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## **Deepwater In-Line SLED Installation Methods and its Application to Frade Project**

Kevin Huang, Andy Ji, and Edgar Uribe, Acergy USA

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### **Abstract**

Flexible flowlines and risers have been increasingly used for deepwater and ultra-deepwater field applications, partially because of its low submerged weight and better dynamic characteristics comparing to rigid pipelines. The offshore installation of flowline itself is fast. However, its low bending stiffness brings challenges for installation when it contains heavy subsea equipments to be tied-in. Recently we have successfully installed a total of more than 100km flexible flowlines with 24 in-line SLEDs/PLETs in water depth up to 1300m. This paper reflects these subsea equipments installation experience and lessons learnt during the Frade project.

In this paper we highlight the installation issues and solutions during the in-line SLEDs and PLETs installation. First we discuss three of the possible installation options. For each option we modeled the whole installation sequence with finite element analysis software tools and analyzed each critical stage to ensure the product and equipment integrity. Based on each option's pros and cons we defined their application scopes. Then we present some of the installation concerns such as current drag forces, rigging snatching loads, SLED-sea floor interaction during landing, etc, their analysis investigation, and adopted solutions. After that we present the high level installation procedures used for offshore installation, including different flowline type and installation scenarios, such as flowline installation with single or multiple in-line SLEDs, flowline initiation with PLET, and flowline laydown with PLET. Some of the lessons learnt are also discussed as well. Finally, the conclusions are drawn.

It is concluded that the present SLEDs/PLETs installation methods are effective and efficient, and proven by successful field operations. These methods are also applicable to the tie-in operations of all other similar subsea equipments for flexible flowlines in deepwater fields.

### **Introduction**

The Frade field is located in the northern Campos Basin approximately 76 miles (120km) from the nearest Brazilian shoreline and 135 miles (220km) north-east of Macae. Chevron Corporation, through its affiliate Chevron Frade Limited Liability Company, along with partners Petrobras and Frade Japao Petroleo Limitada (FJPL), a joint vehicle company of INPEX, Sojitz and JOGMEC, developed the Frade oil field offshore Brazil. The Frade Field contains an estimated 200 million to 300 million barrels of recoverable oil and has a water depth range from 1000m to 1300m. It is expected to begin production in early 2009, with production capacity of approximately 100,000 barrels of crude oil per day and estimated peak annual production of 85,000 oil-equivalent barrels and 300 million cubic feet of natural gas per day. Crude oil export will be by tanker, while natural gas will be transported through the local natural gas pipeline infrastructure.

The development concept consists of horizontal production wells along with vertical water injection wells to maintain reservoir pressure. The wells will be individually tied back to a floating production storage and offloading (FPSO) vessel. The field layout is illustrated in Figure 1, and it includes 1 water injection flowline loop, 6 production flowline loops, 3 gas lift flowline routes, 1 gas import/export (I/E) flowline, 19 wells, 28 SLEDs/PLETs/PLEMs, 71 electrical flying leads, 49 steel