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Report on
Aviation Gasoline:
Study of the Effect on Gasoline Stored
in Duprene-lined Hose.

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ABSTRACT

In this report are given the results of a study of the effects on aviation gasoline of storage in Duprene-lined hose. The results show that such storage does not affect the octane rating but does increase the "gum" content of the gasoline. After repeated extractions, however, the amount of extraction products can be kept below 10 milligrams/100 c.c. provided that the storage contents of the hose are mixed with 10 or more gallons of gasoline which has not been stored in Duprene.

The use of Duprene-lined connectors on the gasoline line from the tank to the carburetor may give a high "gum" content for the first 150 c.c. (6 oz.) of gasoline delivered to the engine. This Laboratory does not know if this is undesirable.

INTRODUCTION

(a) Authorization

1. This problem was authorized by Bureau of Aeronautics Project Order No. 76/36 of 7 December 1935, Bureau of Construction and Repair fifth endorsement JJ7-6(S) of 27 November 1935, and Bureau of Aeronautics letter Aer-E-46-MN JJ7G1 of 20 January 1936.

(b) Statement of Problem

2. The original problem was to investigate the stability and corrosive effect of 100 octane fuel when stored over salt water. In this report is discussed the effect on the gasoline of storage in Duprene-lined hose such as used aboard ship for fueling planes. The gasoline has been studied primarily to ascertain the effect on the gum content and secondly, to determine the effect on the octane rating.

(c) Known Facts Bearing on the Problem

3. Bureau of Aeronautics letter Aer-E-46-MN JJ7G1 of 30 January, 1936, gives an extract from Pan American Airways letter of 16 January 1936, as follows:

*** "In reply to your postscript, we wish to state that the use of the Duprene hose; i.e., Delmar DB, was discontinued not because it adversely affected the octane rating of the gas but because it affected the gum content. Gasoline coming out of this hose showed in laboratory tests a gum content as high as 300 mgs./100.c.c. While we do not definitely know that such a high gum content would have had bad effects on our engines, we do know that this is far in excess of the amount of gum which is allowed in the gasoline as purchased from the vendor. Under our purchase specifications, we reject all gasoline which shows higher than 10 milligrams of gum per 100 c.c.

"In confirmation of this peculiar peculiarity of the synthetic hose experienced during actual service tests, we have run laboratory tests on 2' 1-1/2" inside diameter sections of hose. Gasoline stored in these sections of hose for periods of one day and seven days show that not only is the gasoline contaminated to the point that it shows as much as 380 mgs. of gum per 100 c.c., but also to the point that the hose loses as much as 38 grams of weight during that period. "

For a discussion of "Duprene" see "The Economics of Synthetic Rubber" in Chemistry and Industry, May 29, 1936, page 429, by E. R. Bridgewater.

(d) Theoretical Considerations

4. In the study of this Duprene hose two factors should be considered: first, the increase or decrease in the octane rating during storage when in contact with Duprene-lined containers, and second, the change of the gum content of the gasoline as a result of storage. The gum content was determined in this report by the evaporation of 100 milliliters in a glass dish under prescribed conditions. It should be noted that the gum content as found by this method may not be gum as normally considered in the technical literature, but extraction products from the hose itself. Gum as normally found, due to the oxidation of the hydrocarbons in the gasoline, will form a tough film over the surface of the glass when a sample of gasoline is evaporated.

(e) Original Work at this Laboratory

5. In NRL Report No. P-1224 is found the octane rating given of gasoline stored in a rubber container made from Thiokol. In this report is given the study of gasoline that has been stored in Duprene-lined hose.

METHODS

6. Two lengths of new Duprene-lined hose were received from the Naval Aircraft Factory, Philadelphia, Pennsylvania, under shipment Order No. Aer-Ser 9205. These hoses were (1) washed with water, (2) scrubbed with a cloth, (3) steamed by passage of low pressure steam for one hour, (4) washed with a cloth and water to remove any surface that had become loose, and (5) washed again with distilled water and dried. After drying, the hose was scrubbed with gasoline to remove any gasoline-soluble materials. The hose samples were numbered 1 and 2. The first tests were run for 24 hours storage. After several such tests, a 144-hour test was made to note if the extraction from the hose had been completed. After several runs of this type the hose was treated with benzol, but this is not recommended due to the fact that the hose became exceedingly stiff and it was necessary to let the benzol evaporate that had been absorbed by the hose itself.

7. A final test was made with two small unions of Duprene-lined hose with aluminum tubing between. The relationship between the volume of the gasoline in storage and the area of the Duprene sections exposed were the same as that found aboard a plane for the connections from the gasoline tanks to the carburetor. This test was allowed to run for 72 hours to note the amount of materials extracted from the hose with gasoline.

DATA OBTAINED

8. The data obtained are given in the following table:

<u>Hose</u>	<u>Gasoline</u>	<u>Exposure</u>		<u>Gum</u> <u>Content:</u>		<u>Sulfur Content</u>			<u>% Gain</u> <u>per</u> <u>100 Mgr. Gum</u>
		<u>1936</u>	<u>Hrs</u>			<u>%</u> <u>Formed</u>	<u>%</u> <u>Blank</u>	<u>%</u> <u>Gained</u>	
1	5	3-11	24	644	:	0.043	0.009	0.034	0.005
2	6	"	24	527	:	0.047	0.012	0.035	0.007
1	1	3-12	24	441	:	0.049	0.025	0.024	0.005
2	2	"	24	217	:	0.026	0.014	0.012	0.006
1	4	3-13	24	88	:	0.020	0.009	0.011	0.013
2	3	"	24	127	:	0.025	0.016	0.009	0.007
1	6	3-16	24	180	:	0.023	0.011	0.012	0.007
2	5	"	24	280	:	0.030	0.009	0.021	0.007
1	1		144	493	:	0.037	0.025	0.012	0.003
2	2		144	1003	:	0.046	0.014	0.032	0.003
2	4		163	228	:	0.023	0.009	0.014	0.006
1	3		163	375	:	0.033	0.016	0.017	0.005
1	1		17	92	:	0.028	0.025	0.003	0.003
2	1		17	59	:	0.028	0.025	0.003	0.005
1*	-		72	42	:	0.025	0.025	0.000	0.000

#1 from Naval Air Station, Anacostia, D.C.

* Special apparatus made up for this test.

DISCUSSION

9. Duprene-lined hose should be considered as a hose that has an inside lining of a polymerized hydrocarbon. This polymerized hydrocarbon has a certain solubility in a gasoline as a solvent and the amount dissolved will vary with the gasoline studied, with the age of the hose, with the length of time exposed, and the temperature at which the extraction is made. The material that is removed is not the true gum that is formed due to the oxidation of unsaturated or readily oxidizable material found in gasoline, but is the material that is used to make the Duprene lining in the hose. The composition of this material is probably carbon, hydrogen, chlorine, and some oxygen. The gummy residue, when the gasoline has been evaporated, is not the glazed gum normally obtained when a gasoline is allowed to oxidize, but is a high boiling organic substance. For example, the residue from the first extraction was 644 mm. per hundred c.c., but this was not a glaze on the bottom of the glass dish but rather a heavy liquid which had the viscosity characteristics of about an SAE 50 lubricating oil. It will be noted from the table that the amount of this material extracted decreased as the hose became older. It should also be noted that the amount of this material varies from hose to hose.

10. Eighty-seven octane gasoline obtained from the Naval Air Station, Anacostia, was tested in hoses 1 and 2 and from 4 p.m. to the following 9 a.m., or a period of 17 hours. It was found that from hose #1, 92.2 milligrams of this hydrocarbon was extracted per 100 c.c. of gasoline and from hose #2, 58.8 milligrams. If the delivery to a plane is 100 gallons of gasoline which normally has practically no gum and the volume of the hose is one gallon or less, then when the 92 milligrams of gum, which was the maximum found in the one gallon, is distributed over 100 gallons, the increase of the content reported as gum would be 0.9 of a milligram which is not sufficient to be considered. But it should be noted here that the hose should be extracted several times before it is put on for use.

11. The gasoline that was stored for 17 hours in the Duprene-lined hose was tested for the octane rating at the Engineering Experiment Station at Annapolis and reported to this Laboratory as follows:

Octane Rating				Mg. "Gum"
ASTM - CFR Method				per 100 cc
Current deliveries stored in glass				0.0
"	"	"	" Hose #1	92.2
"	"	"	" Hose #2	58.8

These results show that while the hose may have what is known as "gum" the octane rating is unchanged.

12. If the "gum" content is due to extraction from the hose, then the "apparent" sulfur content in the gasoline should increase due to the halogen content of the material extracted from the hose. The amount of this increase should be dependent upon the amount of "gum" extracted.

This increase in "apparent" sulfur is given in the last four columns of the table on page 3 and the last column shows the "apparent" increase per 100 mgr. of "gum". This value decreases somewhat with the number of times the hose has been extracted but an average value is 0.006% per 100 mgr. gum. This residue was tested and halogens were shown to be present with a sodium fusion. The same was found with a sample of the lining of the hose.

13. The test apparatus made up to study the effect of the Duprene connections on the "apparent" gum content of the gasoline in storage in the lines from the tank to the carburetor had a volume of 8.82 cu.in or 145 c.c. This volume could carry 1.45 x 42 or 61 mgr. of "apparent" gum which would be deposited or burned in the engine due to the Duprene connections. This deposition of 6.1 mgr. gum will occur when the engine is started and may have some deleterious effects. If these Duprene connections in the line from the tank to the carburetor could be replaced by some material that does not have any gasoline-soluble constituents, then this first deposition of high gum content could be avoided.

OPINIONS

14. It is the opinion that Duprene-lined hose can be used satisfactorily for gasoline deliveries provided:

- (a) That the hose is extracted several times previous to its installation on the pump, and
- (b) That the hose be drained after use if such is feasible, and
- (c) That the gasoline delivered after several weeks' service with the hose will contain only a small amount of this material that is extracted from the hose, and if blended with a delivery of 10 gallons or more should not give a gasoline that has a gum content of more than 10 mg./100 c.c. The use of Duprene connections in the gas line between the tank and carburetor should be considered further. It may be advisable to replace the Duprene connections with other material.

SUMMARY

15. The material extracted from Duprene-lined hose and which remains as gum in the gum determination, is not true gum but is a heavy viscous liquid that is extracted from the hose.

16. The amount of extractable material varies with (a) the hose, (b) the length of time in the hose, and (c) the gasoline used.

17. After a certain period, the amount extracted should not be deleterious.

18. The octane rating does not change due to storage in a Duprene-lined hose that has been treated several times to remove the most readily soluble hydrocarbons.

19. The use of Duprene-lined connectors in the gas line between the tank and carburetor should be considered further. Due to material that can be extracted from the Duprene hose it may be advisable to replace it by other material that is not readily extracted.