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Test method for full-scale tensile stress corrosion testing of casing and tubing

套管和油管全尺寸拉伸应力腐蚀试验方法

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0 Warning printed at the head of the document

The test involves high temperature, high pressure and corrosive media. The document does not point out every possible safety problem. The user is responsible for taking suitable safety and health measures and for making sure that the conditions comply with the relevant national regulations.

3 Terms and definitions

3.1 tensile stress corrosion: corrosion of a metal caused by the joint action of a corrosive environment and tensile stress. A note states that it leads to the formation of cracks and to a fall in the load-bearing performance of the metal structure.

3.2 pitting corrosion: pit-shaped cavities produced by localised corrosion, such as holes spreading inward from the metal surface. The definition is cited from GB/T 10123-2022, 4.15.

4 Principle of the test

Full-scale high-temperature high-pressure tensile stress corrosion test equipment for casing and tubing, or similar equipment, is used to reproduce the service conditions of casing and tubing.

The test medium is injected into the full-size casing or tubing, a constant axial tensile force is applied at the same time, and a set test temperature, pressure and duration are maintained.

The corrosion resistance of the casing or tubing and of the connection, and the seal performance of the connection, are then assessed under those particular service conditions.

5 Test conditions

5.1 Test solution. The solution is made up from the media that the casing and tubing meet in actual field service, mainly acid solutions, formation water and other solutions that may be present in the field. The user settles the solution from the field service conditions or the simulated service environment. All reagents shall be of chemically pure grade, and the water shall be distilled or deionised water meeting the grade three requirement of GB/T 6682.

5.2 Test gas. The gas is injected according to the gas met in actual field service. It may be a single gas or a mixture. A single gas is injected directly through the gas line. For a mixture, either a commercial mixed gas whose composition has been confirmed by analysis is used, or the mixing ratio and quantity are adjusted as needed before injection. Where

pressurisation is needed, nitrogen is added until the total pressure reaches the required test value. The purity of each gas shall be not lower than 99.5 per cent.

5.3 Test temperature and pressure are settled from the field service conditions or the intended service environment. The test pressure shall not exceed the maximum allowable pressure of the product.

5.4 Axial tensile stress. The axial tensile stress should be 80 per cent of the yield strength measured on the material of the test piece at the test temperature. Another level of applied stress may be used where the actual case requires it.

5.5 Test duration. The duration is counted from the moment the temperature and pressure have settled at the required test values. The recommended durations by medium are: fresh acid solution of the acidising stage, 4 hours to 6 hours; spent acid solution of the acidising stage, the time taken to flow the spent acid back, generally 72 hours to 168 hours; formation water of the production stage, 720 hours to 2160 hours; and other solutions that may be present in the field, settled by agreement according to the actual case.

6 Test equipment and measuring instruments

6.1 General. The equipment shall be able to heat, to inject the medium and to apply tensile stress. Figure 1 is a schematic of equipment with those functions; its key names the test machine main frame, the rear tension seat, pull head 1, seal end 1, the adjusting pin hole, the full-size test piece, seal end 2, pull head 2, the front tension seat, the cylinder rod, the cylinder seat, the loading cylinder, the moving crosshead, the thermocouple, the heating wire and insulating wool, the venting and liquid inlet line, the gas inlet and liquid outlet line, the pressure gauge, the data acquisition and automatic control system, and the safety alarm and protection system.

6.2 Heating and heat retention. The test medium is heated by wrapping heating wire and insulating wool around the outside of the test piece, and the temperature is monitored by a thermocouple in the seal end at one side of the test piece; the sensitivity of the temperature sensor is plus or minus 1 degree Celsius. To keep the heating system from damaging the equipment, a cooling water circulation may be fitted inside the front and rear tension seats.

6.3 Medium injection and pressurisation. The medium is injected and pressurised through the gas and liquid inlet lines in the seal end at the other side of the test piece, which also serve for venting, draining and purging after the test. A pressure gauge and a flow meter shall be fitted on the gas and liquid inlet lines so that the pressure and flow of the medium can be monitored during the test.

6.4 Tensile stress loading. The tensile stress is applied by the full-scale test equipment. The accuracy of the test machine is plus or minus 1 per cent and the error of the maximum test force shall be less than plus or minus 2 per cent. The deformation of the test piece is measured and recorded by a displacement transducer fitted at one end of the tensile

equipment, with an accuracy of plus or minus 0.01 millimetres; strain may also be measured with strain gauges.

7 Test pieces

7.1 General. Test pieces are taken from finished pipe meeting the product standard or from casing and tubing already used in the field. Where the test piece includes a coupling or another special connection, that connection shall lie at the middle of the test piece. Before the test, the piece shall be checked under GB/T 19830 or the relevant product standard for appearance, dimensions covering diameter, wall thickness and length, basic properties covering tensile, impact and hardness, and by non-destructive examination, and the results shall meet the product standard. A sample shall be taken from the end of the test piece for a tensile test at the test temperature of 5.3, to obtain the measured yield strength, tensile strength and other basic mechanical properties; the sample information record form is Table A.1 of Annex A.

7.2 Length. The length of the test piece shall be in the range 1 metre to 12 metres and shall be not less than ten times the nominal outside diameter of the piece.

7.3 Preparation. On a test piece without a coupling, marks are made at eight equal intervals around the circumference at the cross-sections corresponding to the one-half, one-quarter and three-quarter positions, and the original wall thickness is measured at those 24 points by ultrasonic thickness measurement, to the nearest 0.01 millimetres. On a coupled casing or tubing test piece, the marks may be made at the cross-sections 200 millimetres to 300 millimetres from each side of the coupling edge and at the one-quarter and three-quarter positions, again at eight equal intervals around the circumference, and the original wall thickness measured at those 32 points. After measurement, the mean of the eight points on each cross-section is calculated and taken as the wall thickness at that section.

The test piece may be sealed by welding a steel solid plug whose outside diameter matches the bore of the piece into each end, or by a special threaded connection. The seal connection at one side carries the thermocouple port for temperature measurement, and the one at the other side carries the gas and liquid inlet and outlet ports, with a pressure gauge and a flow meter on the gas and liquid inlet lines. Figure 2 is a schematic of the seal connection; its key names plug 1 or special threaded connection 1, the pull head, the test piece, plug 2 or special threaded connection 2, the liquid inlet and vent line, the gas inlet and liquid outlet line, and the thermocouple port.

Steel rings larger than the outside diameter of the piece are welded to the outside wall at both ends to form the pull heads, by which the piece is clamped into the front and rear tension seats. The size and strength of the pull heads shall make the clamping suitable and shall keep them from deforming during the test.

7.4 Calculation of the load. The load for the test is calculated by formula (1), in which the