



AEROSPACE INFORMATION REPORT

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Airline Tow Tractor - Baggage/Cargo Factors for Design Consideration

RATIONALE

It was decided to review AIR1316B during the AGE-3 meeting on March 18th, 2024. Added related publication in Section 2. Added characteristics in 4.1, 4.2, and 4.3. Modified 5.4.1 to match AIR1854 wording. Editorial changes for better formulae understanding.

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1. SCOPE

This document outlines the functional and design requirements for baggage/cargo tow tractors used for airline services.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

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 +1 724-776-4970 (outside USA), www.sae.org.

ARP1247 Aerospace Ground Support Equipment - General Requirements

3. DRAWBAR CALCULATION CLARIFICATION

The following methods for the determination of Tractive Effort (TE), Drawbar Pull (DBP), Gross Vehicle Weight (GVW), Engine Torque (T), Engine Brake Horsepower (BHP), and Braking Capacity are presented for the purpose of assisting potential buyers and users of airline baggage/cargo tow tractors in the evaluation of their towing requirements and the capabilities of the various vehicles as offered by the equipment manufacturers.

4. DESIGN FACTORS

In order to match or size a tractor to a particular application, the following design factors should be considered and evaluated in establishing baggage/cargo tow tractor performance requirements.

4.1 Towed Load Characteristics

- Number of units being towed
- Gross weight of each towed unit
- Towbar and coupler configuration of each unit
- Turn radius of towed train
- Coefficient of breakaway resistance of the train (as a percentage of the total gross weight of the train) for initial motion directed:
 1. Straight ahead
 2. In a turn
- Coefficient of rolling resistance of the train (as a percentage of the total gross weight of the train) for constant velocity on various surfaces on:
 1. A horizontal plane
 2. A grade

- Maximum safe speed of the train
- Maximum desirable acceleration of the train
- Maximum frontal area of the train (wind resistance)
- Maximum length, width, and height of the train

4.2 Airport Environment

- Maximum grades to be negotiated
- Maximum allowable speeds
- Road and building clearance (width and height) limitations
- Anticipated towing distances and routes between various airport areas
- Maximum approach and breakover angles to be negotiated on ramps, inclined building entrances and exits, and access roads
- 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, deicing fluid on airport surface
 8. Other pollutants on airport surface
- Other towing equipment limitations, natural, physical, or regulatory unique to the local station

4.3 Tow Vehicle - General Characteristics and Requirements

- Vehicle power and power train
- Vehicle weight and traction
- Tractive effort and drawbar pull
- Braking capability
- Wheel and tire type(s) and size(s)
- Method, type, location, and operation of coupler device
- Maximum speed (no load and full load)

- Minimum and maximum required acceleration under full load
- Dimensional limitations
- Visibility requirements
- Operator and passenger accommodations (environmental protection)
- Engine instrumentation requirements
- Vehicle propulsion and steering controls
- Operational lighting requirements
- Steering characteristics
- Ground control communications requirements
- Maintenance requirements and service accessibility
- Human factor requirements:
 1. Environmental protection of operator and passenger(s) (cab)
 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.
- Special requirements imposed by airport authorities and regulations
- Special requirements imposed by the tractor user or buyer

5. DESIGN DATA, EXPLANATIONS, AND EXAMPLES

Limiting this report paper in scope, the performance aspects of the tractor will be discussed. It is recommended that the specification or design engineer verify any data that they use for a specific situation, since the multiple and interrelated factors affecting the towing forces preclude the use of general formulas that account for all variables. The following items should only be considered as general guidance.

5.1 Tow Vehicle - Power Train Requirements

5.1.1 Engine Power

The tow vehicle engine must be capable of developing enough torque and horsepower to move both the tow vehicle and the towed load under the design considerations of weight, speed, direction, surface conditions, and resistance to motion.

5.1.2 Torque (T)

This is the ability of an engine to produce work and is measured in pound-feet (Newton meters) or pound-inches (Newton meters).

5.1.3 Horsepower (BHP)

This is the ability of an engine to produce power, which is a measure of work being done within a unit of time. The units of measurement are pound-feet per minute (joules) or pound-feet per second (joules). The value for horsepower can be determined by dividing this by 33000 lb-ft/min (44741 J) or 550 lb-ft/s (746 J), respectively.

5.1.4 Rim Pull (RP)

This is the total force, in pounds (Newtons), which is available at the outer (rolling) radius of the tractor drive tires for the transmission of engine torque to the surface on which the tires rotate. Rim pull (RP) can be expressed as:

$$RP = \frac{T \times R \times e \times C}{r}$$

where:

T = gross engine torque, pound-feet (Newton meters)

C = correction factor for engine torque to determine net torque available at engine flywheel

R = overall gear reduction ratio of tractor drivetrain

e = mechanical efficiency of drivetrain, generally = 0.85

r = drive tire rolling radius, feet (meters)

5.2 Tow Vehicle - Weight and Traction

5.2.1 Weight

The ability of a tow vehicle with sufficient horsepower to impart motion to a given load without slipping its wheels is dependent upon the weight of the tow vehicle supported by the driving wheels. When the resistance to motion has been defined for the specific design situation, the weight required to allow the tow vehicle to develop the drawbar pull necessary to accomplish the desired motion with a given coefficient of friction can be determined.

5.2.2 Traction

Traction capabilities can be modified to match changing friction coefficients by the addition (or subtraction) of ballast to the tow vehicle. Consideration must be made for additional (less) available horsepower at a later date if the ballast of the tractor is to be increased (decreased) and it is desired to maintain the same performance. Wheel slippage may also be alleviated by the specification of "limited slip" differentials to transfer the available torque to the wheel that is not slipping.

5.3 Tractive Effort (TE)

Assuming adequate rim pull is available, TE is the maximum force in pounds (Newtons) which can be exerted by the tractor at the coupler to produce towing motion without slipping the drive wheels. It is a function of the portion of the tractor weight supported by the drive wheels, the tractor wheel base dimension, the effective height, above ground level, of the tow coupler, and the coefficient of traction between the tractor tires and the driving surface and may be expressed as:

$$TE = u \left[\frac{GVW_R \times WB}{WB - u(h)} \right] = (X)(u) \left[\frac{GVW \times WB}{WB - u(h)} \right]$$

where:

GVW = gross vehicle weight of tractor, pounds (kilograms)

GVW_R = portion of tractor gross vehicle weight supported by rear drive wheels, pounds (kilograms)

WB = tractor wheel base, inches (meters)