International Journal of Advancements in Electronics and Electrical Engineering
Volume 5 : Issue 1 [ISSN 2319 - 7498]
Publication Date : 31 August, 2016

CONDITION ASSESSMENT OF HV ISOLATOR USED IN HIGH VOLTAGE SUBSTATIONS BY THERMAL METHOD

[Viswanatha C , Rakesh K G]

Abstract— **Conservation of Energy and Reduction of Energy losses requires condition monitoring and optimum utilization of substation equipments, in which HV Isolators are important component. Characteristics of thermal, mechanical, electrical environmental are all inter related in an electrical apparatus. So and so with respect to electrical isolator /disconnector which is widely employed in electrical network of power system. The isolator is a device to make or break electrical network at intended locations in the electrical lines. The mechanical operation is essential for proper functioning to connect or disconnect the circuit at planned time with safety and optimal performance. The mechanical operation is governed by proper thermal expansion and contraction of conductors present at fixed assembly and movable assembly. In this aspect it is imperative that isolator/ disconnector functions efficiently both by thermal and mechanical aspects besides electrical insulation co-ordination. In this background, it is interesting to see the thermal performance of movable assembly and fixed assembly of electrical isolator. The conductor position of movable assembly and components of fixed jaws need to have desired thermal properties. With these points in view, studies are undertaken to determine temperature and temperature rise at critical locations such as contact points, incoming terminal, outgoing terminal and other locations. This thermal mapping has been done at thermal equilibrium which is taken as the reference standard for determining temperature rise at various locations of isolator/ disconnector. This paper attempts to understand the thermal nature of disconnector/ isolator and some of the interesting results are discussed in this work.**

Keywords— **Isolator/ disconnector, electrical equipment, temperature, thermal performance, thermal mapping, electrical network.**

I. Introduction

Conservation of Energy and Reduction of Energy losses requires condition monitoring and optimum utilization of substation equipments, in which HV Isolators are important component. Condition assessment of an electrical equipment has been practiced by utilities, industry and final end users for electrical equipment in electrical network since decades. The electrical equipment such as Generators, Transformers, Motors, and others equipments have been assessed by diagnostic techniques and condition assessment methods whereas, in the case of isolator which plays vital function in interruption of bus system in electrical network of substations. The operation of breaking and making contacts will determine the proper function of the isolator along with connected electrical network. The function of disconnector has to be such that it will not come under undesirable incidents of operator as well as electrical equipments. Hence enough care is required to be exercised in monitoring electrical isolator in the substations or in electrical power systems.

The electrical isolators are employed in all substations for connectivity and operation of bus system [1]. Due to the passage of load in the bus and environmental temperature it is likely that the conductors, contacts of the assemblies both movable as well as fixed assembly would experience thermal contraction by cooling and expansion by heating phenomenon. When the conductors in that assembly of disconnectors changes its dimensions, the operation becomes difficult by the process of non-functioning, hard functioning due to mechanical issues. Hence it becomes necessary to monitor the temperature at the critical points of the assembly which in turn will map the nature of movable as well as fixed assembly of disconnector. The condition assessment of electrical isolator is very important to determine healthiness of disconnector. Proper temperatures and rise at rated current will ensure the proper operation of disconnector. This method is called thermal method where in temperatures and temperature rises are mapped at critical locations in the disconnector. Disconnector at normal load would have temperatures along the bus conductor in movable assembly and fixed assembly. These have to be at reasonable/ optimal thermal conditions of temperature/ temperature rise. Therefore, a rated current of disconnector for which it is designed is chosen for the study. Two types of disconnectors are chosen for experiments that is 66 kV isolator and 220 kV isolator with rating 1250A for both. The critical locations for both 66 kV and 220 kV disconnectors are identified and are thermally mapped using thermal method. Temperature and temperature rise at these pre-determined points will ensure thermal condition at main components of disconnector. Therefore, thermal nature at various locations of isolators is assessed by thermal method, where in thermocouples are used to sense the temperatures at various points of disconnector.

The studies are focussed on electrical isolators of rating 66 kV and 220 kV type and employing the methods underlined in IEC specifications. Thermal mapping and understanding thermal behavior of disconnector has been carried out to assess their condition.

Dr. C. Viswanatha
Central Power Research Institute, Bangalore
India

Rakesh K. G
Central Power Research Institute, Bangalore
India

SEEK DIGITAL LIBRARY

II. Experimental Details

The experiments have been conducted on 220 kV isolator and 66 kV isolator. The experimental setup consists of current source, temporary connections and sample under test that is isolators [2, 3]. The current source used this of rating 5000A and 16V capacity and can deliver the rated current continuously over a period of 12 hours when required. The current measurement are made with help of three current transformers mounted on each phase of current source. The ratio of current transformers are 5000/5A and they have required accuracy of ±0.5% and able to measure the current with a precision of 0.01A. From current source copper flexible braids of adequate cross-section are used to connect the current source and temporary connections of the sample. The flexible conductors are pure copper and connects to the temporary connections and delivers required amount of current to the sample. From copper braids temporary connections are connected. The length and cross-section of temporary connections chosen are as per specification of International Electrotechnical Commission so that the temporary connections which are supposed to protect both sample and current source in case of failure of the sample during the experiment. Also temporary connections which are of copper busbars will deliver required amount of current without transferring neither excessive heat to the sample nor excessive dissipation of heat to the surrounding that is they enable us to supply right quantity of heat to the sample without much energy losses. The sample employed are disconnector isolator are 66 kV and above upto 220 kV, for this 66 kV, 1250A isolator with central break arrangement is employed. The arrangement is shown in the Fig. 1.

Fig. 1 Experimental arrangement for 66 kV Isolator with central break system

For 66 kV isolator Fig. 2 and Fig. 3 shows the movable assembly and fixed assembly of the isolator. The movable assembly consists of copper tube of thickness 4.5 mm and length of 1.2 meters. The ends of copper tube are flatten both the ends and are coated with micron thickness silver material which provides intimate contact with fixed assembly of isolator. Fig. 4 describes the fixed assembly with silver coating.

Fig. 2 A View of Movable assembly for 66 kV Isolator

Fig. 3 A View of Fixed assembly for 66 kV Isolator

The 220 kV and 1250A isolator is used for the experimental studies. The moving contact on consists of copper tube of thickness 9mm with ends silver plated. The length of silver plating is about 150mm which establishes good contact with fixed contact jaws. The jaws of fixed contact are also silver plated. The length of moving contact arm is 2.5 meters both moving and fixed contact are supported in isolated for each pole by a stack of insulators which are of height approximately 2.5 meters above the ground. Fig. 5, Fig. 6 and Fig. 7 shows the details of isolators in closed condition, moving contact assembly and fixed contact assembly respectively. Thermocouples are used to measure the temperatures at predefined points of

SEEK DIGITAL LIBRARY

isolator such as moving contact, fixed contact, incoming and outgoing terminals of isolator and moving contact rod.

Fig. 4 Experimental arrangement for 220 kV Isolator with central break system

Fig. 5 A View of Movable assembly for 220 kV Isolator

Fig. 6 A View of Fixed assembly for 220 kV Isolator

These points are so chosen that complete thermal mapping can be done to find thermal status of isolator. Data loggers and computer employ to collect record and compile the experimental data for all the locations of the sample studied for 220 kV and 66 kV isolator. The general arrangement of the experimental setup is shown in the Fig. 1. The data obtained from these experiments on isolator/ disconnector [4, 5] is presented in the results and analysis of this work.

III. Results & Analysis

The results obtained from experiment conducted based on IEC specifications on 66 kV and 220 kV disconnector/ isolator are detailed below:

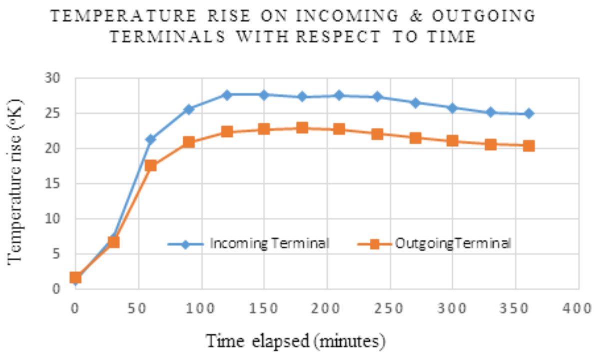

Fig. 7 Variation of Temperature rise with time elapsed for Incoming & Outgoing terminals of 66 kV isolator

The same characteristics both for temperature and temperature rise for 220 kV isolators have been obtained. However, the temperature rise characteristics of 66 kV and 220 kV disconnectors are presented in the following paragraph.

The characteristics of temperature rise with time for terminals of both incoming and outgoing are depicted in Fig. 7. Initially temperature rise rises steeply upto 150 minutes and then gradual variation at steady state obtained at the interval of 300 minutes. Incoming terminal shows higher magnitude than outgoing, temperature rise values are 25°K and 20°K for incoming and outgoing terminals respectively.

Fig. 8 presents temperature rise variation with time for fixed contact of 66 kV isolator. Both incoming and outgoing fixed contacts shows the same trend in temperature rise, the values being 37°K and 31°K for incoming and outgoing fixed contacts. Here it is noted that the fixed contacts are silver coated over length of 150 mm with thickness in microns.

SEEK DIGITAL LIBRARY

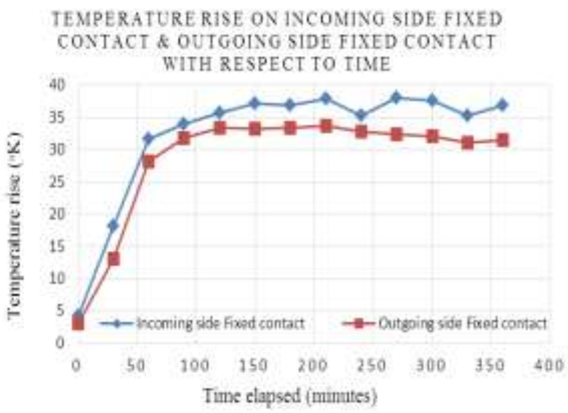

Fig. 8 Variation of Temperature rise with time for Incoming & Outgoing side fixed contact of 66 kV isolator

Fig. 9 shows temperature rise characteristics for moving contact of 66 kV isolator. Here incoming is more than outgoing in temperature rise magnitude. Initially temperature rise rises steeply upto 60 minutes, there after the increase is gradual. The incoming and outgoing temperature rise for moving contacts are 46°K and 39°K, the difference in magnitude is 5°K. Although the variation of temperature rise with time is same for moving contacts, which are again silver plated.

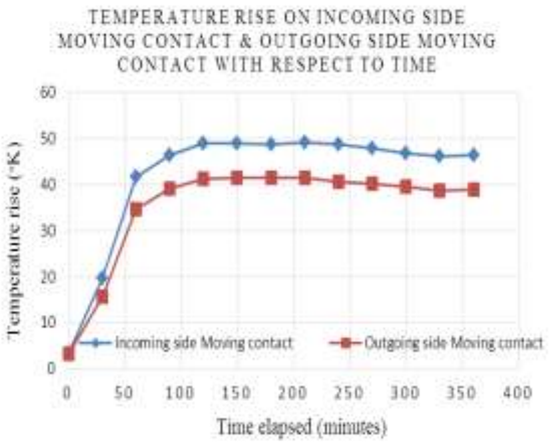

Fig. 9 Variation of Temperature rise with time for Incoming & Outgoing side moving contact of 66 kV isolator

The resistance measurement measured before and after experiment of temperature rise shows variation to the extent of 11% as shown in Table Ia.

TABLE I a.

Sl. No.	Measurement of change of Resistance for 66 kV Isolator		
	Before Temperature Experiment R_0 ***(μΩ)***	***After Temperature Experiment*** R_h ***(μΩ)***	***Change in Resistance*** $\Delta R = \frac{R_h - R_0}{R_0}$ ***x100 (%)***
1	78.7	87.4	11.05

The results of temperature and temperature rise with magnitudes are mentioned in Table Ib for 66 kV isolator with different components. These values can be seen from Table Ib and based on that material characteristics the temperature rise values and experimental values are in with in the limits of requirements of IEC specifications [2].

TABLE I b.

Temperature & Temperature rise at different components of 66 kV Isolator			
Particulars	***Temperature (°K)***	***Temperature rise (°K)***	***Temperature rise values as per IEC (°K)***
Incoming Terminal	58.3	25.0	50 (Bare)
Outgoing Terminal	53.8	20.5	50 (Bare)
Incoming side Fixed contact	70.1	36.8	65 (Silver)
Outgoing side Fixed contact	64.7	31.4	65 (Silver)
Incoming side Moving contact	79.6	46.3	65 (Silver)
Outgoing side Moving contact	72.2	38.9	65 (Silver)
Ambient	33.3	---	40°C

The temperature rise characteristics for 220 kV isolator are depicted in Fig. 10, Fig. 11, and Fig. 12 respectively for terminals, fixed contacts, moving contacts. The characteristics of 220 kV isolator for incoming and outgoing terminals show identical trend in the variation of temperature rise with time as shown in Fig. 10.

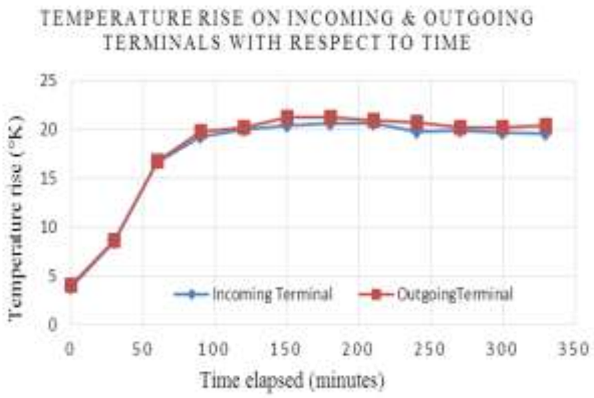

Fig. 10 Variation of Temperature rise with time elapsed for Incoming & Outgoing terminals of 220 kV Isolator

Temperature and temperature rise are linear in characteristics upto 90 minutes and then there is a gradual variation of temperature rise with respect to time. At steady state the difference of temperature rise between incoming and outgoing terminal is the same magnitudes being 20°K.

Fig. 11 presents temperature rise with time elapsed for fixed contacts of 220 kV isolator. As in the previous case the temperature rise steep has increase upto 90 minutes then

SEEK DIGITAL LIBRARY

incremental change at steady state for incoming is 25°K and outgoing is 29°K of temperature rise. The characteristic of temperature and temperature rise is the same.

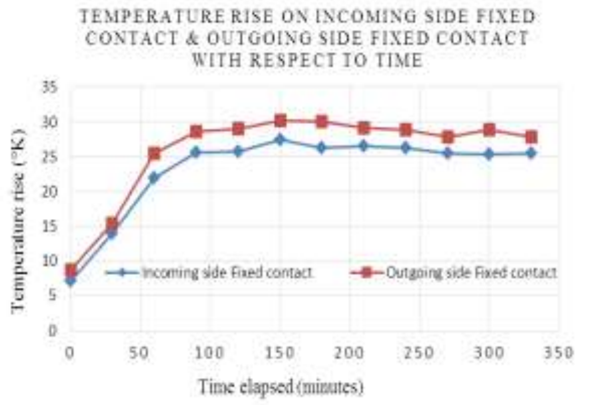

Fig. 11 Variation of Temperature rise with time for Incoming & Outgoing contacts of fixed assembly of 220 kV isolator

Fig. 12 depicts variation of temperature rise with time for moving contact. Initial linear rise of temperature rise is same as Fig. 11 upto 90 minutes and that there is a gradual variation at steady state incoming at 31°K and outgoing is 34°K respectively.

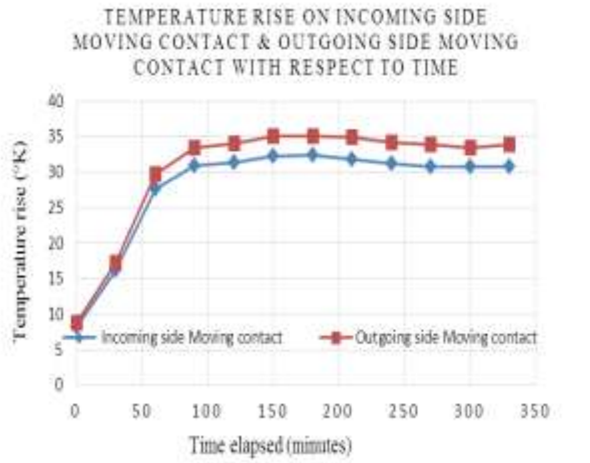

Fig. 12 Variation of Temperature rise with duration for Incoming & Outgoing side Moving Contact of 220 kV Isolator

The resistance before the experiment of temperature rise and after the experiment shows the variation 4.5% of Table IIa.

TABLE II a.

Sl. No.	Measurement of change of Resistance for 220 kV Isolator		
	Before Temperature Experiment $R_{0\,(\mu\Omega)}$	*After Temperature Experiment $R_{h\,(\mu\Omega)}$*	*Change in Resistance $\Delta R = \frac{R_h - R_0}{R_0} x100$ (%)*
1	107.8	112.7	4.54

Table IIb describes the magnitudes of each component of 220 kV isolator and it also shows the values required for temperature rise for different components based on material and type of component [2, 3].

TABLE II b.

Temperature & Temperature rise at different components of 220 kV Isolator			
Particulars	*Temperature (°K)*	*Temperature rise (°K)*	*Temperature rise values as per IEC (°K)*
Incoming Terminal	52.3	19.6	50 (Bare)
Outgoing Terminal	53.1	20.4	50 (Bare)
Incoming side Fixed contact	58.2	25.5	65 (Silver)
Outgoing side Fixed contact	60.6	27.9	65 (Silver)
Incoming side Moving contact	63.5	30.8	65 (Silver)
Outgoing side Moving contact	66.6	33.9	65 (Silver)
Ambient	32.7	---	40°C

From that Table IIb, the type of 220 kV isolator performs within the specified limits of temperature rise as can be seen from Table IIb.

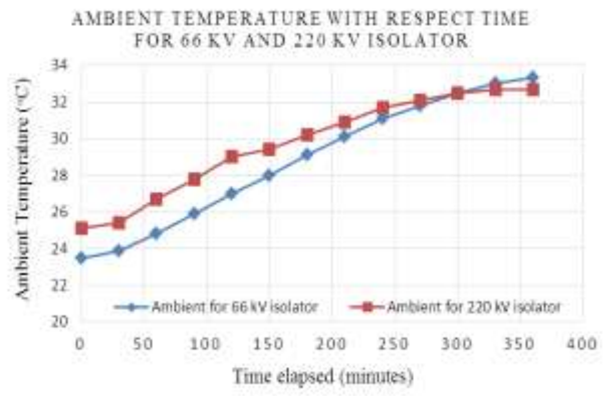

Fig. 13 Variation of Ambient Temperature with period during current energisation of sample.

From Fig. 13 the ambient temperature controls the experimental conditions hence the ambient variations of temperatures has also been studied throughout the experiment. In the case of isolator/ disconnector the variation of temperature and temperature rise have been analysed and the characteristics variation of temperature and temperature rise seen to behave same trend during the experiment.

In all terminals, fixed contacts and moving contacts of isolators shows steep rise of temperature rise upto 100 minutes and the rate of increase of temperature rise gradually reduces from the temperature rise characteristics

SEEK DIGITAL LIBRARY

of isolator. The steady state value of temperature rise are useful to determine the thermal condition of disconnector. With reference to IEC standard this limits along with resistance measurement can be employed as a reference to determine thermal condition of disconnector/ isolator by this thermal method.

IV. Conclusions

Based on studies conducted on isolators the following inferences are obtained:

- For proper functioning of disconnectors/ isolators of HV rating not only mechanical aspects but also thermal performance is needed to ensure safety and reliability of electrical system.
- The thermal performance of HV isolators can be carried out by using temperature mapping at critical points of the equipment.
- Proper temperature limits at contact zones of movable assembly and fixed assembly will determine healthiness of HV isolators.

Acknowledgement

The Authors are grateful to management of Central Power Research Institute Bangalore for the kind permission to publish this paper in this conference. Also the authors are thankful to HRT lab engineers Kumari. M. Satya Bhavani, Kumari. S. V. Sindhu and Kumari. R. Vishnuvi.

References

[1] R K Mishra and Debasis Das, Power transmission and distribution, National Power Training Institute, Nagpur, Public printing service, New Delhi, pp. 9 - 10, 162, April 2012.
[2] International Electrotechnical Commission 62271 – Part 102: Alternating Current Disconnectors and earthing switches, Geneva, Switzerland, pp. 147, 2013.
[3] International Electrotechnical Commission 60694: Common specifications for High Voltage switchgear and controlgear standards, Geneva, Switzerland, pp. 65 – 69, 2001.
[4] Indian Standard 9921 – Part 2: Alternating Current Disconnectors (Isolators) and earthing switches for voltages above 1000 V, Bureau of Indian Standards, New Delhi, pp. 10, 1982.
[5] Indian Standard 9921 – Part 4: Alternating Current Disconnectors (Isolators) and earthing switches for voltages above 1000 V, Bureau of Indian Standards, New Delhi, pp. 18 - 20, 1999.

About Author (s):

Viswanatha C
has obtained M.Sc.(Engg.) from IISC, Bangalore and Ph.D. from Bangalore University. He has been working in CPRI for the past 30 years in various capacities in the area of electrical engineering. Currently he is working as Joint Director in DCCD. He has published several national and international papers at various conferences. His areas of interest are electric insulation engineering, conductors, dielectric, renewable energy and associated areas.

Rakesh K G
completed Degree in Electrical and Electronics Engineering in 2013 from BMS Evening Collage of Engineering, Bangalore - VTU, Karnataka. Have 5 years (from 2005-2010) of experience in Electrical industry in Production & Quality Assurance of Oil & Winding Temperature indicator used in transformers. Joined CPRI on 8th February 2010 & experienced in testing of Transformers, LT/HT Panels, Isolators, Instrument transformers, Busducts, HV/EHV SF6 Breakers etc.

SEEK DIGITAL LIBRARY