

## Survey results: PD in bushings during factory acceptance testing

The survey was sent to the members and guests of the Dielectric Test Subcommittee on September 23, 2019.

Proposal: Add the following text to standard C57.12.90 Section 10.8.5:

“If the partial discharge is observed during the induced testing of the transformer and appears to be generated within an OIP bushing(s), it is permissible to “vent” the bushing(s) to the atmosphere using the bushing manufacturer’s instructions to allow for the dissipation of gas bubbles in the oil. Gas bubbles sometimes form following a temperature rise test during cool down or may be present for other reasons. Reestablishment of the bushing gas space blanket and resealing of the bushing must also be performed in accordance with the bushing manufacturer’s instructions following completion of the induced test.”

### Summary of Survey Responses

	Number	%	Comments
Ballots	929		
Returned	132	14.2%	
Abstain	11		1
Responses	121		
Approve	105	86.8%	10
Reject	16	13.2%	16

### Comments to Reject:

1. **REJECT:** I cannot understand we allow gas bubbles in oil in any product and to change conditions of a product during FAT is a no go for me. I heard only one supplier has issues with gas bubbles in an OIP bushing during heat run test. Erich Buchgeher
2. **REJECT:** In my opinion it is a technological problem from the bushing manufacturing process, which cannot affect the standards. For some technologies/manufactures this issue does not exist. - Everton Luis De Oliveira
3. **REJECT:** We as ABB Bushing manufacturer have to REJECT your proposal as a generic solution for all bushing types, since we do not recommend this for larger bushings. Larger OIP bushings have a an overpressure when delivered from the factory. If the bushing is vented during or after temp rise test this overpressure will become a lower pressure inside the bushing when cooled down. This lower pressure can cause PD activity and subsequently failure at low ambient temperatures in service. We recommend that the

OEMs wait until the bushing has cooled down before any venting. This is due to the gas content during heating must reach equilibrium in oil before venting. However this can be applied on small bushings, typically GSU types. – Niklas Gustavsson

4. REJECT: The text below suggests that OIP bushings can be vented to the atmosphere according to the bushing manufacturer's instructions if partial discharge is observed during the induced test. But the PD test is the last test which follows the impulse tests, therefore it happened that we damaged bushings during the impulse test because there were gas bubbles already in the bushing which weakened the insulation. This has led to considerable time delays and cost. I did not see any manufacturer's instruction which identified clearly all bushing types which can produce partial discharge in the dielectric tests after a heating cycle and they also do not specify the admissible heating cycle for each type of bushing. Therefore all the responsibility to identify which bushing shall be vented is transferred to the buyer of the bushing, which is not acceptable. Also there is no instruction available from the bushing manufacturers on how to avoid oil spill when the venting cap of the bushing is removed. Oil can be spilled during the heat run of the transformer when the oil in the bushing is heated and expands and the oil level is higher than the level of the opened venting plug. The oil is spilled to the transformer and to the floor of the test room and can lead to considerable health and safety risks which are not acceptable. The bushing manufacturers do also not specify in their instructions the type of oil which shall be used to refill the bushings if the mentioned oil spill happens. Filling the bushing with an oil chosen by the transformer manufacturer can compromise the integrity of the bushing. Therefore I propose that we work out clear instructions to avoid all the risks mentioned above. – Egon Kirchenmayer
5. REJECT: It would see this clause as shift of responsibility from product supplier in the direction of the manufacturer – Kurt Kaineder
6. REJECT: I thought we agreed on "it is permissible to "vent" the bushing(s) to the atmosphere **if the bushing manufacturer is contacted and they provide specific instructions**" to allow for the dissipation of gas bubbles in the oil. – Mario Locarno
7. REJECT: The presence of gas in the bushing and subsequent venting should require the test that caused the bubbles is repeated. This may also indicate the bushing was not properly processed during manufacturing and the subsequent PD tests on the bushing. Just venting does not assure the final user this activity will be resolved when the bushing is subjected to load at the user's location. Bad idea and we have always disallowed this practice. – Thomas Lundquist

8. REJECT: Background is that venting of OIP bushing if it fails during FAT because of bubble formation seems not acceptable since it should have been stable = moisture free during manufacturing. Just my comment as an end user. If we would be venting it to equalize pressure between atmosphere and bushing (which is under vacuum) then there is a possibility of moisture ingress (if surrounding atmosphere has high humidity). – Darrell Mangubat
9. REJECT: This is a technology problem which cannot be transferred to the standards. Bushing manufacturers should solve this issue. By the way, a kind of temperature rise test followed by PD test shouldn't be part of the bushing standards? – Juliano Montanha
10. REJECT: I think that the condition that appear during testing could also appear in service. – Sylvain Plante
11. REJECT: The reason of my negative vote is if the bubble formation is also occurring in service, this will possibly lead soon or later to a bushing failure. We shall be very careful, mainly for EHV bushings that are very sensitive to the impact of gas bubbles. Perhaps, this allowance can be limited to less than 245 kV. – Pierre Riffon
12. REJECT: If I look on the short ABB manual i.e. for the OIP bushings I can find: "Our default recommendation is not to open a bushing because this can compromise the integrity of the bushing's internal environment. Opening the bushing adds the risk of contamination and the possibility of failure to reseal the bushing properly. However, we recognize that there are circumstances which mandate breaking the bushing seal. Venting is done on a relatively frequent basis by transformer manufacturers and bushing users without unsatisfactory results." So we need probably add some more information in the sentence. – Janusz Szczechowski
13. REJECT: The last sentence states "Reestablishment of the bushing gas space blanket" however, many bushings do not have any gas blanket over the oil. Can be accepted if this portion of the statement is deleted. – Vinay Mehrotra
14. REJECT: Proposal is acceptable to me if " Reestablishment of the bushing gas space blanket and resealing of the bushing must also be performed in accordance with the bushing manufacturer's instructions following completion of the induced test" is replaced by "Venting/resealing of the bushing(s) shall be performed in accordance with the bushing manufacturer's recommendation." Reasoning – Not all bushing types have a blanket. – Ajith Varghese
15. REJECT: I reject the wording of the proposed statement. If gas bubbles appear in a bushing during the transformer induced test, damage may have occurred in the bushing

during said induced test. I would be satisfied if the bushing were vented to atmosphere or nitrogen, whatever gas is supposed to be in the expansion cap, as suggested, and an induced test at the bushing's appropriate voltage level is then placed on the bushing by itself. This should also include before and after power factor/capacitance tests and partial discharge tests during it induced test.– Loren Wagenaar

16. REJECT: If this practice is to be allowed, parameters of when to perform the practice should be included so as to require other diagnostic methods and only subjecting the bushing to air as a last resort. – Kris Zibert
17. ACCEPT (with changes): “If **partial discharges above the limit are measured** during the induced **test**, and appears to be generated within an OIP bushing, it is permissible to relieve **the gas in** the bushing to the atmosphere using the bushing manufacturer's instructions to allow for the dissipation of gas bubbles in the **liquid**. Gas bubbles sometimes form **during cool down** following a temperature rise test, or may be present for other reasons. Reestablishment of the bushing gas blanket and resealing of the bushing must be performed in accordance with the bushing manufacturer's instructions following completion of **all the tests**.” - Juan Castellanos
18. ACCEPT: The assumption is made that gas bubbles may have formed in the bushing as a result of the temperature rise test, which is legitimate - but not a proven conclusion. My concern is that there could be other factors playing a role – but hopefully this would show up in subsequent testing. Another concern is that the gassing in the bushing may have been caused because of a problem with the bushing, and venting the gas from the bushing without further investigation could potentially mask a problem that could cause a bushing failure later on, but that may not be detected during the testing. – Alwyn VanderWalt
19. ACCEPT: The topic of having to vent Bushings is an concern in our industry and there should be better solutions. However it is a good first step to include such a procedure in the standards clarifying how to deal with it. – Arnaud Martig
20. ACCEPT: This proposal is pretty good. I remind you that unless things have changed, ABB does not support relieving the gas. Their comment was that it will void the warranty on the bushing. You may want to follow up on that. In cases that venting is used on the test floor to resolve the issue of high pd, the only comment I would suggest adding is: “make sure that the induced test is fully repeated after the venting.” – Joe Melanson
21. ACCEPT (with changes): “If the partial discharge is observed during the induced testing of the transformer and appears to be generated within an OIP bushing(s), it is permissible to “vent” the bushing(s) to the atmosphere using the bushing manufacturer's instructions to allow for the dissipation of gas bubbles in the oil. **This « venting » procedure must be**

approved by the purchaser and documented in the transformer test report. Gas bubbles sometimes form following a temperature rise test during cool down or may be present for other reasons. Reestablishment of the bushing gas space blanket and resealing of the bushing must also be performed in accordance with the bushing manufacturer's instructions following completion of the induced test. – Art Del Rio

22. ACCEPT (offered changes): If the partial discharge is observed during the induced testing of the transformer and appears to be generated within an OIP bushing(s), it is permissible to “vent” the bushing(s) to the atmosphere ~~using the bushing manufacturer's instructions~~ to allow for the dissipation of gas bubbles in the oil. Gas bubbles sometimes form following a temperature rise test during cool down or may be present for other reasons. ~~Reestablishment of the bushing gas space blanket and resealing of the bushing must also be performed in accordance with the bushing manufacturer's instructions following completion of the induced test.”~~ Venting of the bushing(s) shall be performed in accordance with the bushing manufacturer's instructions.” - John Foschia
23. ABSTAIN: I infer from the text that purpose for venting the bushings is to remove trapped gas bubbles from the bushing insulation. Venting must be done in a dry atmosphere as hot core can easily absorb air humidity. One of the common failure of OIP bushings is moisture ingress. Therefore, I'm not sure if a bushing manufacturer will agree to guarantee a bushing performance when user vents it. I have no experience in this and so, I chose to Abstain. – Raja Kuppuswamy