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ADS-20-HDBK
19 DECEMBER 2005

SUPERSEDING
ADS-20-A
JUNE 1993

AERONAUTICAL DESIGN STANDARD HANDBOOK

ARMAMENT AND FIRE CONTROL SYSTEM SURVEY FOR ARMY AIRCRAFT

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AMSC N/A **FSC 10GP**

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FOREWORD

1. This handbook is approved for use by the U.S. Army Research, Development and Engineering Command and is available for use by all departments and agencies of the Department of Defense.

2. This handbook includes guidance for use of an Armament and Fire Control System Survey on Army aircraft. It also includes format changes to comply with MIL-STD-967, *Department of Defense Standard Practice for Defense Handbooks Format and Content*.

3. Comments, suggestions, or questions on this document should be addressed to Commander, U. S. Army Research, Development and Engineering Command, Aviation and Missile Research, Development and Engineering Center, ATTN: AMSRD-AMR-SE-TD-ST, Huntsville, AL 35898 or emailed to WilliamSmith@rdec.redstone.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil/online/start/.

4. Technical questions may be addressed to the following office:

U.S. Army Aviation and Missile Research, Development and Engineering Center
Redstone Arsenal ATTN: AMSRD-AMR-AE-S-W
Building 4488, Room C-316
Redstone Arsenal, AL 35898-5000
Telephone: Commercial (256) 313-8465

AERONAUTICAL DESIGN STANDARD HANDBOOK FOR

ARMAMENT AND FIRE CONTROL SYSTEM SURVEY FOR ARMY AIRCRAFT

FUNCTIONAL DIVISION: _____

David B. Cripps
Chief, Mission Equipment Division
Aviation Engineering Directorate
Research, Development, and Engineering Command

SUBMITTED BY: _____

Dr. William D. Lewis
Acting Director of Aviation Engineering
Research, Development, and Engineering Command

APPROVED BY: _____

Tony D. Hodgens
AMCOM and PEO Aviation
Standards Executive

DATE: 12/19/05

Certification Record

Board date:

Document Identifier and Title: ADS-20-HDBK, Armament and Fire Control System Survey for Army Aircraft

Rationale for Certification:

Decision:

General Type	Decision (√)	Certification
Specification		Performance
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook	√	Handbook (non-mandatory use)
Alternative Action		

	Concur	Non-Concur	Date
Chief, Mission Equipment Division David B. Cripps			
AMCOM Standardization Branch Chief William J. Smith	√		12/15/05 *
Director, Aviation Engineering Dr. William D. Lewis	X		
AMCOM and PEO Aviation Standards Executive Tony D. Hodgens	X		12/19/05

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1. SCOPE

1.1 Scope. This handbook contains guidance for the performance of a "survey" on armament and fire control subsystems integrated on an aircraft. A survey is the act of collecting information to determine the current state of the design with respect to established performance requirements. The survey will consist primarily of ground and flight tests. Unless otherwise specified in the contract, the survey will be used to find needed improvements or problem areas that need resolution prior to commitment to the demonstration phase that verifies compliance with contract requirements. Surveys are normally conducted on new or major modifications to reduce program risk. At the discretion of the Government, surveys can be required for smaller armament and fire control modification programs. For purposes of this handbook, the terms "armament" and "weapon" are interchangeable.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

MIL-STD-882	Standard Practice for System Safety
MIL-STD-1289	Airborne Stores Ground Fit and Compatibility, Requirements for
MIL-HDBK-799	Fire Control Systems, General
MIL-HDBK-1763	Aircraft Stores Compatibility: Systems Engineering Data Requirements and Test Procedures

Copies of the above specifications, standards, and handbooks are available from the Standardization Document Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094 or online at the following web site: http://assist.daps.dla.mil/online/start/.

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

U. S. ARMY AVIATION AND MISSILE COMMAND (AMCOM)

ADS-45-HDBK	Data and Test Procedures for Airworthiness Release for Helicopter Armament Testing (Guns, Rockets, Missiles)

ADS-62-SP	Data and Test Requirements for Airworthiness Release for Helicopter Sensor Data and Testing Requirements in Development Stage
ADS-37A-PRF	Electromagnetic Environmental Effects, Management, Design and Test Requirements
ADS-51-HDBK	Rotorcraft and Aircraft Qualification (RAQ) Handbook
Aviation Policy Memo 03-02	Program Executive Officer (PEO), SFAE-AV-PI, Memo Subject: Risk Management Process

Copies of these documents are available from the Army Aviation and Missile Command (AMCOM) Standardization Office at Redstone Arsenal in Huntsville, Alabama and are available online at web address: http://www.redstone.army.mil/amrdec/sepd/tdmd/StandardAero.htm.

3. DEFINITIONS

3.1 Acronyms.

ADS	Aeronautical Design Standard
AIL	Avionics or Aircraft Integration Lab
AMCOM	U. S. Army Aviation and Missile Command
AMRDEC	U.S. Army Aviation and Missile Research, Development and Engineering Center
AMSC	Acquisition Management Systems Control
AFCSS	Armament and Fire Control System Survey
AWR	Airworthiness Release
CEP	Circular Error Probable
DID	Data Item Description
EMC	Electromagnetic Compatibility
FLIR	Forward Looking Infra-Red
FOD	Foreign Object Damage
FOV	Field-of-View

FRR	Firing Readiness Review
GFE	Government Furnished Equipment
GPS	Global Positioning System
HDBK	Handbook
HERO	Hazards of Electromagnetic Radiation to Ordnance
INS	Inertial Navigation System
IGE/OGE	In-Ground Effect/Out-of-Ground Effect
IFFC	Integrated Fire and Flight Control
LOAL	Lock-On-After-Launch
LOBL	Lock-On-Before-Launch
LST	Laser Spot Tracker
N/A	Not Applicable
NOE	Nap-of-the-Earth
PIM	Pulse Interval Modulation
PRF	Pulse Repetition Frequency
RAQ	Rotorcraft and Aircraft Qualification
RDEC	U. S. Army Research, Development and Engineering Command
SAR	Safety Assessment Report
SIL	Software Integration Lab
SOF	Safety of Flight
SP	Standard Practice
UAV	Unmanned Air Vehicle
V_H	Maximum level flight speed at engine(s) intermediate power rating or power transmission system continuous rating, whichever is less
V_{max}	Maximum level flight airspeed

WCA Warnings, Cautions and Advisories

WILI Weapon Inhibits, Limits and Interrupts

4. GENERAL REQUIREMENTS

4.1 Survey description. General guidance on "surveys" and their difference from "demonstrations" can be found in ADS-51-HDBK. The Armament and Fire Control System Survey (AFCSS), through ground and flight tests, should be used to assess the design and performance of each armament and fire control subsystem prior to commitment to formal contractor demonstrations. It should be used to assess the integration of armament and fire control with each other and other mission equipment and aircraft systems. Also, the AFCSS should assess the effects of armament carriage and firing on the aircraft and its systems, including avionics, support structure and dynamic systems. This survey encompasses installation, ground checkout, ground firing, preflight and flight testing of the armament and fire control systems in the aircraft.

Note: With prior Government agreement, a properly planned and executed AFCSS could be accepted as a contractual demonstration, if it is conducted with production-representative hardware/software, and if the results demonstrate contract compliance.

4.2 Prerequisites for ground and flight tests. Prior to any aircraft ground and flight tests, the armament and fire control subsystems should go through Software Integration Lab (SIL) and Avionics/Aircraft Integration Lab (AIL) tests to validate critical component and software parameters, and subsystem/software integration. Weapons Inhibits, Limits and Interrupts (WILIs) should be validated to show that weapons are prohibited from interfering with each other and are prohibited from firing when firing constraints are exceeded. The aircraft flight test phase should be conducted after SIL/AIL tests, hazard analyses, Safety-of-Flight (SOF) analysis and tests, and aircraft ground tests are conducted to substantiate that the armament and fire control subsystems are safe to flight test.

An Airworthiness Release (AWR) is required to conduct aircraft flight tests. Guidance on obtaining the AWR for armament is contained in ADS-45-HDBK. Also, guidance for sensor data required to support the AWR is contained in ADS-62-SP. A Firing Readiness Review (FRR) is required prior to the first airborne firing of armament.

4.3 Test articles. "Armament" or "weapons" are easily identified; however, the "fire control" test articles are less obvious. For purposes of this handbook, the fire control system will consist of any hardware and software that is necessary to perform target acquisition/designation, target state estimation, aircraft state sensing, environment sensing, sensor input processing, ballistic solution processing and the stores management, aiming, launching/firing/dispensing and conduct post-launch controlling of the munitions. General guidance on fire control systems can be found in MIL-HDBK-799. While the particular elements of the test may be tailored for each survey, the items (hardware and associated software) that are usually tested under an AFCSS are the following:

a. Missile Subsystem.
b. Aerial Rocket Subsystem.

c. Gun Subsystem.
d. External Stores Subsystem.
e. Target Acquisition/Designation Subsystem including detectors, trackers, designators and range finders.
f. Helmet Mounted Sight Subsystem.
g. Fire Control Subsystem, including interfacing sensors such as air data, aircraft attitude, rate sensors, radar, electro-optics and inertial navigation system (INS)/global positioning system (GPS).
h. Cockpit displays, symbol generator, and control panels.
i. Fire control computer, weapons and mission processors, weapons/fire control algorithms and ballistic coefficients.
j. Aircraft Data Bus Subsystem.
k. Stores Management System.
l. Armament/fire control datalinks (munitions post-launch control and armed unmanned air vehicle (UAV) control).
m. Target cueing, slaving and handover equipment and interfaces.
n. Boresighting Subsystem.
o. Armament loader/downloader and other support equipment.

5. DETAILED REQUIREMENTS

5.1 AFCSS test plan. The contractor will prepare an AFCSS test plan that describes a systematic ground and flight test program designed to proceed in an orderly manner from installation of the system through determination of the armament and fire control capabilities. The plan should include the following elements:

a. State the aircraft configuration required for ground and flight testing.

b. Define the location and conditions required for ground and flight testing, including any required Government Furnished Equipment (GFE) such as ammunition.

c. Define the fire control tests, including target acquisition/designation, and the armament firing tests for both day and night conditions.

d. Define the instrumentation for tests.

e. Define the data analyses methods and reporting criteria.

f. Provide a proposed schedule, including any required AWRs for tests and meetings/reviews with the Government, such as an FRR.

5.2 Test requirements. The tests usually consist of both aircraft ground tests and flight tests. Ground tests include non-firing and firing tests and flight tests include non-firing and firing tests. To maximize safety, non-firing tests are conducted first, followed by firing tests.

Note: When no guidance document is specifically cited in the following sub-paragraphs, ADS-45-HDBK and MIL-HDBK-1763 are considered to be the best top-level documents to use.

5.2.1 Non-firing ground tests. These tests encompass all items requiring verification of safe functionality before the ground firing tests. They usually include, but are not limited to, the following:

5.2.1.1 Armament/fire control operations. Verify cockpit procedures utilizing the installed armament/fire control system. Armament/fire control/aircraft control logic interface should be checked. Functional checkout of target acquisition/designation subsystem modes (including symbology) should be conducted. The armament and fire control WILIs should be verified to the extent possible in ground tests, using actual out-of-constraint signals or by injecting signals into the databus to simulate the actual signals.

5.2.1.2 Armament/fire control boresight. Boresight procedures, boresight accuracy and boresight retention should be checked. Particular attention should be paid to the elements of the target acquisition/designation subsystem. If an onboard/in-flight "dynamic" boresight capability exists, both static (ground test) and dynamic (flight test) capabilities should be tested.

5.2.1.3 Arming procedures. Procedures for the uploading and downloading of ammunition and stores, including safety procedures, should be developed and verified.

5.2.1.4 Static clearances. Clearances should be verified using MIL-STD-1289. Intended to insure clearance for worst case aircraft maneuvers, stores clearances should be verified by measurement in static ground fit tests. They should include store-to-ground, store-to-aircraft, store-to-store, store-to-pylon, munition-to-munition within a store (rail launched) and store ejection clearance. Trajectory clearance from the aircraft for all armament munitions should be verified prior to first launch/firing.

5.2.1.5 Display resolution. Determine sensors performance parameters (minimum resolvable temperature, sensors field of view, etc.) while installed on the aircraft and in operating status with aircraft power, instead of employing laboratory measurement.

5.2.1.6 Display. Determine adequacy of light security, image uniformity, and image clarity when operating off aircraft power. Verify the accuracy of the armament aiming and cueing symbology.

5.2.1.7 Sensor switching. Determine switching time between fields-of-view (FOVs) and interchange of all elements.

5.2.1.8 Target acquisition/designation subsystem. Determine turret slew rates, acceleration, position accuracy, and gimbal freedom throughout the specified angular coverage.

5.2.1.9 Laser designator. Verify laser designation characteristics and safety.

5.2.1.10 Laser rangefinder. Verify laser rangefinder characteristics, i.e., range accuracy, receiver sensitivity, etc.

5.2.1.11 Laser spot tracker (LST). Check LST coding tracking accuracy, sensitivity, and stabilization.

5.2.1.12 Cryogenic cooling. Verify Forward Looking Infra-Red (FLIR) sensor cool-down time.

5.2.1.13 Fire control integration. Evaluate and validate the joint functioning of installed subsystems such as fire control computer or weapons processor, air data sensors, helmet sights, target acquisition/designation subsystem, flexible guns and navigational inputs. Validate software functioning (accuracy, correctness) and end-to-end integration, including verification that there is no adverse impact on other aircraft systems.

5.2.1.14 Electromagnetic environmental effects. Ensure that operation of the armament/fire control subsystems does not affect other aircraft systems nor is affected by other aircraft systems and the external operating environment. See applicable portions of ADS-45-HDBK. These requirements also apply to firing ground tests and flight tests.

5.2.1.15 Environmental conditions. Verify operability throughout the range of conditions specified in the aircraft system specification (limited to extent feasible at test site). See applicable portion of ADS-45-HDBK.

5.2.1.16 Shipboard operations. Verify the capability of the armament and fire control subsystems to operate safely and effectively on and in proximity to Navy ships. Factors to assess should include Hazards of Electromagnetic Radiation to Ordnance (HERO) and Electromagnetic Vulnerability requirements (see ADS-45-HDBK), ordnance uploading/downloading, boresighting, ship/aircraft tie-down compatibility and safeing of the weapon systems (power down).

5.2.2 Firing ground tests. Firing tests should be conducted with the aircraft on the ground to verify/determine the following:

a. Start-up time to first launch/firing.

b. Debris pattern and its potential for foreign object damage (FOD) to the aircraft.

c. Gas accumulation in cockpit and any effects on the crew and engine(s).

d. Cockpit noise level at all expected crew member locations and any effects on the crew.

e. Turret/gun system performance parameters such as elevation and traverse limits, slew rates, acceleration and position accuracy. Where feasible, armament parameters should be first verified in non-firing tests.

f. External stores travel, slew rates, acceleration synchronization and position accuracy with typical loads.

g. Missile, rocket and gun projectile trajectory clearance of the rotor and other aircraft surfaces.

h. Gun firing rates, recoil loads and ammunition belt loads (if linked).

i. Effects of gun firing and missile launch on the target acquisition/designation subsystem (including tracking), on the crew/cockpit (flash intensity) and vibration.

j. Airframe and target acquisition/designation subsystem response to blast effects, debris and weapon rate of fire throughout the coverage of the subsystem.

k. Existence of launch transients that could cause erratic or errant missile/rocket flight trajectory.

5.2.3 Flight tests. Aircraft flight tests should consist of non-firing tests followed by firing tests. The non-firing flight tests should consist of captive-carriage tests with captive flight trainers, training missiles and dummy ordnance in lieu of live ordnance. The armament and fire control WILIs should be rechecked in captive carriage tests.

The non-firing tests should confirm safe functionality before the start of flight firing tests. Flight tests should be conducted within the design operational flight envelope. These tests should include hover (IGE/OGE) cruise and V_H conditions. Dynamic engagement maneuvers, planned for use by the military user community, should also be included. The items examined should include, but are not limited to the following:

5.2.3.1 Aircraft flight performance. Determine the effects of the armament subsystem installation or aircraft performance stability and control throughout the flight envelope of the aircraft, including hover, low speed translational flight, take-off and landing, climb, level flight, maneuvering flight and autorotation.

5.2.3.2 Target acquisition/designation subsystem pointing. Verify target acquisition/ designation subsystem day/night pointing throughout the gimbal field-of-regard and flight envelope. This test should include boresight retention.

5.2.3.3 Laser range. Verify laser ranging accuracy.

5.2.3.4 Laser designator. Determine laser designation characteristics including beam divergence, pulse energy, pulse width, average power, pulse repetition frequency/pulse interval modulation (PRF/PIM) codes, center wavelength, line width, pulse-to-pulse stability and missing pulses.

5.2.3.5 Target acquisition/designation. Establish target acquisition (detection, recognition)/designation capability during day/night conditions. Specific data points should be developed that exercise the following parameters:

a. Aircraft parameters
Straight and level
Diving engagement
Hover – mask/unmask
Evasive maneuvers – exercise sensors gimbal angles
Altitude – exercise elevation angles
Airspeed – varied to V_{max}
NOE flight

b. Sensor/mode of operation
FLIR (day and night)
TV
Laser designation (codes)
Laser tracker (coding, accuracy, sensitivity)
Radar
Direct view optics
Sensor fusion
Boresight
Manual/autotrack
Seeker video to ownship

c. Target parameters
Moving
Stationary
Evasive
Search to find tactical targets and target boards (for Precision Measurement of tracking accuracy)
Hovering Pop-up

d. Meteorological conditions
Target/background contrast varied
Night/day
Low sun angles/backlighted target
Reduced visibility (fog, haze, smoke, light rain)

5.2.3.6 Navigation capability of target acquisition/designation subsystem. Determine navigational accuracy that can be achieved when using the target acquisition/designation subsystem for visual reference during checkpoint navigation. Determine extent to which the target acquisition/designation subsystem may be used to assist the pilot during low level obstacle avoidance. However, while making this determination and until the performance of the target acquisition/designation subsystem and its impact on the pilot's situational awareness are verified, the subsystem should not be used as a primary flight reference.

5.2.3.7 Target acquisition/designation subsystem handoff. Verify target acquisition/designation subsystem handoff. Conduct trials using the on-board LST to verify target handoff both air-to-air and ground-to-air. In addition, conduct trials with other tri-service laser seekers to ensure compatibility with on-board laser designator.

5.2.3.8 Target acquisition/designation subsystem/weapon firings. Establish effects of weapons firing on target acquisition/designation subsystem performance (vibration, smoke, debris). Particular attention should be given to day/night automatic tracking.

5.2.3.9 Jettison. Tests should be conducted to verify safe ejection of stores from all external store support systems. See MIL-STD-1289 for guidance.

5.2.3.10 Fire control timeline. Determine the end-to-end fire control response time from target selection until the munition leaves the aircraft.

5.2.3.11 Missile accuracy. Establish missile day/night hit probabilities or Circular Error Probable (CEP) capabilities, consistent with available missile assets. All modes of fire should be exercised to the maximum extent feasible. Analysis from validated simulation can be used to supplement live firing.

5.2.3.12 Gun operation. Verify gun operation, duty cycle, range, accuracy, dispersion and airframe response to firing rates and recoil forces. Accuracy can be demonstrated through a combination of actual firing and analysis from validated simulation.

5.2.3.13 Fire control/installation. Verify fire control integration and interface. Verify all armament engagement modes such as autonomous or cooperative, active or passive, ripple/rapid fire, fire-and-forget, laser designation, missile Lock-On-Before-Launch (LOBL) and Lock-On-After-Launch (LOAL). Verify armament/sensors cueing and slaving to optimize weapon aiming and to shorten engagement timelines. Verify interface with targeting information from sources external to the launch platform.

5.2.3.14 Fire control data links. Assess the operation of data link control of munitions after launch. If a requirement exists for ownship control of an armed UAV, the ownship controls and data link for launch/firing of the UAV armament should be assessed.

5.2.3.15 Integrated flight and fire control (IFFC). Assess the operation of the IFFC and the effects of the flight control and fire control subsystems on each other. Verify the effect of the IFFC on armament effectiveness and fire control timelines.

5.2.3.16 Rocket operation. Verify rocket inventory capability, fire rates, selection functions, fuzing, range and accuracy. Accuracy can be demonstrated through a combination of actual firing and analysis from validated simulation.

5.2.3.17 External stores. Verify external stores operation, stiffness and free-play, boresight and boresight retention.

5.2.3.18 Dynamic clearances. Verify missile/rocket clearance cones and gun projectile trajectory clearance with the aircraft throughout the flight-firing envelope (see MIL-STD-1289 for guidance).

5.2.3.19 Engine and drivetrain operation. Verify effect of firing missile/rocket/gun on engine and drivetrain operation. Worst case armament payload configuration, firing and flight conditions should be verified.

5.2.3.20 Boresight retention. Verify the ability of armament and fire control subsystems to retain boresight. Boresight should be rechecked periodically throughout the flight firing tests to determine the degree of boresight retention. If an on-board dynamic boresight system exists, its data latency and other performance factors should be assessed for real-time effectiveness of the armament and fire control system.

5.2.3.21 Human factors. Assess crew and maintainers' safety and effectiveness, optimization of workload, and other human performance requirements. Verify the compatibility of the armament and fire control system with day and night operations. If applicable, assess

compatibility to operate, support and maintain the armament and fire control with cold weather and mission-oriented protective posture (MOPP) gear.

5.2.3.22 System safety. Assess the system safety of the aircraft-integrated armament and fire control systems. Determine if there are any potential hazards, their likelihood of occurrence and the ways to mitigate the hazards. Determine if there are any required operating restrictions and warnings, cautions and advisories (WCA) necessary to safely operate the armament and fire control. Safety issues encountered during the AFCSS should be addressed using the guidelines in MIL-STD-882 and Aviation Policy Memo 03-02 (Risk Management Process) or applicable PM safety management process or plan. The previously developed Safety Assessment Report (SAR) should be assessed and updated, based on the information gained in the AFCSS.

5.3 Instrumentation and data analysis. Test instrumentation should be provided to record armament, fire control, and aircraft data to assess the survey factors. The contractor should define the instrumentation and data analysis methods in the test plan. The instrumentation should include recording of target acquisition/designation subsystem video during flight. An aircraft databus monitor is highly recommended. If technically feasible and affordable, armament and fire control sources of errors should be instrumented to provide data for assessment of accuracy error budgets. General guidance on instrumentation on helicopters is provided in ADS-51-HDBK. Guidance for test procedures and instrumentation for armament stores is contained in MIL-HDBK-1763.

5.4 AFCSS test report. All armament, fire control, ground and flight tests (including training) should be summarized with the presentation of the survey data. The contractor should prepare an AFCSS test report which will address ground and air test results. The report should also address the armament and fire control capabilities and the problem areas that need resolution. The report should:

a. State the aircraft configuration tested.

b. State any deviation from test plan.

c. State the results for both ground and air tests during day and night.

d. Compare the test results with system requirements.

6. NOTES

6.1 Intended use. Conducting an AFCSS is a Government program option. It is normally used for new or major aircraft modification programs to reduce risk prior to commitment to the formal demonstration phase. At the Government's discretion, an AFCSS can also be required for smaller modification programs. While the omission of an AFCSS might appear to reduce cost and schedule, its performance could uncover design defects that could result in timely resolution and the avoidance of major cost and schedule delays. The formulation of this ADS handbook did not consider "unconventional weapons" such as directed energy and non-lethal weapons. An AFCSS would require additional tailoring to accommodate these weapons.

6.2 Associated data item descriptions (DIDs). Applicable DIDs should be listed on the Contract Data Requirements List (DD Form 1423). Specialized DIDs do not exist for an AFCSS. Standard DIDs or contractor format for test plans and reports may be used.

6.3 Subject term (key word) listing.

Helicopter
Rotorcraft
Survey
Armament, helicopter
Weapon, helicopter
Fire control, helicopter
Stores, helicopter

6.4 Changes from previous issue. This document was changed from an Aeronautical Design Standard to a handbook. Specific changes are not called out by margin change bars, but have been subsumed within the issuance of this handbook.