. Two categories are used to classify the conditions, or manner, of jettisoning stores: emergency jettison and selective jettison.

6.2.2.6.1 Emergency jettison tests. Under emergency conditions in which it becomes necessary to discard stores or suspension equipment, the pilot may have little or no option to establish desired flight speeds and attitude to improve safe separation. Therefore, separation boundaries must be defined for each store loading which can be jettisoned simultaneously, or nearly simultaneously, in a predetermined emergency sequence. For those aircraft having emergency jettison circuits with a preset, programmed sequence, jettison envelopes should be applicable to that sequence.

6.2.2.6.1.1 Emergency jettison envelope. Predicted envelopes from analytical and wind tunnel test studies should be used as the basis for the program build up. Since an acceptable emergency jettison envelope may include more risk than normal separation envelopes, even to tolerating minor damage to the aircraft, the flight test program need not include all extremes of the flight envelope. Flight testing should begin at low risk conditions and buildup toward the maximum limits using the predicted data as a guide. The final envelope will be established by correlations of the predicted and flight results to provide for safe separation under emergency conditions.

6.2.2.6.2 Selective jettison. Permitting the pilot to exercise his option and control of the flight conditions, where stores and suspension equipment are jettisoned, should extend the safe envelopes over those under emergency conditions. The flight test procedures to define those envelopes are the same as used for employment envelopes. To be complete, the program should prescribe the best flight maneuvers at all speeds and altitudes for safest jettisoning of empty, partial or full stores. The most desirable jettison sequence should also be identified.

6.2.2.7 Ballistics. Continued refinement of the accuracy of weapon delivery avionics (computers, displays, navigation systems, etc.), external sensing devices, and self-compensating weapon racks, resulting in a significant decrease in the relative error contribution of ballistics errors to the weapon delivery solution, makes the accurate definition of separation effects on free-stream ballistics a vitally important consideration. Obtaining the data, required for determining the effects on ballistics, must be a primary part of the flight test planning for separation and not a tacked-on requirement to be accomplished, if convenient.

6.2.3 Carrier suitability tests. Carrier suitability tests shall be as specified in 6.2.3.1 through 6.2.3.3.

6.2.3.1 Laboratory tests. It is intended that each store be dynamically tested in the laboratory for those combined inertia design load factors, as specified in MIL-A-8591, for catapulting, and arresting (as well as any design loads, which may result from analyses of store responses to catapulting and arrested landing conditions) for those existing aircraft that are required to carry the store. Such tests are required to be performed to ultimate loads.

6.2.3.2 Catapult launches and arrested landings. For new carrier-based airplanes, carrier-suitability tests are required, in accordance with MIL-D-8708, for critical store loading configurations. Catapult launches and arrested landings for such store/aircraft combinations, to the test limits of the airplane, are required if any old or new store is required to be carried on any airplane (or airplane store carriage station) which has not been previously demonstrated as being safe for carrier operations and which, by analyses, is shown to result in critical loads or stresses. Prior to such flight tests, fit tests are required to assure safe clearance of the store with all deck hardware and obstructions for all catapulting and arresting environmental conditions. The test limits of the airplane are specified in the applicable addendum to MIL-D-8708.

6.2.3.3 Short airfield for tactical support (SATS). Every applicable new model or updated version of an airplane/store combination, which has been satisfactorily tested for catapult and arresting operations, should also be considered cleared for all wing stations of the same airplane for SATS operations. All cleared airplane/store centerline station configurations should also be considered cleared for SATS operations, except for any store which exceeds either the geometrical size or weight, or both, of a full Aero-1D 300 gallon fuel tank. Such a store should be SATS tested to assure airplane/store structural adequacy, bridle and hold-back bar clearance, and suitable flying qualities and performance to establish SATS Launch Bulletins. The test store should also be arrested on all other shore based arresting gears (E-5, E-14, BAC-11, and BAC-12), to assure that airplane/store to pendant contact does not occur.

6.2.3.3.1 SATS capability for non carrier-based airplanes. For new airplanes which are not carrier-based, but are required to have SATS capability, SATS tests will be required for critical store loading configurations in accordance with specified contractural documents (for Navy airplanes, the applicable addendum to MIL-D-8708). SATS tests (to the test limits of the airplane) for these critical store loading configurations are required if any new or old store is specified to be carried on any SATS capable airplane (or SATS capable store station) which has not been previously demonstrated as being safe for SATS operations, and which, by analyses, is shown to result in critical loads or stresses. Prior to such flight tests, fit tests are required to assure safe clearance of the store with all SATS hardware and obstructions for all SATS operating conditions. The airplane/store will also be arrested on all other shore based arresting gears (E-5, E-14, BAC-11, and BAC-12) to assure that airplane/store to pendant contact does not occur. The test limits of the airplane are specified in the appropriate contractural document for Navy airplanes, which is the applicable addendum to MIL-D-8708.

6.2.4 Propulsion effects tests. Propulsion effects testing is required:

(a) To define any change in the engine operating or stall margin due to gunfire, missile, or rocket launching.

(b) To show that the engine will not have flameout, stall, overtemperature, afterburner blowout, operating instability, or sustained loss of power.

(c) If available on powerplant, to determine the requirements for, and optimize, the operation of engine ingestion compensation devices.

6.2.4.1 Critical flight conditions. Airplane/weapon compatibility verification testing should be performed at the critical flight conditions as determined by:

(a) Theoretical analyses.

(b) Wind tunnel data.

(c) Any flight test evaluation data available.

Test planning should consider the effects of altitude, speed, angle of attack, yaw angle, and load factor in determining the critical test conditions.

6.2.4.2 Gun systems. It should be verified that the engine will not flameout, stall, or suffer sustained power loss when subjected to gun gas ingestion or muzzle blast caused by firing the gun at any flight condition within the gun firing or aircraft envelope whichever is less. In addition, gun muzzle blast from a fixed gun installation or gun pod should not cause damage to adjacent stores or aircraft structure.

6.2.4.3 Missile/rocket systems. It should be verified that the engine will not flameout, stall, or suffer sustained power loss when subjected to missile or rocket launch at any flight condition within the aircraft missile or rocket launch envelope.

6.2.4.4 Engine ingestion compensating devices. As applicable, it should be verified that these devices, when utilized, work as required to meet engine performance and operational requirements in the problem areas and do not adversely affect the engine performance in other areas of the aircraft envelope.

6.2.5 Helicopter application. Test and qualification requirements for stores compatibility on U.S. Army rotary wing aircraft are contained in AMC Pamphlet AMCP 706-203, Helicopter Engineering, Qualification Assurance, April, 1972.

7. REPORTING AND DOCUMENTATION

7.1 Parameters. To determine aircraft, store, and suspension equipment compatibility and to establish safe operating limitations for aircraft/store/suspension equipment combinations, the following factors must be known and evaluated:

(a) Structural integrity of the store and suspension equipment and of the aircraft/store/suspension equipment combination for:

(1) Carriage conditions, including field take-offs and landings and catapult take-offs and arrested landings (where applicable).

(2) Employment and jettison.

(b) Aeroelastic characteristics.

(c) Stability and control and flying qualities.

(d) Employment and jettison characteristics.

(e) Electro-mechanical interface.

(f) Shipboard suitability of the aircraft with stores and suspension equipment aboard, including stowage compatibility of the store and suspension equipment and the ship (where applicable).

(g) Store/delivery computation equipment compatibility.

(h) Store/stores management equipment compatibility.

(i) Aero-acoustic and vibration characteristics.

(j) Aerospace ground equipment (ground support equipment) characteristics.

7.1.1 Substantiation. Substantiation of the factors of 7.1 may be based on design analysis, fit and flight test data, shipboard suitability data, take-off and landing test data, laboratory-test data (including wind tunnel test), in-flight separation tests of the store and suspension equipment, comparison with existing stores and suspension equipment or aircraft/stores/suspension equipment combinations, or any combination(s) of the aforesaid. The specific analyses, test reports, and data required to be submitted should be as specified in the applicable contractual and specification requirements. These requirements should include submission of the following:

(a) Description of the store and suspension equipment, including:

(1) Weight.

(2) Shape and dimensions.

(3) Center-of-gravity location.

(4) Size, type, shape, and location of mechanical and electrical interconnections.

(5) Store moments of inertia (pitch, yaw, and roll).

(6) Store lift, drag, rolling, pitching and yawing moment coefficients, damping coefficients, and center of pressure as a function of Mach number and angle of attack.

(7) Installed drag coefficients as a function of Mach number for each aircraft on which the store/suspension equipment is intended to be carried.

(8) For suspension equipment, a list of the stores intended to be carried thereon.

(9) For tow targets, a description of the tow-target reel high-speed operating characteristics, expected drag versus length of tow line, target release modes, and variations of weight and center of gravity.

(10) Store operational options, if any.

(b) Identification of the aircraft on which the store/suspension equipment is intended to be carried:

(1) Model designations.

(2) Description of intended suspension equipment (if applicable) and location for carriage, including orientation of the store/suspension equipment with respect to the aircraft.

(3) Anticipated operations and maneuvers and planned operating speeds and altitudes, if such are to be less than the limits of the carrying aircraft.

(4) Adequacy of existing stores management controls and displays with identification of any changes required.

(5) Adequacy of existing stores delivery computational equipment for all delivery modes; i.e., are the necessary ballistic settings or computations available, can compensations for separation effects be accommodated, and what changes are required?

(c) Effects of the stores/suspension on aircraft performance characteristics:

(1) Stall speed.

(2) Take-off and landing distances.

(3) Rate of climb.

(4) Ceilings.

(5) Range.

(6) Radius.

(7) Fuel flow.

(8) Maximum speed.

(d) Store/suspension design strength:

(1) Strength envelopes for take-off, catapulting (if applicable), flight, employment/jettison, landing, and arrested landing (if applicable).

(2) Basis for strength envelopes (i.e., specification(s) or other document(s)).

(e) Substantiation of store/suspension structural integrity:

(1) Flight and ground loads data.

(2) Design analyses.

(3) Laboratory test plans and test data.

(4) Flight test plans and test data, including instrumentation.

(5) Shipboard suitability data (if applicable).

(6) Take-off and landing test plans and test data, including instrumentation.

(7) Thermal effects data.

(f) Store/suspension equipment aeroelastic characteristics:

(1) Aeroelastic analysis of the store and suspension equipment.

(2) Aeroelastic analysis of aircraft/store/suspension equipment combination(s).

(3) Wind tunnel aeroelastic test plans and test data of aircraft/store/suspension equipment combination model.

(4) Aeroelastic flight test plans and test data of the aircraft/store/suspension equipment combinations.

(g) Store/suspension equipment aerodynamic characteristics:

(1) Wind tunnel test data of store and suspension equipment.

(2) Wind tunnel test data of aircraft/store suspension equipment combination model.

(3) Flight test data of aircraft/store/suspension equipment combinations which determine effects on stability and control, flying qualities, and performance.

(h) Store/suspension employment or jettison, and separation characteristics:

(1) Store or suspension equipment employment, jettison, and separation characteristics.

(2) Store or suspension equipment employment, jettison, and separation test data.

(i) Store/suspension aeroacoustic characteristics:

(1) Aeroacoustic test data for ground tests of aircraft/store suspension equipment combinations.

(2) Flight test data of aircraft/store/suspension equipment combinations which determine effects of the aeroacoustic environment.

(j) Store/suspension aerospace ground equipment (ground support equipment) suitability:

(1) AGE (or GSE) aircraft/store compatibility data.

(k) Store/suspension equipment electrical and functional interface compatibility.

(1) Detailed generic (aircraft independent) interface control (ICDs) for store electrical, electronic, and software interfaces with the carrier vehicle. ICDs include functional and operational description of store modes including test modes.

(2) Aircraft specific ICDs similar to that described in (1) above.

(3) Data on the influence of interface data accuracy on weapon system performance.

7.2 International standardization agreements. Certain provisions of this document are the subject of international standardization agreements. When change notice, revision, or cancellation of this document is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations. Table IV identifies the paragraphs containing the requirements for the international standardization agreements.

Table IV. Paragraphs containing international standardization agreements.

Paragraph	Paragraph title	International standardization
5.1.2	Store/aircraft clearance and fit	STANAG 3791 AA AIR STD 20/21 STANAG 3898 AA AIR STD 20/21 STANAG 3899 AA AIR STD 20/21
5.1.3.7	Location of electrical disconnects	STANAG 3558 AA AIR STD 20/14
5.2	Suspension equipment design	STANAG 3842 AA STANAG 3575 AA AIR STD 20/10
5.2.3	Electrical connector selection	STANAG 3837 AIR STD 20/22
5.2.6.3.1	Free fall store	STANAG 3575 AA AIR STD 20/10
5.2.6.4	Ejection force	STANAG 3575 AA AIR STD 20/10
5.2.6.5	Cartridge firing pin selection	STANAG 3575 AA AIR STD 20/10
5.2.7	Cartridges	STANAG 3556 AA AIR STD 20/10
5.2.9.1	Mechanical arming units	STANAG 3605 AA AIR STD 20/17
5.3.9	Store electrical interface	STANAG 3837 AA AIR STD 20/22
5.3.9.3	Connector location	STANAG 3558 AA AIR STD 20/14
5.3.10	Store mechanical interface	STANAG 3842 AA STANAG 3575 AA AIR STD 20/10
5.3.10.3	Store lugs	STANAG 3726 AA AIR STD 20/15
5.3.14	Fuzing and arming	STANAG 3525 AA AIR STD 20/15
6.1.6	Fit and function test	STANAG 3899 AA AIR STD 20/21

7.3 Subject term (key word) listing.

Carriage
Fuzing and arming
Safe separation
Separation analysis
Structural interface
Sway brace

7.4 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

CONCLUDING MATERIAL

Custodians:
Air Force - 18
Army - AV
Navy - AS

Preparing Activity:
Navy - AS
(Project No. 15GP-0082)

Applicable International Organization:
Air Standardization Coordinating Committee (ASCC)
North Atlantic Treaty Organization (NATO)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-HDBK-244A	2. DOCUMENT DATE (YYMMDD) 6 APRIL 1990

3. DOCUMENT TITLE GUIDE TO AIRCRAFT/STORES COMPATIBILITY

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, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)*
Commanding Officer NAEC (SESD) Code 53	(1) Commercial (201) 323-2142 (2) AUTOVON 624-2142
c. ADDRESS *(Include Zip Code)* Lakehurst, NJ 08733-5100	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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