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Aircraft ground equipment — Design, test and maintenance for towbarless towing vehicles (TLTV) interfaced with nose-landing gear —

Part 1:
Main-line aircraft

Matériels au sol pour aéronefs — Conception, essais et entretien des tracteurs sans barre (TLTV) s'accouplant au train d'atterissage avant —

Partie 1: Aéronefs de ligne

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20683-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

ISO 20683 consists of the following parts, under the general title *Aircraft ground equipment — Design, test and maintenance for towbarless towing vehicles (TLTV) interfaced with nose-landing gear*:

— *Part 1: Main-line aircraft*

— *Part 2: Regional aircraft*

Introduction

This part of ISO 20683 specifies design, testing, maintenance and associated requirements to be applied on towbarless aircraft-towing vehicles to be used on main-line civil transport aircraft in order to ensure their operation cannot result in damage to aircraft nose-landing gears, their steering systems, or associated aircraft structure.

Throughout this part of ISO 20683, the minimum essential criteria are identified by the use of the key word “shall”. Other recommended criteria are identified by the use of the key word “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 careful consideration, extensive testing and thorough service evaluation have shown them to be equivalent.

Aircraft ground equipment — Design, test and maintenance for towbarless towing vehicles (TLTV) interfaced with nose-landing gear —

Part 1:
Main-line aircraft

1 Scope

This part of ISO 20683 is applicable to towbarless towing vehicles (TLTVs) interfacing with the nose-landing gear of main-line civil transport aircraft with a maximum ramp mass over 50 000 kg (110 000 lb). The requirements for regional transport aircraft with a lower maximum ramp mass are specified in ISO 20683-2. It is not applicable to TLTVs which were manufactured before its date of publication.

This part of ISO 20683 specifies general design requirements, testing and evaluation requirements, maintenance, calibration, documentation, records, tracing and accountability requirements in order to ensure that the loads induced by the tow vehicle will not exceed the design loads of the nose gear or its steering system, or reduce the certified safe life limit of the nose gear, or induce a stability problem during aircraft push-back and/or gate relocation or maintenance towing operations.

This part of ISO 20683 specifies requirements and procedures for TLTVs intended for aircraft push-back and gate relocation or maintenance towing only. It is not intended to allow for dispatch (operational) towing (see Clause 3). Dispatch towing imposes greater loads on nose gears and aircraft structure due to the combination of speed and additional passenger, cargo, and fuel loads.

This part of ISO 20683 does not apply to TLTVs interfacing with aircraft main landing gear.

NOTE See also informative references in the Bibliography.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6966-1, *Aircraft ground equipment — Basic requirements — Part 1: General design requirements*

ISO 6966-2, *Aircraft ground equipment — Basic requirements — Part 2: Safety requirements*

Federal Aviation Regulations (FAR) 14 CFR Part 25, *Airworthiness Standards: Transport category airplanes,* paragraphs 25.301, *Loads*, and 25.509, *Towing loads* [1)]

1) FAR Part 25 constitutes U.S.A. Government transport aircraft airworthiness Regulations, and can be obtained from: US Government Printing Office, Mail Stop SSOP, Washington DC 20402-9328, U.S.A.

Joint Airworthiness Regulations (JAR) Part 25, *Airworthiness Standards: Transport category aeroplanes,* paragraphs 25.301, *Loads*, 25.509*, Towing loads,* 25X745(d*), Nose-wheel steering, and* ACJ (interpretative material) 25X745(d) 2)

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
main line aircraft
civil passenger and/or freight transport aircraft with a maximum ramp mass over 50 000 kg (110 000 lb)

3.2
regional aircraft
civil passenger and/or freight transport aircraft with a maximum ramp mass between 10 000 kg (22 000 lb) and 50 000 kg (110 000 lb)

3.3
maximum ramp mass
MRW
maximum ramp weight
maximum mass allowable for an aircraft type when leaving its parking position either under its own power or towed, comprising maximum structural take-off mass (MTOW) and taxiing fuel allowance

3.4
push-back
moving a fully loaded aircraft [up to maximum ramp mass (MRW)] from the parking position to the taxiway

NOTE Movement includes pick-up, push-back with turn, a stop, a short push or tow to align aircraft and nose wheels, and release. Engines may or may not be operating. Aircraft movement is similar to a conventional push-back operation with a towbar. Typical speed does not exceed 10 km/h^{-1} (6 mph).

3.5
maintenance towing
movement of an aircraft for maintenance/remote parking purposes (e.g. from the parking position to a maintenance hangar)

NOTE The aircraft is typically unloaded with minimal fuel load [light gross weight (LGW)], with speeds up to 32 km/h^{-1} (20 mph).

3.6
gate relocation towing
movement of an aircraft from one parking position to an adjacent one or one in the same general area

NOTE The aircraft is typically unloaded with minimal fuel load (LGW), with speeds between push-back and maintenance towing.

2) JAR Part 25 constitutes the European Governments transport aircraft airworthiness Regulations, and can be obtained from: JAA Headquarters, Saturnusstraat 8-10, P.O. Box 3000, NL 2130 KA Hoofddorp, Netherlands.

3.7
dispatch towing
operational towing
towing a revenue aircraft [loaded with passengers, fuel, and cargo up to maximum ramp mass (MRW)], from the terminal gate/remote parking area, to a location near the active runway, or conversely

NOTE 1 The movement may cover several kilometers with speeds up to or over 32 km/h^{-1} (20 mph), with several starts, stops and turns. Replaces typical taxiing operations prior to takeoff or after landing.

NOTE 2 In the definitions of the towing modes, the frequency of operation has not been included. This should not be interpreted to mean that no limitations are present. For limitations on the frequency of push-back and maintenance operations, refer to the appropriate airframe manufacturer's documentation or consult directly with the airframe manufacturer.

3.8
towbarless towing vehicle
TLTV
towing vehicle acting without towbar on an aircraft's nose-landing gear

3.9
nose-landing gear
NLG
aircraft nose-landing gear in a tricycle landing-gear layout

3.10
light gross weight
LGW
reference aircraft mass for combined testing of the vehicle and aircraft, defined as the manufacturer's operating empty mass of the aircraft type concerned, plus fuel remaining in the tanks on landing (10 % to 20 % of total tanks capacity)

3.11
heavy gross weight
HGW
reference aircraft mass for combined testing of the vehicle and aircraft, defined as the manufacturer's operating empty mass of the aircraft concerned, plus at least 50 % of the maximum total fuel tanks' capacity on the type, or its equivalent in mass (payload may be accounted if present, providing aircraft balance condition remains within limits)

3.12
maximum limits
limits (fore and aft tractive 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

NOTE Maximum 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/JAR paragraph 25.301 (a).

3.13
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

3.14
aircraft family
grouping of aircraft types or subtypes, defined by their manufacturer, for which the same maximum limits may be applied

NOTE A family usually encompasses all sub-types of a given type, but may also include other types. Testing for one (usually the lightest) model of the family results in towbarless towing approval for the whole family. See airframe manufacturers towbarless towing evaluation documentation.

3.15
TLTV setting
grouping of aircraft types or sub-types, defined by the TLTV manufacturer, for which a single operational limit setting is used

NOTE A single TLTV setting usually encompasses aircraft types or sub-types, which may be produced by different airframe manufacturers, in a same defined MRW range.

3.16
drag load
tow force
total force from the tow vehicle on the nose gear tires in the **X axis** (3.17)

3.17
X axis
fore and aft axis of the tow vehicle, parallel to the ground

3.18
oversteer
exceedence of maximum torsional load or angular limits where potential damage to the nose-landing gear structure or steering system could take place

NOTE 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).

3.19
snubbing
sudden relief and reapplication of acceleration/deceleration loads while TLTV and aircraft are in motion

3.20
jerking
sudden application of push/pull forces from a complete stop

4 Design requirements

4.1 General

4.1.1 TLTVs shall comply with the applicable general requirements of ISO 6966-1.

4.1.2 Airframe manufacturers should provide information for each aircraft type which allows TLTV manufacturers or airlines to self-test or evaluate the towbarless tow vehicles themselves. Refer to the airframe manufacturer's documentation for evaluation requirements and detailed testing procedures, that may be different from or additional to those contained in this part of ISO 20683.

4.1.3 TLTV manufacturers should prepare and provide customers or regulatory agencies, as required, with a certificate of compliance or equivalent documentation, as evidence that successful testing and evaluation of a specific tow vehicle/aircraft type combination has been completed in accordance with this part of ISO 20683 and/or the applicable airframe manufacturer's documentation. This certification shall allow use of the vehicle on specifically designated aircraft model types. The certificate should be established under an appropriate quality control program meeting the requirements of ISO 9001[2] or equivalent pertinent industry standard.

4.2 Pick-up and holding system

4.2.1 The TLTV's nose-landing gear pick-up/release device should operate in a smooth and continuous manner. Abrupt or oscillating loads during the pick-up/release sequence should not occur. It should be designed to minimize the loads during the pick-up/release sequence. The drag loads induced during pick-up/release should fall well below the "peak" loads experienced during a typical operation.

4.2.2 The maximum loads induced by pick-up and release sequences shall be measured either on an aircraft or on a fixture representative of the nose gear geometry. The vertical load on the nose gear or fixture shall be equal to the vertical load used for fatigue justification (refer to the appropriate airframe manufacturer's documentation). The maximum lift (height above the ground) of the nose gear shall not exceed the values given in the airframe manufacturer's documentation if such values are provided.

4.3 Nose wheels retention

4.3.1 The nose wheels shall be held by the vehicle in such a way that pitch-up of the aircraft shall not cause the wheel to disengage from the pick-up device at any nose gear steering angle. A positive wheel retaining feature must be provided. If the nose gear is “canted”, a turning maneuver will cause uneven loading on the nose gear (i.e. for an aft-canted gear, the vertical load on the inboard nose wheel will tend to increase and conversely, the vertical load on the outboard nose wheel will tend to decrease). The retention feature must allow for uneven tire displacement without imposing additional loads on the nose gear.

4.3.2 The geometry of the holding device shall be such that no interference with aircraft structure may occur (e.g. torque links, weight and balance sensors, tires, water spray deflector, etc.) at all wheel steering angles up to the limits defined by the airframe manufacturer's documentation, and the full range of shock strut extensions and tire deflections. Surface contact area between pick-up device and tire surface should be sufficient to preclude unacceptable tire loading (refer to tire manufacturer for bearing pressure specifications).

4.4 Safety

4.4.1 General

TLTVs shall comply with the applicable safety requirements of ISO 6966-2.

4.4.2 Pick-up, release and associated loads

4.4.2.1 During the loading sequence, safety equipment shall inhibit any movement of the loading device if the nose wheel is not properly positioned. Positive clamping and correct positioning of the nose wheel shall be ensured.

4.4.2.2 When the positioning pick-up/release sequence involves a relative motion between the vehicle and the aircraft, only the vehicle shall be allowed to move (see 4.2). The aircraft parking brake should be applied or wheels properly chocked during this phase. TLTV design shall ensure that no loads higher than authorized are applied to the aircraft.

4.4.2.3 In order to avoid damage to the aircraft, the net load from all points of contact between the vehicle and nose gear tires shall be limited (on X axis) at a value lower than or equal to the operational limit. Any single failure of the tow vehicle’s load limiting system shall not cause loads which exceed the maximum limits.

4.4.2.4 If the pickup/release sequences are fully automatic, an emergency stop or deadman switch shall allow the operator to freeze the sequence at any time. An automatic or manual system shall allow reversal of the sequence and restore the starting position.

4.4.2.5 If aircraft type selection is necessary prior to the pickup or towing/push-back sequence, a safety system in the vehicle shall inhibit further operation if the incorrect aircraft type is selected.

4.4.3 Acceleration, deceleration and associated loads

4.4.3.1 If towing is attempted while aircraft brakes are applied or wheel chocks are in place, a safety device on the TLTV shall limit the maximum static force to the safety limit as defined in 4.4.3.2 a).

4.4.3.2 The vehicle’s maximum pulling and braking forces shall be limited to the maximum permissible nose-landing gear loads of the aircraft (see airframe manufacturer's documentation and FAR/JAR paragraph 25.509). One or two limiters may be used:

a) a primary maximum load limiter, designed to the maximum load limits specified by the airframe manufacturer, shall be installed to limit the loads applied to the nose gear during all operations. It shall not be possible to override the limiter. Any activation of the maximum load limiter constitutes a recordable event;

b) a secondary operational load limiter, designed to lower operational loads, may be installed. If installed, whenever operational limits during acceleration or deceleration are exceeded, a safety system shall inhibit the further loading effort of the vehicle (engine back to idle or gear box to neutral without braking of the vehicle). The safety system shall allow resetting only when the vehicle is stopped. No record of the event is necessary.

4.4.3.3 Control of the loads may be based either on a limitation of the acceleration/deceleration or on a limitation of the tow force/brake force. It may also be possible to control tow forces by controlling acceleration/deceleration.

4.4.4 Emergency braking

If an emergency braking system is incorporated or installed in the TLTV, the braking or decelerating load shall not exceed the maximum allowable nose-landing gear limits, but it may exceed the operational limits. Emergency braking activation shall be well-protected against inadvertent triggering.

4.4.5 Oversteer limits

4.4.5.1 Oversteer angular and torsional limits shall not be exceeded. Oversteer testing should not be performed on the aircraft.

4.4.5.2 For European registered or operated aircraft, the JAA [JAR 25X745(d)] require oversteer alert or protection systems on the aircraft or the TLTV (see 4.4.6). If a TLTV is designed to meet JAR requirements, then testing to demonstrate vehicle oversteer limit alerting or protection functionality should be performed by the TLTV manufacturer in a suitable test facility or rig. TLTV manufacturers or airplane operators should consult with the airframe manufacturer or local aviation regulatory authorities, as appropriate, for current regulation status.

4.4.5.3 The maximum steering angle for conventional towbar towing, as listed in the airframe manufacturer's documentation, is applicable for nose gear towbarless towing, unless otherwise noted. Airframe manufacturers may establish different maximum steering limits between conventional towbar and towbarless towing due to the absence of shear protection provided by traditional towbar connections.

4.4.6 Oversteer alerting and/or protection

4.4.6.1 The tractor shall be equipped with a fail-safe oversteer alerting/indication or protection system that

a) activates an in-cab (red) warning light and audible alarm to indicate the maximum safety limit has been reached, and

b) requires a specific recordable action to complete the push-back/towing operation, in order to make it unmistakable to the tow vehicle driver that an inspection of the nose-landing gear by an authorized engineer must be initiated.

4.4.6.2 In addition, it is desirable that the device activate an in-cab (amber) warning light and audible signal to indicate an operational limit has been reached. The oversteer indication system shall allow sufficient time for the tow vehicle operator to take appropriate action to avoid reaching a safety limit.

4.4.6.3 The system shall be automatically activated when the airplane is coupled to the tow vehicle.

4.4.6.4 The oversteer indication and/or protection system shall be designed to protect the range of aircraft types that can be handled by the tow vehicle. Oversteer is defined as exceeding maximum allowable steering angle or torsional load.

4.4.6.5 An optional system may provide a structural fuse (or other reliable load-limiting system) on the tow vehicle which will prevent the application of torsional loads on the nose-landing gear that exceed the airframe manufacturer's specified maximum limit.

4.5 Testing operations

4.5.1 Snubbing and jerking

Snubbing and jerking effects or movements should be avoided during testing.

4.5.2 Vibrations

If severe or abnormal vibrations occur, testing should be discontinued and the cause determined.

4.5.3 Aircraft braking

The aircraft brakes should not be used while the aircraft is being towed by a TLTV, except in an emergency situation. 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 nose gear collapse. For these reasons, it is recommended that airlines take appropriate steps to preclude aircraft braking during normal towbarless towing. The carrier's or airframe manufacturer's maintenance manual and operational procedures shall be complied with.

4.5.4 Stability

4.5.4.1 Attention shall be paid to aircraft stability. Stability may be affected by aircraft type, mass, center of gravity location, weather condition, runway roughness and slope. Stability shall be demonstrated by tests in accordance with the airframe manufacturer's documentation.

4.5.4.2 The testing shall be conducted under maximum speed capability of the vehicle.

4.5.4.3 If a lateral instability is detected, a margin of 5 km/h^{-1} (3 mph) shall be maintained between the speed at the beginning of instability and the maximum towing speed.

4.5.4.4 With minimal static load on the nose-landing gear sufficient to move the airplane, no pitch oscillation of the aircraft shall occur, such that it would extend the shock absorber beyond the allowable strut extension in the ground mode.

4.5.4.5 Proper operational procedures shall be defined and followed to ensure vehicle and airplane stability.

4.6 Nose gear steering angle limit

The maximum steering angle for conventional towbar towing, as specified in the airframe manufacturer's documentation, is applicable for nose gear towbarless towing, unless otherwise noted.

4.7 Vehicle classification

The TLTV model shall be classified according to its intended use, and tested accordingly, as either:

a) category I: push-back only; or

b) category II: maintenance towing only; or

c) category III: both push-back and maintenance.

4.8 Placarding

Limitations and warnings imposed by all conditions shall be placarded in a location readily visible to the tow vehicle driver, including but not necessarily limited to

a) classification category defined in 4.7,

b) types of aircraft the TLTV is qualified for (by TLTV setting if applicable),

c) maximum allowable speed, and

d) maximum allowable towing angle, etc.

5 Testing requirements

5.1 General

5.1.1 No testing with an aircraft shall be performed if any requirement in Clause 4 is not met.

5.1.2 In case of a vehicle for which only partial qualification is required (e.g. push-back only), the tests performed shall be appropriate to its category classification in 4.7.

5.1.3 Dynamic numeric simulation may be used instead of the specified tests, unless prohibited by airframe manufacturer's documentation, and providing it guarantees at least equivalent results reliability.

5.2 Testing objectives

a) To measure the maximum values of the loads introduced into the airframe during extreme conditions, such as maximum acceleration and braking.

b) To verify that potential oversteer does not exceed the airframe manufacturer's specified limits. Also to verify/demonstrate the capability of the TLTV to recognize steering angle or torsional load limits and to alert the vehicle operator accordingly. However, because of the potential for damage, no actual testing with an aircraft shall be performed for oversteer indication or protection calibration.

c) To verify the stability of the tow vehicle/aircraft combination throughout the total range of operational speeds.

d) To evaluate the fatigue loads introduced into the airframe by normal utilization of the vehicle during the specific category of operations for which qualification is intended.

5.3 Aircraft configuration

5.3.1 Before any calibration or testing is accomplished, all landing gear must be properly serviced as defined by the airframe manufacturer's instructions.

5.3.2 Aircraft masses, light and heavy gross masses and center of gravity position for testing shall be in accordance with the requirements in the calibration and test requirements (see 5.4 and 5.5) and the airframe manufacturer's documentation. The airframe manufacturer should be consulted for any deviation from documented weights.

5.3.3 The aircraft shall be in the correct towing configuration as defined by the airframe manufacturer's maintenance and operational documentation.

5.4 Calibration

5.4.1 General

5.4.1.1 Tests may be performed with an instrumented aircraft or an instrumented towing vehicle. Calibration of both are discussed in 5.5.1 for restrictions in the use of instrumented vehicles.

5.4.1.2 To measure fore and aft tow loads on the nose-landing gear, strain gauges shall be installed at the specified nose gear locations (drag brace, torque arm, or other components). Calibration of the strain gauges is accomplished by pushing and pulling the nose gear with known tow loads.

5.4.1.3 To measure fore/aft and torsional tow loads on the TLTV, strain gauges shall be installed at vehicle locations specified by the vehicle manufacturer and shall be calibrated to a known tow load input.

5.4.1.4 Once the strain gauges have been calibrated, the aircraft can be towed with the TLTV and the tow loads can be determined directly from the strain measurements. The following procedure outlines how to calibrate the strain gauges.

5.4.2 Aircraft calibration

5.4.2.1 General

The calibration test shall be performed with known tow/torsional loads. Using an X-Y plotter, the microstrain (X-axis) is plotted against the known tow load input (Y-axis) (see Figures 1 and 2). The slope of the line is the calibration factor.

5.4.2.2 Instrumentation

a) Nose gear measured output in microstrain;

b) calibrated input tow load (kN);

c) both the strain gauges and strain gauge circuits must be temperature-compensating. Other compensating requirements such as bending of the drag brace/torque link may be specified by the aircraft manufacturer. Selection of strain gauges, bonding material, gauge protection, etc., should take into account the type of material being gauged and any possible adverse conditions that could occur during testing.

5.4.2.3 Calibration

a) Calibration tests may be accomplished at the “light” and “heavy” reference test weights for the particular aircraft model being tested, to be specified by the airframe manufacturer. However, if calibration is to be done at only one weight, the heavy gross weight (HGW) must be used in order to be conservative;

b) calibration shall be performed with the aircraft and wheels placed on a level and smooth surface;

c) immediately prior to calibration testing, the nose gear strut extension shall be recorded;

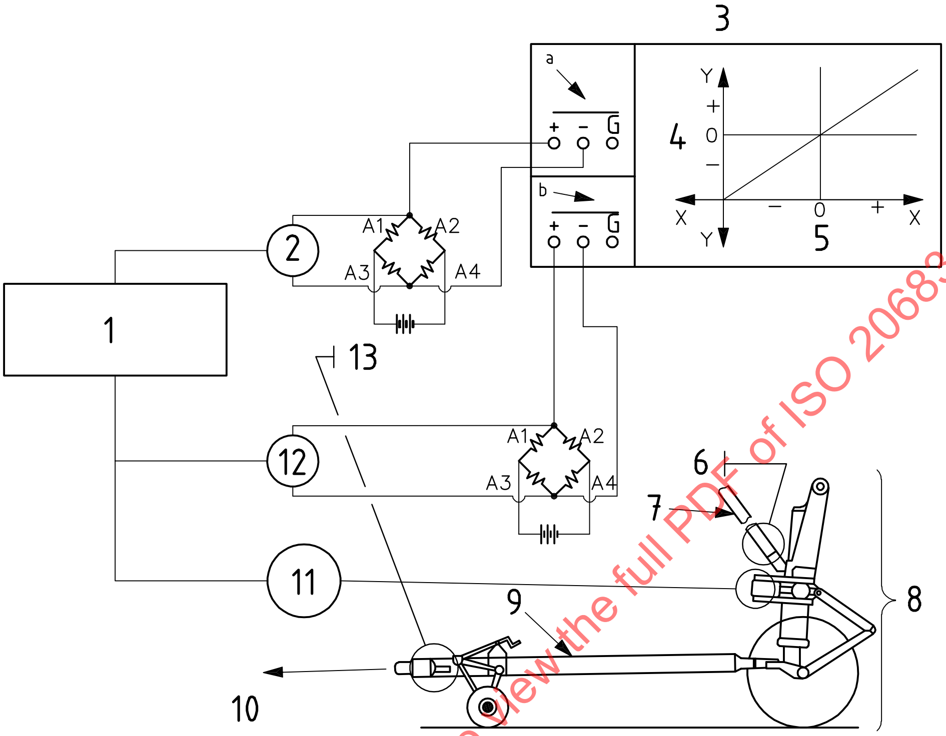
d) all calibration tests shall be performed with all main gear tires chocked and aircraft parking brake set;

e) using the known tow load input, the aircraft shall be pushed and pulled while plotting microstrain versus tow load. Two push/pull tests shall be performed at 0° nose gear steering angle;

f) for 0° nose gear steering angle, the calibration load shall be from 10 % to approximately 50 % but not to exceed 75 % of the aircraft limit tow load as specified by the airframe manufacturer. If main gear tire slipping or skidding occurs, the calibration is not valid and must be repeated;

g) the calibration plots must be linear. If the two calibration plots at 0° steering angle differ by more than 5 %, appropriate action should be taken to improve measurement repeatability. If any non-linearities exist in the calibration plots, appropriate adjustments to the test instruments should be made;

h) if the criteria through 5.4.2.3 g) above are satisfied, the relevant calibration factor may be used to convert strain gauge measurements directly to tow load during towbarless vehicle testing.

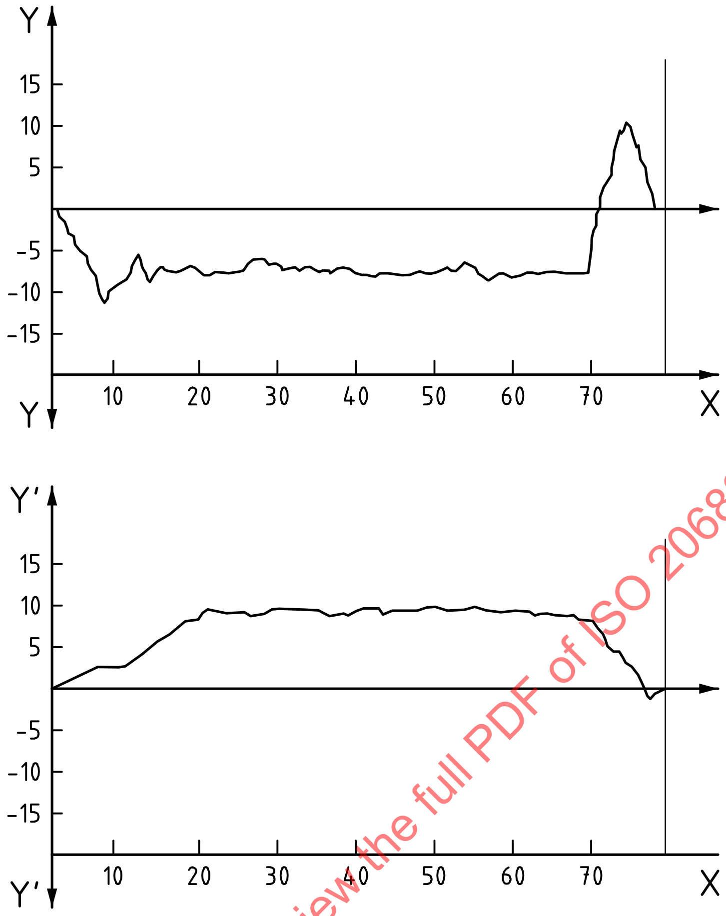


Key

1 digital recording instrument
2 force input
3 X-Y recorder
4 tow force
5 drag brace strain
6 drag brace bridge circuit
7 drag brace
8 nose gear structure
9 conventional towbar
10 forward
11 steering angle input
12 strain input
13 calibrated test towbar transducer

[a] Y input.
[b] X input.

Figure 1 — Example of tow load calibration



Key

Y load

X time (s)

Y′ velocity

Figure 2 — Example of calibration test results (load history example and velocity history example)

5.4.3 TLTV calibration

5.4.3.1 General

The calibration test shall be performed with a known tow/torsional load. Using an X-Y plotter, the microstrain (X-axis) is plotted against the known tow load input (Y-axis) (see Figure 2). The slope of this line is the calibration factor.

5.4.3.2 Instrumentation

The instrumentation requirements are to be specified by the vehicle manufacturer and shall be in accordance with current state-of-the-art techniques.

5.4.3.3 Calibration

a) The calibration procedure shall be specified in writing by the tow vehicle manufacturer.

b) The calibration loads shall include loads from 10 % to 50 % of the aircraft limit load for which the aircraft qualification is requested, as specified by the airframe manufacturer.

c) Influence of vertical and side loads, as defined by the airframe manufacturer's documentation, shall be considered during calibration.

d) The calibration plots must be linear. If the two calibration plots differ by more than 5 %, appropriate action should be taken to improve measurements' repeatability. If any non-linearities exist in the calibration plots, appropriate adjustments to the test instruments should be made.

e) If the criteria through 5.4.3.3 d) are satisfied, the relevant calibration factor may be used to convert strain gauge measurements directly to tow load during towbarless vehicle testing.

5.4.4 Oversteering calibration

Calibration of TLTV oversteer detection systems, either angular or torsional load, shall be accomplished in a suitable test facility by the vehicle manufacturer. Calibration shall not be performed on in-service aircraft because of potential risk of damage to nose-landing gears or aircraft structure. Maximum allowable limits are determined by the airframe manufacturer's documentation.

5.5 Test procedure

5.5.1 General

5.5.1.1 Prior to the tests

a) a check shall be performed on the clearances between any part of the aircraft and tow vehicle structural parts as described in 4.3.2;

b) instrumentation should be in a serviceable condition and all items should have a valid calibration certificate.

5.5.1.2 Tests may be performed with an instrumented aircraft and/or an instrumented towing vehicle. Towing load measurements on the vehicle are restricted to cases where accurate tow load measurements are possible (e.g. where pick-up device geometry allows accurate measurements).

5.5.1.3 Once calibration of the nose gear or tow vehicle strain gauges is accomplished, towbarless towing tests can be performed and tow loads can be measured directly. For any change in weight or center of gravity of the aircraft, the instrumentation should be "zeroed" just prior to testing.

5.5.1.4 During testing, the steering angle should not exceed steering angle limits specified by the airframe manufacturer.

5.5.1.5 All tests shall be performed on typical airport taxiways.

5.5.2 Data recording

5.5.2.1 During testing, the following data shall be recorded on a time-history chart (see example in Figure 2):

a) calibrated nose gear drag loads in units of force (kN) (Y′-axis of chart);

b) towing speed (km/h^{-1}) (Y′-axis of chart);

c) time (s) (X-axis of chart).

5.5.2.2 Data should be recorded analogically or at a minimum sampling rate of 30 samples/s (i.e. 30 Hz).

5.5.2.3 The following data should be recorded prior to commencement of the tests:

a) aircraft gross mass;

b) aircraft center of gravity location;

c) strut extension for all landing gear, for each gross mass tested (not applicable to in-service fatigue evaluation trials);

d) runway surface conditions during testing (e.g. dry runway, 24 °C (75 °F), etc.) (not applicable to in-service fatigue evaluation trials);

e) aircraft model and serial number.

6 Evaluation

6.1 Evaluation criteria

6.1.1 Tests shall be performed in order to evaluate the following conditions:

a) normal condition testing;

b) stability testing;

c) extreme condition testing.

6.1.2 In order to minimize testing cost, complexity and duration while gathering all of the required data

a) the defined testing program shall be appropriate to the intended vehicle classification (see 4.7);

b) testing should preferably use test rigs simulating the aircraft interface whenever possible (e.g. static testing), and shall use such devices whenever necessary to avoid a risk of damaging the aircraft (e.g. oversteering testing);

c) trials should preferably be performed during in-service aircraft handling operations.

6.2 Normal condition testing

6.2.1 Testing methods

Normal condition tests shall be performed according to the intended use and classification of the tow vehicle (maintenance towing and/or only push-back), and may be performed in either of two ways:

a) by means of in-service trials; or

b) by means of dedicated trials specifically meant for the evaluation.

6.2.2 Tests number

The number of tests should be specified by the airframe manufacturer. If no specific number of tests is required, the numbers specified in 6.2.3 through 6.2.5 shall apply.

6.2.3 Push-back

A total of 30 push-backs shall be performed with three different tow vehicle drivers (10 trials each), as follows:

a) The push-back maneuvers shall consist of an aft tow, with turn, and a short push or tow to align the nose gear parallel to the taxiway.

b) Each push-back should be performed either under operational flight departure conditions or in a manner that simulates typical in-service push-back conditions (i.e. typical speed, starts, stops, turns, distance, etc.) as judged by each driver:

c) The push-back tests shall be performed either under operational flight departure conditions or at the reference heavy gross weight defined with the manufacturer.

d) Half the push-back tests shall be performed with aircraft engines on at idle thrust. The other tests shall be performed with aircraft engines off. Alternately, the tests with engines on may be replaced by adding the known engines idle thrust to the towing loads recorded during the tests without engines: in this case, a total of 15 push-backs only is necessary.

e) Aircraft gross masses, the number of drivers and engines off and on status shall be recorded.

6.2.4 Maintenance towing

A total of 12 maintenance towings shall be performed with three different tow vehicle drivers, each driver performing four trials, as follows:

a) Each maintenance towing shall include four intermediate stops.

b) It shall either be conducted under operational maintenance towing conditions or simulate typical maintenance conditions (typical speed, turns and distance).

c) Approximately 80 % of the loaded towing vehicle maximum speed shall be reached and stabilized between each stop.

d) The trials shall be performed either under the operational maintenance towing weights encountered or under the reference weights defined with the airframe manufacturer. In either case, qualification of the tractor shall be limited to the highest weight effectively tested.

6.2.5 Pick-up and release

A total of 20 pick-up and releases shall be performed at the same weights used for either push-back or maintenance towing according to intended use and classification (see 4.7) of the tow vehicle. Should the operation not be fully automatic, three different drivers shall perform the test. In case of in-service trial, this phase may be included as part of the push-back and/or maintenance towing tests.

6.3 Stability testing

6.3.1 These tests are to ensure TLTV-aircraft stability over the velocity range capability of the vehicle during typical runway conditions and towing operations.

6.3.2 The tests shall be performed under aircraft reference light gross weight (LGW) and the maximum speed attainable by the aircraft and tow vehicle assembly.

6.3.3 Two trials under these conditions shall be performed, and their results recorded. For each test, the required speed shall be attained, and maintained for a minimum of 20 s.

6.3.4 For the range of speeds thus tested, the TLTV should not induce oscillation or vibration loads on the nose gear. The tow vehicle must also demonstrate stability over the vehicle's full operational range, including starts, stops and turns. For safety purposes, turns may be at less than the defined test speed. If either the data or the vehicle driver indicates instabilities or oscillatory loads, the tow vehicle's maximum speed should be limited to a speed that is at least 5 km/h^{-1} (i.e. 3 mph) below the speed at which the instability was detected.

6.4 Extreme condition testing

6.4.1 Testing methods

Extreme condition tests shall be performed according to the intended use and classification of the tow vehicle (maintenance and/or only push-back), and include

a) static testing and

b) loads measurement and assessment during maximum towbarless tow vehicle acceleration and braking.

6.4.2 Static load tests

Four static load tests shall be performed as follows:

a) With the aircraft/tow vehicle stopped on the taxiway, apply full aircraft brakes.

b) Keeping the aircraft brakes on, progressively and quickly apply full vehicle power. Maintain maximum vehicle power for 5 s. Repeat two push and two pull tests for a total of four trials.

c) The trials can be conducted at either the light or heavy gross weight. The test should be conducted with dry conditions to prevent abnormal sliding of the aircraft or spinning of the vehicle wheels.

If the subject TLTV and overload limiter devices have never been tested before, it is highly recommended to perform these tests with a simulated aircraft interface test rig.

6.4.3 Maximum acceleration and braking

Maximum accelerations and braking tests shall be accomplished as follows:

a) From a dead stop, use maximum power of the tow vehicle to accelerate until the desired velocity is reached.

b) Once the target velocity is reached, maintain that velocity until the tow vehicle and aircraft stabilize. Once stabilized, apply tow vehicle maximum braking until the aircraft comes to a complete stop.

c) Perform the push tests similar to the pull tests, except push the aircraft aft instead of pulling the aircraft forward. The braking and acceleration procedures are the same for the push tests.

d) Acceleration and braking tests are designed to check the vehicle's full capability. Therefore, drivers should apply the brakes as hard as possible and accelerate as quickly as possible.

e) Table 1 outlines the acceleration/braking trials and sequence.

Table 1 — Acceleration/braking trials and sequence

Direction	Heavy gross weight Pull				Heavy gross weight Push	
Velocity km/h^{-1} (mph)	5 (3)	10 (6)	20 (12)	max	5 (3)	10 (6)
Number of trials	2	2	2	2	2	2
Test sequence	1	2	3	4	1	2

6.5 Oversteer testing

No testing of the TLTV oversteer indication and protection system shall be performed on an in-service aircraft. This precaution is to preclude any possible damage to the nose-landing 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 to be used. However, if the TLTV oversteer limits are appreciably lower than the maximum limits specified by the airframe manufacturer, then confirmation or confidence checks of these lower limits may be performed with an in-service aircraft.

7 Maintenance

7.1 General

7.1.1 This Clause covers the special requirements and procedures for inspection, maintenance and calibration of TLTV tractive force and steering protection systems or alerting devices, where necessary to ensure protection of the aircraft.

7.1.2 The TLTV aircraft NLG tractive force and steering protection systems or alerting devices which, in the event of failure or malfunction, would as a consequence of failure not preclude potential damage to the aircraft's nose-landing gear and its steering system, shall be inspected, maintained, tested and calibrated to the TLTV manufacturer's requirements for its classification on all the designated aircraft types which the TLTV is designed to handle.

7.1.3 Inspection, maintenance and calibration schedules, any special tools and training requirements for the TLTV's protection systems or alerting devices must be available.

7.1.4 The TLTV's aircraft NLG protection systems or alerting devices shall be inspected, maintained and calibrated in accordance with the requirements of this part of ISO 20683 and the TLTV manufacturers' maintenance manuals and schedules.

7.1.5 The organization responsible for the maintenance of the TLTV shall keep documented records of each TLTV's aircraft NLG protection systems or alerting devices inspection, maintenance and calibration in maintained files to be made available for review and audit by the aircraft airworthiness regulatory authorities when requested.

7.1.6 Records should be kept for a minimum period of two years or in accordance with the requirements of the controlling aircraft airworthiness regulatory authority.

7.2 Maintenance manual

7.2.1 The TLTV manufacturer's maintenance manual shall incorporate a separate section covering the inspection, maintenance and calibration of the TLTV aircraft NLG steering and tractive force protection systems or alerting devices. The maintenance manual shall be in accordance with 7.2.2 to 7.2.8.