# Design and Analysis of High Current Heat Cycles Test Set for Underground Cable

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## *ABSTRACT*

*According to IEC standards, the heating cycle test on cable is required to verify the loading capability. Current is fed to heat up cable for 8 hours and cut off for 16 hours to allow cable to cool down. Tested cable is regarded as heating cycle compliance if conductor temperature still remains within stated limit for at least 2 hours of each heating period. Using PLC control algorithm, the proposed test set showed its effectiveness for cable heating cycle test. Not only acceptable error of 1.45%-1.62% is obtained but also cost of implementation is very low compared to imported one.*

## *KEYWORDS*

Cable, Calibration, Heat cycles test set, Programmable Logic Control (PLC)

## INTRODUCTION

Heat cycles test set is the test equipment used for cables quality evaluation as required by several standards that equipment should be tested to ascertain that it is free from abnormality prior to the actual operation, especially, when the equipment is subjected to temperature change in cyclic manner. Heat cycle feeds current into the tested cable until heat is built up and then stop the feeding current. The cable will let cool itself down naturally in the set time period. The above mentioned action will be repeated in a number of cycles as required by the standard. The cable sample undergone the test will then be subjected to quality evaluation and shall still comply with all the requirements required by the standard.

In order to develop a highly reliable and efficient heat cycles test set that can satisfy the requirement of the standard. The heat cycle test is then desired to possess the following characteristic and ability:

1)Two sets of separate current controller that can be used to control the resulted temperature during on-cycle automatically.
2) Digital data recorder with 6 inputs (extendable to 12) to accommodate as many as temperature and other sensors, communicable via RS232 and RS485. The recorder can upload its contents to flash memory card, have 2 to12 digital outputs for alarms, and a 5.5 inch LCD monitor.
3) Number of cycles and time period can be set.
4) Feedback controllable using constant current or temperature.
5) Fuzzy logic used in regulating current and temperature.
6) 2 selectable operation modes: manual and computer control.

The heat cycles test set under the above mentioned design is believed to have high reliable result and cost effective when compares with the costly foreign product.

## STANDARD FOR CABLE TEST

The cable testing standards that are referred to in this research are 1) IEC 60502-2 (2005) which covers cable rated 1 to 30 kV, The test of MEA's 12/20 kV cable is defined in this standard. 2) IEC 60840 (2011) which covers cable rated over 30 to 150 kV. The test of MEA's 69 and 115 kV cables are defined in this standard. The heat cycles test is part of the test and its procedure is as follows.

### IEC 60502-2 (2005)

Firstly, lay the sample which passed the previous tests, on the floor and heat it by passing current through the conductor till the conductor reaches a steady temperature 5 to 10 °C above its maximum normal operating temperature. For three-core cables, the heating current shall be passed through all conductors. The heating duration shall be at least 8 hours. Secondly, maintained the conductor temperature within the stated temperature limits for at least 2 hours of each heating periods. Finally, let the sample cool down naturally in the air for at least 3 hours until its temperature falls within 10 °C of ambient temperature. Repeat the heating up and cooling down cycle for 20 times. When finish, the sample shall then be subjected to a partial discharge test whether it comply with the requirements [1]. The 12/20 kV XLPE single core cable, copper conductor with copper wire shield is shown in Fig. 1.

### IEC 60840 (2011)

Firstly, apply a voltage of $2U_0$ ($U_0$ is the rated voltage) to the assembly. Secondly, heat the assembly by passing current through the conductor till the conductor reaches a steady temperature 5 to 10 °C above its maximum normal operating temperature. The heating duration shall be at least 8 hours. Record the conductor current during the last 2 hours of each heating period. Thirdly, maintained the conductor temperature within the stated temperature limits for at least 2 hours of each heating periods. Finally, let the sample cool down naturally in the air for at least 16 hours until its temperature falls within 10 °C of ambient temperature. Repeat the heating up and cooling down cycle for 20 times [2]. The 115 kV XLPE single core cable, copper conductor with copper wire shield is shown in Fig. 2.