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AEROSPACE RECOMMENDED PRACTICE

ARP 1409

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Revised

REQUIREMENTS FOR AIRCRAFT ON BOARD WEIGHT AND BALANCE SYSTEM

1. PURPOSE

This Aerospace Recommended Practice (ARP) establishes requirements for the function, characteristics and installation of an Aircraft On Board Weight and Balance System for primary use on civil transport aircraft. This ARP is not intended to specify design methods, mechanisms or material to accomplish the requirements set forth.

2. DESCRIPTION

The basic Aircraft On Board Weight and Balance System (OBWBS) shall provide a direct accurate measurement and display of the actual aircraft weight and center of gravity under ground static conditions. Optional functions, such as noted herein, may be included. The system shall function independent of any system external to the aircraft with the exception of ground electrical power when ships power is not available.

3. WEIGHT AND BALANCE CONTROL

The objective of the OBWBS shall be to serve as the primary means to indicate compliance with such regulations as U.S.A. FAR Part 121.691, .693, .697, and FAA Advisory Circular No. 120-27, as they pertain to weight and balance control of the aircraft at dispatch.

4. REQUIREMENTS

The system shall determine actual aircraft weight and center of gravity as follows:

4.1 Range of Operation:

4.1.1 Weights: The system shall determine and display the aircraft weight throughout a range from 10% less than aircraft empty weight to 10% greater than maximum taxi gross weight.

4.1.2 Center of Gravity: The system shall determine and display the aircraft center of gravity throughout a system range determined as follows:

Determine aircraft maximum center of gravity range expressed in Percent Reference Chord such as Mean Aerodynamic Chord (MAC) or equivalent by subtracting most forward limit from most aft limit. Extend most forward aircraft limit forward by an amount equal to 50% of the aircraft range, but not exceeding the forward point equivalent to zero MAC. Extend most aft aircraft limit aft by an amount equal to 50% of the aircraft range, or to the static aft tipping point, whichever is further aft.

4.1.2.1 Lateral Center of Gravity: Where required for a specific aircraft usage the system shall be capable of determining the lateral center of gravity of the aircraft throughout a symmetric envelope 10% greater than the aircraft certified lateral center of gravity limits.

4.2 Mode of Operation: The system shall determine the aircraft weight and center of gravity in the ground static mode and shall compensate for the following factors.

4.2.1 Automatic Compensation:

4.2.1.1 Any combination of ramp slopes up to 3%, aircraft pitch and/or roll attitude changes up to 3 deg in excess of the established range of aircraft ground handling attitude excursion.

4.2.1.2 Aircraft brakes locked or released.

4.2.1.3 Landing gear steering set for zero to minimum turning radius.

4.2.1.4 Aircraft brakes at ambient or at maximum temperatures permitted for dispatch.

4.2.1.5 Plus or minus 50% variations of normal landing gear oleo strut pressure for any permissable degree of strut extension.

4.2.2 Compensation by Correction Chart or Other Means:

4.2.2.1 40 kt. wind through an azimuth of 360 degrees.

4.2.2.2 Any combination of operating engines from zero to ground idle thrust, over the aircraft's approved range of airport elevation.

4.3 Accuracy: The system shall be capable of determining and displaying aircraft weight and center of gravity within ±1.0% of actual aircraft weight and ±1.0% Mean Aerodynamic Chord. Lateral center of gravity if required shall be determined and displayed with 1% of the lateral center of gravity range.

4.4 Response Time: The system shall respond to a command to display weight and center of gravity within 1 minute including warm up time.

4.5 System Components: The system shall consist of the minimum components required to perform the functions defined by this ARP. A typical system may consist of four subsystems plus connecting lines or cabling; the Display Unit, the Computer Unit, the Calibration Unit and the Sensors. No external equipment, ramps, stabilizer or temporary aircraft to ground supports shall be required.

4.5.1 Component Description:

4.5.1.1 Display Unit: The unit shall provide digital readout of aircraft weight to nearest 100 lb or 50 kilos and aircraft center of gravity to nearest 0.10% Reference Chord (MAC or equivalent), in lighted digits of 0.25 in. (0.64 cm) minimum size. The readout shall be visible in conditions of full sunlight to total darkness. Display unit lighting intensity shall be controlled by normal cockpit instrument lighting controls. The display unit shall contain all controls necessary to operate and self-test the system. If controls are required for inflight adjustment they shall be located on the display unit. The display unit shall provide separate indication when preset weight and center of gravity limits are exceeded.

4.5.1.2 Computer Unit: The computer unit shall perform the operations required by the system functions. The unit may have provisions for signal outputs to additional remote display units and signal outputs when preset weight and center of gravity limits are exceeded. The computer shall provide the controls or provisions for malfunction trouble shooting.

4.5.1.3 Sensors: The sensors shall detect changes in aircraft weight and attitude and transmit them to the computer unit. Number, mounting and location of sensors shall be determined by the specific aircraft design. Devices to overcome landing gear system friction if required and attitude sensors shall be considered a part of the sensor subsystem.

4.5.1.4 Calibration Unit: The calibration unit shall contain the controls necessary to adjust the system to read within the specified accuracy limits on a particular aircraft. These controls shall be protected from unauthorized or inadvertent use.

4.5.2 Component, Dimensions, Interface: Component dimensions shall be a minimum consistent with function, maintenance and reliability requirements. The display unit shall be compatible with front mounted installation requirements for a specific aircraft. The computer unit shall be compatible with ARINC Characteristic 404A electronic rack interface requirements. Sensor units shall be compatible with landing gear or structure attachment requirements for a specific aircraft and shall take into account the environmental maintenance and reliability requirements of this ARP.

4.5.3 Power Requirements:

4.5.3.1 Power Supply: The system shall operate from aircraft electrical power, 115 VAC 400 Hz; 28 VDC or 5 VAC for lighting purposes. The system shall also operate when the aircraft is powered from a ground power source.

4.5.3.2 Power Consumption: The system shall consume no more than 500 watts peak power; power factor shall be not less than 0.86.

4.5.4 Weight: System weight shall be minimized consistent with function, maintenance and reliability requirements. Design objective of the system weight, less connecting lines or cables, shall not exceed 50 lb (22.7 kg).

4.6 Compatibility: There shall be no structural, electrical, functioning or servicing interference between the OBWBS and any other aircraft system or component, whether the OBWBS is operating, not operating or has experienced any failure mode to be expected in service. The system design shall provide protective devices to insure the system offers no mechanical, electrical or explosive hazard with the system operating, non-operating or in any normal failure mode. The OBWBS shall be protected from any electromagnetic interference.

4.7 Environmental and Functional Requirements: The system shall meet the requirements of Radio Technical Commission for Aeronautics Document No. DO-160, "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments", dated 28 Feb. 1975 as follows:

4.7.1 All components within the pressurized fuselage shall meet DO-160 equipment class A-2 requirements for temperature and altitude.

4.7.2 All other components shall meet DO-160 equipment class D-2 and E-2 requirements for temperature and altitude.

4.7.3 All components shall meet the requirements for DO-160 category B "Severe Humidity" requirements.

4.7.4 All components shall meet all other DO-160 requirements except that components within the pressurized fuselage are exempt from DO-160 chapter 10, "Water Proofness," and DO-160 chapter 11, "Hydraulic Fluid" requirements.

4.7.5 The system shall withstand an aircraft weight range from zero weight to 100% greater than maximum taxi gross weight, without damage or loss of calibration.

4.7.6 The system shall withstand center of gravity range 100% greater than aircraft ground operating cg range without damage or loss of calibration.

4.7.7 Cyclic Loading: The sensors shall withstand, without damage or fatigue, the stresses and deflections of the landing gear during landing, taxi, braking and loading operations for a period equal to 15,000 landing cycles. Maximum loading shall be 300% of aircraft maximum taxi gross weight.

4.8 Maintainability and Reliability:

4.8.1 Construction: Standard parts, fittings and fasteners will be used wherever possible.

4.8.2 Component Replacement: A minimum of special tools shall be required to remove and replace system components. System component replacement shall require a minimum displacement of other aircraft systems or components. It shall be a design objective to be able to replace any system component, adjust as required, and test the system within one hour. Sensor and sensor mounting design shall minimize the possibility of sensor damage during removal or replacement.

4.8.3 Malfunction Troubleshooting: Self-test of the system shall be accomplished by one person at the display unit. The computer shall be equipped with a test connector for malfunction troubleshooting of its functions. The system design shall permit isolation and testing of individual sensors. The equipment shall be designed so that failure of the self-test feature cannot cause the system to malfunction.

4.8.4 Calibration: The system's components shall be designed so that calibration shall not be required at intervals of less than that equivalent to 10,000 aircraft flight hours.

4.8.5 Adjustment: The system shall be designed so that controls are available on the display unit for any required minor adjustment to the system basic zero reference. Adjustment may be accomplished on the ground or inflight. Adjustment procedure must be simple and brief and must be accomplished without use of tools.

4.8.6 Reliability: The system shall be designed to have a mean-time between failure not less than that equivalent to 10,000 aircraft flight hours.

4.8.7 Interchangeability: All components shall be so designed that they can interchange with any identical component for a particular aircraft type with minimum adjustment of the system and with no requirement for calibration.

5. OPTICAL FUNCTIONS

The following have been identified as potentially desirable additional functions to be individually specified as required. Optional functions shall have no adverse effect on basic system functions, characteristics or installation.

5.1 In-Flight Weight and Balance: The system shall accept inputs such as fuel flow, fuel quantity and fuel transfer monitors and angle of attack or pitch attitude from Navigation System and calculate and display inflight weight and center of gravity based upon the last static reading.

5.2 In-Flight Fuel Usage Planning: The system shall forecast the effect on aircraft weight and balance due to a proposed fuel usage or transfer schedule.

5.3 Ground Load Planning: The system shall forecast the effect on aircraft weight and balance due to a single selected load or processed loading schedule.

5.4 Permanent Record: The system shall make a permanent record of instantaneous and/or continuous weight and balance readouts throughout the ground and flight modes.