

## CHAPTER 1 INTRODUCTION

*This chapter describes the purpose and scope of this handbook, introduces the concept of air vehicle qualification, and provides an overview of qualification methods.*

### 1-1 PURPOSE

The purpose of this handbook is two-fold. First, it is intended to serve as a tutorial for persons unfamiliar with the airworthiness qualification process. This includes Government and contractor personnel who are involved in development of requirements or members of the design team who are not directly involved in the qualification process. In this context the handbook provides an overview of the airworthiness process for developing requirements. It describes air vehicle and typical system requirements as a guide for airworthiness qualification. Second, it is intended to serve as a reference guide for those involved in preparing airworthiness qualification documentation. This includes persons who are responsible for generating and reviewing documentation that establishes the airworthiness of systems and subsystems. Requirements for and examples of airworthiness documentation are covered in the Appendices to this handbook.

### 1-2 SCOPE

This handbook addresses the airworthiness qualification of air vehicles and related systems. The air vehicle and systems to which an airworthiness qualification program is applicable might be completely new or might be the result of major modification of a previously qualified system. This handbook is for guidance only. It cannot be cited as a requirement. If it is, the contractor does not have to comply. It is not intended to provide mandatory or regulatory requirements that must be achieved during the course of a program. Such requirements will be included in the specific contractual

requirements for the program. Excluded from the discussions of this handbook are tests normally conducted after completion of airworthiness qualification testing, such as force development test and experimentation (FDTE) tests that are intended to provide insight into the type of force structure best suited to the operation of the air vehicle.

### 1-3 DEFINITIONS OF ROTORCRAFT AND AIRCRAFT\*

#### 1-3.1 ROTORCRAFT

A rotorcraft is defined as a heavier-than-air air vehicle that depends principally for its support in flight on the lift generated by one or more rotors and may include static lifting surfaces contributing less than half the required lift. An airworthy rotorcraft is a rotorcraft whose capability to function satisfactorily when used within prescribed limits has been demonstrated.

#### 1-3.2 AIRCRAFT

An aircraft is defined as a powered (heavier-than-air) air vehicle whose principal lifting surfaces are statically positioned, i.e., fixed-wing airplane. Similarly, an airworthy aircraft is one whose capability to function satisfactorily within prescribed limits has been demonstrated.

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\* Note: Reconfigurable air vehicles, e.g., tilt rotor and tilt wing air vehicles, have unique features that are not specifically covered in this handbook except for a reference to a vertical takeoff and landing (VTOL) air vehicle specification, but they may be qualified by combining rotorcraft and aircraft qualifications and defining unique qualification requirements to demonstrate satisfactory operation of their transient and unique features.

## **1-4 INTENDED AUDIENCE**

This handbook is intended for both Government and contractor audiences. For Government design team personnel this handbook provides an overview of the philosophy of airworthiness qualification and a source of detailed references upon which to base contractual airworthiness qualification program requirements. For contractor design team personnel this handbook provides a guide to responding to requests for proposals (RFPs) and to implementing and executing airworthiness qualification programs.

## **1-5 AIR VEHICLE QUALIFICATION**

The paragraphs that follow provide a description of the purpose, scope, and techniques of air vehicle airworthiness qualification.

### **1-5.1 PURPOSE**

The main purpose of air vehicle qualification is to ensure that the product meets its intended requirements. Airworthiness qualification, specification compliance verification, military qualification, first article validation, flight safety parts qualification, and structural integrity verification are all processes leading to qualification of systems, subsystems, and components. All of these processes include test methods and techniques used to ensure continued validity of the qualification results in expected environments. Each has a different focus, but all lead to the ultimate goal of qualification. Although treated separately in the following subparagraphs, these activities are often interrelated and overlap during the conduct of air vehicle qualification programs. The purpose of each is discussed in the subparagraphs that follow.

### **1-5.1.1 Airworthiness Qualification**

Airworthiness qualification is defined as an analysis, design, test, and documentation process used to determine that an item—air vehicle system, subsystem, or component—is airworthy. The primary purpose of airworthiness qualification is to demonstrate that the air vehicle has the capability to function satisfactorily and safely when used within prescribed limits. In addition, airworthiness qualification is required to ensure that a system or component is properly integrated into an airworthy platform. Airworthiness qualification is conducted to ensure the overall risk of operating the air vehicle is minimal.

### **1-5.1.2 Specification Compliance Validation**

Specification compliance validation is defined as the process used to determine that an item meets its established requirements. The purpose of specification compliance validation is to show through inspection, analysis, demonstration, and/or testing that an item satisfies all contractual performance specification requirements. Even though specification compliance validation is primarily a process used to demonstrate that the contractor has met the requirements of the contract, much of the data may be used to substantiate the airworthiness of the system.

### **1-5.1.3 Military Qualification**

Military qualification is defined as a test and documentation process used to ensure the military utility of an item is established. Its purpose is to ensure that an item will perform adequately in a tactical environment. Thus military qualification usually includes extensive testing requirements over a wide range of environmental conditions.

#### **1-5.1.4 First Article Validation**

First article validation is the process used to determine that the first item produced by either the original developer or an alternate source meets its physical performance requirements. The purpose of first article validation is to ensure that the manufacturing processes employed yield an acceptable product that will retain the properties of previous qualification. The first article validation process is usually conducted after the item being procured enters the production phase of development. This validation is also used to verify that the production tooling and processes have not changed the characteristics that were qualified on a prototype.

#### **1-5.1.5 Flight Safety Parts Qualification**

Flight safety parts qualification is defined as a process of identification and intensive analysis, testing, control, and management of parts that have been determined to be critical to the operational safety of an air vehicle. The purpose of flight safety parts qualification is to ensure not only that these critical parts are properly designed, analyzed, manufactured, and tested as part of the air vehicle qualification program but also that critical characteristics are identified and the manufacturing process is established and frozen. The primary differences between qualification of flight safety parts and qualification of other parts are the increased level of management and the increased level of technical detail required for flight safety parts.

#### **1-5.1.6 Structural Integrity Verification**

Structural integrity verification is defined as a process used to establish, evaluate, and substantiate the structural integrity—airframe strength, rigidity, damage tolerance, and durability—of an air vehicle. The purpose of structural integrity verification is to ensure compliance with the struc-

tural design criteria. Structural integrity verification is used to verify that load paths and stresses are as predicted and to identify poor structural design details to alleviate and prevent (where possible) future maintenance difficulties.

### **1-5.2 SCOPE**

The range of the scope of determinations and tests that are the basis for each aspect of qualification is discussed in the following subparagraphs. Determinations are findings supporting qualification substantiation that may be verified by data review, inspections, or other actions that require no further tests or analyses.

#### **1-5.2.1 Airworthiness Qualification**

Airworthiness qualification is a progressive assessment process performed at the component, subsystem, and system levels to ensure that a system meets airworthiness requirements. The scope of determinations and tests that are the basis for airworthiness qualification includes determinations of the desired operating envelope, testing to verify operations within that envelope, and establishing any limit actions to assure safe operation. The process of airworthiness qualification includes engineering analysis, formal inspections, design reviews, safety assessments, contractor demonstrations, and contractor and Government qualification tests. The requirements for airworthiness qualification are developed by the procuring activity and documented in the Airworthiness Qualification Plan (AQP). The Airworthiness Qualification Specification (AQS) defines the contractor's obligation to conduct specific analyses, reviews, tests, surveys, and demonstrations to fulfill the requirements and objectives specified in the AQP.

#### **1-5.2.2 Specification Compliance Validation**

Specification compliance validation is a comprehensive assessment of whether a system performs in compliance with the specification requirements. The emphasis is on performance, and the quality assurance portion of the system specification should normally contain a compliance matrix that indicates how compliance with each paragraph of the specification is determined. The scope of a specification compliance validation matches the specification. For example, a subsystem-level specification compliance validation would address the subsystem-level specification requirements.

### **1-5.2.3 Military Qualification**

Military qualification may be achieved by establishing that an item possesses the required military utility by either analysis or test. The scope of military qualification is the process by which an item is tested for performance, reliability, and maintainability in the full range of its expected operating environments. Expected environments for military qualification include, but are not limited to, possible global field conditions, i.e., extreme cold, sand and dust, altitude, etc.; weapon effects, such as blast, radiation and ballistic impacts; and human interface and engineering considerations in global military environments for operability and maintainability.

### **1-5.2.4 First Article Validation**

First article validation consists of establishing that the article was manufactured according to its applicable processes and procedures and that the manufactured part meets its performance requirements in its specified environment. The critical aspect of first article validation is ensuring that the production manufacturing procedures and processes can result in a product of the same performance level as the product resulting from the prototype development and qualification effort. The scope of determi-

nation and test that constitutes first article validation is a subset of previous qualification to reconfirm performance and additional testing to validate manufacturing processes.

### **1-5.2.5 Flight Safety Parts Qualification**

The scope of determinations and tests that are necessary for flight safety parts qualification (FSPQ) is the detailed identification of characteristics of parts that are critical to sustaining safe flight and the identification of tests for those characteristics. FSPQ activities include analyzing the design of flight safety parts, testing at the component level for specific flight safety characteristics of the part, and establishing inspection criteria and part tracking requirements.

### **1-5.2.6 Structural Integrity Verification**

Structural integrity verification encompasses the establishment of acceptable structural design criteria, adequate materials, process and joining methods, design analyses, load analyses, stress analyses, damage tolerance analyses, vibration analyses, materials tests, full-scale static tests, fatigue tests, and flight and ground loads surveys.

## **1-5.3 GENERAL TECHNIQUES**

Qualification may be performed at the component, subsystem, or system level. General qualification techniques include testing, analysis, modeling, similarity (equivalency), and combinations of these techniques.

The techniques described may be applied individually or in combination depending upon the specific circumstance of a program. The application of total quality management and concurrent engineering principles and techniques to qualification requires early involvement in the design process of not only the designers of the item but also of those involved in the testing, manufacture, and support of the item. Ap-

plication of these principles and technique ensures that the design process produces an item that is testable, producible, and supportable.

### **1-5.3.1 Testing**

Testing involves applying the scientific principles of experimentation to characterize the properties of an item under controlled conditions. A test has a stated objective, a predefined set of procedures to be performed during its conduct, a method for collecting and assessing the test data, a set of pass-fail criteria, and a description of the test results.

### **1-5.3.2 Analysis**

An analysis is an evaluation of the characteristics of an item performed on the basis of engineering and scientific principles to determine whether the item meets its performance requirements.

### **1-5.3.3 Modeling**

Modeling techniques involve the investigation of the properties of a model—either physical or conceptual—of the real system in order to infer the characteristics of the real system.

### **1-5.3.4 Similarity**

Similarity qualification is based on the concept that if two items are similar with respect to a characteristic of interest and one of the items has been previously qualified, the similar items may also be considered for qualification. A statement of similarity without any basis for comparison is insufficient and should not be accepted.

## **1-5.4 DEVELOPMENT TECHNIQUES**

Qualification techniques that apply primarily during the development portion of the life cycle of an item include analyses, modeling, prototyping, informal and formal

prequalification testing under controlled, known conditions, and qualification testing. Issues unique to rotorcraft include hovering performance, vibratory characteristics, and transitional flight performance. Issues unique to aircraft with fixed-wings include high-speed landing gear considerations, stall characteristics, cabin pressurization, and thrust/propeller reversals.

## **1-5.5 SUSTAINMENT TECHNIQUES**

Qualification techniques that apply primarily during the operational and support phase of the life cycle of an item include testing and similarity. During the operational and support phase, qualification activities center primarily on changes to and improvement of an existing design, and similarity techniques are often applicable. When such techniques are not applicable, test and analysis may be used as appropriate. Also of significant importance during sustainment is the verification of characteristics, such as durability, that could not be fully assessed during a development program because of limited test time. Another qualification technique that applies during the sustainment phase is the assurance that replacement parts or repair items meet or exceed the criteria established by the original manufacturer. This is otherwise known as the qualified parts program.

## **1-6 QUALIFICATION ITEMS, TIMING, AND OBJECTIVES**

Items that require qualification include components, subsystems, systems, and modifications to systems that ensure satisfactory performance of the item.

### **1-6.1 INTRODUCTION**

The time span of a piece of military equipment development can be viewed as a life cycle in which the item passes through various stages. Typically, these life cycle phases are concept exploration and defini-

tion, demonstration and validation, engineering and manufacturing development, production and deployment, and operation and support. Demilitarization and disposal should be considered during all life cycle phases because of the potential safety considerations, e.g., hazardous material, that carry forward to the final activity of the life cycle. If a mission need cannot be satisfied by a nonmaterial solution, i.e., change in doctrine, operational concepts, tactics, training, or organization, a Mission Need Statement (MNS) is developed. The MNS is a broad statement of need rather than system-specific solutions. Phase 0 begins with approval of the MNS. Descriptions of the life cycle phases follow.

#### **1-6.1.1 Concept Exploration and Definition (Phase 0)**

During concept exploration and definition, conceptual alternatives to satisfy mission needs and airworthiness requirements are defined.

#### **1-6.1.2 Demonstration and Validation (Phase I)**

During demonstration and validation a likely candidate or candidates to satisfy the stated need is(are) tested to show that the selected candidate(s) is(are) viable.

#### **1-6.1.3 Engineering and Manufacturing Development (Phase II)**

During engineering and manufacturing development, design engineering and testing are performed to define an end-item that satisfies the military need. The main product of engineering and manufacturing development is documentation of information for use in the production of the end-item for field use.

#### **1-6.1.4 Production and Deployment (Phase III)**

During production and deployment the item is manufactured based on the data developed in the engineering and manufacturing development phase. The manufactured item is sent to the using unit or to a depot for storage.

#### **1-6.1.5 Operations and Support (Phase IV)**

The operations and support phase consists of use of the system by operational units and the associated training, supply, and maintenance activities. It also includes removal of weapons, environmentally safe detoxification or containment of hazardous material, deformation of expended life items to prevent reuse, and commercial resale or recycling.

### **1-6.2 NEW SYSTEM**

A new system is defined as a newly designed system that requires performance of a full range of development activities. Typically, it requires engineering development, prototype fabrication and testing, and production efforts.

#### **1-6.2.1 Items**

Qualification is an incremental process that typically is performed on components, subsystems, and systems. These items are normally prototype hardware fabricated during the development process.

#### **1-6.2.2 Timing**

Because qualification is an incremental buildup process, timing is critical to the success of a qualification program. Components should be qualified before the subsystem into which they will be integrated is qualified. The subsystem-level tests and analyses should achieve certain minimum goals prior to initiation of system-level tests. Similarly, numerous analyses and ground tests should be successfully completed prior to flight testing. Flight testing is an incre-

mental, progressive activity during which periodic assessments of progress are made prior to proceeding to the next phase of the qualification program.

### 1-6.2.3 Objectives

The objectives of qualification during development are to ensure that a newly developed item meets its intended requirements. Because the item is newly developed, it can be expected to require significantly more qualification effort than modification programs.

## 1-6.3 MODIFICATION

A modification program is defined as a change to an existing system to provide an added capability or exploit technological advances. Modifications can range from minor changes to a component to major changes affecting the entire system. Minor changes, however, do not usually require qualification. Modifications that would measurably affect the airworthiness of an aircraft include but are not limited to

1. Those that could affect
  - a. Structural integrity
  - b. Propulsion, transmission, and drivetrain stability and control
  - c. Air vehicle flight performance
  - d. Aerodynamic characteristics, including rag
  - e. Control response and stability
  - f. Electromagnetic characteristics
  - g. Navigational system effectiveness
  - h. Flight control system authority and effectiveness
  - i. Weight and balance
  - j. Flight control system logic and software.
2. Those that could restrict the flight crew in the performance of normal duties
3. Those that could increase the danger to the crew in the event of an accident

4. Those that incorporate a source of energy which could be hazardous, such as explosive ordnance, explosive or flammable fluids, and laser energy

5. Those that could affect the operating limits and/or emergency procedures specified in the operator's manual, see AR70-62, *Airworthiness Qualification of US Army Aircraft System (Ref. 1)*.

6. Those that could affect the currently approved ordnance configuration or its controlling software.

### 1-6.3.1 Items

The qualification test articles that are normally available during modifications may be a combination of prototype hardware for those items undergoing modification and production hardware for those items already developed and not requiring modification. As in new developments, the components, subsystems, and system may undergo qualification depending on the nature and magnitude of the modification effort.

### 1-6.3.2 Timing

The timing discussions of subpar. 1-6.2.2 apply to a modification program as well. Specific timing considerations are a function of the magnitude and nature of the modification effort.

### 1-6.3.3 Objectives

The objectives of qualifying a modification are to ensure that the changes incorporated do not adversely impact the system from an airworthiness standpoint and that the desired capabilities or performance improvements as expressed in the changed objective for the item have been achieved.

## 1-7 SOURCE QUALIFICATION

Source qualification, applicable primarily at the part or component level, is the qualifying of a producer's manufacturing and inspection processes and procedures as be-

ing acceptable for the production of specified items.

### **1-7.1 QUALIFIED PARTS LISTS (QPL)**

When a supplier has demonstrated that he can consistently produce an item in accordance with the requirements of an applicable specification, that manufacturer's item is placed on the QPL for that specification. The agency responsible for the particular specification establishes the criteria for and determines compliance with requirements for QPLs.

### **1-7.2 SOURCE-CONTROLLED ITEMS**

The concept of source-controlled items is to use existing items known to be effective in the system being qualified without detailed knowledge of the item or its critical characteristics. This usually is applied to complex subsystems in which one or more adequate products exist, typically involving critical proprietary processes that are not practical to duplicate.

### **1-7.3 SPECIFICATION CONTROL ITEMS**

Specification control items are items that are certified by their manufacturer to have been built and tested in accordance with an applicable specification. For electronic equipment the Defense Electronic Supply Center (DESC) conducts audits to ensure that a source meets the requirements of the specification or standard.

### **1-7.4 ALTERNATE SOURCES**

During the course of or subsequent to the original qualification process, alternate sources may be qualified by demonstrating that they can produce the item to a performance and quality level equivalent to that of the original source. The purpose of alternate sourcing is to eliminate dependency on a single source for a critical item. A

procurement contract may stipulate that the contractor developing an item is required to participate in the selection and qualification of alternate sources.

## **1-8 USE AS TEXTBOOK, REFERENCE, AND PREPARATION GUIDE**

This handbook has a number of intended uses. First, as a textbook, it provides an overview of airworthiness qualification programs and testing by describing the elements and procedures necessary for successful accomplishment of an airworthiness qualification program. Second, this handbook provides a tutorial text on airworthiness qualification for new personnel by providing "how-to" instructions on structuring an Airworthiness Qualification Program. Finally, this handbook is intended to be a reference for preparing each of the following documents: Airworthiness Qualification Plan (AQP), Airworthiness Qualification Specifications (AQS), Contractor Flight Release (CFR), Airworthiness Release (AWR), Statement of Airworthiness Qualification (SAQ), and Airworthiness Qualification Substantiation Report (AQR) both in terms of essential elements as described in the appendices to the handbook and required content as described in the body of this handbook. *The Department of Defense Index of Specifications and Standards* (DODISS) (Ref. 2) is used to identify unclassified federal and military specifications and standard, QPLs, military handbooks, and those industry documents coordinated for Department of Defense (DoD) use. The DODISS is composed of an alphabetical listing and a numeric listing, and it contains procedures for ordering these documents.

## REFERENCES

1. AR 70-62, *Airworthiness Qualification of US Army Aircraft System*, 15 July 1978.
2. *Index of Specifications and Standards*, Department of Defense, published yearly.