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FAIRCHILD ENGINE AND AIRPLANE CORPORATION



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March 15, 1949 - April 15, 1949

DATE April 20, 1949

Work performed by
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CALIFORNIA RESEARCH CORPORATION
RICHMOND, CALIFORNIA

CRC-NEPA REPORT NO. 16
NEPA CONTRACT NO. SC-2011
PROGRESS REPORT, MAR. 15-APR. 15, 1949

Conference at the General Electric Co.,
Schenectady, N. Y. - March 15, 1949

On March 15 a meeting was held at the General Electric Co. in Schenectady, N. Y. Those present included Mr. K. N. Mathes, Asst. Division Engineer in the General Engineering and Consulting Department, his assistant Mrs. Alice Bonk, Dr. J. R. Miller of the Knolls Atomic Power Laboratory, Dr. V. P. Calkins and Mr. H. H. Wallace of NEPA, and Messrs. J. W. Kent and F. A. Christiansen of California Research Corp. The purpose of this meeting was to discuss arrangements for irradiating lubricants in the Hanford piles. Mr. Mathes had recently returned from Hanford where he had made preliminary arrangements to have our lubricants irradiated both in the piles and by gamma flux alone.

(a) Gamma Exposures

The reason for exposing samples to gamma flux alone is to ascertain what fraction of the damage observed in pile irradiations is caused by the gamma rays. This information will also be valuable to anyone utilizing lubricated equipment which will be exposed only to gamma rays, as for example, in many of the proposed power pile installations. The method of exposing samples to gamma flux alone is to place the samples in pyrex tubes, place the tubes inside an empty Hanford slug can, place the can inside a ring of seven irradiated Hanford uranium slugs, and place the whole assembly under 25 feet of water in the Hanford pile canal. In this manner samples may be irradiated with the gamma rays from the slugs for any period of time. One can obtain a gamma flux of 10^{10} - 10^{11} γ 's/cm²/sec. The energy of these gammas will average 1.7 Mev during the first six days after being pushed from the pile. After 422 days, this average energy will decrease to 1.2 Mev.

The ampoules and the sample cans must be vented and work on a suitable design is in progress. Mr. Mathes is undertaking the development of a method for heating the sample can so that some of the gamma experiments can be carried out at the bottom of the canal but at a temperature of 140°C. The samples we plan to ship to Mr. Mathes for the gamma exposures are listed in Table I.

Encl.- Tables I thru VII

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Belets

(S) Hanford File 1X13008

The reason for exposing our lubricants in the Hanford piles is to determine whether the damage suffered by the lubricants is proportional to the radiation dosage, (flux x time), or whether the damage is a higher-order function of the magnitude of the flux. Two facilities are available for the pile irradiation of our lubricants: (1) Wet process tubes which operate at a temperature of 20°C. and a neutron flux of approx. 4×10^{13} neutrons/cm²/sec. (2) Dry process tubes which operate at temperatures as high as 275°C. and a neutron flux of 3.6×10^{13} to 4.8×10^{13} neutrons/cm²/sec. Both the wet and the dry process holes are about 1-3/8" in diameter.

Venting the samples will be a major difficulty in carrying out these irradiations. Because no corrosive gases are formed during the irradiation, it may be possible to vent directly to the cooling water in the wet tubes and to vent to the pile helium stream which might be bled into a dry hole. It might be necessary, however, to run vent lines to the outside of the pile.

During the discussion it was also learned that no sample can be irradiated in a wet or dry process tube for less than six days and that this period may extend as long as fourteen days. No control can be exercised over the length of this period, nor can it be predicted for us beforehand by the pile operators. Considering this length of time and the magnitude of the flux, only our most radiation-resistant lubricants will be irradiated. In order to obtain a direct comparison on an equal neutron dosage basis, it will be necessary that samples be irradiated in the X-10 pile for a period of six months to one year.

It has been arranged with Mr. Mathes, that one set of samples will be irradiated in a wet process tube and another set in a dry process tube. These irradiations are tentatively scheduled to begin in June. We will package the samples in vented quartz or aluminum ampoules which will be placed in an inner tube of aluminum. These assemblies will be sent to Mr. Mathes who will place them in Hanford slug cans and ship them to Hanford for loading in the pile.

Visit to Argonne National Laboratory
Chicago, Illinois - Mar. 18, 1949

A visit was made by Messrs. J. W. Kent and F. A. Christiansen to Argonne National Laboratory on March 18 to discuss the results of the recent pile irradiation of grease samples. The Argonne personnel present at the discussion were: Dr. Harold Etherington, Head of the Naval reactor Division; Dr. E. B. Ashcraft, Head of the Materials and Experimental Section; Messrs. N. J. Palladino, J. R. Humphreys, and A. Amorosi of the Materials and Experimental Section; Messrs. L. W. Brehm and N. Shaw of

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the Mechanical Design Section; and Mr. J. A. Dietrich, Asst. to Dr. Etherington.

The results of the recent pile irradiation of several grease samples submitted to us by Westinghouse at Argonne's request were discussed. It was pointed out that the best conventional grease from the standpoint of consistency change was California Research Corporation High Temperature Grease No. 50175-R which had been irradiated along with the samples from Westinghouse. The metal specimens used in three-hour corrosion tests conducted at room temperature and at 300°F. at Richmond were shown to the Argonne representatives. It was noted that unirradiated High Temperature Grease 50175-R stained copper at 300°F. in the corrosion tests, and that irradiated 50175-R showed an even darker staining. It was explained that this staining should not cause any trouble in high speed bearings even though the retainers were made of brass or bronze. However, it was agreed that the corrosion tests would be repeated for a longer period of time to determine if any surface attack of metals occurs. The results of the latter tests are included in this report under Phase I.

Phase I - In Progress at Richmond, California

Batch 6A

Table II lists the samples irradiated for one week at 30°C. in Hole 12 in the X-10 pile at approximately 76% of maximum flux. The purpose of this irradiation was to show how radiation damage is influenced by the temperature at which the irradiation was carried out. The most radiation-resistant materials were not chosen for this experiment, but instead materials for which we had extensive data at 140°C. and at 80°C. The samples irradiated for four weeks, Batch 6B, have just been received at Richmond and will be reported upon later. Therefore, a more complete discussion of temperature effects will be given in the next progress report. Even now, however, some interesting observations can be made on the one week samples. The following table compares the 210°F. viscosities of the various materials irradiated for one week at 30°C., 80°C., and 140°C.

	Viscosity at 210°F., cSt			
	Original	30°C.	80°C.	140°C.
Solvent refined Western Paraffinic				
SAE 30	63.9	86.5	94.4	138
Poly(propene oxide)	57.8	84.0	-	56.6
Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide	37.4	41.9	42.7	42.7
Alkylbenzene (MW \approx 350) + 2% Di- alkyl Selenide	47.6	49.2	49.3	53.3
Didecyl Terephthalate + 2% Dialkyl Selenide	48.7	56.7	57.7	65.4
Alkylbenzene (MW \approx 250) + 4% Acry- loid + 2% Dialkyl Selenide	38.9 (184 VI)	34.1 (45 VI)	33.9 (43 VI)	33.7 (5 VI)

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These data show that the Solvent Refined Western Paraffinic lubricant is affected markedly by the temperature at which the irradiation is performed. It is to be noted further that this lubricant is affected seriously even at the lowest temperature, 30°C., after only one week of irradiation. The deterioration suffered by di(2-ethylhexyl) sebacate plus 2% Dialkyl Selenide appears to be almost independent of the temperature of the irradiation, at least during the first week. Likewise, the deterioration of alkylbenzene (MW \approx 350) + 2% dialkyl selenide does not appear to be greatly dependent upon temperature. The deterioration of didecyl terephthalate + 2% dialkyl selenide is dependent upon the temperature of the irradiation. The behavior of the poly(propene oxide) is puzzling, although we have noted in previous reports that this material never behaves during the first week of irradiation in the same manner as it does in succeeding weeks. The deterioration of alkylbenzene (MW \approx 250) + 4% Acryloid + 2% dialkyl selenide again appears to be independent of the temperature if one considers only the 210°F. viscosity data. However, examination of the viscosity index data also points to the conclusion that the deterioration of this material is also dependent upon the temperature.

Batch 7

The data for the Batch 7B samples was reported in CaC-NEPA Report No. 15 and is also included in Table III of this report for convenience in studying the effect of one-week versus four-week irradiations.

In previous irradiations it was found that copper and iron wire catalysts increased the rate of thickening of poly(propene oxide). The use of mercaptobenzothiazole, zinc dibutyldithiocarbamate, alizarin, and 2,2-Bis(4-hydroxyphenyl) propane all improve the radiation resistance in a one-week irradiation, whereas the first two inhibitors show an improvement and the latter two show an adverse effect in a four-week irradiation.

In general the data which have been obtained on the various poly(propene oxide) samples, with and without addition of inhibitors, is inconsistent. This may be due to varying amounts of oxidation caused by differences in sizes of the ampoule capillaries. It is planned to investigate the effect of varying the capillary size.

A sample of alkylbenzene saturated with iodine showed some promise in one week of irradiation but after four weeks of exposure, it was more viscous than uninhibited alkylbenzene.

Three samples prepared by Dr. V. P. Calkins of NEPA were irradiated. Two of the samples were prepared using poly(propene oxide) base oil, one containing 0.02% quinone phosphate and the other containing 0.02% quinone oxalate. The third sample consisted of alkylbenzene oil (SI-114) and 0.02% quinone phosphate. During the four-week irradiation the sample containing the quinone phosphate in the poly(propene oxide) showed the least change in 210°F. viscosity of any sample to date irradiated for a comparable period at 140°C. The quinone oxalate was not

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effective in poly(propene oxide) but it is understood that this sample was not prepared by the standard method. The quinone phosphate did not prove to be effective in the alkylbenzene oil. Additional samples of poly(propene oxide) and alkylbenzene oils have been shipped to Dr. V. P. Calkins of NEPA for use in preparing additional samples containing his inhibitors.

Batch 8

This batch of samples was irradiated in a low flux stringer area in an effort to determine the effect of flux intensity on lubricant damage. The samples have been examined and the results of the viscosity determinations are shown in Table IV. When we receive the necessary data on percent maximum flux, stringer position and pile power for this batch of samples, we will then be able to analyze the results for the effect of irradiation dosage versus lubricant damage.

Batch 9

The samples in Batch 9 are being withdrawn from the pile at the rate of one per week for six weeks. Two oils are being used for this experiment, (1) poly(propene oxide), and (2) Alkylbenzene (MW \approx 350). Samples have been received for the 1, 2 and 3-week irradiations. As soon as the 4, 5 and 6-week samples and the necessary data of percent maximum flux, stringer position and pile power are received, we will determine if the radiation damage, as shown by viscosity changes, follows a uniform rate law.

Phase I - Grease Samples

Seven samples of grease were irradiated at the request of Argonne National Laboratory for a period of seven to nine days. A sample of California Research Corporation High Temperature Grease 50175-K was also included in these irradiations. A special grease containing an aluminum soap and Alkylbenzene oil had been made prior to the Argonne request for inclusion in Batch 7. Following irradiation of the above samples, tests were performed to determine the change in consistency and corrosion characteristics. These data are shown in Tables V and VI. The special alkylbenzene-aluminum soap grease shows the least change of any of the greases tested, thereby demonstrating (1) that a soap whose metallic constituent has a low cross section is desirable or (2) that a radiation resistant oil is desirable in a grease. This grease is not intended for a high temperature application such as contemplated by Argonne. The common premium grades of ball bearing greases such as are represented by the other eight grease samples have rather poor radiation resistance. The Dow-Corning DC 44 (containing a silicone oil) became extremely hard and brittle. None of the petroleum greases are satisfactory from the standpoint of hardening during irradiation. This is not surprising in view of the large viscosity increase resulting when petroleum oils were irradiated previously.

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Phase II

Experiments are continuing with the small scale oxidation test equipment. The test procedure requires the use of only one or two ml. of oil sample, thereby enabling oxidation tests to be conducted on irradiated oil samples. Six irradiated samples have been tested and the same six oils unirradiated are currently being tested. It is hoped that sufficient data will have been accumulated on fresh versus irradiated oils so that it may be reported in the next progress report.

Phase III

No active work is underway at this time on Phase III.

Thus far in our NEPA research, several items have been discovered which may be patentable. In accordance with the provisions of our sub-contract, we are completing AEC Form 213 for these items. These completed forms will be forwarded to NEPA in the near future.

J. W. KENT *JWK*

F. A. CHRISTIANSEN *FAC*

R. O. BOLT *ROB*

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TABLE I

SAMPLES PROPOSED FOR GAMMA IRRADIATION AT HAMPFORD

A. At About 10°C.

1. Solvent Refined Western Paraffinic Lube Oil (SAE 30)
2. Solvent Refined Western Paraffinic Lube Oil (SAE 30) + 20% 1-Methyl naphthalene
3. 1-Methylnaphthalene
4. Octadecylbenzene
5. Octadecylbenzene + Iron and Copper Wires
6. Octadecylbenzene + 2% Dialkyl Selenide + Iron and Copper Wires
7. Octadecylbenzene + 5% Dialkyl Selenide
8. Octadecylbenzene + 5% Dialkyl Selenide + Iron and Copper Wires
9. Octadecylbenzene + 5% Dialkyl Selenide-B + Iron and Copper Wires
10. Octadecylbenzene + Dialkyl Selenide (Sample No. 15 from Phase II Oxidation Test) + Iron and Copper wires
11. Alkylbenzene (MW \approx 250) + 4% Poly(lauryl methacrylate) + 2% Dialkyl Selenide
12. Alkylbenzene (MW \approx 350) + 2% Dialkyl Selenide
13. Di(2-ethylhexyl) Sebacate
14. Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide
15. Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide + Iron and Copper Wires
16. Di(2-ethylhexyl) Sebacate + 20% 1-Methylnaphthalene + 2% Dialkyl Selenide
17. Didecyl Terephthalate + 2% Dialkyl Selenide
18. Poly(propene oxide)
19. Poly(propene oxide) + Iron and Copper Wires
20. Poly(propene oxide) + 2% N,N'-diphenyl-p-phenylenediamine
21. Poly(propene oxide) + 2% Phenyl Dibutyl Dithiophosphate
22. Poly(propene oxide)-B
23. Poly(propene oxide)-B + Iron and Copper Wires
24. Poly(propene oxide)-B + 2% Mercaptobenzothiazole + Iron and Copper Wires
25. Poly(propene oxide)-B + 0.02% Quinone Phosphate
26. Poly(propene oxide)-B + 2% Conedendrol

B. At About 140°C.

1. Solvent refined Western Paraffinic Lube Oil (SAE 30)
2. Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide
3. Didecyl Terephthalate + 2% Dialkyl Selenide
4. Poly(propene oxide)
5. Alkylbenzene (MW \approx 350) + 2% Dialkyl Selenide
6. Alkylbenzene (MW \approx 250) + 4% Poly(lauryl methacrylate) + 2% Dialkyl Selenide
7. Octadecylbenzene + Iron and Copper Wires
8. Octadecylbenzene + 5% Dialkyl Selenide + Iron and Copper wires

California Research Corporation
Richmond, California

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TABLE II

BATCH 6A

SUMMARY OF DATA ON PHASE 1, BATCH 6A SAMPLES - IRRADIATED IN X-10 PILE AT 30°C. AND APPROXIMATELY 76% MAX. FLUX

Identity	GEC No.	Amp. No.	Notebook Ref. No.	Wks. Irr.	Original				Irradiated				Evap., etc. Loss, Vol. %	Remarks
					Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color	Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color		
Solvent Refined Western Paraffinic - SAE 50	SL-34	134	48-111-1	1	545	63.9	89	Yellow-Green	1017	86.5	90	Light Brown	20	
Di(2-ethylhexyl)sebacate + 2% Dialkyl Selenide	SL-35	135	48-111-2	1	67.9	37.4	160	Light Amber	105.9	41.9	153	Vry. Lt. Yellow	0	
Alkylbenzene (MW = 350) + 2% Dialkyl Selenide	SL-36	136	48-112-1	1	367.8	47.6	-19	Light Yellow	377.9	49.2	11	Brown	0	Cloudy
Didecylterephthalate + 2% Dialkyl Selenide	SL-37	137	48-112-2	1	280.5	48.7	88	Vry. Lt. Yellow	409.3	86.7	86	Vry. Lt. Yellow	0	
Poly(propene Oxide)	SL-38	138	48-113-1	1	265.5	57.8	135	Lt. Amber	643.1	84.0	124	Vry. Lt. Yellow	0	
Alkylbenzene (MW = 350) + 4% Acrylate + 2% Dialkyl Selenide	SL-39	139	48-113-2	1	73.8	38.9	184	Lt. Yellow	58.0	34.1	45	Light Amber	0	
50% Benzene (G.P.) + 50% Ethyl Alcohol (95%)	SL-40	140	48-114-1	1	-	-	-	Water white	-	-	-	Light Yellow	45	
5 ml. Allyl Acetate + 1 ml. Water	SL-41	141	48-114-2	1	-	-	-	Water white	614	Boils	-	Vry. Lt. Yellow	25	

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Richmond, California

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TABLE III

SUMMARY OF DATA ON PHASE 1, BATCH 7 SAMPLES IRRADIATED IN X-10 PILE AT 140°C. AND APPROX. 70% OF MAXIMUM FLUX

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Identity	CNC No.	Amp. No.	Notebook Ref. No.	wks. Irr.	Original				Irradiated				Evaporation, etc. Loss, (Vol. %)	Remarks
					Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color	Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color		
Poly(propene oxide) + Iron and Copper Wires + 1% Mercaptobenzo Thiazole	SL-67	209	48-125-2	1	268.2	58.8	143	red brown	379.8	63.3	125	Dark Brown	5	Cu and Fe - Black
		208	48-125-2	4	268.2	58.8	143	red brown	732	79.1	105	Dark Brown	25	Cu and Fe - Black
Poly(propene oxide) + Iron & Copper Wires + 1% Zinc Dibutylidithiocarbamate	SL-68	211	48-126-1	1	260.5	58.5	143	light amber	502.1	76.5	130	Light Brown	3	Sediment; Cu - brown varnish Fe - dulled
		210	48-126-1	4	260.2	58.5	143	Lgt. Amber	1118	99.4	105	Brown	20	Sediment; Cu - reddish deposit Fe - OK
Poly(propene oxide) + Iron & Copper Wires & Saturated with Alizarin	SL-69	213	48-126-2	1	270.0	58.6	140	red brown	607.1	84.3	126	Light Brown	0	Fe and Cu - OK
		212	48-126-2	4	270.0	58.6	140	red brown	500.3	300	113	Lt. Amber	25	Fe and Cu - OK
Poly(propene oxide) + Iron & Copper Wires + 1% 2,2-Bis(4-Hydroxyphenyl)-Propane	SL-70	215	48-127-1	1	282.5	59.5	139	Lt. Amber	621.9	84.4	126	Lt. Amber	2	Fe and Cu - ends black; rest OK
		214	48-127-1	4	282.5	59.5	139	Lt. Amber	4782	286	114	Amber	15	Fe and Cu - OK
Poly(propene oxide) Saturated with N,N'-Diphenyl-p-Phenylene diamine	SL-46	252	48-117-1	1	283.5	58.7	136	Black	620.9	86.5	127	Dk. Brown	5	
		146	48-117-1	4	283.5	58.7	136	black	solid	solid	-	black	-	
Poly(propene oxide) + 2% Hexadecanethiol	SL-51	254	48-119-2	1	243.0	56.2	140	amber	312.4	58.0	125	Lt. Orange	3	
		151	48-119-2	4	243.0	56.2	140	amber	654	76.6	110	Dark Brown	25	
Poly(propene oxide) + 1% Paraformaldehyde	SL-57	173	48-122-2	1	276.0	58.1	136	Lt. Amber	554.4	76.4	123	Lt. Yellow	2	
		153	48-122-2	4	276.0	58.1	136	Lt. Amber	2282	155	106	Yellow	20	
Poly(propene oxide) + 2% Lauryl Alcohol	SL-56	181	48-122-1	1	245.0	56.5	143	Lt. Amber	507.7	75.2	123	Lt. Yellow	0	
		175	48-122-1	4	245.0	56.5	143	Lt. Amber	1350	108	100	Yellow	20	
Poly(alkene oxide) (Low Vis.)	SL-49	253	48-118-2	1	52.5	33.1	40	Lt. Amber	67.6	35.6	65	Lt. Yellow	2	
		149	48-118-2	4	52.5	33.1	40	Lt. Amber	278	51.1	100	Lt. Yellow	20	
Poly(propene oxide) - B	SL-75	205	48-129-2	1	273.8	65.3	153	Lt. Yellow	462.0	74.0	132	Lt. Yellow	5	
		204	48-129-2	4	273.8	65.3	153	Lt. Yellow	1209	104	105	Lt. Amber	20	
Poly(propene oxide) - B + Iron & Copper Wires	SL-76	207	48-130-1	1	273.8	65.3	153	Lt. Yellow	336.3	60.2	126	Yellow Green	5	Resinous deposit on quartz; black spot on both Fe & Cu at liquid level
		206	48-130-1	4	273.8	65.3	153	Lt. Yellow	1409	117	118	Lt. Amber	20	Fe - OK; Cu - tarnished
80% Poly(propene oxide) + 20% 1-Methylnaphthalene	SL-42	162	48-115-1	1	140	46.1	149	Lt. Amber	-	-	-	-	-	ampoule broken; no sample received at Richmond
		142	48-115-1	4	140	46.1	149	Lt. Amber	1432	126	114	Amber	10	
80% Solvent Refined Western Paraffinic 30 + 20% 1-Methyl naphthalene	SL-43	163	48-115-2	1	279.5	50.9	88	Amber-Green	428.6	59.0	93	Vry. Dk Brn.	0	Sediment
		143	48-115-2	4	279.5	50.9	88	Amber-Green	4352	202	92	Black	10	
78% Di(2-ethylhexyl) sebacate + 20% 1-Methyl naphthalene + 2% Di-alkyl selenide	SL-44	164	48-116-1	1	55.3	34.5	131	Lt. Yellow	75.2	37.9	140	Lt. Amber	0	
		144	48-116-1	4	55.3	34.8	131	Lt. Yellow	393	63.8	112	Brown	10	
80% Solvent Refined Western Paraffinic 150 Neutral + 20% 1-Methyl naphthalene	SL-58	256	48-123-1	1	69.5	36.4	91	Yellow-Green	116.2	40.2	80	Dark Brown	0	Lot of dark brown sediment
		186	48-123-1	4	69.5	36.4	91	Yellow-Green	1317	95.3	83	Dark Brown	0	

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TABLE III (CONT.)

Identity	CRC No.	Amp. No.	Notebook Ref. No.	Wks. Irr.	Original				Irradiated				Evaporation etc., Loss, (Vol., %)	Remarks
					Vis. C 100°F., SSU	Vis. C 210°F., SSU	V.I.	Color	Vis. C 100°F., SSU	Vis. C 210°F., SSU	V.I.	Color		
Solvent Refined Western Paraffinic - 150 Neutral	SL-48	168	48-118-1	1	149.0	42.8	91	Amber-Green	309.2	52.4	93	Brown	0	
		148	48-118-1	4	149.0	42.8	91	Amber-Green	11,035	433	105	Dark Brown	10	
Alkylbenzene (MW=250)	SL-45	165	48-116-2	1	6.13 cs	1.73 cs	24	Lt. Yellow	9.12 cs	2.14 cs	13	Lt. Yellow	2	
		145	48-116.2	4	6.13 cs	1.73 cs	24	Lt. Yellow	25.94 cs	3.87 cs	-8	Lt. Amber	5	
Alkylbenzene (MW=250) Saturated with benzoquinone	SL-50	170	48-119-1	1	6.06 cs	1.63 cs	-20	Lt. Yellow	9.82 cs	2.22 cs	3	Dark Brown	0	
		150	48-119-1	4	6.06 cs	1.63 cs	-20	Lt. Yellow	36.6 cs	4.9 cs	22	Orange Brown	5	
Alkylbenzene (MW=250) + 2% Diethylbenzene	SL-54	163	48-121-1	1	5.82 cs	1.60 cs	-18	water-white	8.56 cs	2.08 cs	22	Lt. Yellow	0	
		174	48-121-1	4	5.82 cs	1.60 cs	-18	water-white	26.06 cs	3.90 cs	-5	Lt. Amber	10	
Alkylbenzene (MW=250) + 0.8% Sulfur	SL-53	255	48-120-2	1	6.44 cs	1.76 cs	-6	Lt. Yellow	8.67 cs	2.11 cs	22	Dark Brown	0	Sediment
		180	48-120-2	4	6.44 cs	1.76 cs	-6	Lt. Yellow	22.2 cs	3.72 cs	28	Black	5	Sediment
Alkylbenzene (MW=250) Saturated with Dinitrobenzene	SL-60	257	48-124-1	1	6.23 cs	1.77 cs	32	Lt. Yellow	9.15 cs	2.13 cs	12	Dark Brown	0	
		184	48-124-1	4	6.23 cs	1.77 cs	32	Lt. Yellow	34.2 cs	4.52 cs	-100	Dark Brown	5	
D1(2-ethylhexyl)sebacate + 10% Dialkyl selenide	SL-47	167	48-117-2	1	67.4	36.8	133	Lt. Amber	90.0	40.2	160	Lt. Amber	0	
		147	48-117-2	4	67.4	36.8	133	Lt. Amber	507	77.5	132	Lt. Amber	20	
78% D1(2-ethylhexyl) sebacate + 20% Poly(propene oxide) + 2% Dialkyl selenide	SL-59	187	48-123-2	1	80.7	39.5	167	Lt. Amber	138.2	45.2	145	Lt. Yellow	5	
		179	48-123-2	4	80.7	39.5	167	Lt. Amber	351.6	76.7	123	Lt. Amber	20	
D1(2-ethylhexyl) Sebacate + Platinum Black	SL-71	201	48-127-2	1	69.9	37.5	156	Lt. Yellow	161.8	47.7	144	Greenish	-	Black sediment
		200	48-127-2	4	69.9	37.5	156	Lt. Yellow	Solid	Solid	-	-	-	
Polyester S-16 + 2% Dialkylselenide	SL-72	203	48-129-1	1	125	45.5	160	Lt. Brown	282.0	56.1	127	Yellow	10	
		202	48-129-1	4	125	45.5	160	Lt. Brown	12,358	1200	125	Amber	30	
Synthetic Oil 48-109-2 + Iron & Copper Wires	SL-66	258	48-125-1	1	249	49.8	102	Lt. Yellow	139.1	43.1	115	Brown	-	black sediment; Cu - black Fe - dulled
		191	48-125-1	4	249	49.8	102	Lt. Yellow	127.0	42.3	115	Black	20	
Phenyl Methyl Silicone	SL-55	162	48-121-2	1	1100	154	134	Lt. Yellow	3512	372.2	125	Lt. Amber	0	
		175	48-121-2	4	1100	154	134	Lt. Yellow	Solid	Solid	-	-	-	
Poly(propene oxide) + 0.02% Quinone Phosphate	-	240	48-147-1	1	274	58.6	137	Yellow	249	54.4	134	Lt. Amber	8	
		244	48-147-1	4	274	58.8	137	Yellow	518.4	62.9	90	Lt. Amber	25	
Poly(propene oxide) + 0.02% Quinone Oxalate	-	241	48-147-2	1	274	59.1	138	Lt. Amber	275	57.3	133	Lt. Yellow	20	
		245	48-147-2	4	274	59.1	138	Lt. Amber	1617.5	123.5	103	Lt. Amber	25	
Alkylbenzene (MW=250) + 0.02% Quinone Phosphate	-	242	48-147-3	1	6.34 cs	1.74 cs	25	Vry. Lt. Yel.	7.68 cs	1.96 cs	28	Lt. Yellow	0	
		246	48-147-3	4	6.34 cs	1.74 cs	25	Vy. Lt. Yel.	49.76 cs	4.09 cs	-1	Lt. Brown	5	
Alkylbenzene (MW = 250) Saturated with Iodine	SL-52	243	48-120-1	1	6.21 cs	1.72 cs	16	Deep Red	7.15 cs	1.87 cs	22	Black	0	
		251	48-120-1	4	6.21 cs	1.72 cs	16	Deep Red	16.41 cs	3.10 cs	20	Vy. Dk. Brown	8	Sediment on walls

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TABLE IV

SUMMARY OF DATA ON PHASE I, BATCH 8 SAMPLES - IRRADIATED IN CLINTON PILE AT 50°C. AND ABOUT 50% MAXIMUM FLUX

CRC No.	Amp. No.	Notebook Ref. No.	Wks. Irr.	Original				Irradiated				Evap., etc. Loss, Vol. %	Remarks	
				Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color	Vis. @ 100°F., SSU	Vis. @ 210°F., SSU	V.I.	Color			
Solvent Refined Western Paraffinic (MAE 50)	SL-105	216	48-134-1	1	545	63.9	89	Yellow-Green	744	73	87	Dark Brown	0	Ampoule broken
		222	48-134-1	4	545	63.9	89	Yellow-Green	-	145.7	-	Dark Brown	Spill	
Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide	SL-106	217	48-135-1	1	67.9	37.4	140	Lt. Yellow	86.4	39.1	141	Lt. Yellow	0	
		223	48-135-1	4	67.9	37.4	140	Lt. Yellow	160.4	47.8	146	Lt. Amber	0	
Alkylbenzene (MW = 350) + 2% Dialkyl Selenide	SL-107	218	48-135-2	1	368	47.6	-19	Lt. Yellow	336	47.5	-21	Lt. Amber	0	
		224	48-135-2	4	368	47.6	-19	Lt. Yellow	464.3	58.3	17	Lt. Brown	0	
Didecyl Terephthalate + 2% Dialkyl Selenide	SL-108	219	48-136-1	1	250	48.7	88	Vry.Lt.Yellow	296	51.0	88	Vry.Lt.Yellow	0	
		225	48-136-1	4	250	48.7	88	Vry.Lt.Yellow	608.6	65.9	83	Vry.Lt.Yellow	0	
Poly(propene oxide)	SL-109	220	48-136-2	1	265	57.4	135	Lt. Amber	371	65.1	131	Vry.Lt.Yellow	5	
		226	48-136-2	4	265	57.4	135	Lt. Amber	528.8	75.2	121	Lt. Yellow	0	
Alkylbenzene (MW = 250) + 4% Poly(lauryl methacrylate) + 2% Dialkyl Selenide	SL-110	221	48-137-1	1	68.7	37.8	170	Vry.Lt.Yellow	64.4	33.9	81	Lt. Yellow	0	
		227	48-137-1	4	68.7	37.8	170	Vry.Lt.Yellow	59.7	34.2	30	Lt. Amber	0	

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TABLE V

WORK STABILITY OF GREASES

Samples	Micropenetrometer Penetrations				Working Time, Sec.		Irradiation Time, Days	Remarks
	Unworked		Worked 60 Strokes		Fresh	Irradiated		
	Fresh	Irradiated	Fresh	Irradiated*				
Andek C	47	18	51	32(32)	60	90	9	-
Royco E-532	149	8	152	51(57)	60	110	9	-
Texaco TG-398	55	22	81	138(162)	60	88	9	Crust on Surface
Calif. Res. Corp. 50175-R	66	30	154	208(262)	60	92	9	Crust on Surface
Dow Corning DC 44	85	Too Hard	99	Too Hard	60	-	9	Brittle hard gel
Socoony Vacuum Aero Ex H1	75	19	114	71(81)	60	94	7	-
Keystone J-C	46	16	56	144(65)	60	85	7	Oil separation
No. 185 Alsop, Alkyl-	(76)	134	76	140(114)	60	92	7	Gelatinous
bensene Oil	(76)	61	76	209	60	60	28	

Samples irradiated at approximately 75% of maximum flux in the X-10 pile at approximately 285°F.

* Values in parenthesis are the micropenetrations after the worked irradiated samples stood for 24 days.

For all penetration data the Texas Micropenetrometer was used. The worked penetrations were taken in the micropenetrometer cup. The unworked penetrations were taken in the original container. The greases were worked in a microworker.

NLGI Grade No.	ASTM Penetration	Approx. Micro Penetration
0	355 - 385	210 - 360
1	310 - 340	135 - 180
2	265 - 295	95 - 120
3	220 - 250	65 - 85
4	175 - 205	45 - 60
5	130 - 160	30 - 40
6	85 - 115	15 - 25

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TABLE VI

Sample	THREE-HOUR CORROSION TEST OF GREASES AIR ATMOSPHERE								120-HOUR CORROSION TEST CO ₂ ATMOSPHERE	
	Fresh Grease				Irradiated Greases*				Fresh Grease	Irradiated Grease*
	Steel		Copper		Steel		Copper		Copper	Copper
	70°F.	300°F.	70°F.	300°F.	70°F.	300°F.	70°F.	300°F.	300°F.	300°F.
Andok C	A	A	A	A	A	A	A	A	FI	FI
Royco E-532	A	B	A	B	A	A	A	A	BI	I
Texaco TG-398	B	B	BG	BG	B	B	B	B	HK	I
Calif. Res. Corp. 50175-R	A	B	A	BF	A	B	A	BG	HJ	HJ
Dow Corning D.C. 44	B	B	B	BF	← - - - solid - - - →				-	-
Socony Vacuum Aero Ex H1	B	B	B	B	A	A	A	A	FI	I
Keystone 3-C	A	B	B	B	A	B	B	B	I	KI
No. 185 Alsoap, Alkyl- benzene Oil	B	D	A	DF	A	C	A	C	C	C

Small gobs of grease (approximately 0.5 gms) were placed on polished steel and copper specimens. Corrosion or discoloration was observed at the end of the time indicated.

- A - No change in grease; no corrosion
- B - Slight oil smear on strip around grease; no corrosion
- C - Grease melted down to oily smear; no corrosion
- D - Grease melted slightly; no corrosion
- F - Brown discoloration under grease; no corrosion
- G - Very dark brown discoloration under grease; no corrosion
- H - Black stain
- I - Black, carbonaceous deposit at edge of grease
- J - Etched
- K - Slightly etched

* - Corrosion test on irradiated greases after working 60 strokes in microworker

TABLE VII

SAMPLES PROPOSED FOR IRRADIATION IN STRINGERS IN X-10 PILE
AT ABOUT 75% OF MAXIMUM FLUX AND 140°C.

1. 1-Methylnaphthalene
2. Solvent Refined Western Paraffinic 150 Neutral + 20% 1-Methylnaphthalene + Alizarin
3. n-Heptadecane
4. 9-n-Dodecylanthracene
5. 9-(2-Phenylethyl) heptadecane
6. 9-(2-Cyclohexylethyl) heptadecane
7. 9-(3-Cyclopentylpropyl) heptadecane
8. Poly(vinyl butyl ether)-B
9. Poly(propene oxide) (Very viscous)
10. Poly(propene oxide) + 0.02% Quinone Phosphate + Iron and Copper Wires
11. Poly(propene oxide) + 0.02% Naphthoquinone
12. Poly(propene oxide) + 2% Naphthoquinone
13. Poly(propene oxide) + 2% Conedendrol
14. Poly(propene oxide) + 0.02% Quinone Phosphate + 2% N,N'-Diphenyl-p-phenylenediamine
15. Poly(propene oxide) + 0.02% Naphthoquinone + 2% N,N'-Diphenyl-p-phenylenediamine
16. Poly(propene oxide) + 2% Phenyl Dibutyl Dithiophosphate + Iron and Copper Wires
17. Poly(propene oxide) + 2% Phenyl Dibutyl Dithiophosphate + Iron and Copper Wires + Alizarin
18. Poly(propene oxide) + 2% Dialkyl Selenide + Alizarin + Iron and Copper Wires
19. Poly(propene oxide) + 2% Mercaptobenzothiazole + Alizarin + Iron and Copper Wires
20. Poly(propene oxide)-B + 20% 1-Methylnaphthalene
21. Tetracresyl Silicate
22. Di(2-ethylhexyl) Sebacate + 10% Dialkyl Selenide + 20% 1-Methylnaphthalene
23. Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide + 20% 1-Methylnaphthalene + Alizarin
24. Di(2-ethylhexyl) Sebacate + 2% Dialkyl Selenide + 20% 1-Methylnaphthalene + Alizarin + Iron and Copper Wires
25. Di(2-ethylhexyl) Sebacate + 10% Phenyl Dibutyl Dithiophosphate
26. Di(2-ethylhexyl) Sebacate + 10% Phenyl Dibutyl Dithiophosphate + Iron and Copper Wires
27. Di(2-ethylhexyl) Sebacate + 10% Phenyl Dibutyl Dithiophosphate + Alizarin + Iron and Copper Wires
28. Di(2-ethylhexyl) Sebacate + 0.02% Quinone Phosphate
29. Di(2-ethylhexyl) Sebacate + 2% Naphthoquinone
30. Di(2-ethylhexyl) Sebacate + 0.02% Naphthoquinone

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