AD678478

NATIONAL RESEARCH LABORATORIES

Ottawa, Canada

REPORT

Division of Mechanical Engineering

Fuels and Lubricants Laboratory

Pages - Preface	- 4	Report:	MP-30
Text	- 6	Date:	13 March 1964
App.	- 2	Lab. Order:	14809A
Tables	- 12	File:	M2-17-13.S-6

For: Internal

Reference: Meeting of the Group on Drum Storage of Fuel, 12 September, 1957.

Subject: LONG TERM STORAGE OF HYDROCARBON FUELS IN COATED DRUMS. PART III: EXAMINATION OF FUELS AFTER FIVE YEARS OF STORAGE

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SUMMARY

Aviation turbine fuel, aviation gasoline and automotive gasoline have been stored in about 200 coated drums at an outdoor site in Ottawa since October, 1957 under a long term storage project designed to evaluate the coatings. This is of interest to the R.C.A.F., who have had corrosion and fuel contamination problems arising from the storage of drums of these products in northern caches.

[redacted]

SUMMARY (Cont'd)

Fuels from 64 of the drums were examined after four years of storage for evidence of deterioration and for contamination. At that time only deterioration from weathering arising from leaky drums, and trace solid contamination in some samples, were noted.

The fuels were again examined after five years of storage in conjunction with withdrawal of 60 drums for an examination of the coatings. Substantially the same results were obtained as after four years of storage. Some of the fuel/water mixtures recovered from those drums into which water was added at the start of the storage project, however, showed noticeable rust.

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LONG TERM STORAGE OF HYDROCARBON FUELS IN COATED DRUMS
PART III: EXAMINATION OF FUELS AFTER FIVE YEARS OF STORAGE

1. INTRODUCTION

The R.C.A.F. have large numbers of drums of fuel stored in northern caches and have problems arising from drum corrosion and consequent contamination of the fuels. The Coatings Laboratory of the Division of Building Research selected the most promising coatings on the basis of a laboratory storage programme[1)] and also arranged for the fabrication and coating of about 300 drums[2)] used in the storage project, about 200 of which were filled with fuel.

Three fuels were selected: aviation gasoline, automotive gasoline and aviation turbine fuel. The drums, after receiving the coatings, were filled with the fuels late in October, 1957. Full specification tests were performed on each fuel and recorded in an earlier report (Part I)[3)].

Late in 1961, after four years of storage, 64 drums were sampled and tested to determine the extent of contamination and deterioration of the fuel. The results of these tests, which were given in a report issued in March, 1962 (Part II)[4)], revealed that contamination by solid material was very slight and that fuel deterioration, apart from weathering encountered in a few leaky drums, was non-existent.

Because the Coatings Laboratory withdrew 60 drums from the project late in 1962 for a coatings evaluation, fuels from these drums were again subjected to laboratory tests, largely as in Part II, but with emphasis on examination of the solid matter found in them. The Coatings Laboratory is preparing a report on their evaluation of the coatings.

2. SAMPLING

As for the examination after four years of storage, the drums were selected so that every combination of interior coating and surface preparation would be covered for the three fuels, and two of the fuels plus water.

Before sampling, the drums were gently up-ended so as not to disturb appreciably the coatings and the drum contents, and the large bung carefully loosened and removed. Approximately two quarts of fuel were withdrawn from each of the 60 drums by suction, the intake line resting on the lowest point in the drum. The drums were slightly inclined during sampling to create a truly low point and thus to ensure that the solid matter and water, if present, would collect there. When the next series of drums is withdrawn from the project at a future date, consideration might be given to jarring the drums and agitating the fuels before withdrawal to see if the coatings can withstand rough treatment without contaminating the fuel.

Sampling was again carried out late in the fall when the ambient temperature was low enough to keep vapour looses at a minimum.

After sampling, all 60 drums were emptied preparatory to the coatings examination. The emptying was accomplished by first pumping out most of the fuel, then inverting the drums and allowing the rest of the fuel to drain out.

3. TESTS AND RESULTS

As in the earlier evaluation, selected specification tests thought to be significant in detecting deterioration and contamination were performed on the samples. These included appearance, existent gum, and specific gravity tests on all samples; tetraethyl lead on the aviation and motor gasolines; water tolerance (water reaction) on the aviation fuels; and distillation, and Reid vapour pressure on the motor gasoline samples. A total solids test by the Millipore filter technique was performed on the fuels without water as a measure of the solid contaminant content. Also the solvent-washed gum was determined on the automotive gasoline, because this is now defined as the existent gum of automotive gasoline in ASTM D381, and a mandatory step in the conduct of the existent gum test. Results are summarized and compared with previous average results and specification limits in Tables I to V.

Full specification tests were performed on composites of the remainder of the quart portions as a check on possible deterioration of other properties not examined on the individual samples. The composites are identified as follows:

Composite No.	Fuel	Composite of Fuel From Drums
NRL 22300	Aviation Gasoline	Listed in Tables I & II
NRL 22301	Automotive Gasoline	Listed in Table III
NRL 22302	Aviation Turbine Fuel	Listed in Tables IV & V

Thermal stability and total solids were also performed on the aviation turbine fuel composite because of their appearance in the current 3-GP-22e specification. Results of the full specification tests, and those obtained originally[3)] and after four years of storage[4)], along with appropriate specification limits in effect in 1957, are compared in Tables VI to VIII.

A close examination of the aviation fuel/water mixtures was made since it was thought that the water added at the start of the storage project might have accelerated the rusting of exposed metal, leading to contamination by rust around the fuel/water interface. The results of a visual examination of the fuel/water mixtures and pH of the aqueous portions are given in Tables IX and X, while results of examination of the solid matter recovered from these mixtures are given in Tables XI and XII.

A brown, powdery deposit was found on one side (low side with drums in their normal storage position) in each of the twelve drums of automotive gasoline. The particles were of the order of 20 microns in size and about one or two grams per drum in quantity. The ratio of organic to inorganic content was one to one. Iron was the chief metallic constituent in the inorganic portion but 12 other metals were also present in roughly equal and substantial amounts, as determined spectrographically. Some particles were magnetic. The heterogenous nature of these particles, and their size, suggests that at one time they may have been airborne particles which found their way into the unaged fuel. Because they settled out in all the automotive gasoline drums, irrespective of coating surface, they are obviously not related to the coating evaluations. Deposits which could be attributed to the fuel appeared absent in the aviation gasoline and turbine fuel drums.

4. SIGNIFICANT CHANGES IN PROPERTIES

Aviation Gasoline

Emulsions were noted at the interface of the water tolerance tests performed on the fuels from drums 29 (Table I) and 33 (Table II). This did not occur with these gasolines from the same drums after four years of storage. Gasoline from both drums 193 and 221 showed slight increases in gum content over the test results obtained on these drums after four years of storage (Table I).

Automotive Gasoline

The fuel from drum 61 continued to show the effects of weathering. Gasoline in drums 87 and 109 showed gum increases but, because drums 23 and 61 showed similar increases after four years, followed by decreases a year later, the increases recorded for 87 and 109 are considered not significant.

The oxidation stability of the automotive gasoline had dropped slightly (Table VII).

Aviation Turbine Fuel

Emulsions were noted at the interfaces of the water tolerance tests performed on the fuels from drums 36, 81 and 199 (Table IV) and 39 and 184 (Table V).

The thermal stability of the fuel was excellent (Table VIII).

5. EXAMINATION OF THE FUEL/WATER MIXTURES

Aviation Gasoline and Water

All aviation gasoline/water mixtures had 0.03 gm./400 ml. or less of solid matter, except those from drums 33 and 78 which had 0.18 and 0.60 gm. respectively. Iron, quite probably as rust, was present in both; lead was substantially absent. The water from drum 78 showed a very low pH of 3.8 as against 6 to 7 for the water portions from the remaining drums.

Aviation Turbine Fuels and Water

All aviation turbine fuel and water mixtures had 0.05 gm./400 ml. or less of solid matter except for the fuel from drum 84 (and possibly drum 39; unfortunately this sample was lost before a quantitative estimate of solid matter could be made). Again iron, probably rust, was the major metallic constituent in the solid matter from most drums. The pH of the water portions on the whole tended to be lower than those from the aviation gasoline/water mixtures, ranging from 4.0 to 7.2.

6. COMMENTS

Comparing the properties of the fuels after five years of storage with those after four years of storage, and with the unaged fuels, it would appear that significant changes are few and slight. While moderate increases in gum content were noted in some fuel samples, particularly the automotive gasoline, corresponding decreases were noted in others over the figures after four years of storage, thus tending to nullify the importance of the increases. Again, some changes in properties, e.g. drop in Reid vapour pressure and increase in tetraethyl lead were noted, due to weathering from leaky drums. A quantitative test for solids was introduced for testing the dry samples to replace the visual method and thus to obtain better records for comparisons.

While noticeable solid matter (mostly rust) was observed in some of the fuel/water mixtures, from the fuel properties there appeared to be no interaction between coatings and fuel, but only between water and exposed drum metal. Traces of rust appeared to be present in most of the fuel/water samples.

7. REFERENCES

1. Dennis, D., Stafford, B.S., Harris, J. — Organic Coatings for the Interior of Gasoline Drums. N.R.C., Div. Bldg. Res. Report No. 51, November, 1954.

2. National Research Council files M43-17-14.A-6 and M2-17-13.S-6.

3. Stringer, P.L. Whyte, R.B. Long Term Storage of Hydrocarbon Fuels in Coated Drums: Part I: Setting up of Project. N.R.C., Div. of Mech. Eng., Report MP-14, May 1959.

4. Stringer, P.L. Long Term Storage of Hydrocarbon Fuels in Coated Drums: Part II: Examination of Fuels after Four Years Storage. N.R.C., Div. of Mech. Eng., Report MP-24, March 1962.

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TABLE I

AVIATION GASOLINE TEST RESULTS

(No Water Added to Drums)

FIVE YEARS' STORAGE Drum No.	Appearance	Existent Gum mg./100 ml.	Water Tolerance	Specific Gravity, 60/60°F	Tetraethyl Lead ml./I.G.	Total Solids mg./I.G. (8)
1	Pass	0.4	Pass	0.7086	3.72	<0.1
29	Pass	0.8	Note (1)	0.7089	3.69	<0.1
49	Pass	0.4	Pass	0.7079	3.64	<0.1
75	Pass	0.2	Pass	0.7079	3.61	<0.1
97	Pass	0.8	Pass	0.7093	3.68	<0.1
123	Pass	1.8	Pass	0.7086	3.52	<0.1
149	Pass	1.0	Pass	0.7079	3.64	<0.1
169	Pass	0.8	Pass	0.7086	3.66	<0.1
193	Pass	4.5	Pass	0.7093	3.68	<0.1
221	Pass	4.5	Pass	0.7086	3.60	<0.5
243	Pass	1.4	Pass	0.7093	3.68	<0.1
269	Pass	0.4	Pass	0.7093	3.66	<0.1
Avg.	Pass	1.4	Pass	0.7087	3.65	<0.1
FOUR YEARS' STORAGE						
Avg. (2)	Pass	0.5	Pass	0.7084	3.60	-
NO STORAGE						
Avg. (3)	Pass	0.8	Pass	0.7080	3.60	-
SPECIFICATION 3-GP-25c						
Limits	Pass (4)	3 max.	Pass (5)	No Limit	5.52 max.	No Limit

TABLE II

AVIATION GASOLINE TEST RESULTS

(Water Added to Drums)

FIVE YEARS' STORAGE Drum No.	Appearance	Existent Gum mg./100 ml.	Water Tolerance	Specific Gravity, 60/60°F	Tetraethyl Lead ml./I.G.
5	Pass	0.4	Pass	0.7086	3.59
33	Pass	0.8	Note (1)	0.7079	3.61
52	Pass	0.0	Pass	0.7089	3.65
78	Pass	0.2	Pass	0.7079	3.67
100	Pass	0.0	Pass	0.7082	3.59
121	Pass	0.2	Pass	0.7086	3.63
152	Pass	0.0	Pass	0.7079	3.59
172	Pass	0.4	Pass	0.7082	3.64
196	Pass	0.2	Pass	0.7079	3.60
240	Pass	0.0	Pass	0.7089	3.60
246	Pass	0.2	Pass	0.7093	3.58
272	Pass	0.2	Pass	0.7079	3.66
Avg.	Pass	0.2	Pass	0.7084	3.62
FOUR YEARS' STORAGE					
Avg. (2)	Pass	0.2	Pass	0.7081	3.58
NO STORAGE					
Avg. (3)	Pass	0.8	Pass	0.7080	3.60
SPECIFICATION 3-GP-25c					
Limits	Pass (4)	3 max.	Pass (5)	No limit	5.52 max.

TABLE III

AUTOMOTIVE GASOLINE TEST RESULTS

FIVE YEARS' STORAGE Drum No.	Appearance	R.V.P. lb.	Existent Gum mg./100 ml. (9) Evap. Res.	Existent Gum mg./100 ml. (9) Solvent-Washed	Specific Gravity, 60/60°F	Tetraethyl Lead ml./I.G.	Distillation I.B.P. °F	Distillation % Evaporated at 122°F	Distillation % Evaporated at 203°F	Distillation % Evaporated at 302°F	Distillation F.B.P. °F	Distillation Res. %	Distillation Loss %	Total Solids mg./I.G. ([illegible])
23	Pass	13.5	3.6	2.0	0.7121	3.79	81	14	55	95	342	1.2	2.8	3.0
[illegible]	Pass	13.5	3.2	1.8	0.7114	3.72	83	15	55	96	336	1.1	3.9	0.6
61	Pass	12.[illegible]	3.0	1.6	0.7157	4.27	90	11	52	95	346	1.1	2.9	[illegible].7
[illegible]7	Pass	13.0	7.3	3.1	0.7139	3.97	86	12	52	94	339	0.9	2.6	0.3
[illegible]	Pass	12.9	6.5	3.2	0.7103	3.85	84	13	55	95	338	1.0	3.0	0.[illegible]
136	Pass	13.7	2.6	2.4	0.7106	3.70	81	16	55	96	340	1.2	3.8	6.2
161	Pass	13.3	2.4	1.4	0.7111	3.65	85	15	55	96	333	1.0	5.0	0.6
[illegible]	Pass	13.3	3.2	2.4	0.7118	3.80	85	15	54	95	339	1.0	3.5	0.4
[illegible]	Pass	13.[illegible]	2.2	1.2	0.7111	3.72	70	17	55	96	336	1.1	3.9	2.3
[illegible]	Pass	13.6	1.6	0.6	0.7111	3.82	82	16	55	96	335	0.9	4.1	2.2
[illegible]	Pass	13.3	2.4	0.8	0.7111	3.74	82	16	55	96	332	0.6	3.4	2.3
[illegible]	Pass	13.3	1.8	0.8	0.7114	3.66	84	15	55	96	342	1.0	4.0	0.4
Avg.	Pass	13.3	3.3	1.8	0.7113	3.81	84	15	54	96	338	1.0	3.6	1.6
FOUR YEARS' STORAGE														
Avg. (2)	Pass	13.3	3.3	-	0.7117	3.81	87	17	56	97	334	0.6	5.4	-
NO STORAGE														
Avg. (3)	Pass	13.4	2.3	-	0.7100	3.71	83	16	55	97	338	1.0	5.9	-
SPECIFICATION 3-GP-7b														
Limits	Pass (4)	12-14	4 max.	-	No Limit	3.6 max.	-	10 min.	50 min.	90 min.	-	2.0 max.	-	No Limit

Table III
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Table IV
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TABLE IV

AVIATION TURBINE FUEL TEST RESULTS

(No Water Added to Drums)

FIVE YEARS' STORAGE		Existent Gum mg./100 ml.	Water Reaction	Specific Gravity 60/60°F	Total Solids mg./I.G. (8)
Drum No.	Appearance				
8	Pass	0.0	Pass	0.7690	0.8
36	Pass	1.7	Note (1)	0.7690	0.4
55	Pass	1.1	Pass	0.7690	0.1
81	Pass (6)	0.6	Note (1)	0.7690	1.6
103	Pass	0.0	Pass	0.7690	0.7
130	Pass	1.2	Pass	0.7694	1.2
155	Pass	0.2	Pass	0.7690	0.1
187	Pass	1.1	Pass	0.7694	0.0
199	Pass	0.0	Note (1)	0.7690	0.1
233	Pass	0.4	Pass	0.7694	0.1
249	Pass	1.8	Pass	0.7694	0.2
275	Pass	0.3	Pass	0.7694	0.1
Avg.	Pass	0.7	Pass	0.7692	0.4
FOUR YEARS' STORAGE					
Avg. (2)	Pass	0.3	Pass	0.7690	-
NO STORAGE					
Avg. (3)	Pass	0.7	Pass	0.7686	-
SPECIFICATION 3-GP-22b					
Limits	Pass (4)	7.0 max.	Pass (5)	0.751-0.802	4.5 max. (7)

TABLE V

AVIATION TURBINE FUEL TEST RESULTS

(Water Added to Drums)

FIVE YEARS' STORAGE Drum No.	Appearance	Existent Gum, mg./100 ml.	Water Reaction	Specific Gravity 60/60°F
16	Pass	0.0	Pass	0.7707
39	Pass	0.6	Note (1)	0.7699
58	Pass	0.0	Pass	0.7703
84	Pass	0.0	Pass	0.7703
106	Pass	0.0	Pass	0.7694
133	Pass	0.0	Pass	0.7703
158	Pass	0.8	Pass	0.7694
184	Pass	0.4	Note (1)	0.7694
202	Pass	0.0	Pass	0.7707
236	Pass	0.6	Pass	0.7699
[illegible]	Pass	0.0	Pass	0.7703
278	Pass	0.0	Pass	0.7699
Avg.	Pass	0.2	Pass	0.7700
FOUR YEARS' STORAGE				
Avg. (2)	Pass	0.4	Pass	0.7690
NO STORAGE				
Avg. (3)	Pass	0.7	Pass	0.7686
SPECIFICATION 3-GP-22b				
Limits	Pass (4)	7.0 Max.	Pass (5)	0.751-0.802

Table VI
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TABLE VI

COMPARISON OF AVIATION GASOLINE RESULTS

(Full Specification Tests)

Tests	Requirements of CGSB Specification 3-GP-25c, 100/130	No. (10) Storage	Drum No. 29 4 Years' Storage (11)	NRL 22300 (12) 5 Years' Storage
Appearance	Pass	Pass	Pass	Pass
Colour	Green	Green	Green	Green
Sulphur, % w	0.05 max.	0.009	0.012	0.029
Freezing Point, °F	-76 max.	< -88	< -95	< -76
Existent Gum, mg./100 ml.	3 max.	0.7	0.2	1.2
Potential Gum, 16 hr., mg./100 ml.	6 max.	0.6	0.6	1.2
Lead Precipitate, mg./100 ml.	2 max.	0.0	0.0	0.0
Calorific Value, Net, B.t.u./lb.	18,700 min.	18,980	18,900	18,910
Aniline-Gravity Product	7,500 min.	9,850	9,820	9,830
Aniline Point, °F	-	144.1	143.8	143.9
Copper Strip Corrosion	No. 1	No. 1	No. 1	No. 1
Specific Gravity, 60/60°F	No limit	0.7080	0.7082	0.7082
Distillation				
Initial Boiling Point, °F	-	104	105	98
% Evaporated at 167°F	10 - 40	23	24	22
% Evaporated at 221°F	50 min.	66.5	69	65
% Evaporated at 275°F	90 min.	95.5	96	94
Final Boiling Point, °F	338 max.	321	317	318
Sum, 10% + 50% Evaporated, °F	307 min.	355	351	356
Residue, %	1.5 max.	1.2	0.8	1.0
Loss, %	1.5 max.	0.9	1.3	1.0
Reid Vapour Pressure, lb.	5.5 - 7.0	6.4	6.5	6.4
Tetraethyl Lead, ml./I.G.	5.52 max.	3.60	3.56	3.65
Lean Mixture Knock Rating				
Octane No.	99.0 min.	> 99	> 99	> 99
Performance No.	-	106.9	106.3	105.4
Rich Mixture Knock Rating				
Performance No.	130.0 min.	131.3	134.1	134.3
Water Tolerance	Pass	Pass	Pass	Pass

TABLE VII

COMPARISON OF AUTOMOTIVE GASOLINE RESULTS

(Full Specification Tests)

Tests	Requirements of CGSB Specification 3-GP-7b, Type II	NRL 16451 No Storage (10)	No. 45 4 Years' Storage (11)	NRL 22301 (12) 5 Years' Storage
Appearance	Pass	Pass	Pass	Pass
Colour	Red	Orange	Orange	Orange
Sulphur, % w	0.15 max.	0.052	0.048	0.031
Existent Gum, mg./100 ml.	4 max.	2.3	3.4	3.1
Oxidation Stability, min.	480 min.	2000	2100	1855
Tetraethyl Lead, ml./I.G.	3.6 max.	3.75	3.76	3.80
Copper Strip Corrosion	No. 1	No. 1	No. 1	No. 1
Motor Octane No.	83 min.	86.6	85.5	-
Research Octane No.	91 min.	90.9	91.2	90.7
Distillation				
I.B.P.	-	83	87	83
% Evaporated at 122°F	10 min.	16	17	15
% Evaporated at 203°F	50 min.	55	56	54
% Evaporated at 302°F	90 min.	97	97	96
Final Boiling Point	-	338	334	337
Residue, %	2.0 max.	1.0	0.6	1.1
Loss, %	-	5.9	5.4	3.6
Reid Vapour Pressure, lb.	12 - 14	13.4	13.4	13.4
Freezing Point, °F	-75 max.	-74	< -75	< -75
Specific Gravity, 60/60°F	-	0.7100	0.7111	0.7111

Table VIII
MP-30

TABLE VIII

COMPARISON OF AVIATION TURBINE FUEL RESULTS

(Full Specification Tests)

Tests	Requirements of CGSB Specification 3-GP-22b	No Storage (10)	No. 37 4 Years' Storage (11)	NRL 22302 (12) 5 Years' Storage
Appearance	Pass	Pass	Pass	Pass
Colour	-	Colorless	Colorless	Colorless
Freezing Point, °F	-76 max.	< -88	< -90	< -76
Distillation				
I.B.P., °F	-	142	145	146
% Evaporated at 290°F	20 min.	64	66	66
% Evaporated at 370°F	50 min.	> 98	> 98	> 98
% Evaporated at 400°F	-	> 98	> 98	> 98
% Evaporated at 470°F	90 min.	> 98	> 98	> 98
Final Boiling Point, °F	-	374	378	374
Residue, %	1.5 max.	0.8	0.6	1.0
Loss, %	1.5 max.	0.6	1.1	0.2
Reid Vapour Pressure, lb.	2.0 - 3.0	2.6	2.7	2.6
Specific Gravity, 60/60°F	0.751 - 0.802	0.7686	0.7694	0.7686
Aromatics, % vol.	25.0 max.	22.0	20.5	21.3
Olefins, % vol.	5.0 max.	0.8	0.5	0.8
Sulphur, % w	0.4 max.	0.05	0.02	0.01
Existent Gum, mg./100 ml.	7.0 max.	0.7	0.6	0.4
Accelerated Gum, 16 hr., mg./100 ml.	14.0 max.	0.4	1.8	0.4
Smoke Point	-	21.9	23.3	24.0
Smoke Volatility Index	54.0 min.	63.1	64.7	65.6
Heat of Combustion, Net, B.t.u./lb.	18,400 min.	18,560	18,570	18,570
Aniline-Gravity Product	5,250 min.	5,595	5,590	5,605
Aniline Point, °F	-	106.4	106.7	106.6
Water Reaction	Pass	Pass	Pass	Pass
Mercaptan Sulphur, % w	0.005 max.	0.001	-	-
Copper Strip Corrosion	No. 1	No. 1	No. 1	No. 1
Total Solids, mg./litre	1.0 max. (7)	-	-	0.64
Thermal Stability Change in Pressure Drop, in. Hg.	13 max. (13)	-	-	nil
Preheater Deposit Rating	< 3 (13)	-	-	2

TABLE IX

APPEARANCE OF SAMPLES COMPRISING AVIATION GASOLINE AND WATER

(400 ml. Drawn from Bottom of Drum and Mixture Allowed to Settle Before Examination)

Drum No.	Volume, ml.		Gasoline Layer		Water Layer				Interface		
	Gasoline	Water	Colour	Haze (14)	Colour	pH	Haze	Sediment	White or Light Brown Scummy Film	Black-Brown Lumps (15)	Rust-like Flakes (16)
5	250	150	Green	Slight	Straw	7.2	Moderate	Some particles	Trace	Some	None
33	150	250	Green	Moderate	Light straw	6.5	Moderate	Much brown	Present, largely dark brown	Some	Many
52	125	275	Green	Slight	Straw	6.6	Slight	Some, brown lumps	Present	Many	Some
73	200	200	Green	Moderate	Brown	3.8	Moderate	Much, brown film present	Dark brown film present	Probably present, difficult to see interface	Present on entire interface
100	200	200	Green	Slight	Straw	6.1	Slight	Much fine brown	Present	Some	None
121	75	325	Green	Slight	Very light straw	6.4	Slight	None	Present	Many	None
152	50	350	Green	Slight	colorless	7.0	Slight	None	Present	Some	None
172	50	350	Green	Slight	Colorless	6.2	Slight	Moderate brown	Present	Some	None
196	75	325	Green	Slight	Light straw	7.0	Slight	None	Present	Some	None
240	200	200	Green	Slight	Light straw	7.0	Slight	None	Present	Some	None
246	75	325	Green	Slight	Straw	6.6	Slight	None	Present	Some	Few
272	225	175	Green	Slight	Light straw	6.8	Moderate	Trace light brown	Present	Many	None

Table X
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TABLE X

APPEARANCE OF SAMPLES COMPRISING AVIATION TURBINE FUEL AND WATER

(400 ml. Drawn from Bottom of Drum and Mixture Allowed to Settle Before Examination)

Drum No.	Volume, ml.		Fuel Layer		Water Layer				Interface		
	Fuel	Water	Colour	Haze (14)	Colour	pH	Haze	Sediment	Film	Brown Lumps (15)	Rust-Like Flakes (16)
16	75	325	Color-less	Some floc suspended	Color-less	7.2	None	1 or 2 specks, flaky	Fine layer, white and brown, scummy	Trace	None
33	175	225	Color-less	Some fine dark brown material suspended	Light-brown	-	Cloudy, light brown material in sus-pension	50% of bottom of container covered with dark brown flakes and light brown particles	Dark brown particles covering interface completely	Some	Some
58	25	375	Color-less	None	Color-less	6.8	None	None	Fine layer white scum, some brown scum	Trace	None
54	200	200	Light brown	Some brown particles in suspen-sion	Brown	4.9	Some brown parti-cles in suspen-sion	Entire bottom of container covered with brown matter to a depth of 1/32"	Dark brown sediment, covering interface completely to a depth of 1/32"	Many	Some
106	50	350	Color-less	None	Color-less	4.6	None	Trace	Dark brown sediment covering interface completely, in parts to a depth of 1/32"	Many	Some
133	225	175	Light brown	Some fine brown par-ticles in suspension	Light brown	4.6	Some fine white par-ticles sus-pended	Trace, fine brown, settled	Fine dark brown par-ticles covering interface completely	Some	None

TABLE X (Cont'd)

APPEARANCE OF SAMPLES COMPRISING AVIATION TURBINE FUEL AND WATER

([illegible] ml. Drawn from Bottom of Drum and Mixture Allowed to Settle Before Examination)

Drum No.	Volume, ml.		Fuel Layer		Water Layer				Interface		
	Fuel	Water	Colour	Haze (14)	Colour	pH	Haze	Sediment	Film	Brown Lumps (15)	Rust-Like Flakes (16)
[illegible]	Trace	400	Colorless	None	Light	5.0	None	None	Thin red-brown scum covering 35% of surface	Trace	None
134	Trace	400	Colorless	None	Light brown	5.3	Some brown flakes suspended	None, except for suspended flakes	Thin red-brown scum covering 20% of surface	Trace	None
222	100	300	Light brown	Light brown particles suspended	Colorless	4.7	None	Fine light brown particles completely covering the bottom of the container	Light brown particles completely covering interface	Some	None
236	150	250	Light brown	Light brown particles suspended	Colorless	4.7	None	Fine light brown particles completely covering the bottom of the container	Light brown particles completely covering interface	Some	None
252	150	250	Light brown	Light brown particles suspended	Colorless	4.4	None	None	Light brown particles completely covering interface	Some	None
278	250	150	Light brown	Light brown suspension	Light brown	4.0	Light brown suspension	Bottom of container almost covered with fine light brown sediment	Light brown particles completely covering interface	Many	None

Table X (cont'd)
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Table XI
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TABLE XI

EXAMINATION OF SOLID MATTER RECOVERED FROM AVIATION GASOLINE AND WATER SAMPLES (17)

Drum No.	Solid Matter		Ash			Iron as Fe_2O_3, % of Ash (18)	Metals Present in Ash (19)
	Colour	Wt., g.	Colour	Wt., g.	Percent		
5	Dark brown, some rust-like particles	0.01	Dark brown, some white	0.01	Almost 100	-	Dark brown largely Fe; some Ti, Si, Pb, Bi, Al, Zn; white mostly Fe, Zn, and Ti, some Pb, Si, Al
33	Dark brown	0.18	Red-brown	0.03	15	60	-
52	Dark brown some large rust-like particles	0.02	Brown, some white	0.01	50	-	-
78	Brown, fine particles	0.60	Rust-brown	0.47	80	80	Largely Fe
100	Dark brown, muddy	0.02	Dark brown, some white	0.01	50	-	-
121	Dark brown some rust-like particles	0.02	Chocolate brown, some white	0.02	100	60	-
152	Brown	0.01	Brown and white	0.01	100	-	-
172	Dark brown, some rust-like	0.03	Brown	0.01	50	-	-
176	Dark brown	0.01	Light brown some white	0.01	25	-	-
240	Dark brown	0.01	Brown some white	0.01	50	-	-
272	Dark brown, some rust-like	0.01	Red-brown	0.01	50	-	-

TABLE XII

EXAMINATION OF SOLID MATTER RECOVERED FROM TURBINE FUEL AND WATER SAMPLES (17)

Drum No.	Solid Matter		Ash			Iron as Fe_2O_3 % of Ash (18)	Metals Present in Ash (19)
	Colour	Wt., g.	Colour	Wt., g.	Percent		
16	Dark brown some rust-like	0.01	Light brown some white	0.01	100	-	-
39*	-	-	-	-	-	-	-
58	Brown and rust-like	0.01	Brown, some white	0.01	100	-	-
84	Rust-like	1.50	Rust-like	1.24	85	85	Largely Fe
106	Dark brown, red-brown	0.01	Light brown	0.01	50	-	-
133	Dark brown	0.03	Red-brown	0.02	65	70	-
158	Dark brown, red-brown	0.01	Grey some white	0.01	50	-	Largely Mg, Fe, Si; some Mn, Al, Zn, Na, Ti, Ca.
184	Brown, some rust-like	0.01	Brown, some white	0.01	50	-	-
202	Orange-brown	0.04	Red-brown	0.04	80	70	Largely Fe; some Si, Zn
236	Orange-brown	0.04	Red-brown	0.02	100	85	-
252	Dark brown	0.01	Light brown, white	0.01	25	-	-
278	Brown, rust-like	0.02	Red-brown white	0.02	75	80	-

* Sample bottle broke and sample lost.

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LONG TERM STORAGE OF HYDROCARBON FUELS IN COATED DRUMS. PART III: EXAMINATION OF FUELS AFTER FIVE YEARS OF STORAGE.
P. L. Strigner. March 1964. 10 pp. + 12 tabs.

Aviation turbine fuel, aviation gasoline and automotive gasoline have been stored in about 200 coated drums at an outdoor site in Ottawa since October, 1957 under a long term storage project designed to evaluate the coatings. This is of interest to the R.C.A.F., who have had corrosion and fuel contamination problems arising from the storage of drums of these products in northern caches.

Fuels from 64 of the drums were examined after four years of storage for evidence of deterioration and for contamination. At that time only deterioration from weathering arising from leaky drums, and trace solid contamination in some samples, were noted.

The fuels were again examined after five years of storage in conjunction with withdrawal of 60 drums for an examination of the coatings. Substantially the same results were obtained as after four years of storage. Some of the fuel/water mixtures recovered from those drums into which water was added at the start of the storage project, however, showed noticeable rust.

UNCLASSIFIED

1. Fuel storage tanks - Coatings
2. Fuels - Storage

I. Strigner, P. L.
II. NRC MP-30

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National Research Council, Canada. Division of Mechanical Engineering.

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APPENDIX A

NOTES PERTAINING TO TABLES I TO XII

(1) Observations made during Water Tolerance (Reaction) Tests

(a) Drums 29 (Table I) and 33 (Table II) and 184 (Table V). Layer of fine bubbles 1 ml. thick visible on interface. Otherwise meets requirement.

(b) Drums 36, 81 (Table IV) and drum 39 (Table V). Layer of fine bubbles 2-3 ml. thick visible on interface. Otherwise meets requirement.

(c) Drum 199 (Table IV). Fine lace 1 1/2 ml. thick on interface. Suspension of bubbles in fuel layer. Otherwise meets requirement.

(2) Average obtained from figures in appropriate Table in MP-24.

(3) Average of samples NRL 16649 and NRL 16650, Report MP-14.

(4) The fuel shall be free from undissolved water, sediment and suspended matter.

(5) The fuel shall be substantially immiscible with water. The fuel and water layers shall be sharply defined with no evidence of emulsion, precipitate or suspended matter within or upon either layer. Neither layer shall have changed in colour, and the aqueous layer shall not have changed in volume by more than one millilitre. Evidence of a slight pink colour shall not be cause for rejection.

(6) Trace of sediment visible.

(7) Limit taken from specification 3-GP-22e; in mg./litre, 1.0

(8) Determined by Millipore filter method 3-GP-0, 123.1.

(9) The evaporation residue was considered existent gum at the time specification 3-GP-7b was in effect. Currently, in 3-GP-7c, the solvent-washed (with n-heptane) gum is considered existent gum. See ASTM Method D381-58T and D381-61T.

(10) Results taken from Report MP-14.

(11) Results taken from Report MP-24.

Notes Pertaining to Tables I to XII (Cont'd)

(12) NRL 22300 is a composite of nearly all aviation gasoline samples (Tables I and II).

NRL 22301 is a composite of nearly all automotive gasoline samples (Table III).

NRL 22302 is a composite of nearly all aviation turbine fuel samples (Tables IV and V).

(13) Requirement for Thermal Stability in 3-GP-22e.

(14) The haze tended to clear on standing.

(15) The brown or black-brown lumps can be better described as stringy and filmy solid material partly coalesced into a shapeless mass. It is light and fluffy and easily broken up when disturbed yet tending to congregate in the centre of the interface.

(16) Resembling rust-scale.

(17) Total solid matter recovered by filtration from the fuel and water samples.

(18) Determined colorimetrically by the thiocyanate method.

(19) Determined spectrographically by the Analytical Section of the Division of Applied Chemistry.