Recommended Practice for Performance Testing of Cementing Float Equipment

ANSI/API RECOMMENDED PRACTICE10F
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ISO 10427-3:2003 (Identical), Petroleum and natural gas industries—Equipment for well cementing—Part 3: Performance testing of cementing float equipment

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API FOREWORD

This standard is under the jurisdiction of the API Standards Subcommittee on Well Cements. This API standard is identical with the English version of ISO 10427-3:200 31. ISO 10427-3:2003 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries,* SC 3, *Drilling and completion fluids, and well cements.*

For the purposes of this standard, the following editorial changes have been made:

- Introduction - change 1st sentence to: “This International Standard is based on API Recommended Practice 10F and supercedes API RP 10F, Second edition, November, 1995.”

- Clause 4.2 last paragraph – Replace ISO 13500 with “API Spec 13A” and replace ISO 10414-1 with “API RP 13B-1.”

- Figure 2 - key 6 change “of” to “or.”

- Bibliography
  Replace Item 1, ISO 13500 with “API Specification 13A, Drilling Fluid Materials”
  Replace Item 2, ISO 10414-1 with “API Recommended Practice 13B-1, Standard Procedure for Field Testing Water-Based Drilling Fluids”

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International Standard ISO 10427-3 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 3, *Drilling and completion fluids, and well cements*.

Annex A of this International Standard is for information only.

Introduction

This International Standard is based on API Recommended Practice 10F and supercedes API RP 10F, Second Edition, November, 1995.

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

In this International Standard, where practical, U.S. Customary units are included in brackets for information.

Contents

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Petroleum and natural gas industries — Performance testing of cementing float equipment

1 Scope

This International Standard describes testing practices to evaluate the performance of cementing float equipment for the petroleum and natural gas industries.

This International Standard is applicable to float equipment that will be in contact with water-based fluids used for drilling and cementing wells. It is not applicable to float equipment performance in non-water-based fluids.

2 Functions of cementing float equipment

The term “cementing float equipment” refers to one or more check valves incorporated into a well casing string that prevent fluid flow up the casing while allowing fluid flow down the casing. The primary purpose of cementing float equipment is to prevent cement that has been placed in the casing/wellbore annulus from flowing up the casing (U-tubing). In some cases, such as liner cementing, float equipment may be the only practical means of preventing U-tubing. In other cases, the float equipment serves to allow the cement to set in the annulus without having to increase the pressure inside the casing to prevent U-tubing. Increased pressure in the casing while cement sets is generally undesirable because it can result in gaps (micro-annuli) in the cemented annulus.

Float equipment is also sometimes used for the purpose of lessening the load on the drilling rig. Since float equipment blocks fluid flow up the casing, the buoyant force acting on casing run with float equipment is greater than the buoyant force acting on casing run without float equipment. If either the height or the density of the fluid placed inside casing equipped with float equipment while the casing is being run is less than that of the fluid outside the casing, the suspended weight of the casing is reduced compared with what it would be without the float equipment.

The ability of float equipment to prevent fluid flow up the casing is also important in certain well control situations. If the hydrostatic pressure of the fluid inside the casing becomes less than the pressure of formation fluids in formations near the bottom of the casing, fluids from the well may try to flow up the casing. In such a situation, the float equipment becomes a primary well control device.

Float equipment is also sometimes used as a device to assist in pressure-testing of casing. This is normally done by landing one or more cementing plugs on top of the float equipment assembly. The plugs seal the casing so that the pressure integrity of the casing may be tested.

Float equipment is also used by some operators as a device to lessen the free fall of cement inside the casing. The free fall of cement is the tendency of cement to initially fall due to the density differences between the cement and the fluid in the well. The float equipment lessens the free fall, to some extent, by providing a constriction in the flow path.

Casing fill-up float equipment is a special type of float equipment that allows the casing to fill from the bottom as the casing is run. This is desirable, in some cases, to help reduce pressure surges as the casing is lowered. Fill-up type float equipment also helps ensure that the collapse pressure of the casing is not exceeded. Once the casing is run, the check valve mechanism of fill-up type float equipment is activated. This is normally done by either pumping a surface-released ball through the equipment or by circulating above a certain rate.

3 Float equipment performance criteria

3.1 General

There are a number of performance criteria, listed below, that may be used to evaluate the suitability of a particular piece of float equipment for a given well.

3.2 Durability under downhole conditions

Float equipment should still function after a fluid containing abrasive solids has been circulated through the equipment for a period of time. The equipment should function in various orientations and while exposed to elevated temperatures and pressures.

3.3 Differential pressure capability from below

Float equipment should be capable of withstanding a differential pressure with the higher pressure being exerted from below the check valve, because the hydrostatic pressure of the fluid occupying the annulus immediately after the cement has been placed is usually greater than the hydrostatic pressure of the corresponding column of fluid inside the casing, or while the casing is being run.

3.4 Ability to withstand force exerted through cementing plugs from above

Float equipment should be able to withstand a force exerted through cementing plugs from above. Some operators occasionally pressure-test the casing by increasing the pressure shortly after a cementing plug (top plug) used to separate the cement from the displacement fluid has landed downhole. This can cause a force to be applied to the float equipment that could cause the equipment to fail.

3.5 Drillability of the equipment

Float equipment should be easy to drill through, since in many cases, float equipment must be drilled out after cementing.

3.6 Ability to pass lost circulation materials

Float equipment may be required to allow easy passage of lost circulation material (LCM). On occasion, the fluid that is circulated through cementing float equipment contains LCM designed to bridge on highly permeable, vugular or fractured formations to lessen the amount of fluid that is lost to the formations. Since float equipment generally provides a constricted flow area for fluid passage, there can be a tendency for the LCM to bridge on the float equipment valve and partially or totally block fluid circulation. Therefore, the ease with which the LCM can pass through the float equipment may be a performance criterion for some wells.

3.7 Flow coefficient of the valve

Since float equipment provides a constriction in the flow path, there will be a pressure loss associated with circulating fluid through the float valve. If the pressure loss through the float equipment is too high, circulation rates can be limited. In some cases, however, a large pressure loss is desirable to reduce free fall of the cement. The flow coefficient of the valve provides a means of estimating the pressure loss for a given fluid density and a given rate.

3.8 Reverse-flow resistance of casing fill-up valves

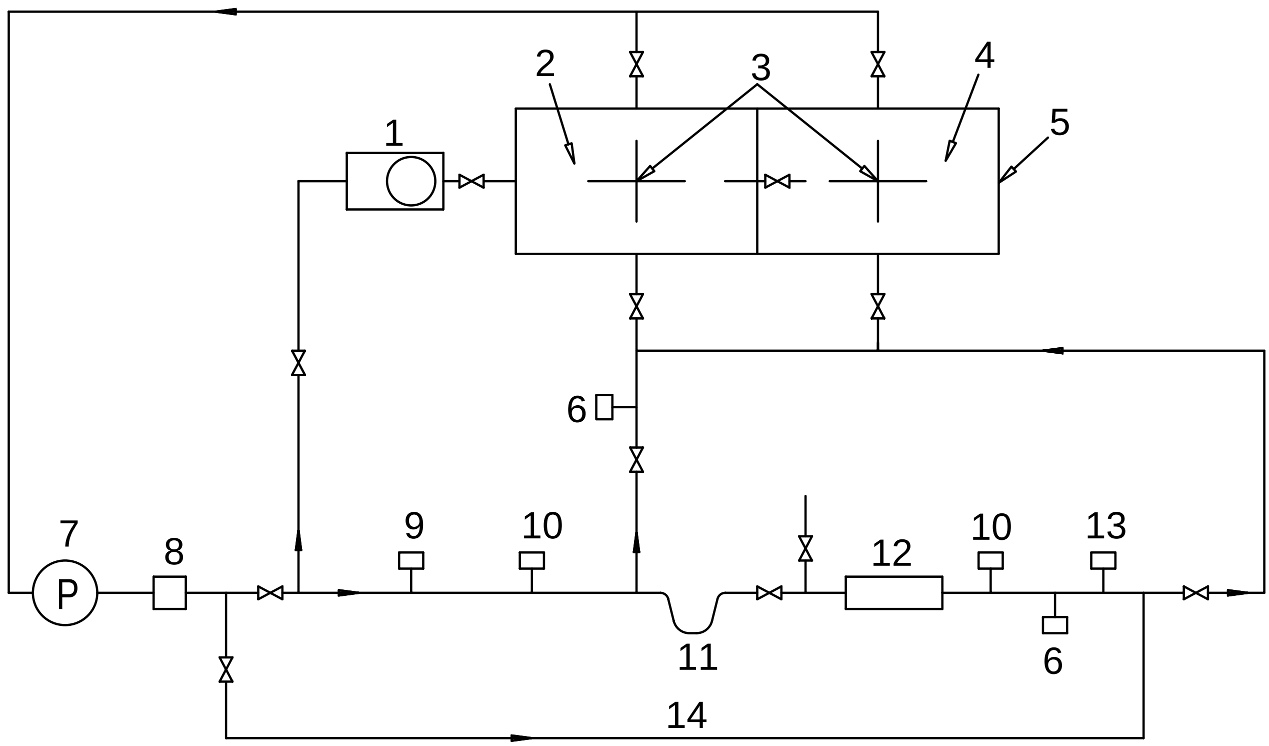
One of the functions of casing fill-up float equipment is to reduce pressure surges as the casing is run by allowing flow into the casing from the bottom. Therefore, the resistance of the valve to reverse flow is indicative of the relative performance of the valve in reducing surge pressure.

4 Apparatus and materials

4.1 Flow loop

4.1.1 General

Figure 1 shows a diagram of one possible configuration of a flow loop for durability testing. Other configurations are possible. The major components of the loop are the mud tank, the piping network, the pump and the instrumentation. These components are discussed in the following paragraphs.



Key

1	Hopper	8	Flow meter
2	Compartment 1	9	LP safety valve
3	Agitator	10	Pressure transducer
4	Compartment 2	11	Hose
5	Mud tank	12	Float collar
6	Temperature probe	13	HP safety valve
7	Triplex pump	14	High-pressure line

Figure 1 — Suggested layout for cementing float equipment test flow loop

4.1.2 Mud tank

It is suggested that the mud tank consist of two compartments, with each compartment capable of holding about 15,9 m^3 (100 bbl) of fluid. Each compartment should be fitted with adequate agitation and mixing devices to ensure that the fluids remain well mixed. A valve should be arranged to allow communication between the compartments so that the volume of fluid in the active tank can be adjusted. This will facilitate temperature regulation during a test. A mud hopper should be arranged to facilitate the mixing of mud chemicals.

4.1.3 The piping network

The piping network should consist of 101,6 mm to 152,4 mm (4 in to 6 in) diameter pipe and valves. It is suggested that the low-pressure portion of the piping network be rated to allow an operating pressure of at least 3 400 kPa (500 psi), and it is suggested that the high-pressure portion of the flow loop, as shown in Figure 1, be rated to at least 34 500 kPa (5 000 psi) working pressure. To facilitate testing fill-up type float equipment, it is suggested that the piping be laid out in such a manner that the flow direction through the float equipment can easily be changed. Both the high-pressure and the low-pressure portions of the flow loop should be equipped with pressure-release type safety valves. It is suggested that a portion of the low-pressure side of the flow loop be made from a flexible hose or an expansion joint to facilitate spacing out different length float equipment.

4.1.4 The pump

A triplex pump is suggested as the primary pump for the flow loop. The pump should be capable of pumping at least 1,6 m^3/min (10 bbl/min) and pressure testing to 34 500 kPa (5 000 psi). As an alternative, a centrifugal type pump may be used. However, this will necessitate the use of a second high-pressure type pump to perform the back-pressure tests. It is suggested that a backup primary pump be available during testing periods.

4.1.5 The instrumentation

The instrumentation for the flow loop should consist of a flowrate meter, temperature probes and pressure transducers, located as shown in Figure 1. It is suggested that a data acquisition system be provided for recording the outputs from these devices during testing.

4.1.6 Safety precautions

In designing and operating the flow loop, the following safety precautions should be followed:

a) the flow loop should be constructed in a controlled-access, isolated area;

b) the piping should be periodically inspected for reduced wall thickness, especially in areas of maximum erosion such as bends, elbows and tees;

c) the handling and mixing of the test fluid chemicals should be done by qualified personnel using the appropriate safety precautions;

d) during pressure testing, all operating personnel and observers should be a safe distance from the high-pressure portion of the flow loop;

e) the pump controls and maximum-pressure transducer readouts should be located a safe distance from the high-pressure portion of the flow loop.

NOTE This list is not exhaustive.

4.2 Circulating test fluid

The circulating test fluid should be a water-based drilling fluid that has the following properties at 50 °C (120 °F):

— density: 1 440 kg/m^3 to 1 500 kg/m^3 (12,0 lb/gal to 12,5 lb/gal);

— plastic viscosity: 10 mPa·s to 50 mPa·s (10 cP to 50 cP);

— yield point: 2,4 Pa to 12,0 Pa (5 lbf/100ft^2 to 25 lbf/100ft^2);

— 10-s gel strength: > 1,9 Pa (4 lbf/100ft^2);

— sand content: 2 % to 4 % volume fraction.

NOTE Non-water-based fluids may be subject to solvent/hardware incompatibility.

The weighting material used in the test fluid should be barite that meets the specifications of API Spec 13A [1]. The fluid properties should be measured in accordance with API RP 13B-1 [2]. The sand used in the test fluid should be 70/200 US mesh sand. This material is available from most well-cementing service companies and certain suppliers of blasting sand.

4.3 High-temperature/high-pressure test cell

4.3.1 Apparatus

A special test apparatus is recommended for applying temperature and pressure to float equipment as described in later clauses of this document. Figure 2 is a schematic diagram of a suggested apparatus for applying temperature and pressure to float equipment. Other apparatus and methods for applying temperature and pressure to float equipment are also acceptable, provided proper precautions are taken. The apparatus shown in Figure 2 is described as follows.

- The apparatus should be designed for safe operation at temperatures up to 204 °C (400 °F) and pressures up to 34 500 kPa (5 000 psi).
- The test apparatus shown in Figure 2 consists of a chamber body with attached welded flange and a mating flange to which the float equipment is attached. The chamber body inside diameter (ID) should be larger than the outside diameter (OD) of the largest piece of float equipment to be tested. Economics should be considered when determining the size of the chamber body. For pressure-testing all sizes of float equipment, it may be more economical or desirable to build several chambers rather than one large chamber. The chamber body and welded flange should be strong enough to withstand the maximum differential pressure (plus safety factor) applied during testing. A mating flange cap, containing a pressure inlet and relief or exit port, is used to support the float equipment during testing. The pressure rating of the flanged cap should be equal in strength to the chamber body. The equipment to be tested is suspended from the cap by a swage and extension as shown in Figure 2.
- The supporting members should be strong enough to withstand the collapse pressure (plus safety factor) encountered during maximum differential-pressure tests. The exhaust, or relief, outlet should contain a safety screen to retain pieces of the float equipment in the event of an “absolute failure.”

During pressure-temperature tests, the entire chamber should be filled with a silicone-based oil with a flash point well above 204 °C (400 °F). The chamber is completely submerged in oil and heated from an external heat source or directly by electrical resistance heaters.

4.3.2 Safety precautions in designing and operating the high-temperature high-pressure apparatus

a) The test apparatus should be in an enclosed room (such as a concrete, steel-reinforced test cell) with sufficient wall thickness to contain absolute failure of test apparatus or equipment. The test facility should be in an isolated area to prevent injury to operating personnel or observers.

b) All pump and temperature controls, with relief valves, should be housed outside the test cell. A secondary automatic shutdown control system should also be incorporated. The operator should maintain visual contact with the test apparatus at all times. Visual access can be provided by using a mirror positioned so that the line of sight is not in direct line with the test apparatus. The observation window should be protected by high-impact glass.

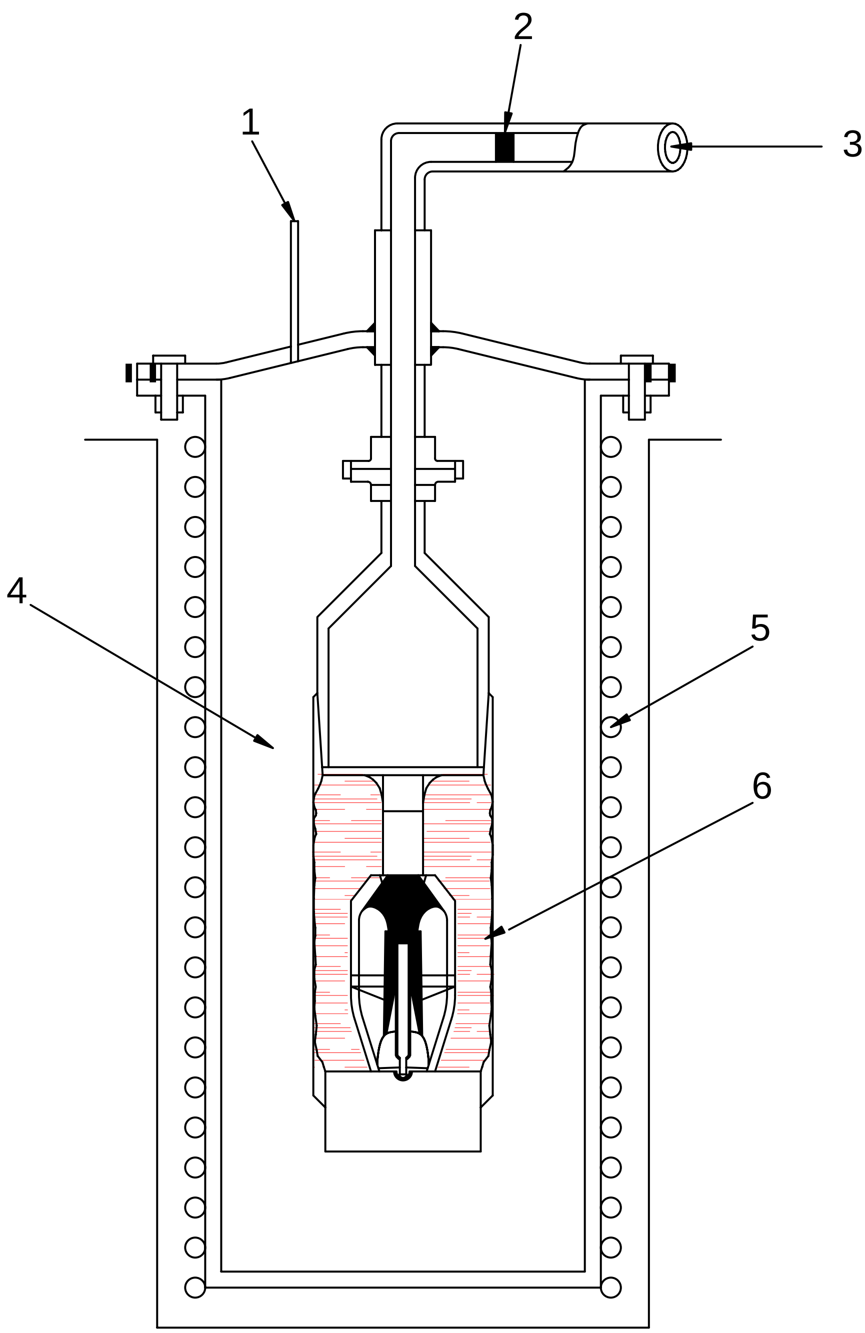
c) The test cell should have limited-access doorways that are visible to operating personnel at all times.

d) Adequate ventilation or exhaust fans should be incorporated into the test cell to remove smoke or irritating vapors.

e) Oil used as a heating medium should be periodically checked for contamination and replaced when necessary. Contamination lowers the flash point of the silicone-based oil.

f) Fire extinguishers should be located inside and outside the test facility. An automatic fire-extinguishing system is desirable.

NOTE This list is not exhaustive.



Key

1 Pressure inlet
2 Debris screen
3 Exhaust outlet (atmospheric pressure)
4 Synthetic oil
5 Heating elements
6 Float collar or float shoe

Temperature range : 21 °C (70 °F) to 204 °C (400 °F)
Pressure range : 0 kPa to 34 500 kPa (5 000 psi)

Figure 2 — Controlled pressure-temperature test cell

5 Durability test

5.1 Test set-up

5.1.1 The test fluid should be prepared in accordance with 4.2. It is suggested that a minimum of 7,9 m^3 (50 barrels) of fluid be prepared and that the fluid be circulated (bypassing the float equipment) until the fluid properties have stabilized.

5.1.2 The float equipment to be tested should be mounted in the test section of a flow loop such as described in 4.1. The orientation of the float equipment may be either horizontal or vertical. For float equipment to be used in wells with a final deviation angle greater than 45°, it is recommended that the float equipment be tested horizontally. The float equipment orientation during testing should be clearly indicated on a test results reporting form similar to that shown in annex A. For horizontal testing of flapper-type float equipment, the hinge of the flapper should be on the bottom (low side) so that closure is not assisted by gravity. For vertical testing, the direction of the flow through the float equipment should be downward.

5.2 Test categories

To facilitate communication between users and suppliers of cementing float equipment, three service categories of flow durability testing are suggested. These are shown in Tables 1 and 2.

Table 1 — Categories of flow durability tests for regular float equipment

Category	Duration[a] h	Maximum pressure[b] kPa (psi)
I	8	10 300 (1 500)
II	12	20 700 (3 000)
III	24	34 500 (5 000)

[a] Circulation rate is 1,6 m^3/min (10 bbl/min) for float equipment larger than 88,9 mm (3 1/2 in) and 1,0 m^3/min (6 bbl/min) for 88,9 mm (3 1/2 in) and smaller float equipment.

[b] The maximum test pressure should be the lesser of the values shown or 80 % of the manufacturer's rated burst or collapse pressure for the float equipment casing, whichever is applicable.

Table 2 — Categories of flow durability tests for casing fill-up equipment

Category	Duration h		Maximum pressure[c] kPa (psi)
	Reverse[a]	Forward[b]	
I	2	8	10 300 (1 500)
II	4	12	20 700 (3 000)
III	6	24	34 500 (5 000)

[a] Circulation rate for all categories is 0,5 m^3/min (3 bbl/min).

[b] Circulation rate is 1,6 m^3/min (10 bbl/min) for float equipment larger than 88,9 mm (3 1/2 in) and 1,0 m^3/min (6 bbl/min) for 88,9 mm (3 1/2 in) and smaller float equipment.

[c] The maximum test pressure should be the lesser of the values shown or 80 % of the manufacturer's rated burst or collapse pressure for the float equipment casing, whichever is applicable.

5.3 Procedure

5.3.1 Regular apparatus

5.3.1.1 Perform a back-pressure test on the float equipment by pressurizing the high-pressure portion of the flow loop to 700 kPa (100 psi) and then opening a valve upstream of the float equipment to atmospheric pressure. Record the volume of fluid necessary to achieve valve closure. If the valve will not close, attempt to achieve valve closure by increasing the reverse flowrate through the valve. Record the rate necessary to obtain valve closure. Increase the pressure to 1 700 kPa (250 psi) and hold for 5 min. If the float valve cannot hold 1 700 kPa (250 psi) for 5 min, stop the test.

5.3.1.2 Circulate through the float equipment for a total flow period of 8 h, 12 h or 24 h, depending on the test category being followed. The circulation rate for float equipment larger than 88,9 mm (3 $^{1}/_{2}$ in) should be 1,6 m^3/min (10 bbl/min). The circulation rate for 88,9 mm (3 $^{1}/_{2}$ in) and smaller float equipment should be 1,0 m^3/min (6 bbl/min). The test fluid temperature should be at least 43 °C (110 °F) for at least 75 % of the flow period. At 2-h intervals, stop circulation and perform a back-pressure test in accordance with 5.3.1.1. The mud properties should be measured at 2-h intervals and adjusted if necessary.

5.3.1.3 Perform a low-temperature/high-pressure back-pressure test in the following manner. It is suggested that the float equipment be removed from the flow loop and installed in an apparatus specifically designed for safely applying high differential pressure across the float valve, such as that described in 4.3. This test may also be performed with the float equipment in the flow loop. The maximum test pressure should be the lesser of 10 300 kPa, 20 700 kPa or 34 500 kPa (1 500 psi, 3 000 psi or 5 000 psi), depending on the test category being followed, or 80 % of the manufacturer's rated burst or collapse pressure for the float equipment casing, whichever is applicable. Achieve valve closure, if necessary, by a reverse-flow surge. Increase the pressure to the maximum test pressure over a period not greater than 2 min and hold for 30 min.

5.3.1.4 Disassemble the float equipment and visually inspect the valve mechanism for any signs of abrasion or wear. For cement-filled equipment, visually inspect the cement for any signs of cracking or abrasion. Note any abnormalities.

5.3.2 Casing fill-up equipment

5.3.2.1 Circulate in the reverse direction through the float equipment at 0,5 m^3/min (3 bbl/min) for 2 h, 4 h or 6 h. Measure and record the pressure drop in the reverse-flow direction.

5.3.2.2 Activate the check valve of the float equipment in accordance with the manufacturer's recommendation. Record the pressure and/or rate required to activate the check valve.

5.3.2.3 Perform the durability test for regular float equipment indicated in 5.3.1.

6 Static high-temperature/high-pressure test

6.1 Test categories

To facilitate communication between users and suppliers of cementing float equipment, three service categories of static high-temperature/high-pressure testing are suggested. The categories for static high-temperature/high-pressure testing are shown in Table 3.

Table 3 — Categories of static high-temperature/high-pressure tests

Category	Temperature[a] °C (°F)	Maximum pressure[b] kPa (psi)
A	93 (200)	10 300 (1 500)
B	149 (300)	20 700 (3 000)
C	204 (400)	34 500 (5 000)

[a] Duration at temperature is 8 h for all categories.

[b] The maximum test pressure should be the lesser of the values shown or 80 % of the manufacturer's rated burst or collapse pressure for the float equipment casing, whichever is applicable.

6.2 Procedure

6.2.1 Perform a flow durability test in accordance with clause 5.

6.2.2 Review, verify, and observe safety precautions indicated in 4.3.2.

6.2.3 Install the float equipment in a high-temperature/high-pressure test apparatus similar to the one described in 4.3.

6.2.4 Heat the test apparatus until the test piece and test chamber achieve a constant test temperature of 93 °C ± 5 °C, 149 °C ± 5 °C or 204 °C ± 5 °C (200 °F ± 10 °F, 300 °F ± 10 °F or 400 °F ± 10 °F), depending on the test category being followed. Maintain the test temperature for a period of 8 h.

6.2.5 Pressure-test by applying differential pressure to the float valve by pumping into the chamber to achieve valve closure and a fluid seal. Pressurize to 340 kPa (50 psi), using an appropriate low-volume, high-pressure pump, to check for low-pressure fluid seal.

Air-activated pumps are recommended for this application.

Ball-type float equipment may require a high-volume pump to initiate valve closure, or the exhaust valve can be closed, the chamber pressurized below the test piece, and the exhaust valve quickly opened to provide a fluid surge to obtain initial valve closure.

6.2.6 Increase pressure to 3 400 kPa (500 psi) and hold for 15 min. Increase pressure in 3 400 kPa (500 psi) increments every 15 min until a maximum test pressure of 10 300 kPa, 20 700 kPa or 34 500 kPa (1 500 psi, 3 000 psi or 5 000 psi), depending on the test category being followed, is reached or until failure occurs, whichever occurs first. If the test pressure and test apparatus cause a collapse load to be imposed on the float equipment casing, the maximum test pressure should be limited to a value less than 80 % of the manufacturer's rated collapse pressure for the float equipment casing. If the test pressure and test apparatus cause a burst load to be imposed on the float equipment casing, the maximum test pressure should be less than 80 % of the manufacturer's rated internal yield pressure for the float equipment casing.

6.2.7 Release pressure, cool and disassemble float equipment. Perform visual inspection. Note any abnormalities.

7 Test results

A suggested form for reporting the results of the performance tests described in this International Standard is shown in annex A.

Annex A
(informative)

Results of performance tests on cementing float equipment

I. GENERAL INFORMATION

Manufacturer ______________________________

Type of float equipment tested ______________________________

Size of float equipment tested ______________________________

Model number of float equipment tested ______________________________

Location of plant where float equipment manufactured ______________________________

Date of float equipment manufacture ______________________________

Valve description ______________________________

Valve material ______________________________

____

II. FLOW DURABILITY TESTING

Dates of testing ______________________________

Flow durability testing category: I. __________ II. __________ III. __________

Test result: Pass __________ Fail __________

Float equipment orientation: Horizontal __________ Vertical __________

Type of pump used for circulation ______________________________

Average fluid temperature during test ______________________________

Type of fluid used for testing ______________________________

Average sand concentration during test ______________________________

If pass, maximum volume for closure ______________________________

If pass, maximum rate for closure ______________________________

If pass, maximum test pressure used ______________________________

If fail, total duration until failure ______________________________

If casing fill-up equipment, reverse-flow pressure drop across valve ______________________________

If casing fill-up equipment, pressure and/or rate to activate ______________________________

Description of valve after test ______________________________

____

III. HIGH-TEMPERATURE/HIGH-PRESSURE TESTING

Dates of testing ______________________________

HT/HP test category A. __________ B. __________ C. __________

Test result: Pass __________ Fail __________

Type of pressure application: Internal only __________ Internal and external __________

Type of fluid contacting valve ______________________________

If pass, maximum test pressure used ______________________________

If fail, maximum test pressure achieved ______________________________

Description of valve after test ______________________________

Signature ____________________ Title ____________________

Name ____________________ Telephone number ____________________

Date signed ____________________

Bibliography

[1] API Specification 13A, *Drilling Fluid Materials*

[2] API Recommended Practice 13B-1, *Standard Procedure for Field Testing Water-Based Drilling Fluids*

[3] API RP 10F, *Recommended practice for performance testing of cementing float equipment.* Second edition, November 1995

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