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INSULATION REMEDIAL SYSTEM AS A SOLUTION FOR LOW INSULATION RESISTANCE PROBLEM ON SUBSEA ELECTRICAL FAILURE OF TERANG SIRASUN BATUR SUBSEA CONTROL SYSTEM

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ABSTRACT

This paper describes the method of reviving the insulation property of electrical and communication lines which have deteriorated due to water ingress by means of introducing electrochemical process to the failing electrical and communication lines. This method was applied to the failing power and communication lines of subsea control system at Kangean's Terang Sirasun Batur (TSB) gas field. The result indicates that this method of introducing electrochemical process increases the low insulation resistance value back to the acceptable range of operating value.

INTRODUCTION

Subsea control system typically consists of electrical (electrical current to power the subsea instrumentations and to operate the valves), hydraulic, and communication lines. To prevent contact between the conducting elements themselves or between conducting elements and seawater or commonly termed water ingress, the conducting elements must be sufficiently insulated. The insulation must typically have a minimum insulation resistance value for it to sufficiently insulate the conducting elements. They are typically in the range of 10 mega ohms and above. An alarm and system shutdown (trip) would be typically set to the value below 800 kilo ohms. Below this limit the electrical and communication lines fail to function which means total loss of control of subsea equipments and instrumentation readings. In this particular case presented in this paper it was established that the drop in insulation resistance value of the power and communication lines were caused by water ingress.

The conventional method to rectify this problem is to replace the component that is exposed to the seawater.

Replacing a subsea component involves meticulous planning which requires many long lead activities such as the procurement of the component itself and obtaining vessels with the qualified personnel capable of carrying out the replacement activity. Subsea intervention would undoubtedly have an effect on the day-to-day operational activity and hydrocarbon production.

Electrochemical process method allows a rectification activity to this problem without the need of subsea intervention and minimal effect on the day-to-day operation activity. Identification of the exact location or component that is exposed to seawater is also not required.

This paper shall describe the method of electrochemical process as a solution to revive the low insulation resistance and the general electrical configuration of the equipment promoting the electrochemical process, and the advantage of this recently invented method over the conventional method of rectifying low insulation resistance.

ELECTROCHEMICAL PROCESS

Electrochemical process by definition is any process either caused or accompanied by the passage of an electric current and involving in most cases the transfer of electrons between two substances – one a solid and the other a liquid.

In the particular case of rejuvenation of subsea electrical line the electrochemical process shall involve an electrical conductor element (Copper, Cu) and seawater (H_2O + NaCl). The process of formation of barrier element of copper chloride (CuCl) is illustrated in the Figure 1.

The precipitate forms outwards from the conductor top produce a plug, rather inwards from the insulation. It will takes place only at the locations where seawater is in direct contact with the copper

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conductor, it has no effect on any other parts of the circuit. In the case of Terang Sirasun Batur the IR faults were in the section of the subsea control system shown in the Figure 2 (Clouded section) i.e. the section that is exposed to seawater.

REVIVING THE LOW INSULATION RESISTANCE OF ELECTRICAL LINE

a. The principle

A bias signal is selected as such that in when an electrical current flowing between the conducting element and seawater an electrochemical reaction is triggered resulting in the formation of a barrier element restricting the current leakage flow thus improving the insulation resistance of the cable.

b. Subsea control system configuration

The Figure 3 shows the configuration of typical Topside-Subsea control system.

c. Electrical configuration

The Insulation Remedial equipment is connected to the topside control system with the configuration shown in Figure 4.

It must be noted that the formation of the barrier element, being directly in contact with the seawater, will tend to dissolve overtime if the bias signal is not maintained. The bias signal has been fine-tuned through the development of the technology to produce a precipitate plug that is stable and long lasting. This continuous supply of bias signal from the topside will perpetually maintain this process cycle. Thus this process is a self – maintaining process.

RESULTS

The followings are the recorded value of the insulation resistance of the subsea control system before and after the application of bias signal to promote an electrochemical reaction at the part of the electrical line that is exposed to seawater.

It is evident that the barrier generated by the electrochemical process immediately took place by the sharp increase of the insulation resistance over a short period of time.

It can also be seen that during the recovery period the insulation resistance improved dramatically and then dropped again shortly after albeit not to the critical level. This fluctuation was expected as it was part of the recovery process before the insulation resistance finally reached a steady level onward.

Figure 5 shows the process of formation of the barrier on the area that exposed to seawater. The process above took place under controlled laboratory condition so that the process can be observed visually.

Figures 6, 7 and 8 show the improvement of insulation resistance on the electrical signal and power lines. It can be seen that the improvement on the lines also depend on the initial value of the insulation resistance. The lower the initial value the longer it takes for the proposed method to reach a steady operating value of insulation resistance.

The following is a case where success of rejuvenate process reduced. EPU – 3 signal channel has Insulation Resistance value extremely low 10 kOhm while measured with IR tester during pre installation test. Meanwhile the minimum specification Remedial System is as low as 20 kOhm.

In the graph (See Figure 9) The rejuvenation process can only make an improvement from 143 kOhm to 163 kOhm. This 163 kOhm is far too low from the minimum operating value of 10 MOhm. Due to the 10 minutes update rate the process of improvement from 10 kOhm to 143 kOhm cannot be displayed in the graph. However, the rejuvenating process had already started from the moment the machine was switched on.

CONCLUSION

To have the subsea control system functioning at all time is vital, thus when there is sudden loss of power and communication to the subsea equipments and instrumentations it is critical to have decision immediately made and action taken to have the faulty lines rectified.

To have decision for rectification will require several consideration i.e. (1) technical complexity for onsite repair or replacement option (overall or part of subsea equipments), long lead items, troubleshooting, root cause analysis, installation and recover to surface (2) cost, (3) time, (4) resources for contractor's personnel, support vessel ROV or Diver, testing equipment (5) remaining hydrocarbon production, (6) insurances, (7) importation formalities and (8) equipment dimension/size. The current proposed method is better than conventional methods considering its small size (hand carried), simple transportation procedure, simple and quick installation, and its more cost effective. The overall cost of the proposed method is 42.7% lower than the conventional method.

Even though the propose method has been shown to improve the insulation resistance. The chances of success may reduce when applied this technology to the lower Insulation Resistance. Experience shows that the probability of success is much reduced if the failed circuit has an initial IR significantly below 20 kOhm.

REFERENCES

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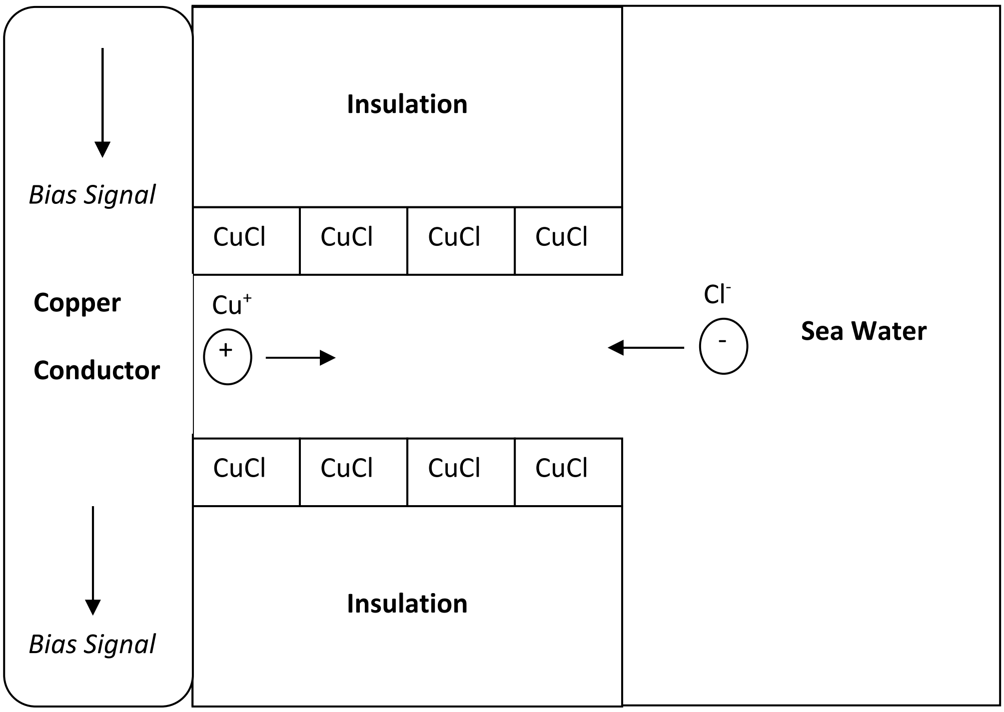

Figure 1 - A diagram illustrating of rejuvenation.

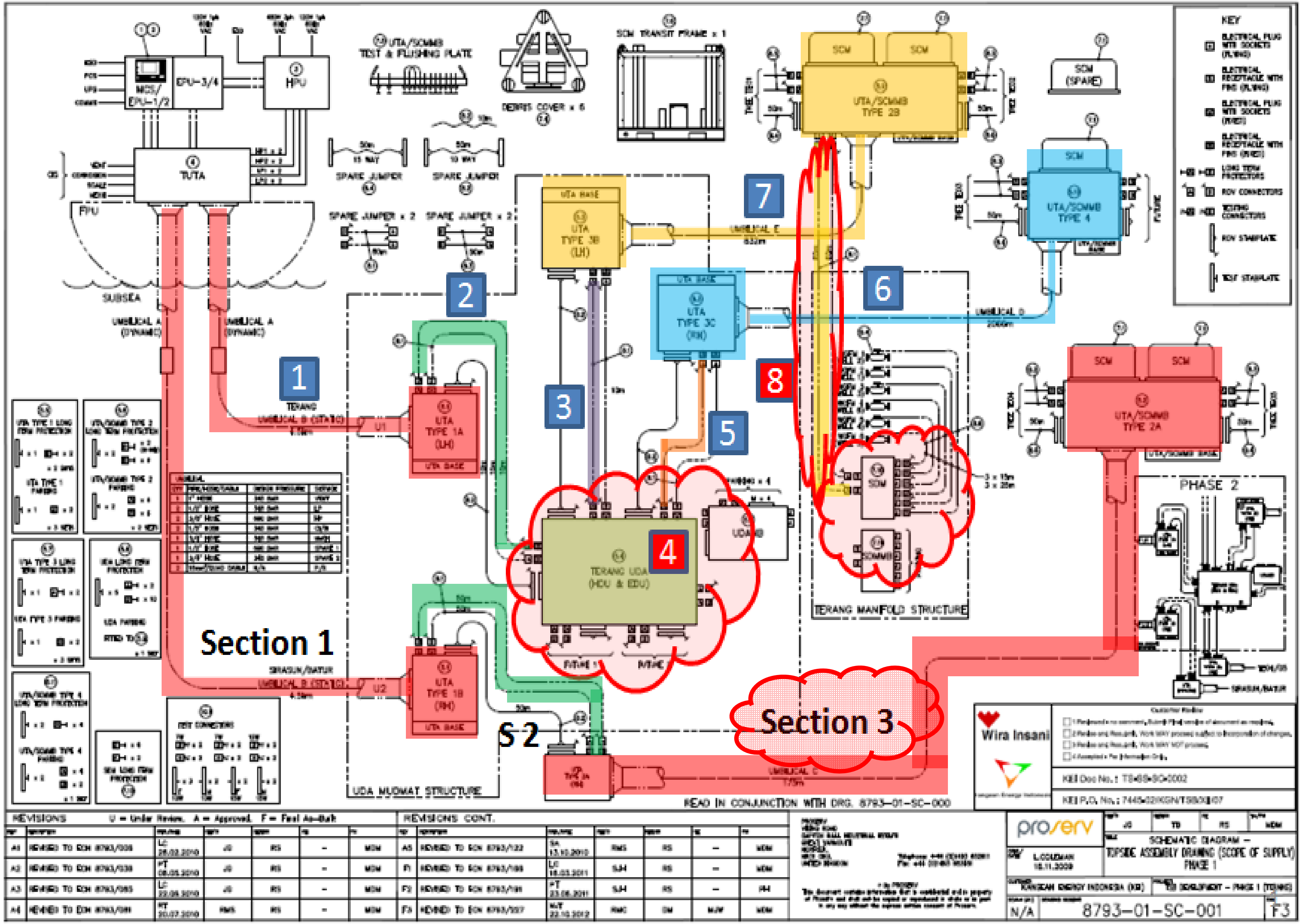

Figure 2 - Insulation Resistance Low problem location at TSB Field.

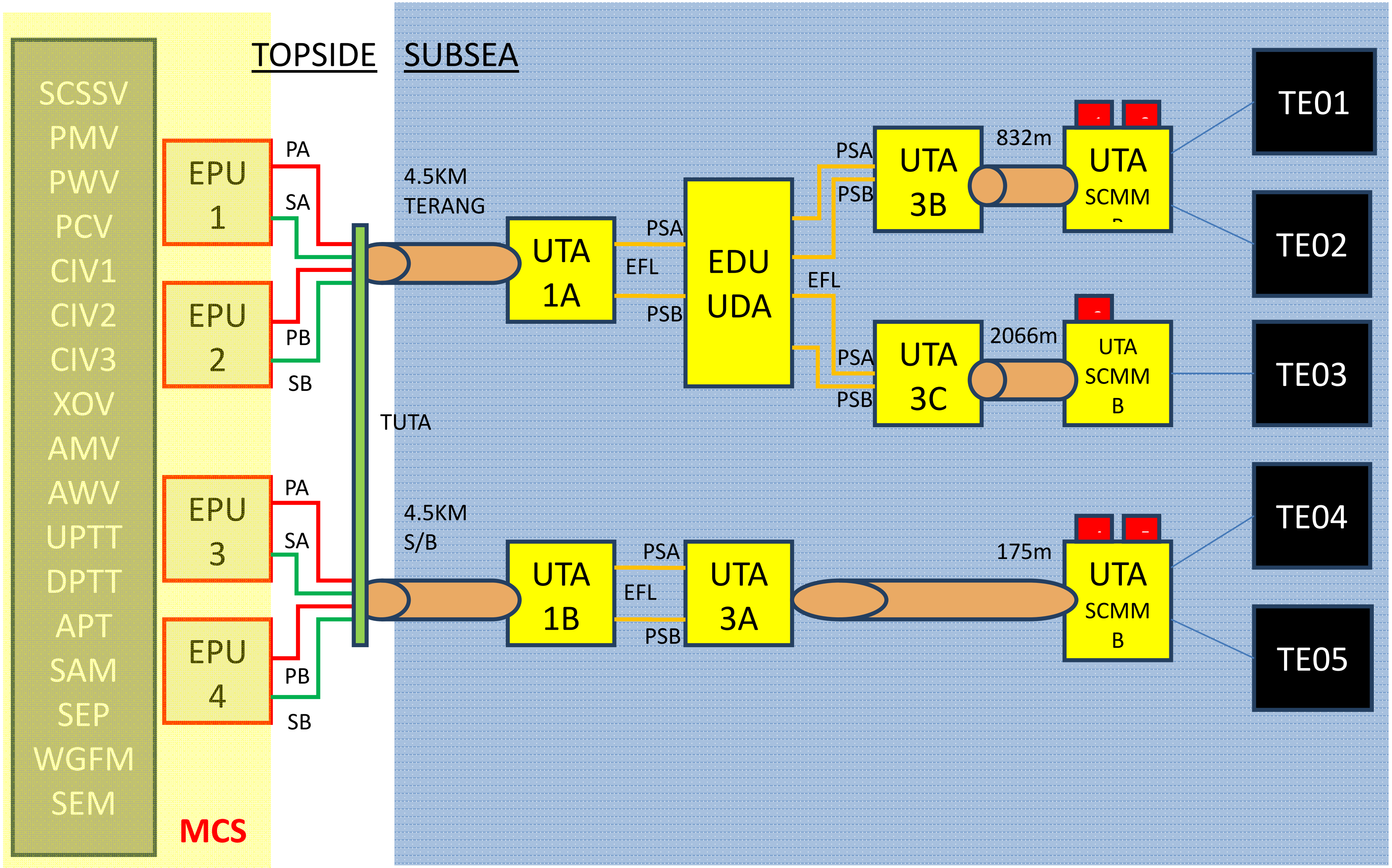

Figure 3 - Simplified TSB Subsea Control System Configuration.

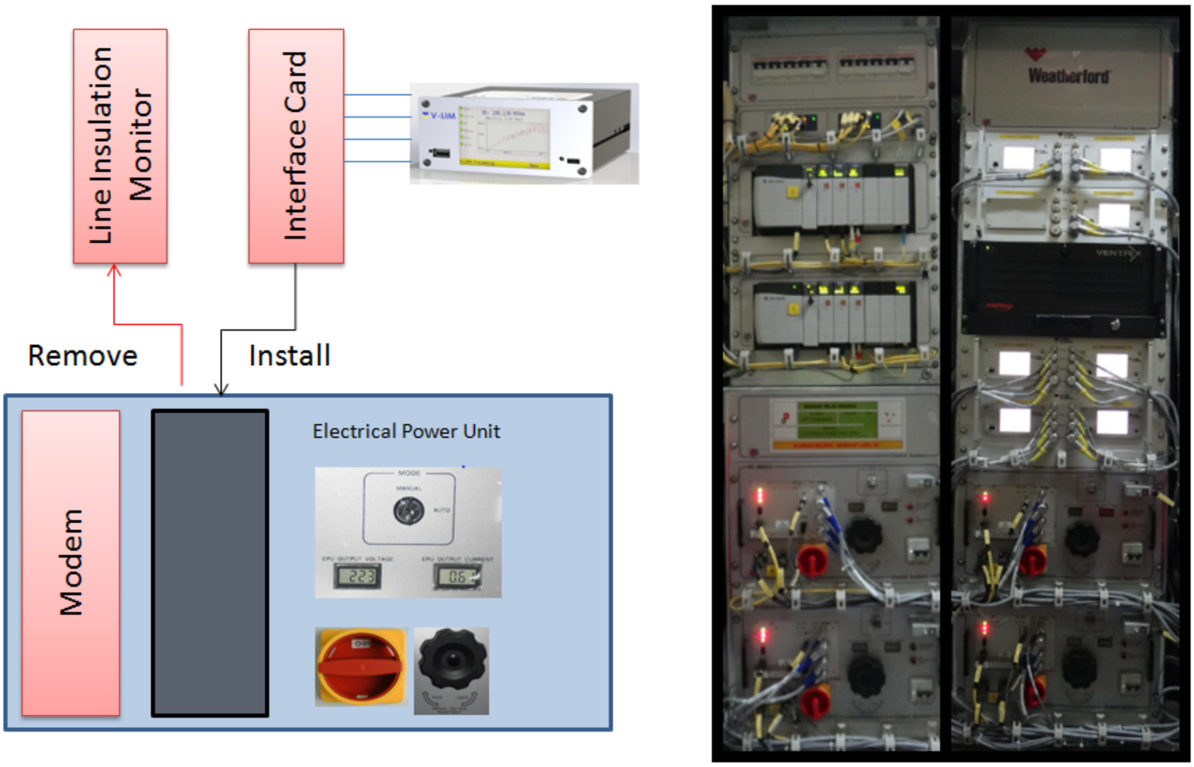

Figure 4 - Insulation Remedial System electrical configuration and installation.

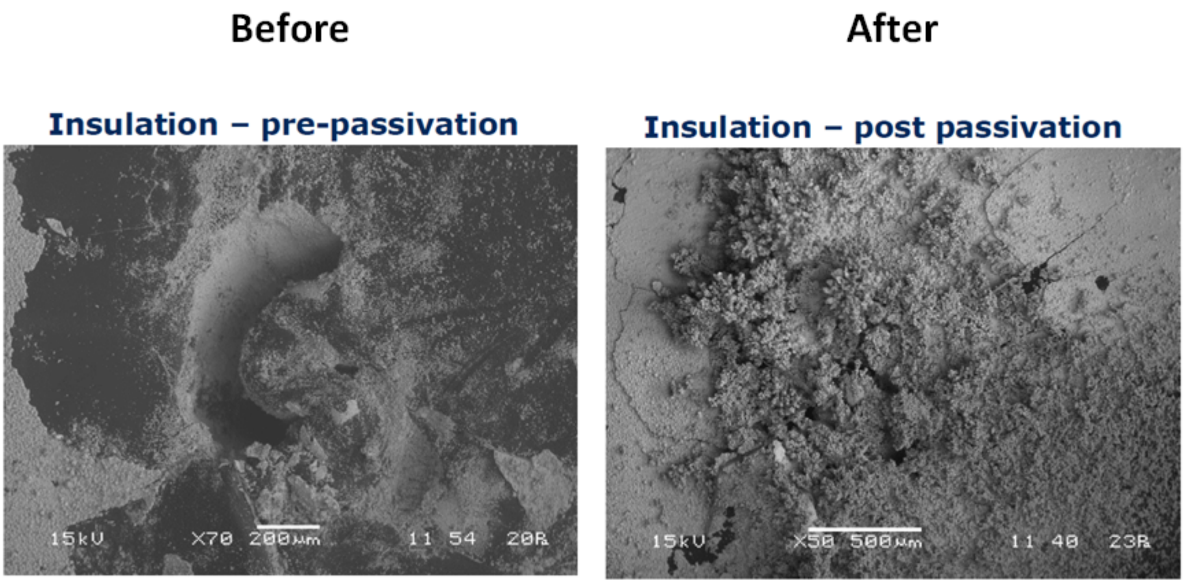

Figure 5 - Electrochemical process under laboratory condition
(Photos is courtesy from "General Presentation with V-Life for Kangean Energy" by Viper Technology Limited 2015).

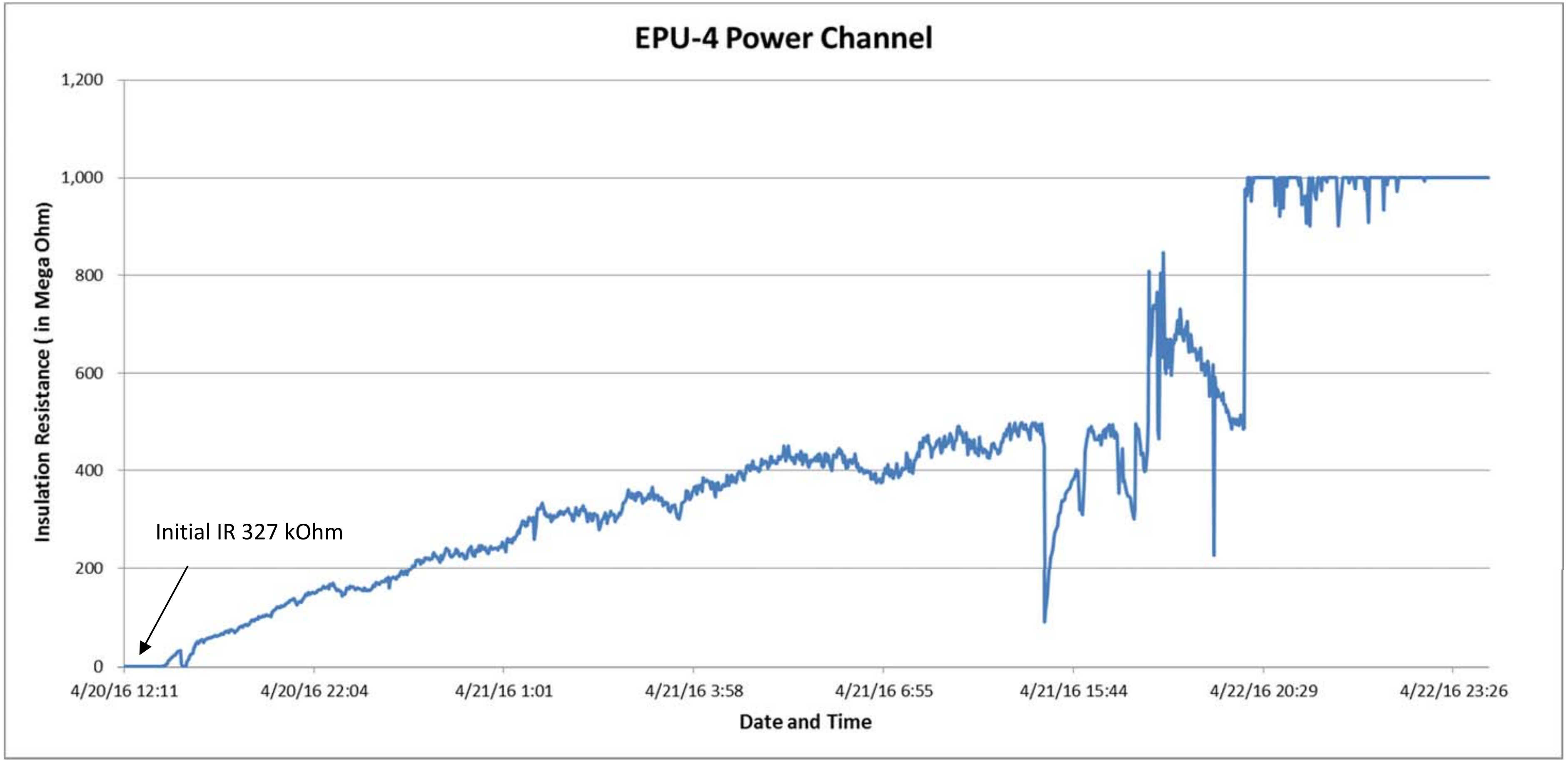

Figure 6 - Remedial process on EPU-4 Power channel.

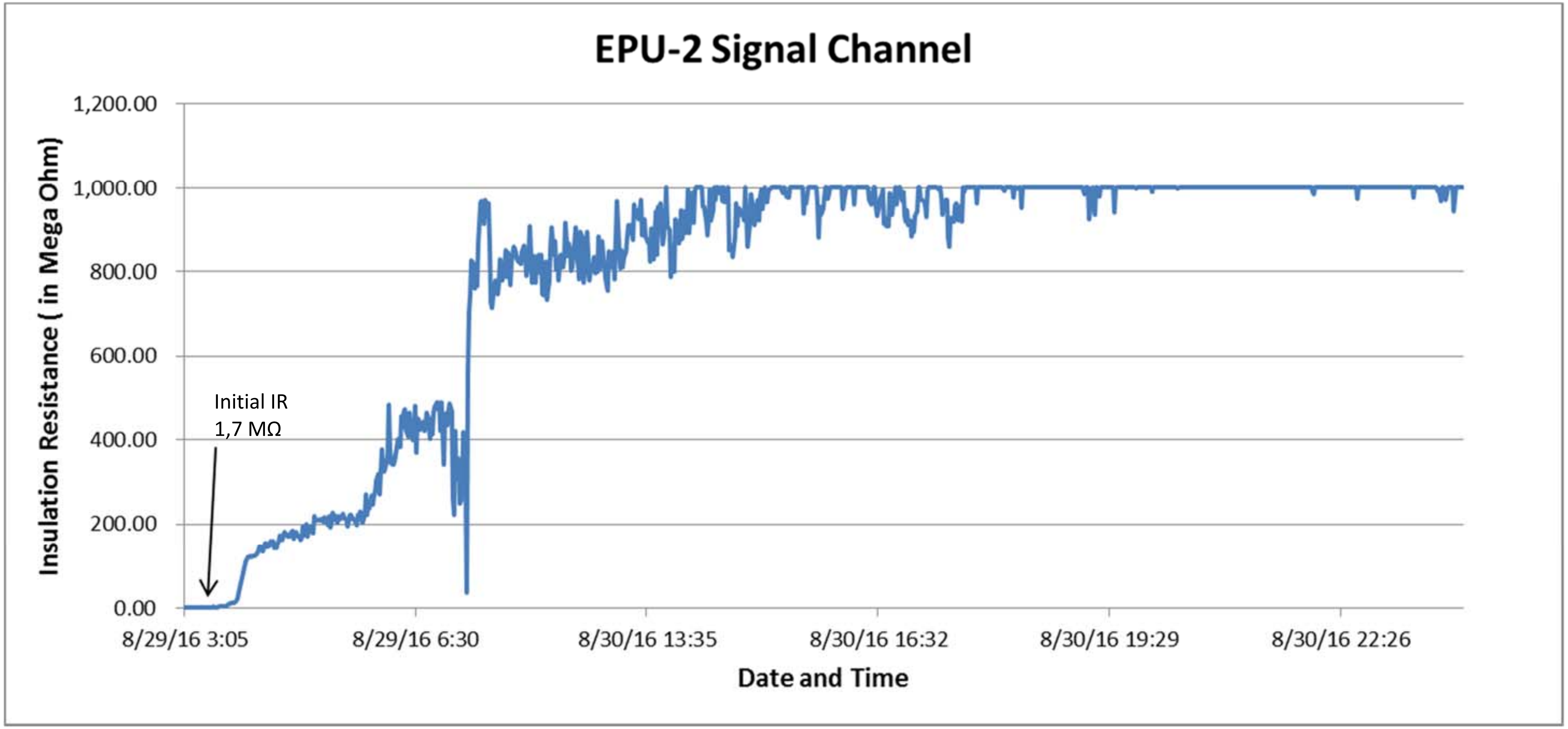

Figure 7 - Remedial process on EPU-2 Signal channel.

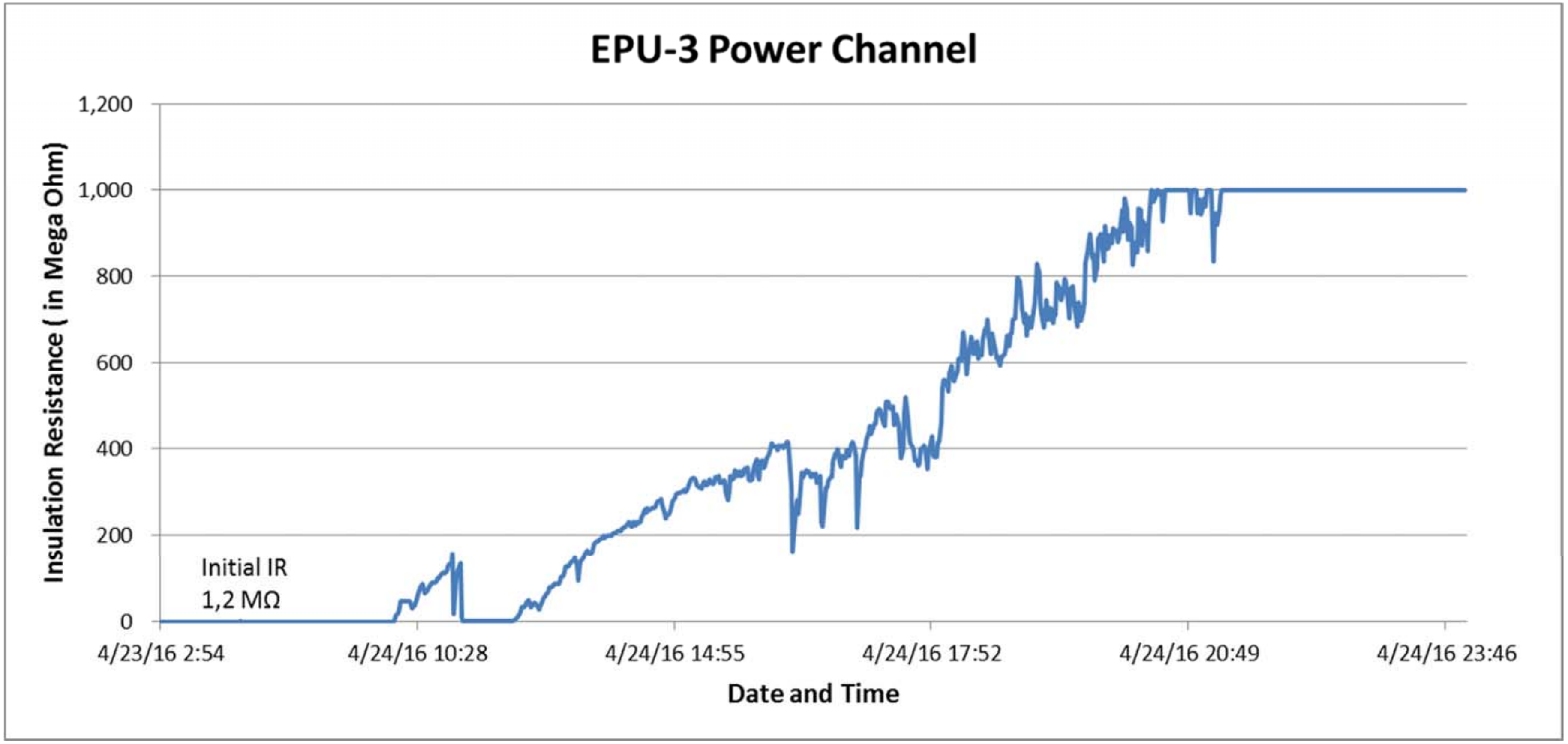

Figure 8 - Remedial process on EPU-3 Power channel.

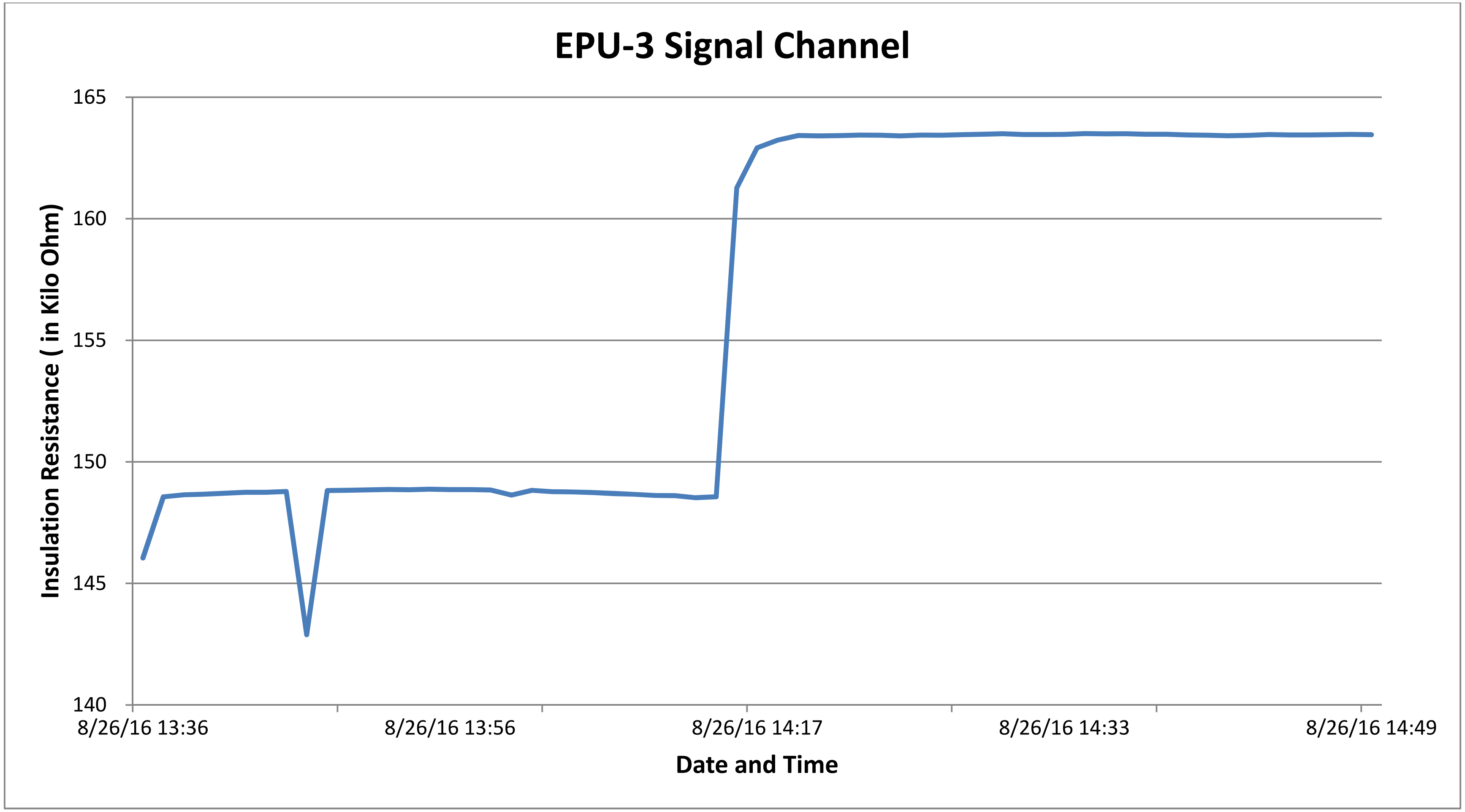

Figure 9 - Remedial process on EPU-3 Signal channel.