Earthquake calculation on tap-changer type UZE/UZF

Product information

The transformer and its foundation is assumed to be rigid but not stiff, so the ground acceleration $a_{\text{HG}}$ is considered to be amplified through the transformer tank to the tank cover with the amplification factor $K$, which is prescribed to be 1.5 (IEC 61463).

Static calculation on a somewhat flexible structure, taking into consideration the response factor $R$ as an alternative to the method by dynamic analysis, gives a simple and at the same time a more conservative method for calculation.

The bending moment $M_s$ in the critical cross-section on the part of the tap-changer under consideration is then calculated from an equivalent acceleration $a_{\text{MP}}$ of the center of gravity of that part:

$$M_s = a_{\text{MP}} \cdot h \cdot m_p$$

The value of $S_c$ depends on the natural frequency of the mounted part and if no value is known, the conservative value $S_c = 1.5$ should be used. This coefficient aims to take into account the effects of both multifrequency excitation and multimode response. $R$ can be assumed to be equal to the conservative value 1.74 when information for frequency and damping of the tap-changer on a transformer is not available. This value corresponds to the frequency range 2.4 Hz to 9 Hz and 5 % damping ratio.
Calculation
(Calculation of the load and stress on the clamping screws of the tap-changers epoxy resin moulding)

For the tap-changer UZE/UZF is the following valid:
\[ h_1 = 0.7 \text{ m} \]
\[ h_2 = 3.0 \text{ m} \text{ (Conservative values)} \]
\[ m_p = 40 \text{ kg} \]
\[ h_E = 0.25 \text{ m} \]
\[ K = \left( \frac{h_1}{h_2} \right) \cdot 1.5 \]
\[ R = 1.74 \]
\[ S_c = 1.5 \]

Assume the strongest type of earthquake with a ground acceleration level \( a_{HG} \approx 0.5 \text{ g} \) (Richter scale >7.0) which gives that:
\[ a_{HG} = 5 \text{ m/s}^2 \]
\[ a_{HC} = K \cdot a_{HG} \]
\[ a_{MP} = a_{HC} \cdot S_c \cdot R \]

The bending moment \( M_s \) in the critical cross-section will be:
\[ M_s = a_{MP} \cdot h \cdot m_p \]
\[ M_s = 45.675 \text{ Nm} \]

The force \( F \) from the acceleration is:
\[ F = a_{MP} \cdot m_p \]
\[ F = 182.7 \text{ kg} \cdot \text{m} \cdot \text{s}^{-2} \]

The distance \( h_{E2} \) between the clamping screws which hold the epoxy resin moulding is 240 mm. Six screws M16 on each side clamp the moulding and are prestressed to about 8 kN. The balance between the force \( F \) from the acceleration \( a_{MP} \) and the reaction forces \( F_2 \) at the clamping area gives that \( F_2 = 190 \) newton. It means that even a single screw (with prestress of 8 kN) would be enough to take care of the force \( F \) from the earthquake acceleration. In practice the number of screws is six.

Note
The mass \( m_p = 40 \text{ kg} \) does not include the part of the epoxy resin moulding, which is close to the transformer wall connection.