DETERMINATION OF CF_3J INERTING CONCENTRATION METHANE-AIR AND HEPTANE-AIR MIXTURES

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One of the main indices that characterize the efficiency of the substance used for the fire-fighting agent is its minimal inerting concentration (MIC) for vapour/gas/air blends of combustible substances.

A lot of published data is available on MIC for various substances considered as perspective fire-fighting agents. The scatter in the MIC values is very large. They were obtained for plants with various volumes of test vessels, various igniters and various combustible blends. There is evidence for the considerable growth of the obtained MPC values with the vessel volume and the igniter capacity [1, 2].

To obtain comparative data for the complete raw of fire-fighting agents under study we in our institute determined MIC for each vapour/air blend of n-heptane at the same unit and using the same technique.

The tests were carried out at atmospheric pressure and ambient temperature in a glass (pyrex) vertical cylinder 80 mm in diameter and 240 mm in height. An organic glass grinded plate was used for the vessel bottom, it bounced at explosion thus preventing the vessel from damage. Ignition was initiated with spark discharge from automotive igniting system, the igniter starting period was up to 10 sec, the spark gap was 6-7 mm. The amount of energy transferred during 3 sec from the igniter to the gas was about 4 J as it was estimated from the pressure rise within the nitrogen-filled vessel. The igniter was located along the vessel axis at about 1/3 of its height from the bottom. The fact of ignition was observed visually. The obtained data are presented in the table below.

Inerter	**MIC, % vol..**
CF_2ClBr	7,9 - 8,1
CF_3Br	8,3 - 8,7
CF_3CFBrH	8,0 - 9,0
CF_3J	8,8 - 9,0
C_2F_5J	7,7 - 8,0
$H(CF_2)_4H$	8,8 - 9,0
C_2F_5H	15,5 - 16,0
CF_3CFHCF_3	9,8 - 10,0
CO_2	35,5 – 36,0

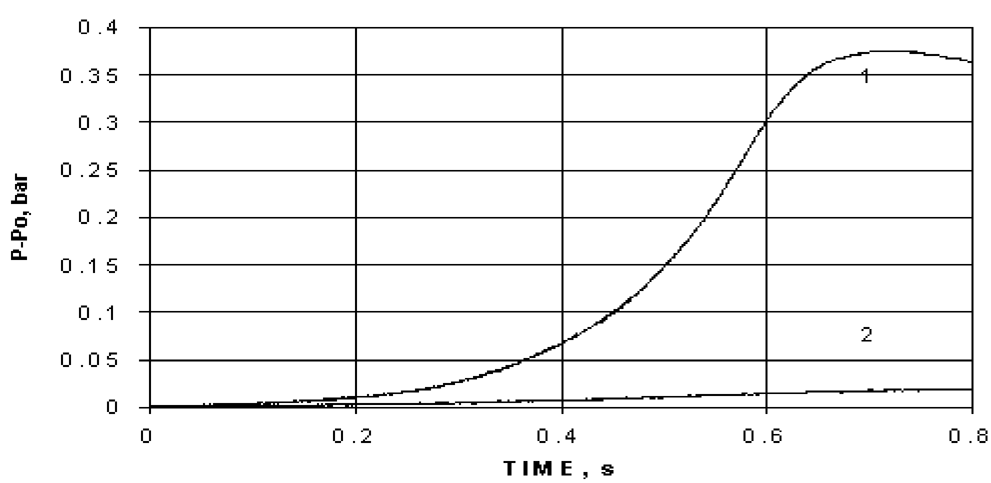
The presented data, save for CF_3J и C_2F_5J, do agree with the well-known literature data. As far as it concerns CF_3J and C_2F_5J, it must be underlined that those two substances are usually mentioned as the most efficient fire-fighting agents and the MICs given for them are much lower than those shown in the table.

In this connection and also taking into account the above-mentioned probable dependence of the MIC on the volume of the test-vessel and the capacity of the igniter, we carried out additional testing of CF_3J as inerting agent for heptane/air and methane/air blends.

The blends were tested in a vertical cylindrical stainless steel autoclave of volume 4,8 l (148 mm in diameter). The explosion pressure was recorded with the help of a low-inertial sensor (the eigenfrequency of the sensor membrane vibrations was no less than 10 kHz), electronic transformer and digital oscilloscope. The pressure sensor was located at the upper edge of the autoclave. The igniter was placed at 20 – 30 mm from the bottom of the autoclave near to its axis. A piece of nichrome wire (0,25 mm in diameter, 12-13 mm in length) fused with electric voltage (180V) was used for igniter. The amount of energy transferred during 3-4 msec from the igniter to the gas was about 10 J as it was estimated from the pressure rise within the nitrogen-filled vessel.

The fact of ignition was determined from the form of the pressure curve registered in the autoclave after the response of the igniter (Fig.1). CF_3J contained no less than 97 % of the main substance, C_3F_7J being the chief impurity. Both the composition and the homogeneity of the blend were checked by chromatography prior to testing.

Fig. 1. Oscillogram of pressure



1 - CH_4 - 6 %, vol, CF_3J - 45 %, vol, "explosion"
2 - CH_4 - 6 %, vol, CF_3J - 50 %, vol, "no explosion"

The result was quite unexpected. We started with testing a blend that contained CH_4 (6 % by vol.) and CF_3J (5 % by vol.) and to achieve the combustible blend inerting we had to increase the content of CF_3J up to 50 % (Fig. 1). It exceeded even MIC established for carbon dioxide and nitrogen. But even 50% of CF_3J was found to be insufficient for inerting of vapour/air blends with heptanea (2,6 % by vol.). The same technique was applied in control tests with CF_3CFHCF_3 and CF_3Br used for inerting agents with methane/air and heptane/air blends. The obtained results only a little differed from those shown in the table (11 – 12 % by vol. and 9 – 11 % respectively).

Then we carried out control tests with CF_3J in the glass vessel (see above). A piece of nichrome wire (0,25 mm in diameter, 12-13 mm in length) fused with electric voltage (80V) was used for igniter. The voltage here applied was reduced, because 180V was too high for the small (1,2l) vessel and extremely bright response flash made it difficult to control the process visually. The tests have shown that in this case as well MIC CF_3J was much higher than 20 % (the precise value was not determined).

Therefore, it was the igniter and not the vessel volume that was found to be the governing factor in the observed growth of MIC CF_3J.

The fact that the MIC CF_3J thus obtained exceeded MIC both for carbon dioxide and for nitrogen, though specific heat capacity of CF_3J exceeds considerably those of these two gases, is clear evidence for participating of CF_3J in combustion process that results in increase of heat releasing. Thermodynamic calculations have shown, e.g., that for the blend heptane(2,6%vol.)/CF_3J(50%)/air(remains) participating of CF_3J in the combustion process that results in HF, CF_2O, CF_4 and soot, would grant 2,3-3 times increase of the related combustion heat as to compare with heptane oxidation by oxygen, if only CF_3J were an inert component. It is our opinion that this explains very well the absence of CF_3J inerting action when introduced into a combustible blend. The considerable amount of iodine among other combustion products revealed at disassembling and cleaning of plants confirm this our hypothesis as well.

It should be underlined that mathematic simulation of possible participating of other halocarbons, particularly, CF_3CFHCF_3 and CF_3Br, in combustion give similar results. And the stronger is the inerting molecule, the lower is the increase of the heat effect. Besides, the stronger is the inerting molecule, the lower is the probability of its involvement in the combustion process, and the higher is the needed capacity of the igniter. Perhaps it may explain why in our experiments there was not recorded considerable augmentation of MIC for $CF_3CFH\ CF_3$ and CF_3Br with the igniter capacity increase. However, it is known [2], that with even more high-powered pyrotechnic igniters one may observe considerable increase of MIC CF_3Br for methane/air blends (up to 18 %), while MIC $CF_3CFH\ CF_3$ were practically unchanged.

CONCLUSIONS

1. It is revealed that the igniter has strong influence on the experimental results of MIC CF_3J determination.
2. It is shown that for its inerting action CF_3J, apparently should not be considered as a perspective fire-fighting substance.

REFERENCES

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