A FLEXIBLE SWITCHING, COST SAVING AND POWER SAFETY REMOTE CABLE EARTH SWITCH CLOSURE

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Abstract: Offshore installation is an important and complicated process for the submarine cable system delivery. It will face various threats that may damage cable or submersible plant, so real-time cable performance monitoring is critical for cable offshore installation. However, the electrical test will be limited to conductor resistance or insulation resistance if traditional loop fiber end seal is adopted, that may due to pre lay shore end activity delays. In this case, it is challenging to locate the cable fault exactly and promptly if incident happened, which may induce significant added cost loss. In this paper, a remote cable earth switch closure is introduced, which can perfectly solve this challenging situation by providing flexible switching, cost saving and safer method during operations.

1. INTRODUCTION

Submarine cable bears more than 90% international communications traffic, which makes cable safety a key factor for commercial traffic reliability. Offshore installation is an important, complicated and critical process for safe and stable cable lifecycle. The cable will face various threats that may damage cable or submersible plant during offshore activity, such as bad weather, unfavorable seabed condition, onboard equipment failure, fishing activity etc., so it has to monitor cable performance during cable offshore installation to ensure its safety and marine operation quality.

Optical and electrical performance monitoring are two familiar methods for cable performance monitoring. Electrical performance monitor is an indispensable way, which includes insulation resistance and conductor continuity for unrepeated system or voltage drop for repeated system. The electrical performance can directly reflect installed submarine cable performance. For example, if the insulation layer of submarine cable is damaged due to bad weather, unfavorable seabed condition, onboard equipment failure or fishing activity etc., the insulation resistance of submarine cable will decrease significantly. But the cable continuity may maintain well if insulation layer is not fully breakdown.

And if the submarine cable is broken or the insulation layer is damaged, both system conductor resistance and insulation resistance will change. In fact, it has been a conventional solution for cable fault point locating.

Comprehensive monitoring including insulation and continuity test to ensure the cable performance must be done, while another way is optical performance monitor, which includes OTDR (optical time domain reflectometer) for unrepeated system and COTDR (coherent optical time domain reflectometer) for repeated system, using optical reflect characteristic in fiber to monitor the cable performance. It is a significant aspect but not the main topic of this paper.

2. RESTRICTION OF PRESENT METHOD

Normally, the cable will DSE (direct shore end) in BMH (beach man hole) from the main lay vessel, and may extend to CLS (cable landing station) by land cable. After checking the shore cable performance, the main vessel will continue laying the main cable. The cable monitoring test will be conducted from the installation vessel in certain interval, it requires some partners in remote cable end which landed first in shore to cooperate.

Taking insulation resistance monitoring as an example, the remote cable end need work in open circuit mode when insulation resistance test in vessel. In contrast, for conductor continuity or voltage drop test, the remote cable end needs to work in short circuit. The test will be a routine operation in vessel in certain interval such as 6 hours, or once submersible plant laying. It requires that the remote cable end state changes between open to short circuit modes.

Currently, this switching activity is manually controlled by TPSO (terminal power safety officer) in CLS/BMH. Manual switching will inevitably face high-voltage security issues.

On the other hand, the vessel and remote cable end need to communicate by PSM (power safety message) for safety, normally using email. If the remote sites with poor land-based communication conditions, or maritime satellite communications because of bad weather, PSM communicating will be hard or time-consuming. And the cable installation vessel will work all day long, forcing the engineer in CLS/BMH to standby at the same time, which will induce great work and safety risk for TPSO in remote cable end.

In addition to that, sometimes longer shallow water depth area may lead that the main vessel fails to sail nearby the shore. The cable landing activity will conduct separately with main cable laying which called PLSE (pre-laying shore end). In this scene, the shore end cable will be installed by a separated shore end vessel, and after that the main vessel will come to pick up the shore end cable end and make a joint with main cable, then start the main cable laying. In this case, the PLSE cable performance will be tested before main cable jointing.

After that, the cable performance monitor is almost the same than in DSE mode. However, sometimes the PLSE can’t be completed before main installation vessel arrives. The main installation vessel has to sail and lay the main cable end first, and install the main cable in advance, then it will return to make the joint after the shore end cable is ready.

At present, LFES (looped fiber end seal) is used for the main cable remote cable end sealing. LFES has its own earth electrode. If you want the cable end work in short circuit mode, a connection kits needs to be installed, which will connect cable conductor element with LFES earth electrode.

On the other hand, you may need to install a disconnect kit to make the cable conductor disconnect with its earth electrode to make the cable end work in open circuit.

Both connection kit and disconnection kits are available, but they cannot be switched or controlled flexibly. Once integrated with the system, the monitoring method will also be fixed so that the cable end mode can’t change during cable laying. It means that LFES can only support the remote cable end working in open or short circuit mode, the cable mode can’t command control or automatic switching. In this case, the cable electrical performance can only be partially monitored from vessel, insulation performance or continuity performance, but can’t be monitored at the same time.

If any project PLSE install later than main cable laying, the project technical director has to make difficult choices between monitoring insulation resistance performance and continuity performance during cable laying. Once the decision is made, it only can do one testing mode during the main cable installation, but either of them has its own limitation as introduced above.

If the cable end is in open circuit mode, the insulation performance can be monitored, while the cable electrical discontinuity cannot. COTDR also cannot be used in repeated system since the system cannot be powered up.

If the cable end is in short circuit mode, the cable continuity performance can be tested, but insulation performance cannot be monitored. In another word, the cable fault might not be located exactly, which may induce costly installation delay if installation incident happens when cable installation fails to be prompt located or decided.

3. IMPROVEMENT FOR THE LFES

In order to solve the above conflicts, the author's team develop a new LFES. The working mode of the new LFES can be remote controlled from vessel without manual switching the LFES grounding state in remote cable end.

Figure 1 illustrates the repeated system voltage drop test method. It only needs switch the cable end to short circuit mode, and then powers on the system of PFE on vessel, the system voltage drop can be checked from PFE directly. In this mode, the system cable optical and repeater optical amplify performance also can be monitored by COTDR with powered repeaters.

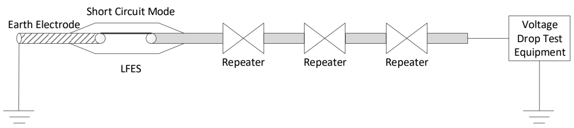

Figure 1: Voltage Drop Test Configuration

Figure 2 illustrates the insulation test method, the cable end can be switched to open circuit mode from vessel first, and then apply the insulation resistance test voltage from vessel to check the cable insulation performance.

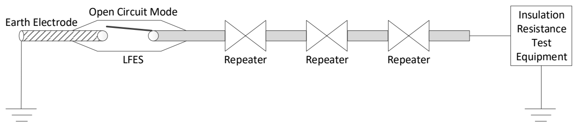

Figure 2: Insulation Resistance Test Configuration

In unrepeated system, the above methodology is also available, the difference is the cable optical performance can always be monitored from the vessel with an OTDR since it has no active repeaters.

To ensure this method will not lead to any negative effect, comparison tests were done on repeated and unrepeated system respectively. The system electrical insulation and conductor resistance were tested at different cable end mode.

In a 2000km+ repeated system, insulation performance and voltage drop were tested for different cable end modes, results are shown in table 1.

The insulation performance are proven equal, and the voltage drop results are also identical in different cable end mode.

Cable End State	Insulation Resistance (MΩ)	Voltage Drop (V)
Short by Traditional LFES	-	1946
Short by Improved LFES	-	1946
Open by Traditional LFES	40	-
Open by Improved LFES	70	-

Table 1: Repeated System Comparison Test

Insulation performance and conductor resistance were also tested at different cable end mode for a 100km cable as shown in table 2.

Insulation performance were indicated at the same level, while the conductor resistance was slightly different from each other, which indicates the improved circuit fixed resistance can be corresponding with its specification.

Cable End State	Insulation Resistance (GΩ)	Conductor Resistance (Ω)
Short by Traditional LFES	-	105.8
Short by Improved LFES	-	107.3
Open by Traditional LFES	17	-
Open by Improved LFES	27	-

Table 2: Unrepeated cable Comparison Test Result

The above test results prove that the improvement LFES did not induce any negative effect for the test results. The insulation performance were at the same level, even though conductor resistance has a little bit confirmed difference, it can be removed from the test result if an accurate result is needed.

Once this technology is adopted, the cable performance can be monitored precisely, regardless of any delay to the PLSE cable and attributed by the main lay vessel operations.

It can perfectly solve the above conflicts so as to save significant vessel standby cost. This technology is also able to be applied in CTC (cable termination cubic) or beach joint situations. If adopted in CTC/BMH in DSE situation, it will alleviate power safety concern as there will be no need for TPSO to manually switch the cable end. It will also decrease the dependence on communications quality for PSM. By releasing the TPSO requirement in cable end, reduced manpower cost for the project will also be achieved thus overall cost savings can be provided.

3.3 CONCLUSION AND DISCUSSION

The improved LFES will be helpful to increase precision when locating the cable faults once the incident occurred, which may increase installation cost due to PLSE delay scene.

It also can be adopted in CTC or beach joint, which will alleviate power switching safety concerns, and decrease manpower involvement. It offers flexible switching, cost saving and safer solution for offshore installation cable monitoring.

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