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# AZT Investigation Report

**Report No.:** 03.02.019

**Client / Regarding:** Firma Starkstrom Gerätebau GmbH
Ohmstrasse 10
93055 Regensburg

**Order No. / VS No.:** Order No. 0502312 dated 4/2/2003, Martin Goertz

**Process No.:**

**Object:** Low temperature carbonization gas analysis of resin-encapsulated dry-type transformer components

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**Contents:** 3 Page(s)
Illustration(s)
3 Appendices

**Responsible:** Strohhäcker/lei/cs

**Date of issue:** 31/3/2003

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## 1. Requirements

The requirement was for the plastic components of a resin-encapsulated dry-type transformer to be carbonized at low temperature and the constituents of the carbonization gases to be identified. The combustion of proportional mixes of materials to derive the carbonization gases was carried out in accordance with DIN VDE standard 0532, Part 6, Appendix ZC.

The compositions of the supplied samples were as listed in Appendix 1.

## 2. Test set-up and performance

An aliquot amount of the mixtures was taken and carbonized in a tube furnace at 490 ℃ and 900 ℃ with an air flow of 60 I/h, the smoke gas co llected in a gas sampling cylinder and analysed in a gas chromatography / mass spectrometry analysis unit (manufacturer: HP).

The tests were performed in accordance with DIN 53 436 "Producing thermal decomposition products from materials in an air stream and toxicological testing thereof (Part 1)". The test temperature of approx. 490 ℃ was selected because this temperatur e is associated with the highest expected rate of dioxin formation. 900 ℃ is the typical flame te mperature in fires. In preliminary tests it was found that there were no significant differences in the composition of the smoke gas between the beginning and the end of the test, such that for the purposes of the analysis an average test sample of the smoke gas was used. As agreed, repeat determinations were made.

## 3. Test results

Appendices 2 and 3 show the percentage breakdowns of the smoke gas compositions at the carbonization temperatures of 490 ℃ and 900 ℃.

It is evident from the test results that the two carbonization temperatures produce differences both in terms of the gas components and the concentrations involved. The test temperature of 490 ℃ results in the generation far fewer gaseous, organic carbonization products (- 5%). These are mainly

styrenes and benzaldehydes, long-chain hydrocarbon compounds (benzenes), phenols, and non-halogenated furans and cyclohexenes.

At the test temperature of 900 °C the gaseous, orga nic carbonized gas concentrations are approx. 35%, the main element of which is comprised of long-chain hydrocarbon compounds (approx. 31%). In addition, styrenes and phenol and non-halogenated furans were also identified.

The composition of the carbonization gases, given the test set-up used and the associated resultant test conditions, is not directly comparable with the composition of the smoke gases in a real-life fire because of the possibility of different gas concentrations and components occurring in dependency on the temporal development of the fire and different temperature profiles, plus the possible involvement of other combustible substances as well (compare, for example, the data for 490 °C with the data for 900 °C). In principle it c an be said that, as in every fire, organic materials will be found in this particular case as well which have to be classified as “harmful to health”.

## 4. Conclusion

The purpose of the investigation was to check for the presence of smoke gas components as required, for example, by DIN VDE standard 0532, Part 6, Appendix ZC (Practical guidelines for special test trials for the verification of fire behaviour classes).

In conclusion, the results of the analyses show that the listed conflagration gas components were identified but that no halogen hydrocarbon components were identified.

# Analysis of carbonization gas

| Type | Designation | Weight in kg | ing | Material No. | Material |
|---|---|---|---|---|---|
| Core | Corrosion protection, core | approx. 5 kg | 3.39 | M213407/ M213408 | Acrylic resin / polysiocyanate |
| | Connecting rod shim | 0.150 | 0.10 | M218149 | NOMEX |
| | Insulation shim | 0.120 | 0.08 | M218115 | NOMEX |
| | Core support | 0.760 | 0.51 | M216082 | Hm (resin bonded glass) |
| | Distance bar | 0.360 | 0.244 | M218130 | HGW (laminated fabric) |
| | Column lining | 0.159 | 0.11 | M208461 | Polyester |
| | | | | | |
| Support/ holder | Insulating bushing - 40-material | 0.156 | 0.105 | M113044 | GFRP – |
| | Insulating cylinder - 30/20* | 0.476 | 0.32 | Ml 13047 | GFRP |
| | Insulating bushing – 50-mat. | 0.240 | 0.16 | M I13045 | GFRP |
| | Elastic support (Rubber support, plate, block support, core rail ) | 9.298 | 6.30 | | EPDM |
| | Rubber support | | | M211115 | EPDM |
| | Plate | | | M218210 | EPDM |
| | Block support | | | M114392 | EPDM |
| | Item strip 0 16 | | | M208761 | EPDM |
| | Disc (foam rubber) | 0.019 | 0.012 | M216345 | Foam rubber |
| | Pin insulator (Permali) | 1.350 | 0.91 | M209823 | Polyester GFRP |
| | Adhesive dots (block) - 60 | 0.072 | 0.05 | M213219 | Duplomat |
| | | | | | |
| Low voltage | Interlayer insulation | 7.560 | 5.12 | M211412 | Voltaflexpreg |
| | KTF tubes | 0.023 | 0.02 | M2.14780 | Polyamide |
| | Shrink-fit lining | 1.00 | 0.68 | M207021 | Vliespreg |
| | | | | | |
| High voltage | High voltage insulation | 118.2 | 80.05 | M218102 / M218103 / M103973 / M103974 / M103975 | Epoxy resin, etc. |
| | | | | | |
| Coil connector | Shrink-fit hose | 0.378 | 0.26 | M113131 | Ethylene propylene rubber |
| | | | | | |
| Other | Insulating hose 0 4-7mm | 0.035 | 0.02 | M213305 | Polyurethane |
| | Thermoelements | 0.016 | 0.01 | M21800x / M215156 | PTFE |
| | Terminal strip | 0.082 | 0.06 | M218010 | Polyamide |
| | Nameplates (high voltage/low voltage side) | 0.0455 | 0.03 | M20977(0...2) | Resopal |
| | Barrier cylinder (1225 x 900) | 2.035 | 1.38 | M215306 | Combimat |
| | Spacer – barrier cylinder | 0.122 | 0.08 | M218145 | GFRP |

Σ 147.65kg 100g

Appendix 1

**Report No.: 03.02.019/01**

## Test Order: Low temperature carbonization gas analysis

**Responsible:** str
**Laboratory assistant:** rei
**Sampling:**
**Date of receipt:** 20/2/2003

**Sample designation:** **Item.1 / Temperature 490 ℃**
**Item.2 /Temperature 900 ℃**

**Terms of reference:** Low temperature carbonization gas analysis of resin-encapsulated dry-type transformer components

**Preparation:** All the components in the transformer were weighed in proportionally to 1g and burnt at 490 ℃ and 900 ℃ with an air flow of 60 1 air/min.

**Results:**

**Item 1**

| No. | Component | Qty in % |
|---|---|---|
| 1 | Air (including generated CO2 and CO) | 95.012 |
| 2 | 2-Nonynoic acid | 0.051 |
| 3 | 2-Propenoic acid, 2-methyl-, methylester | 0.312 |
| 4 | Benzene, methyl | 0.166 |
| 5 | Heptane, 3-methylene | 0.503 |
| 6 | Styrene | 2.277 |
| 7 | Benzaldehyde | 0.299 |
| 8 | Benzene, (1-methylethenyl)- | 0.105 |
| 9 | Benzene, 1, 2, 3-trim ethy l- | 0.123 |
| 10 | Cyclononyne | 0.129 |
| 11 | Benzene, 1-ethyl-, 4-methyl- | 0.063 |
| 12 | Phenol, 2-methyl- | 0.121 |
| 13 | Propanal, 3-phenyl- | 0.033 |
| 14 | Benzfuran, 4,7-dimethyl | 0.015 |
| 15 | 2-Propenoic acid, 6-methyheptylester- | 0.067 |
| 16 | Benzfuran, 4,6-dimethyl | 0.021 |
| 17 | Benzonitril, 4-(dimethylamino)- | 0.022 |
| 18 | 1,3-Isobenzofurandione | 0.128 |
| 19 | Cyclohexene | 0.444 |
| 20 | 1,2-Benzoquinone | 0.026 |
| 21 | Propanoic acid, phenyl-, methylester- | 0.025 |
| 22 | 1,2 Benzenedicarboxylic acid, diethylester | 0.022 |

**Report No.: 03.02.019/01**

**Test Order: Low temperature carbonization gas analysis**

**Responsible:** str
**Laboratory assistant:** rei
**Sampling:**
**Date of receipt:** 20/2/03

**Item 2**

**Results:**

| No. | Component | Qty in % |
|---|---|---|
| 1 | Air (including generated CO2 and CO) | 65.176 |
| 2 | Benzene | 24.18 |
| 3 | Benzene, methyl- | 5.839 |
| 4 | Benzene, ethyl- | 0.429 |
| 5 | Benzene, 1,2-dimethyl- | 0.347 |
| 6 | Benzene, ethynyl- | 0.413 |
| 7 | Styrene | 2.316 |
| 8 | Benzene, 1,2,3-trimethyl | 0.127 |
| 9 | Phenol | 0.124 |
| 10 | Benzene, (1,methylethenyl)- | 0.171 |
| 11 | Benzofuran | 0.238 |
| 12 | 1 H-Indene | 0.088 |
| 13 | Phenol, 2-methyl- | 0.061 |
| 14 | Naphthalene | 0.028 |
| 15 | Phenol, 3-(1-methylethyl)- | 0.021 |
| 16 | 1,3-Isobenzofurandione | 0.121 |
| 17 | Cyclohexene | 0.121 |
| 18 | 1,2 -Benzenedicarboxylic acid, diethylester | 0.004 |

Appendix 3