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Proposal of a test protocol for reliability assessment of the new all-electric intelligent completion interface

Eduardo Menezes, Isis Lins, Márcio Moura, Rafael Azevedo, Caio Maior

Center for Risk Analysis and Environmental Modeling, Brazil. E-mail: eduardo.novaesmenezes@ufpe.br, isis.lins@ceerma.org, marcio.cmoura@ufpe.br, azevedo144@hotmail.com, caio.maior@ufpe.br

Manoel Feliciano da Silva Jr., Marcos Vinicius Nóbrega

CENPES/Petrobras - Research Center Leopoldo Américo Miguez de Mello, Brazil. E-mail: feliciano@petrobras.com.br, marcos_nobrega@petrobras.com.br

Fabricio Damico, Marcelo Medici

Navcon Engineering, Brazil. E-mail: fabricio.damico@navcon.com.br, marcelo.medici@navcon.com.br

One of the large breakthroughs in the O&G industry is the complete electrification of the completion. In this regard, a whole new group of equipment has been developed for implementing electric completion. One of the most critical is the subsea interface (SI), with the role of providing the subsea valves with the necessary power and the communication layer to the topside instrumentation and control. In order to evaluate the reliability of the SI, a complete test protocol must be designed, encompassing mechanical, thermal, electronic and electrical testing, since the equipment involves different mechanical support parts, power electronics and communication devices. In this work, the elaboration of a test protocol for the SI is executed according to the most recommended guidelines, academic research and reliability considerations.

Keywords: accelerated test protocol, O&G industry, intelligent completion, test guidelines.

1. Reliability assessment in the O&G industry

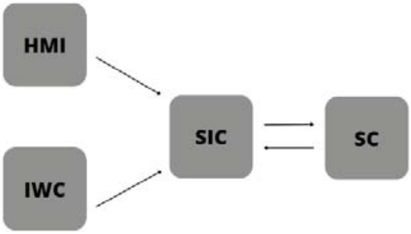
Given the complexity and long useful life of O&G equipment, the reliability evaluation needs to utilise alternatives to traditional methods. Indeed, the main source for reliability estimation relies on data from the equipment, describing its useful lifetime and failure conditions. The data can be obtained from experimental tests specifically designed to obtain reliability estimates, in which the tested device is led until failure, or from field data of equipment in real field applications. In the O&G industry this is not possible to accomplish due to the cost and long time-to-failure of the components, designed to endure 20-30 years of operation. In this context, accelerated life tests must be employed(Modarres et al., 2015). Besides this methodology, the qualification tests of industry standards can also be used to estimate reliability, although with less impact (API, 2018).

2. Subsea interface for intelligent completion

2.1. *System*

The intelligent completion valves are operated from a top-side computer, the intelligent well computer (IWC). This is a dedicated system with embedded intelligence. It delivers commands for the subsea interface top-side computer (SIC), which processes and forward commands for the subsea computer (SC). This is the last interface, which sends the commands for the downhole valves. The SIC can also receive

Fig. 1.SI schematic diagram



inputs from an operator, by means of a human-machine interface (HMI), as shown in Fig. 1. As an important part of the SI, there is a health monitoring system, with plenty of sensors collecting temperature and vibration data.

2.2 *Construction of FMECA*

The first step to establish the test protocol is the construction of a Failure Modes, Effects and Criticality Analysis (FMECA) (Peyghami et al., 2019). A multidisciplinary team was gathered to rank the most import failure modes of the SI. These were identified as no power supply, no communication, degraded communication, incorrect command, loss of sealing of SI compartment. Each failure mode is associated with a risk priority number (RPN). The reliability analysis established that every failure mode with RPN > 20 must be tested.

2.3. *Stressors*

Following the methodology to establish a test protocol, each failure mode is associated with a failure mechanism and stressor. The latter corresponds to the physical variable responsible for causing the failure. In the identified failure modes, these were: vibration, shock, temperature, electromagnetic field and input overvoltages. These act on the SI main components: compartment, electronic devices (power converters and sources), modems and CPUs, and the health monitoring sensors.

3. Designed tests

The tests have been designed following the methodology of accelerated life tests and a test matrix was elaborated, containing all the recommended levels for the stressors (Novaes Menezes et al., 2021).

3.1. *Vibration and shock*

For sweep vibration test, follow API17F for vibration screening. For random vibration, an accelerated vibration life test must be established, following the power law to estimate test time. We use $m=5$ as acceleration test coefficient, which is a common value for electronic components. This results in *9.75 grms* of vibration, consisting in 48h of test time, corresponding to 15-years of accelerated life.

3.2. *Temperature*

The steady temperature test should follow Arrhenius Law to estimate test time. Use 0.7 eV as baseline value (Toshiba Electronic Devices & Storage Corporation, 2018). This results in 85ºC and a test time of 5000h. The degradation should be evaluated before end-of-test, which consists in 15-years of accelerated life. For cycle tests, use Coffin-Manson law, with k=3.4 (typical value in literature).

3.3. *Input overvoltage and electromagnetic interference*

In this case, the recommended test follows the API17F power variation in item 9.2.3.2.4. For surge, use the wave shape in IEC EMI-related standards (IEC 60533 and IEC 61000). It is worth noting that the electrical stressors can not be accelerated since they are not related with degradation over time.

4. Conclusion

Executing a systematic procedure from FMECA definition towards accelerated test design based on prevailing literature can improve O&G reliability evaluations.

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