

**KOTMALE POWER STATION**  
**CEYLON ELECTRICITY BOARD**



**REPORT ON UNIT 02 STATOR WINDING REPAIR**

Prepared By:	Checked By:	August 2011
Nizam Salih Electrical Engineer (Maintenance) Kotmale Power Station	T.M.S.K Tillekaratne Chief Engineer Kotmale Power Station	Date of fault occurred: June 19, 2011

## Abbreviations

AMHE	Asset Management Hydro Electrical
C	Capacitance
CT	Current Transformer
DAQ	Data Acquisition System
IR	Insulation Resistance
PH	Power House
PI	Polarization Index
PT	Potential Transformer
SY	Switchyard
t/f	Transformer

## Contents

1. Incident.....	4
2. Action Taken .....	4
3. Identification of Earth Fault Location in the stator .....	5
4. Rotor Tests .....	7
4.1 Rotor Pole Impedance Drop Test.....	7
4.2 Rotor Pole IR Measurement .....	8
4.3 Rotor Pole Resistance .....	9
4 Temporary Insulation Stator Tests.....	10
5.1 Stator Insulation Test after repair.....	11
5.2 Stator Resistance Measurement after repair.....	12
5 Conclusion .....	13
6 Recommendations .....	13

## List of Tables

Table 2.1 IR Values taken after the fault. ....	4
Table 3.1 IR Values taken after clearing the earth fault. ....	5
Table 4.1 Rotor Pole Impedance Drop Pre/Post (Winding temperature - 42.2 °C).....	7
Table 4.2 Rotor Pole IR Test .....	8
Table 4.3 Rotor Pole Winding Resistance .....	9
Table 5.1.1 Stator IR values taken from neutral end without cable.....	11
Table 5.1.2 Stator IR values taken from Neutral end with cable .....	11
Table 5.2.1 Stator winding resistance measured after clearing the fault .....	12
Table 5.2.2 Commissioning values of stator resistance (1985).....	12

## List of Figures

Fig. 3.1 Slot 130 where insulation was removed between conductor and Slot walls for a depth of about 3cm.....	6
Fig. 3.2 The status of the slot after applying the insulation and slot filling.....	10

## 1. Incident

Unit No. 2 machine tripped on 19/06/2011 at 15.40 hrs. with the following important indications in PH and SY DAQs. (Other indications are not given here)

- U02 Neutral Point Voltage Relay +RAB3.D09.101.307 Operated (SY)
- U02 Stator Earth Fault Protection Trip
- Voltage t/f 13.8 KV side PT fuse failure +RAB.2.D09.107.301

## 2. Action Taken

On inspection it was found that there is an earth fault in the W phase 1W1 circuit. The IR value was zero in this circuit. There was no problem in U, V phases and 2W1 circuit of W Phase. Table 2.1 shows the Insulation Resistance readings taken after the fault. The IR value of W Phase was almost zero.

Table 2.1 IR Values taken after the fault.

Date: 19/06/2011	Time: 19:50 hrs		Instrument used: BBC, West German DIN 41571 Megger	
Time / (min)	IR Readings / (MΩ)			Applied Voltage /V DC
	U Phase / (MΩ)	V Phase /(MΩ)	W Phase /(MΩ)	
1	450	400	0.5	5000
2	1400	1400	-	5000
3	2200	2200	-	5000

After removing the neutral point and line connections of the Phases, it was found that 1W1 circuit of W phase shows zero IR value.

### 3. Identification of Earth Fault Location in the stator

A high voltage test was conducted by Colombo City cable testing unit. Flashes inside the stator could be heard and observed when the applied voltage was 4kV dc. On further inspection and testing it was confirmed that the arching was taking place at the bottom of conductor 130 (slot 130) of the stator.

It was suspected that the arching at slot 130 to be between conductor insulation and the walls of the slot at the stator bottom not far from the slot wall end where free coil parts coming out of the iron core.

Therefore the insulation between the conductor and walls of the slot was partly removed to get space to insert new insulation material. This was a very tedious job and took almost two continuous days to remove the insulation up to about 3cm depth.

After the continued removing of the insulation around the slot 130 conductor for about 3cm the earth fault disappeared. This happened on 25<sup>th</sup> June, 2011 after 06 days of the failure.

Table 3.1 shows the Insulation Resistance readings taken after clearing the fault. No insulation was applied at this time of taking readings. Fig. 3.1 shows the area of slot 130 where the work was carried out.

Table 3.1 IR Values taken after clearing the earth fault.

Instrument used: Transformer ohm meter, Model No. 830280 Brand: Megger [AMHE]			Date: 25/06/2011 Time: 15:00 hrs	
Time / (min)	IR Readings / (MΩ)			Applied Voltage /V DC
	1W1 Circuit / (GΩ)	2W1 Circuit / (GΩ)	W Phase / (GΩ)	
1	0.730	-	-	500
1		4.09	1.92	1000
10	1.34		-	1000
	PI = 1.85 C= 206 nF	C=206nF	C=413nF	

Fig. 3.1 Slot 130 where insulation was removed between conductor and Slot walls for a depth of about 3cm.



## 4. Rotor Tests

The following tests were carried out for the rotor poles.

- a) Rotor Pole Impedance Drop Test
- b) Rotor Pole IR Test
- c) Rotor Pole Resistance

### 4.1 Rotor Pole Impedance Drop Test

Table 4.1 shows the rotor pole impedance drop tests carried out just after the fault and after clearing the fault. 200V and 224V, 50Hz supply was connected to the rotor pole end and voltage drop of each pole was measured.

Table 4.1 Rotor Pole Impedance Drop Pre/Post (Winding temperature - 42.2 °C)

Pole No	Voltage /V	Current /A	Pole VOLTAGE drop		Current /A	Voltage /V	Pole VOLTAGE drop	
			21/06/2011	25/06/2011			21/06/2011	25/06/2011
1	200	1.5	12.69	12.6	1.7	224	14.14	14.08
2	200	1.5	12.72	12.68	1.7	224	14.26	14.2
3	200	1.5	12.3	12.27	1.7	224	13.75	13.73
4	200	1.5	12.66	12.82	1.7	224	14.22	14.36
5	200	1.5	12.4	12.59	1.7	224	13.88	14.09
6	200	1.5	12.62	12.45	1.7	224	14.17	13.94
7	200	1.5	12.79	12.47	1.7	224	13.91	13.96
8	200	1.5	12.55	12.7	1.7	224	14.02	14.23
9	200	1.5	12.36	12.51	1.7	224	13.78	14.01
10	200	1.5	12.53	12.5	1.7	224	14.00	14.01
11	200	1.5	12.27	12.31	1.7	224	13.67	13.7
12	200	1.5	12.32	12.69	1.7	224	14.18	14.23
13	200	1.5	12.32	12.51	1.7	224	13.73	14.01
14	200	1.5	12.51	12.5	1.7	224	13.96	14
15	200	1.5	12.52	12.45	1.7	224	14.02	13.99
16	200	1.5	12.83	12.5	1.7	224	14.38	14.44
max. value			12.83	12.82			14.38	14.44
min. value			12.27	12.27			13.67	13.7
average			12.52	12.53			14.00	14.06
<b>Index</b>			<b>4.47</b>	<b>4.39</b>			<b>5.07</b>	<b>5.26</b>

## 4.2 Rotor Pole IR Measurement

Table 4.2 shows the measured IR value of the rotor. The applied voltage was 500V DC.

Table 4.2 Rotor Pole IR Test

Instrument: BBC, West German, DIN 41571 Megger Voltage applied: 500V DC		Date: 25/06/2011
		Time: 17:50 hrs
Time / (min)	<b>Pole IR Readings / (M<math>\Omega</math>)</b>	Applied Voltage /V DC
1	300	500



### 4.3 Rotor Pole Resistance

Table 4.3 shows the measured Rotor Pole Resistance values. According to U02 commissioning report (1985) the resistance in rotor winding was 108.5 mΩ at 28°C. The total resistance measured on 26/06/2011 was 109.7 mΩ

Table 4.3 Rotor Pole Winding Resistance

Instrument used: Transformer ohm meter, Model No. 830280 Brand: Megger [AMHE]	Date: 26/06/2011
	Time: 15:00 hrs
Pole No.	Resistance / (mΩ)
1	6.86
2	6.87
3	6.87
4	6.88
5	6.87
6	6.86
7	6.87
8	6.87
9	6.87
10	6.87
11	6.88
12	6.87
13	6.87
14	6.87
15	6.87
16	6.87

## 4 Temporary Insulation Stator Tests

The earth fault at this time was suspected to be a loosen stator iron core lamination damaging the conductor insulation and thus making the conductor to be earthed. As a temporary measure AMHE staff used a resin and hardener mixed to glass powder to insulate between conductor and the slot walls where the insulation was removed. This was done on 26.06.2011.

Fig. 3.2 shows the status of the slot 130 bottom area after applying the insulation. Here two numbers T=0.5 slot fillings were used with the above insulation as can be seen in fig. 3.2

Fig. 3.2 The status of the slot after applying the insulation and slot filling



## 5.1 Stator Insulation Test after repair

IR readings were taken after 24 hrs. of applying this insulation.

Table 5.1.1 shows the IR values of the stator taken from neutral end without cable whereas Table 5.1.2 shows the IR values of the stator taken from neutral end with cable. The applied voltage was limited to 1 KV to measure the IR between 1W1 circuit and earth. This circuit was not subjected test voltages above 1kV.

Table 5.1.1 Stator IR values taken from neutral end without cable

Instrument: 10KV digital Insulation Tester, Model No. MIT 1020/2 , Brand: Megger, Voltage applied: 1000V [AMHE]	
Time /(min)	IR /(GΩ)
1	0.86
2	1.42
3	1.91
4	2.27
5	2.60
6	2.90
7	3.06
8	3.41
9	3.53
10	3.64
PI =4.23	
C = 1.23 μF	

Table 5.1.2 Stator IR values taken from Neutral end with cable

Instrument: 10KV digital Insulation Tester, Model No. MIT 1020/2 , Brand: Megger, Voltage applied: 1000V [AMHE]	
Time /(min)	IR /(GΩ)
1	0.706
2	1.3
3	1.63
4	1.93
5	2.21
6	2.27
7	2.48
8	2.71
9	2.73
10	2.90
PI = 3.72	
C = 3.55 μF	

## 5.2 Stator Resistance Measurement after repair

Table 5.2.1 shows the Stator winding test values. The commissioning values (1985) of stator resistance are given in table 5.2.2

Table 5.2.1 Stator winding resistance measured after clearing the fault

Instrument used: Transformer ohm meter, Model No. 830280 Brand: Megger [AMHE]	
Phase Circuit	Resistance / mΩ
1W1	9.3
2W1	9.5
1V1	9.3
2V1	9.5
1U1	9.4
2U1	9.4

Table 5.2.2 Commissioning values of stator resistance (1985)

Phase	Resistance / mΩ at 15°C
R	4.19
Y	4.19
B	4.19

## **5 Conclusion**

The machine was started on 28.06.2011. It has since being running without any problems.

## **6 Recommendations**

The insulation applied to the conductor in slot 130 was a temporary measure. Stator windings were not tested for voltages higher than 1 KV. It has been 25 years since the generator is in service. A complete rehabilitation of the U2 generator is recommended.