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

Industries du pétrole et du gaz naturel — Mode opératoire des tests des équipements de cimentation des cuvelages

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 18165 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, 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.

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

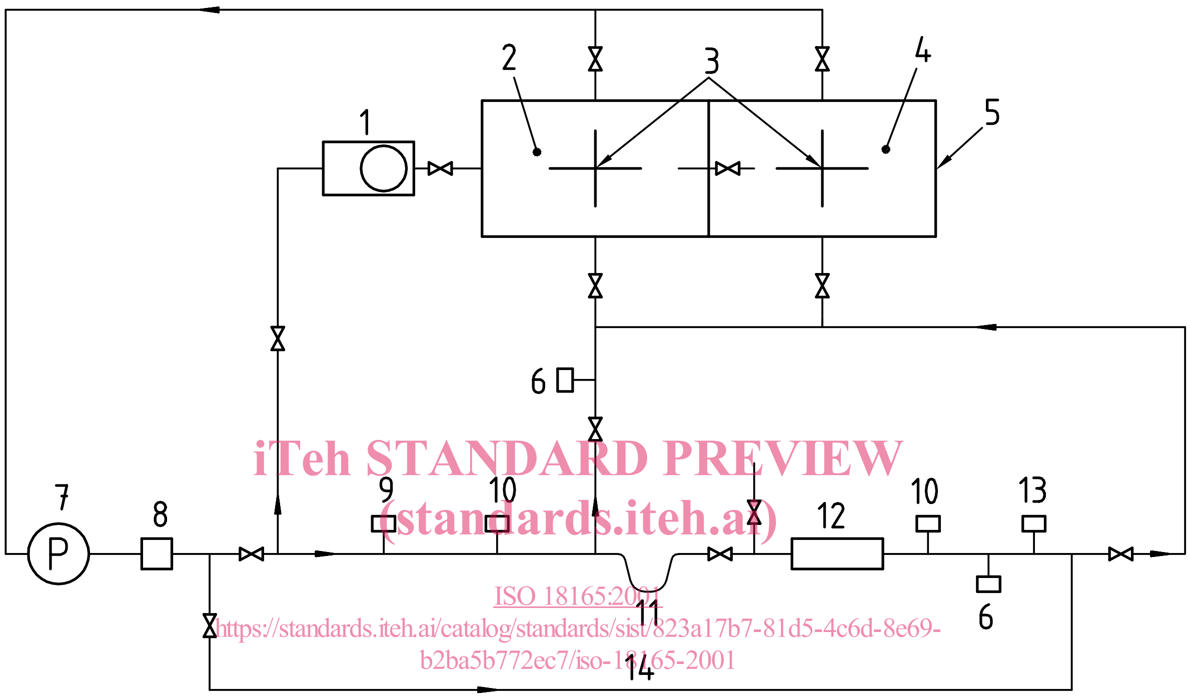
One of the functions of casing fill-up float equipment is to reduce pressure surges as the casing is run by allowing flow into the casing from the bottom. Therefore, the resistance of the valve to reverse flow is indicative of the relative performance of the valve in reducing surge pressure.

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 ISO 13500 [1]. The fluid properties should be measured in accordance with ISO 10414-1 [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 vapours.

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.