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THE EFFECT OF ICING INHIBITOR ADDITIVES ON THE FLASH POINT OF H--ETC(U)
AUG 68 W A AFFENS, G W MCLAREN

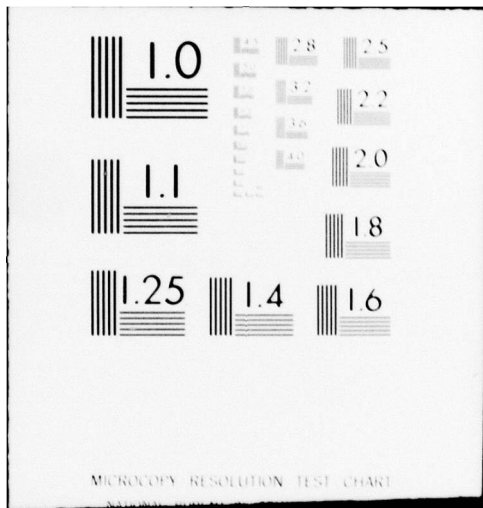
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6180-122A:WAA:GWM:ec

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Subj: (6) The Effect of Icing Inhibitor Additives on the Flash Point of Hydrocarbon Fuels,

- Ref:
- (a) Ross, K., "The Vapour Pressure of Aviation Turbine Fuels at Temperatures Below 200°C", Report K. 175, Thornton Research Centre, "Shell" Research Ltd., Chester, England, March, 1968
 - (b) MIL-J-5624F, Military Specification, Jet Fuel, Grades JP-4 and JP-5, 25 Sept 1962
 - (c) MIL-I-27 686D, Military Specification, Inhibitor, Fuel System Icing, 11 February 1963
 - (d) Affens, W.A., "Flammability Properties of Hydrocarbon Fuels, Part 3 - Flammability Properties of Hydrocarbon Solutions in Air", NRL Report 6617, 21 November 1967.

INTRODUCTION

12 5 p1
 A recent report of research at the Shell Thornton Research Centre in Chester England (reference (a)) described some interesting vapor pressure and flash point work for kerosene and JP-5 type jet fuels. The Shell researchers measured the effect of temperature, vapor/liquid ratio (ullage), and icing inhibitor additives on the vapor pressure and flash point of some jet fuels. By means of a survey study of samples taken from the field, they found that the average vapor pressure of fuels containing small concentrations of ethylene glycol monomethyl ether (methyl cellosolve) icing inhibitors was significantly higher than those fuels which did not contain the inhibitor. → p. 2

There is a very important implication to flammability hazard in these findings because an increase in vapor pressure of a fuel mixture would be expected to cause a corresponding decrease in its flash point temperature. Therefore, it was decided to make an immediate (although limited) investigation of the effect of this additive on the flash point temperatures of pure hydrocarbons, and a sample of JP-5 jet fuel. The Shell work was not done on pure hydrocarbons, nor was the effect of icing inhibitor additive measured directly, i.e., no controls were used in their study.

Encl (1) to NRL ltr 6180-122:WAA:GWM:ec
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The Military Specifications for JP-4 and JP-5 jet fuels (reference (b)) require the use of from 0.1 to 0.15% icing inhibitor additive in JP-4, but none is permitted in JP-5. The additive consists (reference (c)) of 99.6% (v/v) ethylene glycol monomethyl ether and 0.4% (v/v) Glycerine. We chose to study this effect on JP-5 jet fuel, since of the two fuels, only JP-5 (which is intended for use on aircraft carriers) has a minimum flash point requirement (140°F). It would be important to evaluate the effect of the additive in case it is considered for future use in JP-5, or should it be present in this fuel unintentionally.

EXPERIMENTAL

The flash point determinations were made by means of a Tag Closed Cup Tester within the concentration range of 0 to 1% icing inhibitor. Because the additive has limited solubility in hydrocarbon fuels, it was found necessary (especially at concentrations above 0.1%) to shake the mixture of fuel and icing inhibitor additive vigorously before measuring the flash points in order to get reproducible data.

RESULTS AND CONCLUSIONS

The results ^{showed} are shown in Table I and Figure 1. In the plot, (Fig. 1) the depression of flash point temperature with increasing additive concentration is evident. It is noted that there is a reduction of flash point temperature of 5 to 6°F in both curves in mixtures containing 0.15% inhibitor (the maximum allowable concentration for JP-4 in the Specification). It has been shown (reference (d)) that hydrocarbon solutions follow Raoult's Law in regard to vapor pressure, and flash point. The relatively large decrease in flash point temperature for icing inhibitor additives in hydrocarbon fuels is much greater than expected from consideration of Raoult's Law. The flash point temperature of the additive itself was found to be 113 F. Based on Raoult's Law, a hydrocarbon of approximately this flash point, and at such a low concentration, would be expected to decrease the flash point of the original hydrocarbon only a fraction of a degree (reference (d)).

Although this additive is not authorized for use in JP-5 jet fuel at this time, if consideration is ever given to removing this restriction, the effect on the reduction in flash point temperature will have to be given serious consideration. Either

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it will be necessary (besides limiting the concentrations of additives permitted) to lower the 140⁸F minimum requirement of the specification, and thus increase the flammability hazard of the fuel; or, on the other hand, maintain the present flash point requirement of the specification for fuel plus additive, thus in effect raising the flash point minimum for the basic fuel itself, and perhaps increasing its cost, and decreasing its availability.

No explanation for this phenomenon can be given yet. However, if one is permitted to speculate, it is tempting to hazard a guess as to why the icing inhibitor has such a large influence on the flash point temperature. It is most likely to begin with that the reduction in flash point temperature is due to an increase in the total vapor pressure of the mixture, or to deviation from Le Chatelier's Rule on flammability of mixtures (reference (d)), or both. First, let us consider what would happen if what is involved is a matter of immiscibility of solvents. If two phases are formed, the total vapor pressure would be the sum of the independent vapor pressures (rather than their partial pressures), and therefore would be higher. However, in our work, two definite phases (a slight opalescence was observed) were not produced, nor is there a break in the curve (Fig. 1) as would be expected in such a case. This concept is a fascinating one and is worthy of future study. A second possibility is that there is a large deviation from Le Chatelier's Rule. Proof of this would require a knowledge of composition and flammability limits of the vapor phase over fuel-additive mixtures. A third possible explanation is the formation of a low flash point "azeotrope". Whatever the explanation, the matter of small concentrations of one substance unduly increasing the flammability hazard of another is of concern (in addition to having interesting scientific implications), and the Navy must be wary of such possibilities in actual practice.

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Table I

(a)
Effect of Icing Inhibitor on Flashpoint
of Hydrocarbons

Concentration of Icing Inhibitor (% v/v)	Flashpoint (^o F)		(c)
	N-Undecane	JP-5	
0	148	139	
0.0188	147	-	
0.0375	146	137	
0.0750	145	136	
0.0990	144	135	
0.150	144	134	
0.200	141	133	
0.398	134	128	
0.498	132	-	
0.596	-	123	
0.695	126	122	
0.892	123	120	

(a) Phillips Petroleum Co. Icing Inhibitor 5MB3
(Flashpoint 113^oF found)

(b) Tag, Closed Cup

(c) JP-5 Jet Fuel, Sample No. J-439

FIG. 1 EFFECT OF ICING INHIBITOR ON FLASH POINT OF HYDROCARBONS

