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Flexible Flowline Thermal Exchange Coefficient Test Performed at High External Pressures

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Abstract

It is known that the thermal exchange coefficient (TEC) of an insulated flexible pipe may be affected by both external pressure due to the operating water depth and by the annulus condition. International standards state that flexible pipe systems shall be designed considering the effects of these two environmental conditions. If not considered during the flexible pipe design phase, these factors may have an important impact in the production system by reducing the temperature and allowing hydrate and paraffin formation in the pipe bore.

As part of Wellstream's research and qualification programme, a TEC test was performed to assess and quantify the effects of external pressure and the annulus condition during the flexible pipe system operation. The test was carried out using a 3m long sample taken from a 6 inch internal diameter production flowline designed to 1500m water depth and a maximum fluid temperature of 60°C with 276 bar internal pressure. Special end fittings were designed to reduce the pipe axial heat loss during the test.

The tested pipe was designed in accordance with Wellstream methodology and design tools to provide a pipe structure with a TEC lower than a predicted value, even when subjected to external pressure due to the operating water depth, or in an annulus flooding event.

The test was conducted in two different phases to separately evaluate the external pressure and annulus condition. The first phase of the test was conducted sequentially at four different levels of external pressure, these being 1, 50, 100 and 150 bar on a dry pipe annulus.

The second phase of the test was carried out after flooding the annulus with water under an external pressure of 165 bar for 72 hours to soak the insulation tapes, which are responsible for the greatest part of the thermal exchange characteristics. After this period, the pipe TEC was measured sequentially at four different levels of external pressure.

By the end of the test it was possible to determine thermal exchange characteristics when the pipe was subjected to environmental conditions representative of actual applications. The relationship between the external pressure and the TEC variation could also be assessed and furthermore, it was possible to evaluate the behaviour of the flexible pipe thermal properties after an annulus flooding event. The test also demonstrated that Wellstream's design methodology properly accounts for the effects that both the external pressure, due to the operating water depth, and the annulus condition has on the pipe's TEC.