SURFACE VEHICLE STANDARD

J2600™ OCT2015

Issued 2001-10
Revised 2015-10

Superseding J2600 NOV2012

Compressed Hydrogen Surface Vehicle Fueling Connection Devices

RATIONALE

SAE J2600 has been revised to reflect the incorporation of additional geometries for different pressures, and to modify, add, or delete testing requirements based on lessons learned as the state of the art has progressed. In addition, the document moved from a Recommended Practice to Standard.

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TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
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1. SCOPE

SAE J2600 applies to the design and testing of Compressed Hydrogen Surface Vehicle (CHSV) fueling connectors, nozzles, and receptacles. Connectors, nozzles, and receptacles must meet all SAE J2600 requirements and pass all SAE J2600 testing to be considered as SAE J2600 compliant.

This document applies to devices which have Pressure Classes of H11, H25, H35, H50 or H70.

1.1 Purpose

SAE J2600 is intended to:

- Prevent vehicles from being fueled with a Pressure Class greater than the vehicle Pressure Class;
- Allow vehicles to be fueled with Pressure Class equal to or less than the vehicle Pressure Class,
- Prevent vehicles from being fueled by other compressed gases dispensing stations;
- Prevent other gaseous fueled vehicles from being fueled by hydrogen dispensing stations.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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.

SAE J2574 Fuel Cell Vehicle Terminology

SAE J2578 Recommended Practice for General Fuel Cell Vehicle Safety

SAE J2579 Technical Information Report for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles

SAE J2601 Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles

SAE J2601/2 Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles

SAE J2601/3 Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks

SAE J2719 Hydrogen Fuel Quality for Fuel Cell Vehicles

SAE J2799 70 MPa Compressed Hydrogen Surface Vehicle Fueling Connection Device and Optional Vehicle to Station Communications

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE/ASTM SI 10 Use of the International System of Units: The Modern Metric System

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM B117-09 Standard Practice for Operating Salt Spray (Fog) Apparatus.

ASTM D572 – 04 (Reapproved 2009) Standard Test Method for Rubber - Deterioration by Heat and Oxygen

2.1.4 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, Tel: 212-642-4900, www.ansi.org.

ISO 1817:1998 Rubber, vulcanized or thermoplastic - Determination of the effect of liquids

ISO 9227:1990 Corrosion tests in artificial environments - Salt spray tests

ISO 15501-1:2001 Road vehicles - Compressed natural gas (CNG) fuel systems - Part 1: Safety

ISO 15501-2:2001 Road Vehicles - Compressed natural gas (CNG) fuel systems - Part 2: Test methods

ISO 12103-1; 1997 Road Vehicles - Test dust for filter evaluation - Part 1: Arizona test dust.

2.1.5 ISA Publications

Available from ISA, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709

ANSI/ISA-75.02.01:2008Control Valve Capacity Test Procedures

2.1.6 BSI Publications

Available from BSI, 389 Chiswick High Road, London, W4 4AL, United Kingdom

EN 60534 Industrial-process control valves - all parts

2.1.7 GM Worldwide Engineering Standard

GMW14872-2006 Cyclic Corrosion Laboratory Test

3. DEFINITIONS

See SAE J2574 for fuel cell vehicle terminology.

3.1 AIR, DRY

Air with a maximum dew point of –40 °C.

3.2 CONNECTOR

A joined assembly of a nozzle and receptacle which permits rapid connection and disconnection of fuel supply hose to the vehicle fuel system.

3.3 CYCLE

The process of a making a positive connection between the nozzle and the receptacle, pressurizing to Design Pressure, depressurizing and disconnecting.

3.4 HELIUM, DRY

Helium which meets or exceeds the following quality level; maximum water content of 5 ppm, product grade of 4.5 (99.995).

3.5 HYDROGEN, DRY

Hydrogen which meets or exceeds the quality level in J2719.

3.6 LEAK TEST GAS

Dry hydrogen or helium, preferably hydrogen. Adequate safety precautions shall be taken when testing with hydrogen.

3.7 NOZZLE

Device connected to a fuel dispensing system, which connects to the CHVS receptacle and permits transfer of fuel.

TYPE A - A nozzle for use with dispensing hoses that may remain fully pressurized at dispenser shutdown. The nozzle shall not allow gas to flow until a positive connection has been achieved. The nozzle shall be equipped with an integral valve or valves, incorporating an operating mechanism which first stops the supply of gas and safely vents the trapped gas before allowing the disconnection of the nozzle from the receptacle. The operating mechanism shall ensure the vent connection is open before the release mechanism can be operated and the gas located between the nozzle shut-off valve and the receptacle check valve is safely vented prior to nozzle disconnection.

TYPE B - A nozzle for use with dispensing hoses that may remain fully pressurized at dispenser shutdown. A separate three-way valve connected directly, or indirectly, to the inlet of the nozzle is required to safely vent trapped gas prior to nozzle disconnection. The nozzle shall not allow gas to flow until a positive connection has been achieved. Venting is required prior to disconnection of the nozzle. External three-way valves shall be constructed and marked so as to indicate clearly the open, shut and vent positions.

TYPE C - A nozzle for use with dispensing hoses which are depressurized (0.5 MPa and below) at dispenser shutdown. The nozzle shall not allow gas to flow until a positive connection has been achieved.

3.8 POSITIVE LOCKING MEANS

A feature which requires actuation of an interlocking mechanism to verify proper connection of the connector before pressure is applied.

3.9 PRESSURE CLASS

Pressure Class is a non-dimensional rating for hardware that defines the operational pressure and temperature limits of a component. The pressure class is denoted by the letter “H” followed by the nominal working pressure in MPa.

Table 3.9.1 - Pressure class designations

Pressure Class	**Nominal Working Pressure @ 15°C**	**Design Pressure** (1.5 x NWP)
H11	11 MPa	16.5 MPa
H25	25 MPa	37.5 MPa
H35	35 MPa	52.5 MPa
H50	50 MPa	75.0 MPa
H70	70 MPa	105.0 MPa

3.10 PRESSURE, DESIGN (OR RATED)

The maximum pressure at the most severe temperature level that a component will experience in actual service. The Design Pressure is to be, at a minimum, 150% of the Nominal Working Pressure for the purpose of this document. For further information regarding all pressure definitions used for hydrogen fueling system refer to SAE J2579.

3.11 PRESSURE, NOMINAL WORKING

The steady state pressure of a fully fueled vehicle storage tank at the given gas temperature of 15 °C (this defines a full tank gas density). For further information regarding all pressure definitions used for hydrogen fueling system refer to SAE J2579.

3.12 PROTECTIVE CAP

A means to prevent road dirt and other contaminants from getting into the inlet of the vehicle receptacle

3.13 RECEPTACLE

Device connected to a vehicle or storage system which receives the station nozzle and permits transfer of fuel. This may also be referred to as a fuelling inlet.

4. REQUIREMENTS

4.1 Quality Assurance

4.1.1 General

Quality system programs shall be established and operated to show that components will be produced in accordance with the qualified design. Quality systems shall be in accordance with 4.1.2, Approved Quality Systems.

4.1.2 Approved Quality System

Quality management systems shall be registered for compliance with *ISO 9001, Quality Management Systems Requirements*, by an accredited registrar. Other systems which incorporate *ISO TS 16949, Quality management systems -- Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations, ISO 9000*, such as *QS 9000, Quality System Requirements,* are acceptable.

Comparable quality systems shall be required of suppliers to components manufacturers. The manufacturers shall verify that their suppliers meet the requirements of 4.1.2, Approved Quality System.

4.2 General Requirements

4.2.1 Testing requirements

4.2.1.1 All test procedures listed in this document are type (design verification) test procedures unless otherwise noted.

4.2.1.2 All products must pass all tests to be considered to be in compliance with standard.

4.2.1.3 Communications hardware, such as IrDA, which is used to meet the requirements of SAE J2601 and/or SAE J2799 and is supplied with the nozzle by the manufacturer shall be attached to the nozzle and subjected to all of the nozzles tests. The communications hardware is to be demonstrated to be operating correctly upon completion of the all type and quality testing.

4.2.2 Pressure class interchangeability: The nozzle and receptacle designs noted herein shall:

- Prevent vehicles from being fueled with a Pressure Class greater than the vehicle Pressure Class;
- Allow vehicles to be fueled with Pressure Class equal to or less than the vehicle Pressure Class,
- Prevent hydrogen vehicles from being fueled by other compressed gases dispensing stations
- Prevent other gaseous fueled vehicles from being fueled by hydrogen dispensing stations.

This requirement is met by completing section 5.2 and successfully conducting a leak test per section 5.6.

4.2.3 Temperature Range: The nozzle and receptacle designs noted herein shall:

- Shall be designed to operate properly with a local ambient temperature of –40 to 65 °C.
- Shall be designed to operate properly for a gas process temperature –40 to 85 °C for H11 and H25 hardware.
- Shall be designed to operate properly for a gas process temperature –45 to 85 °C for H35, H50 and H70 hardware.

This requirement is met by the completing section 5.6 and section 5.7.

4.2.4 Features

4.2.4.1 General - Nozzles and receptacles made to this document shall be designed in accordance with reasonable concepts of safety, durability and maintainability as demonstrated by the successful completion of all of the type tests in section 5.

4.2.4.2 Design and Documentation - Nozzles and receptacles shall be well fitted and manufactured in accordance with good engineering practice. All specifications as to construction set forth herein may be satisfied by the construction actually prescribed or such other construction as will provide at least equivalent performance. Following the pressure technology requirements of ASME, JSME and/or the EC Pressure Equipment Directive shall be considered prima facie evidence of meeting this requirement.

4.2.4.3 Damage - Nozzles and receptacles shall be designed to be secure against displacement, distortion, warping or other damage.

This requirement is met by the completing sections 5.2, 5.6, 5.9 and 5.14.

4.2.4.4 Electrical Continuity - Nozzles and receptacles shall be constructed to maintain electrical continuity under normal and reasonable condition of handling and usage.

This requirement is met by completing the relevant portion section 5.12.

4.2.4.5 Materials of Construction - Materials used in the construction of nozzles, receptacles and dust caps shall be non-sparking or spark-reducing.

4.2.4.6 Contamination - Nozzles and receptacles shall be designed so that they are either tolerant of solid contamination, or have a means to protect themselves from said contamination when connected or disconnected. For example, the requirement is met if the receptacle has a filter upstream of adequate size to protect the functionality of the check valve. A receptacle shall have a means to prevent the ingress of fluids and foreign matter when disconnected.

This requirement is met by the completing the relevant portion section 5.15.

4.2.4.7 Thermal Cycles - The nozzle and receptacle shall be able to withstand thermal cycles.

This requirement is met by the completing the relevant portion section 5.16.

4.2.5 Units

4.2.5.1 Pressure - All references to pressures (MPa) throughout this document are to be considered gauge pressures unless otherwise specified.

4.2.5.2 System - SI Units stated herein are in accordance with the IEEE/ASTM SI 10.

4.2.6 Compatibility

4.2.6.1 Test medium - For the purposes of this document, compressed hydrogen gas should meet the minimum requirements of SAE J2719.

4.2.6.2 Hydrogen - Nozzles and receptacles shall be manufactured of materials suitable and compatible for use with compressed hydrogen at the pressure and the temperature ranges to which it will be subjected.

4.2.6.3 DI-Water - All pressure bearing and wetted components shall also be made from adequate material that is compatible with de-ionized water or distilled water.

4.2.6.4 Seals - Seals and non-metallic synthetic material shall be a material that is suitable for this application (compatible with hydrogen and compressor oil, synthetic or mineral).

This requirement is met by the completing section 5.4 and 5.5.

4.2.6.5 Corrosion Resistance - Nozzles and receptacles shall not sustain corrosion or loss of protective coatings.

This requirement is met by the completing section 5.13.

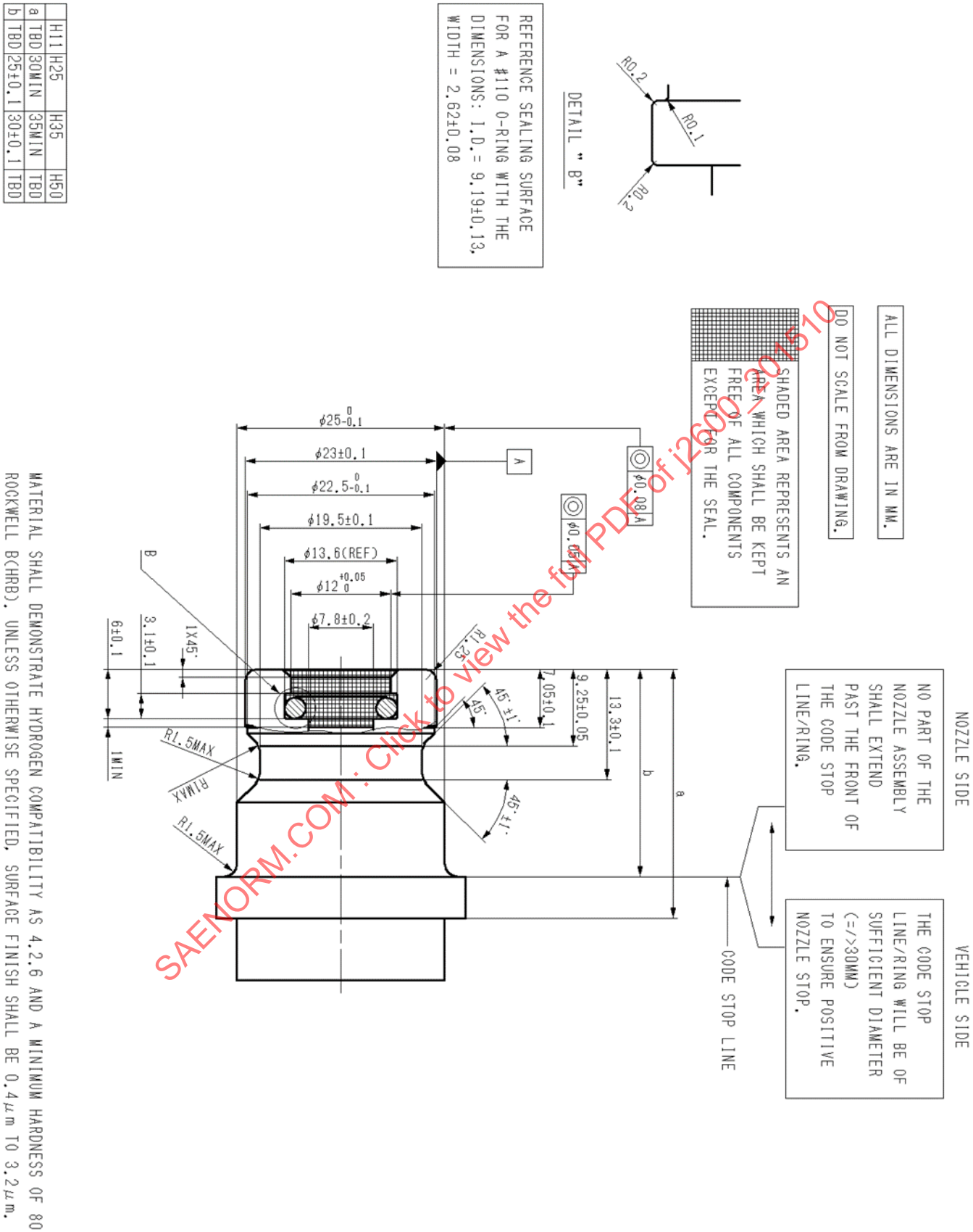
4.3 Receptacle

4.3.1 General Requirements

4.3.1.1 The failure of any test conducted with the receptacle and nozzle test samples shall constitute a failure of the receptacle design.

4.3.2 Outside Geometry

4.3.2.1 Receptacles shall comply with the design specifications detailed in Figures 4.3.2.1 and 4.3.2.2.



	H11	H25	H35	H50
a	TBD	30MIN	35MIN	TBD
b	TBD	25±0.1	30±0.1	TBD

Figure 4.3.2.1 - H11 to H50 hydrogen receptacles

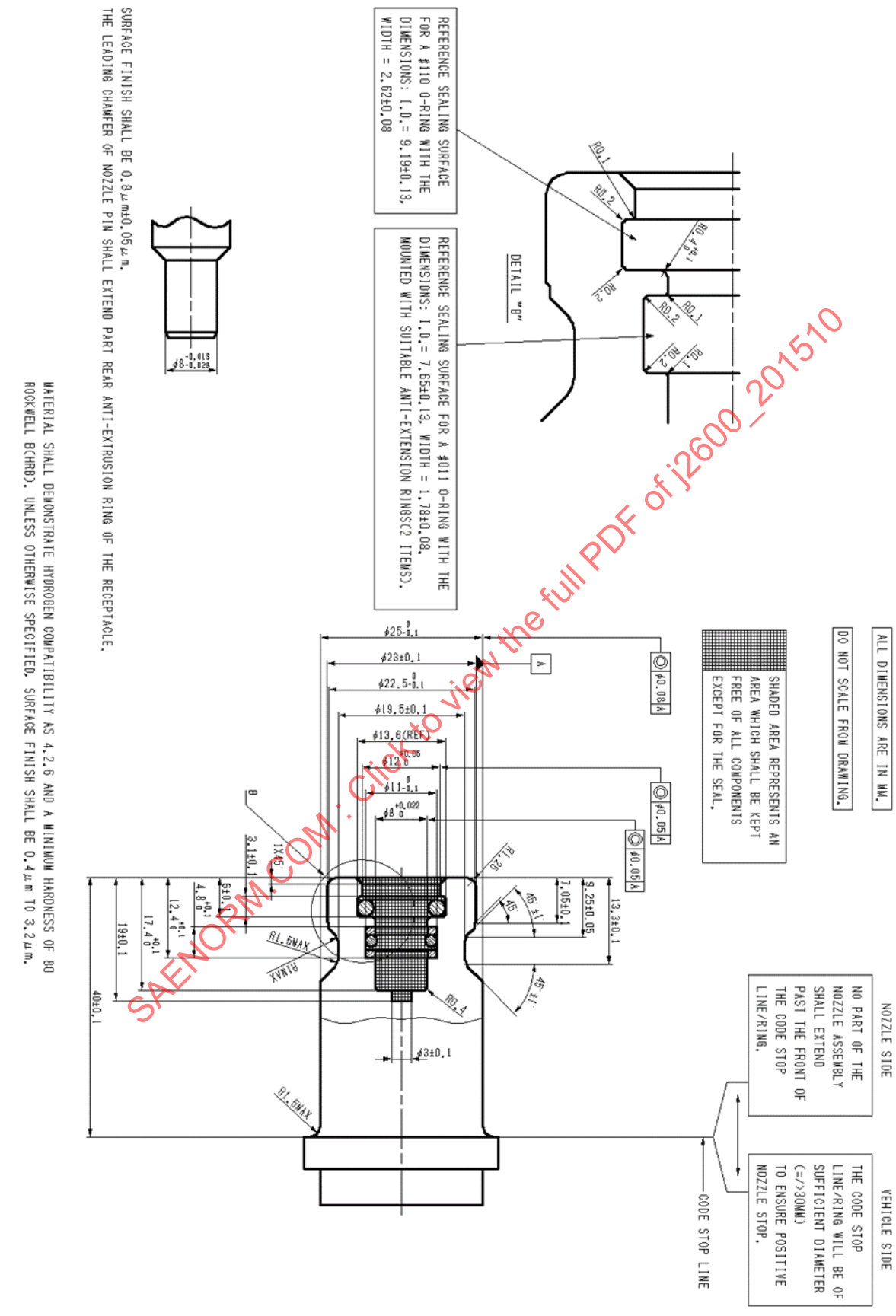


Figure 4.3.2.2 - H70 Hydrogen receptacle

4.3.3 Flow Requirements (Cv)

The minimum Cv value for the receptacle shall be 0.35 or as listed in the manufacturer's literature. Determination may be by test or analysis. Measuring method is to be documented with the Cv value. Refer to ANSI/ISA-75.02.01 or the EN 60534 series of documents for guidance.

4.3.4 Wear requirements (Cycles to minimum tolerance)

Receptacles shall be designed for a life of 15 000 cycles and 15 years with manufacturer specified maintenance.

This requirement is met by the completing section 5.12.

4.3.5 Bulkhead Requirements

4.3.5.1 Clearance - Receptacle designs which employ means on the back diameter to accommodate mounting, or for mounting accessories or marking purposes, shall not have such means extend beyond the back diameter dimensions of the profile specified in section 4.3.2, as applicable.

Acceptable means shall include wrench flats, protective cap anchoring grooves, use of hex stock, undercutting for marking, and threads for protective caps. Such receptacle designs shall not compromise proper nozzle interchangeability.

4.3.5.2 Mounting - The receptacle shall be mounted on the vehicle in compliance with the following:

- For pressure classes less than or equal to H25, the receptacle shall be mounted on the vehicle in compliance with SAE J2578 and ISO 15501.
- For pressure classes greater than H25, the receptacle shall be mounted on the vehicle in compliance with SAE J2578 and the figure below.

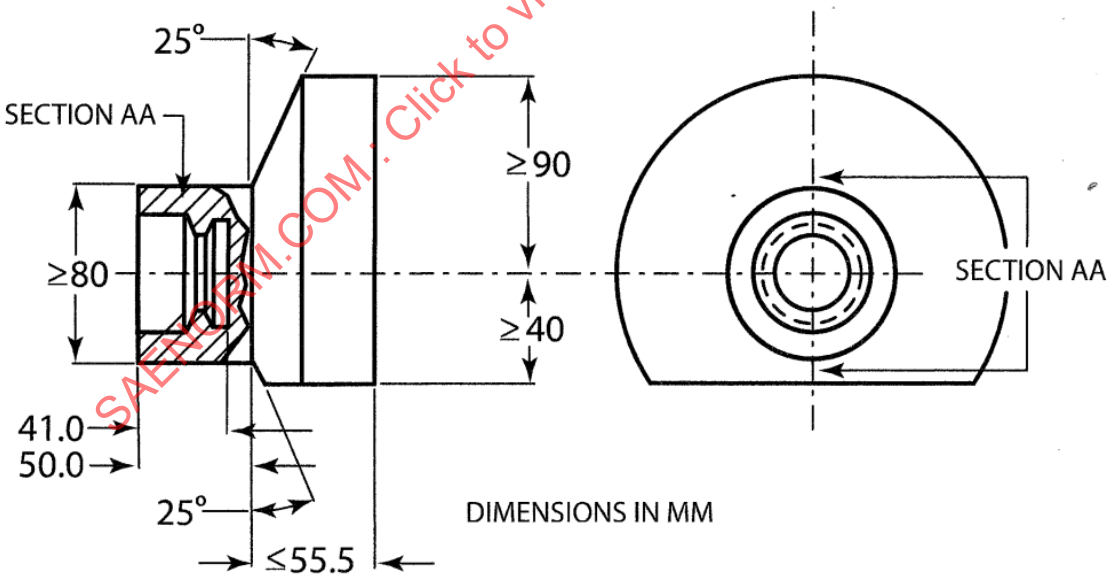


Figure 4.3.5.2 - Clearance for receptacles of pressure classes greater than H25

4.3.6 Check Valve

4.3.6.1 Sealing - The receptacle shall be equipped with an internal check valve to prevent the escape of gas.

4.3.6.2 Valve Design - The check valve shall be of the non-contact type, opening by differential pressure only

4.3.7 Vehicle Interconnect

4.3.7.1 Receptacle Vibration Resistance - Following completion of vibration as specified in section 5.10, receptacles shall not be damaged and shall comply with the receptacle leakage tests in section 5.6 and 5.8.

4.3.7.2 Low and High Temperatures - The receptacles shall be evaluated over the expected operating range of temperatures and pressures for leakage. This is demonstrated by completing sections 5.6, 5.7 and 5.17 (for precooled fuel).

4.3.7.3 Receptacle Cycles - A receptacle shall be capable of withstanding 15 000 cycles of operation as specified in section 5.12.

4.3.7.4 Hydrostatic (or Ultimate) Strength – The receptacle shall demonstrate itself capable of containing fluid when hydrostatically tested to 3 times the Nominal Working Pressure of the receptacle as specified in section 5.8.

4.3.7.5 Abnormal Load - The barrel of receptacle with the nozzle attached is not damaged when an abnormal load (both axial and moment) is applied to the nozzle. This requirement is met by completing sections 5.11 and 5.20

4.3.7.6 Air Intrusion

The allowable volume of air that can be trapped in the receptacle when mated to the nozzle shall not exceed 3 cm^3 at room temperature and pressure.

This requirement can be met by calculation based on the component drawings.

4.3.7.7 Pre-Cooled Hydrogen Exposure Test

Verify that the H35 and H70 hardware can withstand exposure to pre-cooled hydrogen during fuelling. This is demonstrated by successfully completing section 5.17.

4.3.7.8 Deformation of Assembled parts.

The receptacle/fuel storage connection shall be able to withstand normal abuse encountered in the installation and maintenance process without damage or deformation to the joint. Additionally, leakage at the joint is not permitted. This is demonstrated by successfully completing section 5.14.

4.4 Protective Cap (mounted on vehicle)

4.4.1 General Requirements

4.4.1.1 Foreign Debris - Protective caps are intended to protect the receptacle from foreign debris.

4.4.1.2 Pressure Containment - Protective caps are not intended to hold pressure.

4.4.1.3 Attachment - All protective caps must have a retainer to attach them to the receptacle or vehicle.

4.4.1.4 Vibration - Protective caps shall not be damaged or dislodged following completion of vibration as specified in section 5.10.

4.5 Nozzle

4.5.1 General Requirements

4.5.1.1 Dimensional Requirements - Nozzles shall comply with the dimensional requirements of section 4.3.2.1 and 4.3.2.2 to ensure proper interchangeability.

4.5.1.2 Tools - Nozzles shall be operated to either connect or disconnect without the use of tools.

4.5.1.3 Dispensing - The function of preventing flow can be controlled by the dispenser as long as it is receiving a positive connection signal from the nozzle.

4.5.1.4 De-pressurization - The act of venting, or de-pressurizing, of the connection space between all nozzle types and receptacles is required prior to disconnection. A provision must be made for venting or de-pressurizing of all nozzles types so that the vented gas shall be directed to a safe location. This is demonstrated by completing 5.12.

4.5.1.5 H70 Receptacle/Low Pressure Nozzle Compatibility – lower operating pressure nozzle designs are to demonstrate seal tolerance compatibility by successfully completing section 5.19.

4.5.1.6 Clearance - The nozzle shall fit within the envelope described in section 4.3.5.2.

4.5.1.7 Disconnect - It shall not be possible to remove a nozzle when the contained pressure is greater than 0.7 MPa. This demonstrated by successfully completing section 5.2.

4.5.1.8 Sealing -The nozzle shall not have any mechanical means of opening the receptacle check valve.

4.5.1.9 Markings - A Type A nozzle shall bear integral markings, or a permanently attached marking plate indicating the direction of the ON and OFF operation of the actuating mechanism. These markings shall be embossed, cast, stamped or otherwise formed in the part or plate. This includes markings baked into an enameled surface. Permanently attached marking plates shall be securely attached by mechanical means.

4.5.1.10 Flow Requirements (Cv)

The minimum Cv value for the nozzle shall be 0.35 or as listed in the manufacturer's literature. Determination may be by test or analysis. Measuring method is to be documented with the Cv value. Refer to ANSI/ISA-75.02.01 or the EN 60534 series of documents for guidance.

4.5.1.11 Deformation of Assembled parts.

The nozzle/hose connection shall be able to withstand normal abuse encountered in the installation and maintenance process without damage or deformation to the joint. Additionally, leakage at the joint is not permitted. This is demonstrated by completing section 5.14.

4.5.2 Performance Requirements

4.5.2.1 Low and High Temperatures - The nozzle shall be evaluated over the expected operating range of temperatures and pressures for leakage. This is demonstrated by completing sections 5.6, 5.7 and 5.17 (for precooled fuel).

4.5.2.2 Hydrostatic (or Ultimate) Strength - The nozzle shall demonstrate itself capable of containing fluid when hydrostatically tested to 3 times the Nominal Working Pressure of the receptacle. This is demonstrated by completing section 5.8.

4.5.2.3 Valve Operating Handle - If a nozzle is equipped with a valve operating handle, it shall be capable of withstanding 200 N applied at the point farthest away from the axis of rotation, without damage to the operating handle or the operating handle stops. This is demonstrated by completing section 5.3.

4.5.3 Cycle Requirements

4.5.3.1 Nozzle - Nozzles shall be capable of withstanding 100 000 operational cycles. This is demonstrated by completing section 5.12.

4.5.3.2 Valve - Type B nozzle three-way valves shall meet the same number of cycles as the nozzle.

4.5.4 Abnormal Loads

The nozzle when attached to the receptacle shall not be damaged when an abnormal load (both axial and moment) is applied to the nozzle.

This requirement is met by completing sections 5.11 and 5.20.

4.5.5 Air Intrusion

The allowable volume of air that can be trapped in the nozzle when mated to the receptacle shall not exceed 9 cm^3 at room temperature and pressure.

This requirement can be met by calculation based on the component drawings.

4.5.6 Pre-Cooled Hydrogen Exposure

The H35 and H70 hardware shall withstand exposure to pre-cooled hydrogen during fuelling. This is demonstrated by successfully completing section 5.17.

4.5.7 Misconnected Nozzle Test (applies to Type C nozzles only)

Verify that a misconnected Type C nozzle does not flow gas. This requirement is met by successfully completing section 5.18.

5. TYPE (DESIGN VERIFICATION) TESTS

5.1 General Requirements

5.1.1 General - Unless otherwise stated:

a. Tests shall be conducted at 15 °C ± 7 °C;

b. All pressure tests shall be conducted with leak test gas unless otherwise noted;

c. All leak tests shall be conducted with Leak Test Gas.

d. Test fluids and devices shall be at equilibrium conditions with the test environment at the beginning of all tests.

5.1.2 Receptacle Tooling

Nozzle tests are to be done with the test fixtures, defined in Table 5.1.2 as applicable:

Table 5.1.2 - Test fixture tooling dimensions

	H11-H50	H70
Receptacle dimensions	Figure 4.3.2.1	Figure 4.3.2.2
Worn test fixture dimensions	Figure 5.12.1.1	Figure 5.12.1.2
Loose test fixture dimensions	Figure 5.12.2.1	Figure 5.12.2.2
Tight test fixture dimensions	Figure 5.12.3.1	Figure 5.12.3.2 (tight)

Test fixtures conforming to the previous edition of this document and fabricated prior to the publication of the current edition of this document may be substituted for the fixtures defined in this edition.

5.1.3 Receptacle Compatibility

Receptacles shall be evaluated with a representative sample of other manufacturer's nozzle(s) which have been certified to this document. The failure of any test conducted with the receptacle and nozzle test samples shall constitute a failure of the receptacle design.

5.2 User-Machine Interface Test

5.2.1 Objective

The objective of this test is to verify that the connection and disconnection forces and torques for only the nozzles in the unpressurized and pressurized states.

5.2.2 Test Procedure

Testing is to be conducted at room temperature. When testing a nozzle design, the mating component shall be as described in 5.2.3.1 and 5.2.3.2.

The connection/disconnection forces and torques shall be applied in a direction that tends to connect and lock/unlock and disconnect the nozzle, as appropriate. The torque shall be applied to the unhooking/release actuator or three-way valve. Forces and torques will be measured for connecting/disconnecting depressurized connectors, and for attempting to connect/disconnect pressurized connectors.

5.2.3 Acceptance Criteria

5.2.3.1 Unpressurized Devices

Test nozzles will be tested against Tight Fit test fixtures (Figure 5.12.3.1 and 5.12.3.2) of the same pressure rating as the nozzle and greater. The axial force to connect and lock or unlock and disconnect the test device shall be less than or equal to 90 N. On a secondary positive locking means which incorporates an axial locking mechanism, the connection and disconnection forces shall be less than or equal to 90 N.

On a secondary positive locking means which incorporates a rotary locking mechanism, the torque to lock or unlock the locking means shall not exceed 1 N•m.

Testing shall be conducted at pressures less than 0.1 MPa and the nominal and minimum temperatures stipulated in section 4.2.3.

5.2.3.2 Pressurized Devices

Test nozzles will be tested against Loose Fit test fixtures (Figure 5.12.2.1 and 5.12.2.2) of the same pressure rating as the nozzle and greater. The minimum force to facilitate disconnection at pressures of 7.5 MPa or more with the vent port plugged on a Type A nozzle shall be at least 5 times those values specified in section 5.2.3.1.

A Type A nozzle shall prevent connection if the vent line is pressurized above 0.7 MPa.

Testing shall be conducted at pressures of 7.5 MPa, 50% of the design pressure and 100% of the design pressure as defined in section 3.9 and the nominal and minimum temperatures stipulated in section 4.2.3.

5.3 Valve Operating Handle Test

5.3.1 Objective

The objective of this test is to verify that nozzles with valve operating handles can withstand a maximum force without damage. This test is applicable to test nozzles whose design includes a valve operating handle.

5.3.2 Test Procedure

A 200 N force shall be applied to the valve operating handle at the point furthest away from the axis of rotation. The test shall be performed both on a shut valve in the shut direction and an open valve in the open direction. The test shall be performed both with the nozzle properly connected to a Loose Fit test fixture (Figure 5.12.2.1 and 5.12.2.2) of the same pressure rating as the nozzle and greater, and with the nozzle intentionally improperly engaged relative to the Loose Fit test fixture.

5.3.3 Acceptance Criteria

There shall be no visible damage to the valve operating handle or the handle stops.

5.4 Oxygen Aging Test

5.4.1 Objective

Verify sealing material resistance to aging. This test is applicable to sealing materials in nozzles and/or receptacles being tested.

5.4.2 Test Procedure

Sealing material shall be listed and rated by the manufacturer as being resistant to Oxygen Aging. Samples of synthetic rubber parts shall be subjected to 96 h of exposure at 70 °C and at 2 MPa. This test shall be conducted in accordance with ASTM D572:2004 Standard Test Method for Rubber - Deterioration by Heat and Oxygen

5.4.3 Acceptance Criteria

At the end of the test procedure, synthetic rubber parts of fueling connection devices shall not crack or show visible evidence of deterioration.

5.5 Hydrogen Resistance Test

5.5.1 Objective

Verify sealing material resistance to damage from hydrogen diffusion and subsequent depressurization. This test is applicable to sealing materials in test nozzles or test receptacles.

5.5.2 Test Procedure

Representative samples of non-metallic synthetic material shall be prepared, measured, and weighed. The samples shall then be immersed in hydrogen at Nominal Working Pressure and nominal temperature, as stipulated in section 4.2.3, for 168 h. Following this time period, the test pressure shall be reduced to atmospheric pressure in less time than the seals would experience when depressurizing in actual service, not to exceed 1 s, after which the test samples shall be inspected.

The test shall be repeated for samples immersed in hydrogen at Design Pressure and minimum temperature, as stipulated in section 4.2.3, for 168 h.

5.5.3 Acceptance Criteria

At the end of the test procedure, the samples shall not exhibit evidence of explosive decompression damage, swelled more than 25%, have shrunk more than 1%, or have incurred a weight loss of more than 10%.

5.6 Room Temperature Leak Test

5.6.1 Objective

Verify leakage rate of nozzle, receptacle, connector, and receptacle check valve at room temperature. This test is applicable to test nozzles and test receptacles.

5.6.2 Test Procedure

5.6.2.1 General Procedure

Tests shall be conducted at 0.5 MPa and 150% of the Nominal Working Pressure at the nominal temperature stipulated in section 4.2.3.

The nozzle designs being evaluated shall be tested with loose (Figure 5.12.2.1 and 5.12.2.2) and tight (Figure 5.12.3.1 and 5.12.3.2) fit test fixtures for the nozzle pressure class and greater.

The receptacle designs being evaluated shall be tested with hardware stipulated in section 5.1.3.

All devices shall be checked for leakage from the time of connection, through pressurization, to the time of disconnection. Leakage is detected by submerging the test device in water and visually looking for bubbles for 1 min.

If bubbles are detected then the leak rate shall be measured by either an external vacuum test using Leak Test Gas (global accumulation test) or an equivalent method.

5.6.2.2 Nozzle, Receptacle, and Connector Procedure

Tests will be conducted on a disconnected nozzle, a disconnected receptacle, and a connector.

Pressurized Leak Test Gas shall be applied to the inlet of the connector, inlet of the disconnected nozzle, or outlet of the disconnected receptacle.

5.6.2.3 Receptacle Check Valve Procedure

Pressurized Leak Test Gas shall be applied to the inlet of the connector. The upstream portion of receptacle shall be quickly depressurized, the nozzle disconnected and the receptacle check-valve checked for leakage.

5.6.3 Acceptance Criteria

The device being tested shall be bubble free for 1 min or have a leak rate less than 20cm^3_n/h.

5.7 Low and High Temperature Leak Test

5.7.1 Objective

Verify leakage rate and operation of nozzle, receptacle, and connector at low and high temperatures as stipulated in section 4.2.3.

5.7.2 Test Procedure

5.7.2.1 Preparation

The nozzle designs being evaluated shall be tested with nominal dimension (Figure 4.3.21 and 4.3.2.2) fit test fixtures for the nozzle pressure class and greater.

The receptacle designs being evaluated shall be tested with hardware stipulated in section 5.1.3.

All tests shall be conducted while the devices are continuing to be exposed to the specified test temperatures. The outlet of the device shall be plugged and the test pressure shall be applied to the inlet of the device.

5.7.2.2 Leakage Procedure

Fueling connection devices shall be tested in accordance with the test conditions listed in this section after 2 h of conditioning for the components and leak detector (if used):

a. The connector, conditioned at -40 °C and pressurized at 0.5 MPa and 125% of Nominal Working Pressure.

b. The connector, conditioned at 85 °C and pressurized at 1 MPa and 125% of Nominal Working Pressure.

c. The receptacle uncoupled, conditioned at -40 °C and pressurized at 0.5 MPa and 125% of Nominal Working Pressure.

d. The receptacle uncoupled, conditioned at 85 °C and pressurized at 1 MPa and 125% of Nominal Working Pressure.

e. The nozzle uncoupled, conditioned at -40 °C and pressurized at 0.5 MPa and 125% of Nominal Working Pressure.

f. The nozzle uncoupled, conditioned at 85 °C and pressurized at 1 MPa and 125% of Nominal Working Pressure.

These pressures were selected so that density is constant.

Pressurized Leak Test Gas shall be applied to the test components, and the nozzle and receptacle connected and disconnected 10 times. The external body shall be inspected for leakage using immersion in 100% denatured ethyl alcohol at -40 °C and water at 85 °C for 1 min.

If bubbles are detected then the leak rate shall be measured by either an external vacuum test using Leak Test Gas (global accumulation test) or an equivalent method.

5.7.3 Acceptance Criteria

The devices being tested shall connect and disconnect normally, and be bubble free for 1 min or have a leak rate less than 20cm^3_n/h.

5.8 Hydrostatic (or Ultimate) Strength Test

5.8.1 Objective

Verify that the nozzle, receptacle, and connector will not fail when subjected to pressures resulting in stresses near their Ultimate Strength. Because the devices are subjected to stresses near their Ultimate Strength, do not use the test samples for testing or any other pressure-containing use after this test. This test is applicable to test nozzles and test receptacles.

5.8.2 Test Procedure

The nozzle designs being evaluated shall be tested with loose (Figure 5.12.2.1 and 5.12.2.2) and tight (Figure 5.12.3.1 and 5.12.3.2) fit test fixtures for the nozzle pressure class and greater.

The receptacle designs being evaluated shall be tested with hardware stipulated in section 5.1.3

Outlet openings of the uncoupled or coupled device shall be plugged, and valve seats or internal blocks made to assume the open position. A hydrostatic pressure of 300% of the Nominal Working Pressure shall be applied to the inlet of the nozzle or outlet of the receptacle for a period of at least 3 min. After depressurizing, inspect the receptacle and nozzle.

5.8.3 Acceptance Criteria

The connector will exhibit constant, stable pressure during the 3 min test period with no visible damage to the nozzle or receptacle upon inspection.

5.9 Drop Test

5.9.1 Objective

Verify that a nozzle can withstand a drop of 2 m under -40 °C conditions. This test is applicable to test nozzles.

5.9.2 Test Procedure

The nozzle designs being evaluated shall be tested with nominal dimension (Figure 4.3.2.1 and 4.3.2.2) fit test fixture for the nozzle pressure class and greater.

The receptacle designs being evaluated shall be tested with hardware stipulated in section 5.1.3.

A nozzle conditioned at -40 °C for 2 h shall be connected to a 5 m length fueling hose rated for the same H class as the nozzle being tested, and then dropped 2 m onto a concrete floor as shown in Figure 5.9.2. The nozzle shall be dropped 10 times within 5 min of removal from the conditioning chamber, then pressurized to 150% of the Nominal Working Pressure and subjected to 10 additional drops within 5 further min. After the last drop, conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic Strength Test of section 5.8.

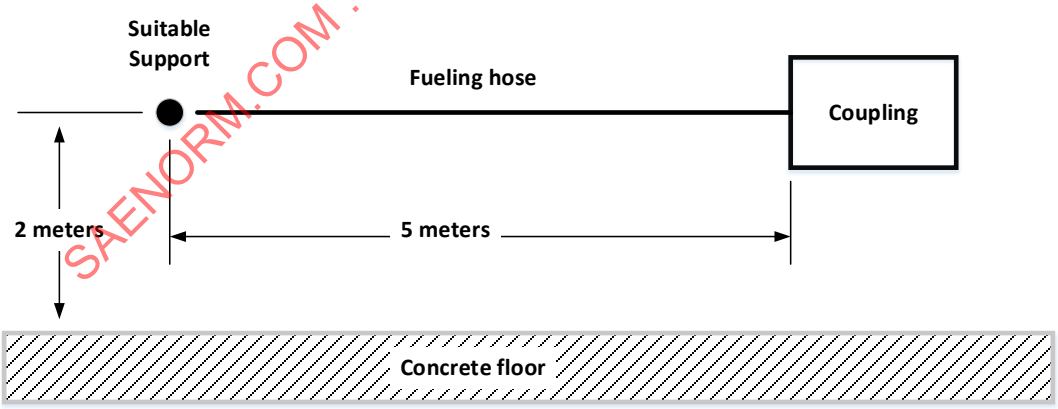


Figure 5.9.2 - Test arrangement for dropping test

5.9.3 Acceptance Criteria

Following all drops described in this section, the nozzle shall be capable of normal connection to the receptacle, and successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic Strength Test of section 5.8.

5.10 Receptacle Vibration Resistance Test

5.10.1 Objective

Verify receptacle and protective cap resistance to vibration.

5.10.2 Test Procedure

The receptacle and protective cap shall be secured in a test apparatus and vibrated at each integer frequency from 5 to 60 Hz, for 8 min at each frequency. The amplitude of the vibration shall be at least 1.5 mm from 5 to 20 Hz, 1.2 mm from 20 to 40 Hz, and 1 mm from 40 to 60 Hz. The tests shall be conducted once in the axial direction and once in the radial direction.

After the last vibration test, conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic Strength Test of section 5.8.

5.10.3 Acceptance Criteria

There shall be no visible damage to the receptacle and protective cap. The protective cap shall not have been dislodged from its seated position. The receptacle shall successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic Strength Test of section 5.8.

5.11 Abnormal Loads Test

5.11.1 Objective

Verify that the nozzle can withstand abnormal loads in service, both axial and moments about the end fitting. This test is applicable to test nozzles.

5.11.2 Test Procedure

The nozzle designs being evaluated shall be tested with loose (Figure 5.12.2.1 and 5.12.2.2) fit test fixture for the nozzle pressure class and greater. The fixture, with the nozzle attached, shall be mounted cantilever to a supporting member. The supporting member shall be capable of withstanding the specified loads without displacement or deflection. The nozzle shall be properly connected to the test fixture, and the load test performed both depressurized and pressurized to the Nominal Working Pressure. An axial load 1000 N acting to separate the connector shall be applied for 5 s, followed by a radial load of 360 Nm applied at the hose end of the nozzle for 5 s.

After the Abnormal Load Test, conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic Strength Test of section 5.8.

5.11.3 Acceptance Criteria

There shall be no visible damage to the nozzle. The nozzle shall successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic Strength Test of section 5.8.

5.12 Durability Cycling Test

5.12.1 Objective

Verify that the nozzle and receptacle can withstand anticipated life-time cycling (100 000 and 15 000 cycles, respectively). This test is applicable to test nozzles and test receptacles.

5.12.2 Test Procedure

During testing, all devices shall be maintained according to the manufacturer's instructions. Requirements for maintenance at intervals less than specified by the manufacturer shall be considered as non-compliant with this document.

5.12.2.1 Nozzle Test

5.12.2.1.1 Nozzle Test Procedure

One cycle of operation for a nozzle shall consist of:

a. Properly connecting the nozzle to the specified receptacle test fixture

b. Pressurizing the connector to 125% NWP using Leak Test Gas

c. Hold pressure for 30 s

d. Depressurizing the connector

e. Disconnecting the nozzle

f. Rotating the test fixture relative to the nozzle at random or equal increments

Perform 100 000 cycles, replacing the receptacle test fixture each 15 000 cycles as specified in Table 5.12. Measure the used Tight or Loose Fit Receptacle test fixture and compare to the Worn Receptacle test fixture of Figure 5.12.1.1 or 5.12.1.2 as appropriate. Measure the electrical resistance of the connector from receptacle to nozzle after connection for the first cycle. Measure the electrical resistance of the connector from receptacle to nozzle prior to first cycle and prior to disconnection after the last cycle.

Table 5.12 - Test fixture selection for nozzle durability tests

Cycle Numbers in Thousands	Figure	Geometry
0-15	5.12.3.1 and 5.12.3.2	Tight Fit
15-30	5.12.3.1 and 5.12.3.2	Tight Fit
30-45	5.12.2.1 and 5.12.2.2	Loose Fit
45-60	5.12.2.1 and 5.12.2.2	Loose Fit
60-75	5.12.3.1 and 5.12.3.2	Tight Fit
75-90	5.12.3.1 and 5.12.3.2	Tight Fit
90-100	5.12.2.1 and 5.12.2.2	Loose Fit

At the end of the cycling test, Couple the nozzle to the Worn Receptacle test fixture from Figure 5.12.1.1 and 5.12.1.2 as appropriate, and visual inspect the nozzle to ensure it is properly engaged on the receptacle. Using the appropriate Worn Receptacle test fixture, conduct the User-Machine Interface Test of section 5.2, the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic (or Ultimate) Strength Test of Section 5.

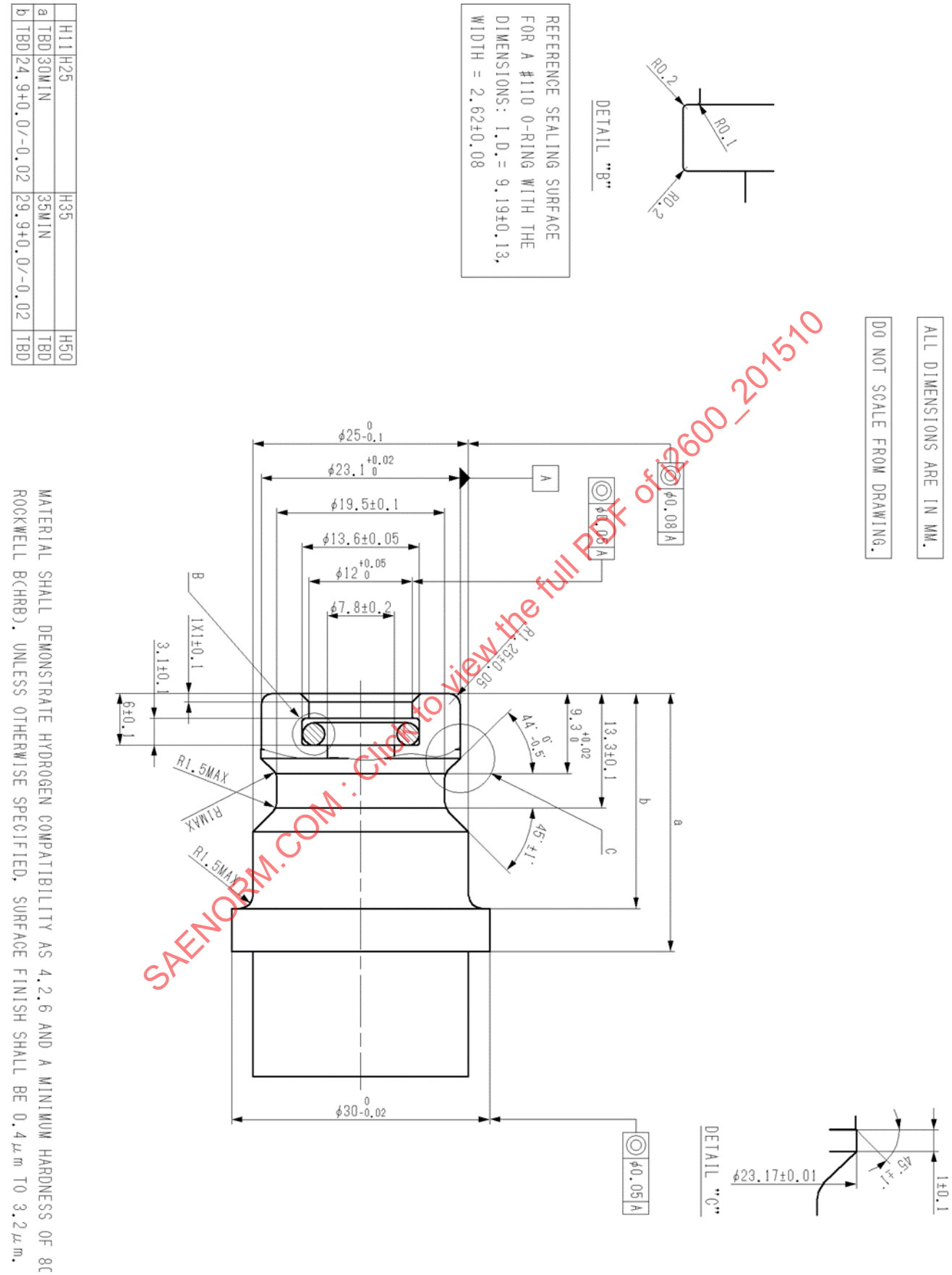


Figure 5.12.1.1 - H11 to H50 worn fit test fixture

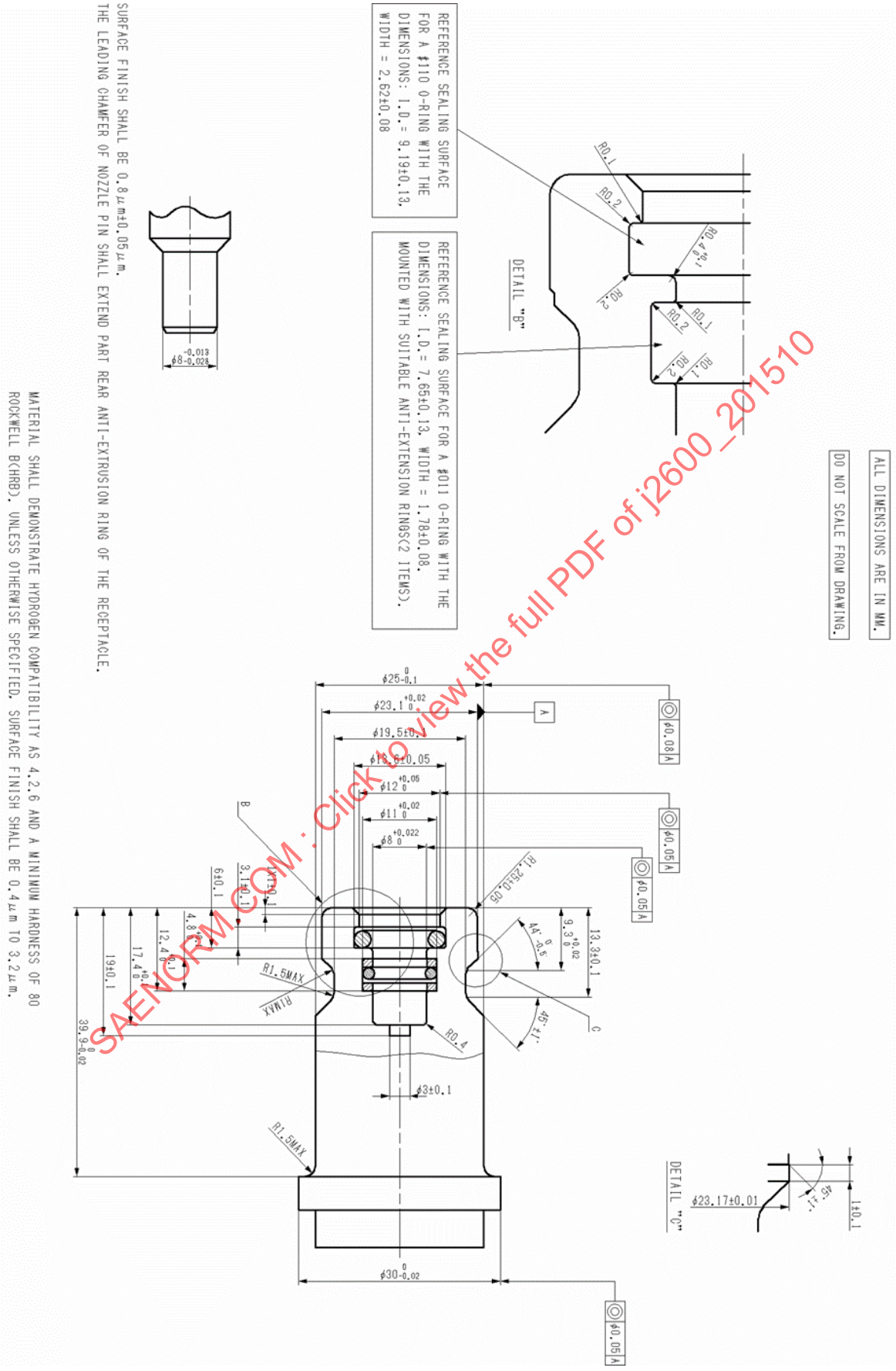


Figure 5.12.1.2 - H70 worn fit test fixture

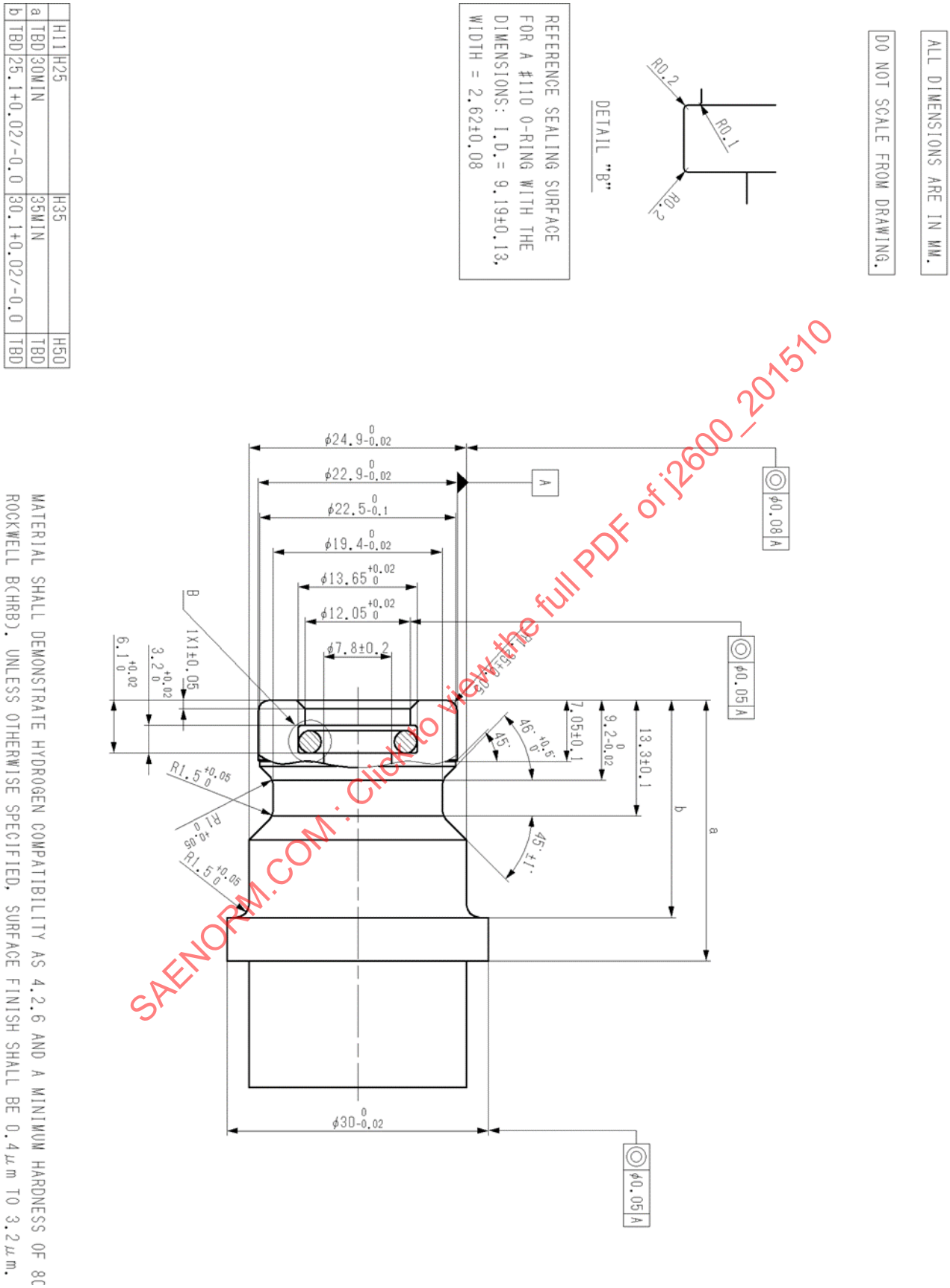


Figure 5.12.2.1 - H11 to H50 loose fit test fixture

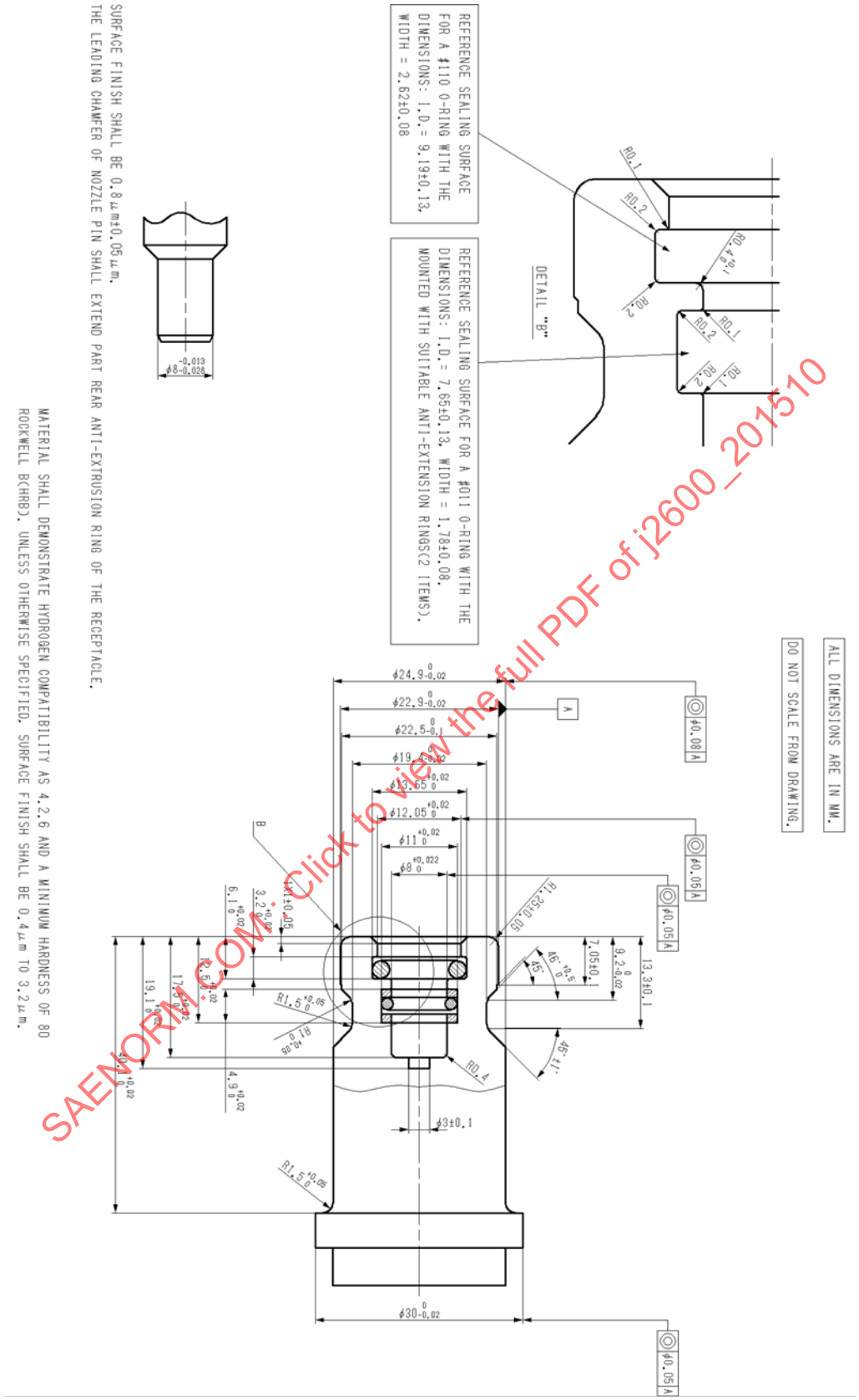


Figure 5.12.2.2 – H70 loose fit test fixture

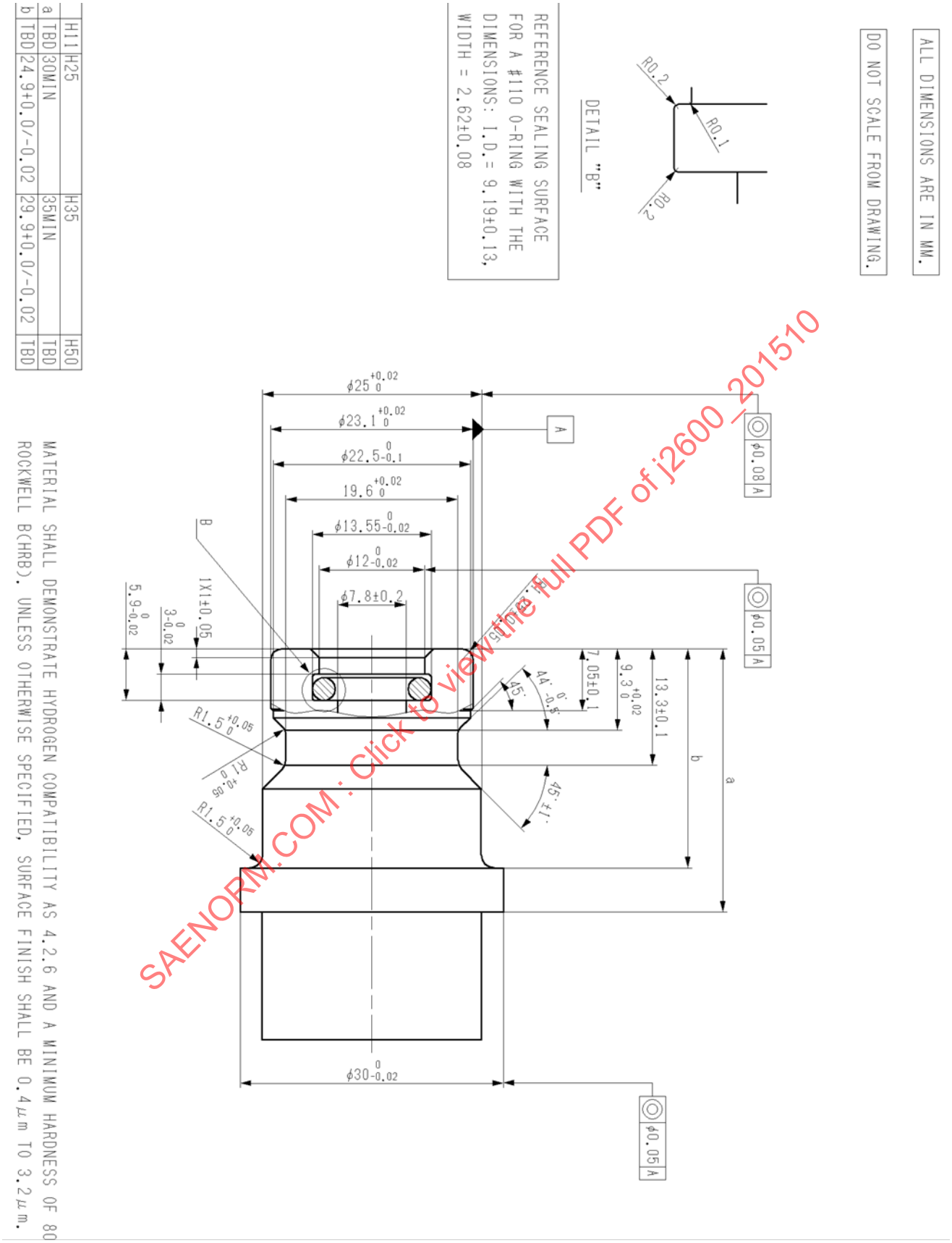


Figure 5.12.3.1 - H11 to H50 tight fit test fixture

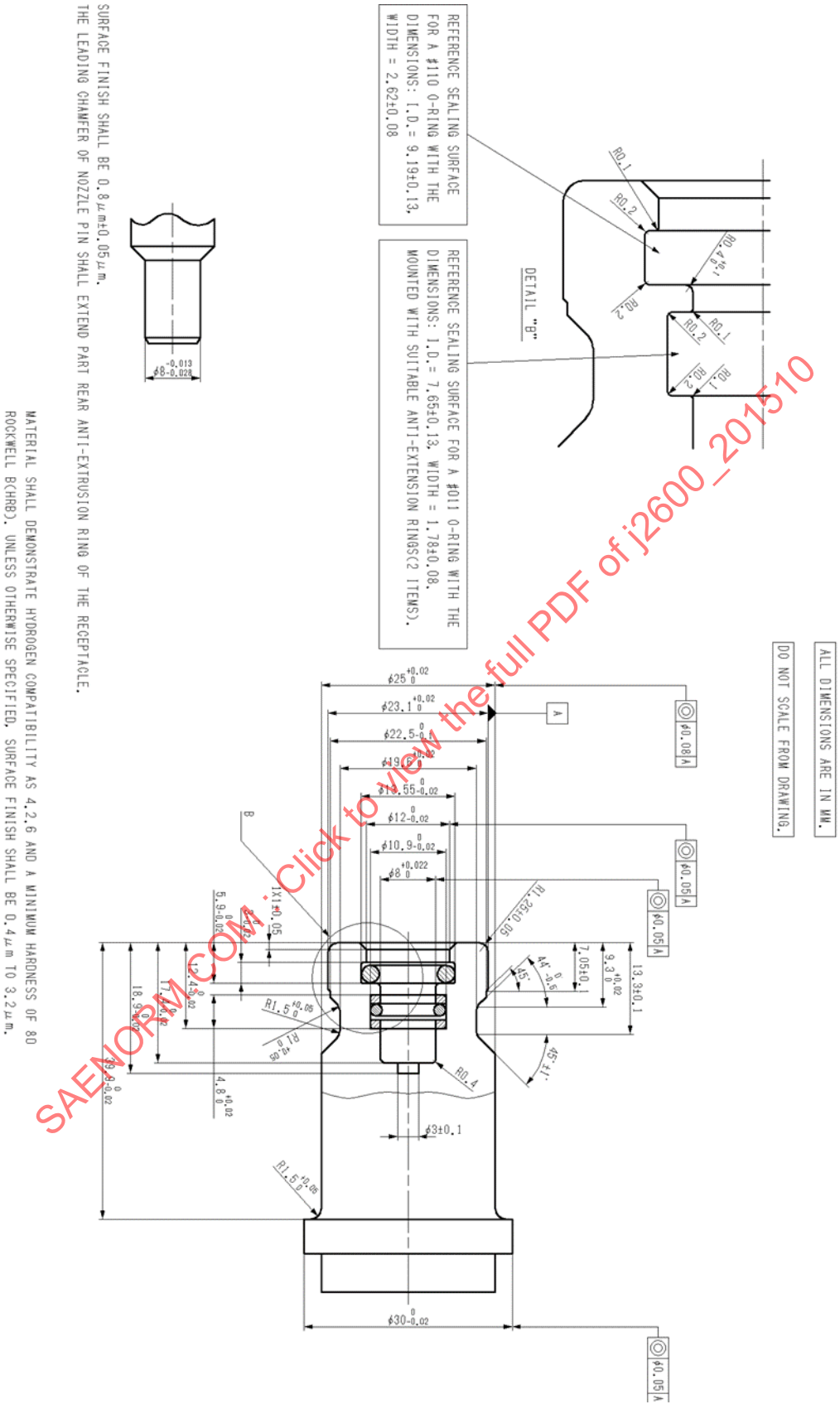


Figure 5.12.3.2 - H70 tight test fixture

5.12.2.1.2 Acceptance Criteria

At the end of the Nozzle Durability Cycling Test, the nozzle shall properly engage the appropriate Worn Receptacle test fixture. The nozzle shall successfully complete the User-Machine Interface Test of section 5.2, the Room Temperature Leak Test of section 5.6, and the Hydrostatic (or Ultimate) Strength Test of section 5.8.

Measurements of the used Tight and Loose Fit Receptacle test fixtures shall not show wear in excess of the appropriate Worn Receptacle text fixture.

Each measured electrical resistance shall be less than 1,000 Ω.

5.12.2.2 Receptacle Check Valve

5.12.2.2.1 Receptacle Check Valve Test Procedure

One cycle of operation for a receptacle check valve shall consist of:

a. Properly connecting the receptacle to the nozzle test fixture

b. Pressurizing the connector to 125% NWP with 6 pulses using Leak Test Gas

c. Hold pressure for 30 s

d. Depressurizing the connector by first venting the upstream side of the receptacle check valve and then lowering the pressure on the downstream side of the receptacle check valve to between 0 and 0.5 MPa prior to the next cycle.

Following 15 000 cycles of operation, the receptacle check valve shall then be subjected to 24 h of flow at the inlet/outlet flow conditions that cause the most severe chatter. Measure the electrical resistance of the connector from receptacle to nozzle after connection for the first cycle. Measure the electrical resistance of the connector from receptacle to nozzle prior to disconnection after the 24 h of flow.

Conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic (or Ultimate) Strength Test of section 5.8.

5.12.2.2.2 Acceptance Criteria

The receptacle shall successfully complete the Room Temperature Leak Test of 5.6 and the Hydrostatic (or Ultimate) Strength Test of section 5.8. Each measured electrical resistance shall be less than 1,000 Ω.

5.12.2.3 Receptacle Test

5.12.2.3.1 Receptacle Test Procedure

One cycle of operation for a receptacle shall consist of:

a. Properly connecting the nozzle to the receptacle

b. Pressurizing the connector to the 125% NWP using Leak Test Gas

c. Hold pressure for 30 s

d. Depressurizing the nozzle

e. Disconnecting the nozzle

f. Depressurizing the receptacle

The receptacle shall undergo 15,000 cycles. Measure the electrical resistance of the connector from receptacle to nozzle after connection for the first cycle. Measure the electrical resistance of the connector from receptacle to nozzle prior to disconnection after the last cycle.

Conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic Strength Test of section 5.8.

5.12.2.3.2 Acceptance Criteria

The receptacle shall successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic (or Ultimate) Strength Test of section 5.8. Each measured electrical resistance shall be less than 1,000 Ω.

5.12.2.4 Connector Electrical Bonding Test

5.12.2.4.1 Connector Test Procedure

The nozzle designs being evaluated shall be tested with nominal dimension (Figures 4.3.2.1 and 4.3.2.2) fit test fixtures for the nozzle pressure class.

The receptacle designs being evaluated shall be tested with a single sample of the hardware stipulated in section 5.1.3

The outlet of the assembled hardware is to be open to atmospheric pressure. The supply port of the nozzle is to be connected to a supply system which will supply sufficient compressed Leak Test Gas as required in this section. The test supply system shall not limit the flow during this test.

One cycle of operation for a connector shall consist of:

a. Connecting the test nozzle to the test receptacle.

b. Ensure supply pressure is at the Nominal Working Pressure

c. Flowing Leak Test Gas for 2 s as fast as the connector will allow, but not exceeding 60 g/s, while monitoring supply pressure to ensure it does not fall below 53% of the Design Pressure.

d. Disconnecting the test nozzle from the test receptacle

Conduct 30 cycles. Measure the electrical resistance of the connector from receptacle to nozzle after connection for the first cycle. Measure the electrical resistance of the connector from receptacle to nozzle prior to disconnection after the last cycle. Conduct the Room Temperature Leak Test of section 5.6.

5.12.2.4.2 Acceptance Criteria

The connector shall successfully complete the Room Temperature Leak Test of section 5.6. Each measured electrical resistance shall be less than 1,000 Ω.

5.13 Corrosion Resistance Test

5.13.1 Objective

Verify nozzle and receptacle resistance to corrosion. This test is applicable to test nozzles and test receptacles.

5.13.2 Test Procedure

The nozzle designs being evaluated shall be tested with nominal dimension (Figures 4.3.2.1 and 4.3.2.2) fit test fixtures for the nozzle pressure class.

The receptacle designs being evaluated shall be tested with a single sample of the hardware stipulated in section 5.1.3.

5.13.2.1.1 Test Method

The manufacturer has the option to show compliance by successfully completing one of the following test methods:

Option 1 – Original Test Method

The assembled hardware shall be supported in a horizontal position. The nozzle shall be exposed for 96 h and the receptacle for 1,000 h to a salt spray as specified in EN ISO 9227: 2006, Corrosion tests in artificial environments - salt spray tests.

Throughout the test, the temperature within the test chamber shall be maintained between 33 °C and 36 °C. The salt spray solution shall consist of 5% sodium chloride and 95% reagent water defined as ASTM D1193 type 2 (by weight).

Option 2 – HGV3 and HPRD1 Test Method

The assembled hardware shall be supported in a horizontal position. The nozzle and receptacle shall be installed in accordance with the manufacturers recommended procedure and exposed for 144 h to a salt spray (fog) test as specified in the current standard method ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.

Option 3: GMW14872 Test Method

The assembled hardware shall be supported in a horizontal position. The nozzle shall follow exposure C, as specified in GMW14872, for 7 cycles with a cycle duration of 24 h. The receptacle shall follow exposure C for 25 cycles with a cycle duration of 24 h.

5.13.2.2 Test Details

A pressure of 0.5 MPa air shall also be continuously applied to the inlet of the nozzle. The nozzle shall be operated once an hour to dispense air (to the atmosphere through a dummy receptacle) during the first 8 h test period.

Immediately following the 96 h test the nozzle shall be rinsed and gently cleaned of salt deposits.

Immediately following the 1000 h test, the areas of receptacles protected by protective caps shall be examined. The receptacle shall then be rinsed and gently cleaned of salt deposits.

After cleaning, inspect the receptacle and nozzle. Conduct the Room Temperature Leak Test of section 5.6, followed by the Hydrostatic Strength Test of section 5.8.

5.13.3 Acceptance Criteria

The nozzle and receptacle shall not show evidence of corrosion or loss of protective coatings. There shall be no evidence that water has entered the area protected by the protective cap. The device shall successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic (or Ultimate) Strength Test of section 5.8.

5.14 Deformation of Field Connected/Assembled Parts Test

5.14.1 Objective

Verify that field connected/assembled parts can withstand a specified installation over-torque. This test is applicable to the nozzle with a representative hose attached following the installation/maintenance manual procedures. This test is also applicable to the receptacle with a representative fuel system attached following the installation/maintenance manual procedures.

5.14.2 Test Procedure

The hardware shall be assembled in accordance with the nozzle manufacturer's directions, except torque to 150% of the specified torque of any threaded connection (straight o-ring, split flange, etc.). Conduct visual inspection. While still connected/assembled, conduct the room temperature leak test of section 5.6 at the Nominal Working Pressure and the Hydrostatic Strength test of section 5.8.

5.14.3 Acceptance Criteria

No visible damage to connected/assembled parts. The device shall successfully complete the Room Temperature Leak Test of section 5.6 and the Hydrostatic (or Ultimate) Strength Test of section 5.8.

5.15 Contamination Test

5.15.1 Objective

Verify that the nozzle and receptacle can withstand contamination. This test is applicable to test nozzles and test receptacles.

5.15.2 Test Procedure

The nozzle designs being evaluated shall be tested with nominal dimension (Figures 4.3.2.1 and 4.3.2.2) fit test fixtures for the nozzle pressure class.

The receptacle designs being evaluated shall be tested with a single sample of the hardware stipulated in section 5.1.3

The assembled hardware shall be exposed to a solution consisting of a suspension of 5% by volume salt and sand (ISO 12103-A4 Coarse Grade Test Dust, GMW14872-2006 appendix D or equivalent) dissolved/suspended in distilled water. Place in a tank or vessel of adequate size that the test devices can be submerged without touching the bottom. At no point during this procedure is the nozzle or receptacle to be cleaned.

One cycle of operation shall consist of:

a. Dip the connection end of the nozzle and receptacle into the test solution/suspension for 1 to 5 s and remove. The devices are to be dipped in a manner that the entire connection area is submerged without touching the bottom.

b. The solution is to air dry on the hardware.

c. Connect the nozzle to the receptacle.

d. Flow hydrogen through the connector at 150% Nominal Working Pressure for 5 s.

e. Conduct the Room Temperature Leak Test of 5.6

f. Disconnect the nozzle from the receptacle.

Conduct 10 cycles.

5.15.3 Acceptance Criteria

The test specimen shall successful complete of the Room Temperature Leak Test, section 5.6, after each cycle.