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SUBJECT: Possible Substitutes for Freon-11 in HRT Cold
Trap Refrigeration System

TO: W. R. Gall

FROM: R. C. Robertson and J. E. Kuster

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As has been mentioned in a previous report⁽¹⁾, the radiation effects on Freon-11 may require that another liquid be substituted in the HRT cold trap circulating system. Sulfur dioxide has been considered⁽²⁾, but its relatively high toxicity is objectionable. This memorandum suggests that tetrahydronaphthalene ($C_{10}H_{12}$) is a better substitute than SO_2 and also discusses use of chilled water as a coolant if the problem becomes acute.

Mr. John Kuster has called attention to the fact that the coolants considered for the Sodium Graphite Reactor have been xylene, toluene, and tetralin, or tetrahydronaphthalene. The first two have low flash points (63 F and 40 F, respectively), are explosive in concentrations of 1 to 7% volume, and are thus considered a fire hazard. They are also toxic, with allowable concentrations of about 200 ppm.

Tetralin has a higher flash point (171 F) and is considered less of a hazard. It is also less toxic⁽³⁾. It is in the liquid phase from about -22 F to 405 F at atmospheric pressure. Its resistance to radiation and corrosive action on iron and aluminum have been investigated⁽⁴⁾. Tetralin was irradiated at 150 F in the MTR gamma facility over the dosage range 0.5 to 3.6×10^8 roentgen. Radiation resistance was evaluated on the basis of gas evolution. At 2.1×10^8 R, and based on a 3-year exposure, the gas evolution would be 0.15 ml/gm and the penetration of both iron and aluminum would be 0.01 mils/3 years. Corrosion and radiation-induced corrosion effects were considered negligible for the SGR application.

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- (1) "Radiation Damage to Freon", Michelson, 9-30-55, CF 55-9-163.
 - (2) "Use of SO_2 Rather than F-11...", Robertson, 12-9-55, CF 55-12-50.
 - (3) Readily-available data on toxicity only general in character.
 - (4) Sodium Graphite Reactor Quarterly Progress Report, Apr-June 1955, NAA-SR-1457, page 31 (Confidential).

Tetralin has a vapor pressure of only 0.51 psia at 212 F, a density of about 60.6 lbs/cu ft, a specific heat of about 0.4 Btu/lb F, a viscosity of about 3.9 centipoise at -20 F, and would thus have satisfactory pumping and heat transfer characteristics. While not permitting a temperature of -40 F (the HRT design valve) because of its -22 F freezing point, tetralin does appear to offer some possibilities as a replacement for the F-11. The effect of raising the exit oxygen temperature from the cold traps to about 10 F is shown in the table, following.

Should selection of a secondary refrigerant prove to be a major operation problem, the use of pure water may be mentioned. Raising the exit temperature of the cold traps to 40 F does not greatly affect the rate of D₂O deposition but does greatly increase the partial pressure of the water vapor in the mixture fed to the charcoal absorber beds. Relative values are shown in the table. While the chilled water system would obviously have no utility insofar as freeze jacket operation is concerned, and the increased partial pressure of the water vapor may reduce the effectiveness of the charcoal beds, water could be considered as a last resort without a great sacrifice in D₂O economy.

EFFECT OF COLD TRAP EXIT TEMPERATURE

	Gas Temp. at Cold Trap Exit			
	-20 F	-10 F	+10 F	40 F
pp H ₂ O, psia	0.00602	0.0108	0.0309	0.1217
Exit Spec. Hum. (a)				
lbs D ₂ O/lb O ₂	0.0002509	0.0004503	0.001291	0.005112
Lbs D ₂ O deposited/lb O ₂ (b)	0.1086	0.1084	0.1076	0.1038
Lbs D ₂ O deposited/24 hrs (c)	2.210	2.206	2.190	2.112

(a) Based on total assumed pressure of 15 psia and ignoring partial pressure of xenon and krypton. Spec. Hum. = $\frac{p_{D_2O} \text{ Mol. Wt. } D_2O}{p_{O_2} \text{ Mol. Wt. } O_2}$

(b) Based on entering O₂ stream at 130 F and saturated with D₂O.

(c) Based on oxygen flow rate 0.848 lbs/hr.