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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

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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