

Thermovision diagnostics of metal oxide surge arresters

K.L. Chrzan^{1*}

¹Wroclaw University of Technology, Institute I – 7, 50-370 Wroclaw, Poland

*Email: krystian.chrzan@pwr.wroc.pl

Abstract: The surge arresters diagnostics based on infrared temperature measurement was evaluated. The 110 kV metal oxide arresters with porcelain housings with two different varistor columns were used. The first one consisted of new varistor elements and the second one consisted of in field degraded varistors. The internal temperature was measured by means of two Tinytalk probes inserted in the varistor column at the bottom and at the top. The external temperature of the housing was measured by means of infrared camera. The maximum temperature of new varistors has grown about 4°C over the ambient temperature and the external temperature of the housing increased about 1°C only. The temperature of deteriorated varistors increased up to 15°C. Therefore, the arrester housing temperature increased about 4°C.

1 INTRODUCTION

The infrared radiation discovered by William Herschel over 200 years ago finds more and more applications. Today the modern thermovision systems are used in the science and engineering for many purposes, e.g. to evaluate the quality of thermal insulation in civil engineering, to prevent the self firing of coal piles or to find enemy targets in the battle field. The thermal fields measurements of electrical apparatus, overhead power lines and underground cables are very important for their reliable condition based maintenance [1]. The first InSb and later HgCdTe infrared sensors were cooled to very low temperatures in the range of – 70°C or even - 200°C. The new systems offered since 1997 have sensors that work in room temperatures and Peltier's elements as temperature stabilizers. These innovations caused a decrease of cameras dimensions and a rapid price lowering [2].

The accuracy of infrared temperature measurement depends on few factors, the surface state (contamination), distance between camera and object, observation angle, air humidity or CO₂ content in air. However, for diagnostics purposes the precise temperature knowledge is sometimes not necessary, the detection of hot spots with temperature over a given threshold can be sufficient.

Diagnostics of high voltage metal oxide surge arresters is usually carried out every few years. The standard procedures base on the current analysis [3]. The number of medium voltage surge arresters is many

times higher. On the other hand the access to many medium surge arresters mounted close to pole transformers is difficult. Therefore the thermovision diagnostics of medium voltage surge arresters seems to be a promising proposal. In the present paper the infrared diagnostics of 110 kV metal oxide surge arresters with porcelain housing was evaluated.

2 OBJECTS AND EXPERIMENTAL PROCEDURE

ThermaCam PM 575 camera with FPA micro bolometric sensors manufactured by Flir Systems was applied. The system operates in the infrared wave range from 7,5 to 13 mm with the accuracy of 2% and the sensitivity of 0,1 °C. The thermograms are stored in 14 bit files and recorded on PCMCIA card. Three computer programs: ThermaCam Explorer 99, ThermaCam Reporter 99 and ThermaCam Report Viewer can be used for data analysis.

The 110 kV metal oxide surge arresters (MOAs) GXA 96 with porcelain housing were used (fig. 1a). The parameters of surge arrester are given in tab. 1. The measurements were also carried out with the varistor stack without the housing (fig.1b). The stack consists of 42 varistor discs with a diameter of 55 mm. They are grouped into three segments that are separated by two aluminium tins. The varistor stack is situated in the housing centre with a distance of 3 cm to the porcelain.

Tab. 1: Parameters of GXA 96 surge arrester

Maximum continuous operating voltage	77 kV
Rated voltage	96 kV
Residual voltage at the impulse current 8/20 µs of 10 kA	252 kV
Energy absorption ability	7 kJ/ kV of rated voltage

Two different varistor columns were used. The first one consisted of new varistor elements and the second one consisted of in field degraded varistors. The varistors were degraded due to moisture ingress into the surge arrester after over 7 years of service at Glogow test station [4]. The measurement were conducted with the complete MOAs and with the varistor stacks without the housing. Additionally, the varistor temperature inside the housing was measured by means of Tinytalk probes manufactured by Gemini Data Loggers [5]. The

probes were built at the top and at the bottom of varistor stacks (fig. 1b).

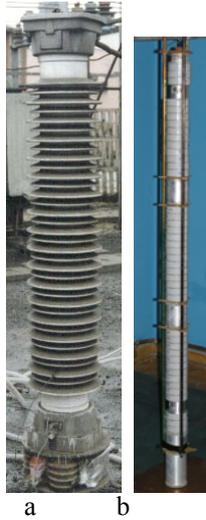


Fig. 1: Test objects,
a – surge arrester, b – varistor column

3 MEASUREMENT RESULTS

The measurement results divided into three parts are presented below.

3.1. Single varistors

Current flowing through a new varistor under dc voltage of 2 kV is very low, about 5 μ A. The varistors inside the surge arrester exposed to moisture ingress in the field were degraded. Only few of them did not change the voltage-current characteristic (varistors number 1, 6, 31, fig. 2). Under the dc voltage of 2 kV the currents of many varistors considerably increased. Four varistors were damaged (current higher than 1 mA).

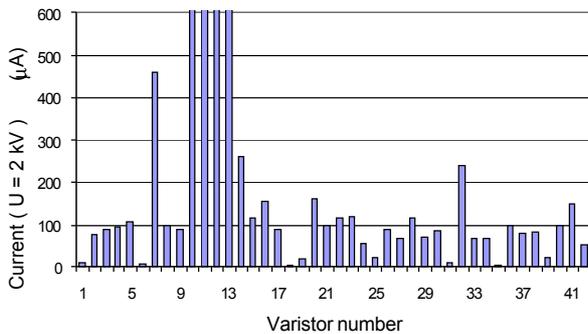


Fig. 2: The varistor currents measured 1 minute after application of dc voltage of 2 kV.

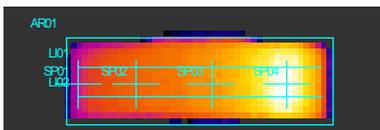


Fig. 3: Thermogram of varistor number 31

Most varistors tested under the dc voltage of 2 kV warmed up uniformly. However, few varistors with distinct hot spots were found (fig. 3). A considerable temperature difference of 11°C was measured for the varistor about number 31 (fig.4).

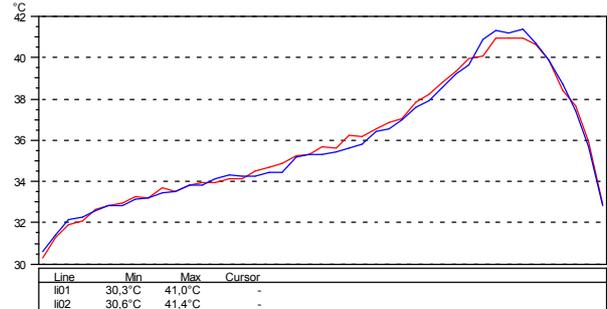


Fig. 4: Temperature distribution along the side wall of varistor with number 31.

3.2. New and aged varistor columns

There is a small temperature gradient along the new varistor column (fig. 5, fig. 6). The maximum temperature at the top is 28°C and the minimum temperature at the bottom is 25°C. The varistor column has the length of 130 cm. The natural temperature gradient measured along the empty porcelain housing represent the bottom line in fig. 5. The temperature at the top of the housing is about 0,7°C higher than at the bottom. The temperature difference of 3°C is mainly caused by the non-uniform voltage distribution along varistor column [6]. In fact, the temperature gradient is a result of power voltage and the natural temperature gradient in a closed space. The temperature of two aluminium separators is about 1,5°C lower than the temperature of neighbouring varistors.

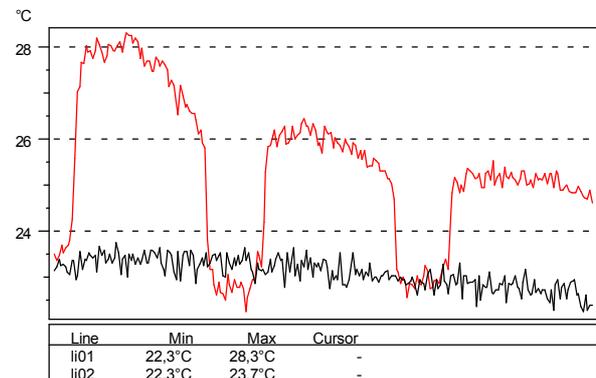


Fig. 5: The temperature along the new varistor column with two aluminium separators (top line) and the temperature along the empty porcelain housing.

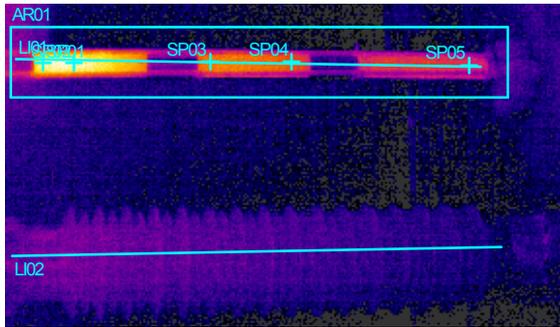


Fig. 6: The thermograms of new varistor column and of empty porcelain housing.

The temperature along the aged varistor column is shown in fig.7. The column has two aluminium separators. Additionally, two Tinytalk probes were inserted at the bottom and at the top. Therefore, the four “temperature valleys” are seen in fig. 7. Compared to the new varistors, higher temperature were measured.

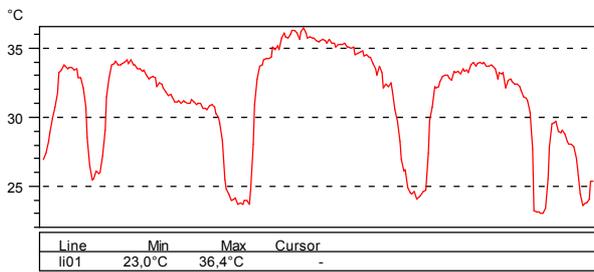


Fig. 7: The temperature along the aged varistor column with two aluminium separators and two Tinytalk probes.

3.3. Complete surge arresters

The upper line in fig. 8 shows the external temperature along the complete arrester housing containing new varistors. The bottom line represents the temperature along the empty housing. The temperature of the arrester housing is only 1°C higher than the temperature of the empty housing.

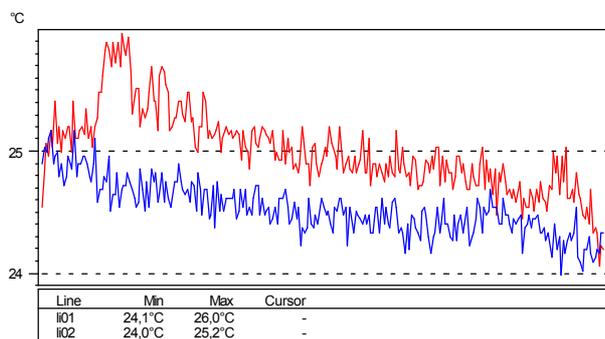


Fig. 8: Temperature along the housing with the new varistors (upper line) and the temperature of the empty housing.

The upper line in fig. 9 shows the external temperature along the complete arrester housing containing aged varistors. The bottom line represents the temperature along the empty housing. The temperature of the arrester housing is 3°C higher than the temperature of the empty housing. Figure 10 shows the thermograms of both housings.

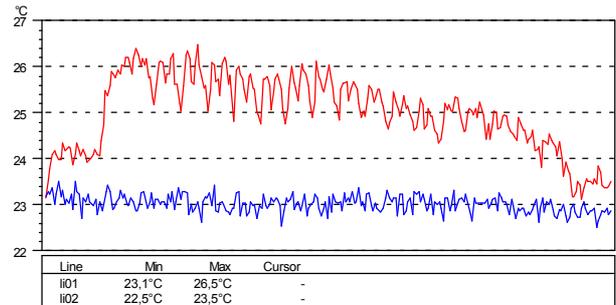


Fig. 9: Temperature along the housing with aged varistors (upper line) and the temperature of the empty housing.

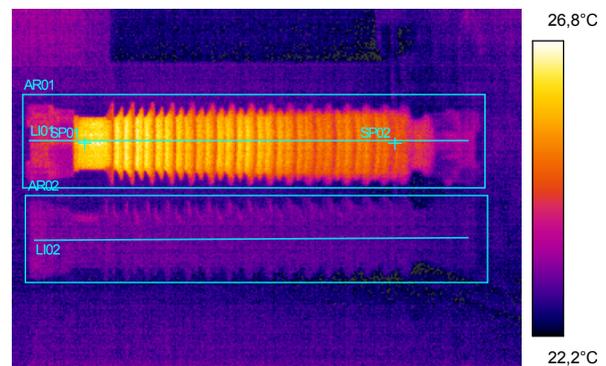


Fig. 10: Thermogram of the arrester housing containing aged varistors and the thermogram of empty housing.

The results of three measurement series of complete arresters containing new or aged varistors under the voltage of 65 kV or 70 kV are given in tab. 2. The temperature of internal elements were measured by means of Tinytalk probes. The tab. 2 gives the values of temperature increase over the ambient measured in steady state conditions 8 or 13 hours after voltage application.

Tab. 2: Temperatures increase of housings and varistors

Temperature increase of (°C)		Test conditions
Varistors	housing	
5	1	70 kV ac, 13 h, new varistors
15	4	70 kV, ac, 8 h, aged varistors
13	3	65 kV, ac, 13 h, aged varistors

4 ON-LINE DIAGNOSTICS

Moisture ingress and partial discharges are responsible for many outages of surge arresters [7]. The thermovision cameras are used for on-line diagnostics of gaped surge arresters since 1980s [8] and later for gapless surge arresters [9], [10]. Thermoscans along the length of an arrester have been found to be an indicator of potential future problems (fig. 11). The field measurements are influenced by the sun radiation, the distance of the test object from the camera, the material emissivity and wind. To avoid the influence of the leakage currents on polluted housings the measurements should be carried out under relative humidity less than 75% [11].

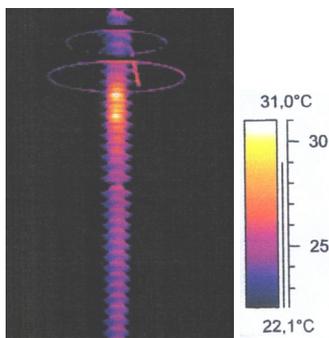


Fig. 11: Thermogram of surge arrester taken in the field

5 CONCLUSIONS

The varistor temperature inside of new 110 kV metal oxide arrester with porcelain housing is 5°C higher than the ambient temperature. The external temperature of the housing increases only 1°C. The aged varistor column with the temperature 15°C higher than the ambient temperature warms the porcelain housing about 4°C.

The measurements in the field are influenced by environmental conditions. This subject should be studied in the future.

6 ACKNOWLEDGMENT

Author thanks Jacek Dolinski, M.Sc. for his valuable help in the elaboration of measurement data

7 REFERENCES

- [1] P.O. Moore: Infrared and thermal testing. Nondestructive testing handbook. American Society for Nondestructive testing 2001
- [2] W. Minkina, Thermovision measurements (in polish), Wydawnictwo Politechniki Czestochowskiej 2004
- [3] K.L. Chrzan, Diagnostics of high voltage metal oxide arresters procedure errors. Int. Symposium on High Voltage Engineering ISH, London 1999, paper 2.385
- [4] K.L. Chrzan, A. Haddad, Behaviour of insulators and surge arresters at Glogow pollution test station. 39th Int. Universities

Power Engineering Conference UPEC, Bristol 2004, Vol. 1, pp. 193-196, Available:

<http://ieeexplore.ieee.org/iel5/9986/32065/01491990.pdf>

- [5] K.L. Chrzan, V. Hinrichsen, Temperature monitoring of metal oxide surge arresters. Int. Conference on Advances in Processin, testing and Applications of Dielectric Materials APTADM, Wroclaw 2001, pp. 183-186
- [6] K.L. Chrzan, J. Gielniak, Voltage distribution along metal oxide surge arresters. 13th Int. Symposium on High Voltage Engineering ISH, Delft 2003, Summary on page 129
- [7] K.L. Chrzan, Influence of moisture and partial discharges on the degradation of high voltage surge arresters. European Trans. on Electrical Power, Vol. 14, 2004, pp. 175-184
- [8] A. Szopa, Energopomiar Elektryka, private information
- [9] F.B. Barbarosa, E. Gomes, Brazilian research centre develops software tools and diagnostic test for network components. Insulator News and Market Report, Vol. 14, NO. 1, 2006, pp. 70-75
- [10] M. Nowak-Gajewska, A. Kania, Thermovision diagnostics of surge arresters, (in Polish), Energetyka, No 12, 2005, pp. 835-838
- [11] K.L. Chrzan, F. Moro, Concentrated discharges and dry bands on polluted outdoor insulators. IEEE Trans. on Power Delivery, vol. 22, No. 1, Jan. 2007, pp. 446-451