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Study and Analysis of Insulator used in Substation

Hnin Yu Lwin, U Hla Myo Htay

Lecturer, Electrical Power Department, Technological University, Mandalay, Myanmar

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ABSTRACT

The main purpose of this paper was that to compare design of post insulators and their performance of different post insulator the relative performance of different insulator materials used in substation as lightning arrester, current transformer and potential transformer. Insulators are used to protect from the dangerous effects of electricity flowing through conductors. This paper presents the role of post insulators are key components of most electrical substation equipment and their features and ability are changing due to the difference type of electrical power incoming line and pollution level of their rating. The peak voltage rating of each arrester at 132 kV is 118.6 kV, creepage distance is 2904 mm and maximum continuous operating voltage is 94.88 kV. The creepage distance of current transformer and potential transformer at 132 kV are 4065 mm. Therefore, in this paper, the effects of material changes, rating changes, pollution level changes of lightning arrester, current transformer and potential transformer in substation are described. Then, analysis and discussion of lightning arrester and instrument transformer are described in this paper.

KEYWORDS: *lightning arrester, current transformer, potential transformer, substation*

1. INTRODUCTION

Power system includes three parts such as generation, transmission and distribution. An electrical distribution system is all of that part of an electric power system between bulk power source or sources and the consumer's service switches. All types of electric utility customers such as residential, commercial, institutional and industrial are heavily dependent on the availability of electric power. Distribution substation is a combination of switching, controlling and voltage step down equipment arranged to reduce sub-transmission voltage to primary distribution voltage for residential, farm, commercial and industrial loads. Electricity distribution is the final stage in the delivery of electricity to end users. Electrical power systems utilize several voltage levels using power transformers to transfer voltages and connect parts of the power system with different voltage levels. Electric power distribution systems have many unique aspects and requirements.

Distribution system can be divided into six parts, namely, sub-transmission circuits, distribution substation, distribution or primary feeders, distribution transformer, secondary circuits or secondary feeders and consumer's service connections and meter. The distribution plant occupies and important place in any electric power system. Briefly, it function is to take electric from the bulk power source or sources and distribute or deliver it to the consumer's. The effectiveness with a distribution system fulfills this function is measured in terms of voltage regulation, service continuity flexibility, efficiency and cost. These are completely depends upon sub-station design. The sub-transmission circuits extend from the bulk power sources to the various distribution sub-stations located in the local area. They may be radial circuits connected to a bulk power source at only one end or load and ring circuits connected to one or more bulk power sources at both ends. The sub-transmission over head open wire conductions carried on poles, or some combination of them. The sub-transmission voltage is usually between 11 kV and 33 kV.

The distribution substation must be required measuring and protected system to prevent equipment and circuits, hazards to the public and utility personal, and to maintain a high level of service by preventing power interruption. An electrical insulator is a material whose internal electric charges do not flow freely, and which therefore does not conduct an electric current, under the influence of an electric field. Insulators are used in electrical equipment to support and separate electrical conductors without allowing current through themselves. Insulators are the integral part of the power system. Among them polymeric insulators are essential for the better performance. There are many shapes and types of insulators used in power system transmission with different densities, tensile strengths and performing properties with the aim to withstand the worst conditions such as surge during lightning and switching operations which will voltage to spike. Reliability of the insulator is the most important property that must take into consideration whether it is a polymeric (composite) insulator or ceramic insulator. The good insulator should offer optimum electrical and mechanical strengths.

2. LITERATURE REVIEW

The transition from transmission to distribution happens in a power substation, which has the following functions:

1. Circuit breakers and switches enable the substation to be disconnected from the transmission grid or for distribution lines to be disconnected.
2. Transformers step down transmission voltages, 35 kV or more, down to primary distribution voltages. These are medium voltage circuits, usually 600-35,000 V.
3. From the transformer, power goes to the bus-bar that can split the distribution power off in multiple directions. The bus distributes power to distribution lines, which fan out to customers.

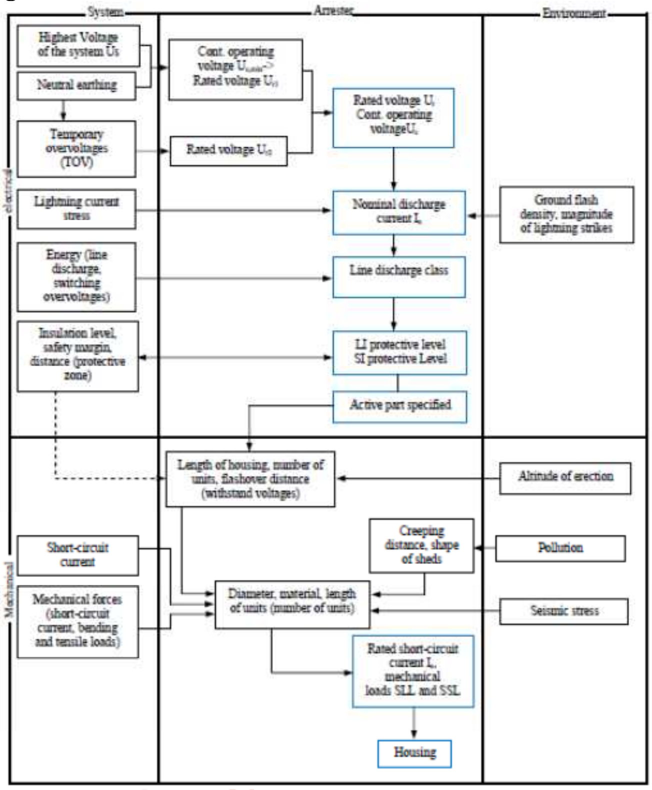
Urban distribution is mainly underground, sometimes in common utility ducts. Rural distribution is mostly above ground with utility poles, and suburban distribution is a mix. Closer to the customer, a distribution transformer steps the primary distribution power down to a low-voltage secondary circuit, usually 240 volts in the Myanmar for residential customers. The power comes to the customer via a service drop and an electricity meter.

The main components of electrical distribution substation are:
1. Lightning Arrester
2. Capacitive Voltage Transformer
3. Disconnecting Switch With Earth
4. Gas Circuit Breaker
5. Disconnecting Switch
6. Current Transformer
7. Potential Transformer
8. Power Transformer

3. Sizing of Lightning Arrester Rating

Choose of Surge Arresters are required by two paths as followings,
1. Electrical characteristics and
2. Mechanical characteristics.

Choose of electrical characteristics and mechanical characteristics are calculated as step by step as following figure.



Performance of Choosing Arrester

4. RESULT DATA OF LIGHTNING ARRESTER, CURRENT TRANSFORMER AND POTENTIAL TRANSFORMER

Table 4.1 IEC Standard of Lightning Arrester

NO.	DESCRIPTION	TECHNICAL PARAMETERS			
a	Nominal system voltage (kV)	400	220	132	33
b	Highest system voltage (kV)	420	245	145	36
c	BIL of transformers (kVp)	1300	900	550	170
d	System fault level (kA) for 3 sec.	50 for 1 sec.	40 for 3 sec.	31.5 for 3 sec.	25 for 3 sec.
e	Lightning Impulse withstand voltage for arrester housing (kVp)	1425	1050	650	170
f	Rated Voltage (kV)	360 or as specified in the schedule	198	120	42
g	Maxm. Continuous operating voltage (kVrms)	306	168	102	36
h	Nominal Discharge Current (kAp) of 8/20 micro second wave	10//20	10	10	10
i	Line discharge class	3	3	3	2
j	Minimum Energy Discharge capability (kJ/kV) at rated voltage	10	7.5	7.5	5
k	Temporary over voltage withstand capability (kVrms) for 10.0 secs	360 or as specified in the schedule	198	120	42
l	Insulation Housing withstand voltages i) Lightning Impulse (Dry) ii) Power frequency (wet) for 10 kA for 5 kA	As per IEC 60099-4			
m	Minimum Creepage Distance (mm)	10500	6125	3625	900
n	Pressure Relief Class	← A →			
o	(Minimum) High Current Impulse withstand (4/10 micro second wave) kA (peak)	100	100	100	100

p	Maxm. Lightning Impulse (8/20 micro-second Wave) residual voltage (kVp) 5 kA 10 kA	800 850	517 550	320 340	112 120
q	Maxm. switching surge (30/60 micro-second wave) protective level (kVp) 500 Amps 1000 Amps 2000 Amps	- - 750	- 455 -	- 280 -	98 - -
r	Maxm. Steep Impulse (1/20 MS impulse) residual voltage at 10 kA (kVp)	1050	600	372	130
s	Partial Discharge (pico-coulomb) when energized at 1.05 times its continuous operating voltage	Not exceeding 10 PC			
t	Rated Frequency (Hz)	50			
u	Minm. visible corona discharge voltage (kVrms)	320	-	-	-
v	Min. Bending load (kgm)	1000	1000	500	500
w	1 min. p.f. withstand (kVrms) voltage (dry & wet) for arrestor housing	630	460	275	70
x	Switching Impulse withstand voltage (250/2500 micro second) dry & wet for arrestor housing (kVp)	± 1050	-	-	-
y	Pressure relief Current i) High Current (kA rms)	40	40	40	40
	ii) Low Current (kA rms)	As per IEC			

Table 4.2 Analysis of Calculation Results for Post Insulator in LA

System Voltage (kV)	132	33
Nominal Creepage Distance (mm)	2904	726
Shed Number	Big 30, small 29	Big 9, small 8

Table 4.3 IEC Standard of Post Insulator (110 kV - 145 kV) for CT and PT

Catalog No			2814	2819	2820	2821	2831
Rated Voltage (kV)			110	110	110	110	110
Nominal Creepage Distance (mm)			2650	3150	3150	3200	2016
Mechanical Load (min)	Bending (kN)		16	6	10	20	Mechanic-al Load (min.)
	Torsion (kN.m)		6.0	3.0	4.0	6.0	
Withstand Voltage (kV)	Lightning Impulse		450	450	450	450	Withstand Voltage (kV)
	Power Frequency	Dry	245	245	245		Power Frequency
		Wet	185	185	185		
Shed Number			23	big 12 small 12	big 12 small 12	big 12 small 12	16
Weight (kg)			93	77	87	102	50

Table 4.4 IEC Standard of Post Insulator (20 kV - 35 kV) for CT and PT

Catalog No			2229	2200	2204	2206	2209	2213
Rated Voltage (kV)			20	35	35	35	35	35
Nominal Creepage Distance (mm)			400	648	625	648	650	1260
Mechanical Load (min)	Bending (kN)		20	6	8	4	4	4
	Torsion (kN.m)		-	3.0	2.0	1.2	1.2	1.8
Withstand Voltage (kV)	Lightning Impulse		150	185	185	185	200	250
	Power Frequ-ency	Dry	75	100	100	100	110	135
		Wet	50	80	80	80	70	95
Shed Number			4	7	6	7	7	big 5 small 4
Weight (kg)			31	17	16	12	15	27

5. CONCLUSIONS

Electrical power distribution is the final stage in the delivery of electric power, it carries electricity from the transmission system to individual consumers. Insulators are the integral part of the power system. The insulators are subjected to the environmental stresses such as humidity, temperature and pollution. Therefore, it has dual functions as electrical and mechanical function in power system networks. Insulators are made from dielectric materials such as ceramic and non-ceramic insulating materials. Lightning arrester is made with non-ceramic insulating materials and current transformer and potential transformer are made with ceramic insulating material.

Lightning arrester and instrument transformers (CT and PT) are equipped at the incoming line and outgoing line of substation. Without equipping the instrument transformers, the substation may be damaged because of overcurrent and overvoltage. So, it is important to have right current and voltage rating of CT and PT for different lines.

Numbers of shed, minimum creepage distance, dry arcing distance and diameter are differ according to its rating. In this paper, the efficiency and design of LA, the peak voltage rating of each arrester at 132 kV is 118.6 kV, creepage distance is 2904 mm and maximum continuous operating voltage is 94.88 kV. The creepage distance of current transformer and potential transformer at 132 kV are 4065 mm.

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