Earthquake calculation on tap-changer type VUCG

Product information

The transformer and its foundation is assumed to be rigid but not stiff, so the ground acceleration $a_{HG}$ 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 $a_{MP}$ of the center of gravity of that part:

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

The acceleration $a_{MP}$ is calculated from the cover acceleration $a_{HC}$ by multiplication with a coefficient $S_c$ and the response factor:

$$a_{MP} = a_{HC} \cdot S_c \cdot R$$

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 multi-frequency 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 VUCG selector C
For tap-changer VUCG/C the following is valid:

\[ m_p = 360 \text{ kg} \cdot 9.81 = 3530 \text{ N} \]
\[ h = 1.15 \text{ m} \]
\[ K = 1.5 \]
\[ R = 1.74 \]
\[ S_c = 1.5 \]

Assume the strongest type of earthquake with a ground acceleration level \( a_{HG} = 0.5 \text{ g} \) (Richter scale >7.0) which gives that:
\[ a_{HG} = 5 \text{ m/s}^2 \]
\[ a_{HC} = K \cdot a_{HG} \]
\[ a_{MP} = a_{HC} \cdot S_c \cdot R \]
\[ \Rightarrow a_{MP} = 1.5 \cdot 5 \cdot 1.5 \cdot 1.74 = 19.575 \]

The bending moment \( M_p \) in the critical cross-section will be:
\[ M_p = a_{MP} \cdot h \cdot m_p \]
\[ \Rightarrow M_p = 19.575 \cdot 1.15 \cdot 3530 = 7.95 \cdot 10^3 \text{Nm} \]

Bending tests has been made on an VUCG/C, which show that a bending moment of about 20 kNm does not give any problem with leakage or damage. As this moment is much greater than the calculated moment \( M_p \), the tap-changer is capable to withstand even the most severe earthquake.

**Note**
The mass \( m_p = 360 \text{ kg} \) does not include the top-section flange bolted to the transformer cover but only the mass below the top-section flange (cylinder, active insert parts, bottom flange and the tap selector).

Calculation VUCG selector III
For tap-changer VUCG/III the following is valid:

\[ m_p = 400 \text{ kg} \cdot 9.81 = 3925 \text{ N} \]
\[ h = 1.5 \text{ m} \]
\[ K = 1.5 \]
\[ R = 1.74 \]
\[ S_c = 1.5 \]

Assume the strongest type of earthquake with a ground acceleration level \( a_{HG} = 0.5 \text{ g} \) (Richter scale >7.0) which gives that:
\[ a_{HG} = 5 \text{ m/s}^2 \]
\[ a_{HC} = K \cdot a_{HG} \]
\[ a_{MP} = a_{HC} \cdot S_c \cdot R \]
\[ \Rightarrow a_{MP} = 1.5 \cdot 5 \cdot 1.5 \cdot 1.74 = 19.575 \]

The bending moment \( M_p \) in the critical cross-section will be:
\[ M_p = a_{MP} \cdot h \cdot m_p \]
\[ \Rightarrow M_p = 19.575 \cdot 1.5 \cdot 3925 = 11.25 \cdot 10^3 \text{Nm} \]

Bending tests has been made on an VUCG/III, which show that a bending moment of about 20 kNm does not give any problem with leakage or damage. As this moment is much greater than the calculated moment \( M_p \), the tap-changer is capable to withstand even the most severe earthquake.

**Note**
The mass \( m_p = 400 \text{ kg} \) does not include the top-section flange bolted to the transformer cover but only the mass below the top-section flange (cylinder, active insert parts, bottom flange and the tap selector).
**Calculation VUCG selector F**

For tap-changer VUCG/F the following is valid:

\[ m_p = 500 \text{ kg} \cdot 9.81 = 4905 \text{ N} \]

\[ h = 1.6 \text{ m} \]

\[ K = 1.5 \]

\[ R = 1.74 \]

\[ S_c = 1.5 \]

Assume the strongest type of earthquake with a ground acceleration level \( a_{HG} = 0.5 \text{ g} \) (Richter scale >7.0) which gives that:

\[ a_{HG} = 5 \text{ m/s}^2 \]

\[ a_{HC} = K \cdot a_{HG} \]

\[ a_{MP} = a_{HC} \cdot S_c \cdot R \]

\[ \Rightarrow a_{MP} = 1.5 \cdot 5 \cdot 1.5 \cdot 1.74 = 19.575 \]

The bending moment \( M_i \) in the critical cross-section will be:

\[ M_i = a_{MP} \cdot h \cdot m_p \]

\[ \Rightarrow M_i = 19.575 \cdot 1.6 \cdot 4905 = 15.36 \cdot 10^4 \text{ Nm} \]

Bending tests has been made on an VUCG/F, which show that a bending moment of about 20 kNm does not give any problem with leakage or damage. As this moment is much greater than the calculated moment \( M_i \), the tap-changer is capable to withstand even the most severe earthquake.

**Note**

The mass \( m_p = 500 \text{ kg} \) does not include the top-section flange bolted to the transformer cover but only the mass below the top-section flange (cylinder, active insert parts, bottom flange and the tap selector).