



AEROSPACE RECOMMENDED PRACTICE

ARP1595™**REV. B**

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Superseding ARP1595A

(R) Design and Verification of Aircraft Nose Wheel Steering Systems

RATIONALE

This document defines the aircraft industry recommended practice for the design and verification of aircraft nose wheel steering (NWS) systems.

ARP1595B has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This document provides recommended practices for the design, development, and verification testing of NWS systems.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
ARP1383	Impulse Testing of Aerospace Hydraulic Actuators, Valves, Pressure Containers, and Similar Fluid System Components
ARP4754	Guidelines for Development of Civil Aircraft and Systems
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP4852	Design Specification for Towbarless Push-Back Tow Vehicles

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Full document details: SAE ARP1595B

For more information on this standard, visit <https://www.sae.org/standards/content/ARP1595B/>

Documents



Documents Sharing Hub

ARP4853	Design Specification for Towbarless Tow Vehicles
ARP5283	Nose Gear Towbarless Tow Vehicle Basic Test Requirements
ARP5284	TLTV - Aircraft NLG Steering and Tractive Force Protection Systems or Alerting Devices - Inspection, Maintenance and Calibration Requirements
ARP5285	Towbarless Towing Vehicle Operating Procedure
AS5440	Hydraulic Systems, Military Aircraft, Design and Installation, Requirements For
AS8775	Hydraulic System Components, Aircraft and Missiles, General Specification For
AS8860	Landing Gear Structural Requirements as Listed in MIL-886X Series of Specifications
AS40401	Solenoid, Electrical, General Specification For
AS50881	Wiring Aerospace Vehicle

2.1.2 EASA Publications

Available from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Koeln, Germany, Tel: +49-221-8999-000, www.easa.eu.int (sections pertinent to NWS systems are identified in Table 1).

CS-23	Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes
CS-25	Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes
CS-27	Certification Specifications for Small Rotorcraft
CS-29	Certification Specifications for Large Rotorcraft

2.1.3 FAR Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov (sections pertinent to NWS systems are identified in Table 1).

Part 23	Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes
Part 25	Airworthiness Standards: Transport Category Airplanes
Part 27	Airworthiness Standards: Normal Category Rotorcraft
Part 29	Airworthiness Standards: Transport Category Rotorcraft

2.1.4 NASA Publications

Available from NASA, Documentation, Marshall Space Flight Center, AL 35812, www.nas.nasa.gov.

NASA Technical Report R-64

TABLE 1

Part 23 CS 23	Part 25 CS 25	Part 27 CS 27	Part 29 CS 29	Regulation Title
23.305	25.305	27.305	29.305	Strength and deformation
23.405	25.405			Secondary control system
23.471	25.471	27.471	29.471	General, ground loads
23.473	25.473	29.473	29.473	Ground/landing load conditions and assumptions
	25.491			Taxi, takeoff and landing roll
	25.495			Turning
23.499	25.499			Supplementary conditions for nose wheels(23); Nose-wheel yaw and steering (25)
23.509	25.509			Towing loads
23.511	25.511		29.511	Ground load: unsymmetrical loads on multiple-wheel units
23.575				Inspections and other procedures
	25.581			Lightning protection
23.601	25.601	27.601	29.601	General, design and construction
		27.602	29.602	Critical parts
23.603	25.603	27.603	29.603	Materials and workmanship (23,25); Materials (27,29)
23.605	25.605	27.605	29.605	Fabrication methods
23.607	25.607	27.607	29.607	Fasteners
23.609	25.609	27.609	29.609	Protection of structure
		27.610	29.610	Lightning and static electricity protection
23.613	25.613	27.613	29.613	Material strength properties and design values
23.619	25.619	27.619	29.619	Special factors
23.621	25.621	27.621	29.621	Casting factors
23.623	25.623	27.623	29.623	Bearing factors
23.625	25.625	27.625	29.625	Fitting factors
23.627				Fatigue strength
23.683	25.683	27.683	29.683	Operation tests
23.685	25.685	27.685	29.685	Control system details
23.689	25.689			Cable systems
23.693	25.693			Joints
23.745	25.745*			Nose/tailwheel steering
23.771	25.771	27.771	29.771	Pilot compartment
23.777	25.777	27.777	29.777	Cockpit controls
23.779	25.779	27.779	29.779	Motion and effect of cockpit controls
23.867	25.899			Electrical bonding and protection against lightning and static electricity (23); Electrical bonding and protection against static electricity (25)
23.1301	25.1301	27.1301	29.1301	Function and installation
23.1309	25.1309	27.1309	29.1309	Equipment, systems, and installations
	25.1316			System lightning protection
23.1367		27.1367		Switches
23.1381	25.1381	27.1381	29.1381	Instrument lights
23.1419	25.1419	27.1419	29.1419	Ice protection

TABLE 1 (CONTINUED)

Part 23 CS 23	Part 25 CS 25	Part 27 CS 27	Part 29 CS 29	Regulation Title
23.1435	25.1435	27.1435	29.1435	Hydraulic systems
23.1541	25.1541	27.1541	29.1541	General, Markings and Placards
23.1581	25.1581	27.1581	29.1581	General, Airplane/aeroplane flight manual and approved manual material (23,25); Rotorcraft flight manual and approved manual material (27, 29)
23.1583	25.1583	27.1583	29.1583	Operating limitations
23.1585	25.1585	27.1585	29.1585	Operating procedures

*Applicable to CS reference only.

2.1.5 RTCA

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
DO-178	Software Considerations in Airborne Systems and Equipment Certification
DO-254	Design Assurance Guidance for Airborne Electronic Hardware

2.1.6 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <https://assist.daps.dla.mil/quicksearch/>.

AFGS-87139	Air Force Guide Specification Landing Gear Systems
JSSG 2009	Joint Service Specification Guide, Appendix A, Landing Gear
MIL-DTL-31000	Technical Data Packages
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-HDBK-5400	Electronic Equipment, Airborne General Guidelines for
MIL-HDBK-516B	Airworthiness Certification Criteria
MIL-PRF-5606	Hydraulic Fluid, Petroleum Base; Aircraft, missile and Ordnance
MIL-PRF-6106	Relays, Electromagnetic, General Specification for
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric NATO Code Number H-537
MIL-PRF-87257	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile
MIL-S-8812	Steering System: Aircraft, General Requirements For (Inactive for New Design)
MIL-STD-203	Aircrew Station Controls and Displays: Location, Arrangement and Actuation of, For Fixed Wing Aircraft

MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-882	System Safety

2.2 Definitions

2.2.1 Classification of Nose Wheel Steering Systems

Nose wheel steering (NWS) systems may be classified by their importance and operational usage as follows:

Primary (or Class A) Steering System: A primary NWS system is one which is essential to safe ground operation of the aircraft. Redundancy (fail operative) is an implied requisite.

Secondary (or Class B) Steering System: A secondary NWS system is one that is normally in full time use during ground operation, but is not essential for safe ground operation of the aircraft. Fail-safety (fail passive) is an implied requisite.

Tertiary (or Class C) Steering Systems: A tertiary NWS system is one that is used primarily for taxi-parking-catapult spotting, and is not normally required or used for takeoff or landing operations. A totally passive disengaged mode is an implied requisite.

2.2.2 Type of NWS Systems

NWS systems are usually configured as one of the following types:

Mechanically Controlled, Manually Powered: Highly reliable, independent of aircraft power generation, normally employed on small general aviation aircraft.

Mechanically Controlled, Hydraulically Powered: Hydro-mechanical position servo mechanisms, commonly used on transport and business jet aircraft and some smaller military aircraft are normally very reliable, but dependent upon aircraft hydraulic system power.

Electrically Controlled, Hydraulically Powered: Inherently less reliable than mechanically controlled servos, redundancy and/or failure detection features are normally required. Such systems are now in common use on military combat aircraft and some business jet aircraft.

Electrically Controlled, Electrically Powered: Use of all-electrical servos for NWS systems is usually limited to low speed (taxi) control, with notable exceptions on some executive type aircraft.

2.2.3 Commonly Used Terms

Definition of terms commonly used in this and other documents relating to nose wheel steering systems is as follows:

Steering Rate: Steering rate is the rate of change of nose wheel steering angle in degrees (or radians) per second.

Steering Ratio: Steering ratio describes the relationship between input control movement and output nose wheel angle change (i.e., degrees nose wheel angle per inch (mm) of rudder pedal travel).

Powered Steering Angle: The powered steering angle is the number of degrees (radians) the nose wheel is displaced from the center (straight ahead) position while powered by the NWS control system.

Cycle: A full cycle is that nose wheel motion from the center position to one extreme position, returning past the center position to the opposite extreme, and returning again to the center position.

Rated Load: The rated load is the maximum load needed to fulfill the output torque requirement specified in Section 3.

V_{stall}: The minimum speed for level flight in the landing approach configuration with zero thrust.

3. REQUIREMENTS

3.1 Documentation

Aircraft NWS system documentation may vary widely, depending on the system application, and should include the following:

- a. **NWS System Specification:** Prepared by the airframe manufacturer (or prime contractor), which defines overall system requirements, including performance, weight, interfaces, environment, and verification tests and analyses.
- b. **Component (Equipment) Specification:** Normally prepared by the NWS system manufacturer (or subcontractor) to control procured components of the NWS system. Component specifications should be coordinated with and approved by the airframe manufacturer to assure compliance with the system specification requirements.
- c. **Drawings:** The NWS system manufacturer should prepare drawings for submittal to the airframe manufacturer which define the configuration, materials, finishes, weights, envelope, and interfaces, and should include hydraulic/electrical schematics of the NWS system circuitry as seen by the respective aircraft systems.
- d. **Test Procedures and Reports:** The NWS system manufacturer should prepare detailed test procedures based on NWS system specification requirements, to be submitted to and approved by the airframe manufacturer. Verification test results should be reported and submitted for approval as required.
- e. **Analyses:** Appropriate analyses should be provided by the airframe manufacturer and/or NWS system manufacturer as applicable, to substantiate system stability, strength, service life, safety, and performance.
- f. **Certification:** Commercial certification guidelines are defined in ARP4754 and ARP4761 publications. Military aircraft require similar guidelines identified in standards, performance specifications, AFGS-87139, JSSG 2009 Appendix A, and airworthiness certification criteria in accordance with MIL-HDBK-516B. There are corresponding regulations mandated by FAA and EASA that apply for certification of a steering system. A table of appropriate regulations from the FAR in 2.1.3 have been identified for Parts 23, 25, 27, and 29 aircraft. EASA 23, 25, 27, and 29 certification specifications identify NWS requirements in Sections 495, 499, and 745 similar to respective FAR part sections. The designer needs to consult the airworthiness authority for applicable certification requirements to meet either commercial or military guidelines.
- g. **Other technical information necessary to delineate the design and meet the program requirements.**

3.2 Interface Requirements

The NWS system should be designed to meet the interface requirements of the aircraft. These interface requirements should be detailed in the NWS system specification, and should include:

- a. Aircraft hydraulic and electrical supply system characteristics.
- b. Aircraft envelope limits and critical clearances.
- c. Mounting and structural support provisions.
- d. Cockpit control input characteristics.