OUR REFERENCE: OL8098 and OL8097

CONTENT: Clarifications as per meeting dated 03/02/05

ENCLOSURES: TS-1383; IS-1598; IS-1476

GPS-A4/001019 (E687); AT-A1/009027 (E610) , AT-96/021430 (E484); DIN-16390; UNIPD 4571 (E642)

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Revision / Revisione	Description / Descrizione	Date / Data	Compiled / Compilato	Approved /Approvato

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20 mm ICE TEST ON S2DA 550kV

Extention of ice test with 20 mm ice (Operation under severe ice conditions type test) from the S2DA 362 kV to the S2DA 550 kV is quite easily inferred once the following have been observed:

- the two disconnectors have the same ice covers;
- by using ice covers, there is no difference in the load observed while opening or closing in the case of ice compared with the case without ice;
- the only difference between the two disconnectors is the distance between input and output (open gap distance) and the height of the insulators;
- the height of the insulators does not influence the operating torque and moreover the design of the linkages themselves is so that the equivalent torque observed at the shaft of the operating mechanism while opening is the same in the two cases.

Thus, the type test report relative to the 362 kV S2DA disconnector (CESI GPS-A4/001019 dated 04/02/2004) is also valid for the disconnector in subject, i.e. the 550 kV one.

630 kV power frequency withstand of the S2DA 550 kV disconnector

The disconnector in subject has already been certified for the 620 kV power frequency withstand for 1 minute (phase to earth configuration) and evidence is given in the CESI AT-A1/009027 type test report dated 21/03/2001.

According to the test report TS-1383, where a research on 1 minute power frequency withstands for several critical configurations electrode-structure was carried out, we may assert that for a gap distance of 1700 mm withstand to the power frequency test is granted up to 635 kV. For the disconnector of our concern, insulators BIL 1550 are used. Since they are 3350mm high we may conclude that also the 630kV withstand is assured.

Exactly the same considerations apply to the open gap witstand of 815 kV because in this case we have 3690 mm of open gap distance (=4200-750/2-270/2 according to DIN-16390).

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Mechanical operations on the 550 kV S2DA - Additional load due to the wind force

The 5000 OC operations to be carried out with application of 50% of the terminal loads below reported which will have to take into account also the wind effect. Equivalent wind force (F''_b) will now be calculated and such an effect will be added to the terminal loads:

- straight load (F_a)= 1500 N
- cross load (F'_b) = 1500 N
- vertical load (F_c) =1250 N

  (for directions pls see DIN-16390)

Considering the dimensions as per drawing DIN-16390, the equivalent areas of the live part (of baricenter height from base h_1= 3410 mm) and insulator (of baricenter height from base h_2= 1670 mm) are A_1= 0.44 m^2 and A_2= 0.55 m^2 respectivelly. Thus, the forces on the two areas are[1]: F_1= 386 N for the live part and F_2= 440 N for the insulator (only one side of the double side break disconnector is considered). The total equivalent momentum is calculated as $M=F_1*h_1 + F_2*h_2$, hence M= 2051 Nm.

For the equivalent wind force applied at a height of h_3= 3600 mm from insulator base, a load of M/h_3= 570 N is obtained.

We have thus provided evidence for the value of the equivalent force F''_b = 570 N (to be applied to each insulator). So, terminal loads that are to be used at 50% in the 5000 mechanical operations test and at 100% at the 25 operations with applied terminal loads are:

- straight load (F_a)= 1500 N
- cross load (F'_b+ F''_b) = 570+1500= 2070 N
- vertical load (F_c) =1250 N

[1] The force is calculated as: $F= C_x*A*(\rho*v^2/2)$ where C_x is a coefficient depending on the geometry of the part (Cx=0.91 for the live part and 0.83 for the insulator), ρ is the density of air and v is the wind velocity of 40 m/s; $F/(C_x*A)$=964 N/m^2

Consideration of static coefficient for DIN-16390

By summing all the forces applied to the disconnector, the following is obtained:

- longitudinal component equals to F_a;
- trasverse force is the sum of ($F'_b + F''_b$) and the load due to the short circuit which is $0.2*10^{-7}*(40*2.5*1000)^2*(6800/4700)/2$ (factor 2 is used to divide the peak short circuit stress on both insulators), i.e. 691 N;
- resultant force is $((F_a)^2+(F'_b+ F''_b+691)^2)^{0.5}=3142$ N;
- Fraction 8000/3142 (C8 post insulators are being used) provides a value of 2.55, as per technical specifications.

440 kV power frequency withstand of the S2DA 220 kV disconnector

For the S2DAT 220kV disconnectors supplied, while withstand to the 460kV between open gap distance for 1 minute is certified by test report TS-1477 (which is relative to a 2500 mm distance between input and output and has a test value of 530 kV), withstand toward earth for 440kV is explained as follows. Test report TS-1599 which is relative to a disconnector analogous to the one supplied (BIL 950 and 2500 mm between open gap) provides evidence for the withstand values of 460/395 kV between open gap distance and towards earth respectivelly. As insulators BIL 950 are 2100 mm high, exactly in the same way as on page 2, we hereby say that 2100 mm may well assure a withstand level of 440 kV for 1 minute since according to test report TS-1383 for a gap distance of 1250 mm withstand to the power frequency test is granted up to 484 kV.

Note that for the withstand values of 1200 kV and 950 kV, respectivelly between open gap and towards earth, requested in the lightning impulse voltage test (1.2/50), the two certificates IS-1598 (for the 950 kV) and IS-1476 (for the 1200 kV) are sufficient.

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Dielectric tests on the 330 kV S2DA disconnector

Switching impulse withstand voltage test

950 kV peak 250/2500 phase-to-earth and 900kV peak + 345 ac BIAS (i.e. 1245 kV) across isolating distance are to be validated.

According to Gallet formula[2] for the disconnector tested in E610 (CESI AT-A1/009027) a coefficient K=1.45 is calculated since the distance to earth is 3050mm and 50% breakdown voltage of 1386 kV was determined. The 330 kV disconnector in object has insulators BIL 1300, i.e. 2900 mm high, thus a voltage withstand[3] of 1211kV is assured in the phase-to-earth withstand.

According to Gallet formula for the disconnector tested in E610 (CESI AT-A1/009027) a coefficient K=1.49 is calculated since the open gap distance is 4000mm and 50% breakdown voltage of 1717 kV was determined. The 330 kV disconnector in object has an open gap distance of 2990mm, thus a voltage withstand of 1289kV is assured in the open gap distance.

Lightning impulse withstand voltage test

1175kV peak 1.2/50 phase-to-earth and 1425kV peak + 240 ac BIAS (i.e. 1665 kV) across isolating distance are to be validated.

From the well known formula $V_{li\_50\%} = K_{li} \cdot 500 \cdot D_{[m]}$, where D equals 2.85 m and 2.99 m in the phase-to-earth and longitudinal (open gap) cases respectivelly, the values below are obtained:

[2] The well known Gallet formula provides for the 50% breakdown voltage $V_{50\%}$ of an AIS disconnector known the coefficient K_{si} and the distance in air D measured in meters: $V_{50\%} = \frac{K_{si} \cdot 3450}{\left(1 + \frac{8}{D_{[m]}}\right)}$;

[3] Withstand voltage may be calculated as $V_{10\%} = V_{50\%} \cdot (1 - 1.3 \cdot \sigma)$ with standard deviation $\sigma_{si} \cong 0.06$ for switching impulses.

V_10%_phase-to-earth= 1561 [kV] and

V_10%_longitudinal= 1810 [kV]

since $V_{10\%} = V_{50\%} \cdot (1 - 1.3 \cdot \sigma)$ with $\sigma_{li} \cong 0.03$ and K_{li} equals to 1.14 and 1.26 for the phase-to-earth and longitudinal (open gap) cases respectivelly (coefficient values are supported by E484 –CESI AT-96/021430 where withstand 50% of 1858 KV for a height of 3250mm and by E642-4571 at University of Padua Lab).

Power frequency voltages

450 kV phase-to-earth and 610 kV longitudinal (across isolating distance) are to be validated.

From the well known formula $V_{fi\_50\%}[kV] = 350 \cdot D_{[m]}$ (see CIGRE 1963 rod-plane most critical configuration), where D equals 2.85 m and 2.99 m in the phase-to-earth and longitudinal (open gap) cases respectivelly, the values below are obtained:

V_50%_phase-to-earth=998 [kV] and

V_50%_longitudinal=1046 [kV]

which corresponds to:

V_10%_phase-to-earth= 803 [kV] and

V_10%_longitudinal= 842 [kV]

since $V_{10\%} = V_{50\%} \cdot (1 - 1.3 \cdot \sigma)$ and $\sigma_{fi} \cong 0.10 \div 0.15$ ($\sigma_{fi} = 0.15$ was used).