SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

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Superseding ARP5911

Regional Aircraft Towbarless Tow Vehicle - Test Requirements

RATIONALE

ARP5911A has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

Throughout this SAE Aerospace Recommended Practice (ARP), the minimum essential criteria are identified by the use of the keyword "shall". Other recommended criteria are identified by the use of the keyword "should" and, while not mandatory, are considered to be of primary importance in providing safe and serviceable towbarless tractors. Alternative solutions may be adopted only after thorough consideration and in-service evaluation have shown them to be equivalent.

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1. SCOPE

1.1 Purpose

The present Aerospace Recommended Practice specifies for airplane operator and tow vehicle manufacturers the basic testing requirements for towbarless tow vehicles to be used on the nose gear of conventional tricycle type landing gears of commercial civil transport aircraft with maximum ramp weight between 8600 kg (19 000 lb) and 50 000 kg (110 000 lb), commonly designated as “regional aircraft”.

Its purpose is to achieve testing results, or equivalent computer modeling, demonstrating that the loads induced by the tow vehicle will not exceed the design loads of the airplane's nose landing gear and associated structure, reduce the certified safe life limit of the nose landing gear, or otherwise compromise the airplane's structural integrity and airworthiness certification.

1.2 Field of Application

This document is intended to be applicable to all towbarless tow vehicles to be used for push-back and maintenance towing of commercial airplanes in the specified range. See Section 3 hereafter. It is not intended to apply to tow vehicles used for airplane operational (dispatch) towing.

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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.

ARP4852 Design Specification for Towbarless Push-Back Tow Vehicles

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

ARP5916 Design Specification for Regional Aircraft Towbarless Tow Vehicle for Pushback and/or Maintenance Towing Operations

2.1.2 Regulatory (USA)

Available from United States Government Printing Office, 732 North Capital Street, NW, Washington, DC 20401, Tel: 202-512-0000, www.gpoaccess.gov.

Federal Aviation Regulations 14CFR Part 25, Airworthiness Standards: Transport category airplanes, paragraphs 25.301(a), Loads, and 25.509, Towing loads

2.1.3 Regulatory (Europe)

Available from European Aviation Safety Agency, Postfach 10 12 53, D50452 Koeln, Germany.

Certification Specifications for Large Aeroplanes CS-25 paragraphs CS 25.301(a) Loads, and CS 25.509, Towing loads

Certification Specifications for Large Aeroplanes CS-25, paragraph CS 25.745(d) Nose Wheel Steering and associated Advisory Material INT/POL/25/13

2.1.4 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 9001 Quality systems - Model for quality assurance in design, development, production, installation and servicing

ISO 20683-1 Aircraft ground equipment - Towbarless towing vehicle (TLTV) - Design, testing and maintenance requirements - Part 1: Aircraft with a maximum ramp mass over 50 000 kg (110 000 lb)

ISO 20683-2 Aircraft ground equipment - Towbarless towing vehicle (TLTV) - Design, testing and maintenance requirements - Part 2: Regional aircraft

2.1.5 IATA Publications

Available from International Air Transport Association, Publications Assistant, 800, Place Victoria, P.O.Box 113, Montréal Québec H4Z 1M1, Canada, Tel: 1-514-874-0202, www.iata.org.

Airport Handling Manual AHM 957, Functional specification for aircraft nose gear controlled towbarless tractor

2.2 Terms and Definitions

For the purpose of the present document, the following terms and definitions apply:

COMPUTER MODELING: See NUMERIC SIMULATION.

DISPATCH (OPERATIONAL) TOWING: Towing a revenue aircraft, loaded with passengers, fuel, and cargo up to Maximum Ramp Weight (MRW), from the terminal gate/remote parking area, to a location near the active runway, or conversely. The movement may cover several kilometers (miles) with speeds up to 32 km/h (20 mph), with several starts, stops and turns. Replaces typical taxiing prior to take-off or after landing.

JERKING: Sudden application of push/pull forces from a complete stop.

MAINTENANCE TOWING: Movement of an aircraft for maintenance/remote parking purposes (e.g., from gate to maintenance hangar), typically unloaded, with speeds up to 32 km/h (20 mph).

MAXIMUM LIMITS: Limits (tow force, torsional, or angular) established by the airframe manufacturer as not-to-exceed values intended to preclude possible damage to nose landing gear or structure. Limits are established by airframe manufacturer's documentation and may be different for towbarless or towbar towing operations. All aircraft load limits are limit loads as defined in FAR Part 25/ EASA CS-25 paragraph 25.301(a).

MAXIMUM RAMP WEIGHT (MRW): The maximum mass allowable for an aircraft type or sub-type when leaving its parking position either under its own power or towed, comprising maximum structural take-off weight (MTOW) and taxiing fuel allowance.

NLG: Aircraft nose landing gear.

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NUMERIC SIMULATION: Validated simulation of physical test condition and reaction of aircraft employing numerical analysis, computational geometry and computer graphics to obtain proof support and design verification.

OPERATIONAL LIMITS: Limits (fore and aft tractive force, torsional, or angular) which are set at a lesser value than the maximum limits established by the airframe manufacturer.

OVERSTEER: Exceedence of maximum torsional load or angular limits where potential damage to the nose landing gear structure or steering system could take place. These limits are defined in the appropriate airframe manufacturer's documentation. Torsional load limits typically occur after exceeding angular limits, but may occur before the angular limit is reached (e.g., nose gear hydraulic system bypass failure).

PUSHBACK: Moving a fully loaded aircraft (up to Maximum Ramp Weight (MRW)) from the parking position to the taxiway. Movement includes pick-up, pushback with turn, a stop, a short tow to align aircraft and nose wheels, and release. Engines may or may not be operating. Aircraft movement is similar to a conventional pushback operation with a towbar. Typical speed does not exceed 8 to 10 km/h (5 to 6 mph) maximum.

SNUBBING: Sudden relief and reapplication of push/pull loads while TLTV and aircraft are in motion.

TLTV: Towbarless towing vehicle, acting on an aircraft's nose landing gear.

TOW FORCE: Total force from the tow vehicle on the nose gear tires in the defined "X" axis.

VALIDATION: Demonstration to other parties' and/or authority's satisfaction that parameters, algorithms and methods used in a numeric simulation (computer modeling) program provide results of at least equivalent reliability to the specified actual testing alternative.

"X" AXIS: Fore and aft axis of the tow vehicle, parallel to the ground.

3. EFFECTIVITY

3.1 This document is applicable to towbarless towing vehicles intended for commercial transport aircraft airworthiness certified under FAR Part 25/EASA CS-25 up to a maximum ramp weight of 50 000 kg (110 000 lb). It does not apply to:

- towbarless tow vehicles intended for business category aircraft, or aircraft airworthiness certified under FAR Part 23/EASA CS-23 as commuter category airplanes,
- towbarless tow vehicles intended for aircraft airworthiness certified under FAR Part 25/EASA CS-25 but with a maximum ramp weight in excess of 50 000 kg (110 000 lb), which are covered by other Aerospace Recommended Practices (see 2.1.1).

3.2 This document is applicable to towbarless towing vehicles as specified in 3.1, designed or built after its date of publication.

4. REQUIREMENTS

Towbarless towing vehicles shall, either by intrinsic design or through appropriate load limiting devices, ensure that the following maximum limits are not exceeded.

4.1 Towing Loads

4.1.1 The push and pull towing forces induced by the TLTV onto the aircraft's nose landing gear as a result of either accelerating or braking shall be verified as per 5 and/or 6 hereafter, and shall not at any time exceed the maximum values specified by the aircraft manufacturer.

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4.1.2 Depending on the range of aircraft types the TLTV is compatible with, preset towing load values may be used for a number of aircraft types or sub-types in a given MRW range. In this case, each TLTV setting shall comply with the maximum limits specified by the manufacturer(s) of the designated aircraft types, sub-types, or family(s) thereof as defined by the aircraft manufacturers, and each TLTV setting shall be subjected to a separate verification.

4.2 Oversteering Protection

4.2.1 The maximum angular or torsional load limits stated by the aircraft's manufacturer in the event of oversteering shall not at any time be exceeded. See aircraft manufacturer's TLTV assessment criteria document, if published, or Appendix A hereafter, if not.

4.2.2 This may be achieved either by oversteer protection built into the TLTV, or by an oversteer alerting system being provided.

4.2.3 Oversteer protection may be achieved either by intrinsic design precluding the possibility of either limit being reached or exceeded, or by a fail-safe oversteer protection system ensuring they shall not be exceeded. Oversteer alerting shall consist in an appropriate fail-safe warning system installed on the TLTV, providing the driver with unmistakable indication that one of the maximum limits has been reached.

4.2.4 No testing of the TLTV oversteer protection or alerting systems shall be performed on an in-service aircraft, in order to preclude any possible damage to the NLG structure or steering system. Such testing should be accomplished with a suitable ground testing device representative of the specific aircraft model for which the TLTV is intended, or through appropriate numeric simulation demonstration.

NOTE: European Aviation Safety Agency (EASA) requirements.

For aircraft registered or operated under European EASA Regulations, INT/POL/25/13 and future CS-25 AMC 25.745(d), Nose-wheel Steering (Interpretative Material), paragraph 4, Alternate acceptable means of compliance, requires the TLTV manufacturer to provide a Declaration of Compliance of his unit's oversteer protection or oversteer alerting system(s) with the present document and the criteria published by the manufacturer of each aircraft type for which it is intended, and the aircraft manufacturers to list in their appropriate documentation the TLTV models that were specifically accepted for each aircraft type based on this Declaration of Compliance.

5. TESTS

The following tests shall be performed to provide verification that the loads induced by the TLTV do not exceed the allowable maximum limits, and the operation of the unit in an operational push-back environment does not result in events potentially jeopardizing aircraft safety. Dynamic numeric simulation may be used instead of part of the specified tests, providing it guarantees at least equivalent results reliability (see Section 6). See 4.2.4 for testing of oversteering protection features.

5.1 Static Load Tests

5.1.1 Static tests shall be performed as follows to verify inadvertent application of TLTV power while the aircraft is braked or chocked will not result in exceeding the NLG maximum loads.

5.1.2 In order to preclude any possible damage to the NLG structure, such testing may be accomplished with a suitable ground testing device representative of the specific aircraft model(s) for which the TLTV is intended.

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5.1.3 Each test shall consist in a sequence of:

- ensuring the device representative of the aircraft is fully braked,
- progressively applying full power of the TLTV, either push or pull,
- maintaining maximum power for 5 s

while recording the force exerted by the TLTV onto the device.

5.1.4 Two tests shall be performed in each direction. On completion of the tests, the load recordings shall be printed and examined: the maximum towing loads for the aircraft type as per 4.1 above shall not be exceeded at any point of the tests.

5.2 Dynamic Load Tests

5.2.1 Tests shall be performed as follows to verify the maximum push and pull towing forces induced by the TLTV onto the aircraft's nose landing gear as a result of either accelerating or braking.

5.2.2 In order to avoid the difficulties and costs of using an instrumented aircraft, the towing vehicle shall be instrumented to record the towing loads. Installation of strain gauges or equivalent load measuring sensors shall be at the locations most appropriate for accurate and unbiased readings, specified by the TLTV manufacturer. Data should be recorded analogically or, if numerically, at a minimum sampling rate of 50 Hz (50 times per second).

5.2.3 Prior to performing the aircraft test, the strain gauges or equivalent measuring sensors on the TLTV shall be calibrated to known tow load inputs, using a calibration method specified by the TLTV manufacturer, in order to obtain measurements linearity and repeatability. A calibration report should be established.

5.2.4 Each test shall consist in one sequence of:

- aircraft NLG pick-up,
- for push back: using maximum available power of the TLTV to accelerate from a dead stop until reaching maximum speed, or approximately 8 km/h (5 mph), or the maximum speed specified by the airframe manufacturer, whichever is less,
- for maintenance towing: using maximum available power of the TLTV to accelerate from a dead stop until reaching maximum speed, or the maximum speed specified by the airframe manufacturer, whichever is less,
- maintaining the above speed stabilized for a straight line distance not less than 30 m (100 ft),
- applying TLTV maximum available braking until the aircraft comes to a complete stop,
- aircraft NLG release

using the TLTV and the aircraft type concerned. Snubbing and jerking are to be avoided during braking and acceleration. Aircraft brakes shall not be used throughout the test. The push and pull loads on the NLG shall be recorded throughout the sequence, and the weight and CG condition of the aircraft at each test noted for reference.

5.2.5 Tests shall be successively performed in the push and pull directions. The minimum number of tests to be performed should be three in each direction, to be performed by at least two different drivers.

5.2.6 On completion of the tests, the load recordings shall be printed and examined: the maximum towing loads for the aircraft type as per 4.1 shall not be exceeded at any point of the tests. Test reports shall record the aircraft's weight and CG condition.

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5.3 Operational Tests

5.3.1 Operational push-back tests shall be performed in order to verify operation of the TLTV in an operational push-back environment does not result in events potentially jeopardizing aircraft safety.

5.3.2 These tests may be accomplished on in-service scheduled flights, or as dedicated trials consisting of NLG pick-up, an aft push, with turn, a short tow forward to align the nose gear parallel to the taxiway, and NLG release.

5.3.3 Push-back tests shall be performed taking into account the possibilities of aircraft engines being on at idle or off. The minimum number of tests to be performed should be five in each condition, by at least three different drivers, each of them accomplishing tests in both engine conditions if applicable. Test reports shall be established and record any observations as well as the recorded towing loads. Test reports shall record the aircraft's weight and CG condition.

5.3.4 Operational maintenance towing tests shall include verification of aircraft lateral and vertical (NLG strut extension) stability throughout the tests.

5.3.5 Throughout the duration of these tests, there shall be no evidence of abnormal behavior of the aircraft or the TLTV, or risk of interference between them, or potential hazard to the aircraft's or its steering system's structural integrity. The maximum towing loads for the aircraft type as per 4.1 shall not be exceeded at any point of the tests.

5.4 Aircraft Braking

The aircraft brakes shall not be used while the aircraft is being towed by a TLTV, except in an emergency situation.

NOTE: Aircraft braking while the aircraft is under tow may result in loads exceeding the aircraft's design loads and may result in structural damage and/or NLG collapse. For these reasons, it is recommended that airlines take appropriate operational steps to preclude aircraft braking during normal towbarless towing. The airline's or airframe manufacturer's maintenance manual and operational procedures shall be followed.

6. COMPUTER MODELING

6.1 General

Dynamic numeric simulation through an appropriate computer model including the relevant parameters of both the tractor and aircraft may be used instead of the tests specified in Section 5, under the following requirements

6.1.1 The computer model shall be based on stated and recognized mechanical engineering methods and equations, be validated in accordance with 6.2 hereafter, and be approved for this purpose by the manufacturer(s) of the aircraft type(s)/sub-type(s) the TLTV is to be approved for.

6.1.2 It shall integrate all dynamic effects, including transient ones.

6.1.3 It shall provide continuous data or, if non continuous, a sampling rate at least twice the minimum rate stated in 5.2.2 for tests recording purpose.

6.1.4 It shall provide at least equivalent overall results dependability.

6.1.5 Computer modeling results shall be printed, handled and filed in the same manner as the specified testing records.

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