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AIR-TO-AIR (AERIAL) REFUELLING EQUIPMENT: BOOM-RECEPTACLE SYSTEM AND INTERFACE REQUIREMENTS

Edition B, Version 1
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NORTH ATLANTIC TREATY ORGANIZATION

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NATO LETTER OF PROMULGATION

16 June 2022

1. The enclosed Allied Tactical Publication ATP-3.3.4.5, Edition B, Version 1, AIR-TO-AIR (AERIAL) REFUELLING EQUIPMENT: BOOM-RECEPTACLE SYSTEM AND INTERFACE REQUIREMENTS, which has been approved by the nations in the Military Committee Air Standardization Board (MCASB), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 7191.

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Major General, GRC (A)
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
GRC	HAF does not plan to modify existing receiver F-16 and F-4 A/C to comply with STANAG 7191.
NOR	The Royal Norwegian Air Force (RNoAF) only has receiver aircrafts, F16A/B and F35A, and can only comply with Chapter 2 "Receiver Receptacle Systems" of ATP - 3.3.4.5. The RNoAF does not plan to modify existing aircraft to comply with >STANAGG 7191 Ed 2. The national supplement of ATP-3.3.4.2 (C) "RNOAF Standards Related Document (SRD)" is the applicable document for Norwegian fighter aircraft compliance with tanker aircrafts.
USA	USAF equipment in use or projected for USAF use and does not obligate the USAF to undertake purchasing new equipment to meet this NATO standard (AF/JAO).
FRA	Will apply to future equipment only.
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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SUMMARY

The purpose of this ARSAG document is to provide the aerial refueling (AR) systems recommended requirements and to standardize the interfaces required to engage in boom-receptacle refueling operations with a centerline refueling boom, to facilitate aerial refueling between aircraft of cooperating forces. ARSAG Document No. 02-88-12R, Aerial Refueling Equipment: Boom-Receptacle System and Interface Requirements Recommendations, Dated 11 May 2018, is currently in the NATO revision process to update NATO ATP-3.3.4.5 (STANAG 7191). This R2 revision to the document, dated 12 September 2019, was created because of aerial refueling problems uncovered an inadequate ATP-3.3.4.5 requirement for coupled push-pull loads. This made it necessary to create the R2 revision to ARSAG document. Several other minor revisions are included. The nozzle axial rotation requirement was relaxed slightly to a more practical ±3 degrees. The ultimate area loads requirement on the receiver aircraft was corrected from longitudinal to lateral. Two other minor wording revisions were also made, to clarify the intent of the requirements. NATO has agreed to include this new R2 revision in the current update process for ATP-3.3.4.5. This ARSAG document will be released to the USAF for release as a DTIC document. This document will also be transmitted to NATO JAPCC following USAF security review, with the recommendation that it be used to revise NATO ATP 3.3.4.5 (STANAG 7191).

ACKNOWLEDGEMENTS

This ARSAG Recommended Requirements document owes its existence to the work and perseverance of many people, starting with Dexter Kalt, who saw the urgent need for a set of requirements that would help standardize the operating interface between all refueling boom equipped tanker aircraft and all refueling receptacle equipped receiver aircraft. The initial release of this ARSAG requirements document was provided to NATO and with minor revisions was released as NATO requirements document ATP-3.3.4.5 (STANAG 7191). NATO later requested that ARSAG prepare a revision to the requirements for the tri-annual update to NATO ATP-3.3.4.5. The R1 revision owes its existence to the following major contributors: Mark Burket, Technical Advisor, USAF; Harry Slusher, Document Manager, Boeing; Bruno Martinez, Document Review Team Manager, Airbus Military; Robert Tipton, Working Group 6 Lead, Lockheed Martin; Dave Benson, JSB Chair, USAF; Matthew Latham, Parker Hannifin and many other contributors. The following people made major contributions to this R2 revision: Dave Benson, USAF; Sherry Evans, Boeing; Andrew Ferguson, USAF; Jessica Graham, USAF; Justin Hatcher, Boeing; Bruno Martinez, Airbus; Thomas (TJ) Pitsor, USAF; and Harry Slusher, Boeing.

RELATED DOCUMENTS

1. STANAG 7191 Air-to-Air (Aerial) Refuelling Equipment and Interface Requirements, Edition 1, 3 June 2013.
2. NATO Standard ATP-3.3.4.5 Air-to-Air (Aerial) Refuelling Equipment: Boom-Receptacle Systems and Interface Requirements Edition A Version 1 June 2013
3. STANAG 3971 – AIR-TO-AIR REFUELLING - ATP-3.3.4.2
4. STANAG 3447 – AIR-TO-AIR (AERIAL) REFUELLING EQUIPMENT: PROBE-DROGUE INTERFACE CHARACTERISTICS - ATP-3.3.4.6
5. Joint Service Specification Guide (JSSG) JSSG 2009 - Air Vehicles Subsystems, Oct. 30, 1998 or later revision.6.
6. Military Standards MS-27604 -Nozzle, Universal Aerial Refueling Tanker Boom, dated 1968
7. Aerial Refueling Systems Advisory Group (ARSAG) 03-00-03R - Aerial Refueling Pressures: Definitions and Terms, Design and Verification Guidance dated 21 Sept. 2010 or later revision.
8. MIL-STD-464C, 1 December 2010, Department of Defense, Interface Standard, Electromagnetic Environmental Effects, Requirements for Systems
9. STANAG 3614 ED. 5 (2002) Electromagnetic Effects (E3) Requirements for Aircraft Systems and Equipment
10. Aerial Refueling Systems Advisory Group (ARSAG) Aerial Refueling Boom/Receptacle Guide, Document Number 20-08-17, date 28 July 2017. DTIC No. AD1048313
11. MIL-STD-461G, 11 December 2015, Department of Defense, Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
12. Aerial Refueling Lighting Study, Final Report, Sept. 15, 2005, University of Dayton Research Institute, USAF Sponsor
13. Handling Qualities and Pilot Evaluation, Robert P. Harper and George E. Cooper, 1984 Wright Brothers Lectureship in Aeronautics
14. SAE Aerospace Recommended Practice (ARP) 694B, Aerial Refueling Lights-Design Criteria, Revised 2004-1.

DEFINITION OF TERMS

Pressure (Stiff boom) refueling – A procedure for refueling when the receiver receptacle latches are failed in the open position. This involves applying extend force on the boom to keep the nozzle fully seated in the receptacle.

Disconnect envelope and aerial refueling envelope – The maximum and minimum pitch, azimuth (yaw or roll) and extension where aerial refueling can be accomplished.

Control envelope – the limits of controllable boom operation.

Targeted tanker(s) - The group of tankers that the receiver is planning to be aerial refueled by.

Targeted receiver(s) – The group of receivers that the tanker is planning to aerial refuel.

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CHAPTER 1 TANKER BOOM SYSTEMS

See the ARSAG Boom/Receptacle Guidance Document, Related Document 10, for additional information, background and guidance.

1.1. NOZZLE DIMENSIONS

The mating dimensions for the boom nozzle shall conform to Annex A (A-1 through A-4). The nozzle seal surface, which interfaces with the seal in the receptacle sliding valve, shall be as defined by dimensions R, S and T, as illustrated in Figure A-1. The dimension from the nozzle tip plane to the centerline of the ball joint shall be 11 inches (279.4mm), as shown in Figure A-3. The nozzle shall be compatible with latches defined in Section 2.1.5 Receptacle Latches.

1.2. NOZZLE ANGULAR DEFLECTION AND BALL JOINT CONFIGURATION

The boom nozzle shall have the angular deflection capability shown in Figure A-3. The ball joint of the nozzle assembly shall return to within a 1 degree cone angle between the nozzle centerline and the boom centerline after the nozzle is deflected to any point within the 60 degree cone, when the nozzle is not in contact with the receiver aircraft. This requirement shall be met throughout the boom deployed envelope [airspeed, Mach, altitude, pitch, azimuth or roll and boom wet (defined as 10 psig fuel pressure; which represents the worst case fuel head pressure at maximum boom extension and lower elevation limit without fuel pumping pressure) or dry].

1.2.1. Nozzle Ball Joint Configuration

The seal ring of the nozzle ball joint shall be part of the nozzle tip, as shown in Figure A-3, to protect the sealing surface of the ball joint and to minimize the nozzle deflection when the nozzle is placed on the receiver aircraft receptacle slipway, preventing the nozzle tip from deflecting and striking the upper lip of the receiver aircraft receptacle.

1.3. NOZZLE/TELESCOPIC TUBE ENVELOPE

The boom nozzle shall not exceed the maximum nozzle envelope in Figure C-1.

1.4. MAXIMUM BOOM ENVELOPE

No portion of the boom shall extend beyond the maximum boom envelope in Figure C-2.

1.5. NOZZLE AXIAL ROTATION

The boom system shall allow the nozzle to rotate axially ± 20 degrees minimum, with respect to the centerline of the boom, to accommodate receiver aircraft motions, as shown in Figure A-3. Additional axial rotation shall be provided to accommodate roll induced by the boom design, up to the mechanical limits of the boom. The boom system shall return the nozzle assembly to the zero degree position (± 3 degrees) with respect to the vertical plane of the boom after the nozzle is rotated to any position from 10 degrees up to the maximum travel and released. This requirement shall be met throughout the boom deployed envelope (airspeed, Mach, altitude, pitch, azimuth or roll with boom wet or dry).

1.6. BOOM ENVELOPE

The boom system shall meet the following envelope requirements at all airspeeds, altitudes and Mach numbers within the boom refueling envelope:

1.6.1. Deployed Position

The nominal boom deployed position shall be at a 30 degree pitch angle with respect to the tanker waterline, zero degree azimuth or roll and the midpoint of the boom extension disconnect envelope.

1.6.2. Contact Envelope

The boom contact envelope shall be at minimum the Contact Envelope volume defined in Annex F (Figure F-1 and Table F-1), centered at the nominal deploy position.

1.6.3. Disconnect Envelope

The boom disconnect envelope volume shall be at minimum the disconnect envelope volume defined in Annex F (Figure F-1 and Table F-1), centered at the nominal deploy position. The inner disconnect limit shall be at least 60” (1,524 mm) from the fully retracted position of the boom. The outer disconnect limit shall be at least 10” (254 mm) from the fully extended position of the boom, if the boom system includes a rate disconnect capability with adjustable receiver specific disconnect delays or full time automatic independent disconnect, and at least 30” (762 mm) if not equipped with those capabilities.

1.6.4. Control Envelope

The boom shall be fully controllable throughout the boom disconnect envelope.

1.6.5. Mechanical Envelope

The boom mechanical or kinematic limits, beyond which tanker damage may occur, shall be greater than the boom control envelope.

1.7. BOOM CONTROL SYSTEM

The boom control system shall meet the following requirements, at all airspeeds, altitudes and Mach numbers within the boom refueling envelope. Provisions shall be provided to prevent control malfunctions when the boom control system is in an inconsistent mode (the boom control system is in free flight mode and the boom is actually coupled or when the boom control system is in the coupled mode and the boom is actually in free flight).

1.7.1. Control Authority

1.7.1.1. Manual

The boom shall be capable of following the receiver aircraft throughout the full disconnect envelope without imposing radial loads on the receiver aircraft receptacle.

1.7.1.2. Automatic

An Automatic Load Alleviation System (ALAS) shall be capable of controlling the boom so that the nozzle can retract without binding in the receptacle and without sudden boom movements which could damage the receiver aircraft.

1.7.2. Boom Flying Qualities

The boom shall achieve Level l HQ (Handling Qualities) as defined by the Cooper-Harper Rating system (or equivalent) for contacts within the contact envelope in calm air to light turbulence level. See Related Document 13 for further information.

1.8. TELESCOPING SYSTEM

1.8.1. Coupled Push-Pull Loads

While coupled to a receiver aircraft at all telescope extensions, the boom system shall allow telescoping in both extension and retraction at rates up to 6.5 ft/sec (1.98 m/sec) for any operational fuel pressure up to 55 psig (379.2 kilopascals) and the range of operational flow rates. The boom shall resist the push and pull forces generated by the receiver aircraft, acting along the longitudinal axis of the boom, while not exceeding the following loads.

1.8.1.1. Normal Loads (Not Commanded) While in Contact

The boom system shall maintain axial load at the nozzle per Figure G-1 for breakout and receiver motion up to 6.5 ft/sec (1.98 m/sec), with axial load increasing from the breakout load, with no decrease after breakout, in a smooth, continuous manner relative to the increase in telescope rate during receiver motion, while in contact with a receiver within the boom disconnect envelope, and without operator telescope stick input.

1.8.1.2. Loads with Extension or Retraction Commanded While In Contact

The boom system shall limit commanded axial load to less than 3800 lbs. (16,903 Newtons) in compression and tension for receiver motion up to 6.5 ft/sec (1.98 m/sec) while in contact with a receiver within the boom disconnect envelope. The axial load shall be proportional to operator stick or system input.

1.8.1.3. Pressure (Stiff Boom) Refueling

For pressure (stiff boom) refueling, when the receiver aircraft's receptacle toggles have failed to the open position and cannot lock the nozzle into the receptacle, the tanker boom operator must be able to command enough extension force to overcome the nozzle poppet spring, the receptacle sliding valve spring and the fuel pressure acting on the receptacle seal diameter. The boom nozzle force shall be proportional to the operator stick or system input, to prevent fuel leakage without pushing the receiver. The boom system, with extension commanded, shall be capable of maintaining axial loads from 0 to at least 1,000 lbs. (4,448 Newtons) of compressive force at the nozzle for pressure refueling for receiver motion up to 3.0 ft/sec (0.91 m/sec) while in contact with a receiver within the boom disconnect envelope. Maximum loads as per 1.8.1.2 remains applicable.

1.8.2. Telescoping Rates

In free flight, with any combination of aerial refueling pumps operating or not operating, the boom system shall be capable of extending the telescopic tube assembly at a variable rate from 0 to a maximum of 4 ft. /sec (1.22 m/sec), and retracting the telescopic tube at a variable rate from 0 to a minimum of 10 ft. /sec (3.05 m/sec).

1.8.3. Telescoping Control System Failure

The telescopic control system shall be designed so that no single failure will allow the telescopic tube to extend/retract in an uncontrolled manner.

1.9. INDEPENDENT DISCONNECT

The boom system shall have a redundant disconnect capability, independent of the receiver aircraft's toggle latches. The independent disconnect mechanism shall have a maximum release response time of 0.3 seconds from operator initiation to full latch retract. The independent disconnect shall function in all expected operational environmental conditions within the airspeed/altitude envelope of the boom system. The independent disconnect mechanism shall be designed to remain in the disconnect configuration until the nozzle is retracted from the receptacle. The boom nozzle shall provide a clear path for the engaged receptacle latch toggles to move freely aft when the independent disconnect system is activated. See Annex A, Figure A-2c.

1.10. NOZZLE SHOCK ABSORBER

The boom system shall have sufficient energy absorption capability to absorb the kinetic energy of the complete telescopic tube (beam) assembly, full of fuel, at the maximum elevation angle within the contact envelope, and extending at the maximum extend velocity of 4 ft. /sec (1.22 m/sec). The maximum impact load shall be limited to the receptacle limit compression load as defined in paragraph 2.4.1.

1.11. SIGNAL SYSTEM AND SECURE COMMUNICATION

The tanker boom system shall be able to send disconnect and voice signal communications, and receive voice and receptacle system status signal communications through its nozzle induction coil when coupled to a receiver aircraft's receptacle as defined in Annex B or equivalent.

The nozzle shall be inserted and latched into the receiver aircraft's receptacle and the boom nozzle rotated axially to its maximum operational travel within the receptacle (clockwise or counterclockwise) with the maximum air gap attainable with the most adverse tolerances in the receptacle and the nozzle.

1.11.1. Signal Advance

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1.11.2. Nozzle Induction Coil

Deleted

1.11.3. Signal Protocol

When the nozzle is in the seated position in the receptacle:

1.11.3.1. Signal Receiving

The system shall detect a pulse coming from the receptacle when the receptacle coil is excited between 18 Volts and 30 Volts during a minimum of 3 milliseconds.

1.11.3.2. Signal Sending

When transmitting the pulse, the nozzle coil:

a. shall induce in the receptacle coil an OPERATING pulse as per FIGURE B-1 & TABLE B-1
b. shall not induce in the receptacle coil a NON-OPERATING pulse as per FIGURE B-1 & TABLE B-1

1.11.4. Signal Amplifier

The signal amplifier must provide electrical signal pulse and voice communication equivalent to Class 4 signal amplifier per MIL-DTL-38449D.

1.12. BOOM AND TANKER FUEL SYSTEM

1.12.1. Delivery Pressure

The tanker regulated delivery operating pressure shall not exceed 55 psig (379.2 kilopascals) under all receiver valve combinations and relative motion between the tanker and receiver, all steady state fuel flow rates from zero gpm to the maximum design flow rate of the tanker, measured within 31 inches (788 mm) of the boom nozzle inlet, upstream of the ball joint.

1.12.2. Pressure Transients and Surges

Pressure transients and surges generated by the tanker and/or receiver aircraft, shall not exceed the proof pressure of the tanker and the receiver aircraft.

1.12.3. Fuel Pressure Regulation

Failure of the fuel pressure regulation system of the tanker shall be annunciated to the boom operator, including the actual measured pressure during fuel transfer to the receiver aircraft, and shall remain displayed after the contact.

1.12.4. External Fuel Spillage

1.12.4.1. Boom Leakage, Disconnected

There shall be no measurable leakage from the boom (insufficient to form a drop) with fuel pressures from 0 to 55 psig (379.2 kilopascals) prior to connection with the receiver.

1.12.4.2. Boom Leakage, Connected to Receiver

The boom shall have no measureable external fuel leakage (insufficient to form a drop) during static head or fuel transfer, with fuel delivery pressures from 0 to 55 psig (379.2 kilopascals) when the nozzle is rotated around a cone angle as defined in Annex A (Figure A-3) with the nozzle engaged in a receptacle that complies with Annex D (Page D-1).

1.12.4.3. Boom External Spillage, Normal Disconnect

During normal initiated disconnect, center of envelope, pumps off, at 2 ft./sec. (0.61 meters/sec.) nozzle separation, a maximum of 25cc external fuel spillage shall be permitted, with the nozzle engaged in a receptacle that complies with Annex D (Page D-1).

1.12.4.4. Boom External Spillage, Emergency Disconnect

During emergency disconnect (corners of envelope, pumps on, at the maximum boom flow rate, and the corresponding fuel pressure, up to 10 ft./sec (3.05 meters/sec) nozzle separation) a maximum of 200cc external fuel spillage shall be permitted, with the nozzle engaged in a receptacle that complies with Annex D (Page D-1).

1.13. BOOM SYSTEM STRUCTURAL DESIGN CRITERIA

1.13.1. Boom Coupled Design Loads

The boom and the aircraft support structure shall withstand the normal boom airloads (without turbulence) and reactions resulting from the following combination of conditions, without detrimental permanent deformation:

1.13.1.1. Envelope

Boom coupled to the receiver aircraft with the boom anywhere within the boom disconnect envelope (pitch, azimuth or roll, extension).

1.13.1.2. Airspeeds

All airspeeds within the boom airspeed/altitude refueling envelope, up to the boom coupled dive speed.

1.13.1.3. Altitudes

All altitudes within the boom airspeed/altitude refueling envelope.

1.13.1.4. Control System Failure

The boom control system failed in its most adverse mode.

1.13.1.5. Ultimate Loads

The boom shall not fail under the above loads with a 1.5 ultimate load factor.

1.13.2. Axial Loads

The boom and aircraft support structure, while within the boom Disconnect Envelope, and the nozzle ball joint not rotated against its stops, shall be designed for the maximum axial ultimate airloads plus the following:

1.13.2.1. Fully Extended

With the telescopic tube fully extended:

1.13.2.1.1. Tension

16,166 pounds-force (71,910 Newtons) Ultimate tension.

1.13.2.1.2. Compression

The boom structure shall not collapse when subjected to 7,500 pounds-force (33,362 Newtons) Ultimate compression, when the telescopic tube is jammed.

1.13.2.2. Fully Retracted

With the telescopic tube fully retracted: 20,000 pounds-force (88,964 Newtons) Ultimate compression.

1.14. TANKER EXTERNAL LIGHTS

1.14.1. Anti-collision and Rendezvous Beacons

Beacons on the upper and lower fuselage shall be provided for collision avoidance and for rendezvous identification. Controls must permit selection of the desired code sequences to enable the receiver aircraft crew to identify the appropriately equipped tanker. In addition, all upper and lower fuselage beacons used during aerial refueling shall have independent on/off control, so that the lower beacons can be extinguished when operating as a tanker and the upper beacons extinguished when operating as a receiver.

1.14.2. External Lights

The tanker aircraft shall be provided with external lights to aid the receiver aircraft in locating and identifying the tanker aircraft at night, and to enable the receiver pilot to determine the geometry/definition of the tanker in all relative positions during the refueling operation, independent variable intensity dimming control shall be provided for each of the sets of external lights, except the anti-collision beacons, from “full intensity” to completely “off”. External lighting shall not blind or distract the air vehicle crew member(s) of the receiver or the tanker aircraft during the aerial refueling process.

1.14.3. Formation Lights

The tanker shall be equipped with formation lights on the sides of the forward and aft fuselage, the vertical tail and the wingtips, to aid waiting receiver aircraft in maintaining formation off the tanker. Variable intensity dimming control shall be provided from “full intensity” to completely “off”.

1.14.4. Visual Aids

The tanker shall provide visual aids to assist the receiver aircraft in achieving and maintaining the proper astern and contact positions with the tanker in day or night lighting conditions.

1.14.5. Boom Operator Visibility of Receiver Aircraft

The tanker aircraft shall provide clear visibility of the upper surface of the receiver aircraft, to enable the boom operator, whether direct view or with a vision system, to determine receiver aircraft geometry/definition, location of canopy, windshield, antennas and the rate and motion of the receiver, prior to and during refueling operations.

1.14.6. Boom Operator Visibility of Nozzle and Receptacle Slipway

The tanker aircraft shall provide clear visibility to enable the boom operator, whether direct view or with a vision system, to precisely determine the position of the nozzle relative to the receiver aircraft structure and receptacle slipway location.

1.14.7. Boom Marker Lights

Lights shall be provided to illuminate the extension markings on the boom telescopic tube, to enable the receiver pilot to determine the distance that the boom is extended.

1.15. VISUAL CUES

The boom operator, whether direct view or with a vision system, shall have sufficient visual cues to enable a successful contact with the receiver aircraft.

1.16. STATIC DISCHARGE

The boom and tanker systems must be installed in a manner to pass an electrical discharge, caused by the tanker/receiver connection, into the tanker's airframe. All tanker systems, including the boom system, shall meet their operational performance requirements when subjected to a 300 kilovolt discharge between the tanker boom nozzle and the receiver aircraft.

1.17. ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

The tanker aerial refueling (AR) system, including the boom nozzle and related components, boom signaling system and thru-the boom voice intercom system, shall be protected from electromagnetic interference from any tanker aircraft system.

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CHAPTER 2 RECEIVER RECEPTACLE SYSTEMS

See the ARSAG Boom/Receptacle Guidance Document, Related Document 10, for additional information, background and guidance.

2.1. RECEPTACLE INSTALLATION

2.1.1. Receptacle Installation Angle and Location

2.1.1.1. Installation Angle

The receptacle bore axis shall be positioned to provide alignment at contact with the tanker boom centerline, in the center of the contact envelope for all identified tankers. The installation angle shall be established using the following formula, with a tolerance of ± 1 degree:

$$X = 30 - (A+B)/2 + (C+D)/2$$

Where: X = receiver receptacle axial centerline angle with respect to the receiver aircraft waterline.

A = maximum receiver aircraft fuselage pitch angle, within the receiver's normal airspeed/altitude refueling range, including gross weight and external stores variations.

B = minimum receiver aircraft fuselage pitch angle, within the receiver's normal airspeed/altitude refueling range, including gross weight and external stores variations.

C = maximum tanker aircraft fuselage pitch angle, for all identified tankers, including gross weight variations, within the receiver's refueling speed range. Example values of "C" are provided in the Related Document 10, ARSAG Guidance Document Boom/Receptacle, Paragraph 10.1.2. These values must be determined by the receiver designer for the expected tanker/receiver combinations, at the planned refueling weight and speed ranges.

D = minimum tanker aircraft fuselage pitch angle, for all identified tankers, including gross weight variations, within the receiver's refueling speed range. Example values of "D" are provided in the Related Document 10, ARSAG Guidance Document Boom/Receptacle, Paragraph 10.1.2. These values must be determined by the receiver designer for the expected tanker/receiver combinations, at the planned refueling weight and speed ranges.

2.1.2. Receptacle Dimensions

The mating dimensions for the receptacle shall conform to Annex D.

2.1.3. Clearance Requirements

2.1.3.1. Clear Path

The clear path area is defined by a plane parallel to the fuselage skin at the receptacle leading edge. Equipment that protrudes above the aircraft skin line shall not be installed within a clear path 5 feet (1,524 mm) long and 5 feet (1,524 mm) wide forward of and centered on the receptacle face and 2 feet (610 mm) long and 5 feet (1,524 mm) wide aft of and centered on the receptacle face, as shown in Figure C-3. Protuberances containing lights required by Paragraph 2.6.2 may be present, however they shall be no closer than 15 in (381 mm) from the forward edge of the slipway and no closer than 12 in. (305.8 mm) from the centerline of the receptacle. They shall not extend more than 2.00 in. (50.80 mm) above the clear path surface, and shall be protected against damage due to accidental boom nozzle strike.

2.1.3.2. Boom Pitch and Azimuth Clearance

No portion of the receiver aircraft shall extend into the clearance envelope defined by 15 degrees elevation from the forward edge of the Receiver Clear Path Area, as shown in Figure C-3 and ±30º azimuth from the forward outboard corners of the Receptacle Clear Path Area, as shown in Figure C-3.

2.1.3.3. Boom Lateral Clearance

No portion of the receiver aircraft shall extend above a 15 deg. laterally sloping surface starting at the outboard edge of the 5 ft. (1524 mm) wide Receptacle Clear Path Area as shown in Figure C-3. No portion of the receiver aircraft shall extend above a surface connecting the 15 degree forward sloping surface and the 15 degree lateral sloping surface.

2.1.3.4. Combined Receiver Boom Clearance Envelope

The above clear path, boom pitch, boom azimuth and lateral clearance requirements are shown combined for clarity in Figure C-3. No portion of the receiver aircraft shall extend beyond these combined surfaces, except the lights allowed in Paragraph 2.6.2.

2.1.4. Receptacle Contact Sensor

The receptacle shall incorporate a contact limit sensor. Contact shall be sensed between 0.75 and 1.00 inch of sliding valve travel, measured from the fully closed position, and shall have a minimum overtravel of 0.25 inch. The contact sensor shall be located at the 12 or 6 o'clock position of the receptacle.

2.1.5. Receptacle Latches

The receptacle shall be equipped with latches to hold the boom nozzle in the locked position.

2.1.5.1. Latch Dimensions

The latch dimensions shall be as shown in Figure D-3.

2.1.5.2. Latching Forces

The receiver aircraft's receptacle shall provide a minimum latching force of 4800 pounds (21,351 Newtons) and shall not exceed 9,412 pounds (41,877 Newtons) during a tension disconnect at a tanker/receiver aircraft separation rate of up to 10 ft./sec (3.05 meters/sec) in all expected operational environmental conditions within the airspeed/altitude envelope of the boom system.

2.1.5.3. Latch Failures

2.1.5.3.1. Fail Open

The receptacle latch failure mode shall be in the open position in the event of latch mechanical failure or loss of latch actuation capability.

2.1.5.3.2. Failure Load

The latches shall fail under an 11,500 ± 1,000 lbf (51,155 ± 4,448 Newtons) tension force. There shall be no loose debris or parts following this failure.

2.1.5.4. Latch Response

Upon operator or automatic signal command, the latch or unlatch response time shall not exceed 0.6 seconds in all expected operational environmental conditions within the airspeed/altitude envelope of the boom system.

2.1.5.5. Toggle Latch/Unlatch, Disconnect and Override Modes

The receiver pilot (or crew) shall be provided a nozzle/receptacle disconnect switch for use in normal and override modes.

2.2. RECEPTACLE AIRCRAFT SIGNAL SYSTEM AND SECURE COMMUNICATION

The receiver aircraft receptacle system shall be able to receive disconnect and voice signal communications, and send voice and receptacle latch position and disconnect signal communications through its receptacle induction coil when coupled with the tankers reference nozzle as defined in Annex B or equivalent.

The receptacle induction coil shall transmit and receive these signals when the boom nozzle is inserted and latched into the receiver aircraft's receptacle and the boom nozzle is rotated axially to its maximum operational travel within the receptacle (clockwise or counterclockwise) with the maximum air gap attainable with the most adverse tolerances in the receptacle and the nozzle.

The receiver aircraft receptacle system shall be able to receive disconnect and voice signal communications, and send voice and receptacle latch position and disconnect signal communications through its receptacle induction coil when coupled to a tankers nozzle as defined in Annex B (Pages B-1 through B-3).

2.2.1. Signal Advance

Deleted

2.2.2. Receptacle Induction Coil

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2.2.3. Receptacle Induction Coil Location

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2.2.4. Receptacle Induction Coil Construction

Deleted

2.2.5. Signal Protocol

2.2.5.1. Signal Receiving

The receptacle system shall detect a pulse coming from the nozzle when the nozzle coil is excited between 18 Volts and 30 Volts during a minimum of 3 milliseconds.

2.2.5.2. Signal Sending

When transmitting the pulse, the receptacle's coil:

a. shall induce in the nozzle coil an OPERATING pulse as per FIGURE B-1 & TABLE B-1
b. shall not induce in the nozzle coil a NON-OPERATING pulse as per FIGURE B-1 & TABLE B-1

2.2.5.3. Override

An override mode shall be available if there is a malfunction of the signal amplifier in either the tanker aircraft or the receiver aircraft.

2.3. RECEIVER AIRCRAFT FUEL SYSTEM

2.3.1. External Fuel Spillage

2.3.1.1. Normal Disconnect

During normal initiated disconnect [center of envelope, pumps off, at 1 ft./sec (0.61 meters/sec) nozzle separation a maximum of 25cc external fuel spillage shall be permitted, with the receptacle engaged with a nozzle that complies with Annex A (Pages A-1 through A-4).

2.3.1.2. Emergency Disconnect

During emergency disconnect (corners of envelope, pumps on, at the maximum receptacle system flow rate, and the corresponding pressure, up to 10 ft./sec (3.05 meters/sec) nozzle separation) a maximum of 200cc external fuel spillage shall be permitted, with the receptacle engaged with a nozzle that complies with Annex A (Pages A-1 through A-4). The tanker boom nozzle poppet surge damper may be deactivated for receptacle fuel spillage testing.

2.3.1.3. Fuel Leakage Protection

The receiver aircraft's design shall minimize the effect of potential fuel spillage from either the boom nozzle or the receptacle during the aerial refueling process:

2.3.1.3.1. Air Intakes

Air intakes shall not be located in areas where spilled fuel or fumes can enter the receiver aircraft.

2.3.1.3.2. Electronic Bays

Electronic bays located aft of the aerial refueling receptacle shall be sealed.

2.3.2. Overpressure Protection

The receiver aircraft shall provide means to protect itself from the maximum steady state overpressure that the tanker is capable of, in the event of a tanker pressure regulator failure and/or a receiver aircraft fuel system tank level control valve failure.

2.3.3. Receiver Aircraft Fuel System Pressure Design Criteria

The receiver aircraft shall withstand all pressure transients and surges generated by the tanker and/or receiver aircraft, when in contact, during fuel flow initiation and valve closures, throughout the fuel transfer, and disconnect.

2.4. RECEPTACLE STRUCTURAL DESIGN CRITERIA

The receptacle housing and aircraft structure shall be designed for limit and ultimate structural loads imposed at the boom nozzle ball joint.

2.4.1. Limit Loads

Limit tension and compression loads of 9,000/Cos(C) lbf [40,034/Cos(C) Newtons] applied at the boom nozzle ball joint where C is the angle between the boom centerline and the nozzle centerline and may vary from 0 to 17 degrees.

2.4.2. Ultimate Loads

2.4.2.1. Ultimate Tension Loads

Ultimate tension load of 14,000/Cos (A) lbf [66,275/Cos (A) Newtons] applied to the boom at the boom nozzle ball joint where A is the angle between the boom centerline and the nozzle centerline and may vary from 0 to 30 degrees.

2.4.2.2. Ultimate Compression Loads

Ultimate compression load of 20,000 lbf (88,964 Newtons) applied at the boom nozzle ball joint anywhere within a 34 degree cone around the receptacle axial centerline.

2.4.3. Slipway and Adjacent Area Loads

The slipway and adjacent area shall withstand the following loads:

2.4.3.1. Ultimate Slipway Load

An ultimate load, at the center of the slipway, of 2,000 lbf (8,896 Newtons) laterally and 5,000 pounds (22,241 Newtons) vertically, applied simultaneously. These loads shall be applied with a boom nozzle or equivalent with the nozzle centerline at approximately 45 degrees to the surface contact.

2.4.3.2. Ultimate Area Loads

The area extending 12 inches (304.8 mm) around the receptacle installation, shall withstand static ultimate loads of 750 lbf (3,336 Newtons) laterally and 1,800 lbf. (8,007 Newtons) vertically, referenced to the receiver aircraft, applied simultaneously. These loads shall be applied with a boom nozzle or equivalent with the nozzle centerline at approximately 45 degrees to the surface contact.

2.5. RECEIVER AIRCRAFT RECEPTACLE MARKINGS

Receptacle markings shall be in accordance with one of the marking schemes provided in Annex E. Marking color shall contrast with the aircraft background color, and shall be chosen so that they are plainly visible to the boom operator, but are not visible from a distance.

2.6. RECEIVER AIRCRAFT RLIGHTING

2.6.1. Anti-collision Beacons

Beacons on the upper and lower fuselage shall be provided for collision avoidance. In addition, the upper and lower fuselage beacons used during aerial refueling shall have independent on/off control, so that the upper beacon can be extinguished during aerial refueling.

2.6.2. Slipway/Receptacle Area Lighting

Slipway and receptacle area illumination shall be provided, to enable the boom operator to determine the location of the slipway/receptacle and see sufficient surrounding area to identify adjacent skin contours and obstructions. Variable intensity dimming control shall be provided for all slipway/receptacle area lighting from “full intensity” to completely “off”. Slipway/Receptacle area illumination shall be such that it does not blind or distract the boom operator or the air vehicle crew member(s) of the receiver or the tanker aircraft during the aerial refueling process. If these lights are located within the Receiver Clear Path Area, they shall comply with the limitations stated in Para. 2.1.3.1

2.6.3. External Lights

The receiver aircraft shall be provided with external lights to aid the tanker aircraft in locating, tracking and identifying the receiver aircraft at night, and to enable the boom operator to determine receiver geometry/definition, location of the receptacle and relevant features necessary to accomplish the aerial refueling operation. The receiver external lights shall illuminate the receiver’s receptacle and surrounding area. External lighting shall not blind or distract the air vehicle crew member(s) of the receiver or the tanker aircraft during the aerial refueling process. Variable intensity dimming control shall be provided for all external lights, except for the anti-collision beacons, from “full intensity” to completely “off”. In addition, all upper fuselage beacons shall have on/off control that is independent of the lower fuselage beacons. Refer to Related Document 13 for additional information.

2.7. STATIC DISCHARGE

The receptacle installation must be installed in a manner to safely pass an electrical discharge, caused by the tanker/receiver connection, into the airframe. All receiver aircraft systems shall meet their operational performance requirements when subjected to a 300 kilovolt discharge between a tanker boom nozzle and the receiver receptacle, or the area adjacent to the receptacle.

2.8. ELECTROMAGNETIC ENVIRONMENTAL EFFECTS

The receiver aircrafts aerial refueling (AR) system, including the receptacle and associated components, receptacle signaling system and thru-the boom voice intercom system, shall be protected from electromagnetic interference from any of the receiver aircraft’s own system.

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ANNEX A: BOOM NOZZLE – MATING DIMENSIONS

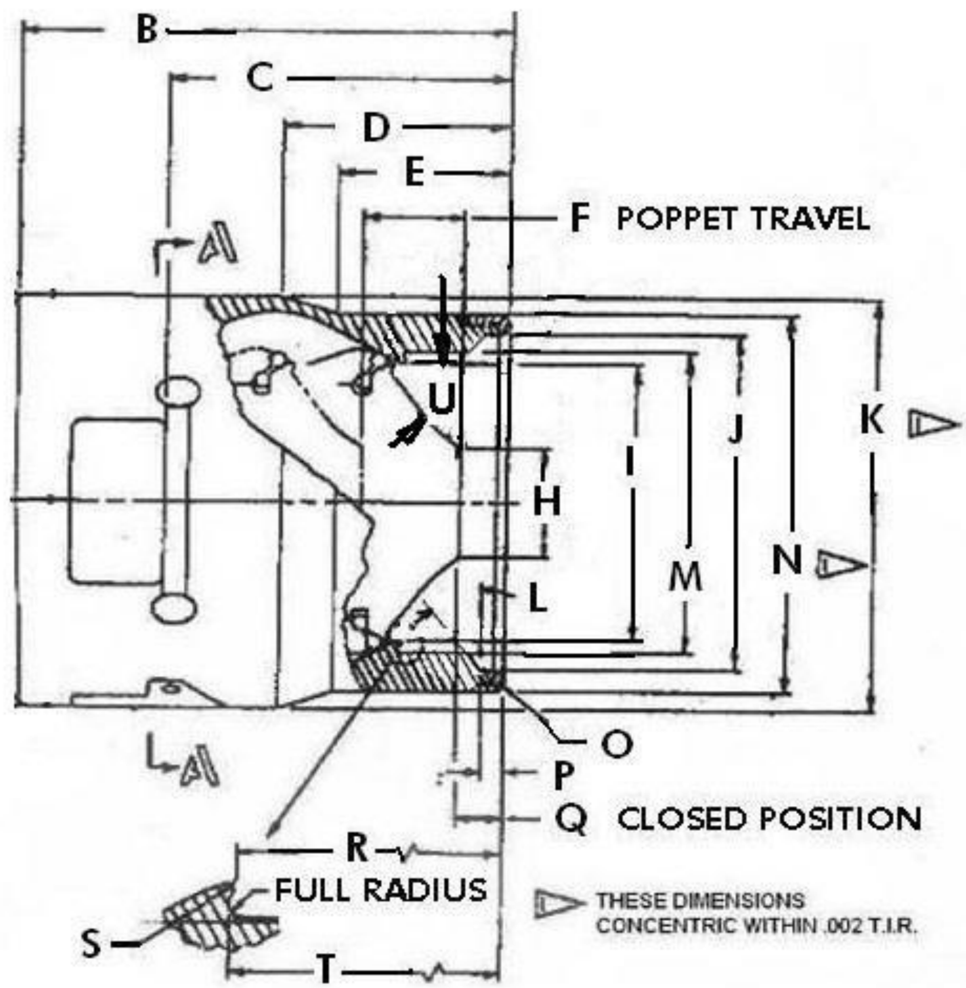


Figure A-1. Boom Nozzle Mating Dimensions

Table A-1. Boom Nozzle Mating Dimensions

DIMENSION	MAXIMUM		MINIMUM		REMARKS
	in.	Mm	in.	mm	
A					Deleted
B			6.22	157.99	Minimum
C	4.4125	112.08	4.3775	111.19	
D	2.865	72.77			Maximum
E			2.14	54.36	Minimum
F	1.31	33.27	1.17	29.72	
G					Deleted
H	1.41	35.81	1.39	35.31	
I			3.53	89.66	Minimum
J	4.3	109.22	4.29	108.97	
K	5.25	133.35	5.248	133.3	
L	50 deg.		45 deg.		Degrees
M	3.89	98.81	3.88	98.55	
N	4.8	121.92	4.798	121.87	
O			0.115	2.92	Radius-Minimum
P	0.359	9.12	0.29	7.37	
Q	0.66	16.76	0.61	15.49	
R	1.345	34.16	1.33	33.78	
S	0.04	1.02	0.03	0.76	Radius
T	1.375	34.93	1.36	34.54	
U	52 deg.		51 deg.		Degrees

Note: Angle L has been revised from MS27604 to reduce receptacle seal damage.

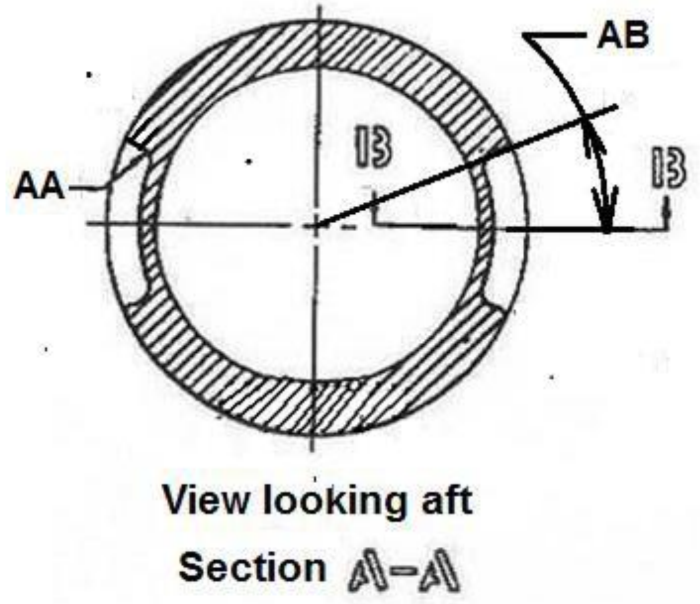


Figure A-2a. Nozzle Latching Recesses

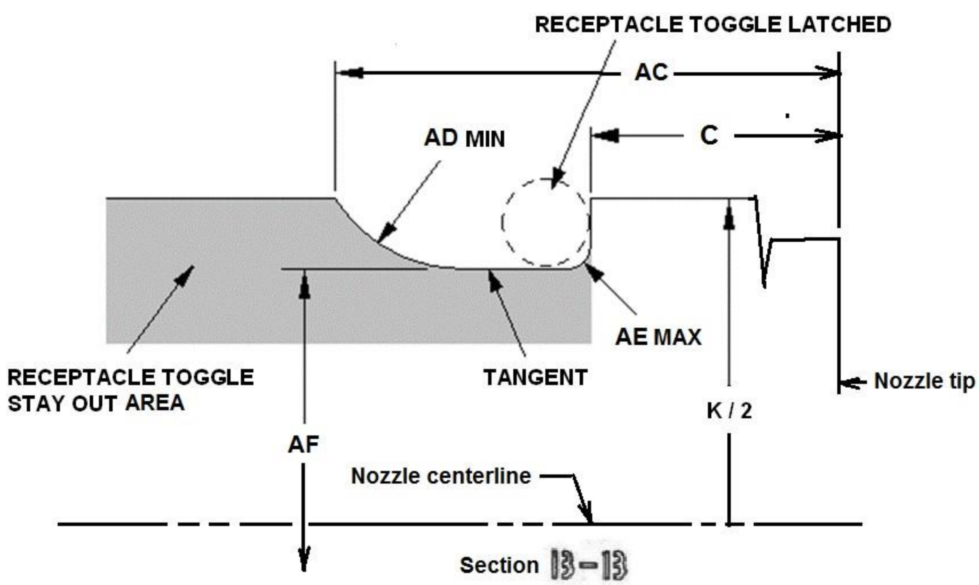
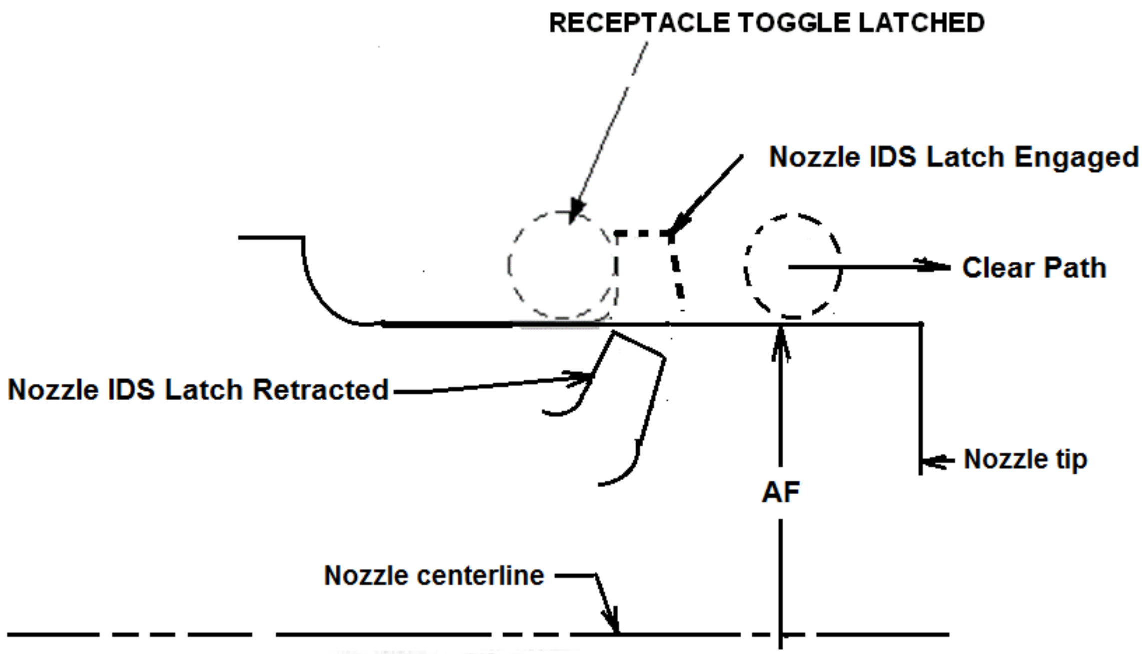


Figure A-2b. Nozzle Latching Recesses without Independent Disconnect (IDS)

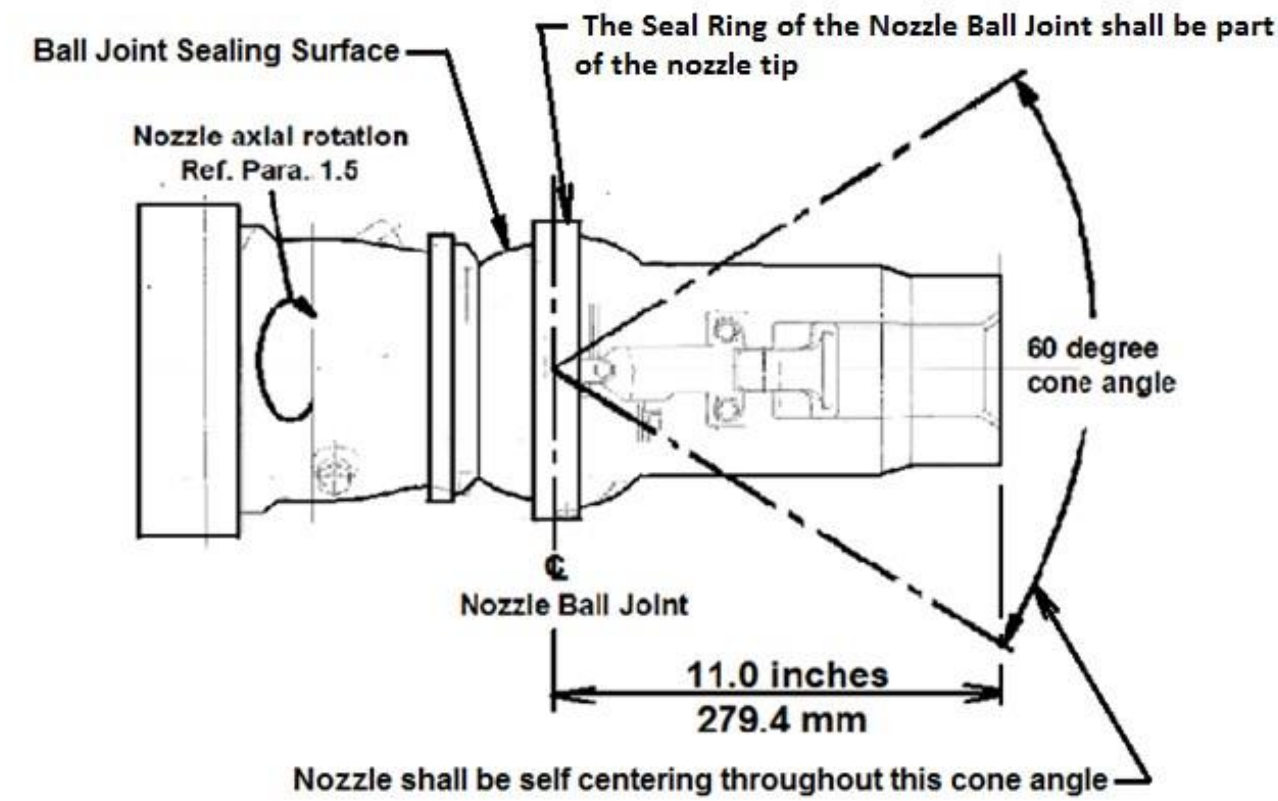


Section B-B with Independent Disconnect iSystem (IDS)

Figure A-2c Independent Disconnect Clear Path

Table A-2. Nozzle Latching Recesses Minimum Profile

DIMENSION	MAXIMUM		MINIMUM		REMARKS
	in.	Mm	in.	mm	
AA	0.26	6.60			Radius-Maximum
AB			23		Degrees-Minimum
AC			5.67	144.02	Minimum
AD	1.89	48.01	1.87	47.50	Radius-tangent to AK
AE	0.265	6.73			Radius - Maximum
AF	4.42	112.27			Diameter-Maximum



Note: See Related Document 10, ARSAG Guidance Document Boom/Receptacle, for further guidance concerning nozzle ball joint configuration.

Figure A-3. Boom Nozzle Articulation

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ANNEX B: ELECTRICAL INTERFACE

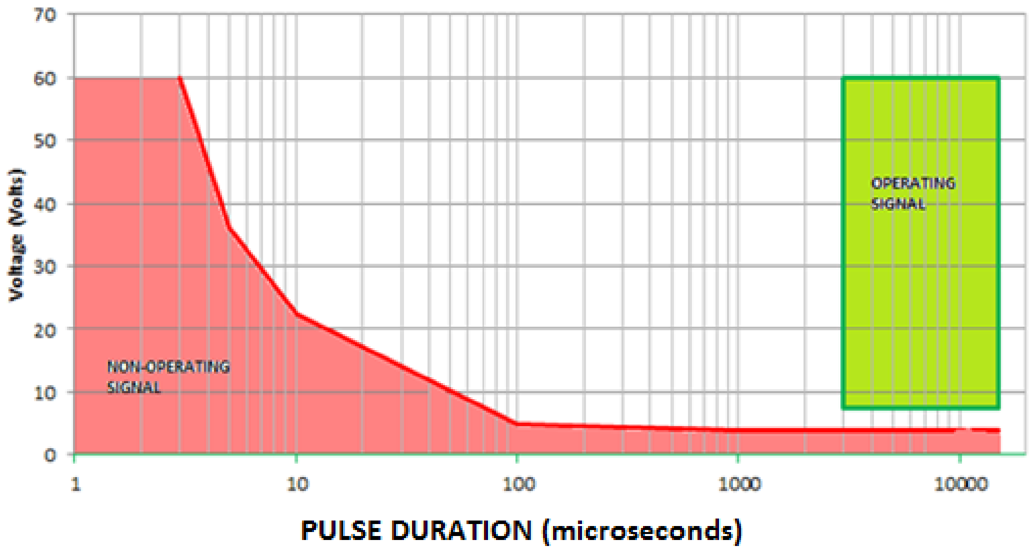
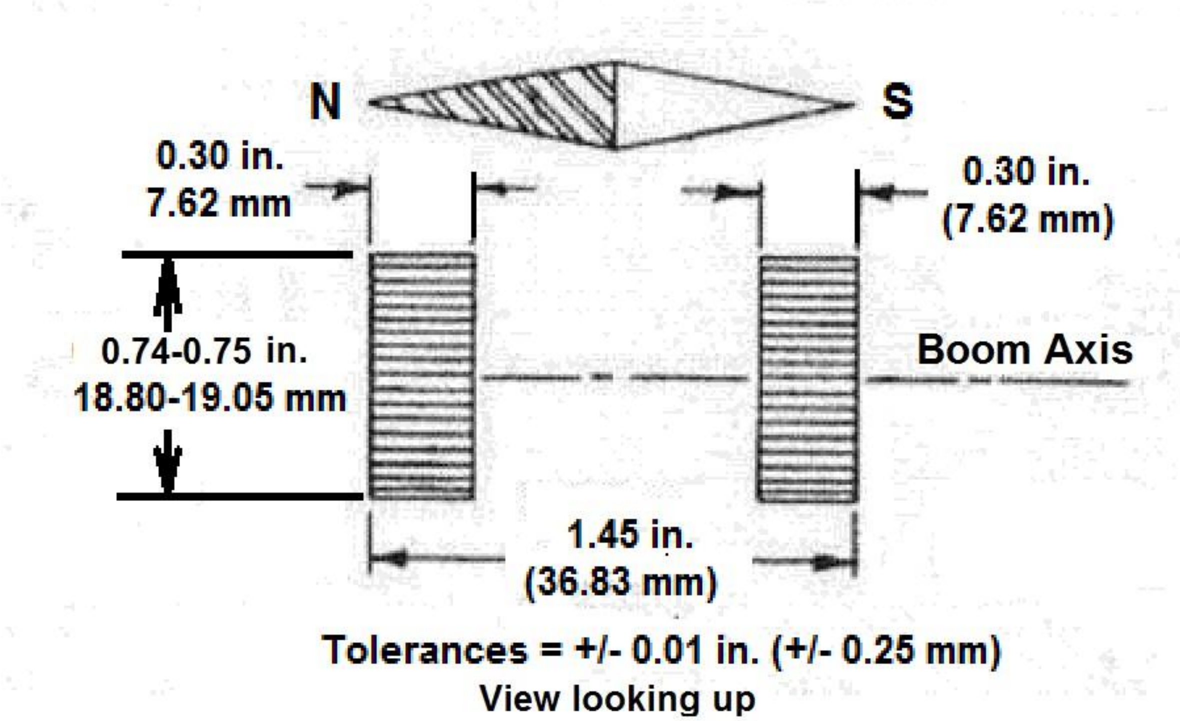


Figure B-1. Signal Advance Characteristics

PULSE DURATION (MICROSECONDS)	VOLTAGE (VOLTS)
NON-OPERATING	
15,000	4.0
1,000	4.0
100	5.0
10	22.5
5	36.0
3	60.0
OPERATING	
15,000	Minimum 7.5 Maximum 60
3,000	Minimum 7.5 Maximum 60

Table B-1. Signal Advance

Tanker Nozzle Induction Coil Requirements



Note: The pole faces shall be centered within 0.03 inches (0.76 mm) of the boom axis.

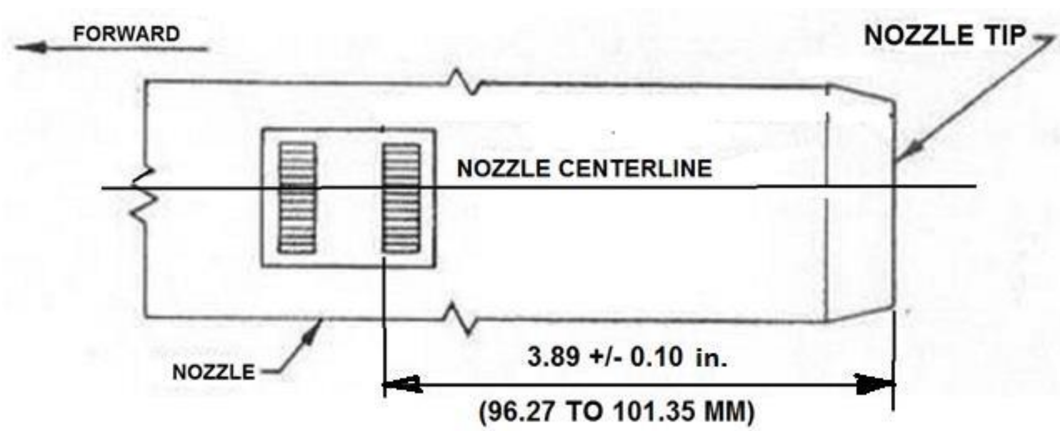
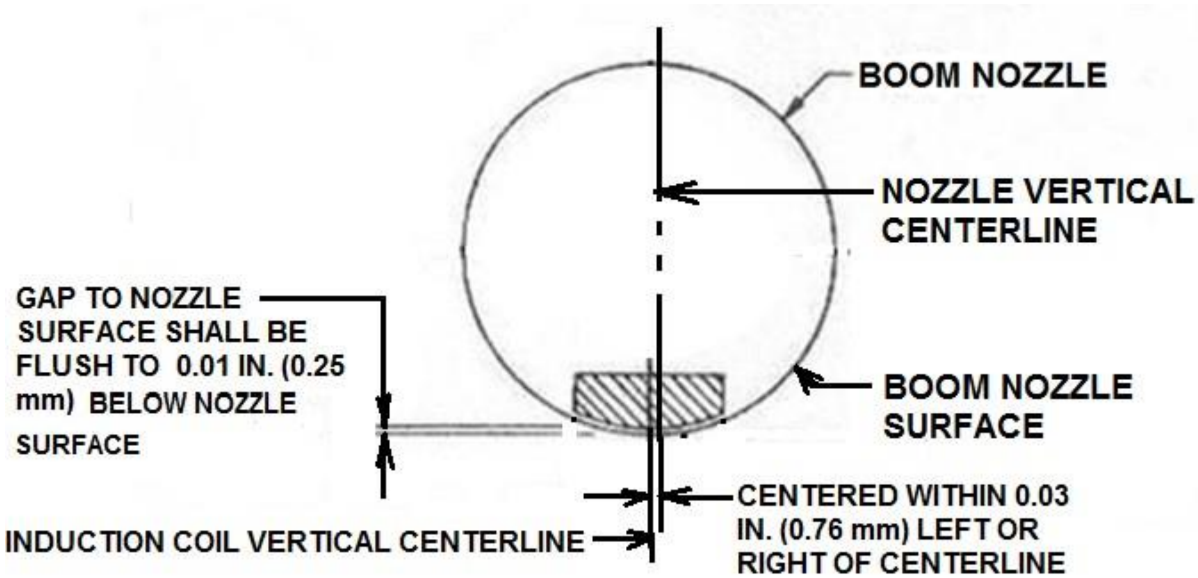


Figure B-2. Boom Nozzle Induction Coil Position

Tanker Nozzle Induction Coil Requirements (Continued)



(View looking forward along boom axis)

Figure B-3. Boom Nozzle Induction Coil Centering and Gap

Receiver Aircraft Receptacle Induction Coil

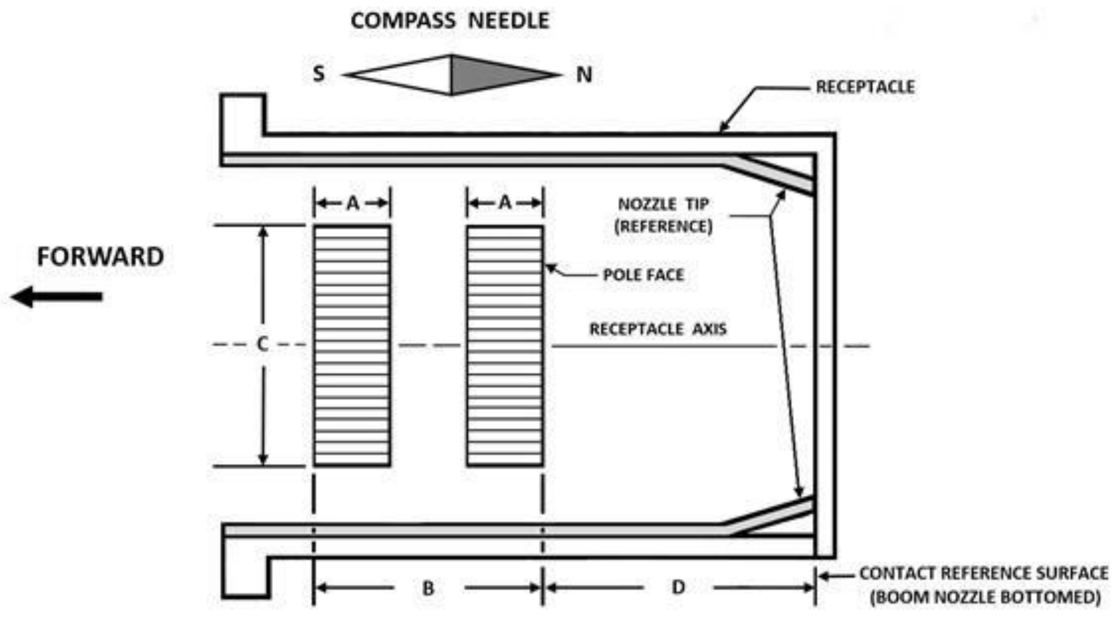


Figure B-4. Receptacle Induction Coil Requirements

Table B-2. Receptacle Induction Coil Dimensions

DIM	MAXIMUM		MINIMUM	
	Inch	Mm	Inch	mm
A	0.56	14.22	0.54	13.72
B	1.71	43.43	1.69	42.93
C	1.71	43.43	1.69	42.93
D	3.50	88.90	3.48	88.39

Table B-3 Nozzle/Receptacle Induction Coil Construction

	Nozzle Coil	Receptacle Coil
Windings	2300 turns of #38 B and S Formex magnetic wire or equivalent with the resistance of 333 to 432	2300 turns of # 38 B and S Formex magnetic wire or equivalent with the resistance of 333 to 484
Laminations	Laminations of 0.01 in. (0.254 mm) thick commercial quality transformer steel with core loss not exceeding 0.72 Watts per pound (1.58 Watts per kilogram). The minimum lamination cross sectional area of 0.09 in^2 (58 mm^2), with the pole face dimensions, shall be as shown in Annex B	Laminations of 0.01 in. (0.254 mm) thick commercial quality transformer steel with core loss not exceeding 0.72 Watts per pound (1.58 Watts per kilogram). The minimum lamination cross sectional area of 0.204 sq. in. (132 sq. mm), with the pole face
Polarity Test	When the positive terminal of a 28 Volt D.C. power source is applied to the signal input lead, the north needle of a compass shall point as shown in Figure B-2.	When the positive terminal of a 28 Volt D.C. power source is applied to the signal input lead, the north needle of a compass shall point as shown in Figure B-4.

Note: Other technical solutions may be acceptable if they can be shown to provide the same results.

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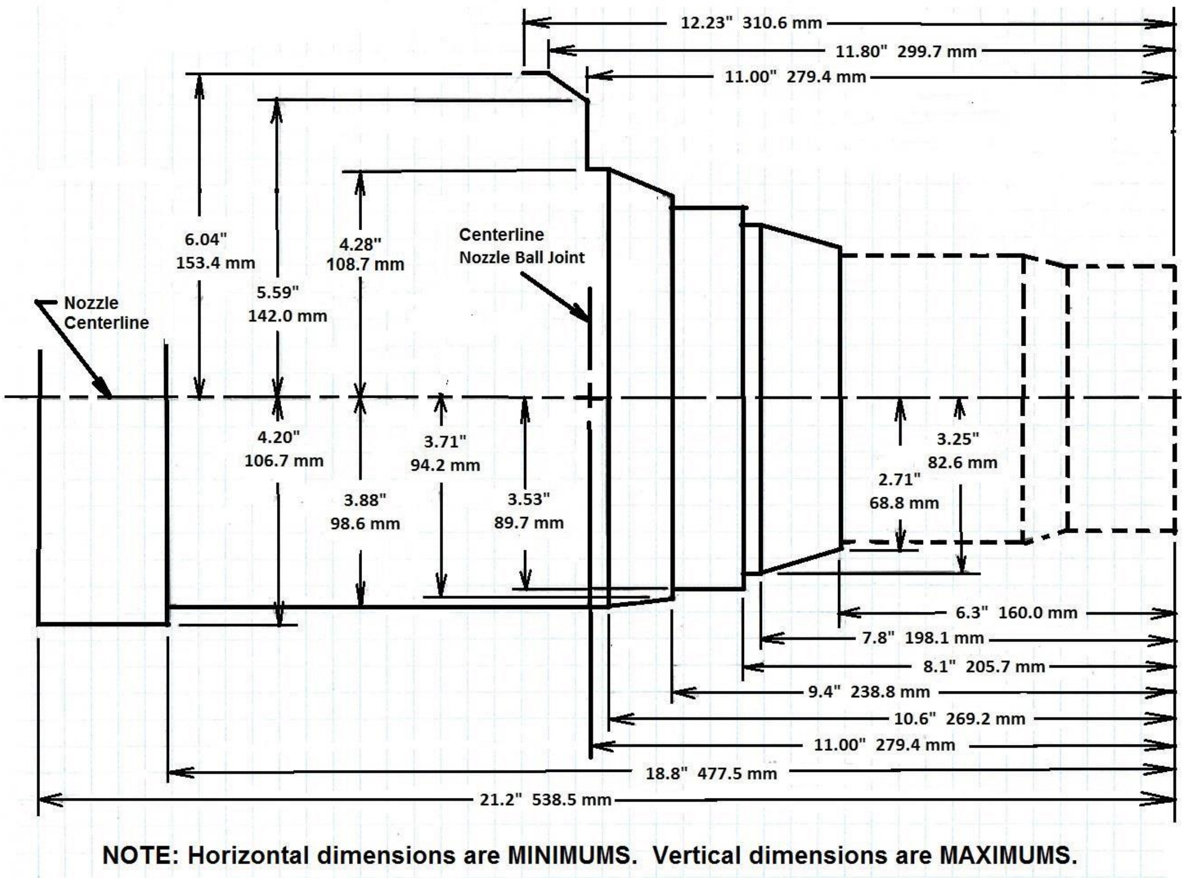
ANNEX C: RECEIVER AIRCRAFT CLEARANCE ENVELOPE



Note: The portion of this diagram below the centerline shall apply to the lower 180 deg. of the nozzle.

Figure C-1. Maximum Nozzle Envelope - Side View

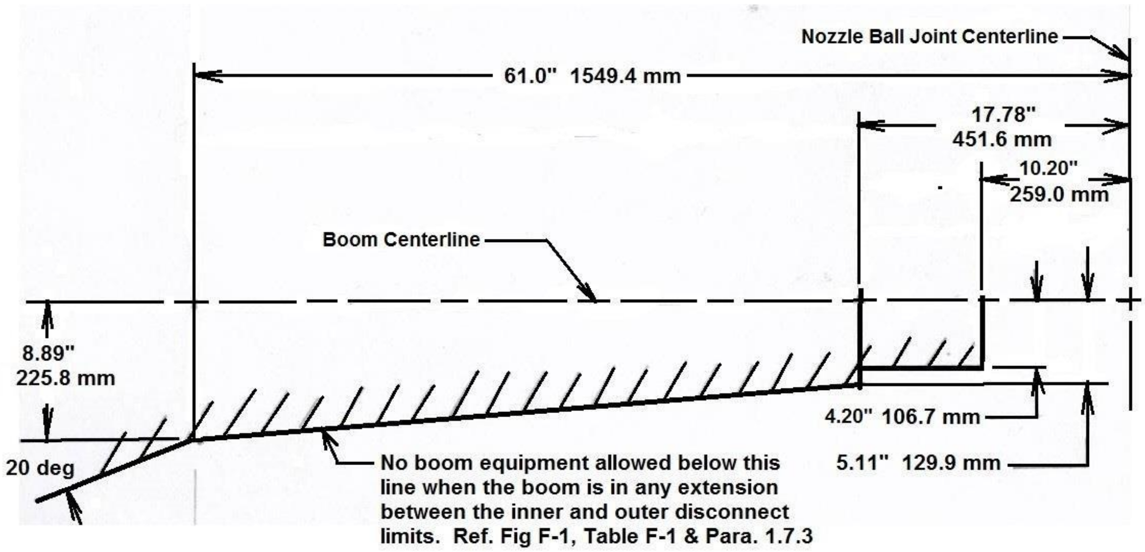
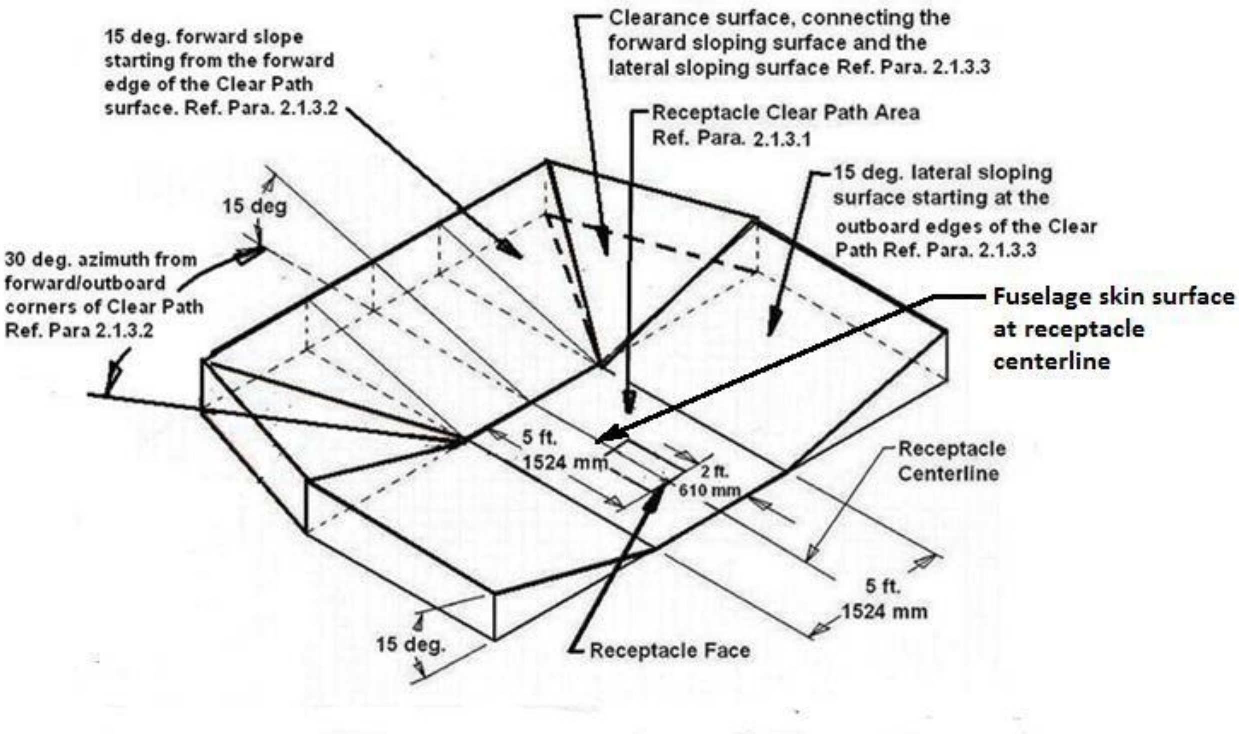


Figure C-2. Maximum Boom Envelope - Side View



Note: No receiver equipment allowed above these surfaces, except the lights allowed in Paragraph 2.6.2

Figure C-3. Combined Receiver Clearance

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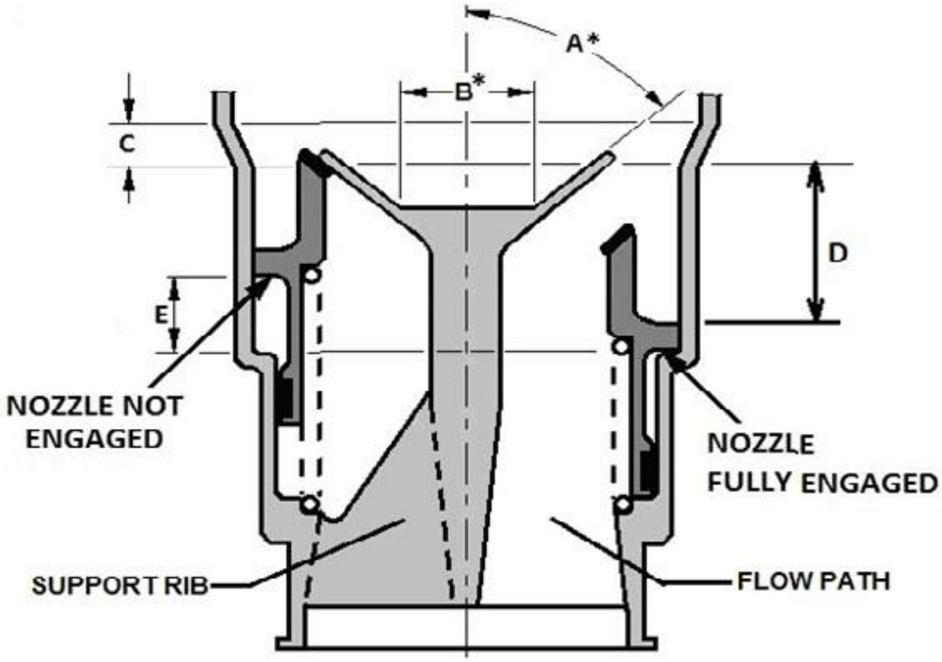
ANNEX D: BOOM RECEPTACLE – MATING CONDITIONS



Note: Dimensions A & B must be equal or greater than the maximum Nozzle Poppet Valve dimensions U & H respectively, on Pages A-1 and A-2

Figure D-1. Boom Receptacle – Sliding Valve

Table D-1. Boom Receptacle – Sliding Valve

DIMENSION	MAXIMUM		MINIMUM		REMARKS
	in.	mm	in.	mm	
A					Minimum Tulip Angle, Deg. See note above
B			1.41	35.81	Minimum Tulip Flat
C	0.63	16.00	0.6	15.24	Taper Length
D	2.225	56.52	2.135	54.23	Aft Bore Length
E	1.125	28.58	0.814	20.68	Sliding Valve Travel

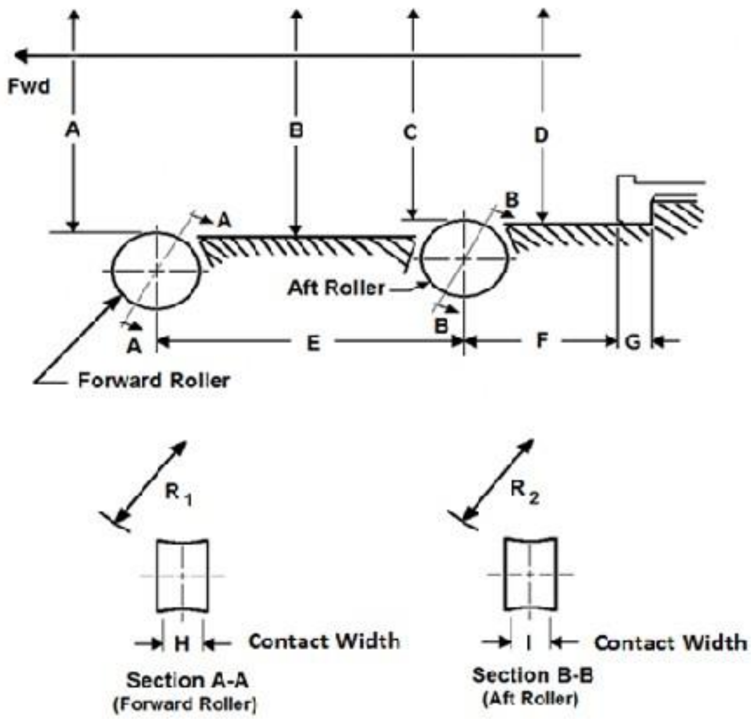
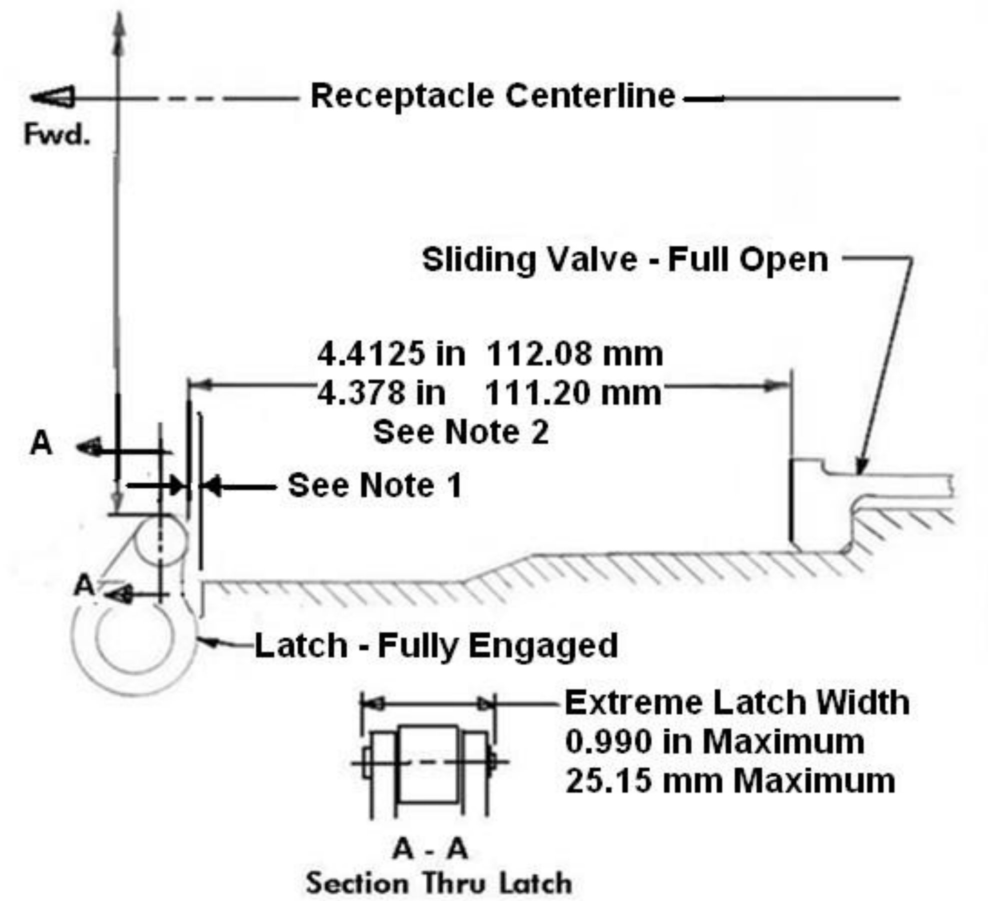


Figure D-2. Receptacle Rollers

Table D-2. Receptacle Rollers

Dimensio	**Maximum**		**Minimum**	
	Inch	**Mm**	**Inch**	**mm**
A	5.28	134.1	5.25	133.53
B	5.31	134.8	5.30	134.62
C	4.82	122.5	4.80	122.05
D	4.90	124.5	4.90	124.46
E	4.00	101.6	3.50	88.90
F	2.01	51.18	1.88	47.88
G	0.43	11.07	0.43	11.02
H	0.75	19.51	0.55	13.97
I	0.75	19.51	0.55	13.97
R_1	2.64	67.06	2.61	66.42
R_2	2.63	66.93	2.39	60.71



Latch must not enter stayout zone on nozzle, Fig A-2, during its complete movement

Symmetrical about Centerline

Note 1: Distance between the toggle and housing shall be controlled to maintain separation in the latched condition

Note 2: Distance shown shall be controlled to ensure a minimum axial latching force of 4,800 lbf (21,351 Newtons) in the latched condition with any boom nozzle compliant with Annex A (A-1)

Figure D-3. Section through Receptacle Latch Toggles

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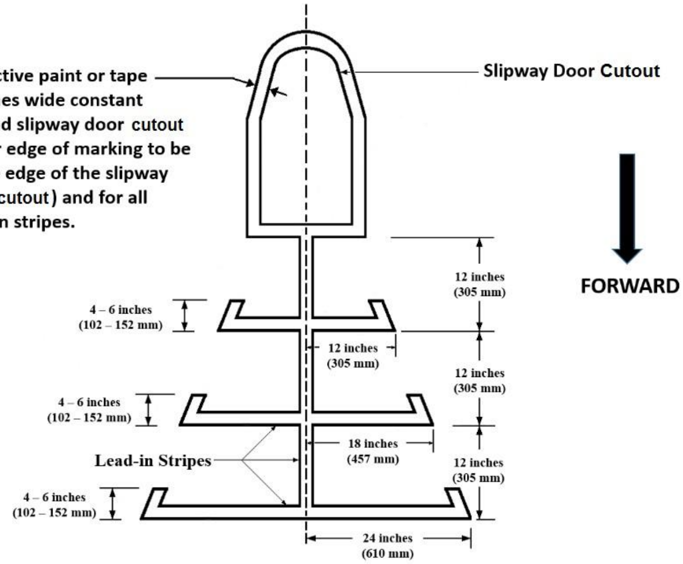
ANNEX E: RECEPTACLE SLIPWAY MARKINGS

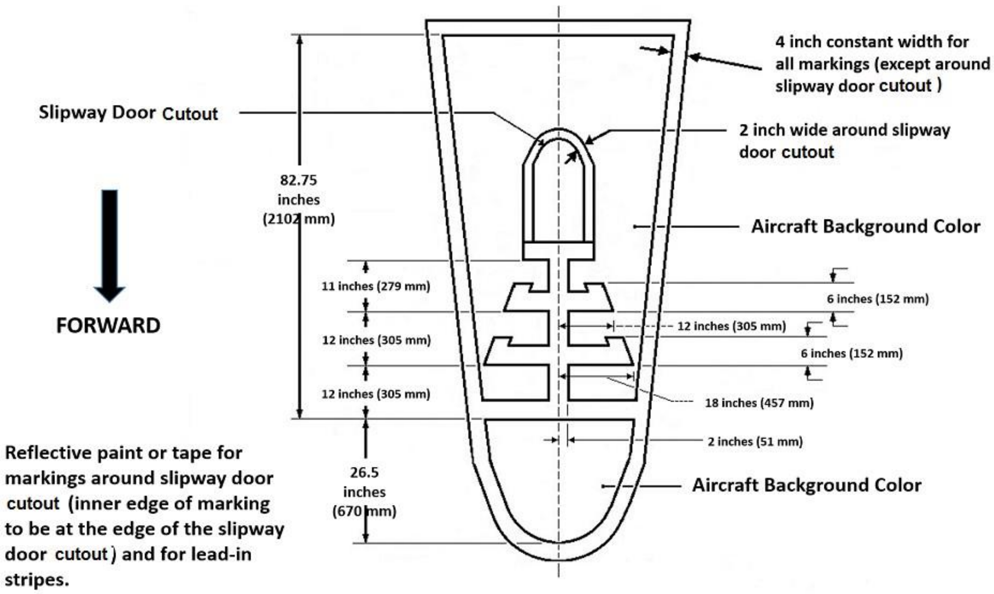


Note: Marking color shall contrast with aircraft background color

Figure E-1. Triple Bar Receptacle Markings

Note: Windshield highlighted with reflective tape (recommended)

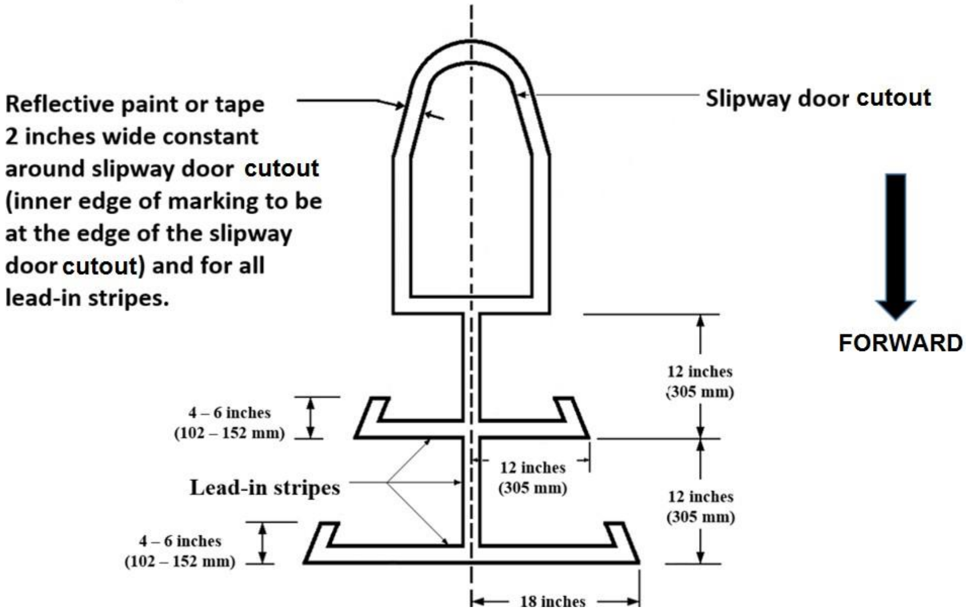
Figure E-2. Triple Bar Receptacle Markings



Note: Marking color shall contrast with aircraft background color and shall be chosen to be plainly visible to the boom operator but not visible at a distance outside the refueling range.

Figure E-3. Triple Bar Camouflaged Receptacle Markings

Figure E-4. Triple Bar Camouflaged Receptacle Markings



Note: Use when Triple Bar Markings do not fit available space

Figure E-5. Two Bar Receptacle Markings

Figure E-6. Two Bar Receptacle Marking

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ANNEX F: BOOM ENVELOPE

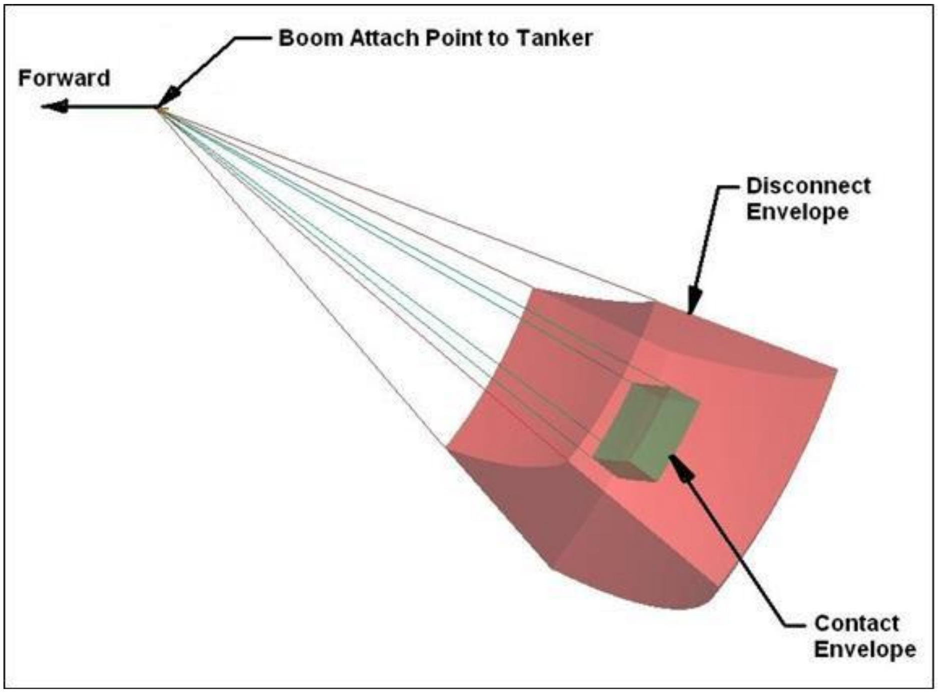
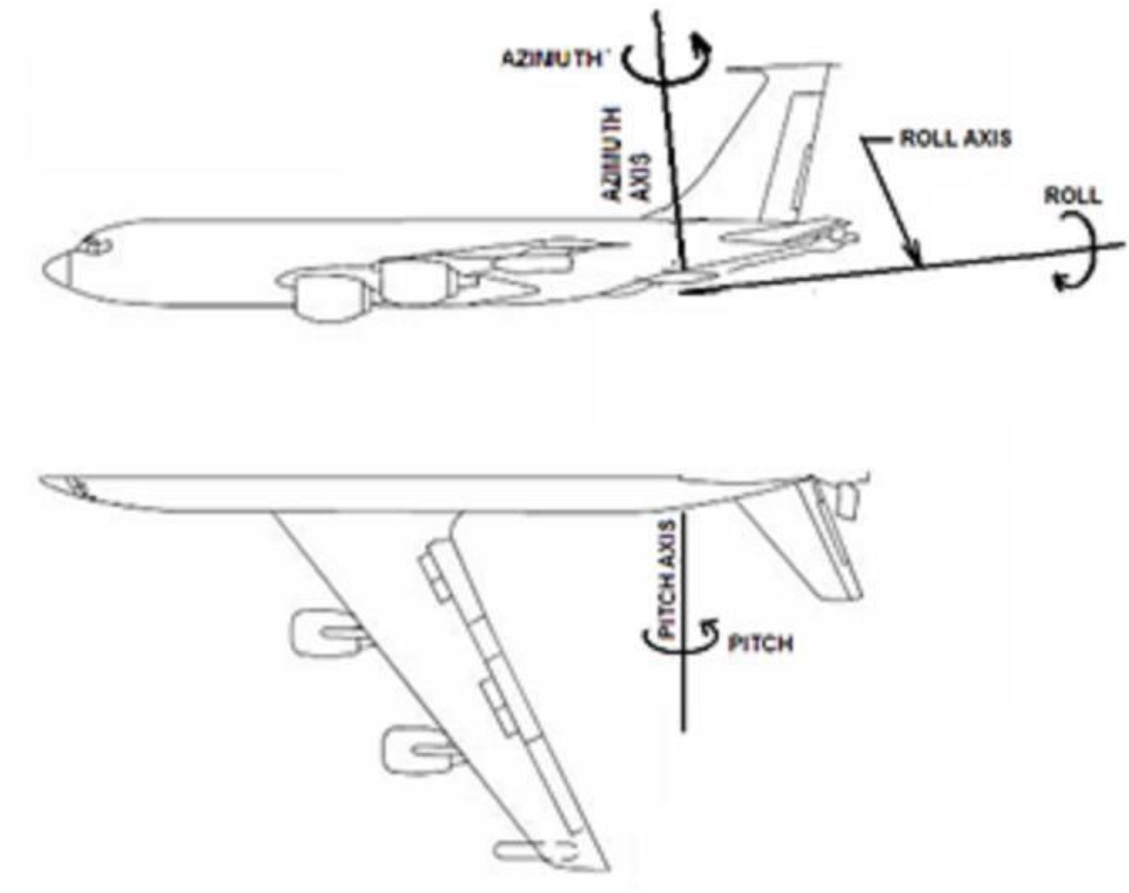


Figure F-1. Minimum Boom Spatial Envelopes

Table F-1. Minimum Boom Spatial Envelopes

MINIMUM BOOM SPATIAL ENVELOPES					
	AZIMUTH/ ROLL	PITCH		EXTENDED LENGTH	
		UPPER	LOWER	INNER	OUTER
CONTACT ENVELOPE Ref. Para. 1.7.2	± 8º	25º	35º	39 ft. 9 in. 12,116 mm	42 ft. 9 in. 13,030 mm
DISCONNECT ENVELOPE Ref. Para. 1.7.3	± 15º	20º	40º	33 ft. 8 in. 10262 mm	45 ft. 11 in. 13995 mm



Note: Azimuth and Roll axes are not necessarily the same as the aircraft axes

Figure F-2. Boom Axes Definition

ANNEX G: BOOM COUPLED NOZZLE LOADS

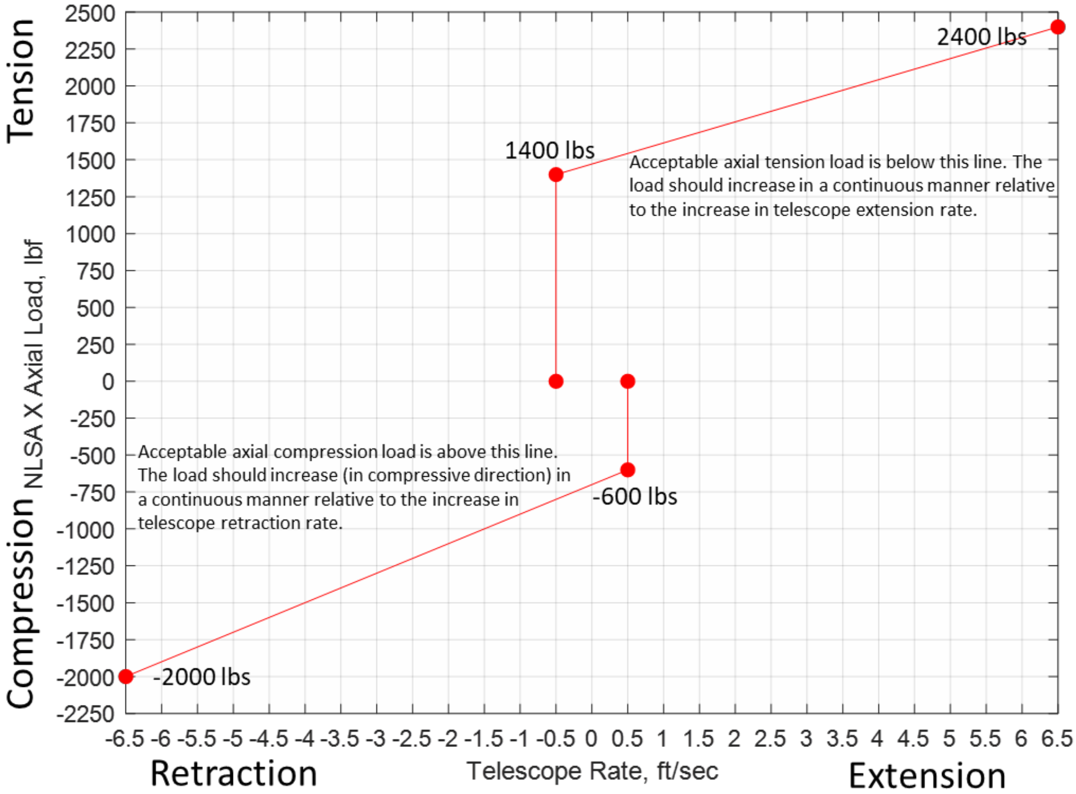


Figure G-1 Boom Nozzle Load without Operator Input

ATP-3.3.4.5(B)(1)