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(R) Design Specification for Towbarless Tow Vehicles

RATIONALE

Five-year review. Removed specific aircraft references. Aircraft categories revised to cover new aircraft types (i.e., A380, A350, B787, A340-500/600, and B747-8). Clarification of requirements. TLTV options added. JAA name change to EASA. Minor editorial changes.

FOREWORD

This SAE Aerospace Recommended Practice (ARP) describes the dimensions, design, layout, performance, and capability of a towbarless tow vehicle (TLTV).

Overall design of the unit is to allow operations under climatic conditions as stated under 5.1 and safe operations during day and night conditions on airport aprons, runways, taxiways, and in hangars.

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1. SCOPE

The tow vehicle should be designed for towbarless movement of aircraft on the ground.

The design will ensure that the unit will safely secure the aircraft nose landing gear within the coupling system for any operational mode.

1.1 One-Man Operation

A one-man towbarless tow vehicle operation is required with all functions to be performed by the driver. Good visibility is required for controlled and safe operations, during day and night conditions.

1.2 Under-Belly Operation (if required)

The coupling of the nose landing gear by the towbarless tow vehicle (TLTV) must be possible in all extensions of the nose strut of the aircraft in the vehicle's design category (see 1.4):

1.3 The TLTV has to be designed to carry out the following tasks:

1.3.1 Push-Back

Push-back shall be defined as the moving of a loaded airplane in a backward direction from a parking position to the taxiway. Movement typically includes push back with a turn, stop, and short tow forward to align the airplane. Aircraft engines may or may not be running.

1.3.2 Maintenance Towing

Maintenance towing shall be defined as the movement of an airplane for maintenance/remote parking purposes (i.e., from the gate to a maintenance hangar or vice versa). Airplane is typically unloaded.

1.3.3 Dispatch Towing (or Operational Towing)

Dispatch towing shall be defined as the towing of a loaded (cargo and/or passenger) revenue airplane from the terminal gate area/remote parking to a location near the runway. This type of towing can involve relatively high speeds and long distances with several starts, stops, and turns. Dispatch towing may not be approved by the airframe manufacturers (refer to airframe manufacturers TLTV assessment criteria and /or service letter)

1.4 Aircraft Nose Gear Load

The TLTV tow tractor should be designed for use with the following aircraft categories:

a. TLTV CAT I:

   Aircraft with a maximum nose gear ground reaction load up to 19 metric tonnes (41 900 lb) static.

   Dynamic loads must be calculated by the tow vehicle manufacturer.

b. TLTV CAT II:

   Aircraft with a maximum nose gear ground reaction load up to 24 metric tonnes (52 900 lb) static.

   Dynamic loads must be calculated by the tow vehicle manufacturer.

c. TLTV CAT III:

Aircraft with a maximum nose gear ground reaction load up to 36 metric tonnes (79 400 lb) static.

Dynamic loads must be calculated by the tow vehicle manufacturer.

d. TLTV CAT IV:

Aircraft with a maximum nose gear ground reaction load up to 48 metric tonnes (105 800 lb) static.

Dynamic loads must be calculated by the tow vehicle manufacturer.

2. 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. The TLTV must fully comply with the most recent issue to the following documents, standards, specifications, and practices as applicable to airport ramp operations.

2.1 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.

ARP1247	Aircraft Ground Support Equipment - General Requirements
ARP1328	Aircraft Ground Support Equipment - Wind Stability Determination
ARP1330	Welding of Structures for Ground Support Equipment
AIR1375	Minimum Safety Requirements for Special Purpose Airline Ground Support Equipment
ARP1801	Measurement of Exterior Sound Level of Specialized Aircraft Ground Support Equipment
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

2.2 Applicable References

ISO 20683-1, Aircraft ground equipment - Design, test and maintenance requirements for towbarless towing vehicles (TLTV) interfaced with nose landing gear - Part 1: Main line aircraft

ISO 20683-2, Aircraft ground equipment - Design, test and maintenance requirements for towbarless towing vehicles (TLTV) interfaced with nose landing gear - Part 2: Regional aircraft

ISO 11532, Aircraft ground equipment - Graphical symbols

IATA AHM 957, Functional Specification for Nose Gear Towbarless Tractor

Applicable airframe manufacturers service letters refering to towbarless towing

Federal occupational safety and health standards (OSHA), subpart N

California occupational safety and health standards (CAL-OSHA)

EU Directive 2006/42/EC on Machinery

EN 1915-1, Aircraft ground support equipment - General requirements - Part 1: Basic safety requirements

EN 1915-2, Aircraft ground support equipment - General requirements - Part 2: Stability and strength requirements, calculations and test methods

EN 1915-3, Aircraft ground support equipment - General requirements - Part 3: Vibration measurement methods and reduction

EN 1915-3, Aircraft ground support equipment - General requirements - Part 4: Noise measurement methods and reduction

EN 12312-7, Aircraft ground support equipment - Specific requirements - Part 7: Aircraft movement equipment

National traffic codes and regulations

Applicable mechanical engineering standards, recommended practices, and safety rules

Applicable aviation regulatory agency rulings or interpretations (FAA, EASA or national CAA)

Standards and safety rules especially applicable to electrical installations

Local Airport Regulations:

If local regulations add requirements, they have to be made known to seller and adhered to.

3. DIMENSIONS (TYPICAL)

3.1 TLTV CAT I & CAT II

a. Length: Maximum 8000 mm (315 in) without towing device

b. Width: Maximum 3500 mm (138 in) without mirrors

c. Turning Circle Radius: Maximum 9000 mm (355 in)

d. Ground Clearance: Minimum 150 mm (6 in)

e. Height: With cab retracted, unloaded maximum 1650 mm (65 in), if under belly operations are performed

3.2 TLTV CAT III & CAT IV

a. Length: Maximum 10 000 mm (394 in) without towing device

b. Width: Maximum 4500 mm (166 in) without mirrors

c. Turning Circle Radius: Maximum 11 000 mm (433 in)

d. Ground Clearance: Minimum 150 mm (6 in)

e. Height: With cab retracted, unloaded maximum 1650 mm (65 in), if under belly operations are performed

3.3 General Requirement

If under-belly operations are performed, TLTVs must not preclude aircraft emergency evacuation procedures.

4. PERFORMANCE

4.1 Tractive and braking forces applied to the aircraft shall be limited by a load limiting device(s). Tractive and braking forces shall be variable depending on the aircraft type according to 4.3 and 4.4. The tractive forces must be sufficient to move aircraft from standstill even under bad surface conditions and aircraft-engines running on idle speed.

The fore-aft load limiting device should be set as a function of the airplane to be towed. This value must not be exceeded during normal towing (acceleration/braking).

Tractive forces and braking applied to the aircraft shall be limited by a load limiting device.

To ensure that the tow vehicle does not negatively impact the certified safe life of the airplane nose landing gear, the tow vehicle must be qualified according to the requirements specified by the Airframe Manufacturer.

4.2 Speed

a. An empty tow vehicle (without aircraft) shall be capable of a maximum speed of no less than 32 kph (20 mph).

b. A loaded tow vehicle (with aircraft) shall not exceed 32 kph (20 mph).

4.3 Acceleration

Maximum speed shall be achieved as quickly as possible, but the acceleration forces must stay within the limits given by the aircraft manufacturers so that there is no negative influence on the structural integrity and safe life-limits of the NLGs.

4.4 Deceleration

Tow vehicle deceleration forces values during towing operation shall be in accordance with aircraft manufacturers requirements. Braking force on the aircraft shall be limited by a protective fail safe device or system.

Braking Ratio: Tow vehicle minimum 35% empty, without aircraft at maximal operational speed.

4.5 Nose Gear Towing Forces

The tractive/brake force settings must not exceed the allowable loads specified by the airframe manufacturers for the aircraft model being towed.

5. DESIGN DETAILS

5.1 Diesel Engine

Standard system shall be designed for temperatures down to -20 °C (-4 °F). A design for temperatures between -20 °C (-4 °F) and -40 °C (-40 °F) should be an option.

The engine will conform to latest exhaust emission regulations according to the location where the vehicle will be used.

5.1.1 Provisions for long intervals between oil changes shall be taken; such as filters, oil quality, and constructional features

5.1.2 Calculation of power output shall be based on 100 kPa (14.69 psi) 20 °C (68 °F) and 60% humidity.

5.1.3 The chosen engine shall be widely in use and of proven design.

5.1.4 The engine will be adequately accessible for maintenance and inspection.

5.1.5 Engine replacement must be possible within an acceptably short time through the top or side of the chassis, using standard hoist equipment and shop means. For removal, it should only be necessary to disconnect supply and control lines, linkages, exhaust and intact piping, fuel lines and, possibly, a driveshaft.

A power converter or mechanical transmission could remain with the engine.

5.1.5.1 Engine shall be provided with adequate hoist provisions offering safe load bearing capability.

5.1.6 The unit shall be equipped with an efficient exhaust system, located to prevent entrance of exhaust gases into the cab, or discharge into a wheel casing.

5.1.7 The engine shall be started electrically.

5.2 Power Train

5.2.1 ASR (traction control/slip positive control), or differential locks or other means to avoid decreased traction forces as well as skidding controls must be provided on each wheel.

5.2.2 Four- or two-wheel drive systems are applicable, but preferably four-wheel drive to prevent wheel skidding.

5.2.3 Power train from engine to the wheels shall be of proven type.

Gear shifting by hand shall not be required in the operational mode. In case of an automatic transmission (via a torque converter), gear change must be smooth.

5.2.4 It should be possible to tow the tow vehicle with a minimum speed of 5 kph (3 mph) over long distances.

5.3 Wheels, Tires, Axles

5.3.1 Tire sizes and a suitable tire tread have to be chosen to suit all airport operations.

Each tire shall have, at minimal inflation pressure, a rated carrying capacity at least equal to the gross load normally imposed on it by a fully equipped and loaded tow vehicle. For cases of tire failure, tire must safely accept one-third of the maximum loaded tow vehicle gross weight.

5.3.2 Wheel change shall be a simple operation using standard tools.

5.3.3 Wheel arches shall provide ample space for wheel articulation and turning, mounting, and operation with snow chains.

5.3.4 Front axle suspension shall be shock dampened. Design shall be such that chassis oscillation cannot build up.

5.4 Brakes

5.4.1 A braking system shall be installed complete with all necessary equipment to safely control the fully equipped and loaded tow vehicle under all operating conditions.

The brake mechanism shall be readily accessible for adjustments. The service brake shall have two independent systems. In case of failures of one system, a signal lamp will flash on the cab instrument panel.

ALB (anti-lock brake) should be an option.

Deceleration forces shall stay within the limits given by the aircraft manufacturer.

5.4.2 The service brake shall operate on all wheels with a minimum fading deceleration. To assist the operator, the service brake must be power assisted.

5.4.2.1 The parking brake shall engage on at least two wheels and shall hold a fully loaded tow vehicle being in neutral shift at standstill. Emergency release for parking brake spring actuator shall be provided.

5.4.2.2 Applied parking brake shall be indicated in the cab by a red warning lamp.

5.4.3 Simultaneous action of the service brake and the parking brake must be rendered impossible by a safety device.

5.5 Steering

5.5.1 Steering Mode

TLTV CAT I, CAT II, CAT III and CAT IV.

Front axle steering
Four-wheel and crab steering (optional)

NOTE: In case of four-wheel steering “front” always defines the direction the driver is facing.

5.5.2 Steering mode shall only be selected while tow vehicle is not moving.

5.5.3 External Turning Radius

All categories shall be a small as possible (see Section 3).

5.5.4 In case the tow vehicle has to be towed away, the front wheel steering has to be functional even with an engine failure at a velocity of approximately 5 kph (3 mph) and for a period of 30 min minimum.

5.5.5 Nose Gear Oversteer Indication and/or Protection

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 maximum safe limit has been reached, and

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

In addition, it is desirable that the device activates 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.

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

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

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

5.5.6 The oversteer indication and/or protection system should be set per allowable (not to be exceeded) values provided by the airframe manufacturers.

5.6 Electrical System

5.6.1 The tow vehicle shall be provided with a complete and good commercial quality electrical starting and lighting system. The system shall be made from reliable components.

5.6.2 The system shall operate with 24 V (or 12) DC system with battery capacity to suit electrical demand.

5.6.3 The following illumination is required:

5.6.3.1 Headlights at front and rear

5.6.3.2 Marker lights at front and rear

5.6.3.3 A combination of lights for indicator lights, for direction flashers, braking and taillight (at both ends of tow vehicle). Direction flashers shall be visible from the side.

5.6.3.4 Warning beacons shall be fitted according to airport regulations.

5.6.3.5 Lamps shall be provided to illuminate coupling area.

A main battery switch is to be provided.

5.7 Sufficient space is to be provided for the fitting of a GPU (Ground Power Unit).

5.7.1 All connectors are to be self-sealing and quickly disconnectable.

5.8 Tow Coupling (for recovery of tow vehicle)

5.8.1 A universal coupling shall be provided at the center of the front end.

5.8.2 There shall be a recovery coupling for emergencies on both sides at the rear-end.

5.9 Cab

5.9.1 Provision must be made to have good visibility of the coupling area.

5.9.2 Driver's seat shall be adjustable in height, seating position, and backward position. The seat shall be turned by activating two foot pedals. Feet have to be in a safe position while seat is turning.

5.9.3 Cabin shall have a sunshine roof (glass with sun protection/tinted) and be located directly above the driver's seat.

5.9.4 The side windows shall be designed as sliding windows. All windows shall be furnished with electrical heating or equivalent to prevent mist forming (optional).

5.9.5 Front and rear windows shall be installed in an appropriate angle to minimize reflections.

5.9.6 A second seat shall be installed for a co-driver.

5.9.7 Ventilation and heating of the cabin shall be provided.

5.9.8 The vehicle shall have front and rear windshield wipers separately activated. Wiper interval switch shall be standard. Washers shall be available as a standard.

5.9.9 Ergonomic guidelines are to be taken into consideration.

5.9.10 If cabin is equipped with a lifting device, an automatic lifting stop shall be installed at a central place on top of the cabin. Activation of the lifting stop shall be visually indicated in the cabin.

5.9.11 Means for allowing observation of the nose landing gear during operation shall be installed in the cabin.

5.9.12 There shall be a storage compartment which can hold a 286 x 324 x 76 mm (11.25 x 12.75 x 3 in) size file.

5.9.13 Interior illumination of the cabin shall be 350 lux.

5.9.14 Two outside mirrors shall be provided to enable driver to observe rear area. Electrical heating and adjustment are optional.

5.9.15 Driver must have a good field of visibility from all seat positions.

5.10 Logic Connection of Driver's Seat and Driving Direction

5.10.1 All controls shall be automatically defined by the direction the driver is facing.

5.10.2 The steering directions (mode) of the vehicle shall always be regarded as forward direction.

The front axle steering will always be automatically changed when the driver's seat is turned.

5.10.3 Illumination

The tow vehicle shall have identical illumination at front and rear which will be switched automatically when driver's seat is turned (i.e., the reversing lights will serve as headlights and vice-versa).

5.11 The tow vehicle shall be equipped with the following controls:

Throttle
Service brake
Flashers/dimming switch
Emergency stop button
Direction selection (vehicle travel)
Steering mode selector
Seat rotation (swivel) control
Parking brake

5.12 The tow vehicle shall be equipped with the following instruments/indicators:

Multiwarning signal (flashing)
Steering mode indicator: all wheel/crab (only by four-wheel steering)
Parking brake set

5.13 The tow vehicle shall be equipped with the following switches and indication/control lamps:

Ignition switch with anti-restart
Start/stop device for diesel engine
Warning beacons
Light switches
Dim switch
Other illumination (working lamps)
Position lights
Windshield wipers and washers in front and rear
Heating/ventilation
Raising/lowering of cabin
Controls for coupling system
Switch to select type of aircraft
Heating for windows in front and rear (optional)
Heating for mirrors (optional)
Electrical adjustment for mirrors (optional)
Dimmer for panel illumination
Testing device for all alarm circuits/lamps
Steering angle indication (optional)

5.14 Monitoring and Alarm Circuits/Lights

5.14.1 The following instrument indicators are mandatory on the operation panel in the cab:

Operation hour meter
Battery charging control light

Engine oil pressure (monitor and warning signal) light
Engine temperature of coolant (monitor and warning signal)
Engine coolant low level warning
Fuel gauge for each tank
Brake pressure warning
Indication: “Vehicle ready for operation” (second/simultaneous verification of aircraft relevant settings)
(Identification of type of aircraft by pickup system)

Speed meter
High beam (headlight) is on (blue signal)
Heater is on
Flashers are on

5.14.2 The following should be optional and mounted in a panel accessible for engineering:

Monitors indicating:

Preliminary heating
Hydraulic oil for each tank
Hydraulic oil temperature
Maintenance required for hydraulic filter
Emergency steering in operation
Emergency stop is activated
Electrical clock

All operating instruments and alarm signals shall be labeled on the panel.

5.15 Miscellaneous

Quick check points for hydraulic oil pressure shall be installed.

Jacking points for wheel change and general maintenance shall be provided on the chassis.

Size of fuel tanks shall allow a one day operation for approximately 12 h with 50% load.

5.16 Coupling System

The tow vehicle should be designed for coupling to the aircraft’s nose landing gear.

5.16.1 The nosewheel coupling and holding system must be capable of capturing all aircraft types defined in 1.4 including telescoping of the nose landing gear strut and turn geometry of nonvertical nose landing gear designs (exception pressureless nosewheel tires).

5.16.2 The nosewheel must only be captured at the tire tread surface.

5.16.3 While in the fully engaged position the nosewheel must remain stabilized in the locking mechanism under all dynamic conditions. The nosewheel must be retained above the axle to prevent escape in the upward direction.