



AEROSPACE INFORMATION REPORT

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Superseding AIR1363

Four Wheel Drive Aircraft Tow Tractors - Factors for Design Consideration

RATIONALE

AIR1363A has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE:

This Aerospace Information Report (AIR) is presented in two parts. The first part is simply a summarization of design factors that must be considered in establishing vehicle specifications and design characteristics. The second part refers particularly to the performance characteristics of an aircraft tow tractor. Some definitions, formulas, data, and an example are provided mainly for assisting the specifying engineers of potential buyers and users of aircraft tow tractors in the evaluation and comparison of their requirements with the performance capabilities of the various tow tractors offered by the tow tractor manufacturers. Although the design engineers could also use the formulas and data in their calculations of the performance specifications of aircraft tow tractors, this AIR is not intended to provide the methods and all data necessary for detailed calculations and design of an aircraft tow tractor.

2. PURPOSE:

The AIR identifies and summarizes the various factors that must be considered and evaluated by the design or specifying engineer in establishing the specifications and design characteristics of four-wheel drive aircraft tow tractors.

3. DESIGN FACTORS:

The following factors must be considered and evaluated in establishing aircraft tow tractor specifications and design.

3.1 Aircraft Characteristics:

- a. Dimensions
- b. Number of landing gears and wheels
- c. Attachment point for towing
- d. Gross weight, empty weight, and weight distribution on the landing gears
- e. Coefficient of breakaway resistance of the aircraft (as a percentage of aircraft weight) for initial motion directed:
 - (1) Straight ahead
 - (2) In a turn
- f. Coefficient of rolling resistance of the aircraft (as a percentage of aircraft weight) for constant motion on various horizontal surfaces
- g. Turn radius of the aircraft
- h. Angular steering limitation of the aircraft tow fitting
- i. Towing load limitations of the aircraft tow fitting at different directions of towing or pushing
- j. Amount of thrust of engines at idle

The aircraft characteristics are normally provided by the aircraft manufacturer in the Facilities Planning Manual of each particular model of aircraft. The design or specifying engineer must consider all models of aircraft that are to be handled by the tow tractor.

3.2 Airport Conditions:

- a. Maximum grades to be negotiated
- b. Minimum speeds required for crossing active taxiways and runways
- c. Parking requirements:
 - (1) Parallel or nose-in at gates
 - (2) Spacing from other aircraft
 - (3) Proximity to other fixed physical features
 - (4) Need for remote parking
- d. Paving strength of ramps, taxiways, runways, and access roads
- e. Road clearance and bridge and overpass limitations
- f. Anticipated towing distances and routes between aircraft maintenance and storage areas and cargo and passenger terminals, etc.
- g. Maximum approach and breakover angles to be negotiated on ramps, taxiways, runways and access roads
- h. Other towing equipment limitations, physical or regulatory, unique to the local situation
- i. Environmental factors and airport surface conditions:
 - (1) Temperature
 - (2) Humidity
 - (3) Altitude
 - (4) Rain
 - (5) Snow or ice
 - (6) Material and condition of airport surface when dry
 - (7) Oil, hydraulic fluid, de-icing fluid on airport surface
 - (8) Other pollutants on airport surface

The airport conditions are specified usually by the user of the tow tractor (airlines, ground handling company or airport authorities).

3.3 Tow Vehicle - General Characteristics:

- a. Dimensional limitations
- b. Visibility requirements
- c. Operator's compartment location(s)
- d. Speed requirements:
 - (1) Maximum speed - tractor only on level surface
 - (2) Maximum towing speed - tractor and towed aircraft with maximum weight on level surface
- e. Braking capability:
 - (1) Minimum stopping distance at maximum speed - tractor only (or maximum deceleration)
 - (2) Minimum stopping distance at maximum towing speed - tractor and towed aircraft (or maximum deceleration)
 - (3) Emergency braking capability

3.3 (Continued):

f. Maneuverability requirements and steering capability:

- (1) Front-wheel steering
- (2) Four-wheel coordinated steering
- (3) Two-mode steering: front-wheel and four-wheel coordinated
- (4) Two-mode steering: four-wheel coordinated and four-wheel crab
- (5) Three-mode steering: front-wheel, four-wheel coordinated and four-wheel crab
- (6) Four-mode steering: front-wheel, rear-wheel, four-wheel coordinated and four-wheel crab
- (7) Emergency steering capability

g. Power train - special requirements concerning the major components (engine, transmission, axles, wheels and tires)

h. Maintenance requirements and service accessibility

i. Requirements for adequate clearance between tractor tires and chassis (e.g. for chains, straps or other traction devices for ice or snow conditions, etc.)

j. Requirements for integral electrical power equipment to support the aircraft systems during towing and standby operations

k. Method of attachment to the aircraft (e.g., type and location of the tow hitches, tow hitch safety locking devices, etc.)

l. Requirements for ground control communications, including communication between tow tractor and aircraft

m. Vehicle lights

n. Human factor requirements:

- (1) Environmental protection of operator, passenger(s) and the man connecting and disconnecting the tow bar (cab, location of the engine exhaust, etc.)
- (2) Comfort - location and type of operator's seat, location of controls and instruments, heating and ventilation, operator's compartment lighting, noise level, etc.
- (3) Safety - access to and from operator's compartment or cab, steps, doors, warning lights and beepers, windshield washer and wipers, visibility to front and rear hitch areas, fire protection, etc.

o. Special requirements imposed by airport authorities and regulations

p. Special requirements imposed by the tractor user or buyer

The general characteristics of a tow tractor shall be determined so that the vehicle would be able to meet the requirements imposed by the characteristics of the different models of aircraft that will be towed and by the airport conditions where the tractor will operate, providing efficient, safe and comfortable operation and maintenance.

4. PERFORMANCE:

4.1 General Notes:

During a towing operation an aircraft tow tractor must be able to overcome all forces resisting the motion of the tow tractor-aircraft train. The power train of the tow vehicle must be able to produce a tractive effort between the tires and airport surface equal to the maximum total resistance, i.e., the maximum amount of all forces resisting the motion of the tractor and aircraft. Since the tractive effort is proportional to the torque on the drive wheels shaft, the power train of the vehicle must be able to develop the torque required to produce the needed tractive effort. The power train of the tow tractor must also be able to develop enough power to accelerate the tow tractor alone to the specified maximum speed and the tractor-aircraft train to the specified maximum towing speed. On the other hand the maximum tractive effort that can be developed between the tires and the ground surface is proportional to the weight over the drive wheels. Therefore a tow tractor must have adequate weight and weight distribution to provide the required maximum tractive effort at specified airport surface conditions.

The braking system of a tow tractor must be able to develop adequate braking force between the vehicle tires and the road surface for a safe braking of the tractor, as well as for a safe braking of the tractor and aircraft. Normally during a towing operation only the braking system of the tow tractor is used for braking tow tractor-aircraft train. However, in case of emergency during towing the tow tractor-aircraft train may be stopped by the aircraft brakes being applied by the captain or braking mechanic of the aircraft. The maximum braking force that can be developed by a tow tractor is proportional to the weight of the tractor. Therefore the weight of the tractor imposes the major limitations on the braking capability.

The following formulas are correct with sufficient approximation at the assumption that an aircraft tow tractor is a relatively heavy, slow-moving, low profile ground vehicle operating on surfaces with not more than 10% grade. However, it is highly recommended that the specifying or design engineer verify any data and use correct formulas depending on the specific type and application of the tow tractor.

For example, the resistance of motion produced by the air is not discussed and included in the formulas for the total resistance since at low speeds the air resistance is insignificant. However, if the tow tractor moves against strong wind, a significant air resistance is added to all other forces opposing the motion, therefore this additional resistance must be considered in the performance calculations.

In this discussion the weight of the tow vehicle is considered as being equally distributed on the four wheels. For simplicity, the effect of the load transfer due to the drawbar pull and to the inertial forces during acceleration or deceleration is neglected as insignificant in establishing the major performance specifications. However, in the detailed calculations and design of the drive system and braking system of the vehicle, the load transfer is one of the major factors for design consideration.