2019 Award Nomination

Title of Innovation:

FlexGel – Corrosion Mitigating Thixotropic Gel

Nominee(s)

Kirk Francis & Stewart Duthie, Flexlife

Category:

(select one below)

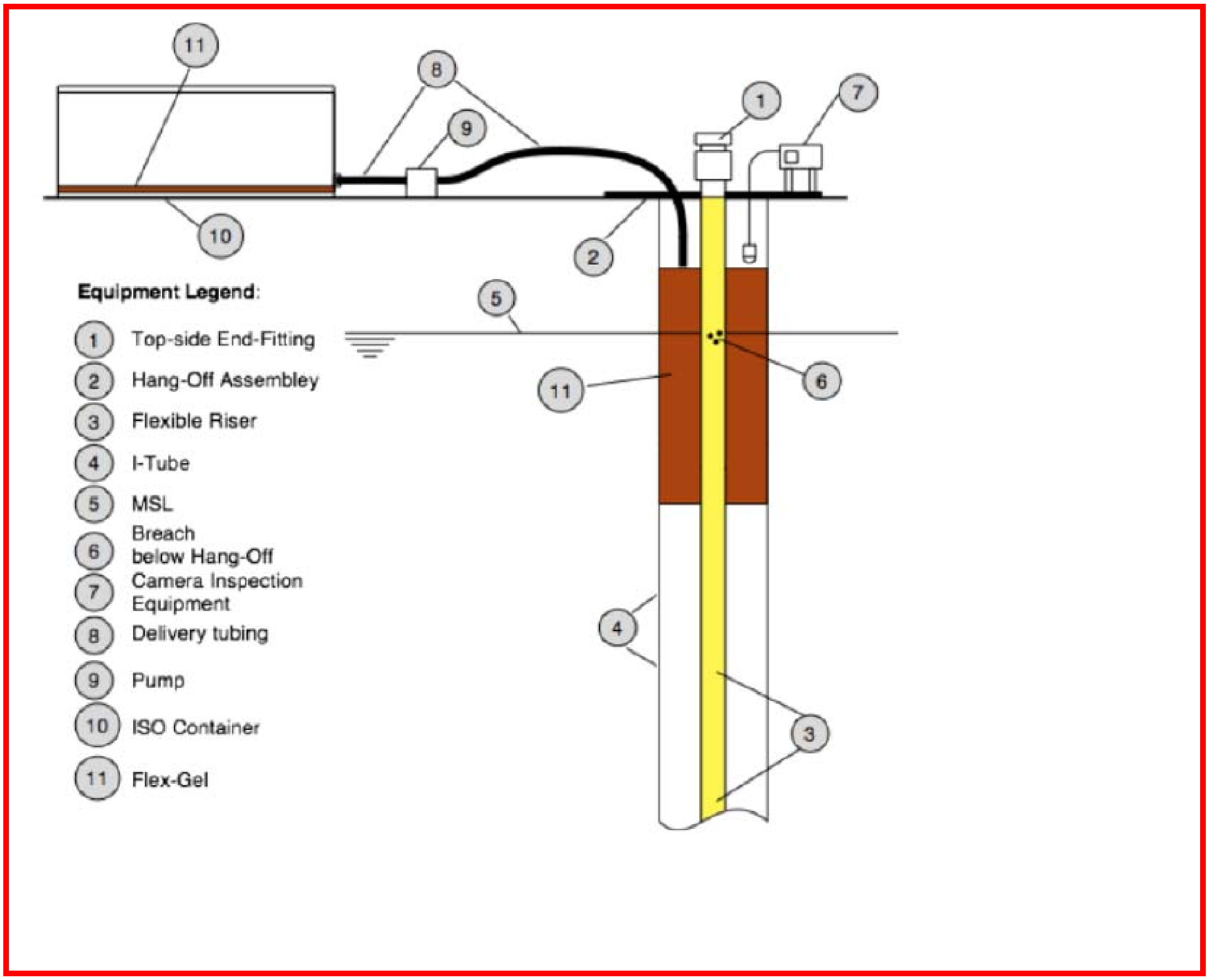
Coatings and Linings	Instrumentation
Cathodic Protection	Testing
Materials Design	Integrity Assessment
Chemical Treatment	Other—fill in

Dates of Innovation Development:

2011 – December 2016

Web site: www.flexlife.co.uk

Summary Description: The FlexGel range of products are various gels which are designed to halt the corrosion of carbon steel in subsea flexible and steel risers in the area of an outer sheath/coating damage, by displacing the oxygenated seawater from the region of the damage, and replacing it with a non-corrosive gel. FlexGel can be used inside I-tubes to eliminate the air-water interface and coat the damaged riser, thus protecting both the OD of the riser, and the ID of the tube. FlexGel can also be injected into flexible riser repair clamps subsea to form a flexible seal and prevent further corrosion. The thixotropic nature of FlexGel allows it to be pumped easily, yet within 48 hours it viscosity increases significantly to prevent splashing or loss of gel due to waves and vessel motions. To additionally prevent MIC, biocides have been suspended in the gel mixture for some applications. The deployment process to install FlexGel in the annulus between a I-tube and riser is shown in the below figure.


11
8
1
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Equipment Legend:
5
1 Top-side End-Fitting
2 Hang-Off Assembley
11
6
3 Flexible Riser
4 I-Tube
5 MSL
6 Breach below Hang-Off
7 Camera Inspection Equipment
8 Delivery tubing
4
9 Pump
3
10 ISO Container
11 Flex-Gel

Full Description:

(Please provide complete answers to the questions below. Graphs, charts, and photos can be inserted to support the answers.)

1. What is the innovation?

FlexGel is a density-tuned, thixotropic corrosion mitigating gel product, which is installed inside an I-tube, pull-tube or other structure which passes through the splash zone, to eliminate the highly corrosive air-water interface by displacing seawater from the splash zone region. This prevents corrosion of carbon steel pipeline risers or other structures inside the I-tube, where coating repair and clamps cannot be performed due to lack of access, and where cathodic protection is not very effective.

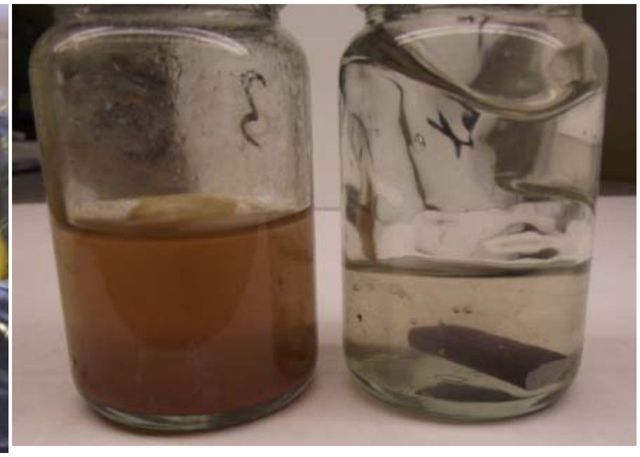
2. How does the innovation work? Since FlexGel in non-aqueous and density tuned to be slightly lighter than seawater, when installed inside a tube, it sits on top of the seawater and displaces it out of the tube, thereby replacing the air-water interface with a plug of FlexGel. The product then increases in viscosity, and stays static within the tube despite external waves and platform motions. The FlexGel has been designed to be compatible with steels and polymer materials, coating them and preventing further corrosion. Biocide in the form of THPS can also be added to the FlexGel mixture, providing protection against MIC. The FlexGel is approved by CEFAS for use in the ocean environment, and has been installed in the North Sea, and Gulf of Mexico.

3. Describe the corrosion problem or technological gap that sparked the development of the innovation? How does the innovation improve upon existing methods/technologies to address this corrosion problem or provide a new solution to bridge the technology gap?

Having pipeline risers pass through the splash zone inside I-tubes or pull-tubes provides some protection from the environment, but it also creates a situation where inspection and repair of coatings and sheaths is not possible in service. When a riser is pulled into the platform through a pull-tube, the coating can be scraped and damaged, with no method for repair. FlexGel solves the problem of not being able to inspect or repair splash-zone coating/sheath damage inside an I-tube or pull-tube, by removing the splash zone from the tube altogether, and replacing it with a non-corrosive gel.

4. Has the innovation been tested in the laboratory or in the field? If so, please describe any tests or field demonstrations and the results that support the capability and feasibility of the innovation.

FlexGel has been both lab-tested and field-tested. In the lab, tests have been performed to prove that carbon steel does not experience any degradation in the FlexGel, and to illustrate the difference between high-strength carbon steels immersed in seawater vs. the same steels immersed in FlexGel. This showed significant corrosion in seawater, and no corrosion in FlexGel. Material compatibility testing has also been performed for FlexGel in contact with common riser outer sheath materials and coating. Additional testing considered the vibration frequencies at which the FlexGel lowers in viscosity, to prove that floating platform motions would not affect the viscosity of the gel in service.



In the field, we have a Client who experience coating disbondment on two steel risers with a J-tube. One of the risers had already catastrophic failed due to corrosion, and concerns remained about the adjacent safety critical gas-lift riser. Flexlife installed 5600 liters of FlexGel inside the tube to displace the water from the critical area. In-line inspection of the riser was performed before installation, and 2 years later, showing no further corrosion after FlexGel was installed. After an additional 3 years, the Client has again stated that the FlexGel continues to perform as desired, allowing them to keep the riser in service.

5. How can the innovation be incorporated into existing corrosion prevention and control activities and how does it benefit the industry/industries it serves (i.e., does it provide a cost and/or time savings; improve an inspection, testing, or data collection process; help to extend the service life of assets or corrosion-control systems, etc.)?

This innovation is quick to install inside an I-tube offshore, and requires no hot work, divers, or other safety critical tasks, allowing production to continue during installation. It is relatively low cost compared to existing inspection and repair tools, and does not face the issues associated with lack of access inside an I-tube. This mitigates the potential issues of not being able to inspect in this region, and provides a repair solution for risers/structures that already experience corrosion problems in this area. FlexGel can be installed both as a preventative measure for new fields, or as a method of life extension for ageing assets.

6. Is the innovation commercially available? If yes, how long has it been utilized? If not, what is the next step in making the innovation commercially available? What are the challenges, if any, that may affect further development or use of this innovation and how could they be overcome?

Yes, FlexGel is commercially available, and has been utilized since 2012. Additional work on material compatibility testing has been performed up to 2016. At the present time, we are performing microtox testing on a new version of FlexGel, called FlexGel-X, which would be installed before the regular FlexGel on highly dynamic vessels that require the FlexGel to go all the way to the bottom of the tube. The FlexGel-X is cross-linking, which cures to form a plug at the bottom of the tube, with the regular FlexGel sitting on top of it. This will prevent the loss of FlexGel out of the bottom of the tube even for highly dynamic situations where I-tube angles during vessel motion would deviate significantly from vertical.

7. Are there any patents related to this work? If yes, please provide the patent title, number, and inventor.

Yes, the FlexGel patent has been granted in Australia, Denmark, United Kingdom, Malaysia, Netherlands, Norway, and Africa. The inventor is CRAIG SCOTT KEYWORTH of Flexlife Limited. Patent Grant numbers for each country are listed below.

Australia	2011287397
Denmark	2601431B
United Kingdom	GB2482610
Malaysia	MY-157426-A
Netherlands	2601431B
Norway	2601431B
African Intellectual Property Organization (OAPI)	16187