DEPARTMENT OF NATIONAL DEFENCE

ROYAL CANADIAN AIR FORCE





SECRET

# SPECIFICATION
## for

DEVELOPMENT OF AUTOMATIC FLIGHT CONTROL SUB-SYSTEM FOR

CF-105 AIRCRAFT

INST 92-5

| ISSUE | DATE | REMARKS |
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**This Specification is not valid for contract purposes unless it is read in conjunction with the Specifications referred to herein, and the cover page bears the signature of the authorized representative of the Chief of the Air Staff.**

**No of Pages in this Specification**
**One Cover Page and** Twelve Sheets and Appendix "A"

**ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF**

**APPROVED**

AVC

**Prepared By:** Air Force Headquarters **File Reference:** S1038 CF105

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## Applicable Specifications, Publications and Drawings

The following specifications, publications and drawings of the issue in effect on the date of invitation to tender, shall form a part of this specification, and the requirements therein are to be complied with, except as otherwise stated herein.

Where there is a variation between this specification and the specifications, publications and drawings listed below this specification shall govern.

### Specifications

Royal Canadian Air Force

| | |
|---|---|
| AIR 7-4(2) | Prototype Supersonic Interceptor Aircraft, Type CF-105 |
| AIR 7-6(1) | Development of an Electronic System for the CF-105 Aircraft |
| PROC 100-2(1) | Preparation of RCAF Drawings |
| PROC 100-4(1) | Identification and Marking of RCAF Property |

U.S. Military

| | |
|---|---|
| MIL-W-5088A | Wiring, Aircraft, Installation of |
| MIL-E-5272A | Environmental Testing, Aeronautical and Associated Equipment (General Specification for) |
| MIL-E-5400 | Electronic Equipment, Aircraft General Specification for |
| MIL-C-5900 | Control Systems, Automatic Flight, Aircraft, General Specification for |
| MIL-I-6181B | Interference Limits, Tests and Design Requirements, Aircraft Electrical and Electronic Equipment |
| MIL-P-7788 | Plate, Plastic, Cockpit and Interior Controls Lighting |
| MIL-E-7894A | Electric Power, Aircraft, Characteristics of |
| MIL-T-9107 | Test Reports; Preparation of |

A.V. Roe of Canada

| | |
|---|---|
| AVROCAN E276 | Specification of CF-105 Damping System |

### Publications

Royal Canadian Air Force

| | |
|---|---|
| EO 00-5-2 | Preparation and Printing of RCAF Engineering Orders |

### Drawings

NIL

TABLE OF CONTENTS

## 1. DEFINITION

1.1 This specification states the requirements of the Department of National Defence, Royal Canadian Air Force, hereinafter called the Department, for the design and construction of a prototype automatic flight control subsystem hereinafter called AFCS, for the CF-105 aircraft in accordance with Specification AIR 7 4.

## 2. GENERAL REQUIREMENTS

2.1 While this specification is intended to cover design and construction of the prototype system only, the design shall be such that the system will be suitable for large scale production as a qualified reliable system.

2.2 Component units produced for the US Services are to be used wherever possible and unless the stated requirements in this specification require a new unit. On these units, acceptance by the US Services will generally be accepted by the Department. New units must be acceptable to the Department.

2.3 The material entering into the construction of this equipment shall be of the best quality. All workmanship and shop practice shall be in accordance with accepted standards of modern engineering practice.

2.4 Construction including material and workmanship shall be free from any characteristics or defects, which may render the equipment unsuitable for the intended purpose.

2.5 The use of materials, parts and processes other than those required by this and concomitant specifications shall be investigated and if a substantial reduction in size and weight or improvement in simplicity of design, performance, or reliability can be realized by their use they shall be adopted. Approval of new materials, parts and processes shall be subject to the component of which the feature is a part passing all required tests and being accepted by the Department.

2.6 Design shall be in accordance with the most advanced electronic equipment component designs and packaging techniques to ensure minimum size, weight, and cooling requirements. Reliability shall be a major design criterion. The use of easily disconnected, plug-in assemblies of one or more related circuits shall be investigated with a view towards reduction of size and weight, simplification of operation and maintenance or improvement in performance.

2.7 The component parts of the AFCS shall be determined during development.

2.8 The AFCS shall be designed to automatically control the aircraft satisfactorily throughout the aircraft range of operation as specified in para 3.6.1 and under the environmental conditions and aircraft configurations encountered in operational use of the aircraft.

2.9 The installation and operation of the AFCS shall not cause any change in the aircraft control system which is objectionable to the Department.

2.10 Aircraft wiring for the AFCS shall be in accordance with Specification MIL-W-5088 unless an improvement for this system is submitted and approved by the Department.

2. GENERAL REQUIREMENTS (Cont'd)

2.11 Console controls in the cockpit shall be lighted in accordance with Specification MIL-P-7788.

3. DESIGN REQUIREMENTS

3.1 Relation to Damping Sub-System

3.1.1 The AFCS shall comprise the electronic circuitry necessary to deliver outputs to the command servos so as to automatically adjust the flight path vector and the orientation of the aircraft as demanded.

3.1.2 It shall be compatible with the damping sub-system, which is defined in Specification Avrocan E-276 for separate development contract. The damping system will provide both the command and damping servo amplifiers, manual control stick force pick off, rate sensors, accelerometers, surface position pick offs, structural integrity cut-outs in the pitch and roll axes, command signal limiter in the roll axis, and the circuitry required to perform the automatic stabilization of the aircraft, to co-ordinate turns, to provide spiral stability, and to provide for unco-ordinated manoeuvres at the option of the pilot.

3.1.3 The normal damping system will be in operation during all normal modes of operation and the emergency damping system will be in operation during emergency conditions.

3.1.4 The Optical Attack Mode and Manual Flight Mode shall be flown manually by flight stick control through the damping system and command servos, independent of the AFCS.

3.1.5 See para 3.3.2 (c) regarding rates.

3.1.6 Computations required for AFCS shall be done in the AFCS equipment or may be done in the central computer if the concept of a central computer for the whole electronic system is used.

3.2 Functions

3.2.1 The AFCS shall in conjunction with other sub-systems enable the interceptor to perform the following functions:

(a) Automatic attack

(b) Automatic navigation

(c) Automatic approach for landing

(d) Pilot assist functions consisting of:

(i) Heading hold

(ii) Bank hold

(iii) Altitude hold

(iv) Mach hold

(v) Manual control by aircraft control stick

These are expanded in greater detail under paragraph 3.6.2 and in Appendix "A".

3. DESIGN REQUIREMENTS (Cont'd)

3.3 Sub-System Inputs

3.3.1 Command Inputs

3.3.1.1 To provide the above functions, the AFCS shall accept command signals from the other sub-systems. These are to be selected by the crew in accordance with the function to be performed and are the modes specified below.

3.3.1.2 Automatic Attack - It shall receive command signals from the computer sub-system to enable the aircraft to fly a correct firing course during the attack and for breakaway by preselection by stick force. Automatic breakaway may become a requirement for this aircraft. A study is to be undertaken to determine how automatic breakaway could be accomplished and what advantages and disadvantages would accrue.

3.3.1.3 Automatic Navigation and Interception - For close control it shall accept command signals from the data link receiver through a coupler if necessary. For automatic broadcast control it shall accept command signals from the navigation computer. For Dead Reckoning navigation it shall accept command signals from the navigation computer and directional gyro on the stabilized platform.

3.3.1.4 Automatic Approach for Landing - An AGCA ground installation shall provide the steering and descent commands for the approach through the data link receiver in the aircraft. Automatic landing may become a requirement for this aircraft. A study is to be undertaken to determine how this could be accomplished satisfactorily.

3.3.1.5 Pilot Assist - The pilot's cockpit controls shall enable him to select the required functions and to provide the command signals necessary to perform the assist functions listed in 3.2.1 (d).

3.3.2 Other Inputs

3.3.2.1 Certain inputs are necessary during the performance of all the functions listed in para 3.2.1.

3.3.2.2 The Flight Data Sub-system (reference Specification AIR 7-6, section 3.6) shall provide information as required for compensation or scheduling for the various modes of operation. These are tentatively indicated in the summary in Appendix "A" and the following list:-

(a) Heading

(b) Pitch Attitude angle

(c) Roll attitude angle

(d) Altitude

3. DESIGN REQUIREMENTS (Cont'd)

(e) Lift acceleration

(f) Differential or Pitot Pressure "q"

(g) Mach Number

3.3.2.3 Computation of these parameters for compensation or scheduling as functions of flight conditions shall be performed in the most reliable manner. Consideration should be given to independent computation even if the concept of a central computer is used.

3.3.2.4 The signals generated in the damping sub system shall be used in the AFCS wherever necessary.

3.4 Sub-System Outputs

3.4.1 The sub-system outputs shall enable the aircraft to perform the automatic flight and pilot assist functions outlined in 3.2.1.

3.5 Design Characteristics

3.5.1 Components of the flight control sub-system shall be part of the integrated electronic system, including cooling ducting, electrical connections, and packaging but shall not contain functions which are not required for the AFCS.

3.5.2 Simplicity, light weight, and reliability shall be considered important design criteria.

3.5.3 To obtain operational simplicity, careful consideration shall be given to minimizing the number and complexity for the controls and indicators in the pilot's cockpit.

3.5.4 Transitions between manual and automatic modes, or between various automatic functions, shall be accomplished in a smooth manner.

3.5.5 The pilot shall be given the ability to disengage the AFCS and take over manual control at any time during automatic flight.

3.5.6 Suitable feedback signals from the flight sensing instrumentation and aircraft damper sub-system shall be provided to assure stable and rapid operation during all flight conditions.

3.5.7 Provision shall be made to keep the aircraft trimmed automatically during all flight conditions except the damping modes and it shall operate at a suitable rate to be determined during development. Manual trim should be cut out during all modes except the damping modes.

3.5.8 Power - An investigation shall be made to determine whether the AFCS can operate satisfactorily for all modes of flight on 115 ± 6 and - 7 volts, 400 ± 20 cycles/sec, single phase A/C power and $27\frac{1}{2} \pm 1\frac{1}{2}$ volt D/C from a source which conforms to MIL-E-7894 or whether stricter control and phase synchronism is necessary.

3. DESIGN REQUIREMENTS (Cont'd)

3.5.9 Engagement - It shall not be possible to engage the AFCS unless the system has been energized and is ready for correct operation. The time required shall not exceed 2 minutes for readying. Engagement shall be possible at any bank or pitch attitude.

3.5.10 Service Life - The AFCS shall be designed with the objective of achieving 2000 hours of service life without overhaul when operated under normal service conditions with reasonable servicing and replacement of parts. The equipment will be energized ready for use during aircraft readiness on the ground and hence should be stable for 24 hours running.

3.5.11 It shall be a design objective to use as few electronic tubes as possible.

3.6 Performance

3.6.1 Range of Operation

3.6.1.1 Speed and Altitude Range - The AFCS shall be capable of operational use throughout the following ranges:-

(a) Altitude - sea level to 65,000 feet aircraft altitude.

(b) Mach Number - M 0.15 at sea level to M2 0 at 65,000 feet and in emergency up to M2.2, limited at all altitudes as in para 3.6.1.1(c)

(c) Equivalent Air Speed - 720 kts maximum.

3.6.1.2 Attitude Range - The AFCS shall control the aircraft throughout the following attitude range.

(a) The range of pitch attitude is to be determined during a study.

(b) 360 degrees of aircraft bank attitude

(c) 360 degrees of aircraft heading.

3.6.1.3 Rate Range - The AFCS shall be capable of controlling the aircraft's inherent rates in all axes sufficiently to provide adequate damping and manoeuvrability and overall aircraft system operation.

3.6.1.4 Acceleration Range The AFCS shall control the aircraft satisfactorily within the following ranges:-

(a) Normal acceleration of + 6 'g' in pull-outs, and + 4 'g' in turns and negatively to 2 'g'.

(b) Lateral acceleration of ± 0.2 'g'.

(c) Fore-and aft acceleration of +1.5 'g' to -1.0 'g'.

3. DESIGN REQUIREMENTS (Cont'd)

3.6.2 Modes of Operation

3.6.2.1 Certain of the function selections described below shall be operable in certain simultaneous combinations as indicated in text and an Appendix "A". When no AFCS mode is selected the aircraft shall be in the manual mode. See para 3.7.5 for Emergency Mode

3.6.2.2 Pilot Assist Mode

3.6.2.2.1 In this mode the AFCS shall maintain the aircraft according to the further selection by the pilot of the subsidiary functions described below. The only commands are those inserted by the pilot; none come directly from navigation equipment, fire control, or data link.

3.6.2.2.2 Function Selections

3.6.2.2.2.1 Heading Hold - This function shall be normally engaged during pilot assist mode; no selection switch shall be provided. It shall disengage automatically when the aircraft bank angle reaches 3 to 5 degrees. It shall automatically re-engage on the new heading when the bank angle returns to this range. The AFCS shall maintain the aircraft at its existing heading with ± 1 degree tolerance.

3.6.2.2.2.2 Bank Hold - The AFCS shall hold the aircraft bank angle selected by the pilot by manual control; no selection switch shall be provided. The threshold for bank holding shall be between 3 and 5 degrees of bank with a suitable light stick force applied; and the value of the latter to be determined during development.

3.6.2.2.2.3 Altitude Hold - When this is selected by means of a switch the AFCS shall maintain the aircraft at its existing pressure altitude plus or minus a tolerance which is to be settled during development. Tolerances as set forth in Specification MIL-C-5900 are to be the design objectives; these are: ± 10 ft or 0.1% whichever is greater.

3.6.2.2.2.4 Mach Hold - When this selection is made by means of a switch whose alternate position shall be Altitude Hold, see para 3.6.2.2.2.3 the AFCS shall maintain the aircraft at its existing Mach Number with a tolerance to be determined during development.

3.6.2.2.2.5 Manual Control - When the pilot commands manoeuvres through the control stick, force sensing pick-offs shall provide the command signals. Suitable light break-out forces, to be determined during development, shall cause disengagement of the hold functions and cause switching from the AFCS to the Manual Mode for the duration of the commands. Upon completion of the command manoeuvres and release of the stick, the appropriate hold functions already selected by the pilot shall be automatically re-engaged.

3. DESIGN REQUIREMENTS (Cont'd)

3.6.2.3 Automatic Dead Reckoning Mode of Navigation - When this mode is selected the AFCS shall steer the aircraft in azimuth in accordance with the heading to destination computed by the navigation computer and heading hold from the directional gyro on the stabilized platform.

3.6.2.4 Broadcast Control Mode of Interception and Return to Base - In this mode the AFCS shall steer the aircraft in accordance with command signals from the navigation computer or from stick force. Mach Hold may be used.

3.6.2.5 Close Control Mode of Interception and Return to Base

3.6.2.5.1 In this mode the AFCS shall accept command signals by Data Link or by stick force.

3.6.2.6 Attack Mode

3.6.2.6.1 For the attack mode of operation the AFCS shall meet the following requirements in a manner to assure optimum system configuration giving better accuracy than under manual mode.

(a) The noise component of the steering command signals shall be adequately smoothed in relation to range and flight parameters to minimize:

(i) miss due to noise

(ii) random control surface movement

(iii) roughness of ride for the crew. This requirement is not to compromise (b) below.

(b) Response to the steering command signals shall be as rapid as the crew will tolerate to reduce initial heading errors quickly and to minimize miss due to target manoeuvre.

(c) Adequate dynamic stability shall be provided in all degrees of freedom of the aircraft and system.

(d) Static bias errors shall be as small as possible.

3.6.2.6.2 Automatic steering in azimuth and elevation shall be provided for lead collision and lead pursuit attacks.

3.6.2.6.3 Optical attacks shall be made using pilot assist mode or Manual Mode.

3.6.2.7 Approach for Landing Mode - In this mode the AFCS shall respond to the same signals as for Close Control.

3.6.3 Command Signal Limiting When the computer demands a manoeuvre approaching the value of normal acceleration which would cause the aircraft to enter the buffet zone or to approach the structural 'g' limit the AFCS shall limit the executive signal to avoid either of these effects. The demanded manoeuvre is to be continued at the limited rate until the demand is satisfied. The Command Signal Limiter shall operate in all modes except the Emergency Mode.

3. DESIGN REQUIREMENTS (Cont'd)

3.6.4 Rates of Response - The AFCS with associated damping system and servos shall be capable of accelerating the aircraft at the maximum rates tolerable by the crew in the pitch, roll and yaw axes unless these rates are greater than those of which the aircraft is capable, in which case the latter shall govern. Notwithstanding the above ability the Command Signal Limiter of paragraph 3.6.3 shall limit the manoeuvre in the prescribed way.

3.7 Safety Provisions and Emergency Operation

3.7.1 Cut-Out Switch - Cut-out switches for the AFCS shall be provided on the stick and on the console.

3.7.2 Malfunctions - One evident failure of the AFCS or one failure evident to the pilot plus one non-evident failure shall not cause:-

(a) the aircraft to exceed the limit load factor by divergence beyond control.

(b) an uncontrollable oscillation of the aircraft.

3.7.3 Adequate interlocks and safety features shall be provided to avoid dangerous flight conditions.

3.7.4 An interlock shall be provided to turn off the weapons circuits when in the Approach to landing mode.

3.7.5 The damping system provides an emergency mode, ref. Specification AVROCAN E-276.

3.8 Maintenance

3.8.1 Design shall be in accordance with current techniques of built-in test and alignment circuitry. Special test equipment shall be kept to a minimum and standard items of JAN field test gear given preference when possible.

3.8.2 A maximum degree of component accessibility shall be provided.

3.8.3 Replaceable inter-component plug-in harnesses shall be provided, in order to simplify maintenance procedures. Test equipment access plugs will be used where access to internal circuits is required.

3.8.4 Interlock type of indication shall be incorporated where self-testing switches, test access plug jumper caps, or similar features are provided.

3.8.5 Provision shall be made during taxi-ing, take-off and while airborne, for the crew to detect major malfunctions in the system.

3.9 Engineering Data

3.9.1 Drawings - Department contracts for equipment, whether procured directly by the Department or through another contractor, require that all drawings prepared by contractors in accordance with the terms of the contract must be in accordance with the requirements of Specification PROC 100-2.

3. DESIGN REQUIREMENTS (Cont'd)

3.9.1.1 Prior to initiating work on drawings the contractor shall be required to apply to, Air Officer Commanding, Air Materiel Command, RCAF Station Rockcliffe, Ottawa, Ont. Attn: SOPD/3.

3.9.2 Engineering Orders - Department Contracts for equipment, require that engineering orders prepared by contractors in accordance with the terms of the contract, shall be in accordance with the requirements of RCAF Engineering Order 00-5-2.

3.9.2.1 Prior to initiating work on publications the contractor shall be required to apply to Air Officer Commanding, Air Materiel Command, RCAF Station Rockcliffe, Ottawa, Ont. Attn: SOPD/L, for detailed instructions regarding EO 00-5-2.

4. INSPECTION AND TEST PROCEDURES

4.1 General

4.1.1 The equipment shall be designed so that production items will pass the qualification tests and production acceptance tests hereinafter outlined.

4.1.2 The development models shall be made with the above end in view but will not be required to pass all tests; the particular tests required will be decided jointly by the Department, the airframe contractor and the AFCS contractor, as development proceeds.

4.1.3 For purposes of testing the AFCS under normal operating conditions it will be expedient in some cases to operate a damping system, servos, and input devices with the AFCS. This shall be permitted.

4.1.4 Acceptance or approval of material or parts during course of development shall in no case be construed as a guarantee of the acceptance of the finished product.

4.1.5 The contractor shall, during all working hours, afford unrestrained opportunity and facilities for the inspection of the work and materials by an authorized representative of the Department, in order to enable him to exercise reasonable control of quality.

4.1.6 Inspection by the Department's representative does not relieve the contractor of responsibility for conforming to; the standard laid down and accepted in general practice; the instructions and dimensions contained on the approved drawings of the parts or equipment and to the specification.

4.1.7 Pre-production tests are those tests to which samples representative of the production item are subjected to determine that the production item fully meets the requirements of this specification.

4.1.8 Acceptance tests are those tests accomplished on production items.

4. INSPECTION AND TEST PROCEDURES (Cont'd)

4.2 Pre-Production Tests

4.2.1 Pre-production test samples shall consist of such number, but need not exceed three, of each component from the preliminary production run as may be required to conduct the tests specified below.

4.2.2 The contractor shall furnish the Department three complete copies of each pre-production Report and each Flight Test Report. Pre-production test reports shall be in accordance with the technical and format requirements of Specification MIL-T-9107.

4.2.3 In cases where environmental tests equivalent to those shown herein have already been completed by the contractor on the component, the contractor shall furnish copies of such reports. The tests need not be repeated if the previous report is accepted for this procurement.

4.2.4 The equipment shall pass the environmental tests of para 4.2.5 before production design is frozen.

4.2.5 Pre-production tests shall consist of the tests under the paragraphs in 4.2.4.1, 4.2.4.2 and 4.2.4.3 and those tests specified under Acceptance Tests under paragraph 4.2.5.

4.2.5.1 Environmental Tests

4.2.5.1.1 The environmental tests shall be conducted in accordance with Specification MIL-E-5272A, except as otherwise specified herein. Prototype equipment shall not be required to meet these tests but must be sufficiently airworthy for test and development flying.

4.2.5.1.2 Pressure and Temperature - Whenever the pressure and temperature are not specified definitely the test shall be accomplished at approximately sea level pressure (about 29.92 inches Hg) and at room temperature, about 25°C.

4.2.5.1.3 Low Temperature Tests - All components shall be tested in accordance with Procedure II of Specification MIL-E-5272A, except that visual examination at cold temperatures is not required. Before conducting the test, the components may be energized for a period of 10 minutes.

Note: The 10-minute warm-up period specified above does not relieve the contractor from compliance with the requirements specified in paragraphs 3.5.11 and 3.7 herein.

Performance shall be checked before the exposure period, and at the conclusion of the exposure period while still at low temperature.

4. INSPECTION AND TEST PROCEDURES (Cont'd)

4.2.5.1.4 Altitude - All components shall be subjected to the altitude tests in Procedure III of Specification MIL-E-5272A at a pressure altitude of 65,000 feet. The temperatures shall be + 70 ± 3 degrees F for all components. The duration of this exposure shall be 10 hours. Performance shall be checked before, during, and after the exposure. The altitude test shall be repeated at the cold temperature called for in MIL-E-5272A for low temperature tests.

4.2.5.1.5 Humidity - Use Procedure I of Specification MIL-E-5272A except that the duration shall be 10 cycles. Performance shall be checked before, and at the conclusion of the exposure period.

4.2.5.1.6 Rain - Use Procedure I of Specification MIL-E-5272A. Performance shall be checked before and at the conclusion of the exposure period. For those components which cannot be sealed, any water that enters shall be free to drain out, and the only evidence of moisture shall be that due to surface adhesion.

4.2.5.1.7 Salt Spray - Follow MIL-E-5272A, checking performance before and at the conclusion of the exposure period.

4.2.5.1.8 Sand and Dust - Use Procedure I of MIL-E-5272A checking performance before and at the conclusion of the exposure period.

4.2.5.1.9 Shock - Use Procedure II of MIL-E-5272A, checking performance before and at the conclusion of the operation.

4.2.5.1.10 Vibration - Use Procedure I or III of MIL-E-5272A as applicable. Performance shall be checked before and at the conclusion of the vibration period. The maximum acceleration to which the gyros shall be subjected shall be specified in the detail specification in accordance with the vibration which it is found the aircraft will generate.

4.2.5.1.11 Explosion Proof Use Procedure I of MIL-E-5272A. The component shall be operated during the exposure period.

4.2.5.1.12 Radio Interference - The radio interference tests shall be conducted in accordance with Specification MIL-I-6181B.

4.2.5.1.13 Voltage Stability - The AFCS shall be tested to determine that it will operate satisfactorily as a system from a power source which reaches but does not exceed the limits specified in Specification MIL-E-7894A, Type 1, and in paragraph 3.5.8 herein. The system shall not be required to engage below 21 V. DC and is not required to remain engaged for direct current transients of more than 10 volts below the steady state.

4.2.5.1.14 High Potential - Each component shall be tested for dielectric strength to ground for those circuits which do not have a path to ground through resistance, capacitance, or inductance according to the following voltage schedule, unless otherwise specified under the individual components. The potential shall be of a frequency of 50 to 60 cps, and shall be applied for 1 minute.

INSPECTION AND TEST PROCEDURES (Cont'd)

| Voltage Rating of Circuit | Applied High Potential |
|---|---|
| under 115 volts | 500 volts rms |
| 115 volts | 1250 volts rms |
| over 115 volts | Twice rated voltage plus 1500 volts rms. |

4.2.5.1.15 High Temperature -

(a) Use Procedure I of Specification MIL-E-5272A for all units not otherwise specified below. Performance shall be tested before and at the conclusion of the exposure period.

(b) The test procedure for amplifiers and calibrators shall be as follows:

Each component shall be placed in a heat chamber, and the internal chamber temperature raised to 160° ±3°F with an internal relative humidity of less than 5%. The test component shall be energized. The equipment shall remain at 160° ±3°F for 10 hours. At the conclusion of this time, the equipment shall undergo 4 test cycles each of 3-1/4 hours duration including 5 minutes at the maximum temperature to which the equipment might be subjected in service. The barometric pressure of the chamber shall then be reduced to that corresponding to the pressure of 30,000 feet. The equipment shall then be subjected to the test specified in Procedure I for a period of 12 hours. At the conclusion of the test, and with the equipment still at 160° ±3°F the performance shall be checked according to the applicable detail specification.

(c) The test procedure for the trim interrupter shall be identical to the procedure in (b) above, except that the equipment shall undergo 10 test cycles. of 1 1/4 hours duration.

4.2.5.2 Acceleration Tests - Before any critical flight tests are conducted, the contractor shall demonstrate that adequate provisions are incorporated to prevent the AFCS from applying control to the aircraft that would cause the aircraft to exceed its structural design limits.

4.2.5.3 System Operation Tests

4.2.5.3.1 The AFCS installed in a CF-105 aircraft shall demonstrate satisfactory performance in accordance with the following requirements:

4.2.5.3.2 Ground Tests

(a) Interlock Test - A test shall be made to demonstrate satisfactory operation of the interlocking functions.

(b) Sense of Operation in Pitch - Signals shall be put into the pitch channel to demonstrate that the controls move in the correct sense.

4. INSPECTION AND TEST PROCEDURES (Cont'd)

(c) Sense of Operation in Roll and Yaw - Signals shall be introduced into the roll and yaw channels to demonstrate that the controls move in the correct sense.

4.2.5.3.3 Flight Tests

4.2.5.3.3.1 The flight tests shall be performed for the purpose of demonstrating compliance with the requirements listed hereunder. Unless otherwise specified the flight tests are to be conducted in fairly smooth air. Unless otherwise specified, the aircraft shall be trimmed manually for straight and level flight for each test prior to engagement of the AFCS. Sufficient tests shall be conducted with external stores in place to determine that the AFCS is able to control the aircraft satisfactorily with such stores in place.

4.2.5.3.3.2 Control Characteristics - Transitions between manual and automatic modes, or between various automatic functions, shall be accomplished in a smooth manner to the satisfaction of the test pilot.

4.2.5.3.3.3 Flight Test Procedure - The flight test procedures listed in Table 1 shall be performed in aircraft flight configuration which will be jointly agreeable to the Department, the airframe contractor, and the AFCS contractor.

4.2.5.3.3.4 Rough Air - With the AFCS engaged, operation in rough air shall not excite sustained periodic oscillations of either the aircraft or the control system during straight and level flight, climbs, dives or co- rdinated turns.

4.2.6 Acceptance Tests

4.2.6.1 Individual Tests - Each production component or complete production AFCS shall be inspected to determine compliance with the individual tests of the latest approved issue of the applicable detail specification. These tests shall not apply to the prototype equipment.

4.2.6.2 Sampling Tests - One of each component of the production AFCS shall be selected at random from every hundred or fraction thereof produced and it shall be subjected to the following test procedures.

(a) The sampling tests shall consist of the sampling tests specified in the latest approved issue of the applicable detail specification.

(b) When sampling tests are specified on a number of items that are selected from a production run, and one or more of this number fails to meet the specified tests, acceptance of all items of the type that failed still on hand and subsequent production shall be with-held until the extent and cause of failure is determined. For operational reasons, individual tests may be continued pending investigation of a sampling test failure; however, final acceptance of the items on hand and subsequent production is contingent upon the inspector's decision regarding the over-all conformance of the product to requirements of this specification. When corrective action has been accomplished, all sampling tests shall be repeated. If investigation indicates that the defects may exist in items previously accepted, full particulars concerning the defects, including recommendations for correction, shall be furnished to the Department.

4. INSPECTION AND TEST PROCEDURES (Cont'd)

(c) Retests - Rejected AFC Systems shall not be re-submitted for inspection without furnishing full particulars concerning previous rejection and the measure taken to overcome the defects.

(d) These tests shall not apply to the prototype equipment.

5. PREPARATION FOR DELIVERY

To be specified by amendment to this specification. Special arrangements will be made for the prototype equipment.

6. CHANGES TO SPECIFICATION AND WORK

6.1 The Department through the Department of Defence Production may order extra work or make changes by altering, adding to or deducting from the specification and or the work; the contract sum being adjusted accordingly. No extra work shall be made unless in pursuance of written order from the Department of Defence Production, and no claim for an addition to the contract sum shall be valid unless so ordered. Drawings, or the equivalent, showing details of all extra work, must be approved by the Department and the right is reserved to reject any work not done in accordance with the approval of the Department's representative.

6.2 If the contractor claims that any instructions, by drawings, or otherwise involve extra cost to this contract, he shall give the Department written notice thereof within a reasonable lapse of time after receipt of such instructions, and in any event, before proceeding to execute the work. No claim shall be valid unless so made.

6.3 The contractor shall state in his tender any item which he cannot fulfil as specified. He shall indicate any deviations, substitutions or changes which he requires as alternatives.

6.4 Any questions relating to this specification are to be referred to the Department's authorized representative.

6.5 If the contractor wishes to suggest alternatives, obtain concessions or otherwise depart from the current issue of the specification, he is to forward his proposals immediately to the Department for approval.

Note: Copies of this specification may be obtained by contacting the Department of Defence Production, Ottawa, Ontario, Canada.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the Canadian Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

FLIGHT TESTS TABLE 1

| ITEM | AFCS FUNCTION | AXIS | TEST PROCEDURE | STABILITY & PERFORMANCE CHARACTERISTICS | REQUIREMENTS |
|---|---|---|---|---|---|
| 1 | Bank Hold | Roll | Engage Pilot Assist Mode. Straight and level flight for a minimum of 3 minutes Heading control disengaged. | Damping | There shall be no oscillation which exceeds ±.5 degree below 5,000 ft, and ± 1 degree above 5,000 ft. The period of the oscillation shall not be less than one-half of the lateral directional, natural period of the aircraft and shall not be objectionable to the Department. |
| | | | | Static Accuracy | The AFCS shall maintain the wings level attitude within ± 1 degree. |
| 2 | | | Apply aileron control input and release at a bank angle of approx. 20 degrees. Control stick steering and synchronization shall be inoperative for roll, and no heading feedback shall be used. | Response | The short period response shall be smooth and rapid and not objectionable to the Department. |
| | | | | Damping | The short period damping shall be adequate to permit one overshoot. The overshoot shall not be greater than 15% of the initial roll attitude amplitude. There shall be no oscillation which exceeds ±.5 degrees below 5,000 ft and ± 1 degree above 5,000 ft. The period of the oscillation shall not be less than 1/2 of the lateral-directional, natural period of the aircraft, and shall not be objectionable to the Department. |
| | | | | Static Accuracy | The AFCS shall return the aircraft to within ± 1 degree of the initial attitude in roll. |

FLIGHT TESTS TABLE 1 (Cont'd)

| ITEM | AFCS FUNCTION | AXIS | TEST PROCEDURE | STABILITY & PERFORMANCE CHARACTERISTICS | REQUIREMENTS |
|---|---|---|---|---|---|
| 3 | | | Apply aileron control input and release at bank angles of greater than 7.5 degrees but less than 60 degrees. Control stick steering & synchronizer shall be used for this test. Heading control will be automatically locked out at bank angles greater than 7.5 degrees. | Response | The short period response shall be smooth and rapid and not objectionable to the Department. |
| | | | | Damping | The short period damping shall be adequate to permit one overshoot. The overshoot shall not be greater than 15% of the initial roll attitude amplitude. There shall be no oscillation which exceeds ±.5 degrees below 5,000 ft and ± 1 degree above 5,000 ft. The period of the oscillation shall not be less than one-half of the latteral-directional natural period of the aircraft and shall not be objectionable to the Department. |
| | | | | Static Accuracy | Upon release of the stick, the AFCS shall engage the roll attitude mode and maintain the aircraft within ± 1.5 degrees of the atittude existing at the time of stick release. |
| 4 | Heading Hold | Heading | Engage Pilot Assist Mode. Straight & level flight for a maximum of 5 minutes with roll and heading loops both engaged. | Damping | There shall be no heading oscillation which exceeds the value of ± 1/2 degree. The period of the oscillation shall not be objectionable to the Department. |
| | | | | Static Accuracy | The AFCS shall maintain the aircraft heading within ± 1 degree of the reference heading. |
| 5 | | | Apply a rudder control input and release.Control stick steering shall be inoperative for this test. The maximum heading change accumulated due to the over-power shall be not more than 3 degrees (Consistent with avoiding more than .2 g lateral acceleration of the aircraft) | Response | The short period response shall be smooth and rapid and not objectionable to the Department. |
| | | | | Damping | There shall be no heading oscillation which exceeds the value of ±1/2 degree. The heading response shall not overshoot by more than 15% of the initial input heading error. |
| | | | | Static Accuracy | Upon release of the control, the AFCS shall maintain the heading within ±1 degree of the initial heading. |

FLIGHT TESTS TABLE 1 (Cont'd)

| ITEM | AFCS FUNCTION | AXIS | TEST PROCEDURE | STABILITY & PERFORMANCE CHARACTERISTICS | REQUIREMENTS |
|---|---|---|---|---|---|
| 9 | Altitude Hold | Pitch | Straight and level flight for a maximum of 5 min. | Damping<br><br>Static Accuracy | There shall be no altitude oscillations which exceed ± .1 degree and the period shall be not less than 11 sec. The oscillation shall not be objectionable to the Department.<br><br>The AFCS shall hold the reference altitude to within ± 10 feet or .1% whichever is greater. |
| 10 | | | Perform coordinated turns with bank angles up to 60 degrees. | Response<br><br>Damping | The response shall be smooth and rapid and shall not be objectionable to the Department. There shall be no altitude oscillations which exceed ± .1 degree and the period shall be not less than 11 seconds. The oscillations shall not be objectionable to the Department. The AFCS shall hold the ref. altitude to within ± 30 ft. or ± 0.2% whichever is greater |
| 11 | | | Trim aircraft for approximately 1000 ft/min descent. Switch altitude control on at the selected reference altitude. | Response<br><br>Damping<br>Static Accuracy | The altitude controller shall cause the aircraft to return to the selected altitude smoothly and rapidly. The under-shoot shall be less than 250 feet. The final altitude shall be within 50 feet or 0.2% of the selected reference altitude, whichever is greater. |
| 12 | | | Trim aircraft for approximately 1000 ft/min ascent. Switch altitude control on at the selected altitude. | Response<br><br>Damping<br>Static Accuracy | The altitude controller shall cause the aircraft to return to the selected altitude smoothly and rapidly The over-shoot shall be less than 250 feet. The final altitude shall be within 50 feet or 0.2% of the selected reference altitude, whichever is greater. |

FLIGHT TESTS TABLE 1 (Cont'd)

| ITEM | AFCS FUNCTION | AXIS | TEST PROCEDURE | STABILITY & PERFORMANCE CHARACTERISTICS | REQUIREMENTS |
|---|---|---|---|---|---|
| 13 | | | Disengage and re-engage altitude control. Apply a stabilizer control input, forcing the aircraft off reference altitude 100 ft or 0.4% whichever is greater, and abruptly release. Automatic-pitch trim shall be inoperative. | Response<br><br>Damping | The response shall be smooth and rapid and shall not be objectionable to the Department. The altitude transient shall return directly to, and remain within 10 feet or 0.1% of reference altitude, whichever is greater. |
| 14 | Automatic Trim | Pitch | Decelerate from .9 Mach No. to equivalent approach speed in an expeditious manner. After stabilizing the approach speed, wait ten seconds and disengage AFCS. Auto trim shall be operating during the speed transient. | Response | The pitch attitude shall not change more than +1° from attitude just prior to disengagement for period of 5 sec. after disengagement. A vertical acceleration transient due to disengagement shall not exceed 0.2 g. |
| 15 | Switching | All Axes | Engage & disengage AFCS. Select all modes of AFCS operation. | Response | Switching shall not cause any transients which exceed .2 seconds duration. These transients shall not be objectionable to the Department. |
| 16 | Broadcast Control Mode of Interception | Yaw | Engage Broadcast Control Mode. Provide inputs to the Computer either by manual input or by data link. | Response | The aircraft shall turn on to the heading required to intercept the supposed moving target. |