SAE International™

SURFACE VEHICLE STANDARD

SAE J2600

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Compressed Hydrogen Surface Vehicle Refuelling Connection Devices

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1. Scope

1.1 SAE J2600 applies to design, safety and operation verification of Compressed Hydrogen Surface Vehicle (CHSV) refuelling connection devices hereinafter referred to as nozzle and receptacle. CHSV Refuelling nozzles and receptacles shall consist of the following components, as applicable. Alternatives may be used as long as the alternative geometries shall not be interchangeable with the standard geometry specified in this SAE Standard and the standard geometry in Section 6 provides insufficient flow rates:

a. Receptacle and protective cap (mounted on vehicle) (see Section 6 and 7);
b. Nozzle (see Section 5).

1.2 This document applies to devices which have Working Pressures of 25 MPa, 35 MPa, 50 MPa or 70 MPa hereinafter referred to in this document as the following (see 9.1c):

H25 - 25 MPa at 15 °C
H35 - 35 MPa at 15 °C
H50 - 50 MPa at 15 °C
H70 - 70 MPa at 15 °C

1.3 This document applies to nozzles and receptacles which (1) prevent hydrogen fuelled vehicles from being refuelled by dispenser stations with Working Pressures higher than the vehicle; (2) allow hydrogen vehicles to be refuelled by dispenser stations with Working Pressures equal to or lower than the vehicle fuel system Working Pressure, (3) prevent hydrogen fuelled vehicles from being refuelled by other compressed gases dispensing stations and (4) prevent other gaseous fuelled vehicles from being refuelled by hydrogen dispensing stations.

1.4 All dimensions used in this document are in metric units [International System of Units (SI)].

1.5 For the purposes of this document, compressed hydrogen gas should meet the requirements of ISO 14687 Hydrogen fuel – Product specification.

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

All test procedures listed in this document are design verification test procedures unless otherwise noted.

All products must pass all tests to be considered to have met this design standard.

2. References

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

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J2574—Fuel Cell Vehicle Terminology
SAE J2578—Recommended Practice for General Fuel Cell Vehicle Safety

2.1.2 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 188:1992—Rubber vulcanized—Accelerated ageing or heat resistance tests
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 14687—Hydrogen fuel—Product specification
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

3. Definitions—See SAE J2574 for any unlisted definitions.

3.1 Air, Dry—Air with a maximum dew point of –40 °C.

3.2 Connector—A joined assembly of CHSV nozzle and receptacle which permits quick connect and disconnect of fuel supply hose to the receptacle.

3.3 Cycle—The process of a making a positive connection between the nozzle and the receptacle, pressurizing to Design Pressure, depressurising and disconnecting.

3.4 Design Pressure—The maximum pressure that a component will experience in actual service. The Design Pressure is 125% of the Working Pressure for the purpose of design of nozzles and receptacles in this document.

3.5 Helium or Hydrogen, Dry—Helium or Hydrogen with a maximum dew point of –40 °C and at least 99% pure.

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 provides the CHSV connector and permits transfer of fuel. This may also be referred to a refuelling connector.

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

3.10 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.

3.11 Working Pressure—Pressure for which the product is intended to be operated at for a given gas temperature of 15 °C (this defines a full tank gas density).

4. General Construction Requirements

4.1 COMPRESSED HYDROGEN SURFACE VEHICLE nozzles and receptacles made to this document shall be designed in accordance with reasonable concepts of safety, durability and maintainability.

4.2 COMPRESSED HYDROGEN SURFACE VEHICLE 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.

4.3 COMPRESSED HYDROGEN SURFACE VEHICLE nozzles and receptacles shall be (1) designed to minimise the possibility of incorrect assembly; (2) designed to be secure against displacement, distortion, warping or other damage; and (3) constructed to maintain operational integrity under normal and reasonable condition of handling and usage.

4.4 COMPRESSED HYDROGEN SURFACE VEHICLE 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 (see 3.4). All pressure bearing and wetted components shall also be made from adequate material that is compatible with deionised water. The material compatibility shall be documented by the component manufacturer or an independent third party, or an independent party to a standard such as ISO 1817. Materials used in the construction of nozzles, receptacles and dust caps shall be documented as non-sparking.

4.5 COMPRESSED HYDROGEN SURFACE VEHICLE connectors shall be operated to either connect or disconnect without the use of tools.

4.6 The receptacle shall be mounted on the vehicle in compliance with SAE J2578 and ISO 15501.

4.7 Protective caps are intended to protect the receptacle from foreign debris and shall not hold pressure. Resistance shall be appropriate to prevent inadvertent dislodging. All protective caps must have a retainer to attach them to the receptacle or vehicle.

5. Nozzles

5.1 Nozzles shall comply with the dimmensional requirements of Section 6 to ensure proper interchangeability. Nozzles shall couple with receptacles of higher Working Pressures, but they shall be designed so that they will not couple with receptacles of lower Working Pressures.

5.2 Nozzles shall be one of three types as described hereunder.

a. 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 (see 10.2.4 through 10.2.7).

b. 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 (see 10.2.4 through 10.2.7). External three-way valves shall be constructed and marked so as to indicate clearly the open, shut and vent positions.

c. TYPE C - A nozzle for use with dispensing hoses which are depressurized (0.5 MPa and below) at dispenser shutdown (see 10.2.4 through 10.2.7). The nozzle shall not allow gas to flow until a positive connection has been achieved. The function of preventing flow can be controlled by the dispenser as long as it is receiving a positive connection signal from the nozzle.

In addition, nozzles shall be designed for a life of 100 000 cycles with manufacturer specified maintenance. The three-way valve used for actuating Type B nozzles shall meet the same number of cycles as the nozzle (i.e., 100 000 cycles).

5.3 The act of venting, or de-pressurising, of the connection space between all nozzle types and receptacles is required prior to disconnection. A provision must be made for venting or de-pressurising of all nozzles types so that they shall be directed to a safe location.

5.4 The means for attaching the nozzle to the fuel dispensing system hose shall not rely on the joint between the male and female threads for sealing, such as tapered pipe threads.

5.5 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 enamelled surface. Permanently attached marking plates shall be securely attached by mechanical means.

5.6 The nozzle shall fit within the envelope described in ISO 15501–2.

5.7 Nozzles shall have a means to prevent the ingress of solid matter from upstream sources. For example, the requirement is met if the nozzle has a filter upstream of adequate size to protect its functionality.

5.8 It shall not be possible to remove a nozzle when the contained pressure is greater than 0.7 MPa

5.9 The nozzle shall be designed to operate properly from –40 °C to 85 °C.

5.10 The nozzle shall not have any mechanical means of opening the receptacle check valve.

6. ***Standard Receptacle Dimensions—***A receptacle shall comply with the design specifications detailed in Figures 1 and 2.

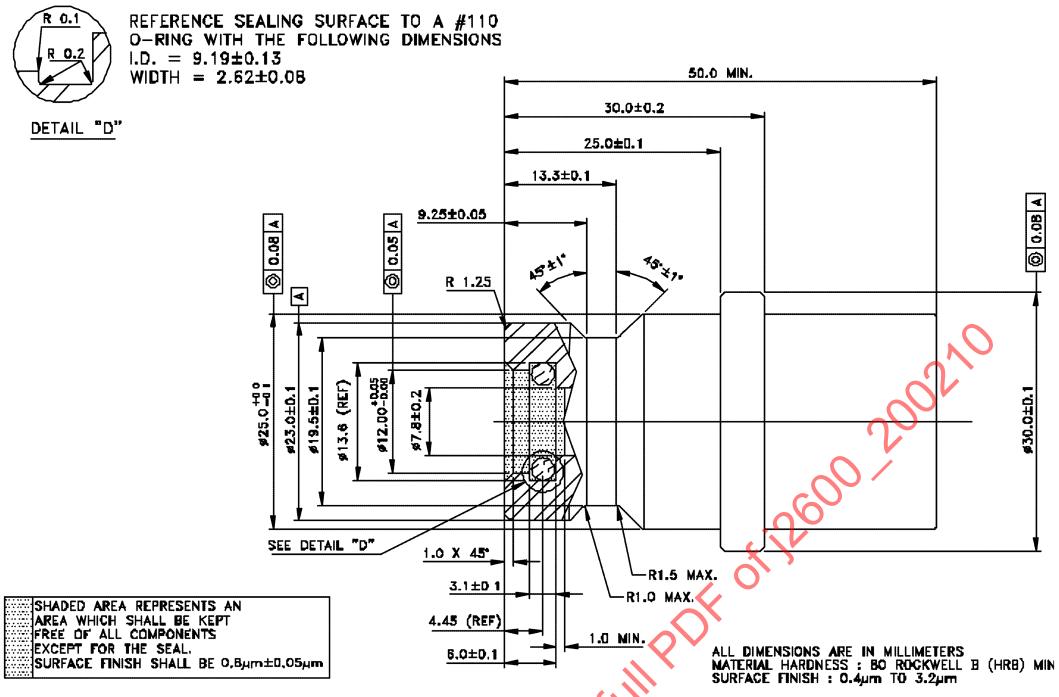

FIGURE 1—H25 HYDROGEN RECEPTACLE

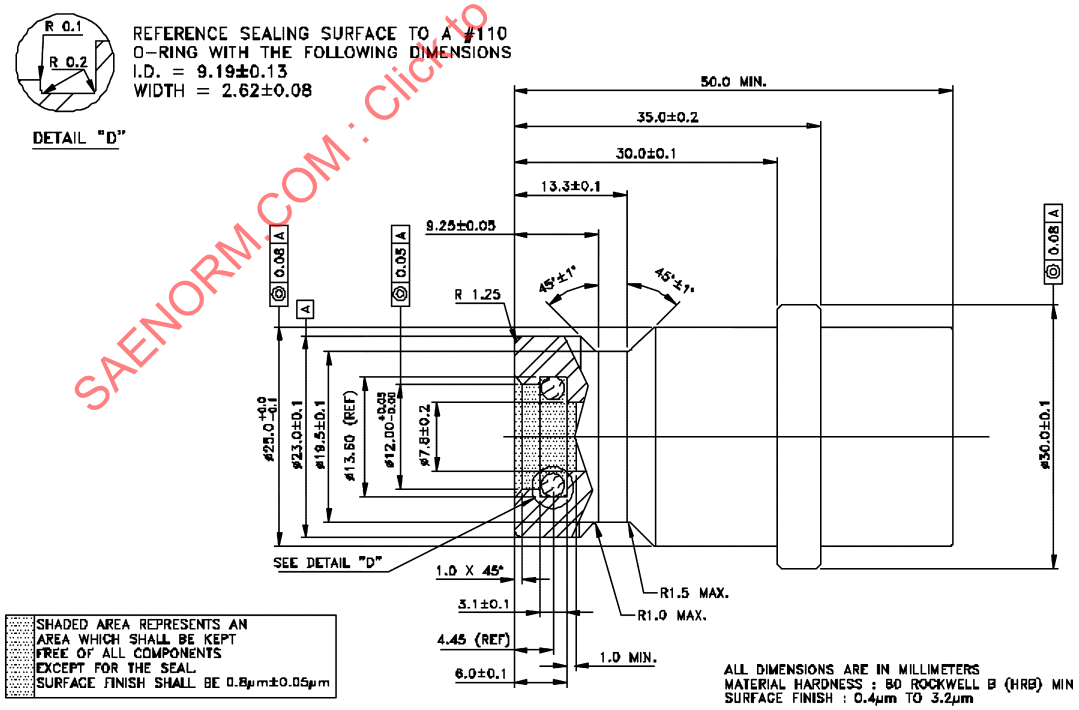

FIGURE 2—H35 HYDROGEN RECEPTACLE

7. Receptacles

7.1 Receptacles shall comply with all sections of this document.

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

In addition, receptacles shall be designed for a life of 15 000 cycles and 15 years with manufacturer specified maintenance.

7.2 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 Figures 1 and 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.

7.3 The receptacle shall be equipped with an internal check valve to prevent the escape of gas. The check valve shall be of the non-contact type, opening by differential pressure only.

7.4 The means for attaching the receptacle to the vehicle fuel system shall not rely on the joint between the male and female threads for sealing, such as tapered pipe threads.

7.5 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.

7.6 The receptacle shall have provisions to be firmly attached to the vehicle and shall comply with applicable abnormal load tests (see 10.7).

7.7 The receptacle shall be designed to operate properly from –40 °C to 85 °C.

8. Instructions—Instructions and provisions required by this section are to be in an easily understandable form.

Special tools required for connection of receptacles to tubing shall be clearly identified in the instructions.

Manufacturers of receptacles and nozzles shall provide clear and concise printed instructions and diagrams in a form that can be easily understood and are adequate for (1) proper field assembly, (2) installation, (3) maintenance, (4) replacement of components as appropriate (may include expected lifetime, i.e., 100 000 cycles), (5) safe operation by all users (6) suitability and use, and (7) transport, storage and handling.

9. Marking—Markings required by this section are to be in a legible and easily understandable form. These markings shall be embossed, cast, stamped or otherwise formed in the part or a plate. This includes markings baked into an enamelled surface. Permanently attached marking plates shall be securely attached by mechanical means. All markings shall be at least 2.5 mm high.

9.1 Nozzles and receptacles shall bear the following information:

a. The manufacturer's or dealer's name, trademark or symbol;
b. The model designation;
c. The appropriate standard designation, H25, H35, H50 or H70
d. The applicable Type A, B or C (Nozzles only)
e. Marking for traceability of receptacles in suitable lots. Nozzles shall carry individual serial numbers.

9.2 A marking to identify this document shall be provided for all components. This marking may be located on the package or on a notice placed inside the package in which the device is shipped.

10. Design Verification Test Procedures

10.1 General Requirements

10.1.1 A nozzle and receptacle shall meet the requirements of all sections of this document.

10.1.2 Unless otherwise stated:

a. Tests shall be conducted at 15 °C ± 5 °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.

10.1.3 Nozzle tests are to be done with the test fixtures, identified under Exhibits A, or B, as applicable. A new receptacle test sample shall be used for each nozzle test. The failure of any test conducted with the nozzle and receptacle test sample shall constitute a failure of the nozzle design.

10.1.4 Receptacles shall be evaluated with any 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.

10.2 User - Machine Interface

10.2.1 The appearance of the nozzle and receptacle shall be such as to clearly suggest the proper method of use.

10.2.2 It shall not be possible to deliver gas using any nozzles unless the nozzle and receptacle are connected properly and positively locked.

10.2.3 Upon disconnection all types of nozzles shall stop the flow of gas. No hazardous condition shall result from disconnection. Type C nozzles shall be at 0.5 MPa during this test.

10.2.4 When the contained pressure is less than or equal to 0.5 MPa, Type A and B nozzles shall be capable of being disconnected with forces less than 22.2 N and torques less than 7 N•m.

10.2.4.1 Test Method—The disconnection forces and torques shall be applied in a direction that tends to unhook and release the nozzle. The torque shall be applied to the unhooking/release actuator or three way valve. For example, if there is a handle, the torque shall be applied through axis rotation of the nozzle handle equal to the exterior handling surface of the nozzle mechanism and in such a direction that tends to unhook and release the nozzle.

10.2.5 On unpressurized devices the axial force to connect and lock or unlock and disconnect the device shall be less than or equal to 90 N.

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

On a locking device which incorporates an axial locking mechanism, the connection and disconnection forces shall not exceed that specified in 10.2.5.

10.2.6 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 2.5 times those values specified in 10.2.4.

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

10.3 Dropping—A nozzle conditioned at –40 °C for 24 hours shall be connected to a 5 m length of 11 mm diameter refuelling hose, and then dropped 2 m onto a concrete floor as shown in Figure 3. The nozzle shall be dropped ten times within five minutes of removal from the conditioning chamber, then pressurized to Design Pressure and subjected to ten additional drops within five further minutes. Following all drops described previously, the nozzle shall be capable of normal connection to the receptacle. In addition, the nozzle shall comply with all leakage tests specified in this document (see 10.4 and 10.12).

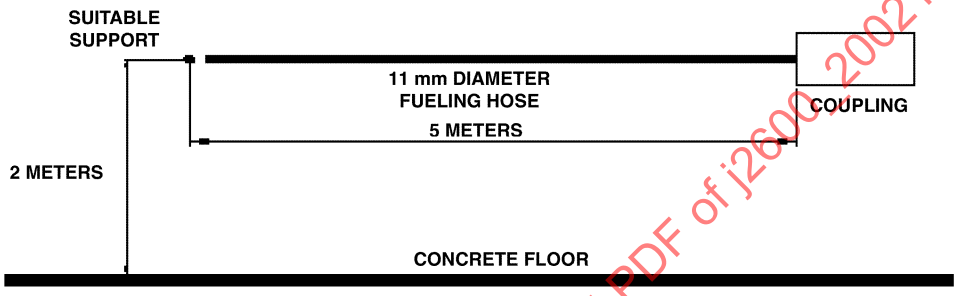

FIGURE 3—TEST ARRANGEMENT FOR DROPPING TEST

10.4 Leakage at Room Temperature

10.4.1 GENERIC TEST PROCEDURE

10.4.1.1 Example Test Method for All Leak Tests—Pressurized Leak Test Gas shall be applied as specified in the specific leak test to the connector or disconnected devices. The external body shall then be checked for bubbles by submerging in water at room temperature unless otherwise specified.

All devices shall be checked for leakage from the time of connection, through pressurization, to the time of disconnection.

If there are no bubbles detected for a period of 1 minute the sample passes the test. 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 to show that the leak rate is less than 20 cm^3_n/h of hydrogen.

Any other equally accurate and repeatable test procedure is acceptable.

10.4.2 A nozzle or receptacle shall have a leak rate less than 20 cm^3_n/h each disconnected. The connector shall have a leak rate less than 20 cm^3_n/h.

Tests shall be conducted at 0.5 MPa and 150% of the Working Pressure.

10.4.2.1 Example Test Method—Pressurized Leak Test Gas shall be applied to the inlet of the connector or disconnected nozzle or outlet of the disconnected receptacle. The Example Test Method For All Leak Tests in 10.4.1 should then be followed.

10.4.3 The receptacle check valve shall be either bubble free on each leak test for 1 minute or have a leak rate less than 20 cm^3_n/h. Tests shall be conducted at 0.5 MPa and 150% of the Working Pressure.

10.4.3.1 Example Test Method—The receptacle shall be connected to a pressure vessel capable of safely accommodating the specified test pressures. The receptacle and pressure vessel shall then be pressurized, at room temperature. Once the pressure vessel has reached the specified test pressure, the upstream portion of the receptacle shall be quickly depressurized and the receptacle check-valve checked for leakage. Bubbles shall be detected by submerging the test unit in water at room temperature.

10.5 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.

10.5.1 EXAMPLE TEST METHOD—This test with the torque or force applied in both the opening and closing directions shall be, (1) performed with the nozzle properly connected to a receptacle, and (2) with the nozzle intentionally improperly engaged relative to the receptacle.

10.6 Receptacle Vibration Resistance—Receptacles and protective caps shall not be damaged and shall comply with the receptacle leakage tests in 10.4 and 10.12 following completion of vibration as specified in the following method of test.

10.6.1 TEST METHOD—The receptacle and protective cap shall be secured in a test apparatus and vibrated at each integer frequency from 5 to 60 Hz for eight minutes 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, once in one radial direction. If the device is not radially symmetrical including the actuator, then a second orthogonal radial direction test is required.

10.7 Abnormal Loads

10.7.1 The nozzle and receptacle mounting hardware may be subjected to the following abnormal loads in service:

a. Pulls along the nozzle or receptacle longitudinal axis
b. Moments applied to the end fitting of the nozzle.

The nozzle and receptacle mounting hardware shall be able to withstand abnormal loads of a=1000 N; b = 120 N•m without distortion or damage. Also, the mounting hardware shall be able to withstand abnormal loads of a=2000 N; b=240 N•m without leakage. The load and moment arm shall be measured from 41 mm from the front of the receptacle to the hose inlet of the nozzle. See Figure 4.

After completing these tests, the receptacle shall comply with Part 10.4 and 10.12.

10.7.2 TEST IN THE UNPRESSURIZED CONDITION—The receptacle test fixture and nozzle shall not be pressurized during the abnormal load tests.

10.7.2.1 Test Method—The “Loose Fit” test fixture shown in Figures 5 and 6 shall be used for this test, regardless of the Design Pressure rating of the nozzle. The test fixture shall be mounted as a cantilever to a supporting member. For the purposes of this test, 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.

The loads applied and the device's ability to resist damage shall be as specified in 10.7.1. After completing the tests, the receptacle shall comply with 10.4 and 10.12.

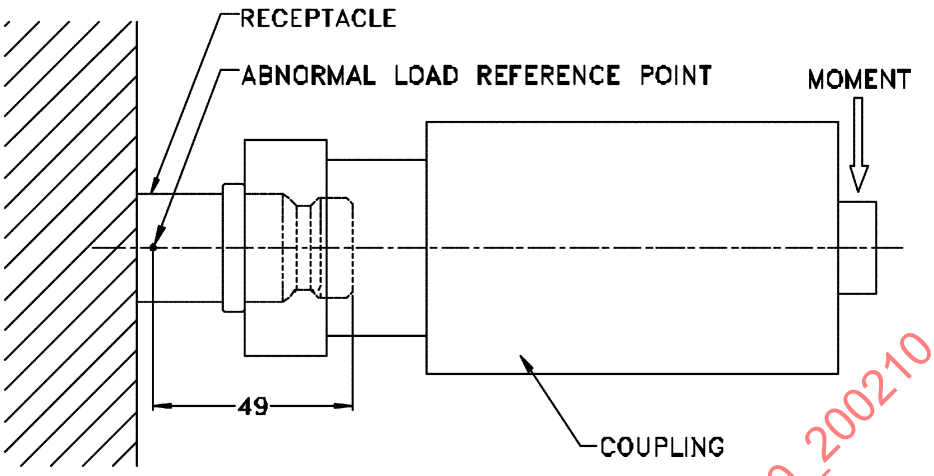

FIGURE 4—ABNORMAL LOAD TEST

10.7.3 TEST IN THE PRESSURIZED CONDITION—The receptacle test fixture and nozzle shall be pressurized to Design Pressure during the abnormal load tests.

10.7.3.1 Test Method—The "Loose Fit" test fixture shown in Figures 5 and 6 shall be used for this test, regardless of the Design Pressure rating of the nozzle. The test fixture shall be mounted as a cantilever to a supporting member. For the purposes of this test, 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.

The loads applied and the device's ability to resist damage shall be as specified in 10.7.1. After completing the tests, the receptacle shall comply with 10.4 and 10.12.

10.8 Rocking/Twisting—The receptacle and its mounting hardware shall not be loosened or damaged when subjected to the following test.

10.8.1 TEST METHOD—Utilizing the receptacle mounting hardware submitted by the manufacturer, the receptacle shall be mounted to a supporting member in accordance with the manufacturer's instructions. For the purposes of this test, the supporting member shall be capable of withstanding the specified loads without displacement or deflection. The nozzle, attached to a pressurized hose as installed for normal use, shall be properly connected to the receptacle. Two equal and opposite 24 N•m moments shall be applied cyclically at alternating times at a point on the nozzle furthest from the receptacle. Both loads shall be applied 2500 times at a frequency not exceeding one cycle per second.

A 4 N•m torque shall then be applied ten times to the receptacle in the direction most likely to loosen the mounting hardware.

Following the previous tests, the receptacle shall comply with room temperature leakage tests (see 10.4). Following room temperature leakage tests, the same receptacle shall comply with hydrostatic strength tests (see 10.12).

10.9 Mounting Hardware Torque—The receptacle and mounting hardware shall withstand, without damage, a turning force equal to 150% of the manufacturer's recommended mounting hardware fastening torque.

10.10 Low and High Temperatures—Prior to conditioning, the devices shall be purged and then sealed from atmosphere under a pressure of 7 MPa leak test gas.

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. The device shall then be tested according to The Example Test Method For All Leak Tests in 10.4 and 10.12.

10.10.1 LEAKAGE—Refuelling connection devices shall meet the leak rate requirement of 10.4.1 when tested as specified in the following test.

10.10.1.1 Test Method—Refuelling connection devices shall be tested in accordance with the test conditions listed below after 2 hours of conditioning for the components and leak detector (if used):

a. The nozzle and receptacle connected, conditioned at –40 °C and pressurized at 0.5 MPa and 80% of Working Pressure.
b. The nozzle and receptacle connected, conditioned at 85 °C and pressurized at 1 MPa and 125% of Working Pressure.
c. The receptacle disconnected, conditioned at –40 °C and pressurized at 0.5 MPa and 80 % of Working Pressure.
d. The receptacle disconnected, conditioned at 85 °C and pressurized at 1 MPa and 125% of Working Pressure.
e. The nozzle disconnected, conditioned at –40 °C and pressurized at 0.5 MPa and 80% of Working Pressure.
f. The nozzle disconnected, conditioned at 85 °C and pressurized at 1 MPa and 125% of Working Pressure.

NOTE— These pressures are selected so that density is consistent for all tests.

Pressurized leak test gas shall be applied to the test components. The external body shall then be checked for bubble tight leakage using:

a. At –40 °C, immersion in a 100% denatured ethyl alcohol mixture for 2 min.
b. At 85 °C, immersion in 85 °C water for 2 min.

The sample passes the test if there are no bubbles for the specified time period. If bubbles are detected, then the leak rate shall be measured by either a vacuum test using helium gas (global accumulation method) or an equivalent method.

10.10.2 OPERATION—The devices shall connect and disconnect normally when tested under the following conditions.

a. The nozzle and receptacle connected and disconnected ten times when conditioned at –40 °C and pressurized to 80% of Working Pressure.
b. The nozzle and receptacle connected and disconnected ten times when conditioned at 85 °C and pressurized to 125% of Working Pressure.

10.11 Durability and Maintainability

10.11.1 Durability Cycling

a. Nozzles—Nozzles shall be capable of withstanding 100 000 operational cycles. During the following tests, all devices shall be maintained according to the manufacturer's instructions. Requirements for maintenance at cycles less than specified by the manufacturer shall be considered as not complying with this document.

1. **Test Method For Type A and B**
   For the purposes of this test, maintain the supply connection to the nozzle at the Design Pressure using leak test gas. One cycle of operation shall be, (1) properly connecting the nozzle to the test fixture, (2) cycle valve to pressurize, then vent and (3) disconnecting the nozzle. While disconnected the test fixture shall be rotated relative to the nozzle at random or equal degree increments throughout this test.
2. **Test Method For Type C**
   For the purposes of this test, one cycle of operation shall be, (1) properly connecting the nozzle to the test fixture, (2) pressuring the device to Design Pressure using leak test gas, (3) depressurising the device, and (4) disconnecting the nozzle. While disconnected the test fixture shall be rotated relative to the nozzle at random or equal degree increments throughout this test.

   At the end of the test, (100 000 cycles) the nozzle shall comply with 10.2, 10.4, 10.11 (check reference) and 10.12 and the nozzle locking mechanism shall be checked at the normal disconnect pressure to ensure it is properly engaged on the nozzle.

   The test fixture shall be replaced at 15 000 cycle intervals. The test fixture shall be selected from Table 1. The worn test fixtures resulting from cycling the test nozzle shall not be in excess of wear patterns shown in Figures 7 and 8 and shall comply with 10.4. In addition, following completion of the required number of cycles, the test nozzle shall comply with 10.4 and 10.12 when tested with the appropriate simulated wear pattern test fixture shown in Figures 7 and 8 as applicable. Failure to comply with any of these tests specified in this paragraph shall be deemed as a failure of the test nozzle. The replacement of nozzle(s) seals at manufacturer specified maintenance intervals shall be acceptable.

TABLE 1—TEST FIXTURE SELECTION FOR NOZZLE DURABILITY TESTS

Cycle Numbers in Thousands	Figures	Geometry
0-15	9, 10	TIGHT FIT
15-30	9, 10	TIGHT FIT
30-45	5, 6	LOOSE FIT
45-60	5, 6	LOOSE FIT
60-75	9, 10	TIGHT FIT
75-90	9, 10	TIGHT FIT
90-100	5, 6	LOOSE FIT

At the completion of cycling, the device shall comply with 10.4 and 10.12.

b. Receptacle Check Valve—The receptacle check valve shall meet the requirements of 10.4.3.

1. **Test Method**
The receptacle shall be connected to a nozzle test fixture. Working Pressure shall be applied to the nozzle and receptacle. Pressure shall then be vented from the upstream side of the receptacle check valve. Pressure on the downstream side of the receptacle check valve shall be lowered to between 0 and a maximum of 0.5 MPa prior to the next cycle.

Following 15 000 cycles of operation, the receptacle check valve shall then be subjected to 24 hours of flow at the inlet/outlet flow conditions that cause the most severe chatter. The receptacle shall then be tested for compliance with 10.4.3 and 10.11.

c. Receptacle—A receptacle shall be capable of withstanding 15 000 cycles of operation as specified in the following test.

1. **Test Method**
For the purposes of this test, maintain the supply connection to the nozzle at the Design Pressure using leak test gas. One cycle of operation shall be, 1) properly connecting the receptacle to the nozzle, and 2) disconnecting the nozzle. After 15 000 cycles, a 20.4 N•m torque will be applied to the pressurized nozzle in the same manner as in Figure 4.

d. The Connected Nozzle and Receptacle—The connected nozzle and receptacle shall be capable of withstanding full flow condition as specified in the following test.

1. **Test Method**
A nozzle test fixture or a receptacle test fixture, as applicable, shall be connected to the device under test. The outlet of the receptacle 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 as follows.

Each nozzle and receptacle shall be cycled as below for 30 cycles. Each cycle shall consist of a total of the full flow of gas with the supply pressure starting at Working Pressure. A cycle shall be two seconds in length and the supply pressure shall not fall below 80% of Working Pressure at the end of each cycle. The test supply system shall not limit the flow during this test.

Following this test the nozzle or receptacle shall meet the requirements of 10.4.

10.11.2 OXYGEN AGING TEST—Sealing material shall be listed and rated by the manufacturer as being resistant to Oxygen Aging. Synthetic rubber parts of Refuelling connection devices shall not crack or show visible evidence of deterioration due to oxygen ageing as specified in the following test method.

10.11.2.1 Test Method—Samples of synthetic rubber parts shall be subjected to 96 hours of exposure at 70 °C and at 2 MPa. This test shall be conducted in accordance with ISO 188: 1992, Rubber vulcanized - Accelerated ageing or heat resistance tests.

10.11.3 NON-METALLIC SYNTHETIC MATERIAL IMMERSION TEST—Non-metallic synthetic material parts of refuelling connection devices which will be in contact with hydrogen shall not show excessive volume change or loss of weight when tested in accordance with the following test method.

10.11.3.1 Test Method—Representative sample(s) of non-metallic synthetic material shall be prepared, measured and weighed. The samples shall then be immersed in hydrogen at Design Pressure for 168 hours. Following this time period, the test pressure shall be reduced to atmospheric pressure in less time than the seals would have to depressurise in actual service, not to exceed 1 second, after which the test samples shall not exhibit evidence of explosive decompression damage. In addition, the samples shall not swell more than 25%, shrink more than 1% and incur a weight loss in excess of 10%.

To evaluate the possible deleterious effects of compressor oils on any non-metallic synthetic material, the material shall also be immersed for a period of 70 hours at room temperature in both commonly used petroleum based and commonly used synthetic compressor oils. Following this time period, observations shall be made as to the condition of the material. The material will be considered to have passed if there is no more than ±3% modification in size, and ±3 shore A in hardness.

10.11.4 ELECTRICAL RESISTANCE—The electrical resistance of the connected receptacle and nozzle shall not be greater than 1000 ohms either in the pressurized or unpressurized state. Tests shall be conducted prior to and after durability cycling (see 10.11.1).

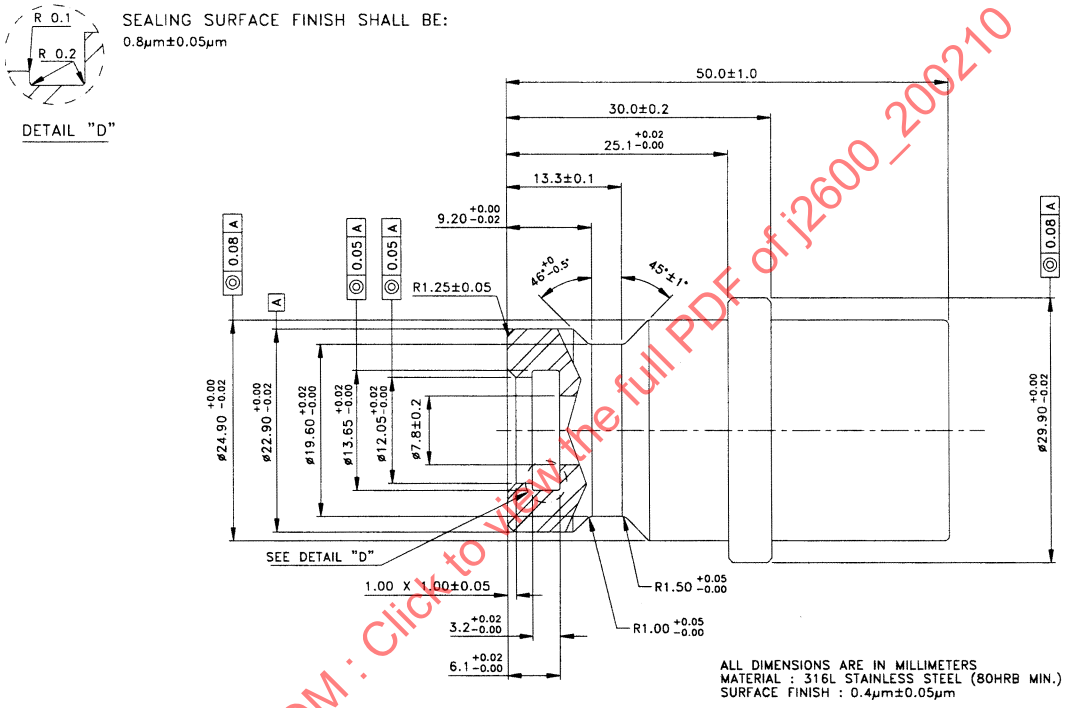

FIGURE 5—H25 LOOSE FIT TEST FIXTURE (normative)

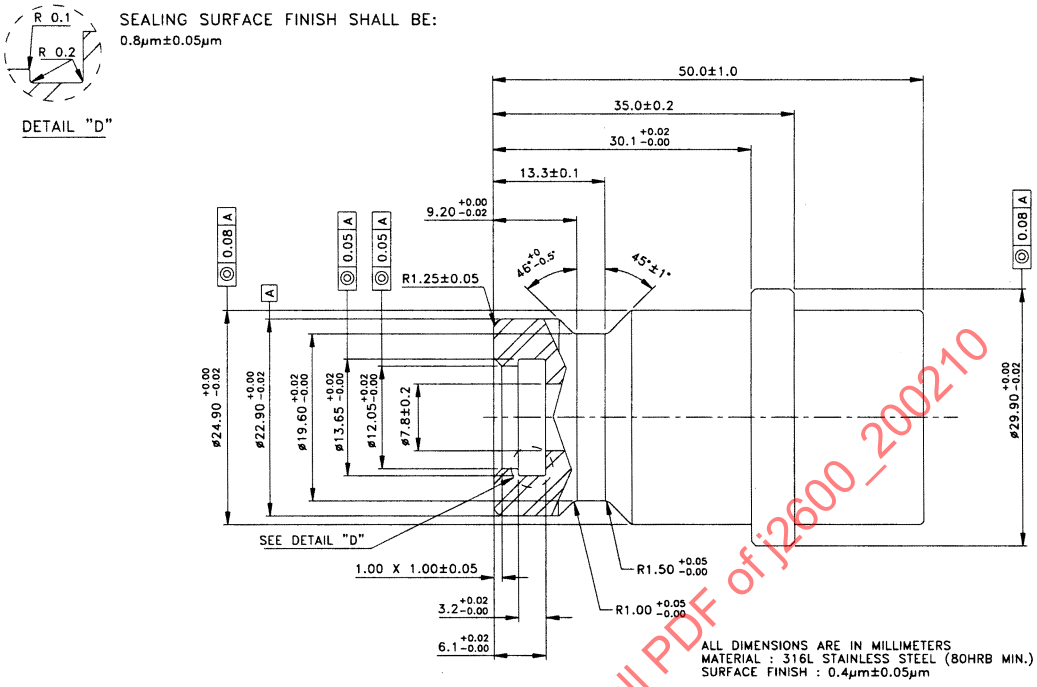

FIGURE 6—H35 LOOSE FIT TEST FIXTURE (normative)

10.12 Hydrostatic Strength—Because the hydrostatic strength test is a terminal test, do not use the test samples for any other testing after this test.

A disconnected nozzle, disconnected receptacle and connected nozzle and receptacle shall not leak when subjected to the following Test Method.

10.12.1 TEST METHOD—Outlet openings of the disconnected or connected device shall be plugged and valve seats or internal blocks made to assume the open position. A hydrostatic pressure of 3 times Design Pressure shall be applied to the inlet of the nozzle or outlet of the receptacle for a period of at least three minutes.

10.13 Materials—Sealing means shall be a material that is listed and rated by the manufacturer for this application, (compatible with hydrogen and compressor oil, synthetic or mineral); and has been documented to meet the requirements of the Oxygen Ageing and Non Metallic Synthetic Material Immersion tests detailed previously under 10.11.2 and 10.11.3, respectively.

10.14 Corrosion Resistance—Nozzles and receptacles shall not sustain corrosion or loss of protective coatings, and shall be capable of performing safely subsequent to the following test method.

10.14.1 TEST METHOD—New samples shall be used. Protective caps shall be in place. Vent holes in the protective caps shall not be plugged. Process connections may be plugged.

The nozzle and the receptacle shall be supported in a horizontal position. The nozzle shall be exposed for 96 hours to a salt spray as specified in ISO 9227: 1990, Corrosion tests in artificial environments - salt spray tests. The receptacle shall be exposed for 1000 hours to a salt spray as specified in ISO 9227: 1990, Corrosion tests in artificial environments - salt spray tests.