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1 Scope

This standard provides minimum performance requirements, test procedures and marking requirements for cementing float equipment that, while limited, are deemed adequate for use in well construction in the petroleum and natural gas industries. This standard is applicable to float equipment that will be in contact with water-based or non-aqueous drilling fluids.

2 Functions of cementing float equipment

The term "cementing float equipment" (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).

Float equipment may be used for 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. To reduce the load on the drilling rig when running in the hole with casing, either the height or the density of the fluid inside casing can be less than that in the annulus.

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 wiper plugs on top of the float equipment assembly. The plugs seal the casing at the float equipment point so that the pressure integrity of the casing above the floats may be tested.

Float equipment may 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, also called "autofill", 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 may help ensure that the collapse pressure of the casing is not exceeded. Once the casing is run, the check valve mechanism of fill-up or autofill type float equipment is activated and the float equipment is converted to "standard" equipment. This is normally done by either pumping a surface-released ball through the equipment or by circulating above a certain rate.

3 Definitions

Autofill: a feature or design of float equipment check valves that allow the flow check system to be temporary disengaged so that fluid may pass in either direction, for the primary purpose of automatic filling of the casing. This action subsequently can reduce surge pressures of the formation that may otherwise be present if float valves remained closed during running of the casing.

Float equipment: casing accessories that contain check valves and become part of the lower section of a casing string for the purpose of preventing the reverse flow of cement once placed in a well bore annulus.

u-tube: The natural tendency of a denser fluid to reverse its flow direction once the pressure used to raise it around any "U" shaped lighter fluid filled flow path is released, allowing to seek its equilibrium on both sides on the "U" shaped path.

Forward Flow process of flowing fluid from the tubular to the annulus in the direction the valve is designed to open.

Reverse Flow process of flowing fluid from the annulus to the tubular in the direction the valve is designed to close.

4 Calibration

Equipment calibrated to the requirements of this standard is considered to be accurate if calibration is within the specified limits.
4.1.1.1 Timers

Timers shall be accurate within ±5s per hour and shall be verified annually over a period of no less than 12 minutes using the time signal from the NIST or similar websites and radio stations. If not within required accuracy, the units shall be adjusted or replaced.

4.1.1.2 Flow Meter Systems

The flow meter system shall be capable of measuring the flow rate of the circulating test fluid being pumped through the float equipment in 0.1 bbl/min or smaller increments and be accurate within ±/− 0.1 bbl/min for the flow rate of the test being performed. The flow meter accuracy shall be verified prior to and after each test. The equipment shall be calibrated as per the manufacturer recommendation at least annually.

4.1.1.3 Pressure Measuring Systems

Pressure measuring systems shall be readable to ±/− 0.5% of the test pressure range or better and cover the range to be measured. The system shall be able to maintain ±/− 2% accuracy of the test pressure range. Calibration shall be done at 25%, 50%, 75% of test pressure, using a certified deadweight tester or master gauge to ±/− 1% of full range or minimum gauge increment, whichever is greater. Calibration shall be conducted annually.

4.1.1.4 Temperature Measuring Systems

Temperature measuring systems shall be accurate to within ±/− 3° F. Calibration shall be conducted at least every six months. [DFL1]

5 Durability Time Categories

Multiple service categories of flow durability testing are noted. The categories are shown in Table 1.

Table 1 — Categories of flow durability tests for float equipment

<table>
<thead>
<tr>
<th>Category</th>
<th>Cumulative* Flow Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>D8</td>
<td>8 (-0 / +15 min)</td>
</tr>
<tr>
<td>D12</td>
<td>12 (-0 / +15 min)</td>
</tr>
<tr>
<td>D24</td>
<td>24 (-0 / +15 min)</td>
</tr>
<tr>
<td>D36</td>
<td>36 (-0 / +15 min)</td>
</tr>
</tbody>
</table>

* Cumulative flow duration does not require continuous flow through the test equipment. For example, a 36 hour test may be conducted over several days.
5.1 Casing fill-up equipment - reverse flow test

For casing fill-up equipment, prior to the conversion of the valve system, Table 2 lists the required reverse flow periods. In all cases, the reverse flow rate shall be not less than 3 bpm\textsuperscript{(DFL2)}. This test shall be performed prior to the flow durability test.

<table>
<thead>
<tr>
<th>Category</th>
<th>Reverse Flow Duration (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D8</td>
<td>2 (-0 / +15 min)</td>
</tr>
<tr>
<td>D12</td>
<td>4 (-0 / +15 min)</td>
</tr>
<tr>
<td>D24 &amp; D36</td>
<td>8 (-0 / +15 min)</td>
</tr>
</tbody>
</table>

6 Durability Rate Categories

Multiple categories for flow rate testing are noted. The categories are shown in Table 3.

<table>
<thead>
<tr>
<th>Category</th>
<th>Flow Rate (bbl/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R6</td>
<td>6 (-0 / +0.5 bbl/min)</td>
</tr>
<tr>
<td>R10</td>
<td>10 (-0 / +0.5 bbl/min)</td>
</tr>
<tr>
<td>R20</td>
<td>20 (-0 / +0.5 bbl/min)</td>
</tr>
</tbody>
</table>

The minimum flow rate of 6 bbl/min is only for use on float equipment for casing sizes 5 ½” and smaller. Larger sized equipment may be tested using either 10 or 20 bbl/min for the duration of the flow test\textsuperscript{(DFL3)}.

7 General

There are a number of performance criteria that may be used to evaluate the suitability of a particular piece of float equipment for a given well. Float equipment should function after a fluid containing solids has been circulated through the equipment for a period of time. The flow period and flow rate can impact the durability of the equipment. Float equipment should be capable of withstanding a differential pressure with the higher pressure being exerted from below the check valve, and capable of functioning at the temperature to which it is exposed. While this specification does not address pressure from above, with the top plug in place, the float equipment assembly should be capable of withstanding differential pressure being exerted from above the check valve.

8 Apparatus and materials

8.1 Flow loop

8.1.1 General

The flow durability test system shall be capable of pumping the circulating test fluid through the float equipment at the circulation rate specified for the float equipment casing size range being tested within a tolerance of -0 / + 0.5 bbl/min. Instrumentation shall be provided to measure and record the circulating test fluid flow rate and temperature as well as the pressure within the piping at each end of the float equipment over the time duration of the test.

The system shall be capable of flowing through the float equipment in a horizontal orientation, within +/- 5°. The float equipment may be removed from the flow loop for applying higher pressures and/or flow rates with alternate means as may be required for conversion of auto-fill equipment according to the manufacturer’s recommendation or for performing high pressure backpressure tests at the conclusion of the flow period.
Figure 1 shows a diagram of an example 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.

Figure 1 — Example layout for cementing float equipment test flow loop Rick Lukay to redraw and improve[DFL4]

### 8.1.2 Mud tank

A mud tank capable of holding a sufficient volume of test fluid is required for the flow endurance testing. The mud tank shall provide adequate agitation to maintain circulating fluid properties over the duration of the test.

### 8.1.3 The piping network

The piping network provides a conduit for the circulating test fluid to flow from the mud tank to the pump, through the float equipment, and back to mud tank. The inside diameter of the piping ahead of the float equipment shall be at least as large as the valve inlet diameter for at least 3 times the valve inlet diameter. The inside diameter of the piping behind the float equipment shall be at least as large as the valve outlet diameter for at least 2 times the valve inlet diameter.
Means shall be provided within the piping system to apply pressure for back pressure testing to at least 250 psi and to release pressure and to measure flow back or leakage across the float equipment. It should also provide a means of taking circulating test fluid samples.

Piping and valves shall be configured and verified such that the measured flow through the flow meter is directed to the float equipment.

### 8.1.4 The pump system

A pump or combination of pumps shall be capable of pumping the circulating test fluid through the float equipment at the rates required for the category of the equipment being tested. An additional pump or pumps may be provided to apply the pressure required for backpressure testing and/or auto-fill float equipment conversion.

### 8.1.5 Instrumentation

The instrumentation for the flow loop shall include a flow meter, a temperature probe and pressure transducers. A data acquisition system shall be provided for recording the outputs from these devices during testing. Data recording rates shall be sufficient to provide an accurate record of each segment of the test.

### 8.1.6 Safety precautions

In designing and operating the flow loop, it is recommended the following safety precautions be considered:

- **a)** flow loop be constructed in a controlled-access, isolated area;
- **b)** the piping be periodically inspected for reduced wall thickness, especially in areas of maximum erosion such as bends, elbows and tees; a means of containment shall be in place in the event the piping or tank become compromised.
- **c)** the handling and mixing of the test fluid chemicals be done by qualified personnel using the appropriate safety precautions;
- **d)** during pressure testing, all operating personnel and observers be a safe distance from the high-pressure portion of the flow loop;
- **e)** the pump controls and maximum-pressure transducer readouts be located a safe distance from the high-pressure portion of the flow loop;
- **f)** appropriate containment system in place in the event of a spill;
- **g)** allow the equipment to cool prior to handling

**NOTE** This list is not exhaustive.

### 8.2 Circulating test fluid

The circulating test fluid shall be a water-based drilling fluid that has the following properties at 120 °F:

- density: 1 440 kg/m³ to 1 500 kg/m³ (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/100ft² to 25 lbf/100ft²);
- 10-s gel strength: > 1,9 Pa (4 lbf/100ft²);
- sand content: 2 % to 4 % volume fraction.

The weighting material used in the test fluid shall be barite that meets the specifications of API Specification 13A [1]. The fluid properties shall be measured in accordance with API RP 13B-1 [2]. The sand used in the test fluid should be 70/200 US mesh sand.
Rick Lukay will look at the mud properties for appropriateness and if any ranges are needed for temperature.

9 Durability test

9.1 Test set-up

9.1.1 The test fluid should be prepared in accordance with 78.2. The fluid shall be prepared and circulated through the test loop (bypassing the float equipment) at the test rate until the fluid properties have stabilized to within the requirements in 8.2.

9.1.2 The float equipment to be tested shall be mounted in the test section of a flow loop as described in 7.1. The orientation of the float equipment shall be within 5 degrees of horizontal.

For 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.

9.2 Procedure

9.2.1 Conventional (non autofill) float equipment

9.2.1.1 Circulate through the float equipment at the test rate for 2 hours (+/- 5 min). Stop circulation and perform a back-pressure test on the float equipment by pressurizing the high-pressure portion of the flow loop to 250 psi +/- 10 psi and then opening a valve upstream of the float equipment sufficiently large enough to bleed the upstream pressure to atmospheric pressure in no more than 10-15 seconds. Maintain the 250 psi +/- 10 psi for 5 min. +/- 30 sec. Following a stabilization period of 2 minutes +/- 15 sec, there should be no visible flow through the float equipment over the next 3 minutes.

If the valve will not close, attempt to achieve valve closure by flowing in a reverse direction against the valve for a maximum of 5 gallons. During this process, the pressure shall not exceed 250 psi. After closure maintain 250 psi +/- 10 psi for 5 min. +/- 30 sec. Following a stabilization period of 2 minutes +/- 15 sec, there should be no visible flow through the float equipment over the next 3 minutes. Valves that do not pass this step after one attempt constitute a failure of this test.

Repeat the 250 psi (+/- 10 psi) back pressure test every 2 hours (+/- 5 min) for the duration of the flow test.

Circulate through the float equipment for a cumulative flow period of 8 h, 12 h, 24 h or 36 h depending on the test category. Following the final back pressure test, back pressures exceeding 250 psi may be applied.

Note: Equipment qualified for longer flow periods is considered qualified for the shorter time periods as well.

At the end of the cumulative circulation period, remove the float equipment from the flow loop and visually inspect the equipment for any signs of abrasion or wear. Note any abnormalities.

Proceed with the high temperature / high pressure test as outlined in section 11.
9.2.2 Casing fill-up equipment

9.2.2.1 Conversion testing

9.2.2.1.1 Circulate in the reverse direction through the float equipment at not less than 3 bbl/min for 2 h, 4 h or 8 h as shown in Table 2.

9.2.2.1.2 Convert the float equipment in accordance with the manufacturer’s recommendation. Record the pressure and/or rate required to activate the check valve.

9.2.2.1.3 Perform the durability test for regular float equipment indicated in 9.2.1.

10 Static high-temperature/high-pressure Category Rating

10.1 Test categories

Five service categories of static high-temperature/high-pressure testing are noted. The categories for static high-temperature/high-pressure testing are shown in Table 3 and 4

Table 3 — Temperature Categories of static high-temperature tests

<table>
<thead>
<tr>
<th>Category</th>
<th>Temperature(^a) (^{°C (°F)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>T200</td>
<td>93 (200)</td>
</tr>
<tr>
<td>T300</td>
<td>149 (300)</td>
</tr>
<tr>
<td>T400</td>
<td>204 (400)</td>
</tr>
<tr>
<td>T500</td>
<td>260 (500)</td>
</tr>
</tbody>
</table>

\(^a\) Duration at temperature is no less than 8 h for all categories. Temperature to be held within +/-5% for the duration of the test.

Table 4 — Pressure Categories of high pressure tests

<table>
<thead>
<tr>
<th>Category</th>
<th>Test Pressure (^{kPa (psi)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1.5</td>
<td>10 300 (1 500)</td>
</tr>
<tr>
<td>P3</td>
<td>20 700 (3 000)</td>
</tr>
<tr>
<td>P5</td>
<td>34 500 (5 000)</td>
</tr>
<tr>
<td>P10</td>
<td>68 950 (10 000)</td>
</tr>
</tbody>
</table>

Control of all pressures for this test shall be - 0 / + 2060 kPa (300 psi)

Insert a note here on the fact that the test pressure is NOT the same as an operating or working pressure test and the numbers should be used at the discretion of the user.
11 High-temperature/high-pressure test cell

11.1 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 acceptable. The apparatus shown in Figure 2 is described as follows.

— The apparatus shall be rated for safe operation at temperatures and pressures required for the test category.

— The test apparatus illustrated in Figure 2 consists of a chamber body with attached flange and a mating flange to which the float equipment is attached. For pressure-testing all sizes of float equipment, it may be more desirable to build several chambers rather than one large chamber. The chamber body, flanges and support equipment shall be manufactured and assembled to withstand the anticipated pressures and stresses.

During pressure-temperature tests, the entire chamber shall be filled with either water, a synthetic oil or a silicone-based oil (with a flash points above the test temperature) such that all air is removed from the chamber.

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

In designing and operating the high temperature high pressure test cell, it is recommended the following safety precautions be considered:

a) The test apparatus be in an enclosed room with sufficient wall thickness to contain absolute failure of test apparatus or equipment.

b) All pump and temperature controls with relief valves be housed outside the test apparatus in a safe location. A secondary automatic shutdown control system be incorporated. Incorporate the ability to maintain visual contact with the test apparatus at all times. Use of a remote video camera is recommended for this purpose.

c) Ventilation or exhaust fans be incorporated.

d) If oil is used as a heating medium, it should be periodically checked for contamination and replaced when necessary.

e) Fire extinguishers be located inside and outside the test facility.

NOTE This list is not exhaustive.
11.3 Procedure

11.3.1 Perform a flow durability test in accordance with clause 10.

11.3.2 Review, verify, and observe safety precautions indicated in 8.1.6.

11.3.3 Install the float equipment in the high-temperature/high-pressure test apparatus.

11.3.4 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 a minimum of 250 psi, using an appropriate pump, to check for low-pressure fluid seal. **(Rick to supply max temperature chart)**

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.

11.3.5 Heat the test apparatus until the test piece and test chamber achieve a constant test temperature of 93°C (200 °F), 149 °C (300 °F), 204 °C (400 °F) or 260 °C (500 °F), depending on the test category being followed. Maintain the test temperature within +/- 5% for a period of no less than 8 h. **Insert a comment to monitor pressure during the heat up of the test cell and assure the pressure does not exceed the pressures found in the table to be provided by Rick.**

11.3.6 Increase differential pressure to the pressure of the test category within 5 minutes. Maintain the pressure as per table 4 for a minimum of 15 minutes.

11.3.7 Monitor the flow through the float equipment during a 15 minute -0/+30 sec hold period. The maximum volume through the equipment during the 15 minute hold period is 750 mL.

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

12 Testing with NAF fluids


(The standard is based on use of specific defined oils but perhaps could be modified to use base oils for NAF)
12.1 Apparatus

12.2 Test procedure

12.3 Reporting of results

13 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)

Depending on what we do earlier in the document, the form will need to reflect any changes to the protocol and add in high rate testing.

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


If we add testing in NAF we need to reference API RP 13B-2
