IMPROVING THE INNER CLIMATE OF MV SUBSTATIONS

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ABSTRACT

Many substations are not suitable to house MV installations for 30 years or more. A poor inner climate causes corrosion and degradation of parts. Due to the inner climate between 10 .. 20 % of the substations have high maintenance costs and a limited lifetime for the MV installation. About 0,1 .. 0,5 % fail due to breakdowns.

For the Enexis and Alliander population with 100.000 substations the annual costs are about 3Meuro and 4 full time jobs. Based on typical costs for overhaul 3keuro, replacement 25keuro and a breakdown 35keuro.

Evaluating the inner climate by dew point measurements on several parts in the substation helps to understand and improve the inner climate conditions of substations. At a glance measurements can show whether the improvements are worthwhile.

INTRODUCTION

Typical for substations with a MV-LV transformer are open floors, no floors, groundwater in the cellar, lower inner temperatures than outside despite the presences of a the MV-LV transformer. And sometimes MV installations are placed in front of an inlet vent.

Without the presence of a MV-LV transformer in the same room as the MV installation, there are besides the previous mentioned problems also condense problems due to high temperature differences due to walls with a low thermal resistance (Rc) like 10 cm concrete or 3 mm steel.

Poor inner climate conditions can be revealed by measuring the basics that are needed for calculating the dew point.

Figure 1: dew curve for several room temperature

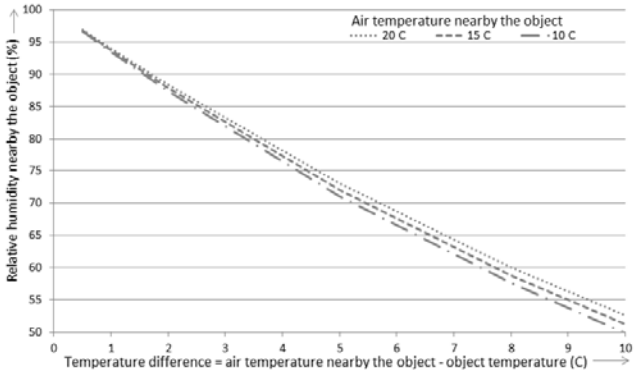


Figure 1 shows the dew curve as a function of the relative humidity nearby the object on the y axis and the difference between the air nearby the object and the object temperature itself on the x axis. Above the curve the air will generate condense on the object.

The basics to acquire the dew point are the object temperature and the temperature and humidity of the air nearby the object. These three parameters are the main parameters for making the assumption that condense will occur. Condense that will lead to corrosion and rust.
The actual temperature in the substation has almost no influence on the inner climate as figure 1 shows for different room temperatures of 10, 15 and 20 C.

CURRENT SITUATION

The following figures show the current situation in substations directly underneath the MV.

Fig 2 substation without a floor and water in the open cellar directly underneath the MV installation.

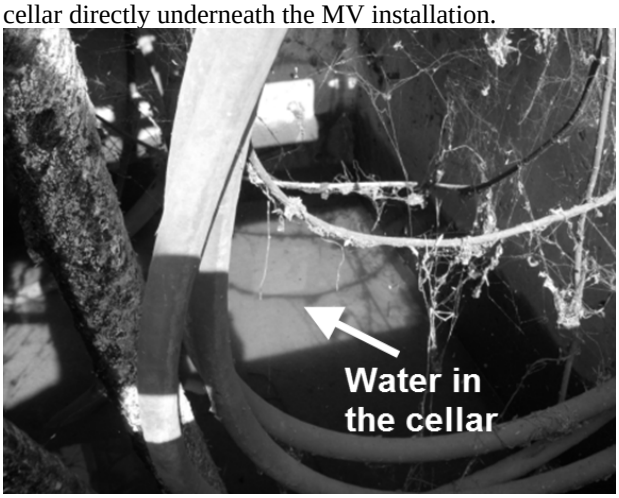


Fig 3 severe corrosion on a MV installation in a substation without a floor = with an open cellar.

Fig 4 water dripping is on top of the MV installation from the ceiling in a substation with no MV-LV transformer in the same room. The ceiling is made of concrete (6..10cm).

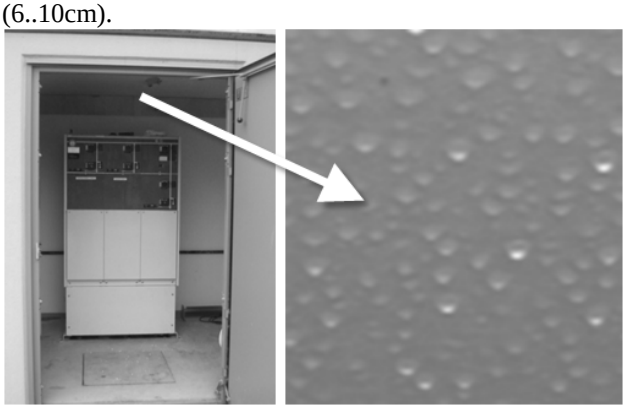
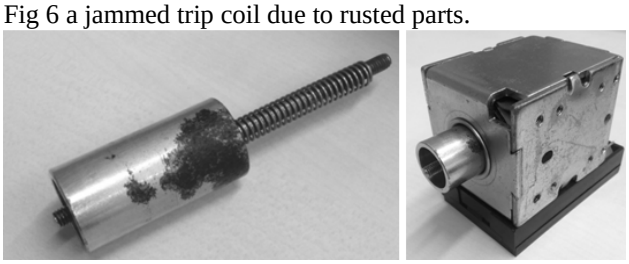


Fig 5 severe condense created on inside of the CB panels due to an open floor beneath the panels. Dripping condense creates water stains on the floor.

Fig 6 a jammed trip coil due to rusted parts.



MEASUREMENTS

In the last 20 years many different solutions are applied to improve inner climate condition of substations. For instance: filling the cellar with sand, stones, crushed shells or plastic chips, by placing sheets straight on the MV installation, installing additional heating or closing vents and isolate the outside of the substation up to an Rc of 3 W/K.m.

To be able to establish the worth of the improving adjustments a better understanding of the mechanism that is responsible for the indoor conditions is required . Measurements can show the impact .

Many measurements have been carried out within Enexis and Alliander to understand what causes the poor inner substation climate. Most measurements were executed with data loggers with 6 temperature and 6 humidity sensors.

Several improvements were carried out in a substation. Not all at once but in schemes of one change per week to be able to establish their individual impact on the inner climate. For instance for a substation with a basement and without a floor: measure one week the “as is”- situation, fill the basement with sand, measure again one week, cover the sand with an 100 % air-tight cover i.e. 3 cm concrete, measure another week, etc.

The unexpected success was that the measurements convince instantly. By first glance measurements can show whether an improvement is worthwhile or not.

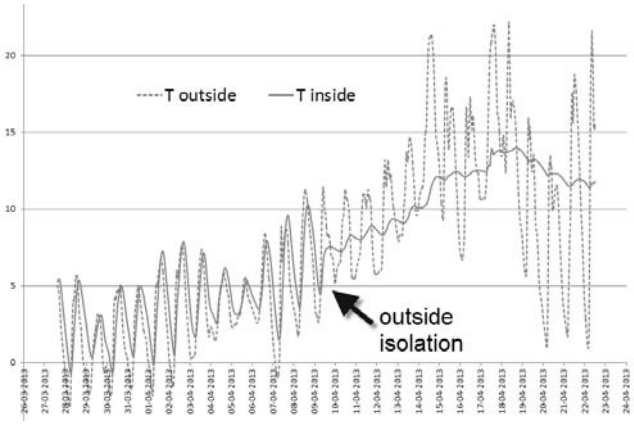
RESULTS

The following figures show measurements with convincingly visual results. First an example regarding thermal isolating the wall and ceiling of a substation without a MV LV transformer. Second an example of a substation with a MV LS transformer with regarding seiling of the open floor. Third an example of a not 100 % air tight floor and cellar.

Example 1: a substation without a MV LV transformer

This example is a substation with 8 CB panels within a concrete building with walls of 10 cm. Trip coils were jammed after about 5 years due to severe corroded parts.

Fig 7 instant improvement of the inner temperature after isolating the 10 cm concrete walls with an Rc of 0,3 up to 3 W/K.m

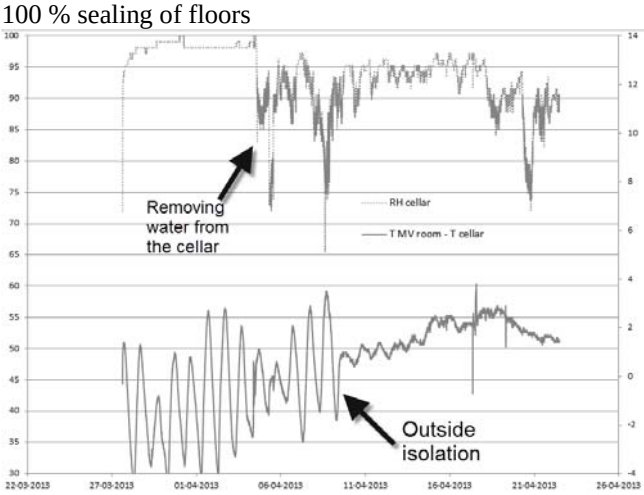


Before the thermal isolation of the substation, the inner temperature followed the outside temperature variety for about 60 %. These fast inside temperature changes caused condense inside the MV installation. This due to the slow acclimation of the MV installation caused by the high mass of metal and isolators inside the installation.

After the thermal isolating of the building the temperature changes inside reduced significantly. They are less than 1 degree per 8 hours. In general this gives enough time for the inventory to acclimate. Regarding figure 1 this 1 degree variety allows a maximum RH of 90 %. This matches the IEC specification for RH for MV equipment's.

By sealing of the floor openings from the cellar the relative humidity decreases under 90 %.

Fig 8 relative humidity in the cellar and the temperature difference between the MV room and the cellar require 100 % sealing of floors



The RH in the cellar was about 100 %. After removing the water from the cellar the RH dropped not that drastically. The RH still various between 70 % and 90 %. A RH of 90 % requires less than 1 degree of temperature changes according to fig 1.

The temperature difference between the cellar and MV room varied about 4 degrees. After isolating the building it stills divers up to 2.5 degrees. According to fig 1 the maximum allowed RH is 85 %.

So, it is necessary to have well sealed floors to prevent condensation in the lower parts of the MV installation.

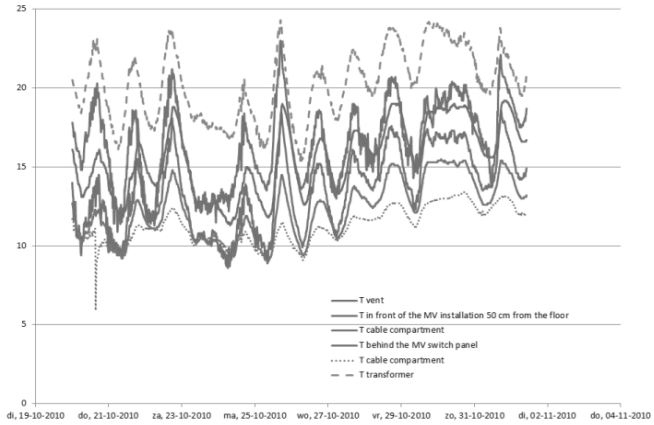
Often heating is used in the room with CB's to prevent this area from frosting. Figure 8 shows that the cellar is always colder than the room with the MV installation. An open floor unnecessarily requires more heating than a well-sealed floor.

Example 2: a substation with a MV LV transformer and an open cellar and therefor without a floor.

This second example is typical for many substations that have no floor and therefore have an MV installation that is in direct open contact with the cold and moist cellar. Normally a substation is calculated to limit a maximum temperature rise of 10 degrees related to the outside temperature.

But the open cellar is much colder than the outside temperature and cools the compartments like the cable compartment in which condense will occur.

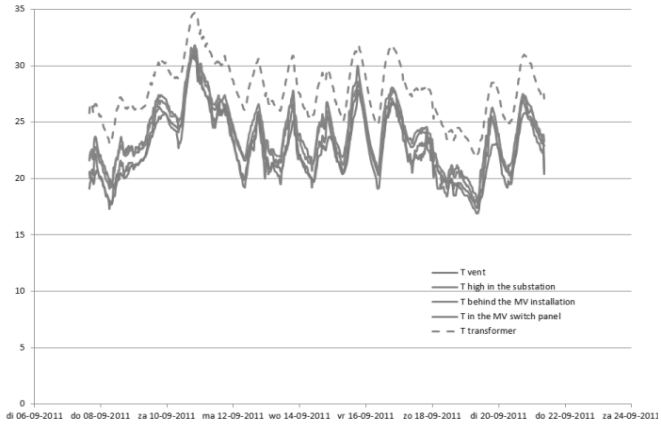
Fig 9: temperatures in a substation with an open floor and a MV LV transformer.



The vents are calculated to cool down the transformers maximum load. The maximum temperature increase at the maximum load is 10 Kelvin. But due to the open cellar the temperature inner climate is 10 degrees colder than outside. The air from the vents is many degrees warmer than the inner climate although there is a transformer in the substation. Figure 9 shows the high temperatures differences in the substation. The warm air inlet easily leads to condensation on the colder MV installation.

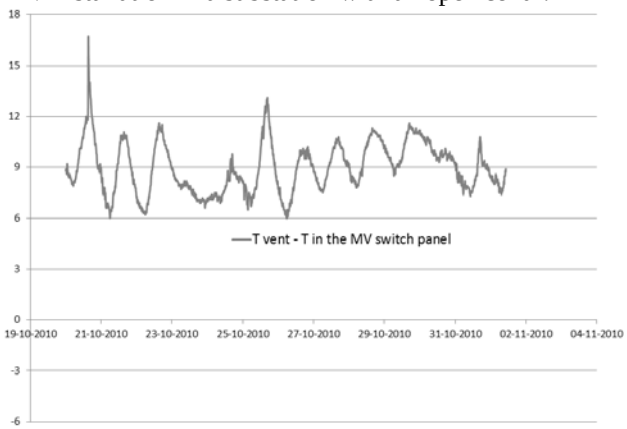
After filling the open cellar with sand and a 1.5 cm thick cover the temperature difference between the out- and inside is much lower. Figure 10 shows all temperature of the same substation without the open cellar. At a glance the graph shows that transformer is in control of the inner climate and all temperatures. Condensation is less possible because the MV installations is warmer than the inlet air.

Fig 10: temperatures in a substation with and a MV LV transformer with a cellar that is filled with sand and sealed.



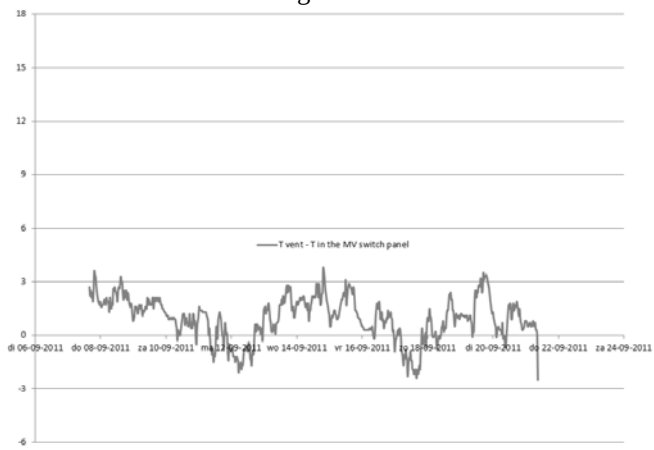
The next two figures are a closer look at the actual temperature difference between the vent and the inside of the MV installation (behind the front of the switch panel).

Fig 11: temperature difference between the vent and inner MV installation in a substation with an open cellar.



The difference is a least 6 degrees Celcius between the vent and the MV installation. Due by the compact layout of the substation, the air in the substation will easily pass the colder MV installation causing condense. See also figure 1.

Fig 12: difference between the vent and inner MV installation temperature in the same substation as fig 11 but now with a 100 % air-tight floor.



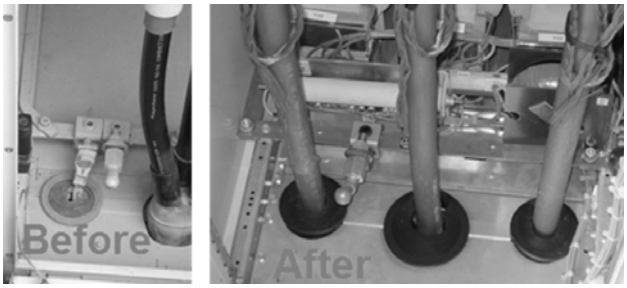
The temperature difference has decreased a lot compared to figure 11. As could be expected (!) the MV installation sometimes has a higher temperature and sometimes a lower temperature than the vent due to its mass. This delayes the changes of temperature caused by the MV LV transformer that heats up and cools down.

At a glance the big difference is recognizable between figures 11 and 12.

Example 3: **a substation with a MV LV transformer without a 100 % air-tight floor.**

The third example is a substation with a MV-installation floor with many small openings. The temperature within the casing of MV-installation is dominated by the cellar.

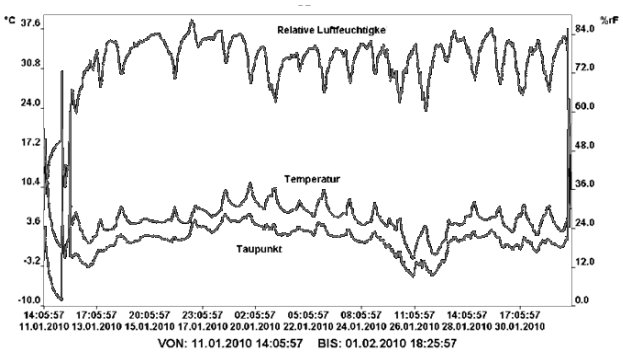
Fig 13: the MV-installation has originally not an air-tight floor. The left picture shows holes en open spaces around the cables. The picture on the right has better sealed of solutions.



Due to the holes in the floor and open spaces around the cables the inner climate in the MV-installation was dominated by the cellar. As fig 12 shows the temperature within the MV-installation is some degrees higher than the dew point.

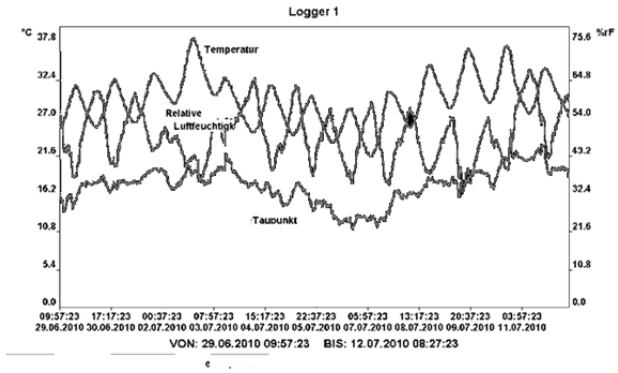
Rapid changes in the temperature within the substation cause condense due to low difference between the temperature and the dew point.

Fig 14: Measurement of the humidity, inner temperature and dew point within the MV installation with a floor that is not 100 % air-tight.



After closing the floor of the MV-installation the inner climate improved. The difference between the inner temperature and the dew point increased a lot.

Fig 15: Measurement of the humidity, inner temperature and dew point within the MV installation with a not 100 % air-tight floor.



After improving the floor of the MV-installation rapid changes in the temperature within the substation cause not often condense.

CONCLUSION

The dew point graph of figure 1 has shown to be a good guidance to determine the value of the results of the improvements carried out by Enexis regarding the MV installations. It helps to visualise the problem with the bad inner climate condition.

In more than hundred substations analysis of the inner climate condition have been carried out. From this analysis the following three basic rules can be applied to improve the inner substation climate significantly.

- every floor has to be 100 % air tight (vapor-tight and waterproof).
- walls of substations without a MV-LV transformer require an Rc of at least 1 W/K.m
- MV-installations should not be placed in front of or nearby vents.

It is necessary to keep away the low temperature and high humidity of the cellar from the surroundings of the MV installation. This prevents condensation . It also prevents needless heating of the basement.

Substations without a MV-LV transformer with concrete and metal walls require thermal isolation to be able to reduce the huge inner temperature changes. This because the MV installation can't adapt to rapid temperature changes.

The worst situation is a MV installation placed in front of or nearby a vent. During the night the installation will cool down. In the morning the outside air is warmer than the MV installation and will form condense immediately for many hours on the MV installation.