



An electric arc occurred when introducing a metal guide into the wind turbine transformer enclosure.

Associated non-conformity code: NC2017003077

Description of the incident

The day before the accident, while the technician was dismantling the sonic anemometer, he lost control of the cable, which disappeared down the tube, something that is not unusual, because it is difficult to hold the old sensor, the screwdriver and the cable, all at the same time. The technician tried unsuccessfully to recover the cable, so the job was left for the following day, in order to use more suitable tools.

The process in cases of the cable disappearing down the tube consists of recovering the cable from inside the nacelle by passing a guide through the tube from outside down to the nacelle, tie the cable to the guide and then pull the guide from outside.



Close-up of the flexible tube inside the transformer enclosure through which the environmental sensor wiring passes.



Close-up of the upper flexible tube fastening inside the transformer enclosure.

The following day, the two maintenance technicians returned to the turbine with a metal cable-passing guide, but it was theirs and did not belong to the company. Since metal guides are not as flexible as nylon ones, they believed it would make the job easier to carry out.

While one technician exits onto the cowling and begins passing the guide, the other remains in the nacelle waiting for the guide tip. After a certain time passing the guide without his companion seeing the other end come out of the flexible tube, the technician on the cowling returns inside the nacelle to see exactly what is happening. Once inside he goes up to the upper grille in the transformer enclosure through which the flexible tube passes and, just then, an explosion is produced inside the transformer enclosure, and the consequent tripping of the wind turbine switchgear panel due to the "arc sensor" and of the substation protections. Because both technicians are inside the nacelle, neither suffered any injuries, only the one close to the grille has slight marks on the hand gripping the grille, probably due to the high-temperature gases from inside the transformer enclosure (the gas temperature around an arc can easily exceed 5.000 °C).



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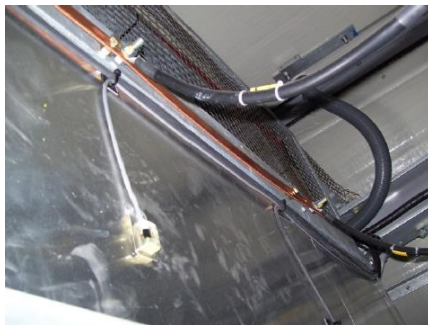
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Accident causes

During the investigation into the accident, it was verified that:

- the metal frame of the lower part of one of the transformer phases showed signs of heat damage.
- there were pieces of metal rod inside the enclosure, which came from the metal guide that had been inserted into the tube in order to pass the sonic anemometer cable.
- the flexible plastic tube was hanging from the transformer enclosure wall (not from the cowling ceiling) and it had several holes that were probably caused by the high temperature of the metal guide coming into contact with the tube.

Because of all this, it is suggested that the flexible tube was freed from its upper fastening due to being pushed and forced by the metal guide, with the latter becoming hooked inside the tube and, instead of exiting outside the nacelle as expected, it was introduced inside the transformer enclosure, increasingly further, until at a given moment, when it came into contact with one of the transformer phases and the frame (earth). This moment was when the short-circuit was produced, coinciding with when the technician was checking where the guide was inside the nacelle by peering through the transformer enclosure grille.



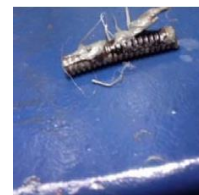
Close-up of the transformer enclosure upper grille and of the flexible tube exit towards the nacelle,



Close-up of inside the transformer where the short-circuit probably occurred.



Close-up of the holes in the flexible tube where it was in contact with the metal guide.



The employed metal guide and close-up of the discovered pieces, probably melted because of the attained high temperature.



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LESSONS LEARNT

- Tools must never, under any circumstances whatsoever, be introduced into an energised HV enclosure, except when absolutely certain that the hazard distances with "live" parts are not going to be invaded. This can only be guaranteed if there is a rigid stable barrier to prevent such contact.
- The current design of the flexible tube, through which the electrical wiring for the environmental sensors (sonic and NRG) pass in the G8X/G90 turbines, cannot be considered a sufficient physical barrier. For this reason and because it is an area that cannot be monitored visually from outside that would allow the tube conservation status and position to be established, it is **strictly forbidden to pass guides inside the transformer enclosure of this type of turbine without first obtaining the corresponding installation work clearance (see S.CR.17.013).**
- **It is forbidden to bring personal tools to work.** All tools for professional use must be company approved.
- All personnel in their technology, installation and plant must check whether this scenario could be repeated in other turbines and other jobs (although the transformer is in a different location) and if this is so, the risks must be assessed and preventive measures adopted to prevent similar accidents.
- The following are put forward as improvements at the actual installation, which will be passed to the Engineering Department so that the solutions can be designed and subjected to the corresponding field testing:
 - Design a permanent fastening system for the sonic anemometer cable that will prevent it disappearing when released (no longer dependent on the human factor).
 - Design a more reliable flexible corrugated tube upper (gondola ceiling) fastening system. It is currently secured by tabs and it is proposed that it be fastened by a pass-through screw.
- Apart from the proposed installation improvements, the turbine transformer maintenance checklist must be immediately updated by including specific verification of the condition of the flexible tube and its fastening.