ENVIRONMENTAL, LEGISLATIVE AND TECHNOLOGICAL ASPECTS OF THE METHODOLOGY FOR SELECTING NON-AQUEOUS WORKING BODIES FOR POWER PLANTS

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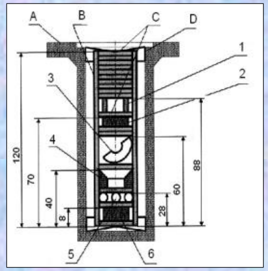
Aims:

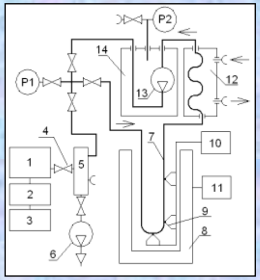
- to prove availability and show thermodynamic advantages of using fluorocarbon compounds as working fluids for thermal and nuclear power plants
- to refute adopted by IPCC-94 methods in calculating lifetime of fluorocarbon compounds in atmosphere and thus eliminate existing greenhouse effect restrictions for its wide use in energy
- to show thermal stability of octafluoropropane (C_3F_8) and decafluorobutane (C_4F_{10}) (under heating up to 650°C)
- stability evaluation of C_3F_8 and SF_6 after α- , β- and γ-irradiation

Materials & Methods:

- Continuous thermal action was carried out in a steel sealed capsule, placed in a muffle furnace. The complete cycle of gas circulation in the loop was 3.5 seconds. About 25,000 cycles of heating to 500-600°C and cooling to 18-20°C. Samples of structural materials were placed. Sample connected to a sample feed system in a MI-1201 mass spectrometer. Samples: nickel (NP-2), steel 95X18, aluminum AD-0, titanium of grade OT2, structural steels.

- Direct irradiation was performed at the experimental reactor IRT-2000 in NNIU MEPhI (Moscow). The spectra were recorded on a MI-1201b mass spectrometer as samples arrived after their irradiation. The dose rate of gamma radiation was 15-20 X-ray/sec (P/s). The duration of exposure was 50 days, which according to the intensity of the collected radiation dose corresponded to 80 ± 15% Mrad.





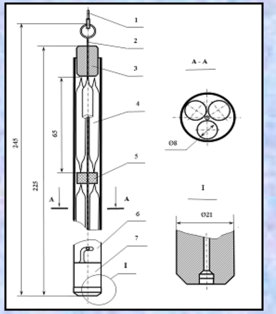


Table 6 – Results of the analysis of C_3F_8 after γ-irradiation

M/e	Ion	Feed gas Peak M/e 69-100%	After 50 days of irradiation and holding for 8 days
31	CF^+	7.44	8.63
43	C_2F^+	0.15	0.37
50	CF_2^+	3.10	4.10
62	$C_2F_2^+$	0.32	0.40
69	CF_3^+	100	100
74	$C_3F_2^+$	0.10	0.13
81	$C_2F_3^+$	0.50	0.53
93	$C_3F_3^+$	0.38	0.44
100	$C_2F_4^+$	6.10	5.58
119	$C_2F_5^+$	8.16	8.71
131	$C_3F_5^+$	0.10	0.17
169	$C_3F_7^+$	25.35	16.95
85	Impurity SiF_4	0	2.30

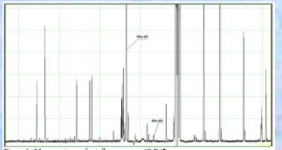


Figure 6 – Mass spectrum of octafluoropropane (C_3F_8)

T, °C		Cat	F^+ 19	CF^+ 31	C_2F^+ 43	CF_2^+ 50	C_3F^+ 55	75	SiF_4^+ 85	$C_3F_3^+$ 93	$C_3F_4^+$ 112	$C_2F_5^+$ 119	$C_3F_5^+$ 131	$C_3F_6^+$ 150	$C_3F_7^+$ 169	$C_4F_7^+$ 181	$C_4F_9^+$ 219
500	Cycle	-					↓						↑				
600	Cycle	-			↓	↑	↓			↑		↑	↑	↑	↑	↑	↑
610	Const	-		↑		↑			↑				↓	↓			↓
640	Const	+		↑	↑	↑	↑	↑	↑			↓	↓	↓	↑	↑	↓
650	Cycle	-	↓	↑		↑			↑	↑	↑	↓	↓	↓	↑	↑	↑

Results & Discussion:

a. Known that number of thunderstorms ("atmosphere cleaners“) on Earth in a year is about three billion. This fundamentally changes the meaning of the limitations on the greenhouse effect on the basis of Lifetime, which existed since 1994 due to the estimated value of the lifetime of various gases in the atmosphere published in IPCC-94. Data of IPCC-2013 is now sufficient for a justified adjustment of the lifetime for the gases mentioned above. Real life-time data derived from material balances remove from the fluorocarbons the greenhouse effect limitations that have existed since 1994 due to the published estimates in IPCC-94 for Lifetime for the fluorocarbon atmosphere. At the same time, the fact that CF_4, the most stable fluorocarbon, is inflated by several orders of magnitude in IPCC-94 is undoubtedly true. Based on calculations based on material balances, it exists in the atmosphere for no more than two years!

b. Thermal stability of fluorocarbon compounds (C_3F_8, C_4F_{10}) under constant and cyclic heating in the presence of structural materials containing catalysts. The temperature of the beginning of the thermal decomposition of C_3F_8 is 630°C, C_4F_{10} is 600°C. The temperature of 600°C can be considered the boundary of the thermal corrosion resistance of the structural materials in the fluorocarbon medium.

c. The stability of C_3F_8 under the action of α- and β-radiation with activity of 1.2×10^7 and 3.2×10^7 Bq has been confirmed (no noticeable effects in the mass spectra of the gas after irradiation have been detected). The effects of exposure to high doses of γ-irradiation on SF_6 and C_3F_8 have been determined experimentally. The validity of the technique for the use of the SiF_3^+ ion as an indicator of the appearance of a free ion of F^+, indicating the onset of the destruction of fluorocarbons and the occurrence of conditions of deep corrosion in structural materials, was confirmed.

Conclusions:

Fluorocarbons are promising for use as a substitute for working bodies that are prohibited for ozone hazard. Lifetime overestimate under IPCC-94 assessment for fluorocarbon CF_4, gives grounds for removing restrictions on the use of fluorocarbons on the basis of the greenhouse hazard and creates the conditions for studying the technological properties of fluorocarbons.