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(R) Nose Gear Towbarless Tow Vehicle Basic Test Requirements

RATIONALE

Towbarless towing has been practiced for over 20 years. During this period airframers as well as towbarless vehicle manufacturers have acquired many data and experience. In the light of this experience test complexity has been reduced and updated in this document while keeping the same level of requirements.

FOREWORD

In this ARP, 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 thorough evaluation has shown them to be equivalent.

The testing requirements listed here within are minimum testing requirements and may not satisfy all of the airframe manufacturer’s requirements for tow vehicle assessment. Some airframe manufacturers have their own documents which are provided for tow vehicle assessment. Any additional test requirements from the airframe manufacturer’s documents shall be included in the test program for the given airframe

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http://www.sae.org/technical/standards/ARP5283A

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1. SCOPE

The purpose of this specification is to provide airplane operators and tow vehicle manufacturers with:

a. General design and operating requirements pertinent to test and evaluation of towbarless tow vehicles. Specific design requirements are provided in ARP4852 and ARP4853.

b. Test and evaluation requirements. The results of these test evaluations will determine if the loads induced by the tow vehicle will exceed the design loads of the nose gear, or are within the aircraft manufacturer's limits so that they do not affect the certified safe limit of the nose gear. The results of these test evaluations will also determine if a stability problem may occur during pushback and/or maintenance towing operations with the tested airplane/tow vehicle combination.

This document specifies general test requirements and a test evaluation procedure for towbarless tow vehicles (TLTV) intended for pushback and maintenance towing only. It is not meant for dispatch (operational) towing (see definitions in Section 3). Dispatch towing imposes more fatigue cycles on nose gears and structure due to additional passenger, cargo, and fuel loads, as well as more starts, stops and turns. Airframe manufacturers may require submittal of test results for evaluation or may provide information 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 than contained in this specification.

TLTV manufacturers may elect to prepare and provide customers or regulatory agencies with a "Certificate of Compliance" or equivalent documentation as evidence that successful testing and evaluation of a specific tow vehicle/airplane type combination has been completed in accordance with this ARP and/or the applicable detailed airframe manufacturer's documentation. This certification will allow usage of the vehicle on specifically designated airplane model types. The certificate should be established under an appropriate quality control program meeting the requirements of ISO 9000 Series or equivalent.

This specification requires that the TLTVs under consideration be maintained and operated in a serviceable condition. In addition, the vehicle to airplane interface protection system shall be calibrated periodically. This information is defined in ARP5284 and ARP5285.

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

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 EASA Publications (Regulatory - Europe)

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

Certification Specifications for Large Aeroplanes CS-25, paragraph CS 25.301(a) Loads and CS25.509 Towing Loads

Certification Specifications for Large Aeroplanes CS-25, paragraph CS 25.745(d) Nose Wheel Steering and Associated Acceptable Means of Compliance CS 25.745(d)

2.3 Airframe Manufacturer's Publications

2.3.1 Airbus

Supplemental documentation or test criteria information is available by contacting Airbus, mailto:airport.compatibility@airbus.com .

2.3.2 Boeing

Available from Boeing, Customer Services and Material Support (CSMS), P.O. Box 3707, Seattle, WA. Fax: (206) 544-9074, Phone: (206) 544-9366.

D6-56872, "Towbarless Towing Vehicle Assessment Criteria"

767-SL-09-002-E Service Letter, "Towbarless Towing" (Basic document number is the same. First 3 digits vary for other airplane models) (Some models have SL-09-001 and others have SL-09-002, revision letter subject to change).

Facility and Equipment Planning Document (document numbers and content vary for different Boeing models)

2.3.3 McDonnell-Douglas

Supplemental documentation by contacting Boeing DSM - Long Beach at Fax: (206) 766-5683 or Phone: (562) 593-6996.

2.4 International Standards

Available from ANSI, 25W 43rd St, New York NY 10036-8002, Tel: 212-642-4900, www.ansi.org, or International Organization for Standardization, 1 rue de Varembe, Case Postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org, or any of the national standardisation institutes

ISO 20683-1, Aircraft ground equipment - Design, test and maintenance 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 for towbarless towing vehicles (TLTV) interfaced with nose-landing gear - Part 2: Regional aircraft

2.5 Definitions

PUSHBACK: Moving a fully loaded aircraft (up to Maximum Ramp Weight (MRW)) from the parking position to the taxiway. Movement includes; pushback with turn, a stop, and short tow forward to align aircraft and nose wheels. Engines may or may not be operating. Airplane movement is similar to a conventional pushback operation with a towbar.

MAINTENANCE TOWING: The movement of an airplane for maintenance/remote parking purposes (e.g., from the gate to a maintenance hangar). Aircraft is typically unloaded with minimal fuel load.

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. The movement may cover several kilometers with speeds up to 32 km/h (20 mph), with several starts, stops and turns. Replaces typical taxiing operations prior to takeoff and may impose greater loads on nose landing gear and structure due to numerous starts, stops and turns.

NOTE: In the definition 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.

OPERATIONAL LIMITS: Fore/Aft, torsional, or angular limits which are less than the maximum limits established by the airframe manufacturer.

MAXIMUM LIMITS: Fore/aft, torsional, or angular limits established by airframe manufacturers 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.

DRAG LOAD/TOW FORCE: Total force, from the tow vehicle on the nose gear tires in the fore and aft axis of the tow vehicle, parallel to the ground.

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

OVERSTEER: Exceedence of 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).

SNUBBING: Sudden relief and reapplication of acceleration/deceleration loads when TLTV and aircraft are in motion.

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

3. PART I - GENERAL REQUIREMENTS

Part I of this specification presents design and operational considerations considered pertinent to test and evaluation of TLTVs. Vehicle manufacturers should also refer to ARP4852 and ARP4853 for other design information. General operating information is provided per ARP5285.

The vehicle manufacturer/operator shall comply with the tests specified in this document and the approval procedure shall be in accordance with the airframe manufacturer's test and evaluation specification. In certain cases, a towing test with stress and load measurements may be requested by the airframe manufacturer.

3.1 Pick-Up and Holding System

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.

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.

3.2 Retention Features

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 pickup 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.

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).

3.3 Safety Equipment, Features and Operation

The following information is considered pertinent for TLTV test and evaluation purposes. Additional information is contained in ARP4852, ARP4853, ARP5284, and ARP5285.

3.3.1 Pick-Up, Release and Associated Loads

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 must be ensured.

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 (reference 4.1). 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.

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 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”.

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.

Should aircraft selection be made, this would be made prior to the pick-up or towing/push-back phase of operations sequence. If the incorrect aircraft type is selected, a safety system in the vehicle shall inhibit further operation.

3.3.2 Acceleration, Deceleration and Associated Loads

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 item (a) below.

The vehicle’s maximum pulling and braking forces shall be limited to the maximum permissible nose landing gear loads of the aircraft. One or two limiters may be used under the following conditions:

a. A maximum load limiter, designed to loads specified by the airframe manufacturer, shall limit the loads applied to the nose gear during all operations. It shall not be possible to override the limiter, except if the vehicle is equipped with an emergency braking system.

b. The control of the maximum loads may be based either on a limitation of the acceleration/deceleration or on a limitation of the tow force/brake force.

If 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.

3.3.3 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.

Emergency braking activation shall be well protected against inadvertent triggering.

3.3.4 Oversteer Limits

Oversteer angular and torsional limits are not to be exceeded. Oversteer testing should not be performed on the airplane.

For operations, EASA may require oversteer alert systems on the airplane or the TLTV. If a TLTV is designed to meet proposed EASA requirements, then testing to demonstrate vehicle oversteer limit alerting 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.

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 that is provided by traditional towbar connections.

3.4 Test Operations

3.4.1 Snubbing and Jerking

Avoid snubbing and jerking effects or movements during testing.

3.4.2 Vibrations

If severe or abnormal vibrations occur, discontinue testing and determine cause.

3.4.3 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 load 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 airline's or airframe manufacturer's maintenance manual and operational procedures must be followed.

3.4.4 Stability

Attention shall be paid to aircraft stability. Stability may be affected by aircraft type, weight, center of gravity location, weather conditions, pavement roughness, and slope.

Stability shall be demonstrated by tests in accordance with the airframe manufacturer's documentation. The testing shall account for or consider the full speed range capability of the vehicle.

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

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.

Proper operational procedures as defined in ARP5285 or airframe manufacturer's recommendations shall be followed to ensure vehicle and airplane stability.

3.5 Nose Gear Steering Angle Limit

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.

3.6 Placard Warning and Unusual Configurations

Unusual TLTV configurations shall be referred to the airframe manufacturer. Limitations and warnings imposed by all conditions shall be placarded for information to the tow vehicle driver, such as:

a. Maximum speed versus turning radius.

b. Warning about maximum towing angle, etc.

4. PART II - TEST SPECIFICATION

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

In case of vehicles for which only partial qualification is required (e.g. pushback only), contact the airframe manufacturer for a possible exception to these requirements.

4.1 Objectives

The objectives of the tests are:

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 TLTV driver 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 type of operations for which qualification is requested.

4.2 Aircraft Configuration

Before any calibration or testing is accomplished, all landing gear must be properly serviced.

Aircraft weights, light and heavy gross weight and C.G. position for testing shall be in accordance with the requirements in the calibration and test requirements sections (5.3 and 5.4), and the airframe manufacturer's documentation. The airframe manufacturer should be consulted for any deviation to documented weights.

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

4.3 Calibration

4.3.1 General

Tests may be performed with an instrumented aircraft or an instrumented towing vehicle. Calibration of both are discussed in this section (reference 5.4.1 for restrictions in the use of instrumented vehicles).

a. To measure fore and aft tow loads on the nose landing gear, strain gages must be installed at nose gear locations specified by the airframe manufacturer (drag brace or other components). Calibration of the strain gages is accomplished by pushing and pulling the nose gear with known tow loads.

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

Once the strain gages 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 gages.

4.3.2 Aircraft Calibration

a. 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 Figure 1 as an example). The slope of the line is the calibration factor.

b. Instrumentation requirements for calibration:

    1. Nose gear measured output in microstrain

    2. Calibrated input tow load (kN or KIPS)

    3. Both the strain gages and strain gage 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 gages, bonding material, gage protection, etc., should take into account the type of material being gaged and any possible adverse conditions that could occur during testing.

c. Calibration:

    1. Before any calibration or testing is accomplished all landing gear must be properly serviced.

    2. Calibration tests may be accomplished at weights between OWE (Operational Weight Empty) and the specified test gross weight (STGW) for the particular model aircraft being tested, to be specified by the airframe manufacturer. If tests are to be conducted at more than one airplane weight and/or cg, the airplane calibration should be completed at each weight to determine the appropriate calibration factor for nose gear stroke, when the calibration factor cannot be obtained analytically.

    3. Calibration shall be performed with the aircraft and wheels placed on a level and smooth surface.

    4. Immediately prior to calibration testing, record the nose gear strut extension.

    5. All calibration tests shall be performed with all main gear tires chocked and with the aircraft parking brake set.

    6. Using the known tow load input, push and pull the nose while plotting microstrain versus tow load. Perform two push/pull tests at 0 degrees nose gear steering angle.

    7. For 0 degrees 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.

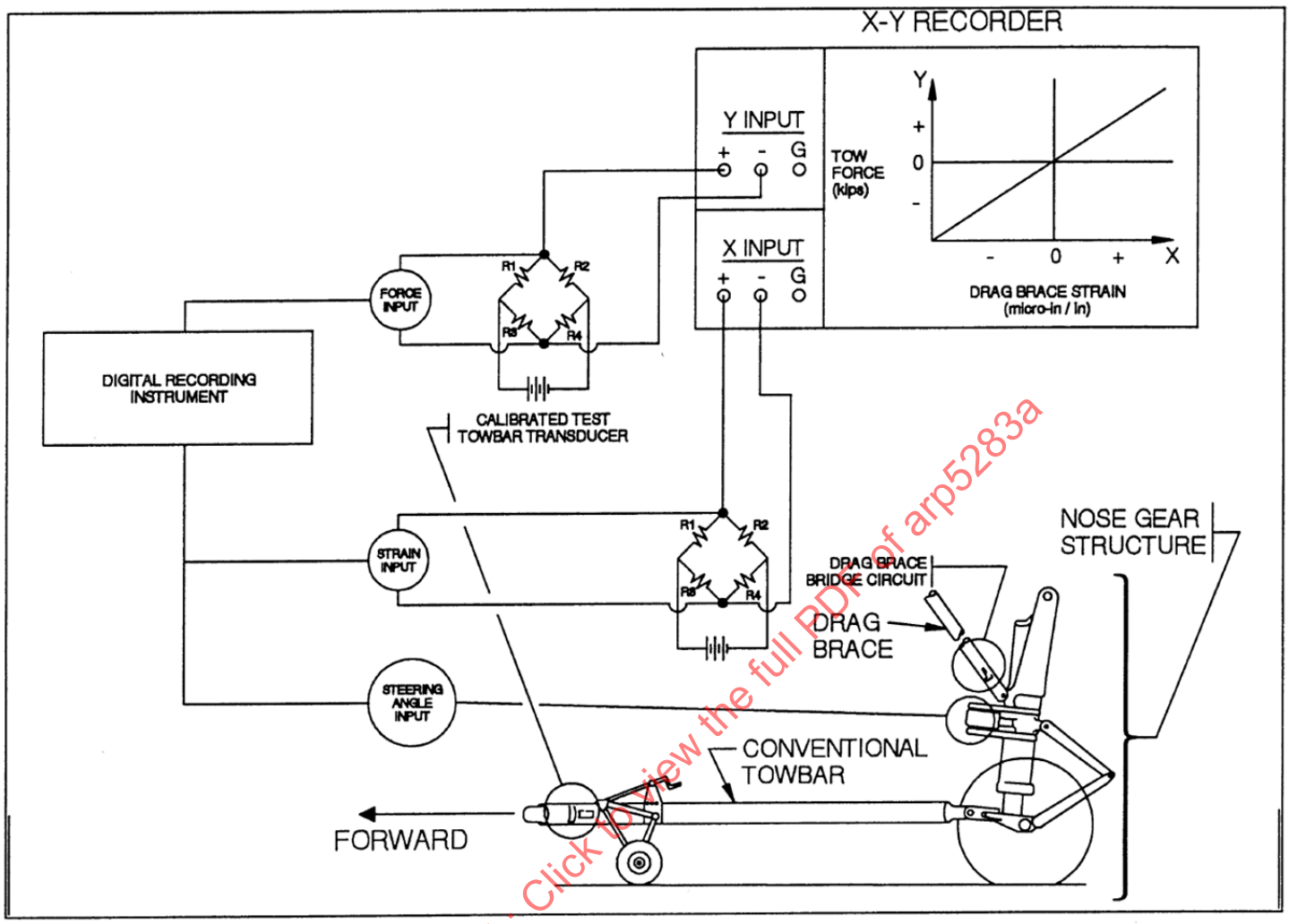

FIGURE 1 - TOW LOAD

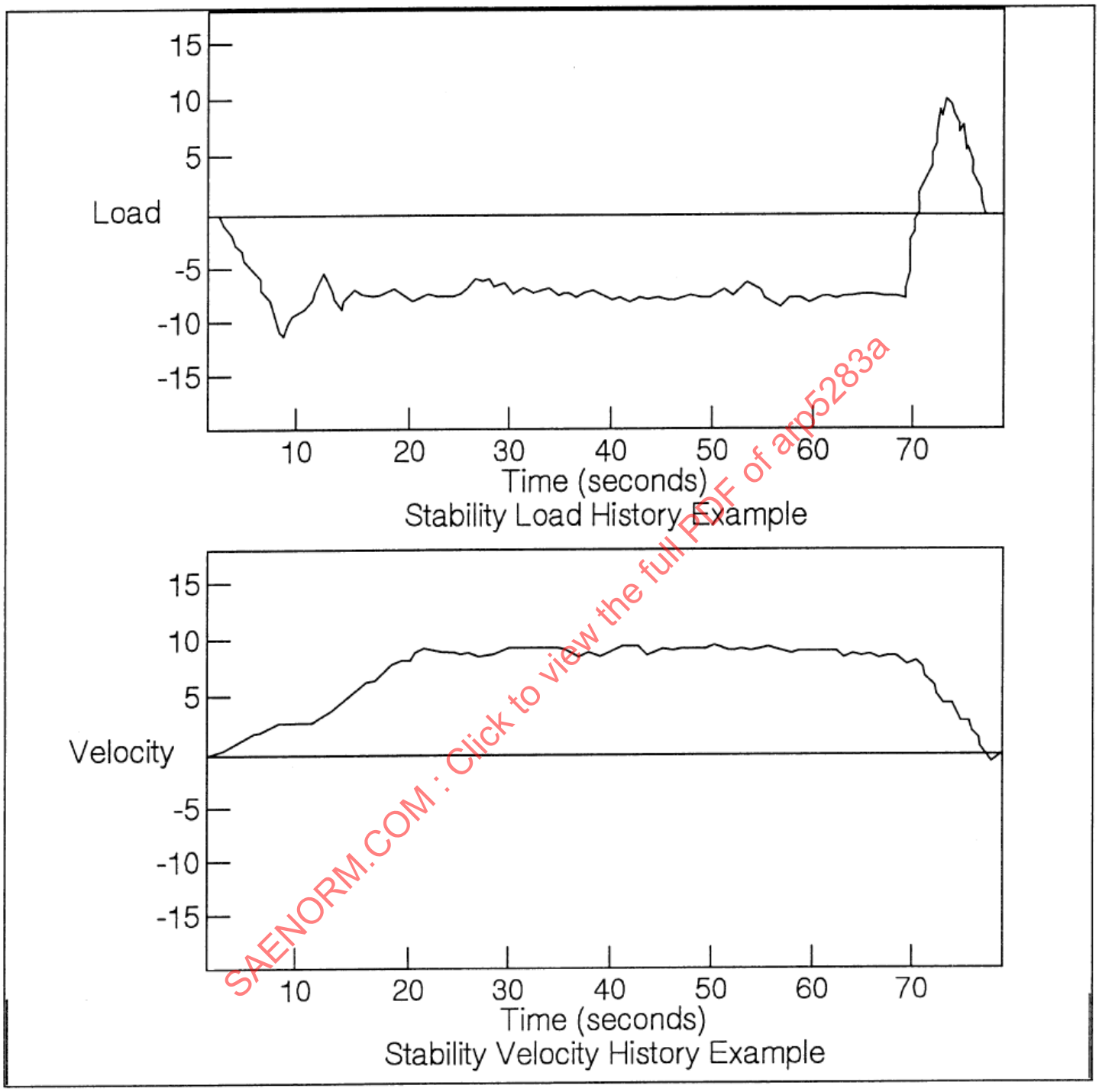

FIGURE 2 - TYPICAL LOAD AND VELOCITY TIME HISTORIES

8. The calibration plots must be linear. If the two calibration plots at 0 degrees 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 must be made.

9. If the criteria through item 8. are satisfied, use the relevant calibration factor to convert strain gage measurements directly to tow load during towbarless vehicle testing.

4.3.3 TLTV Calibration

a. 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 1). The slope of this line is the calibration factor.

b. Instrumentation requirements for calibration:

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

c. Calibration:

1. The calibration procedure is to be specified by the tow vehicle manufacturer.

2. 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.

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

4. 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 nonlinearities exist in the calibration plots, appropriate adjustments to the test instruments must be made.

5. If the criteria through item 4. are satisfied, use the calibration factor to convert strain gage directly to tow load during towbarless vehicle testing.

4.3.4 Oversteer 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 damage to nose landing gears or aircraft structure. Maximum allowable limits are determined by the airframe manufacturer's documentation.

4.4 Test Requirements

4.4.1 General

Prior to tests

a. A check shall be performed on the clearances between any part of the aircraft and tow vehicle structural parts as described in 4.2.

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

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

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

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

All tests shall be performed on typical airport taxiways.