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WADC TECHNICAL REPORT 53-293

PART VIII

ASTIA DOCUMENT No. 150994

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## HIGH TEMPERATURE ANTIOXIDANTS FOR SYNTHETIC BASE OILS

PART VIII. EVALUATION OF ANTIOXIDANTS IN SYNTHETIC FLUIDS

*JAMES W. COLE, JR.*

*UNIVERSITY OF VIRGINIA*

*FEBRUARY 1958*

WRIGHT AIR DEVELOPMENT CENTER

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*JAMES W. COLE, JR.*

*UNIVERSITY OF VIRGINIA*

*FEBRUARY 1958*

MATERIALS LABORATORY  
CONTRACT No. AF 33(616)-3234  
PROJECT No. 7731

WRIGHT AIR DEVELOPMENT CENTER  
AIR RESEARCH AND DEVELOPMENT COMMAND  
UNITED STATES AIR FORCE  
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

## FOREWORD

This report was prepared in the Cobb Chemical Laboratory, University of Virginia, under USAF Contract AF 33(616)-3234. This contract was initiated under Project No. 7331, "Hydraulic Fluids", Task No. 73313, "Hydraulic Fluids". It was administered under the direction of the Materials Laboratory, Directorate of Laboratories, Wright Air Development Center, with Mr. George Baum acting as Project Director.

This report covers work conducted from October 1956 to October 1957.

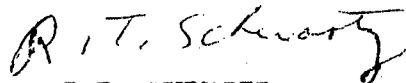
## ABSTRACT

This is a continuation of a laboratory program on the evaluation of the oxidation patterns of synthetic fluids in the presence and absence of inhibitors and metals in the temperature range 400°-700°F. Two methyl chlorophenyl silicones, F-50 and F-60 were examined at 500°F and 600°F. N,N'-di-2-naphthyl-p-phenylenediamine in 0.1 - 0.2% was the most interesting additive. Work with a mineral oil, MLO 57-30, did not reveal additives of outstanding activity. Substances containing sulfur and selenium showed promise, but some attack on silver and copper. The experiences with four tetra-substituted silanes showed that these substances did not have outstanding response to additives. A series of runs with a pentaerythritol ester, MLO 55-584, indicate that ring substituted aryl amines have considerable antioxidant activity over the range 400°-500°F. Some additional data for bis-(2-ethylhexyl) sebacate are included to compare the promising amines with the phenothiazine type. The former retain the inhibition of activity over a wider temperature range. Some attention was given to determining the nature of the components in an oxidized diester which contributes to the acidity. It appears that some improvement may be achieved in a partial oxidized fluid by washing with hydrocarbon solvents. The limitations of a laboratory test procedure are discussed, especially with respect to the evaluation of the effects of the test metals, aluminum, silver, copper, titanium and several steels.

## PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



R.T. SCHWARTZ  
Chief, Organic Materials Branch  
Materials Laboratory

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## HIGH TEMPERATURE ANTIOXIDANTS FOR SYNTHETIC BASE FLUIDS.

### A. Introduction.

The work in this report is a continuation and expansion of the work initiated originally under Contract AF 33(038)-22947 in the Department of Chemistry, University of Virginia. Under this contract a survey was made and a technical report was prepared on the pertinent literature. An experimental procedure was devised for comparing the oxidative behavior of blends of fluids containing about 300 selected additives in the presence and absence of metals. Particular attention was given to elucidating the antioxidant behavior in the temperature range 204°-260°C (400°-500°F) of phenothiazine, its derivatives and typical compounds representing both organic and inorganic substances. The oxidation medium included the following types of synthetic fluids: esters, silicates, silicones and phosphates. The pertinent WADC technical reports and publications are listed in the bibliography.

The work reported in Part VII of this series and continued herein was under Contract No. AF 33(616)-3234. It is a continuation of the program under the former contract and was initiated 1 October 1955 to determine the oxidation pattern of additional selected additives in various new synthetic fluids, and to extend the oxidations in the promising systems to higher temperatures. In Part VII some exploratory oxidation runs with silicones and silanes were reported at temperatures as high as 370°C (700°F). Several additive systems were shown to have promise at the higher temperatures. In Part VIII more attention was given to intermediate temperatures with the view of obtaining information which might be used for recommending blends for engine tests.

The oxidation procedure was essentially the same as previously described in detail. The fluid in a Pyrex brand test cell with glass fittings was heated in an aluminum block, thermostatted furnace while dry air or a gas mixture of 95 % nitrogen and 5 % oxygen was passed through the fluid in a tube inside the overhead condenser and extending to the bottom of the test cell. In most runs, the test metals consisted of aluminum, copper, silver, titanium and one of several steels. The metals were polished washers mounted on the air tube with 3/8 inch glass spacers. For all of the cases reported herein, the volume of fluid was 25 milliliters and the gas flow was one liter per hour. In many of the earlier evaluations, a larger test cell holding 100 milliliters of fluid with a gas flow of five liters per hour was employed. The results were not strictly comparable; but, when examined in light of the behavior of a controlled blend, it is possible to correlate the behavior of the various additive systems.

"Manuscript released by author 24 October 1957 for publication as a WADC Technical Report".

The original problem was to change the properties of a fluid by additives so that after a known period of oxidation at a given temperature the viscosity change, the acid accumulation, and the effects of the test metals would meet described specifications. The blend selected as a basis for comparison of other systems was 1% phenothiazine in bis-(2-ethylhexyl) sebacate (Plexol 201). While oxidation runs without additives have some value as blanks, there are enough sources of error in the procedure to cause considerable variation in the behavior of the uninhibited fluid. The accumulation of acids in a blank fluid was such that the neutralization number appears to approach a maximum. The air delivery tubes are subject to clogging as solid matter is formed and the viscosity increases. Even with a blend as the blank the experimental procedure still left much to be desired when small differences in behavior of the additive are to be interpreted in terms of recommendation for engine uses. The writer has very little knowledge of how the laboratory tests correlate with the next step in the development of a fluid, but it appears that additional attention is needed for better ways of evaluating additive systems in the laboratory if the purpose is to select the optimum blend on the basis of small differences.

In some other studies, designed to elucidate the mechanism of antioxidant action, it appeared that those additives, which were most active in inhibiting or retarding oxidation, gave rise to products which become insoluble in the fluid ahead of the loss of effectiveness or the end of the induction period. It also appeared that by treatment with solvents some of the oxidized products could be removed and the acidity of the fluid lowered.

The problem of evaluating the effects of metals is very difficult. An attempt was made to express the quantitative effect of metals in the form of change in weight of the test metals during an oxidation run. It should be emphasized in reporting the metal weight change in mg/cm<sup>2</sup> that the effects are magnified. This arises because the weight differences in the test specimens were determined on an analytical balance to about one-tenth milligram and then multiplied by a factor. Considerable inconsistencies in the results arose from the method of handling the test metals after an oxidation run. First, the metal was washed with benzene and acetone. If this did not remove the film from the oxidized metal, the surface was rubbed somewhat stronger with tissue, and then with fine glass wool, with the view of removing only the surface film. However, it was observed that different operators apply varying pressure to the metal surface when trying to remove a film of oxidized fluid or additive. With silver and copper these effects are particularly troublesome and at times some of the metal seemed to be removed with the tissue. In the interpretations the data showed that silver was not generally appreciably attacked by the amine-type additive, and the copper was only slightly attacked when the weight loss was reported in the neighborhood of 0.5 mg/cm<sup>2</sup>. The main conclusion from the presence of metals, when the changes are of small order, was that some metals have catalytic action at least for a portion of the oxidation. However,

account must be taken of the cases where metals, especially copper, appear to enhance the antioxidant activity of some additives, particularly aryl amines.

The quantities of additives employed were usually molar equivalent weights based on the formula of phenothiazine as the standard. For example, 0.25 grams of phenothiazine in 25 ml was approximately one per cent by weight, and 0.27 grams was the same number of moles of 10-methylphenothiazine. In all reports the relative effects of antioxidants, inhibitors and oxidation retardants, it is strongly recommended that molar equivalent quantities be used as a basis for comparison. In preparing a mixture for an oxidation run, the ability of the fluid to form a homogeneous system with the additive was noted. Since the molar equivalent quantities of substances were being compared, the run was performed even though all of the additive did not dissolve at room temperature or on heating on the water bath. In practically all cases with effective additives these systems became homogeneous at the oxidation-test temperature.

In comparing the behavior of additives when the view is to select the best system, all of the data must be considered to show subtle differences. A scheme was devised for the comparison of additives in which an index number represents the summation of various property changes. While convenient in some instances the method has limitations. The behavior of volatile acid products sometimes appeared to lower the value of the index number and to give the impression of a better system than was the case. In order to show all effects of oxidation of a blend all of the significant data for each of the fluid systems examined during the past year are tabulated under each fluid. An effort is made to point out the more promising systems in the discussion sections that follow. This involves some subjective analysis as well as the intuition of the writer in some instances.

A page index to the runs for the various additives for Parts VII and VIII of the technical report series is given in Appendix I. Also included are the sources of the additives and fluids. At this point, some explanation on the purity of additives is needed. For those substances obtained through commercial sources, where the purity was not equivalent to Eastman Kodak White Label, the substances were further purified by appropriate crystallization, sublimation or distillation. For materials obtained through WADC channels the substances were used as received. The effect of the purity of additives is interesting. For the phenothiazine type it appeared to make little difference whether a highly purified sample was used. For some of the amines, the higher the purity the better the effectiveness. This aspect is being continued as a problem under another type of support.

In the following section these fluids were new during the current contract year and experiences with them are reported for the first time: A naphthlenic mineral oil, MLO 57-30, two methyl chlorophenyl silicones, F-60 and F-50, didodecyl dioctyl silane, MLO 57-161,

and *n*-octadecyl-tri-*n*-octyl silane, MLO 56-578.

Some experiences with the other fluids have been previously reported, but the tabulated data represents new work with the system, either for purposes of establishing blanks or for comparing additives under new conditions.

#### B. Oxidations in Mineral Oil, MLO 57-30.

This is the first account of experiences with a mineral oil. This fluid was suggested for evaluations by the Materials Laboratory, Wright Air Development Center. Presumably it is of naphthenic base and is designed for use at temperatures in the neighborhood of 500°F. It exhibited considerable inherent stability at this temperature. While no additive was dramatic in action several retarded the increase in viscosity. Those of some promise include: diphenyl sulfide, phenothioxine, diphenyl selenide, 2,2'-dibiphenyl diselenide, *p,p'*-dioctyldiphenylamine (recrystallized) and 2-phenylbenzoselenazole. The selenium compounds showed slightly more oxidation retarding properties, but also attacked silver and copper more vigorously. In Table 1 the additives are listed in approximate decreasing order of effectiveness.

The main property change for evaluation purpose is that of per cent kinematic viscosity change. Values for this have been determined at three temperatures, 130°, 212° and 383°F, Table 1.

The viscosity increased linearly with oxidation time, both in the absence and presence of additives and the test metal washers. The changes in acidity were not of sufficient magnitude to be of value in the screening of additives. The "~~evaporation~~ losses" expressed as per cent weight loss are erratic and do not reflect, except qualitatively, the effect of an additive in inhibiting or retarding the oxidation rate. The erratic behavior in part arises from bumping in the oxidation cells and splashing of liquid on the adapter and condenser walls. The intensity of bumping increases with time and appears to be associated with a more volatile product, produced either by oxidation or pyrolysis. It might be presumed to be water to a considerable extent. No attempt was made to analyse the mixture to be sure of this assumption.

The isooctane insolubles were determined in two ways. First, the oxidized mixture was filtered and the residue washed with isooctane. This residue is termed "isooctane wash", *W*<sup>1</sup>, Table 1. The amount was usually small. The second value, *P*<sup>1</sup> in Table 1, is the per cent insoluble matter precipitated by addition of isooctane to the filtered oil. These values are somewhat erratic and do not help much in evaluating the effectiveness of an additive. The detailed procedure for separating and analysing the solid fractions is included later in the section on bis-(2-ethylhexyl) sebacate.

The effect of this mineral oil under oxidation with metals is not clearly shown because of the inherent difficulties in interpreting

the behavior of metals. In Table 1, two values are given for the weight losses in the test metal washers. Both are in milligrams per square centimeter. The first values are for the losses observed after cleaning the metal with benzene and acetone and soft tissue. The second values are the additional weight losses arising from more vigorous cleaning with fine glass wool and the solvents.

The oxidized fluid itself did not attack the metals severely, so the changes observed reflect the effect of the additives on the test metals. The sulfur containing additives, showing promising oxidation-retarding capacity with surprising low attack on silver and copper, were phenothioxine and diphenyl sulfide. For the selenium compounds 2-phenylbenzoselenazole scarcely attacked the metals, but it was less active in retarding oxidation than diphenyl selenide. The amines showing oxidation retarding activity generally did not strongly attack the metals. The most promising of the amines is recrystallized p,p'-dioctyl diphenylamine, followed by phenyl- $\alpha$ -naphthylamine and dipyridylamine.

The results with the spectrum of additives in this mineral oil indicate that several types may have promise as antioxidants and oxidation retarders. Some modification of the basic structures by substituents may be indicated to reduce volatility and increase the solubility. There is also some indication that mixtures of additives at the same total equivalent concentration will allow the use of lower amounts and promote more homogeneity in the system throughout its period of use.

#### C. Oxidations in a Methyl Chlorophenyl Silicone, F-60

This is the first report of experiences with this fluid. Oxidations were performed on two batches at 500° and 600°F. The first batch of 1 gallon in a metal container arrived 9 September 1956 from Material Laboratory, Wright Air Development Center. The results are noted in Table 2. The second batch of 1 quart in a glass bottle arrived 3 March 1957 and was labelled Dow-Corning F-60 Stock No. 7500-DL. The data for this batch are in Table 3.

The results with the two batches are essentially in agreement in the patterns of behavior toward additives and metals. The oxidations at 500°F were performed on 25 ml samples with dry air at 1 liter per hour. Most of the runs at 600°F were performed under the same conditions with a dry gas mixture consisting of 95% nitrogen and 5% oxygen.

The most attractive oxidation inhibitor and retarder was N,N'-di-2-naphthyl-p-phenylenediamine. A concentration of 0.2% prevented a significant increase in the kinematic viscosity for at least 48 hours at 500°F and 12 hours at 600°F. The changes in neutralization numbers were small and this measurement is not of great value in screening and comparing additives.

This fluid under oxidation attacked copper slightly more than the other test metals, but the metals appeared to have very little

effect in catalyzing the oxidations. The formation of insolubles was not dramatic. The slight effects are more clearly shown with the second batch; Table 3.

This additive is not as readily soluble as would be desired, but lower concentrations might be employed in practice if the available oxygen concentration is low. Some attention was given to the effect of additional purification of the commercial sample of N,N'-di-2-naphthyl-p-phenylenediamine. This substance was obtained as P5691, yellow label, Eastman Organic Chemicals. It was of grey-green color. A portion was placed in boiling ethanol and the mixture filtered. Only a small amount of N,N'-p-di-2-phenylenediamine dissolved in the alcohol, but this washing process helped to remove some impurities. A portion of the alcohol washed solid was dissolved in boiling acetone followed by filtration. Small granules of a almost white color precipitated on cooling. These were washed with cold ethanol and recrystallized from acetone. On drying by pulling air through the filter, the granules acquired a slight greenish tint. The results with the purified materials are reported in Table 2 and are designated by Footnote g/. The purification did not cause any significant change in the oxidation inhibiting behavior. Additives of ring substituted phenylenediamine types are also attractive, and may have better solubility characteristics. The results in Table 2 indicate that quinoid structure apparently possesses the oxidation inhibiting activity and that aryl substituents on the nitrogen are preferred.

In one instance vanadyl-2-ethyl hexoate was mixed with N,N'-di-2-naphthyl-p-phenylenediamine but the combination showed no special advantages. The former has some oxidation inhibiting qualities but the effects were not dramatic. Other additives exhibiting some promise as oxidation inhibitors at 500° and 600°F were diphenylguanidine, di-2-naphthylamine, actidine and 2,2'-dipyridylamine.

In some runs with mixtures of N,N'-di-2-naphthyl-p-phenylenediamine and acridine there appears to be some enhancement of the oxidation inhibiting property as well as an apparent decrease in an attack on copper. The limited supply of this fluid prevented further exploration of the effect of mixtures, particularly derivatives of morpholine. However, it is probably reasonable to assume that the same consideration will hold with this type as shown with the F-50 fluid, Table 5. Attention should be called to Run 329.10 in which 2-phenylbenzoselenazole and p-aminoethyl-morpholine were used. It appears that the morpholine may have some inhibiting effect on the selenium compound.

To show more clearly, the behavior of insolubles in the methyl chlorophenyl silicone fluids, the data are tabulated separately; Tables 4 and 6. A part of the section on bis-(2-ethylhexyl) sebacate describes in detail the experimental procedure used for getting values for four types of insolubles. In brief, at 500°F, the oxidized fluid was filtered through a weighed porcelain crucible with asbestos mat. As much as possible of the liquid was drawn through the filter with suction. Then the crucible was weighed and the change in weight expressed as per cent oil insoluble. Next, the residue was washed with isooctane,

sucked dry and weighed. It appears with the methyl chlorophenyl silicone fluids that there was very little oil insoluble matter produced because, upon evaporation of the isooctane wash, the residue was mainly the starting fluid. Washing the filter mat with acetone generally did not show any significant change. Finally, the oil filtrate was treated with two 50 ml portions of isooctane and the precipitate separated by the centrifuge. The quantities precipitated could be a measure of some of the more polar substituents formed on oxidation. With N,N'-di-2-naphthyl-p-phenylenediamine the quantity of precipitate seemed to be roughly a function of the concentration of additive and the temperature. When the concentrations were in the neighborhood of 0.1%, the isooctane precipitate was usually small. When the expression "not filterable" was used in the tables the implication is that filtration was very slow and a useful quantity of filtrate could not be obtained in a reasonable time. At 600° F the insoluble effects are much more apparent. Here, comparison of a blank oxidation, Run 409.5, with a sample of fluid containing N,N'-di-2-naphthyl-p-phenylenediamine, Run 409.6, suggests that the additive may have some effect in reducing the insoluble matter.

A comparison of the results on the F-60 fluid with the data on the F-50 fluid indicates that the F-60 fluid possesses a greater inherent stability. The general appearance of the infra-red spectra on both oxidized and unoxidized samples of both fluids are essentially the same. This suggests that the difference may be due to a higher phenyl content in F-60. In future work with this type of fluid it is suggested that more attention be directed toward learning more about the oxidation and thermal degradation processes. It is not possible on the basis of data herein to separate the two processes clearly. In future work with additives at higher temperatures it is suggested that more attention be given to evaluating other aryl amines and phenylenediamines, both from the point of achieving better antioxidants and greater thermal stability of the additives.

#### D. Oxidations in a Methyl Chlorophenyl Silicone, F-50 Type.

This is the first report of experiences with a fluid labelled F-50. However, considerable experiences have been reported previously (Part VII) with the closely resembling fluid, MLO 53-446. About a one gallon sample of F-50 was received in a metal container through WADC channels on 18 March 1957. It was labelled Lot No. 124, Versilube F-50, Silicone Fluid from Silicone Products Department, General Electric Company. Tables 5 and 6 contain the detailed experimental data for this fluid. The quantities of additives listed in the table are expressed in grams per 25 ml of fluid. Multiplication of the gram weight by 4 gives an approximate value of the per cent of the additive.

N,N'-di-2-naphthyl-p-phenylenediamine appears to be the most generally available and useful additive for this fluid. However, the same solubility considerations hold as described for the F-60 fluid. Some related types of phenylenediamines, acridine, diphenylguanidine, 2,2'-dipyridylamine, p-aminodiphenyleneamine, and 2,4-bis-(phenyl mercapto) toluene, also showed inhibiting properties. Of some academic interest was Morgan's Base, which is a dibenzo acridine. This substance

is less volatile than acridine and appears to have considerable inhibiting activity.

Table 5 shows the effect of time of oxidation and concentration of N,N'-di-2-naphthyl-p-phenylenediamine at 500°F. There appears to be an induction period up to 48 hours. The concentration of additive is not critical in the range 0.1-0.2%. At 600°F this additive also has some effectiveness, but as with F-60, it is difficult to distinguish between thermal and oxidative effects. Mixtures of additives with N, N'-di-2-naphthyl-p-phenylenediamine may have lowered the attack on the metals, but they did not promote any outstanding or novel oxidation inhibiting properties. It is premature to eliminate mixtures from further consideration because better techniques are needed to determine the corrosion effects, particularly on silver and copper. In no instance, at 500°F, was the attack on the test metals of large order, except in the case of 2,4-bis-(phenyl mercapto) toluene. At 600°F there seems to be an increased effect of corrosion on stainless steel in all systems.

In several determinations of the kinematic viscosity change, two values were reported for 54.5° and 100°C. In determining the kinematic viscosity at these temperatures it has been customary to use a viscometer of the 300 series in order to have a reasonable time flow. In all determinations at 195°C a smaller bore viscometer of the 200 series was used. In those cases where there was considerable oxidation of this silicone fluid, the per cent viscosity change at 195°C was higher than might have been expected. In Table 5, for those cases where the kinematic viscosity were determined in a 200 series viscometer at the three temperatures, the values at 54.5° and 100°C are shown in parenthesis. It is suggested that some type of surface effect is responsible for the anomalies shown. The conclusion on oxidation inhibitors, however, are not seriously affected by this finding.

The overall behavior of the F-50 fluid appears to indicate this fluid has less stability than F-60. The difference is assumed to arise from small amounts of unknown impurities. Some attention has been given to chromatographic separation of both the oxidized and unoxidized fluids followed by obtaining the infra-red spectra of fractions with a Perkin-Elmer, Model 21B, Infra-red Recording Spectrophotometer. The range of this instrument is from 2-15 microns ( $5000\text{ cm}^{-1}$  to  $650\text{ cm}^{-1}$  wave numbers). The chromatographic apparatus constructed is a modification of that described in WADC TR 54-464 Pt III, ASTIA Document No. AD 118215. Comparison of the spectra with that reported for known silicone compounds showed some expected bands. However, assignment of compositions to the chromatographically separated fractions is speculative. It should be mentioned that from unoxidized F-50 a small amount of solid was isolated after elution from alumina with an ethanol-water mixture. It does not seem to have a chloro group in it and loses considerable weight on strong heating to leave a white residue. The infra-red spectrum is not readily fit to known substances. Additional study is needed on this aspect.

#### E. Oxidations in a Methyl Chlorophenyl Silicone. 81406. (MLO 53-446)

The oxidative behavior of this fluid was studied in considerable detail during the previous contract and last year. Parts VI and VII of this series of technical reports contain the details of many oxidation runs, both alone and in the presence of additives and metals. This fluid appears to be very similar to the F-50 fluid and the general considerations discussed in the preceding section will apply. During the current year runs were performed with N,N'-di-2-naphthyl-p-phenylenediamine, which had been shown to be of promise, to determine the minimum equivalent quantity needed to produce maximum oxidation inhibiting effect with low attack on the test metals. The quantities of additives listed in the tables are expressed in terms of grams per 25 ml of fluid. The multiplication of the gram quantity by four gives an approximate value of the percentage of the additive. See Table 7.

At 500°F in the presence of aluminum, silver, copper, stainless steel and titanium, quantities of N,N'-di-2-naphthyl-p-phenylenediamine as low as 0.20% held the viscosity change within 30% for 48 hours in the presence of 95% N<sub>2</sub> and 5% O<sub>2</sub>. With air under the same conditions the viscosity change was about 50% in 24 hours. With a concentration of about 1.0% N,N'-di-2-naphthyl-p-phenylenediamine the viscosity change was held within 10% for 48 hours in the presence of air. The response to concentration is not necessarily linear and there appears to be an optimum quantity for most efficient use. For possible operating conditions it is suggested that about 0.2% be tried.

A few other additives were examined at 500°F, but only N,N'-di-(2-methyl-3-chlorophenyl)-p-phenylenediamine appeared as good as N,N'-di-2-naphthyl-p-phenylenediamine. However, it was noted with this fluid that p-aminodiphenylamine has an interesting functional system and gave indication of considerable activity at low concentrations with very little effect on the test metals. Work with this silicone, MLO 53-446, was discontinued in favor of the more thermally stable F-60 type.

#### F. Oxidations in the Silanes.

Four tetra substituted silanes were examined during the current year. These were: didodecyl-dioctyl silane, MLO 57-161 and MLO 56-611; n-octadecyl-tri-n-octyl silane, MLO 56-578; and diphenyl-di-n-dodecyl silane, MLO 56-280. In the previous year some exploratory runs were made with the tetrakis-n-dodecyl silane, MLO 54-408D. The results were reported in Part VII of this report series. The new data are included in Tables 8, 9, 10 and 11.

The general pattern of oxidation of the silanes indicate considerable inherent resistance to oxidation in these types of fluids under the conditions of the evaluation. No additive showed outstanding antioxidant or oxidation retarding effects. The blank runs without additives were somewhat erratic. This presumably is due in part to excess bumping of this type of fluid during the oxidation run. The additives while not changing the general pattern significantly, did promote more consistency in the behavior. Selenium containing additives seem to be the most effective. However, the behavior could

not be related to concentration. Some heterocyclic amines ~~also~~ showed some inhibiting action. It appears that too large a quantity of additive might catalyze effects due to oxidation or thermal degradation. Of several selenium additives examined 2-phenylbenzoselenazole appeared to be the most versatile. This substance retards oxidation and attacked copper and silver least of the selenium compounds examined.

It is difficult to rate the silanes in order of stability. In an approximation the di-n-dodecyl-di-n-octyl silane, MLO 56-611, appears to be the best.

For future work with the silanes it is suggested that a larger variety of additives be screened, especially those which showed activity at high temperatures in mineral oils.

#### G. Oxidations in a Methyl Phenyl Silicone, MLO 9840.

During the previous year the behavior of this fluid was investigated in considerable detail. The results are reported in Part VII of this series of technical reports. Table 12 contains four runs using acridine to show the effects of purification of the commercial sample. The fraction crystallized from ethanol appeared to have considerable more inhibiting action than the solid fraction contained upon evaporation of the solvent.

#### H. Oxidations in a Pentaerythritol Ester, Hercules J-19, (MLO 55-584)

A series of oxidation runs were performed with this fluid at 400° and 500°F, in the presence and absence of metals and with selected additives, to determine which of several additives appear to be the best for future evaluations under more practical conditions. The results are in Table 13. The standard for comparison is the phenothiazine type. At 400°F this type was very effective, but it had little action at 500°F. One of its main drawbacks is the formation of oil insoluble matter as an end product. No convenient way has been found to eliminate this "dirtiness" factor.

The general pattern of behavior of this ester is the same as that of bis-(2-ethylhexyl) sebacate, which has been studied in much detail. During the current year new attention was given to several aryl-amine-type additives. Diphenylamine showed some effectiveness at 400°F with only a small amount of "dirtiness". However, at 500°F it showed no activity. This is in part due to volatility because di-2-naphthylamine did retain its activity at 500°F. The behavior of 2,2'-dipyridylamine continues to be interesting in the presence of copper. Under these conditions this amine showed promising antioxidant activity at both 400° and 500°F. A thesis problem with this substance gives some indication that a copper-coordination compound is related to the antioxidant activity. With an amino group in the para position, as in p-aminodiphenylamine, the temperature range of the oxidation inhibiting effect was increased and at 500°F this additive showed considerable promise. It did, however, form some oil insoluble matter, but to a somewhat lower extent than phenothiazine. Presumably, the p-amino system

is acting in the same manner as the phenylenediamines, because in an amino diphenyl (CCL No. 367) the activity is not retained at the higher temperature.

A number of commercial preparations of the "Age-Rite" type were examined. Several showed some effectiveness in retarding increases in kinematic viscosity at 500°F. Perhaps the most attractive was "Age-Rite H.P."

Several mixtures of additives were explored but none showed outstanding properties. For future work with the pentaerythritol ester type fluid it is suggested that more attention be given to pyridyl amines and to amines of low volatility, such as substituted aryl amines.

#### I. Oxidations in Bis-(2-ethylhexyl) Sebacate.

This fluid has been the standard of comparison for other fluids since the beginning of this program. Whenever new additives were acquired they were screened in this fluid first as a basis for comparison. A system of 1% phenothiazine is considered the blank. The concentration of additives used was the molar equivalent amounts to 0.25 gram of phenothiazine in 25 milliliters of diester. During the current year considerable attention was given to learning more about the behavior of insolubles and the accumulation of acids in fractions obtained by filtration and treatment with solvents. The results are in Tables 14, 15 and 16.

In the oxidation runs reported in Table 14, 10-methylphenothiazine is taken as a standard at 400°F. This substance has been shown to have slightly better performance than the parent compound, phenothiazine. At 500°F the phenothiazine type showed very little antioxidant activity. Diphenylamine in larger equivalent quantities was slightly active at 500°F, apparently because enough remained in the fluid to retard the oxidation. Ring substituted diphenylamines showed more activity at the higher temperatures. The most attractive appeared to be p-aminodiphenylamine. As previously reported, 2,2'-dipyridylamine continues to be attractive in the presence of copper.

An interesting aspect of N,N'-diphenyl-p-phenylenediamine is that recrystallization of the commercial sample from Eastman Kodak caused considerable increase in the antioxidant activity of the purified compound. Of several "Age-Rite" types examined, "Age-Rite H.P." appeared most promising. However, the differences among this series were small.

Some of the morpholines were interesting in that they seemed to have more activity at the higher temperatures. Two interesting new substances were cadmium diamyl dithiocarbamate and 4,4'-bisthiopicolinamido diphenyl. Both of these had some antioxidant activity but attacked copper and silver. A very low concentration of 4,4'-bisthiopicolinamido diphenyl in mixtures with phenothiazine and 2-phenylbenzoselenazole may have some slight activity in preventing attack on metals.

## J. Acidity Effects in Oxidized Bis-(2-ethylhexyl) Sebacate.

A series of oxidation runs was performed in an attempt to show the behavior of acid accumulation in several fractions of the oxidized fluid, Table 15. The experimental procedure is outlined at the end of this section.

As expected the percentage of fluid insolubles increased as a function of the phenothiazine concentration. In the isooctane precipitate the oil itself seems to be the main contributor. However, the acid material in the oil insoluble fraction appears to arise more from the fluid rather than the additive. The removal of oil insoluble matter lowers the acidity of the oxidized fluid only slightly. Perhaps the best indication of extent of oil insoluble formation is the residue remaining after washing with isooctane. This treatment removes occluded oil and does not seem to dissolve an appreciable amount of the insolubles. The acidity of this solid residue comes mainly from the oxidized fluid, with only a small contribution from phenothiazine.

The precipitation of solids upon addition of a large excess of isooctane to the oxidized fluid, followed by centrifuging and weighing, has been previously reported as per cent isooctane insolubles. The values for the per cent of isooctane precipitate in Table 16, while not strictly comparable because these values are for the precipitate formed after removal of the oil insoluble matter, nevertheless do point to the relative contributions of the oxidized fluid and the expended additive. It appears that both are factors, but that the fluid makes the major contribution after a fraction of the expended additive has been removed by filtrations. The acidity of the isooctane precipitates arise to a considerable extent from the fluid and presumably is sebacic acid and some unknown substances.

The acidities of the oil after removal of the excess isooctane indicate that some improvement of the fluid results from the isooctane wash. No attempt was made to determine the optimum condition for washing an oxidized fluid. The indications are that this procedure may be of value in reclaiming a diester fluid provided the oxidation has not been excessive.

As a thesis problem this investigator expects to continue to study the behavior of a few additives in bis-(2-ethylhexyl) sebacate to learn more about their mechanism of behavior. Particular attention will be given to studying those systems of metals and amines in which the metals appeared to enhance the antioxidant activity. In some exploratory runs this effect seems to be more general than originally expected. From time to time the investigator will also examine other types of compounds with interesting structures in order to fill-in gaps in the total picture of antioxidant and oxidation retarders.

## K. Procedure for Determination of Insoluble Matter

1. Oil Insoluble. A thin filter mat of asbestos (long fiber, acid-washed) is prepared on the bottom of a 25 ml Gooch crucible and dried to

constant weight in an oven at 100°-110° C. About 5 grams of a uniform sample of the oil is added to the crucible and suction from a water pump applied. After pulling as much oil as possible through the filter, the crucible and residue are weighed. The difference between the weight of the empty crucible and the weight of crucible and residue is the weight of oil insoluble matter.

The amount of filtrate from this step is determined by catching the fluid going through the mat in a 10 ml weighed test tube placed under the filter tube inside of a 250 ml suction flask. The crucible is held during filtration by a glass filter crucible holder with most of the top cut off so that only about 1 inch remains above the stem. This shortened holder does not retain a significant quantity of fluid. The difference between the weights of the test tube gives the amount of filtrate. In calculating the per cent oil insoluble, the weight of the fluid sample is the sum of the weight of filtrate plus the change in weight of the crucible.

2. Isooctane Wash. The residue in the crucible is washed with 50 ml of isooctane with gentle suction. After all the isooctane has been removed from the filter and residue, the crucible is again weighed. The per cent not removed by the isooctane wash is found by dividing the weight of the residue by the weight of the fluid sample.

3. Acetone Wash. The residue in the crucible is weighed after washing with 50 ml of acetone twice with gentle suction.

4. Isooctane Precipitate. The oil from the first filtration is put into a 50 ml centrifuge tube and 50 ml of isooctane added and thoroughly mixed. After standing for about 24 hours, the tube is centrifuged for 15 minutes, or until the centrifugate is packed tightly enough to allow supernatant liquid to be removed easily. Another 50 ml of isooctane is added to centrifugate and stirred. After centrifuging again and removing the supernatant liquid, the solid in the tube is heated until all isooctane has evaporated in an oven at 90-100°C. This isooctane precipitate is the difference in weight of the empty centrifuge tube and the weight of the tube plus solid. This is expressed as a per cent of the fluid sample.

The main error in the above procedure is in the value of oil insolubles due to the uncertainty of pulling all of the oil through the filter mat. The weighings are made to 10 mg for the filtrate, 0.1 mg for oil, isooctane and acetone residues, and to 1.0 mg for the isooctane precipitate.

5. Neutralization Numbers. The determination of the neutralization number of each of the residues and the fluids is of interest in the possible reclaiming of partially oxidized fluids. To show the behavior of the acidity of the solvents the filter crucible is placed in a beaker and treated with the usual mixtures of water, acetone and methanol, followed by titration with standard KOH as in a neutralization number determination. The isooctane supernatant was evaporated back to the oil and the acidity of a weighed portion of the oil determined.

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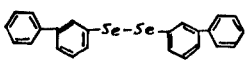
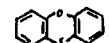
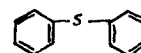
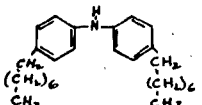
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## APPENDIX I. Tables of Oxidation Data.

**TABLE 1**  
Oxidations in Mineral Oil, MLO 57-30

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                            | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane                   |                |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|------------------------------|----------------|
|                                                                                                                                         |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          | Insoluble,<br>W <sup>1</sup> | P <sup>1</sup> |
| None, No Metals                                                                                                                         | 418.1      | 260°<br>(500°)      | 12             | 1.2                  | 17.0                          | 11.7             | 4.1              | 1.3                      | 0.032                        | 0.50           |
| None, No Metals                                                                                                                         | 418.2      | 260°<br>(500°)      | 24             | 1.4                  | 35.0                          | 11.7             | 12.5             | 1.3                      | .058                         | 0.50           |
| None, No Metals                                                                                                                         | 418.3      | 260°<br>(500°)      | 48             | 3.0                  | 72.3                          | 52.5             | 30.7             | 1.0                      | .081                         | 0.68           |
| None, Al Ag Cu S.S. Ti<br>0.04 .18 .26 .12 -.10<br>0.04 .04 .02 .02 .02                                                                 | 418.4      | 260°<br>(500°)      | 12             | 0.8                  | 11.9                          | 8.1              | 0.0              | 1.3                      | .048                         | 0.59           |
| None, Al Ag Cu S.S. Ti<br>0.12 .18 .20 .18 .00<br>.04 .14 .14 .12 .18                                                                   | 425.1      | 260°<br>(500°)      | 24             | 3.4                  | 43.9                          | 30.9             | 14.9             | 1.7                      | .010                         | 0.63           |
| None, Al Ag Cu S.S. Ti<br>0.18 .14 .22 .32 .06<br>.04 .04 .02 .04 .02                                                                   | 418.5      | 260°<br>(500°)      | 24             | 1.4                  | 41.5                          | 29.1             | 11.3             | 1.2                      | .048                         | 0.68           |
| None, Al Ag Cu S.S. Ti<br>0.22 .22 .20 .40 .08<br>.06 .06 .10 .02 .04                                                                   | 418.6      | 260°<br>(500°)      | 48             | 1.4                  | 60.0                          | 38.3             | 39.4             | 0.9                      | .134                         | 6.9            |
| None, Al Ag Cu S.S. Ti<br>0.00 .06 .08 .32 .04<br>.02 .04 .10 .04 .02                                                                   | 424.3      | 260°<br>(500°)      | 48             | 6.7                  | 82.4                          | 56.3             | 36.0             | 1.0                      | .141                         | 0.68           |
| Phenyl selenide, No. 282PCB,<br>0.30g. Al Ag Cu S.S. Ti<br>0.02-.14 1.78 1.10 .26<br>.18 .62 .46 .34 .24                                | 426.3      | 260°<br>(500°)      | 24             | 4.5                  | 14.3                          | 10.0             | 4.9              | 1.4                      | .000                         | 1.16           |
| 282PCB 0.15g.<br>Al Ag Cu S.S. Ti<br>0.18 .72-.04 .86 -.36<br>.08 .18 .98 .18 .08                                                       | 429.10     | 260°<br>(500°)      | 24             | 3.3                  | 33.3                          | 23.3             | 13.8             | 0.6                      | .019                         | 0.97           |
| 282PCB, 0.30g.<br>Al Ag Cu S.S. Ti<br>0.10 .54 2.54 1.14 .04<br>.06 .04 .06 .06 .00<br>(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Se | 424.6      | 260°                | 48             | 10.8                 | 59.5                          | 42.8             | 27.8             | 0.6                      | .110                         | 0.54           |
| 2,2'-Dibiphenyl diselenide,<br>No. 314, 0.25g.<br>Al Ag Cu S.S. Ti<br>-0.36-2.06 5.6 .14 -.22<br>.20 .94 1.9 .40 .10                    | 428.9      | 260°<br>(500°)      | 24             | 2.7                  | 18.7                          | 12.2             | 6.4              | 1.6                      | .045                         | 0.50           |
| 314 0.125g.<br>Al Ag Cu S.S. Ti<br>2.44 19.6-2.6 5.13-8.68<br>.02 .24 1.2 .14 .00                                                       | 429.3      | 260°<br>(500°)      | 24             | 2.8                  | 24.0                          | 16.8             | 8.6              | 1.0                      | .014                         | 1.01           |
|                                                      |            |                     |                |                      |                               |                  |                  |                          |                              |                |
| Phenanthrene, No. 54, 0.25g.<br>Al Ag Cu S.S. Ti<br>-0.28-.24 .04-.14 -.22<br>.08 .12 .14 .06 .06                                       | 427.3      | 260°<br>(500°)      | 24             | 5.0                  | 20.2                          | 13.3             | 8.3              | 2.3                      | .030                         | 2.41           |
|                                                      |            |                     |                |                      |                               |                  |                  |                          |                              |                |
| Phenylsulfide, No. 132, 0.23g.<br>Al Ag Cu S.S. Ti<br>-0.40 -.30 -.30 -.08 -.08<br>.08 .16 .10 .02 .04                                  | 427.7      | 260°<br>(500°)      | 24             | 6.2                  | 19.9                          | 13.5             | 9.7              | 1.7                      | 0.06                         | 2.36           |
|                                                      |            |                     |                |                      |                               |                  |                  |                          |                              |                |
| 2,2'-Diethyl-2,2'-biphenylamine, No. 22,<br>(recryst.) 0.49g.<br>Al Ag Cu S.S. Ti<br>0.14 .06 .36 .22 .20<br>.14 .28 .08 .14 .12        | 425.9      | 260°<br>(500°)      | 24             | 1.7                  | 21.5                          | 15.3             | 6.6              | 1.7                      | .000                         | 0.87           |
|                                                      |            |                     |                |                      |                               |                  |                  |                          |                              |                |

<sup>1</sup> The values under W are the per cent oil insoluble after the isooctane wash. The values under P are the per cent solid precipitated by oxidation of isooctane to the filtered fluid.

Table 1. Oxidations in Mineral Oil, MLO 57-30 (Cont'd)

25 ml. Sample Air Flow 1 l/Hr.

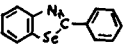
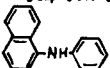
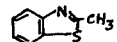
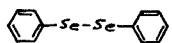
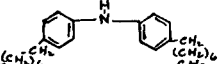
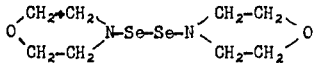
| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                    | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>W <sup>1</sup> P <sup>1</sup> |      |
|-----------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-----------------------------------------------------------|------|
|                                                                                                                 |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                                           |      |
| 2-Phenylbenzoselenazole,<br>No. 300B, 0.32g.                                                                    | 425.4      | 260°<br>(500°)      | 24             | 4.3                  | 22.3                          | 14.7             | 7.1              | 7.1                      | -0.004                                                    | 0.94 |
| Al Ag Cu S.S. Ti<br>0.00 .10 .22 .36 .24<br>.26 .34 .40 .28 .12                                                 |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| 300B, 0.32g. No Metals                                                                                          | 418.7      | 260°<br>(500°)      | 48             | 3.0                  | 77.3                          | 53.0             | 27.3             | 4.5                      | .070                                                      | 2.23 |
| 300B, 0.32g.                                                                                                    | 418.8      | 260°<br>(500°)      | 48             | 3.4                  | 96.0                          | 55.3             | 43.2             | 4.5                      | .097                                                      | 1.20 |
| Al Ag Cu S.S. Ti<br>0.10 .18 1.26 .14 .02<br>.10 .16 .10 .18 .10                                                |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
|                                |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| Benzyl disulfide, No. 321,<br>0.30g.                                                                            | 429.9      | 260°<br>(500°)      | 24             | 2.6                  | 22.1                          | 16.3             | 9.3              | 1.4                      | .048                                                      | .62  |
| Al Ag Cu S.S. Ti<br>-0.22 -3.08 13.3 1.9 -.10<br>.08 3.02 1.1 .34 .06                                           |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| (C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> S-) <sub>2</sub>                                                 |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| Phenyl- $\alpha$ -naphthylamine,<br>No. 61, 0.28g.                                                              | 425.2      | 260°<br>(500°)      | 24             | 2.5                  | 25.3                          | 18.0             | 8.6              | 0.9                      | .000                                                      | .79  |
| Al Ag Cu S.S. Ti<br>0.06 .12 .06 .24 .08<br>.30 .34 .28 .30 .16                                                 |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| 61 0.28g. Al Ag Cu S.S. Ti<br>0.02 .16 .04 .18 .04<br>.04 .02 .06 .04 .00                                       | 424.4      | 260°<br>(500°)      | 48             | 5.7                  | 61.5                          | 45.8             | 30.1             | 0.5                      | .14                                                       | .58  |
|                                |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| 2-Methyl benzothiazole,<br>No. 213, 0.19g.                                                                      | 429.8      | 260°<br>(500°)      | 24             | 3.2                  | 26.2                          | 19.8             | 10.4             | 1.8                      | .047                                                      | .89  |
| Al Ag Cu S.S. Ti<br>-0.16 -.02 .72 .20 -.10<br>.06 .04 .22 .00 .02                                              |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
|                              |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| Diphenyl diselenide, No. 323,<br>0.20g. Al Ag Cu S.S. Ti<br>5.34-7.84 13.6-1.94-1.94<br>.06 .76 .88 .16 .00     | 429.4      | 260°<br>(500°)      | 24             | 3.0                  | 28.1                          | 20.3             | 12.2             | 2.0                      | .060                                                      | .82  |
|                              |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| Dilauryl selenide, No. 271,<br>0.20g. Al Ag Cu S.S. Ti<br>-0.18 2.74 3.30 .16 -.04<br>.00 .28 .10 .00 .06       | 429.1      | 260°<br>(500°)      | 24             | 2.9                  | 35.7                          | 25.5             | 14.9             | 3.9                      | .091                                                      | .58  |
| 271, 0.40g.                                                                                                     | 428.5      | 260°<br>(500°)      | 24             | 3.6                  | 29.0                          | 20.6             | 11.3             | 3.4                      | .000                                                      | .51  |
| Al Ag Cu S.S. Ti<br>-0.26 24.0 6.16 .18 -.28<br>.00 .74 .44 .00 .06                                             |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| [CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> ] <sub>2</sub> Se                                             |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| 2,2'-Dipyridylamine, No. 128,<br>0.24g. Al Ag Cu S.S. Ti<br>0.04 .00 .42 .12 .00<br>.18 .48 .38 .36 .46         | 425.8      | 260°<br>(500°)      | 24             | 3.7                  | 31.0                          | 22.4             | 13.2             | 1.9                      | .000                                                      | .99  |
|                              |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |
| Morpholine diselenide, No. 324,<br>0.10g. Al Ag Cu S.S. Ti<br>-0.08 9.74 5.66 .30 -0.08<br>.10 2.56 .38 .06 .02 | 429.2      | 260°<br>(500°)      | 24             | 2.6                  | 37.8                          | 26.0             | 15.5             | 1.2                      | .090                                                      | .88  |
| 324, 0.20g. Al Ag Cu S.S. Ti<br>-0.02 14.3 10.4 .10 -.18<br>.22 1.5 .82 .26 .12                                 | 428.4      | 260°<br>(500°)      | 24             | 4.4                  | 31.5                          | 21.9             | 13.2             | 1.1                      | .22                                                       | .73  |
|                              |            |                     |                |                      |                               |                  |                  |                          |                                                           |      |

Table 1. Oxidations in Mineral Oil, MLO 57-30 (Cont'd)

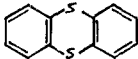
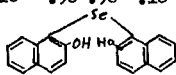
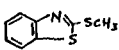
| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                                                                                            | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml, Air Flow 1 l/Hr.              |                               |                               | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>Wt % | P <sup>1</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|---------------------------------------------|-------------------------------|-------------------------------|--------------------------|----------------------------------|----------------|
|                                                                                                                                                                                                                         |            |                     |                |                      | Kinematic<br>Viscosity<br>54.5°C<br>(130°F) | Viscosity<br>100°C<br>(212°F) | Change, %<br>195°C<br>(383°F) |                          |                                  |                |
| Thianthrene, No. 6A, 0.05g.<br>and Phenyl- $\alpha$ -naphthylamine,<br>No. 61, 0.25g.<br>Al Ag Cu S.S. Ti<br>-0.08-.22 -.14 -.20 -.34<br>.06 .10 .10 .02 .04                                                            | 427.2      | 260°<br>(500°)      | 24             | 3.4                  | 30.8                                        | 22.1                          | 12.8                          | 1.2                      | 0.00                             | 1.09           |
|                                                                                                                                        |            |                     |                |                      |                                             |                               |                               |                          |                                  |                |
| Thianthrene, No. 6A, 0.27g.<br>Al Ag Cu S.S. Ti<br>-0.20-.20 .00 -.22 -.22<br>.08 .22 .12 .04 .04                                                                                                                       | 427.1      | 260°<br>(500°)      | 24             | 4.3                  | 34.3                                        | 24.8                          | 10.4                          | 1.5                      | .03                              | .95            |
| l-Cystine, No. 108, 0.30g.<br>Al Ag Cu S.S. Ti<br>-0.30-.40 .68 .80 -.12<br>.12 .44 .60 .10 .04<br>$\left[ \text{HO}_2\text{CCHCH}_2\text{S}- \right]_2$<br>NH <sub>2</sub>                                             | 427.4      | 260°<br>(500°)      | 24             | 4.7                  | 33.6                                        | 22.6                          | 16.6                          | 1.2                      | .13                              | 1.14           |
| 4-Hydroxy-3,5-ditertiary<br>butyl benzyl dimethylamine,<br>No. 371, 0.32g.<br>Al Ag Cu S.S. Ti<br>-0.12 -.08 .20 .08 .14<br>.26 .32 .30 .24 .20                                                                         | 425.6      | 260°<br>(500°)      | 24             | 3.1                  | 40.4                                        | 29.1                          | 15.8                          | 1.3                      | .00                              | 1.05           |
| 371, 0.32g. Al Ag Cu S.S. Ti<br>0.04 .02 .08 .22 .26<br>.12 .06 .06 .02 .02                                                                                                                                             | 424.9      | 260°<br>(500°)      | 48             | 9.3                  | 30.3                                        | 18.9                          | 12.6                          | 0.7                      | .07                              | .71            |
| 371 0.16g. and Na Sul (BSN)<br>Barium Sulfonate Neutral Salt<br>50% Dispersion in Di-2-ethyl<br>hexyl sebacate, 2 drops<br>Al Ag Cu S.S. Ti<br>0.00 .06 .14 .20 .14<br>.12 .38 .30 .16 .24                              | 425.10     | 260°<br>(500°)      | 24             | 3.4                  | 30.0                                        | 23.0                          | 12.5                          | 0.9                      | .00                              | .76            |
| Di-(2-hydroxy-1-naphthyl)<br>selenide, No. 307, 0.46g.<br>Al Ag Cu S.S. Ti<br>-0.40 .28 .6 8.30 -.02 -.20<br>.16 .98 .98 .18 .00<br> | 428.8      | 260°<br>(500°)      | 24             | 3.2                  | 38.0                                        | 26.8                          | 14.7                          | 0.8                      | .45                              | .59            |
| 2-Methyl mercaptobenzothiazole,<br>No. 208, 0.23g.<br>Al Ag Cu S.S. Ti<br>-0.08 -.26 1.36 1.58 -.02<br>.02 .12 .26 .14 .04<br>       | 429.7      | 260°<br>(500°)      | 24             | 4.5                  | 38.1                                        | 26.8                          | 16.4                          | 1.0                      | .06                              | 1.36           |
| Benzyl sulfide, No. 320, 0.27g.<br>Al Ag Cu S.S. Ti<br>-0.30 -1.32 .86 1.02 -.18<br>.02 .44 .66 1.24 .12<br>(C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> ) <sub>2</sub> S                                             | 428.3      | 260°<br>(500°)      | 24             | 5.2                  | 38.4                                        | 27.0                          | 18.9                          | 0.9                      | .06                              | .97            |

Table 1. Oxidations in Mineral Oil, MLO 57-30 (Cont'd)

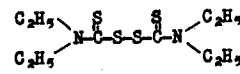
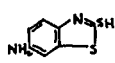
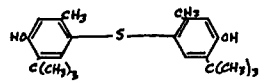
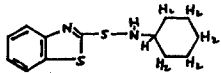
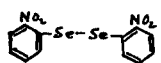
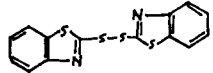
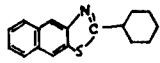
| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                                                                                                     | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Air Flow 1 l/Hr. |                               |                               | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>W <sup>1</sup> P |      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|--------------------------------|-------------------------------|-------------------------------|--------------------------|----------------------------------------------|------|
|                                                                                                                                                                                                                                  |            |                     |                |                      | Kinematic<br>54.5°C<br>(130°F) | Viscosity<br>100°C<br>(212°F) | Change, %<br>195°C<br>(383°F) |                          |                                              |      |
| <b>Tetraethyl thiuram disulfide,</b><br>No. 124, 0.37g.,<br>Al Ag Cu S.S. Ti<br>-0.22 -.16 .10 .28 -.30<br>.14 .80 .54 .42 .20<br>              | 427.5      | 260°<br>(500°)      | 24             | 4.3                  | 39.0                           | 30.3                          | 16.3                          | 1.5                      | 0.02                                         | 1.54 |
| <b>6-Amino-2-mercaptobenzothiazole,</b><br>No. 207, 0.23g.,<br>Al Ag Cu S.S. Ti<br>-0.30 -1.60 .20 .74 -.42<br>.10 1.32 .74 .00 .18<br>         | 429.6      | 260°<br>(500°)      | 24             | 2.4                  | 39.6                           | 31.0                          | 19.7                          | 0.8                      | .35                                          | .77  |
| <b>4,4'-Thiobis 6-tert-butyl-2-cresol</b> 0.44g. No. 156<br>Al Ag Cu S.S. Ti<br>-0.14 -.30 1.34 0.24 -.30<br>.14 .24 .90 .12 .04<br>            | 427.9      | 260°<br>(500°)      | 24             | 2.9                  | 41.3                           | 18.5                          | 10.4                          | 1.0                      | .07                                          | 4.93 |
| <b>N-Cyclohexyl-2-benzothiazole-sulfenamide,</b> No. 163, 0.33g.<br>Al Ag Cu S.S. Ti<br>-0.18 -.18 5.54 .02 -.24<br>.16 .52 1.18 1.48 .08<br> | 428.2      | 260°<br>(500°)      | 24             | 4.4                  | 41.4                           | 31.3                          | 20.0                          | 0.4                      | .10                                          | .61  |
| <b>2,2'-Dinitrodiphenyl diselenide,</b><br>No. 303B, 0.25g.<br>Al Ag Cu S.S. Ti<br>-0.24 14.3 7.72 .14 -.44<br>.00 .76 .60 .04 .16<br>        | 428.7      | 260°<br>(500°)      | 24             | 3.3                  | 42.3                           | 30.9                          | 21.2                          | 1.0                      | .25                                          | .49  |
| <b>2,2'-Dithiobis (benzothiazole)</b><br>No. 155, 0.41g.<br>Al Ag Cu S.S. Ti<br>-0.28 -.40 10.06 2.74 -0.24<br>.10 .52 .66 .78 .08<br>        | 427.8      | 260°<br>(500°)      | 24             | 4.7                  | 42.5                           | 31.7                          | 19.0                          | 1.5                      | .00                                          | 2.36 |
| <b>2-Phenylnaptho(2,1)thiazole,</b><br>No. 299, 0.32g.,<br>Al Ag Cu S.S. Ti<br>-0.20 1.78 1.82 .30 -.08<br>.00 .44 .86 .20 .00<br>            | 428.6      | 260°<br>(500°)      | 24             | 3.6                  | 43.5                           | 29.6                          | 17.5                          | 1.7                      | .06                                          | .58  |
| <b>Phenyl disulfide,</b> No. 322,<br>0.27g.,<br>Al Ag Cu S.S. Ti<br>-0.46 -.30 1.86 .98 -.20<br>.22 .32 .42 .28 .12<br>(C <sub>6</sub> H <sub>5</sub> -S-) <sub>2</sub>                                                          | 428.10     | 260°<br>(500°)      | 24             | 2.2                  | 46.0                           | 33.8                          | 20.0                          | 0.8                      | .08                                          | .53  |

Table 1. Oxidations in Mineral Oil, MLO 57-30 (Cont'd)

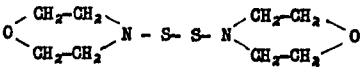
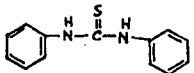
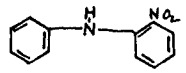
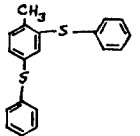
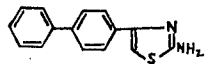
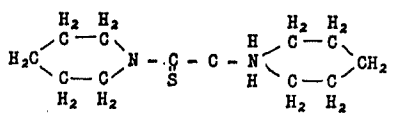
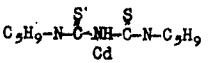
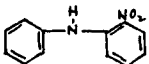
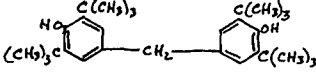
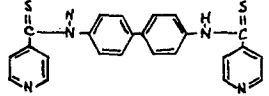
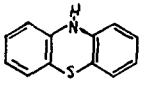
| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                          | Run<br>No.      | Temp.<br>°C<br>(°F)              | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Air Flow 1 l/Hr.<br>Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>W <sup>1</sup> P <sup>1</sup> |             |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------------------------|----------------|----------------------|-----------------------------------------------------------------|------------------|------------------|--------------------------|-----------------------------------------------------------|-------------|
|                                                                                                                                       |                 |                                  |                |                      | 54.5°C *<br>(130°F)                                             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                                           |             |
| 4,4'-Dithiodimorpholine, No. 164,<br>0.30g. Al Ag Cu S.S. Ti<br>-0.46 .10 1.60 .70 -.14<br>.10 .48 .44 .10 .02                        | 427.6           | 260°<br>(500°)                   | 24             | 4.1                  | 49.8                                                            | 36.0             | 21.9             | 1.3                      | 0.02                                                      | 1.58        |
|                                                      |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| N,N'-Diphenylthiourea, No. 159,<br>0.29g. Al Ag Cu S.S. Ti<br>-0.30 -.38 2.74 .12 -.12<br>.06 .30 .30 .12 .02                         | 427.10          | 260°<br>(500°)                   | 24             | 4.1                  | 52.0                                                            | 15.2             | 23.9             | 1.2                      | .06                                                       | 0.67        |
|                                                      |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| 8-Nitrodiphenylamine, No. 87,<br>0.25g. No Metals<br>87, 0.25g. Al Ag Cu S.S. Ti<br>0.22 .22 .52 .22 .04<br>.20 .26 .14 .10 .08       | 418.9<br>418.10 | 260°<br>(500°)<br>260°<br>(500°) | 48<br>48       | 2.9<br>1.7           | 78.7<br>85.5                                                    | 60.1<br>66.2     | 36.7<br>37.8     | 0.8<br>0.8               | .055<br>.131                                              | .43<br>1.38 |
|                                                      |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| 2,4-bis (phenyl mercapto)<br>teluane, No. 372, 0.36g.<br>Al Ag Cu S.S. Ti<br>0.06 .16 .32 .70 .08<br>.06 .12 .12 .02 .06              | 424.10          | 260°<br>(500°)                   | 48             | 5.2                  | 81.0                                                            | 58.8             | 37.2             | 1.0                      | .12                                                       | .55         |
|                                                     |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| 2-Amino-4-(p-diphenyl)thiazole,<br>No. 199, 0.31g.<br>Al Ag Cu S.S. Ti<br>-8.06 -16.74 4.96-47.8 10.3<br>.04 .14 .50 .02 .06          | 429.5           | 260°<br>(500°)                   | 24             | 2.3                  | 66.7                                                            | 49.5             | 29.9             | 1.6                      | .03                                                       | .70         |
|                                                    |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| Piperdinium-1-piperidine-<br>carbodithioate, No. 160,<br>0.31g.<br>Al Ag Cu S.S. Ti<br>-0.06 -.04-.18 .02 -.14<br>.14 .26 .84 .48 .00 | 428.1           | 260°<br>(500°)                   | 24             | 3.1                  | 70.5                                                            | 52.6             | 35.7             | 1.5                      | .04                                                       | .58         |
|                                                     |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |
| Cadmium diamyl dithiocarbamate,<br>No. 399, 0.50g.<br>Al Ag Cu S.S. Ti<br>0.04 -0.08 1.28 .58 .02<br>.04 .34 .24 .06 .02              | 424.8           | 260°<br>(500°)                   | 48             | 6.0                  | 107.1                                                           | 76.2             | 45.6             | 0.6                      | .09                                                       | 1.02        |
|                                                     |                 |                                  |                |                      |                                                                 |                  |                  |                          |                                                           |             |

Table 1. Oxidations in Mineral Oil, MLO 57-30 (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                  | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Air Flow 1 l/Hr.<br>Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>W <sup>1</sup> P <sup>1</sup> |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-----------------------------------------------------------------|------------------|------------------|--------------------------|-----------------------------------------------------------|------|
|                                                                                                                                               |            |                     |                |                      | 54.5°C<br>(130°F)                                               | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                                           |      |
| Acridine, No. 82, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.26 .56 .26 .58 .14<br>.02 .02 .00 .00 .02                                                   | 424.2      | 260°<br>(500°)      | 48             | 7.0                  | 124.0                                                           | 77.4             | 54.6             | 0.6                      | 0.10                                                      | 0.70 |
|                                                              |            |                     |                |                      |                                                                 |                  |                  |                          |                                                           |      |
| 4,4'-Methylele bis-2,6-<br>ditertiarybutyl phenol,<br>No. 370, 0.50g.<br>Al Ag Cu S.S. Ti<br>-0.04 .04 .04 .02 .04<br>.08 .04 .06 .04 .02     | 424.7      | 260°<br>(500°)      | 48             | 7.4                  | 190.5                                                           | 119.0            | 66.3             | 0.6                      | .09                                                       | .62  |
|                                                              |            |                     |                |                      |                                                                 |                  |                  |                          |                                                           |      |
| N,N'-Diphenyl-p-phenylene-<br>diamine, No. 186, 0.34g.<br>(recrystallized)<br>Al Ag Cu S.S. Ti<br>0.02 .02 .12 .10 .12<br>.14 .32 .20 .26 .20 | 425.5      | 260°<br>(500°)      | 24             | 2.6                  | 129.0                                                           | 96.7             | 38.5             | 1.2                      | 0.08                                                      | 2.66 |
| 186 0.34g.<br>Al Ag Cu S.S. Ti<br>0.12 .22 .18 .12 .06<br>.12 .20 .16 .02 .02                                                                 | 420.10     | 260°<br>(500°)      | 48             | 6.3                  | N.M.                                                            | N.M.             | N.M.             | 0.9                      | .11                                                       | .30  |
|                                                              |            |                     |                |                      |                                                                 |                  |                  |                          |                                                           |      |
| 4,4'-bisthiopicolenamido<br>diphenyl, No. 401 0.27g.<br>Al Ag Cu S.S. Ti<br>0.04 .10 3.64 .34 -.02<br>.06 .06 .08 .02 .02                     | 424.5      | 260°<br>(500°)      | 48             | 9.6                  | 211.0                                                           | 144.5            | 74.5             | 0.6                      | 0.50                                                      | 1.12 |
|                                                            |            |                     |                |                      |                                                                 |                  |                  |                          |                                                           |      |
| Phenothiazine, No. 293,<br>0.25g. Al Ag Cu S.S. Ti<br>-0.02 .00 -.86 -.10 -.12<br>.04 .04 .12 .02 .06                                         | 424.1      | 260°<br>(500°)      | 48             | 6.7                  | N.M.                                                            | 275.0            | 116.5            | 0.5                      | 0.52                                                      | 5.97 |
|                                                            |            |                     |                |                      |                                                                 |                  |                  |                          |                                                           |      |

N.M. Too viscous for measurement.

N.F. Not Filterable.

TABLE 2  
Oxidations in Fluid P-60, First Batch

| Additive, CCL No., Formula,<br>Concentration, Metals Present | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|--------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                              |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| None, No Metals 1/                                           | 358.1      | 260°<br>(500°)      | 24             | 1.4                  | 41                            | 36               | 37               | 0.6                      | 0.06                          |
| None, No Metals 1/                                           | 358.2      | 260°<br>(500°)      | 48             | 2.9                  | 153                           | 134              | 115              | 0.4                      | 0.02                          |
| None, Al, Ag, Cu, S.S., Ti 1/                                | 358.3      | 260°<br>(500°)      | 24             | 1.5                  | 25                            | 22               | 17               | 0.7                      | 0.04 a/                       |
| None, Al, Ag, Cu, S.S., Ti 1/                                | 358.4      | 260°<br>(500°)      | 48             | 2.0                  | 61                            | 53               | 47               | 0.7                      | 0.04 b/                       |
| None, Al, Ag, Cu, Cr-Mo, Ti 1/                               | 358.5      | 260°<br>(500°)      | 24             | 1.6                  | 11                            | 9                | 7                | 0.6                      | 0.02 g/                       |
| None, Al, Ag, Cu, Cr-Mo, Ti 1/                               | 358.6      | 260°<br>(500°)      | 48             | 2.1                  | 20                            | 18               | 14               | 0.5                      | 0.00 d/                       |
| None, No Metals 1/                                           | 366.1      | 316°<br>(600°)      | 6              | 4.9                  | 93                            | 84               | 87               | 1.0                      | 0.00                          |
| None, No Metals 1/                                           | 366.2      | 316°<br>(600°)      | 12             | 2.4                  | 665                           | 575              | 670              | 1.4                      | 0.16                          |
| None, No Metals 2/                                           | 351.1      | 316°<br>(600°)      | 6              | 1.4                  | 14                            | 12               | 75               | 1.4                      | 0.10                          |
| None, No Metals 2/                                           | 351.2      | 316°<br>(600°)      | 12             | 2.5                  | 48                            | 43               | 140              | 1.7                      | 0.02                          |
| None, No Metals 2/                                           | 350.1      | 316°<br>(600°)      | 12             | 1.0                  | 41                            | 37               | N.D.             | 1.5                      | 0.08                          |
| None, No Metals 2/                                           | 350.2      | 316°<br>(600°)      | 24             | 1.1                  | 116                           | 105              | N.D.             | 1.3                      | 0.04                          |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 351.3      | 316°<br>(600°)      | 6              | 1.7                  | 19                            | 17               | 84               | 1.7                      | 0.04 g/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 353.1      | 316°<br>(600°)      | 6              | 2.1                  | 19                            | 17               | 25               | 1.5                      | 0.02 f/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 353.4      | 316°<br>(600°)      | 12             | 3.4                  | 50                            | 46               | 87               | 1.8                      | 0.08 g/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 353.3      | 316°<br>(600°)      | 12             | 3.5                  | 66                            | 58               | 112              | 1.4                      | 0.04 h/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 350.3      | 316°<br>(600°)      | 12             | 2.5                  | 53                            | 48               | N.D.             | 1.5                      | 0.04 i/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                | 350.4      | 316°<br>(600°)      | 24             | 4.3                  | 202                           | 183              | N.D.             | 1.2                      | 0.04 j/                       |
| None, Al, Ag, Cu, S.S., Ti 3/                                | 361.3      |                     | 36             | 4.1                  | 179                           | 158              | 189              | 1.7                      | 0.04 k/                       |
| None, Al, Ag, Cu, Cr-Mo, Ti 3/                               | 361.4      |                     | 36             | 7.5                  | 86                            | 73               | 79               | 1.7                      | 0.10 l/                       |
| None, Al, Ag, Cu, S.S., Ti 4/                                | 364.1      |                     | 48             | 3.3                  | 270                           | 244              | 208              | 1.1                      | 0.06 m/                       |
| None, Al, Ag, Cu, Cr-Mo, Ti 4/                               | 364.2      |                     | 48             | 6.6                  | 100                           | 86               | 80               | 1.0                      | 0.06 n/                       |

1/ Gas Flow 1/hr. - Air

2/ Gas Flow 1/hr. - 95% N<sub>2</sub> - 5% O<sub>2</sub>

3/ 24 hours with air at 260°C and 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub> at 316°C.

4/ 24 hours at 260°C, raise to 316°C for 12 hours, after 36 hours drop to 260°C for 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub>. Total 48 hrs.

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

a/ Al 0.06 Ag 0.52 Cu 0.90 S.S. 0.16 Ti 0.12

b/ Al 0.04 Ag 0.56 Cu 1.26 S.S. 0.00 Ti 0.06

g/ Al 0.20 Ag 0.46 Cu 0.86 Cr-Mo 0.28 Ti 0.26

d/ Al 0.02 Ag 0.36 Cu 0.84 Cr-Mo 0.02 Ti 0.02

e/ Al 0.14 Ag 0.46 Cu 0.46 S.S. 0.14 Ti 0.00

f/ Al 0.32 Ag 0.30 Cu 0.30 S.S. 0.20 Ti 0.02

h/ Al 0.28 Ag 1.02 Cu 1.00 S.S. 0.32 Ti-0.02

i/ Al 0.00 Ag 0.24 Cu 0.00 S.S. 0.22 Ti 0.00

j/ Al 0.10 Ag 0.90 Cu 0.38 S.S. 0.28 Ti 0.08

k/ Al 0.04 Ag 0.26 Cu 0.98 S.S. 1.5 Ti 0.02

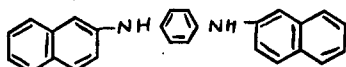
l/ Al 0.20 Ag 0.64 Cu 1.08 S.S. 0.18 Ti-0.06

m/ Al 0.50 Ag 0.60 Cu 1.08 Cr-Mo 0.68 Ti 0.10

n/ Al 2.08 Ag 0.52 Cu 2.00 S.S. 0.92 Ti 0.20

o/ Al 0.32 Ag 0.80 Cu 2.40 Cr-Mo 1.00 Ti 0.18

Table 2. Oxidations in Fluid F-60 (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                      | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | First Batch                    |                               |                               | 25 ml Sample             |     | Iso-octane<br>Insoluble,<br>% |    |
|-----------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|--------------------------------|-------------------------------|-------------------------------|--------------------------|-----|-------------------------------|----|
|                                                                                   |            |                     |                |                      | Kinematic<br>54.5°C<br>(130°F) | Viscosity<br>100°C<br>(212°F) | Change, %<br>195°C<br>(383°F) | Neutralization<br>Number |     |                               |    |
|                                                                                   |            |                     |                |                      |                                |                               |                               |                          |     |                               |    |
| N,N'-Di-2-naphthyl-p-phenylene-<br>diamine, No. 260                               |            |                     |                |                      |                                |                               |                               |                          |     |                               |    |
|  |            |                     |                |                      |                                |                               |                               |                          |     |                               |    |
| 0.05 g. $\frac{1}{2}$ Al, Ag, Cu, S.S., Ti                                        | 1/         | 357.3               | 260°<br>(500°) | 48                   | 1.5                            | 6                             | 5                             | 2.9                      | 0.7 | 0.08                          | b/ |
| 0.05 g., Al, Ag, Cu, S.S., Ti                                                     | 1/         | 357.4               | 260°<br>(500°) | 48                   | 2.1                            | 6                             | 4                             | 3.4                      | 0.6 | 0.06                          | g/ |
| 0.05 g., Al, Ag, Cu, Cr-Mo, Ti                                                    | 1/         | 358.8               | 260°<br>(500°) | 48                   | 1.3                            | 4                             | 3                             | 1.3                      | 0.5 | 0.12                          | d/ |
| 0.10 g. No Metals                                                                 | 1/         | 366.3               | 316°<br>(600°) | 6                    | 1.7                            | 9                             | 7                             | 5.7                      | 0.7 | 0.38                          |    |
| 0.10 g. No Metals                                                                 | 1/         | 366.4               | 316°<br>(600°) | 12                   | 3.0                            | 53                            | 45                            | 41                       | 0.7 | 0.24                          |    |
| 0.10 g. No Metals                                                                 | 1/         | 366.5               | 316°<br>(600°) | 24                   | 1.3                            | 4320                          | 3550                          | N.M.                     | 1.3 | 0.46                          |    |
| 0.10 g., Al, Ag, Cu, S.S., Ti                                                     | 1/         | 366.6               | 316°<br>(600°) | 6                    | 2.5                            | 7                             | 6                             | 4.9                      | 0.9 | 0.30                          | g/ |
| 0.10 g., Al, Ag, Cu, S.S., Ti                                                     | 1/         | 366.7               | 316°<br>(600°) | 12                   | 3.6                            | 62                            | 54                            | 52                       | 1.0 | 0.38                          | f/ |
| 0.10 g., Al, Ag, Cu, S.S., Ti                                                     | 1/         | 366.8               | 316°<br>(600°) | 24                   | 8.3                            | N.M.                          | N.M.                          | N.M.                     | 0.7 | 92.1                          | g/ |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                     | 2/         | 353.2               | 316°<br>(600°) | 6                    | 1.9                            | 5                             | 3                             | 2.8                      | 0.7 | 0.10                          | h/ |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 353.5               | 316°<br>(600°) | 6                    | 1.7                            | 4                             | 2                             | 0.8                      | 0.9 | 0.22                          | i/ |
| 0.10g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 351.9               | 316°<br>(600°) | 6                    | 1.9                            | 5                             | 3                             | 0.8                      | 0.8 | 0.08                          | i/ |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                     | 2/         | 350.5               | 316°<br>(600°) | 12                   | 3.8                            | 31                            | 27                            | N.D.                     | 1.5 | 0.14                          | k/ |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                     | 2/         | 353.4               | 316°<br>(600°) | 12                   | 2.6                            | 21                            | 18                            | 20                       | 0.9 | 0.10                          | l/ |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 353.6               | 316°<br>(600°) | 12                   | 2.9                            | 17                            | 15                            | 15                       | 1.1 | 0.18                          | m/ |
| 0.10g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 351.10              | 316°<br>(600°) | 12                   | 2.3                            | 5                             | 3                             | 3.2                      | 1.0 | 0.26                          | n/ |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                     | 2/         | 350.6               | 316°<br>(600°) | 24                   | 2.4                            | 172                           | 155                           | N.D.                     | 1.3 | 0.10                          | o/ |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 353.7               | 316°<br>(600°) | 24                   | 4.1                            | 69                            | 62                            | 61                       | 1.1 | 0.18                          | p/ |
| 0.10g., Al, Ag, Cu, S.S., Ti                                                      | 2/         | 353.8               | 316°<br>(600°) | 24                   | 4.6                            | 41                            | 36                            | 31                       | 1.1 | 0.40                          | q/ |

$\frac{1}{2}$  The sample of additive tested here was subjected to a purification process. See comment in body of report, Page 6.

1/ Gas Flow 1/hr. - Air

2/ Gas Flow 1/hr. - 95% N<sub>2</sub> - 5% O<sub>2</sub>

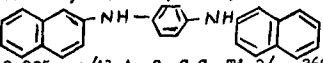
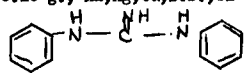
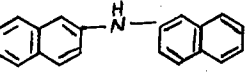
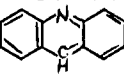
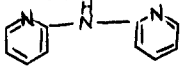
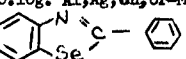
Metal Effects, Weight Loss, mg/cm<sup>2</sup>

b/ Al 0.14 Ag 0.36 Cu 1.52 S.S. 0.04 Ti 0.10  
 g/ Al 0.08 Ag 0.40 Cu 1.76 S.S. 0.06 Ti 0.18  
 d/ Al 0.04 Ag 0.08 Cu 0.74 Cr-Mo 0.02 Ti -0.22  
 e/ Al 0.26 Ag 0.42 Cu 0.86 S.S. 0.34 Ti 0.32  
 f/ Al 0.60 Ag 0.76 Cu 1.10 S.S. 0.42 Ti 0.34  
 g/ Al 1.06 Ag 0.72 Cu 1.26 S.S. 0.70 Ti 0.36  
 h/ Al 0.04 Ag 0.28 Cu 0.44 S.S. 0.10 Ti 0.00  
 i/ Al 0.58 Ag 0.26 Cu 0.60 S.S. 0.02 Ti 0.00  
 j/ Al 0.08 Ag 0.22 Cu 0.58 S.S. 0.14 Ti 0.12  
 k/ Al 0.24 Ag 0.44 Cu 0.70 S.S. 0.42 Ti 0.04  
 l/ Al 0.06 Ag 0.54 Cu 0.56 S.S. 0.18 Ti 0.02  
 m/ Al 0.00 Ag 0.42 Cu 0.60 S.S. 0.20 Ti 0.00  
 n/ Al 0.18 Ag 0.40 Cu 0.82 S.S. 0.16 Ti 0.08  
 o/ Al 0.30 Ag 0.18 Cu 0.98 S.S. 0.70 Ti 0.06  
 p/ Al 0.02 Ag 0.66 Cu 0.56 S.S. 0.34 Ti 0.00  
 q/ Al 0.00 Ag 0.54 Cu 1.08 S.S. 0.14 Ti 0.00

N.M. Too viscous for measurement.

N.D. Not Determined.

Table 2. Oxidations in Fluid F-60 (Cont'd)

| Table 2. Oxidations in Fluid P-100 (Cont'd)                                                                                         |         |               |             |                | First Batch                   |               |               | 25 ml Sample          |                         |
|-------------------------------------------------------------------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
| Additive, CCL No., Formula, Concentration, Metals Present                                                                           | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|                                                                                                                                     |         |               |             |                | 54.5°C (130°F)                | 100°C (212°F) | 195°C (383°F) |                       |                         |
| N,N'-Di-2-Naphthyl-p-phenylene-diamine, No. 260 (Cont'd)                                                                            |         |               |             |                |                               |               |               |                       |                         |
|                                                    |         |               |             |                |                               |               |               |                       |                         |
| 0.025g. $\frac{2}{3}$ Al, Ag, Cu, S.S., Ti                                                                                          | 360.1   |               | 36          | 3.1            | 42                            | 38            | 43            | 0.9                   | 0.12 $\frac{b}{/}$      |
| 0.050g. $\frac{2}{3}$ Al, Ag, Cu, S.S., Ti                                                                                          | 360.2   |               | 36          | 3.4            | 40                            | 35            | 45            | 0.9                   | 0.18 $\frac{a}{/}$      |
| 0.025g. $\frac{2}{3}$ Al, Ag, Cu, Cr-Mo, Ti                                                                                         | 360.3   |               | 36          | 2.7            | 42                            | 37            | 45            | 0.9                   | 0.02 $\frac{d}{/}$      |
| 0.050g., Al, Ag, Cu, Cr-Mo, Ti $\frac{2}{3}$                                                                                        | 360.4   |               | 36          | 3.0            | 27                            | 23            | 25            | 1.1                   | 0.11 $\frac{a}{/}$      |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                                                                        | 361.1   |               | 36          | 4.0            | 41                            | 36            | 37            | 1.5                   | 0.06 $\frac{f}{/}$      |
| 0.05g., Al, Ag, Cu, Cr-Mo, Ti                                                                                                       | 361.2   |               | 36          | 4.2            | 33                            | 29            | 35            | 1.7                   | 0.16 $\frac{g}{/}$      |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                                                                        | 364.3   |               | 48          | 3.1            | 105                           | 95            | 83            | 0.9                   | 0.08 $\frac{h}{/}$      |
| 0.05g., Al, Ag, Cu, Cr-Mo, Ti                                                                                                       | 364.4   |               | 48          | 4.4            | 85                            | 75            | 66            | 0.9                   | 0.10 $\frac{i}{/}$      |
| 0.1g., Al, Ag, Cu, S.S., Ti                                                                                                         | 364.5   |               | 48          | 3.0            | 108                           | 96            | 83            | 0.9                   | 0.10 $\frac{j}{/}$      |
| 0.2g., Al, Ag, Cu, S.S., Ti                                                                                                         | 364.6   |               | 48          | 3.3            | 80                            | 72            | 63            | 1.1                   | 0.02 $\frac{k}{/}$      |
| N,N'-Di-2-naphthyl-p-phenylene-diamine, 0.050 g. and Vanadyl-2-ethyl hexoate, No. 379, 0.001 g., Al, Ag, Cu, S.S., Ti $\frac{1}{/}$ |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 358.7   | 260°C (500°F) | 48          | 1.9            | 4                             | 3             | 1.8           | 0.7                   | 0.10 $\frac{l}{/}$      |
| Vanadyl-2-ethyl hexoate, No. 379 0.050g., Al, Ag, Cu, S.S., Ti $\frac{1}{/}$                                                        | 358.9   | 260°C (500°F) | 48          | 2.3            | 43                            | 38            | 31            | 1.0                   | 0.44 $\frac{m}{/}$      |
| Diphenylguanidine, No. 161, 0.10 g., Al, Ag, Cu, S.S., Ti $\frac{2}{/}$                                                             |         |               |             |                |                               |               |               |                       |                         |
|                                                   |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 351.7   | 316°C (600°F) | 6           | 1.6            | 8                             | 7             | 4.9           | 1.3                   | 0.16 $\frac{n}{/}$      |
|                                                                                                                                     | 351.8   | 316°C (600°F) | 12          | 3.0            | 27                            | 23            | 22            | 1.1                   | 0.24 $\frac{o}{/}$      |
| Di-2-naphthylamine, No. 383, 0.10g., Al, Ag, Cu, S.S., Ti $\frac{1}{/}$                                                             |         |               |             |                |                               |               |               |                       |                         |
|                                                  |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 366.9   | 316°C (600°F) | 12          | 3.1            | 29                            | 24            | 21            | 0.9                   | 0.16 $\frac{p}{/}$      |
|                                                                                                                                     | 366.10  | 316°C (600°F) | 24          | 3.6            | 227                           | 196           | 184           | 1.0                   | 0.28 $\frac{q}{/}$      |
| Acridine, No. 82 0.03g., Al, Ag, Cu, S.S., Ti $\frac{2}{/}$                                                                         |         |               |             |                |                               |               |               |                       |                         |
|                                                  |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 350.7   | 316°C (600°F) | 12          | 2.6            | 45                            | 40            | N.D.          | 1.3                   | 0.04 $\frac{r}{/}$      |
|                                                                                                                                     | 350.8   | 316°C (600°F) | 24          | 6.2            | 164                           | 146           | N.D.          | 1.2                   | 0.06 $\frac{s}{/}$      |
| 2,2'-Dipyridylamine, No. 128, 0.10 g., Al, Ag, Cu, S.S., Ti $\frac{2}{/}$                                                           |         |               |             |                |                               |               |               |                       |                         |
|                                                  |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 351.5   | 316°C (600°F) | 6           | 2.1            | 11                            | 9             | 9             | 0.8                   | 0.14 $\frac{t}{/}$      |
|                                                                                                                                     | 351.6   | 316°C (600°F) | 12          | 3.4            | 33                            | 29            | 28            | 1.5                   | 0.24 $\frac{u}{/}$      |
| 0.10g., Al, Ag, Cu, S.S., Ti $\frac{1}{/}$                                                                                          | 358.10  | 260°C (500°F) | 48          | 2.3            | 35                            | 30            | 25            | 0.4                   | 0.04 $\frac{v}{/}$      |
| 2-Phenylbenzoselenazole, No. 300B, 0.10g. Al, Ag, Cu, S.S., Ti $\frac{3}{/}$                                                        |         |               |             |                |                               |               |               |                       |                         |
|                                                  |         |               |             |                |                               |               |               |                       |                         |
|                                                                                                                                     | 361.5   |               | 36          | 6.3            | 154                           | 134           | 127           | 1.9                   | 0.10 $\frac{w}{/}$      |
| 0.10g. Al, Ag, Cu, Cr-Mo, Ti $\frac{3}{/}$                                                                                          | 361.6   |               | 36          | 8.5            | 152                           | 133           | 133           | 2.1                   | 0.12 $\frac{x}{/}$      |

$\frac{a}{/}$  The sample of additive tested here was subjected to a purification process. See comment in body of report, Page 6.

$\frac{1}{/}$  Gas Flow 1/hr. - Air

$\frac{2}{/}$  Gas Flow 1/hr. - 95% N<sub>2</sub> - 5% O<sub>2</sub>

$\frac{3}{/}$  24 hours with air at 260°C and 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub> at 316°C.

$\frac{4}{/}$  24 hours at 260°C and raise to 316°C for 12 hours, after 36 hours drop to 260°C for 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub>.

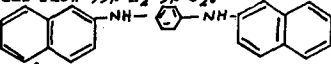
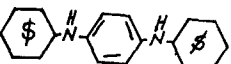
Metal Effects, Weight Loss, mg/cm<sup>2</sup>

$\frac{b}{/}$  Al 0.08 Ag 0.26 Cu 1.26 S.S. 0.30 Ti 0.08  
 $\frac{c}{/}$  Al 0.24 Ag 0.58 Cu 1.36 S.S. 0.54 Ti 0.22  
 $\frac{d}{/}$  Al 0.28 Ag 2.56 Cu 1.16 Cr-Mo 0.76 Ti 0.18  
 $\frac{e}{/}$  Al 0.28 Ag 0.68 Cu 0.98 Cr-Mo 0.58 Ti 0.18  
 $\frac{f}{/}$  Al 0.18 Ag 0.80 Cu 1.06 S.S. 0.24 Ti 0.00  
 $\frac{g}{/}$  Al 0.16 Ag 0.86 Cu 0.86 Cr-Mo 0.54 Ti 0.02  
 $\frac{h}{/}$  Al 1.72 Ag 1.38 Cu 2.24 S.S. 1.16 Ti 0.42  
 $\frac{i}{/}$  Al 0.70 Ag 1.92 Cu 2.00 Cr-Mo 1.42 Ti 0.38  
 $\frac{j}{/}$  Al 0.90 Ag 0.88 Cu 1.94 S.S. 0.52 Ti 0.06  
 $\frac{k}{/}$  Al 0.90 Ag 1.08 Cu 1.38 S.S. 0.44 Ti 0.16  
 $\frac{l}{/}$  Al 0.12 Ag 0.26 Cu 0.58 S.S. 0.08 Ti 0.08  
 $\frac{m}{/}$  Al 0.00 Ag 0.64 Cu 0.82 S.S. -0.08 Ti -0.16  
 $\frac{n}{/}$  Al 0.42 Ag 0.94 Cu 1.00 S.S. 0.18 Ti 0.02  
 $\frac{o}{/}$  Al 0.48 Ag 0.62 Cu 1.24 S.S. 0.30 Ti 0.00

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

$\frac{p}{/}$  Al 0.58 Ag 1.18 Cu 1.12 S.S. 0.38 Ti 0.38  
 $\frac{q}{/}$  Al 0.98 Ag 1.48 Cu 1.42 S.S. 0.56 Ti 0.18  
 $\frac{r}{/}$  Al 0.30 Ag 0.12 Cu 1.32 S.S. 1.02 Ti 0.04  
 $\frac{s}{/}$  Al 0.24 Ag 0.06 Cu 1.88 S.S. 0.75 Ti 0.02  
 $\frac{t}{/}$  Al 1.64 Ag 1.30 Cu 1.30 S.S. 0.58 Ti 0.06  
 $\frac{u}{/}$  Al 1.04 Ag 1.24 Cu 1.26 S.S. 0.54 Ti 0.00  
 $\frac{v}{/}$  Al 0.16 Ag 0.42 Cu 1.46 S.S. 0.10 Ti 0.02  
 $\frac{w}{/}$  Al 0.50 Ag 0.76 Cu 0.56 S.S. 0.44 Ti 0.08  
 $\frac{x}{/}$  Al 0.84 Ag 0.54 Cu 2.62 Cr-Mo 0.52 Ti 0.14

**Table 3**  
**Oxidations in Fluid F-60, Second Batch**

| Additive, COL No., Formula,<br>Concentration, Metals Present                                                                                                                                                                | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | iso-octane<br>Insoluble, % |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|----------------------------|
|                                                                                                                                                                                                                             |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                            |
| None, Al, Ag, Cu, S.S., Ti 1/                                                                                                                                                                                               | 392.1      | 260°C<br>(500°F)    | 24             | 1.9                  | 17.2                          | 16.6             | 13.6             | 0.6                      | a/                         |
| None, Al, Ag, Cu, S.S., Ti                                                                                                                                                                                                  | 392.2      | 260°C<br>(500°F)    | 48             | 3.4                  | 64.6                          | 58.0             | 50.5             | 0.9                      | b/                         |
| None, Al, Ag, Cu, S.S., Ti                                                                                                                                                                                                  | 397.6      | 260°C<br>(500°F)    | 48             | 3.0                  | 66.2                          | 59.3             | 50.7             | 0.6                      | c/                         |
| None, Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub> .                                                                                                                                               | 409.4      | 316°C<br>(600°F)    | 12             | N.D.                 | 47.0                          | 42.6             | 37.8             | 0.6                      | d/                         |
|                                                                                                                                                                                                                             | 411.10     |                     | 12             | N.D.                 | 79.0                          | 72.0             | 62.4             | 1.2                      | e/                         |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> , No. 260,<br>0.010 g., Al, Ag, Cu, S.S., Ti                                                                                                                                   | 398.5      | 260°C<br>(500°F)    | 48             | 2.0                  | 8.9                           | 7.6              | 5.4              | 0.8                      | a/                         |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                                                                                                                                                               | 397.10     | 260°C<br>(500°F)    | 48             | 1.5                  | 4.2                           | 3.7              | 1.6              | 0.6                      | f/                         |
| 0.025g., Al, Ag, Cu, S.S., Ti                                                                                                                                                                                               | 398.4      | 260°C<br>(500°F)    | 48             | 1.9                  | 5.8                           | 4.2              | 3.4              | 0.7                      | g/                         |
| 0.05g., Al, Ag, Cu, S.S., Ti                                                                                                                                                                                                | 392.3      | 260°C<br>(500°F)    | 48             | 2.0                  | 5.2                           | 4.9              | 3.6              | 0.8                      | h/                         |
| 0.03g., Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub> .                                                                                                                                             | 409.2      | 316°C<br>(600°F)    | 12             | 4.3                  | 26.8                          | 24.4             | 20.0             | 1.0                      | i/                         |
| <br><u>N,N'-Diphenyl-1,4-benzenediamine</u> , No. 352<br>0.10g., Al, Ag, Cu, S.S., Ti                                                      | 398.10     | 260°C<br>(500°F)    | 48             | 2.7                  | 8.0                           | 6.4              | 5.7              | 1.0                      | j/                         |
| <br><u>N,N'-Dicyclohexyl-p-phenylenediamine</u> , No. 351<br>0.10g., Al, Ag, Cu, S.S., Ti                                                  | 398.9      | 260°C<br>(500°F)    | 48             | 3.5                  | 14.4                          | 12.3             | 10.2             | 0.9                      | k/                         |
| <br><u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> , No. 260,<br>0.010g. and Diphenylguanidine,<br>No. 161, 0.010g.<br>Al, Ag, Cu, S.S., Ti | 398.7      | 260°C<br>(500°F)    | 48             | 2.2                  | 15.4                          | 13.7             | 10.2             | 0.9                      | l/                         |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> , No. 260,<br>0.010g. and acridine, No. 82,<br>0.050g., Al, Ag, Cu, S.S., Ti                                                                                                   | 398.6      | 260°C<br>(500°F)    | 48             | 1.5                  | 3.3                           | 2.6              | 2.6              | 0.7                      | m/                         |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> , No. 260,<br>0.005g, acridine, No. 82,<br>0.010g. and Diphenyl-<br>guanidine, No. 161, 0.005g.<br>Al, Ag, Cu, S.S., Ti                                                        | 398.8      | 260°C<br>(500°F)    | 48             | 1.3                  | 4.4                           | 4.3              | 3.2              | 0.6                      | n/                         |

**Metal Effect, Weight Loss, mg/cm<sup>2</sup>**

|    |    |      |    |      |    |      |      |      |    |      |
|----|----|------|----|------|----|------|------|------|----|------|
| a/ | Al | 0.14 | Ag | 0.36 | Cu | 0.82 | S.S. | 0.00 | Ti | 0.00 |
| b/ | Al | 0.06 | Ag | 0.78 | Cu | 1.44 | S.S. | 0.00 | Ti | 0.04 |
| c/ | Al | 0.08 | Ag | 0.10 | Cu | 0.94 | S.S. | 0.06 | Ti | 0.04 |
| d/ | Al | 0.02 | Ag | 0.02 | Cu | 0.14 | S.S. | 0.04 | Ti | 0.02 |
| e/ | Al | 0.02 | Ag | 0.10 | Cu | 0.20 | S.S. | 0.00 | Ti | 0.02 |
| f/ | Al | 0.04 | Ag | 0.04 | Cu | 0.44 | S.S. | 0.04 | Ti | 0.06 |
| g/ | Al | 0.02 | Ag | 0.02 | Cu | 0.10 | S.S. | 0.04 | Ti | 0.00 |
| h/ | Al | 0.06 | Ag | 0.20 | Cu | 0.66 | S.S. | 0.04 | Ti | 0.00 |
| i/ | Al | 0.02 | Ag | 0.00 | Cu | 0.36 | S.S. | 0.12 | Ti | 0.00 |
| j/ | Al | 0.02 | Ag | 0.12 | Cu | 0.26 | S.S. | 0.04 | Ti | 0.00 |
| k/ | Al | 0.04 | Ag | 0.16 | Cu | 0.44 | S.S. | 0.04 | Ti | 0.06 |
| l/ | Al | 0.02 | Ag | 0.16 | Cu | 0.70 | S.S. | 0.02 | Ti | 0.02 |
| m/ | Al | 0.12 | Ag | 0.08 | Cu | 0.18 | S.S. | 0.02 | Ti | 0.00 |
| n/ | Al | 0.02 | Ag | 0.18 | Cu | 0.48 | S.S. | 0.00 | Ti | 0.04 |
| o/ | Al | 0.70 | Ag | 0.28 | Cu | 0.22 | S.S. | 0.20 | Ti | 0.16 |

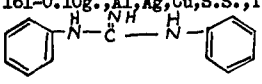
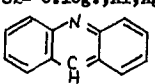
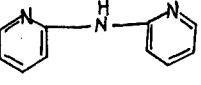
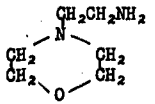
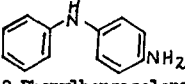
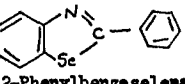
N.D. Not yet determined.

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.  
2/ These values are tabulated in a separate table.

Table 3. Oxidations in Fluid F-60 (Cont'd).

Second Batch

25 ml Sample

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                               | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble, % |
|--------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|----------------------------|
|                                                                                                                                            |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                            |
| <u>Diphenylguanidine</u> , 0.05g. 1/<br>No. 161, Al, Ag, Cu, S.S., Ti                                                                      | 397.8      | 260°<br>(500°)      | 3<br>48        | 1.1                  | 3.9<br>12.1                   | 3.1<br>10.7      | 8.6              | 0.8                      | a/                         |
| 161-0.05g., Al, Ag, Cu, S.S., Ti                                                                                                           | 397.9      | 260°<br>(500°)      | 24             | 1.7                  | 5.4                           | 4.7              | 3.8              | 0.8                      | b/                         |
| 161-0.10g., Al, Ag, Cu, S.S., Ti                                                                                                           | 392.8      | 260°<br>(500°)      | 48             | 6.3                  | 9.6                           | 9.1              | 6.8              | 0.6                      | g/                         |
|                                                           |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>Acridine</u> , No. 82, 0.10g.,<br>Al, Ag, Cu, S.S., Ti                                                                                  | 397.7      | 260°<br>(500°)      | 6<br>48        | 1.7                  | 1.7<br>6.2                    | 1.2<br>5.6       | 4.5              | 0.6                      | d/                         |
| 82- 0.10g., Al, Ag, Cu, S.S., Ti                                                                                                           | 392.7      | 260°<br>(500°)      | 48             | 1.3                  | 6.9                           | 6.4              | 4.1              | 0.7                      | g/                         |
|                                                           |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>2,2'-Dipyridylamine</u> , No. 128,<br>0.10g., Al, Ag, Cu, S.S., Ti                                                                      | 392.6      | 260°<br>(500°)      | 48             | 2.5                  | 33.5                          | 30.8             | 25.7             | 0.7                      | f/                         |
|                                                           |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>N-Aminoethylmorpholine</u> ,<br>No. 117, 0.10g.,<br>Al, Ag, Cu, S.S., Ti                                                                | 392.5      | 260°<br>(500°)      | 48             | 3.6                  | 32.2                          | 27.8             | 22.8             | 0.8                      | a/                         |
|                                                           |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>p-Aminodiphenylamine</u> ,<br>No. 360, 0.05g.<br>Al, Ag, Cu, S.S., Ti                                                                   | 392.4      | 260°<br>(500°)      | 48             | 2.2                  | 23.7                          | 20.5             | 17.5             | 0.8                      | b/                         |
|                                                         |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>2-Phenylbenzazoleselenazole</u> ,<br>No. 300B, 0.10g.,<br>Al, Ag, Cu, S.S., Ti                                                          | 392.9      | 260°<br>(500°)      | 48             | 5.2                  | 43.2                          | 38.1             | 31.8             | 0.7                      | i/                         |
|                                                         |            |                     |                |                      |                               |                  |                  |                          |                            |
| <u>2-Phenylbenzazoleselenazole</u> ,<br>No. 300B, 0.10g. and<br><u>N-Aminoethylmorpholine</u> ,<br>No. 117, 0.05g.<br>Al, Ag, Cu, S.S., Ti | 392.10     | 260°<br>(500°)      | 48             | 3.5                  | 51.2                          | 45.7             | 39.7             | 0.8                      | i/                         |

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

|    |         |         |         |           |         |
|----|---------|---------|---------|-----------|---------|
| a/ | Al 0.08 | Ag 0.16 | Cu 0.94 | S.S. 0.02 | Ti 0.00 |
| b/ | Al 0.16 | Ag 0.12 | Cu 0.36 | S.S. 0.04 | Ti 0.02 |
| g/ | Al 0.00 | Ag 0.16 | Cu 0.84 | S.S. 0.00 | Ti-0.18 |
| d/ | Al 0.10 | Ag 0.08 | Cu 0.50 | S.S. 0.02 | Ti 0.10 |
| g/ | Al 0.00 | Ag 0.56 | Cu 0.66 | S.S. 0.00 | Ti 0.00 |
| f/ | Al 0.02 | Ag 0.44 | Cu 1.42 | S.S.-0.26 | Ti-0.28 |
| g/ | Al 0.02 | Ag 0.40 | Cu 0.98 | S.S. 0.00 | Ti-0.14 |
| b/ | Al 0.04 | Ag 0.32 | Cu 0.92 | S.S.-0.14 | Ti 0.00 |
| i/ | Al 0.00 | Ag 0.84 | Cu 2.26 | S.S.-0.12 | Ti 0.00 |
| i/ | Al 0.04 | Ag 0.76 | Cu 1.44 | S.S.-0.08 | Ti-0.06 |

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/h5.

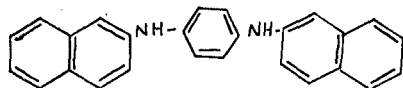
2/ These values are tabulated in a separate table, Table 4.

TABLE 4  
Behavior of Insolubles in Oxidized F-60 Blend

| Additive, GCL No. and Concentration;<br>Metals Present                                                                                                             | Run<br>No. | Time<br>Hours | Temperature<br>°C<br>(°F) | Percentage Insoluble |                   |                 |                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|---------------------------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                                                                                                    |            |               |                           | Oil                  | Isosctane<br>wash | Acetone<br>wash | Isosctane<br>Precipitate |
| None, Al, Ag, Cu, S.S., Ti                                                                                                                                         | 392.1      | 24            | 260°<br>(500°)            | 1.40                 | 0.01              | 0.00            | 0.55                     |
| None, Al, Ag, Cu, S.S., Ti                                                                                                                                         | 392.2      | 48            | 260°<br>(500°)            | 0.72                 | 0.01              | 0.00            | 0.59                     |
| None, Al, Ag, Cu, S.S., Ti                                                                                                                                         | 397.6      | 48            | 260°<br>(500°)            | 0.72                 | 0.00              | 0.00            | 0.10                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine,</u><br>No. 260, 0.010g., Al, Ag, Cu, S.S., Ti                                                                            | 398.5      | 48            | 260°<br>(500°)            | 0.91                 | 0.01              | 0.00            | 0.11                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                                                                                                  | 397.10     | 48            | 260°<br>(500°)            | 1.20                 | 0.07              | 0.05            | 0.13                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                                                                                                  | 398.4      | 48            | 260°<br>(500°)            | 1.12                 | 0.07              | 0.06            | 0.08                     |
| 260 0.05g., Al, Ag, Cu, S.S., Ti                                                                                                                                   | 392.3      | 48            | 260°<br>(500°)            | 1.86                 | 0.10              | 0.10            | 0.47                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                                                                                                   | 409.2      | 12            | 316°<br>(600°)            | Not Filterable       |                   |                 |                          |
| <u>N,N'-Diphenyl-1,4-benzoquinonediimine,</u><br>No. 352, 0.10 g., Al, Ag, Cu, S.S., Ti                                                                            | 398.10     | 48            | 260°<br>(500°)            | 1.13                 | 0.01              | 0.00            | 0.19                     |
| <u>N,N'-Dicyclohexyl-p-phenylenediamine,</u><br>No. 351, 0.10 g., Al, Ag, Cu, S.S., Ti                                                                             | 398.9      | 48            | 260°<br>(500°)            | 1.88                 | 0.18              | 0.16            | 0.21                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine,</u><br>No. 260, 0.010g., and Diphenylguanidine,<br>No. 161, 0.010g., Al, Ag, Cu, S.S., Ti                                | 398.7      | 48            | 260°<br>(500°)            | 1.88                 | 0.02              | 0.01            | 0.13                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine,</u><br>No. 260, 0.010g., and Acridine, No. 82,<br>0.050 g., Al, Ag, Cu, S.S., Ti                                         | 398.6      | 48            | 260°<br>(500°)            | 1.08                 | 0.01              | 0.00            | 0.11                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine,</u><br>No. 260, 0.005g., Acridine, No. 82,<br>0.010g., and Diphenyl guanidine, No. 161.<br>0.005g., Al, Ag, Cu, S.S., Ti | 398.8      | 48            | 260°<br>(500°)            | 0.64                 | 0.02              | 0.01            | 0.12                     |
| <u>Diphenylguanidine, No. 161, 0.05g.</u><br>Al, Ag, Cu, S.S., Ti                                                                                                  | 397.8      | 48            | 260°<br>(500°)            | 0.89                 | 0.00              | 0.00            | 0.13                     |
| 161 0.05g., Al, Ag, Cu, S.S., Ti                                                                                                                                   | 397.9      | 24            | 260°<br>(500°)            | 0.91                 | 0.02              | 0.01            | 0.36                     |
| 161 0.10g., Al, Ag, Cu, S.S., Ti                                                                                                                                   | 392.8      | 48            | 260°<br>(500°)            | 0.98                 | 0.02              | 0.02            | 0.59                     |
| <u>Acridine, No. 82, 0.10g.</u><br>Al, Ag, Cu, S.S., Ti                                                                                                            | 397.7      | 48            | 260°<br>(500°)            | 0.68                 | 0.00              | 0.00            | 0.08                     |
| 82 0.10g., Al, Ag, Cu, S.S., Ti                                                                                                                                    | 392.7      | 48            | 260°<br>(500°)            | 1.82                 | 0.01              | 0.00            | 0.70                     |
| <u>2,2'-Dipyridylamine, No. 128,</u><br>0.10g., Al, Ag, Cu, S.S., Ti                                                                                               | 392.6      | 48            | 260°<br>(500°)            | 0.78                 | 0.01              | 0.00            | 0.42                     |
| <u>N-Aminoethylmorpholine, No. 117,</u><br>0.10g., Al, Ag, Cu, S.S., Ti                                                                                            | 392.5      | 48            | 260°<br>(500°)            | 1.27                 | 0.02              | 0.00            | 1.67                     |
| <u>p-Aminodiphenylamine, No. 360,</u><br>0.05g., Al, Ag, Cu, S.S., Ti                                                                                              | 392.4      | 48            | 260°<br>(500°)            | 0.82                 | 0.03              | 0.02            | 0.52                     |
| <u>2-Phenylbenzoeselenazole, No. 300B,</u><br>0.10g., Al, Ag, Cu, S.S., Ti                                                                                         | 392.9      | 48            | 260°<br>(500°)            | 0.75                 | 0.00              | 0.00            | 0.51                     |
| <u>2-Phenylbenzoeselenazole, No. 300B,</u><br>0.10g., and <u>N-aminoethylmorpholine,</u><br>No. 117, 0.05g., Al, Ag, Cu, S.S., Ti                                  | 392.10     | 48            | 260°<br>(500°)            | 1.54                 | 0.04              | 0.03            | 0.08                     |

Table 5  
Oxidations in Fluid F-50

| Additive, CCL No., Formula,<br>Concentration, Metals Present                         | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble, 2/<br>% |
|--------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|----------------------------------|
|                                                                                      |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                  |
| None, Al, Ag, Cu, S.S., Ti 1/                                                        | 396.1      | 260°<br>(500°)      | 24             | 3.1                  | 439.0                         | 415.0            | 572.0            | 0.9                      | a/                               |
| None, Al, Ag, Cu, S.S., Ti                                                           | 397.1      | 260°<br>(500°)      | 24             | 5.3                  | N.M.                          |                  |                  | N.M.                     | b/                               |
| None, Al, Ag, Cu, S.S., Ti                                                           | 396.2      | 260°C<br>(500°)     | 48             | 10.4                 | N.M.                          |                  |                  | N.M.                     | c/                               |
| None, Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub>          | 409.5      | 316°<br>(600°)      | 12             | 6.3                  | 209.0                         | 196.0            | 193.0            | 0.9                      | d/                               |
| N,N'-Di-2-naphthyl-p-phenylene-<br>diamine, 0.010g. No. 260,<br>Al, Ag, Cu, S.S., Ti | 404.1      | 260°<br>(500°)      | 48             | 3.3                  | 170.9<br>(210.0) 3/           | 157.0<br>(172.0) | 147.0            | 0.9                      | e/                               |
| 260 0.020g., Al, Ag, Cu, S.S., Ti                                                    | 404.2      | 260°<br>(500°)      | 48             | 2.6                  | 22.3<br>(41.3) 3/             | 20.7<br>(24.3)   | 19.8             | 0.8                      | f/                               |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.3      | 260°<br>(500°)      | 3              | 1.7                  | 1.4                           | 1.1              |                  |                          |                                  |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.4      | 260°<br>(500°)      | 48             | 1.5                  | 8.6                           | 7.7              | 8.2              | 0.5                      | g/                               |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.4      | 260°<br>(500°)      | 6              | 1.1                  | 2.3                           | 1.3              |                  |                          |                                  |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.4      | 260°<br>(500°)      | 48             | 2.5                  | 8.4                           | 7.7              | 7.8              | 0.6                      | h/                               |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.5      | 260°<br>(500°)      | 12             | 2.0                  | 2.7                           | 2.7              |                  |                          |                                  |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.5      | 260°<br>(500°)      | 48             | 5.4                  | 10.4                          | 9.7              | 11.8             | 0.4                      | i/                               |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 396.6      | 260°<br>(500°)      | 24             | 1.7                  | 4.4                           | 3.9              | 4.3              | 0.4                      | j/                               |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                    | 397.5      | 260°<br>(500°)      | 48             | 3.0                  | 9.9                           | 9.1              | 8.3              | 0.6                      | k/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.1      | 260°<br>(500°)      | 6              | 1.7                  | 2.2                           | 2.0              | 1.7              | 0.4                      | l/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 482.2      | 260°<br>(500°)      | 12             | 1.3                  | 3.0                           | 3.3              | 2.3              | 0.5                      | m/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.3      | 260°<br>(500°)      | 18             | 1.9                  | 4.6                           | 3.9              | 3.1              | 0.5                      | n/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.4      | 260°<br>(500°)      | 24             | 1.9                  | 5.5                           | 4.8              | 3.5              | 0.6                      | o/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.5      | 260°<br>(500°)      | 30             | 2.4                  | 7.4                           | 6.6              | 6.1              | 0.5                      | p/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.6      | 260°<br>(500°)      | 36             | 2.7                  | 9.1                           | 8.4              | 8.0              | 0.5                      | q/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.7      | 260°<br>(500°)      | 42             | 3.3                  | 11.4                          | 10.5             | 10.5             | 0.6                      | r/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.8      | 260°<br>(500°)      | 48             | 2.5                  | 38.0                          | 34.2             | 34.2             | 0.8                      | s/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 404.3      | 260°<br>(500°)      | 48             | 2.2                  | 12.0<br>(28.8) 3/             | 10.5<br>(11.2)   | 10.6             | 0.7                      | t/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.9      | 260°<br>(500°)      | 54             | 4.3                  | 88.7                          | 80.5             | 81.3             | 0.6                      | u/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti                                                    | 402.10     | 260°<br>(500°)      | 60             | 3.6                  | 89.3                          | 82.0             | 80.5             | 0.6                      | v/                               |
| 260 0.030g., Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub>   | 409.6      | 316°<br>(600°)      | 12             | 4.7                  | 90.5                          | 89.0             | 88.5             | 0.9                      | w/                               |
| 260 0.040g., Al, Ag, Cu, S.S., Ti                                                    | 404.4      | 260°<br>(500°)      | 48             | 1.5                  | 8.7<br>(22.6) 3/              | 7.8<br>(7.1)     | 7.2              | 0.7                      | x/                               |
| 260 0.050g., Al, Ag, Cu, S.S., Ti                                                    | 400.1      | 260°<br>(500°)      | 48             | 3.2                  | 11.8                          | 10.9             | 10.0             | 0.6                      | y/                               |



Metal Effects, Weight Loss, mg/cm<sup>2</sup>

a/ Al 0.50 Ag 1.04 Cu 1.78 S.S. 0.04 Ti 0.02  
b/ Al 0.10 Ag 0.08 Cu 1.16 S.S. 0.08 Ti 0.00  
c/ Al 0.28 Ag 1.02 Cu 2.08 S.S. 0.06 Ti 0.00  
d/ Al 0.02 Ag 0.02 Cu 0.18 S.S. 0.32 Ti 0.00  
e/ Al 0.06 Ag 0.08 Cu 0.46 S.S. 0.04 Ti 0.16  
f/ Al 0.00 Ag 0.00 Cu 0.42 S.S. 0.04 Ti 0.12  
g/ Al 0.20 Ag 0.56 Cu 1.12 S.S. 0.14 Ti 0.10  
h/ Al 0.06 Ag 0.42 Cu 1.02 S.S. 0.08 Ti 0.06  
i/ Al 0.08 Ag 0.22 Cu 0.80 S.S. 0.02 Ti 0.00  
j/ Al 0.06 Ag 0.42 Cu 0.76 S.S. 0.00 Ti 0.00  
k/ Al 0.12 Ag 0.04 Cu 0.74 S.S. 0.06 Ti 0.06  
l/ Al 0.00 Ag 0.02 Cu 0.14 S.S. 0.02 Ti 0.00  
m/ Al 0.06 Ag 0.08 Cu 0.44 S.S. 0.08 Ti 0.02  
n/ Al 0.06 Ag 0.14 Cu 0.56 S.S. 0.04 Ti 0.02  
o/ Al 0.02 Ag 0.08 Cu 0.74 S.S. 0.10 Ti 0.06  
N.M. Too viscous for measurement.

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.  
2/ These values are tabulated in a separate table.

3/ See second paragraph of Page 8 for explanation of parenthesis.

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

p/ Al 0.00 Ag 0.20 Cu 0.74 S.S. 0.06 Ti 0.04  
q/ Al 0.02 Ag 0.10 Cu 0.76 S.S. 0.08 Ti 0.12  
r/ Al 0.02 Ag 0.10 Cu 0.72 S.S. 0.04 Ti 0.00  
s/ Al 0.02 Ag 0.24 Cu 0.62 S.S. 0.02 Ti 0.04  
t/ Al 0.14 Ag 0.00 Cu 0.50 S.S. 0.00 Ti 0.10  
u/ Al 0.02 Ag 0.20 Cu 0.58 S.S. 0.06 Ti 0.02  
v/ Al 0.02 Ag 0.20 Cu 0.42 S.S. 0.06 Ti 0.02  
w/ Al 0.14 Ag 0.10 Cu 0.34 S.S. 0.34 Ti 0.04  
x/ Al 0.02 Ag 0.06 Cu 0.58 S.S. 0.02 Ti 0.06  
y/ Al 0.16 Ag 0.00 Cu 0.54 S.S. 0.12 Ti 0.00

Table 5 . Oxidations in Fluid F-50 (Cont'd)

Sample 25 ml.

| Additive, CCL No., Formula,<br>Concentration, Metals Present                       | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                     |                  | Neutralization<br>Number | Iso-octane<br>Insoluble, 2/<br>% |
|------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|---------------------|------------------|--------------------------|----------------------------------|
|                                                                                    |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F)    | 195°C<br>(383°F) |                          |                                  |
| <u>N,N'-Di-2-naphthyl-p-phenylene-</u><br><u>diamine, No. 260 (cont'd)</u>         |            |                     |                |                      |                               |                     |                  |                          |                                  |
| 260 0.050g., Al, Ag, Cu, S.S., Ti                                                  | 404.5      | 260°<br>(500°)      | 48             | 2.9                  | 10.4<br>(26.7) 2/             | 9.7<br>(9.9)<br>7.5 | 9.7              | 0.7                      | a/                               |
| 260 0.050g., Al, Ag, Cu, S.S., Ti                                                  | 406.1      | 260°<br>(500°)      | 48             | 2.1                  | 7.7                           | 7.5                 | 7.1              | 0.4                      | b/                               |
| 260 0.075g., Al, Ag, Cu, S.S., Ti                                                  | 404.6      | 260°<br>(500°)      | 48             | 2.6                  | 8.8<br>(26.5) 2/              | 8.0<br>(7.5)        | 8.2              | 0.5                      | c/                               |
| 260 0.10g., Al, Ag, Cu, S.S., Ti                                                   | 404.7      | 260°<br>(500°)      | 48             | 1.7                  | 7.8<br>(24.0) 2/              | 7.6<br>(7.7)        | 6.7              | 0.7                      | d/                               |
| 260 0.15g., Al, Ag, Cu, S.S., Ti                                                   | 404.8      | 260°<br>(500°)      | 48             | 2.0                  | 10.2<br>(26.4) 2/             | 9.4<br>(9.4)        | 9.4              | 0.6                      | e/                               |
| 260 0.20g., Al, Ag, Cu, S.S., Ti                                                   | 400.5      | 260°<br>(500°)      | 48             | 3.7                  | 13.6                          | 13.0                | 10.0             | 0.6                      | f/                               |
| 260 0.20g., Al, Ag, Cu, S.S., Ti                                                   | 406.2      | 260°<br>(500°)      | 48             | 3.6                  | 10.4                          | 10.3                | 8.4              | 0.4                      | g/                               |
| 260 0.40g., Al, Ag, Cu, S.S., Ti                                                   | 406.3      | 260°<br>(500°)      | 48             | 3.6                  | 11.3                          | 10.3                | 9.8              | 0.3                      | h/                               |
|                                                                                    |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>N,N'-Di-(2-methyl-3-chloro-</u><br><u>phenyl)-p-phenylenediamine,</u>           | 398.2      | 260°<br>(500°)      | 48             | 5.0                  | N.M.                          |                     |                  | 0.8                      | i/                               |
| No. 350, 0.010g.<br>Al, Ag, Cu, S.S., Ti                                           |            |                     |                |                      |                               |                     |                  |                          |                                  |
| 350 0.030 g., Al, Ag, Cu, S.S., Ti                                                 | 398.1      | 260°<br>(500°)      | 48             | 4.7                  | 181.0                         | 167.0               | 164.0            | 0.8                      | j/                               |
|                                                                                    |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>N,N'-Di-2-naphthyl-p-phenylene-</u><br><u>diamine, No. 260, 0.025g., and</u>    | 400.7      | 260°<br>(500°)      | 48             | 4.4                  | 23.5                          | 21.8                | 20.5             | 0.8                      | k/                               |
| <u>Acridine, No. 82, 0.025g.</u>                                                   |            |                     |                |                      |                               |                     |                  |                          |                                  |
| Al, Ag, Cu, S.S., Ti                                                               |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>N,N'-Di-2-naphthyl-p-phenylene-</u><br><u>diamine, No. 260, 0.050g. and</u>     | 400.9      | 260°<br>(500°)      | 48             | 4.1                  | 15.9                          | 13.9                | 13.3             | 0.8                      | l/                               |
| <u>Phenylmorpholine, No. 141, 0.005g.</u>                                          |            |                     |                |                      |                               |                     |                  |                          |                                  |
| Al, Ag, Cu, S.S., Ti                                                               |            |                     |                |                      |                               |                     |                  |                          |                                  |
| 260 0.010g., 141 0.010g.<br>Al, Ag, Cu, S.S., Ti                                   | 404.10     | 260°<br>(500°)      | 48             | 3.5                  | 130.0<br>(166.0) 2/           | 120.0<br>(134.0)    | 111.0            | 0.7                      | m/                               |
| 260 0.050g., N-Aminoethyl-<br>morpholine, No. 117, 0.005g.<br>Al, Ag, Cu, S.S., Ti | 400.10     | 260°<br>(500°)      | 48             | 4.0                  | 34.4                          | 38.3                | 36.8             | 0.8                      | n/                               |
| <u>N,N'-Di-2-naphthyl-p-phenylene-</u><br><u>diamine, No. 260, 0.010g.,</u>        | 400.8      | 260°<br>(500°)      | 48             | 23.9                 | N.M.                          |                     |                  | N.M.                     | o/                               |
| <u>Acridine, No. 82, 0.010g. and</u>                                               |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>Diphenylguanidine, No. 161, 0.010g.</u>                                         |            |                     |                |                      |                               |                     |                  |                          |                                  |
| Al, Ag, Cu, S.S., Ti                                                               |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>N,N'-Di-2-naphthyl-p-phenylene-</u><br><u>diamine, No. 260, 0.010g.,</u>        | 404.9      | 260°<br>(500°)      | 48             | 3.7                  | 70.0<br>(93.5) 2/             | 64.0<br>(63.5)      | 59.8             | 0.9                      | p/                               |
| <u>Acridine, No. 82, 0.010g.,</u>                                                  |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>N-Phenylmorpholine, No. 141,</u>                                                |            |                     |                |                      |                               |                     |                  |                          |                                  |
| <u>0.010g., Al, Ag, Cu, S.S., Ti</u>                                               |            |                     |                |                      |                               |                     |                  |                          |                                  |

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

|    |    |      |    |      |    |      |      |      |    |      |
|----|----|------|----|------|----|------|------|------|----|------|
| a/ | Al | 0.02 | Ag | 0.04 | Cu | 0.44 | S.S. | 0.00 | Ti | 0.00 |
| b/ | Al | 0.42 | Ag | 0.48 | Cu | 1.08 | S.S. | 0.16 | Ti | 0.04 |
| c/ | Al | 0.00 | Ag | 0.02 | Cu | 0.82 | S.S. | 0.00 | Ti | 0.00 |
| d/ | Al | 0.02 | Ag | 0.02 | Cu | 0.90 | S.S. | 0.02 | Ti | 0.02 |
| e/ | Al | 0.02 | Ag | 0.02 | Cu | 0.72 | S.S. | 0.00 | Ti | 0.00 |
| f/ | Al | 0.30 | Ag | 0.32 | Cu | 0.38 | S.S. | 0.18 | Ti | 0.34 |
| g/ | Al | 0.32 | Ag | 0.38 | Cu | 1.28 | S.S. | 0.24 | Ti | 0.10 |
| h/ | Al | 0.28 | Ag | 0.34 | Cu | 1.18 | S.S. | 0.34 | Ti | 0.04 |
| i/ | Al | 0.04 | Ag | 0.60 | Cu | 0.90 | S.S. | 0.02 | Ti | 0.02 |
| j/ | Al | 0.06 | Ag | 0.02 | Cu | 1.26 | S.S. | 0.00 | Ti | 0.02 |
| k/ | Al | 0.02 | Ag | 0.10 | Cu | 0.00 | S.S. | 0.00 | Ti | 0.28 |
| l/ | Al | 0.06 | Ag | 0.02 | Cu | 0.30 | S.S. | 0.00 | Ti | 0.00 |
| m/ | Al | 0.02 | Ag | 0.10 | Cu | 0.46 | S.S. | 0.02 | Ti | 0.02 |
| n/ | Al | 0.24 | Ag | 0.02 | Cu | 0.78 | S.S. | 0.12 | Ti | 0.00 |
| o/ | Al | 0.24 | Ag | 0.56 | Cu | 1.88 | S.S. | 0.02 | Ti | 0.26 |
| p/ | Al | 0.02 | Ag | 0.14 | Cu | 0.70 | S.S. | 0.02 | Ti | 0.02 |

N.M. Too viscous for measurement.

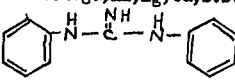
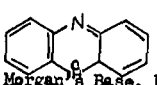
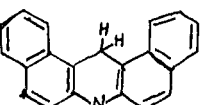
1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.

2/ These values are tabulated in a separate table.

3/ See second paragraph of Page 8 for explanation of parenthesis.

Table 5. Oxidations in Fluid F-50 (Cont'd)

Sample 25 ml

| Additive, CGL No., Formula,<br>Concentration, Metals Present                        | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble, 2/<br>% |
|-------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|----------------------------------|
|                                                                                     |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                  |
| <b>Diphenylguanidine, No. 161</b><br>0.05g., Al, Ag, Cu, S.S., Ti 1/                | 396.13     | 260°<br>(500°)      | 3<br>48        | 2.6<br>5.7           | 6.4<br>50.7                   | 6.5<br>47.4      | 45.0             | 0.8                      | a/                               |
| 161 0.05g., Al, Ag, Cu, S.S., Ti                                                    | 397.3      | 260°<br>(500°)      | 3<br>48        | 1.5<br>3.5           | 6.6<br>232.0                  | 7.3<br>217.0     | 246.0            | 0.9                      | b/                               |
| 161 0.10g., Al, Ag, Cu, S.S., Ti                                                    | 396.14     | 260°<br>(500°)      | 3<br>48        | 1.7<br>2.6           | 7.9<br>19.2                   | 8.2<br>18.3      | 19.3             | 0.6                      | c/                               |
| 161 0.05g., Al, Ag, Cu, S.S., Ti                                                    | 396.11     | 260°<br>(500°)      | 24             | 2.2                  | 15.4                          | 15.0             | 15.0             | 0.7                      | d/                               |
| 161 0.05g., Al, Ag, Cu, S.S., Ti                                                    | 397.4      | 260°<br>(500°)      | 24             | 2.8                  | 16.4                          | 15.7             | 15.9             | 0.6                      | e/                               |
| 161 0.10g., Al, Ag, Cu, S.S., Ti                                                    | 396.12     | 260°<br>(500°)      | 24             | 2.9                  | 15.7                          | 14.0             | 14.3             | 0.2                      | f/                               |
| 161 0.20g., Al, Ag, Cu, S.S., Ti                                                    | 400.6      | 260°<br>(500°)      | 48             | 4.2                  | 26.0                          | 25.6             | 25.6             | 0.5                      | g/                               |
|    |            |                     |                |                      |                               |                  |                  |                          |                                  |
| <b>Acridina, No. 82, 0.05g.,</b><br>Al, Ag, Cu, S.S., Ti                            | 400.2      | 260°<br>(500°)      | 48             | 4.0                  | 26.6                          | 25.1             | 23.4             | 4.0                      | h/                               |
| 82 0.05g., Al, Ag, Cu, S.S., Ti                                                     | 406.4      | 260°<br>(500°)      | 48             | 3.2                  | 19.4                          | 17.8             | 16.7             | 0.8                      | i/                               |
| 82 0.05g., Al, Ag, Cu, S.S., Ti<br>Gas Flow - 95% N <sub>2</sub> 5% O <sub>2</sub>  | 409.10     | 316°<br>(600°)      | 12             | 6.3                  | 172.5                         | 164.5            | 166.0            | 1.1                      | j/                               |
| 82 0.075g., Al, Ag, Cu, S.S., Ti                                                    | 406.5      | 260°<br>(500°)      | 48             | 3.4                  | 19.3                          | 18.4             | 17.5             | 0.6                      | k/                               |
| 82 0.10g., Al, Ag, Cu, S.S., Ti                                                     | 396.7      | 260°<br>(500°)      | 3<br>48        | 2.0<br>3.0           | 2.1<br>18.5                   | 2.4<br>17.5      | 16.7             | 0.7                      | l/                               |
| 82 0.10g., Al, Ag, Cu, S.S., Ti                                                     | 396.8      | 260°<br>(500°)      | 6<br>48        | 2.3<br>3.6           | 3.6<br>37.9                   | 2.8<br>34.6      | 33.3             | 0.8                      | m/                               |
| 82 0.10g., Al, Ag, Cu, S.S., Ti                                                     | 397.2      | 260°<br>(500°)      | 6<br>48        | 1.5<br>1.3           | 3.2<br>20.5                   | 2.8<br>19.3      | 18.9             | 1.0                      | n/                               |
| 82 0.10g., Al, Ag, Cu, S.S., Ti                                                     | 396.9      | 260°<br>(500°)      | 24             | 0.04                 | 9.9                           | 8.9              | 8.8              | 0.5                      | o/                               |
| 82 0.20g., Al, Ag, Cu, S.S., Ti                                                     | 400.4      | 260°<br>(500°)      | 48             | 4.5                  | 65.8                          | 60.8             | 55.8             | 1.0                      | p/                               |
|   |            |                     |                |                      |                               |                  |                  |                          |                                  |
| <b>Morgan's Base, No. 375,</b><br>0.05g., Al, Ag, Cu, S.S., Ti                      | 406.6      | 260°<br>(500°)      | 48             | 3.1                  | 15.6                          | 14.5             | 13.5             | 0.8                      | q/                               |
| 0.075g., Al, Ag, Cu, S.S., Ti                                                       | 406.7      | 260°<br>(500°)      | 48             | 3.0                  | 10.5                          | 10.6             | 9.0              | 0.6                      | r/                               |
|  |            |                     |                |                      |                               |                  |                  |                          |                                  |

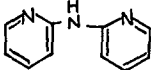
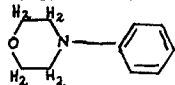
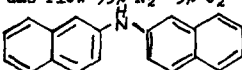
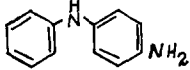
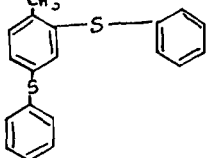
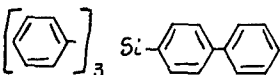
Metal Effects, Weight Loss, mg/cm<sup>2</sup>

|    |         |         |         |           |         |
|----|---------|---------|---------|-----------|---------|
| a/ | Al 0.06 | Ag 0.50 | Cu 1.02 | S.S. 0.02 | Ti 0.02 |
| b/ | Al 0.12 | Ag 0.40 | Cu 1.54 | S.S. 0.22 | Ti 0.16 |
| c/ | Al 0.04 | Ag 0.30 | Cu 0.90 | S.S. 0.02 | Ti 0.00 |
| d/ | Al 0.02 | Ag 0.12 | Cu 0.82 | S.S. 0.02 | Ti 0.00 |
| e/ | Al 0.14 | Ag 0.20 | Cu 1.04 | S.S. 0.10 | Ti 0.08 |
| f/ | Al 0.04 | Ag 0.22 | Cu 0.60 | S.S. 0.00 | Ti 0.00 |
| g/ | Al-0.24 | Ag-0.10 | Cu 0.58 | S.S.-1.76 | Ti-0.28 |
| h/ | Al-0.12 | Ag 0.00 | Cu 0.08 | S.S.-0.16 | Ti 0.00 |
| i/ | Al 0.46 | Ag 0.54 | Cu 0.96 | S.S. 0.22 | Ti 0.22 |
| j/ | Al 0.32 | Ag 0.04 | Cu 0.34 | S.S. 0.10 | Ti 0.00 |
| k/ | Al 0.42 | Ag 0.36 | Cu 1.28 | S.S. 0.24 | Ti 0.10 |
| l/ | Al 0.02 | Ag 0.62 | Cu 0.88 | S.S. 0.00 | Ti 0.00 |
| m/ | Al 0.04 | Ag 0.72 | Cu 0.92 | S.S. 0.02 | Ti 0.02 |
| n/ | Al 0.10 | Ag 0.22 | Cu 0.66 | S.S. 0.16 | Ti 0.16 |
| o/ | Al 0.12 | Ag 0.24 | Cu 0.90 | S.S. 0.00 | Ti 0.00 |
| p/ | Al 0.14 | Ag 0.16 | Cu-0.06 | S.S.-0.14 | Ti-0.24 |
| q/ | Al 0.30 | Ag 0.20 | Cu 0.78 | S.S. 0.06 | Ti 0.06 |
| r/ | Al 0.22 | Ag 0.16 | Cu 0.68 | S.S. 0.14 | Ti 0.04 |

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.  
 2/ These values are tabulated in a separate table, Table 6.

Table 5 . Oxidations in Fluid F-50 (Cont'd)

Sample 25 ml

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                                                                                                                | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble, 2/<br>% |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|----------------------------------|
|                                                                                                                                                                                                                                             |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                  |
| <u>2,2'-Dipyridylamine</u> , 0.05g. 1/<br>Al, Ag, Cu, S.S., Ti, No. 128<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub><br>                               | 409.8      | 316°<br>(600°)      | 12             | 5.0                  | 71.7                          | 70.0             | 74.0             | 1.3                      | a/                               |
| <u>N-Phenylmorpholine</u> , 0.10g.<br>Al, Ag, Cu, S.S., Ti, No. 141<br>                                                                                    | 406.10     | 260°<br>(500°)      | 48             | 4.1                  | 170.0                         | 158.0            | 145.0            | 0.6                      | b/                               |
| <u>Di-2-naphthylamine</u> , No. 383,<br>0.05 g., Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub><br>                                 | 409.9      | 316°<br>(600°)      | 12             | 5.2                  | 149.0                         | 144.0            | 144.0            | 1.2                      | c/                               |
| <u>p-Aminodiphenylamine</u> , No. 360,<br>0.10g., Al, Ag, Cu, S.S., Ti<br>0.05g. Al, Ag, Cu, S.S., Ti<br>Gas Flow 95% N <sub>2</sub> 5% O <sub>2</sub><br> | 396.10     | 260°<br>(500°)      | 24             | 1.6                  | 5.6                           | 5.6              | 6.0              | 0.6                      | d/                               |
|                                                                                                                                                                                                                                             | 409.7      | 316°<br>(600°)      | 12             | 3.6                  | 98.0                          | 99.5             | 99.0             | 0.9                      | e/                               |
| <u>2,4-Bis-(phenylmercapto)</u><br><u>toluene</u> , No. 372, 0.20 ml.<br>Al, Ag, Cu, S.S., Ti<br>                                                         | 406.8      | 260°<br>(500°)      | 48             | 3.6                  | 31.2                          | 28.8             | 19.0             | 0.6                      | f/                               |
| <u>Triphenyl-p-phenylsilyl</u> ,<br>Tech., No. 356, 0.10g.<br>Al, Ag, Cu, S.S., Ti<br>                                                                   | 406.9      | 260°<br>(500°)      | 48             | 25.2                 | N.M.                          |                  |                  | N.M.                     | g/                               |

Metal Effects, Weight Loss, mg/cm<sup>2</sup>

|    |         |         |         |           |         |
|----|---------|---------|---------|-----------|---------|
| a/ | Al 0.28 | Ag 0.04 | Cu 0.70 | S.S. 0.36 | Ti 0.02 |
| b/ | Al 0.76 | Ag 0.10 | Cu 0.78 | S.S. 0.06 | Ti 0.08 |
| c/ | Al 0.06 | Ag 0.10 | Cu 1.06 | S.S. 0.60 | Ti 0.00 |
| d/ | Al 0.04 | Ag 0.38 | Cu 1.08 | S.S. 0.02 | Ti 0.00 |
| e/ | Al 0.10 | Ag 0.02 | Cu 0.28 | S.S. 0.44 | Ti 0.02 |
| f/ | Al 0.22 | Ag 0.26 | Cu 2.88 | S.S. 0.08 | Ti 0.06 |
| g/ | Al 0.38 | Ag 0.08 | Cu 2.18 | S.S. 0.02 | Ti 0.04 |

N.M. Too viscous to measure.

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.

2/ These values are tabulated in a separate table, Table 6.

TABLE 6  
Behavior of Insolubles in Oxidized F-50 Blend

| Additive, CGL No. and Concentration<br>Metals Present                                   | Run<br>No. | Time<br>Hours | Temperature<br>°C<br>(°F) | Percentage Insoluble |                   |                 |                          |
|-----------------------------------------------------------------------------------------|------------|---------------|---------------------------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                         |            |               |                           | Oil                  | Isosctane<br>Wash | Acetone<br>Wash | Isosctane<br>Precipitate |
| None, Al, Ag, Cu, S.S., Ti                                                              | 396.1      | 24            | 260°<br>(500°)            | 1.03                 | 0.03              | 0.03            | 0.00                     |
| None, Al, Ag, Cu, S.S., Ti                                                              | 397.1      | 24            | 260°<br>(500°)            | Gel.                 |                   |                 |                          |
| None, Al, Ag, Cu, S.S., Ti                                                              | 396.2      | 48            | 260°<br>(500°)            | Gel.                 |                   |                 |                          |
| None, Al, Ag, Cu, S.S., Ti                                                              | 409.5      | 12            | 316°<br>(600°)            | 5.86                 | 0.42              | 0.30            | 10.00                    |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine.</u><br>No. 260, 0.010g., Al, Ag, Cu, S.S., Ti | 404.1      | 48            | 260°<br>(500°)            | 0.41                 | N.D.              | N.D.            | 0.09                     |
| 260 0.020g., Al, Ag, Cu, S.S., Ti                                                       | 404.2      | 48            | 260°<br>(500°)            | 0.81                 | 0.02              | 0.02            | 0.21                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                       | 396.3      | 48            | 260°<br>(500°)            | 0.62                 | 0.03              | 0.03            | 0.08                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                       | 396.4      | 48            | 260°<br>(500°)            | 0.71                 | 0.04              | 0.03            | 0.31                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                       | 396.5      | 48            | 260°<br>(500°)            | 0.66                 | 0.03              | 0.03            | 0.09                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                       | 396.6      | 24            | 260°<br>(500°)            | 1.13                 | 0.04              | 0.04            | 0.20                     |
| 260 0.025g., Al, Ag, Cu, S.S., Ti                                                       | 397.5      | 48            | 260°<br>(500°)            | 0.70                 | 0.02              | 0.01            | 0.24                     |
| 260 0.010g., Al, Ag, Cu, S.S., Ti                                                       | 398.3      | 48            | 260°<br>(500°)            | 0.76                 | 0.01              | 0.01            | 0.12                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.1      | 6             | 260°<br>(500°)            | 0.92                 | 0.00              | 0.00            | 0.28                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.2      | 12            | 260°<br>(500°)            | 2.47                 | 0.05              | 0.03            | 0.28                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.3      | 18            | 260°<br>(500°)            | 1.56                 | 0.02              | 0.00            | 0.19                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.4      | 24            | 260°<br>(500°)            | 1.41                 | 0.02              | 0.00            | 0.15                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.5      | 30            | 260°<br>(500°)            | 1.09                 | 0.01              | 0.00            | 0.21                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.6      | 36            | 260°<br>(500°)            | 1.39                 | 0.00              | 0.00            | 0.23                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.7      | 42            | 260°<br>(500°)            | 1.48                 | 0.00              | 0.00            | 0.11                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.8      | 48            | 260°<br>(500°)            | 1.66                 | 0.00              | 0.00            | 0.14                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 404.3      | 48            | 260°<br>(500°)            | 0.59                 | 0.03              | 0.03            | 0.43                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.9      | 54            | 260°<br>(500°)            | 1.08                 | 0.00              | 0.00            | 0.12                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 402.10     | 60            | 260°<br>(500°)            | 1.69                 | 0.00              | 0.00            | 0.09                     |
| 260 0.03g., Al, Ag, Cu, S.S., Ti                                                        | 409.6      | 12            | 316°<br>(600°)            | 4.20                 | 0.29              | 0.22            | 5.71                     |
| 260 0.04g., Al, Ag, Cu, S.S., Ti                                                        | 404.4      | 48            | 260°<br>(500°)            | 0.92                 | 0.08              | 0.01            | 0.55                     |
| 260 0.05g., Al, Ag, Cu, S.S., Ti                                                        | 400.1      | 48            | 260°<br>(500°)            | 0.92                 | 0.02              | 0.02            | 0.34                     |
| 260 0.05g., Al, Ag, Cu, S.S., Ti                                                        | 404.5      | 48            | 260°<br>(500°)            | 1.34                 | 0.03              | 0.01            | 0.57                     |
| 260 0.05g., Al, Ag, Cu, S.S., Ti                                                        | 406.1      | 48            | 260°<br>(500°)            | 0.62                 | 0.04              | 0.02            | 1.28                     |
| 260 0.075g., Al, Ag, Cu, S.S., Ti                                                       | 404.6      | 48            | 260°<br>(500°)            | 0.80                 | 0.00              | 0.00            | 0.57                     |
| 260 0.10g., Al, Ag, Cu, S.S., Ti                                                        | 404.7      | 48            | 260°<br>(500°)            | 1.03                 | 0.06              | 0.05            | 0.60                     |
| 260 0.15g., Al, Ag, Cu, S.S., Ti                                                        | 404.8      | 48            | 260°<br>(500°)            | 1.53                 | 0.22              | 0.16            | 0.63                     |
| 260 0.20g., Al, Ag, Cu, S.S., Ti                                                        | 400.5      | 48            | 260°<br>(500°)            | 1.82                 | 0.01              | 0.00            | 0.21                     |
| 260 0.20g., Al, Ag, Cu, S.S., Ti                                                        | 406.2      | 48            | 260°<br>(500°)            | 1.21                 | 0.42              | 0.40            | 1.75                     |
| 260 0.40g., Al, Ag, Cu, S.S., Ti                                                        | 406.3      | 48            | 260°<br>(500°)            | 2.40                 | 1.33              | 1.33            | 2.64                     |
| <u>N,N'-Dicyclohexyl-p-phenylenediamine.</u><br>No. 350, 0.010g., Al, Ag, Cu, S.S., Ti  | 398.2      | 48            | 260°<br>(500°)            | Not Filterable       |                   |                 |                          |
| 350 0.030g., Al, Ag, Cu, S.S., Ti                                                       | 398.1      | 48            | 260°<br>(500°)            | 0.93                 | 0.01              | 0.01            | 2.56                     |

Table 6. Behavior of Insolubles in Oxidized F-50 Blend. (Cont'd)

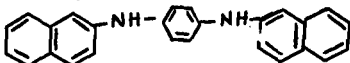
| Additive, CCL No., and Concentration<br>Metals Present                                                                                                                          | Run<br>No. | Time<br>Hours | Temperature<br>°C<br>(°F) | Percentage Insoluble |                   |                 |                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|---------------------------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                                                                                                                 |            |               |                           | Oil                  | Issectane<br>Wash | Acetone<br>Wash | Issectane<br>Precipitate |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> ,<br>No. 260, 0.025g., and <u>Acridine</u> , No. 82,<br>0.025g., Al,Ag,Cu,S.S.,Ti                                                  | 400.7      | 48            | 260°<br>(500°)            | 1.35                 | 0.17              | 0.16            | 0.25                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> ,<br>No. 260, 0.050g., and <u>N-Phenylmorpholine</u> ,<br>No. 141, 0.005g., Al,Ag,Cu,S.S.,Ti                                       | 400.9      | 48            | 260°<br>(500°)            | 0.91                 | 0.02              | 0.00            | 0.29                     |
| 260 0.010g. and 141 0.010g.<br>Al,Ag,Cu,S.S.,Ti                                                                                                                                 | 404.10     | 48            | 260°<br>(500°)            | 1.66                 | 0.00              | 0.00            | 0.15                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> ,<br>No. 260, 0.010g., <u>Acridine</u> , No. 82,<br>0.010g., and <u>Diphenylguanidine</u> , No. 161,<br>0.010g., Al,Ag,Cu,S.S.,Ti  | 400.8      | 48            | 260°<br>(500°)            | Gel                  |                   |                 |                          |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> ,<br>No. 260, 0.010g., <u>Acridine</u> , No. 82,<br>0.010g., and <u>N-Phenylmorpholine</u> , No. 141,<br>0.010g., Al,Ag,Cu,S.S.,Ti | 404.9      | 48            | 260°<br>(500°)            | 2.02                 | 0.02              | 0.02            | 0.16                     |
| <u>N,N'-Di-2-naphthyl-p-phenylenediamine</u> ,<br>No. 260, and <u>N-Amineethylmorpholine</u> ,<br>No. 117, 0.005g.                                                              | 400.10     | 48            | 260°<br>(500°)            | 1.44                 | 0.14              | 0.12            | 0.14                     |
| <u>Diphenylguanidine</u> , No. 161, 0.05g.<br>Al,Ag,Cu,S.S.,Ti                                                                                                                  | 396.13     | 48            | 260°<br>(500°)            | 0.99                 | 0.02              | 0.01            | 0.83                     |
| 161 0.05g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                    | 397.3      | 48            | 260°<br>(500°)            | 0.89                 | 0.02              | 0.01            | 0.26                     |
| 161 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                    | 396.14     | 48            | 260°<br>(500°)            | 2.33                 | 1.44              | 1.43            | 2.22                     |
| 161 0.05g. Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 396.11     | 24            | 260°<br>(500°)            | 1.00                 | 0.04              | 0.04            | 0.28                     |
| 161 0.05g. Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 397.4      | 24            | 260°<br>(500°)            | 0.53                 | 0.02              | 0.01            | 0.18                     |
| 161 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                    | 396.12     | 24            | 260°<br>(500°)            | 0.87                 | 0.04              | 0.03            | 1.34                     |
| 161 0.20g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                    | 400.6      | 48            | 260°<br>(500°)            | 0.93                 | 0.06              | 0.04            | 0.32                     |
| <u>Acridine</u> , No. 82, 0.05g.<br>Al,Ag,Cu,S.S.,Ti                                                                                                                            | 400.2      | 48            | 260°<br>(500°)            | 1.22                 | 0.00              | 0.00            | 0.13                     |
| 82 0.05g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 406.4      | 48            | 260°<br>(500°)            | 0.56                 | 0.00              | 0.00            | 1.92                     |
| 82 0.075g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                    | 406.5      | 48            | 260°<br>(500°)            | 0.66                 | 0.00              | 0.00            | 1.79                     |
| 82 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 396.7      | 48            | 260°<br>(500°)            | 0.77                 | 0.02              | 0.01            | 0.15                     |
| 82 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 396.8      | 48            | 260°<br>(500°)            | 0.71                 | 0.02              | 0.01            | 0.10                     |
| 82 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 397.2      | 48            | 260°<br>(500°)            | 0.66                 | 0.03              | 0.01            | 0.52                     |
| 82 0.10g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 396.9      | 24            | 260°<br>(500°)            | 1.03                 | 0.03              | 0.01            | 0.10                     |
| 82 0.20g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 400.4      | 48            | 260°<br>(500°)            | 1.37                 | 0.02              | 0.00            | 0.16                     |
| 82 0.05g., Al,Ag,Cu,S.S.,Ti                                                                                                                                                     | 409.10     | 12            | 316°<br>(600°)            | 4.82                 | 0.36              | 0.24            | 3.51                     |
| <u>Morgan's Base</u> , No. 375, 0.05g.<br>Al,Ag,Cu,S.S.,Ti                                                                                                                      | 406.6      | 48            | 260°<br>(500°)            | 0.62                 | 0.02              | 0.00            | 2.70                     |
| No. 375 0.075g., Al,Ag,Cu,S.S.,Ti                                                                                                                                               | 406.7      | 48            | 260°<br>(500°)            | 0.96                 | 0.05              | 0.01            | 3.28                     |
| <u>2,2'-Dipyridylamine</u> , No. 128, 0.05g.,<br>Al,Ag,Cu,S.S.,Ti                                                                                                               | 409.8      | 12            | 316°<br>(600°)            | 3.68                 | 0.41              | 0.28            | 6.83                     |

Table 6. Behavior of Insolubles in Oxidized F-50 Blend. (Cont'd).

| Additive, CCL No., and Concentration<br>Metals Present                            | Run<br>No. | Time<br>Hours | Temperature<br>°C<br>(°F) | Percentage Insoluble |                   |                 |                          |
|-----------------------------------------------------------------------------------|------------|---------------|---------------------------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                   |            |               |                           | Oil                  | Isocetane<br>Wash | Acetone<br>Wash | Isocetane<br>Precipitate |
| <u>N-Phenylmorpholine</u> , No. 141, 0.10g.<br>Al, Ag, Cu, S.S., Ti               | 406.10     | 48            | 260°<br>(500°)            | 1.38                 | 0.01              | 0.00            | 2.71                     |
| <u>Di-2-naphthylamine</u> , No. 383, 0.05g.,<br>Al, Ag, Cu, S.S., Ti              | 409.9      | 12            | 316°<br>(600°)            | 4.40                 | 0.36              | 0.28            | 2.69                     |
| <u>p-Aminodiphenylamine</u> , No. 360, 0.05g.<br>Al, Ag, Cu, S.S., Ti             | 409.7      | 12            | 316°<br>(600°)            | 4.79                 | 0.36              | 0.28            | 3.68                     |
| 360 0.10g., Al, Ag, Cu, S.S., Ti                                                  | 396.10     | 24            | 260°<br>(500°)            | 1.23                 | 0.13              | 0.13            | 0.10.                    |
| <u>2,4-bis(phenyl mercapto)-toluene</u> , No. 372<br>0.20g., Al, Ag, Cu, S.S., Ti | 406.8      | 48            | 260°<br>(500°)            | 1.27                 | 0.00              | 0.00            | 5.41                     |
| <u>Triphenyl-p-phenylsilane</u> , Tech.,<br>No. 356, 0.10g., Al, Ag, Cu, S.S., Ti | 406.9      | 48            | 260°<br>(500°)            | Gel                  |                   |                 |                          |

**TABLE 2**  
**Oxidations in G. E. Silicone Fluid No. 81406 (MLO 53-446)**

25 ml. Sample

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                           | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                                                                                        |            |                     |                |                      | 54.5°C *<br>(130°F)           | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| None, No Metals 2/                                                                                                                                     | 338.5      | 260°<br>(500°)      | 24             | 3.2                  | 76                            | 71               | N.D.             | 0.8                      | 0.1                           |
| None, No Metals 2/                                                                                                                                     | 339.5      | 260°<br>(500°)      | 48             | 5.1                  | Solid                         |                  |                  | N.M.                     | N.M.                          |
| None, No Metals 2/                                                                                                                                     | 335.2      | 316°<br>(600°)      | 12             | 2.3                  | 50                            | 46               |                  | 2.2                      | 0.1                           |
| None, Al, Ag, Cu, S.S., Ti 2/                                                                                                                          | 338.9      | 260°<br>(500°)      | 24             | 3.4                  | 93                            | 87               |                  | 0.8                      | 0.02 g/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                                                                                                          | 339.9      | 260°<br>(500°)      | 48             | 22.9                 | Solid                         |                  |                  | N.M.                     | N.M. b/                       |
| None, Al, Ag, Cu, S.S., Ti 2/                                                                                                                          | 335.3      | 316°<br>(600°)      | 12             | 3.6                  | 82                            | 79               |                  | 3.1                      | 0.1 g/                        |
| <b>N,N'-Di-2-Naphthyl-2-phenylene-</b><br><b>diamine, No. 260</b><br> |            |                     |                |                      |                               |                  |                  |                          |                               |
| 0.005 g., Al, Ag, Cu, S.S., Ti 2/                                                                                                                      | 349.5      | 260°<br>(500°)      | 24             | 2.1                  | 16                            | 15               | 16               | 1.0                      | 0.02 d/                       |
| 0.005 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 355.1      | 260°<br>(500°)      | 24             | 3.5                  | 50                            | 47               | 53               | 3.5                      | 0.00 g/                       |
| 0.005 g., Al, Ag, Cu, S.S., Ti 2/                                                                                                                      | 349.10     | 260°<br>(500°)      | 48             | 2.8                  | 30                            | 28               | 30               | 1.0                      | 0.14 f/                       |
| 0.01 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                       | 355.2      | 260°<br>(500°)      | 24             | 2.2                  | 19                            | 18               | 18               | 2.2                      | 0.02 g/                       |
| 0.025 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 355.3      | 260°<br>(500°)      | 24             | 1.3                  | 4                             | 4                | 3                | 1.3                      | 1.1 h/                        |
| 0.025 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 355.5      | 260°<br>(500°)      | 48             | 5.2                  | 12                            | 11               | 9                | 5.2                      | 0.6 i/                        |
| 0.025 g., Al, Ag, Cu, S.S., Ti 2/                                                                                                                      | 350.9      | 316°<br>(600°)      | 12             | 4.9                  | 111                           | 108              | N.M.             | 1.6                      | 1.4 j/                        |
| 0.025 g., Al, Ag, Cu, S.S., Ti 2/                                                                                                                      | 350.10     | 316°<br>(600°)      | 24             | 4.5                  | 985                           | N.D.             | N.M.             | 1.1                      | 0.10 k/                       |
| 0.050 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 355.4      | 260°<br>(500°)      | 24             | 1.9                  | 5                             | 5                | 4                | 1.9                      | 0.7 l/                        |
| 0.050 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 355.6      | 260°<br>(500°)      | 48             | 2.5                  | 9                             | 9                | 7                | 2.5                      | 5.0 m/                        |
| 0.050 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 357.1      | 260°<br>(500°)      | 48             | 3.1                  | 12                            | 12               | 9                | 0.6                      | 0.08 n/                       |
| 0.050 g., Al, Ag, Cu, S.S., Ti 1/                                                                                                                      | 357.2      | 260°<br>(500°)      | 48             | 2.7                  | 12                            | 12               | 10               | 0.7                      | 0.12 o/                       |

1/ Gas Flow 1/hr. - Air

2/ Gas Flow 1/hr. - 95% N<sub>2</sub> - 5% O<sub>2</sub>

Metal Effect, Weight Loss, mg/cm<sup>2</sup>

g/ Al 0.34 Ag 1.10 Cu 0.96 S.S. 0.50 Ti 0.08  
 h/ Al 0.18 Ag 1.22 Cu 2.96 S.S. 0.74 Ti 0.00  
 g/ Al 0.88 Ag 0.54 Cu 1.40 S.S. 0.88 Ti 0.12  
 g/ Al 0.04 Ag 0.36 Cu 0.84 S.S. 0.04 Ti 0.00  
 g/ Al 0.10 Ag 0.46 Cu 0.94 S.S. 0.16 Ti 0.12

Metal Effect, Weight Loss, Mg/cm<sup>2</sup>

f/ Al 0.26 Ag 0.52 Cu 0.94 S.S. 0.26 Ti 0.10  
 g/ Al 0.18 Ag 0.44 Cu 1.58 S.S. 0.10 Ti 0.04  
 h/ Al 0.12 Ag 0.42 Cu 1.24 S.S. 0.34 Ti 0.16  
 i/ Al 0.06 Ag 0.28 Cu 1.06 S.S. 0.04 Ti 0.02  
 j/ Al 0.24 Ag 0.58 Cu 1.00 S.S. 0.66 Ti 0.08  
 k/ Al 0.18 Ag 0.30 Cu 1.24 S.S. 1.04 Ti 0.02  
 l/ Al 0.04 Ag 0.36 Cu 1.38 S.S. 0.00 Ti 0.10  
 m/ Al 0.08 Ag 0.16 Cu 1.30 S.S. -0.04 Ti 0.04

Metal Effect, Weight Loss, mg/cm<sup>2</sup>

n/ Al 0.04 Ag 0.18 Cu 0.96  
 S.S. 0.08 Ti 0.14  
 o/ Al 0.20 Ag 0.48 Cu 1.48  
 S.S. 0.14 Ti 0.04

N.D. Not Determined.

N.M. Too Viscous for measurement.

Table 7. Oxidations in G. E. Silicone Fluid No. 81406 (MLO 53-446) (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                               | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                                            |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| N,N'-Di-2-Naphthyl-p-phenylene-<br>diamine, No. 260, (Cont'd)<br>0.10 g. Al, Ag, Cu, S.S., Ti 1/           | 355.7      | 260°C<br>(500°F)    | 48             | 6.0                  | 9                             | 9                | 6                | 6.0                      | 0.5 a/                        |
| 0.10 g. Al, Ag, Cu, Cr-Mo, Ti 1/                                                                           | 355.9      | 260°C<br>(500°F)    | 24             | 2.9                  | 5                             | 5                | 4                | 2.9                      | 0.8 b/                        |
| 0.10 g. Al, Ag, Cu, Cr-Mo, Ti 1/                                                                           | 355.10     | 260°C<br>(500°F)    | 48             | 2.6                  | 10                            | 10               | 9                | 2.6                      | 0.8 a/                        |
| 0.25g. Al, Ag, Cu, S.S., Ti 1/                                                                             | 355.8      | 260°C<br>(500°F)    | 48             | 7.1                  | 10                            | 10               | 8                | 7.1                      | 0.8 d/                        |
|                                                                                                            |            |                     |                |                      |                               |                  |                  |                          |                               |
| N,N'-Di-(2-methyl-3-chloro-<br>phenyl)-p-phenylenediamine,<br>No. 350<br>0.0125g., Al, Ag, Cu, S.S., Ti 2/ | 349.2      | 260°C<br>(500°F)    | 24             | 2.1                  | 13                            | 12               | 12               | 1.0                      | 0.02 a/                       |
| 0.0125g., Al, Ag, Cu, S.S., Ti 2/                                                                          | 349.7      | 260°C<br>(500°F)    | 48             | 2.4                  | 23                            | 22               | 23               | 1.3                      | 0.02 f/                       |
|                                                                                                            |            |                     |                |                      |                               |                  |                  |                          |                               |
| p-Aminodiphenylamine, No. 360<br>0.0125g., Al, Ag, Cu, S.S., Ti 2/                                         | 349.3      | 260°C<br>(500°F)    | 24             | 2.2                  | 26                            | 24               | 28               | 1.1                      | 0.02 e/                       |
| 0.0125g., Al, Ag, Cu, S.S., Ti 2/                                                                          | 349.8      | 260°C<br>(500°F)    | 48             | 3.1                  | 66                            | 61               | 70               | 0.8                      | 0.04 b/                       |
|                                                                                                            |            |                     |                |                      |                               |                  |                  |                          |                               |
| Thiocarbamylide, No. 332<br>0.0125g., Al, Ag, Cu, S.S., Ti 2/                                              | 349.1      | 260°C<br>(500°F)    | 24             | 2.9                  | 58                            | 54               | 59               | 2.1                      | 0.00 i/                       |
| 0.0125g. Al, Ag, Cu, S.S., Ti 2/                                                                           | 349.6      | 260°C<br>(500°F)    | 48             | 3.7                  | 120                           | 114              | 127              | 1.0                      | 0.00 i/                       |
|                                                                                                            |            |                     |                |                      |                               |                  |                  |                          |                               |
| Stannous naphthenate, No. 373<br>0.005g., Al, Ag, Cu, S.S., Ti 2/                                          | 349.4      | 260°C<br>(500°F)    | 24             | 2.3                  | 62                            | 58               | 74               | 0.9                      | 0.1 k/                        |
| 0.005g., Al, Ag, Cu, S.S., Ti 2/                                                                           | 349.9      | 260°C<br>(500°F)    | 48             | 3.5                  | 119                           | 112              | 162              | 1.1                      | 0.0 l/                        |

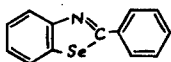
1/ Gas Flow 1 l./hr.- Air  
 2/ Gas Flow 1 l./hr.- 95% N<sub>2</sub>, 5% O<sub>2</sub>  
 Metal Effect, Weight Loss, mg/cm<sup>2</sup>  
 a/ Al 0.02 Ag 0.40 Cu 1.20 S.S. 0.06 Ti 0.02  
 b/ Al 0.10 Ag 0.22 Cu 1.18 Cr-Mo 0.32 Ti 0.12  
 c/ Al 0.02 Ag 0.52 Cu 1.68 Cr-Mo 0.14 Ti 0.04  
 d/ Al 0.04 Ag 0.46 Cu 1.44 S.S. 0.02 Ti-0.08  
 e/ Al 0.00 Ag 0.30 Cu 1.38 S.S. 0.12 Ti 0.10  
 f/ Al 0.04 Ag 0.48 Cu 0.84 S.S. 0.06 Ti 0.02  
 g/ Al 0.00 Ag 0.52 Cu 0.72 S.S. 0.18 Ti 0.00  
 h/ Al 0.00 Ag 0.90 Cu 1.00 S.S. 0.32 Ti 0.16  
 i/ Al 0.14 Ag 0.84 Cu 1.26 S.S. 0.58 Ti 0.14  
 j/ Al 0.10 Ag 0.92 Cu 1.56 S.S. 0.56 Ti 0.04  
 k/ Al 0.06 Ag 0.88 Cu 0.86 S.S. 0.48 Ti 0.04  
 l/ Al 0.12 Ag 0.74 Cu 1.04 S.S. 0.36 Ti 0.08  
 N.D. Not yet determined.

TABLE 8  
Oxidations in Didecyl Diocetyl Silane, MLO 57-161

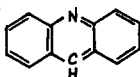
| Additive, CCL No., Formula,<br>Concentration, Metals Present                                             | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Air Flow 1 l/Hr.<br>Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>W <sup>1</sup> P <sup>1</sup> |      |
|----------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-----------------------------------------------------------------|------------------|------------------|--------------------------|-----------------------------------------------------------|------|
|                                                                                                          |            |                     |                |                      | 54.5°C<br>(130°F)                                               | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                                                           |      |
| None, No Metals                                                                                          | 420.1      | 260°<br>(500°)      | 48             | 5.2                  | 70.0                                                            | 51.8             | 38.4             | 11.8                     | 0.04                                                      | 0.02 |
| None, No Metals                                                                                          | 421.2      | 260°<br>(500°)      | 48             | 6.8                  | 70.7                                                            | 50.3             | 45.3             | 2.8                      | 0.01                                                      | 0.52 |
| None, Al Ag Cu S.S. Ti<br>0.20 .14 .80 .16 .18<br>.04 .06 .12 .10 .04                                    | 420.4      | 260°<br>(500°)      | 48             | 4.9                  | 49.2                                                            | 44.1             | 34.4             | 3.6                      | 0.09                                                      | 0.11 |
| None, Al Ag Cu S.S. Ti<br>0.18 .20 .34 .36 .02<br>.10 .16 .06 .12 .02                                    | 421.5      | 260°<br>(500°)      | 48             | 10.1                 | 117.0                                                           | 88.8             | 65.0             | 4.4                      | 0.05                                                      | 0.51 |
| Phenyl selenide, No. 282PCB,<br>0.20g. Al Ag Cu S.S. Ti<br>0.22 .28 3.74 1.26 .12<br>.22 .70 .98 .86 .18 | 421.8      | 260°<br>(500°)      | 48             | 6.9                  | 53.8                                                            | 41.2             | 31.0             | 2.0                      | 0.09                                                      | 0.71 |

(C<sub>6</sub>H<sub>5</sub>)<sub>2</sub>Se

|                                                                                                               |       |                |    |     |      |      |      |     |      |      |
|---------------------------------------------------------------------------------------------------------------|-------|----------------|----|-----|------|------|------|-----|------|------|
| 2-Phenylbenzoselesazole, No. 300B,<br>0.20g. Al Ag Cu S.S. Ti<br>0.66 .34 1.42 .28 .28<br>.04 .12 .16 .00 .02 | 420.7 | 260°<br>(500°) | 48 | 4.2 | 43.8 | 34.9 | 29.7 | 4.0 | 0.14 | 0.16 |
| 300B, 0.30g. Al Ag Cu S.S. Ti<br>0.24 .20 .76 .78 .06<br>.14 .30 .20 .06 .14                                  | 421.7 | 260°<br>(500°) | 48 | 5.6 | 51.5 | 41.2 | 35.5 | 5.8 | 0.07 | 0.49 |



|                                                                                          |       |                |    |     |      |      |      |     |      |      |
|------------------------------------------------------------------------------------------|-------|----------------|----|-----|------|------|------|-----|------|------|
| Acridine, No. 82, 0.24g. Al Ag Cu S.S. Ti<br>0.74 .36 .68 .82 .28<br>.22 .30 .28 .12 .20 | 421.9 | 260°<br>(500°) | 48 | 4.4 | 67.7 | 53.7 | 37.9 | 0.8 | 0.13 | 0.60 |
|------------------------------------------------------------------------------------------|-------|----------------|----|-----|------|------|------|-----|------|------|

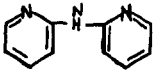
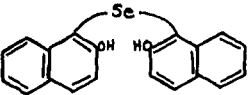
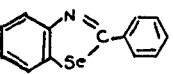
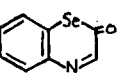


|                                                                                                                                   |        |                |    |     |       |       |       |     |      |      |
|-----------------------------------------------------------------------------------------------------------------------------------|--------|----------------|----|-----|-------|-------|-------|-----|------|------|
| Copper sebacate-2,2'-dipyridyl-amine (Complex), No. 395, 0.30g. Al Ag Cu S.S. Ti<br>0.18 .12 1.40 .80 -.26<br>.10 .28 .32 .42 .36 | 421.10 | 260°<br>(500°) | 48 | 7.3 | 191.5 | 180.0 | 126.0 | 2.1 | N.F. | N.F. |
|-----------------------------------------------------------------------------------------------------------------------------------|--------|----------------|----|-----|-------|-------|-------|-----|------|------|

The Values under W are the per cent oil insoluble after the isooctane wash. The values under P are the per cent solid precipitated by oxidation of isooctane to the filtered fluid.

N.F. Not Filterable.

TABLE 9  
Oxidations in Di-n-Dodecyl Di-n-Octyl Silane, MLO 56-611

| Additive, CCL No., Formula,<br>Concentration, Metals Present <sup>1</sup>                                           | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|---------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                                                     |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| None, No Metals                                                                                                     | 420.2      | 260°<br>(500°)      | 48             | 5.1                  | 52.5                          | 40.4             | 31.1             | 5.1                      | 0.20                          |
| None, No Metals                                                                                                     | 421.3      | 260°<br>(500°)      | 48             | 5.2                  | 45.7                          | 36.2             | 28.4             | 2.8                      | 0.53                          |
| None, Al, Ag, Cu, S.S., Ti                                                                                          | 420.5      | 260°<br>(500°)      | 48             | 7.7                  | 113.6                         | 86.4             | 64.7             | 4.1                      | 0.79 <i>m</i> /               |
| <i>m</i> pne, Al, Ag, Cu, S.S., Ti                                                                                  | 421.6      | 260°<br>(500°)      | 48             | 5.3                  | 65.5                          | 49.8             | 36.8             | 3.6                      | 0.63 <i>o</i> /               |
| None, Al, Ag, Cu, Cr-Mo, Ti                                                                                         | 361.10     | <i>a</i> /          | 36             | 4.2                  | 45.5                          | 34.4             | N.D.             | 3.7                      | 0.1 <i>a</i> /                |
| None, Al, Ag, Cu, S.S., Ti                                                                                          | 364.10     | <i>b</i> /          | 48             | 6.4                  | 38.4                          | 31.6             | N.D.             | 2.1                      | 0.1 <i>d</i> /                |
| 2,2'-Dipyridylamine, No. 128,<br>0.20g., Al, Ag, Cu, S.S., Ti                                                       | 359.10     | 260°<br>(500°F)     | 48             | 4.8                  | 62.0                          | 53.0             | N.D.             | 4.6                      | 6.9 <i>e</i> /                |
|                                    |            |                     |                |                      |                               |                  |                  |                          |                               |
| Phenyl selenide, No. 282<br>PCB, 0.20g., Al, Ag, Cu, S.S.<br>Ti<br>(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Se | 359.6      | 260°<br>(500°F)     | 48             | 7.5                  | 51.4                          | 39.8             | N.D.             | 6.6                      | 0.2 <i>f</i> /                |
| Di-(2-hydroxy-1-naphthyl)<br>selenide, No. 307, 0.20g.,<br>Al, Ag, Cu, S.S., Ti                                     | 359.8      | 260°<br>(500°F)     | 48             | 6.2                  | 47.8                          | 37.1             | N.D.             | 2.8                      | 0.2 <i>f</i> /                |
|                                    |            |                     |                |                      |                               |                  |                  |                          |                               |
| 2-Phenylbenzoselenazole,<br>No. 300B, 0.20g., Al, Ag,<br>Cu, S.S., Ti                                               | 359.7      | 260°<br>(500°F)     | 48             | 6.0                  | 53.0                          | 43.5             | N.D.             | 5.3                      | 0.2 <i>g</i> /                |
| 0.10g., Al, Ag, Cu, S.S., Ti                                                                                        | 361.9      | <i>a</i> /          | 36             | 5.3                  | 46.2                          | 35.8             | N.D.             | 3.4                      | 0.2 <i>h</i> /                |
| 0.20g., Al, Ag, Cu, S.S., Ti                                                                                        | 360.8      | <i>a</i> /          | 36             | 4.6                  | 36.7                          | 29.2             | N.D.             | 4.4                      | 0.1 <i>i</i> /                |
| 0.40g., Al, Ag, Cu, S.S., Ti                                                                                        | 360.9      | <i>a</i> /          | 36             | 6.3                  | 38.8                          | 31.2             | N.D.             | 5.4                      | 0.1 <i>j</i> /                |
| 0.40g., Al, Ag, Cu, Cr-Mo, Ti                                                                                       | 360.10     | <i>a</i> /          | 36             | 6.1                  | 43.0                          | 36.0             | N.D.             | 4.0                      | 0.2 <i>k</i> /                |
| 0.10g., Al, Ag, Cu, S.S., Ti                                                                                        | 364.9      | <i>b</i> /          | 48             | 8.4                  | 52.7                          | 43.3             | N.D.             | 2.6                      | 0.1 <i>l</i> /                |
| 0.20g., Al, Ag, Cu, S.S., Ti                                                                                        | 420.8      | 260°<br>(500°)      | 48             | 6.1                  | 55.7                          | 42.3             | 31.8             | 5.0                      | 0.2 <i>p</i> /                |
|                                  |            |                     |                |                      |                               |                  |                  |                          |                               |
| 1,4,2-Benzoselenazin-3-one,<br>No. 308, 0.20g., Al, Ag, Cu,<br>S.S., Ti                                             | 359.9      | 260°<br>(500°F)     | 48             | 6.2                  | 52.0                          | 40.7             | N.D.             | 2.6                      | 0.2 <i>m</i> /                |
|                                  |            |                     |                |                      |                               |                  |                  |                          |                               |

*a*/ 24 hours with air at 260°C and 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub> gas mixture at 316°C.

*b*/ 260°C for 24 hours, raised to 316°C for 12 hours, after 36 hours the temperature dropped back to 260°C for 12 hours with 95% N<sub>2</sub> and 5% O<sub>2</sub> gas mixture.

*c*/ Al 0.32 Ag 0.10 Cu 0.26 Cr-Mo 0.34 Ti 0.10

*m*/ Al 0.44 Ag 0.10 Cu 1.36 S.S. 0.32 Ti 0.18

*d*/ Al 0.38 Ag 0.62 Cu 0.86 S.S. 0.50 Ti 0.10

*o*/ Al 0.36 Ag 0.06 Cu 0.56 S.S. 0.46 Ti 0.18

*e*/ Al 0.08 Ag 0.08 Cu 1.34 S.S. 0.86 Ti 0.22

*p*/ Al 0.38 Ag 0.30 Cu 1.44 S.S. 0.46 Ti 0.18

*f*/ Al 0.16 Ag 0.40 Cu 2.28 S.S. 2.44 Ti 0.10

*g*/ Al 0.10 Ag 0.10 Cu 0.70 S.S. 0.30 Ti 0.00

*h*/ Al 0.64 Ag 0.10 Cu 0.62 Cr-Mo 0.24 Ti 0.24

*i*/ Al 0.52 Ag 0.40 Cu 0.62 S.S. 0.56 Ti 0.30

*j*/ Al 0.30 Ag 0.32 Cu 0.84 S.S. 0.86 Ti 0.46

*k*/ Al 0.00 Ag 0.46 Cu 1.68 Cr-Mo 1.84 Ti 0.64

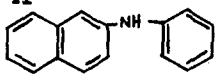
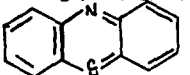
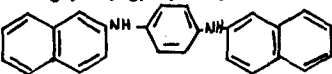
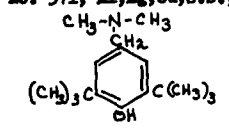
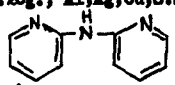
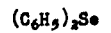
*l*/ Al 0.12 Ag 0.36 Cu 0.90 S.S. 0.48 Ti 0.18

*n*/ Al 0.32 Ag 1.28 Cu 6.42 S.S. 1.46 Ti 0.00

<sup>1</sup>/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.

N.D. Not yet determined.

TABLE 10  
Oxidations in *n*-Octadecyl-tri-*n*-Octyl Silane, MLO 56-578

| Additive, CGL No., Formula, Concentration, Metals Present                                            | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|------------------------------------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
|                                                                                                      |         |               |             |                | 54.5°C (130°F)                | 100°C (212°F) | 195°C (383°F) |                       |                         |
| None, No Metals                                                                                      | 420.3   | 260°C (500°F) | 48          | 7.4            | 52.5                          | 40.5          | 57.4          | 7.6                   | 0.17                    |
| None, No Metals                                                                                      | 421.1   | 260°C (500°F) | 48          | 8.4            | 93.5                          | 70.0          | 53.0          | 3.3                   | 0.53                    |
| None, Al, Ag, Cu, S.S., Ti                                                                           | 420.6   | 260°C (500°F) | 48          | 6.7            | 85.5                          | 63.6          | 47.7          | 5.5                   | 0.17 g/                 |
| None, Al, Ag, Cu, S.S., Ti                                                                           | 421.4   | 260°C (500°F) | 48          | 6.8            | 70.2                          | 52.3          | 38.1          | 3.9                   | 0.60 g/                 |
| None, Al, Ag, Cu, S.S., Ti                                                                           | 356.6   | 260°C (500°F) | 24          | 8.9            | 104.0                         | 79.4          | N.D.          | 4.4                   | 0.3 g/                  |
| None, Al, Ag, Cu, S.S., Ti                                                                           | 356.7   | 260°C (500°F) | 48          | 11.9           | 203.0                         | 149.5         | N.D.          | 5.3                   | 0.1 g/                  |
| None, Al, Ag, Cu, Cr-Mo, Ti                                                                          | 361.8   | g/            | 36          | 5.2            | 56.3                          | 41.0          | N.D.          | 4.5                   | 0.2 g/                  |
| None, Al, Ag, Cu, S.S., Ti                                                                           | 364.8   | g/            | 48          | 10.2           | 68.5                          | 54.0          | N.D.          | 2.3                   | 0.2 g/                  |
| Phenyl- $\alpha$ -naphthylamine, No. 61, 0.10g., Al, Ag, Cu, S.S., Ti                                | 357.10  | 260°C (500°F) | 48          | 10.5           | 111.0                         | 83.5          | N.D.          | 5.1                   | 0.3 g/                  |
|                     |         |               |             |                |                               |               |               |                       |                         |
| Acridine, No. 82 (recryst.), 0.08 g., Al, Ag, Cu, S.S., Ti                                           | 356.9   | 260°C (500°F) | 48          | 14.5           | 491.0                         | 299.0         | N.D.          | 3.6                   | 0.1 g/                  |
|                     |         |               |             |                |                               |               |               |                       |                         |
| N,N'-Di-2-naphthyl-p-phenylenediamine, No. 260, 0.10g., Al, Ag, Cu, S.S., Ti                         | 356.10  | 260°C (500°F) | 48          | 14.5           | 1000.0                        | 592.0         | N.D.          | 3.8                   | 0.2 g/                  |
|                     |         |               |             |                |                               |               |               |                       |                         |
| 4-Hydroxy-3,5-di-tert-butyl benzyl dimethylamine, No. 371, Al, Ag, Cu, S.S., Ti                      | 356.8   | 260°C (500°F) | 48          | 14.2           | 405.0                         | 285.0         | N.D.          | 3.8                   | 0.2 g/                  |
|                   |         |               |             |                |                               |               |               |                       |                         |
| 2,2'-Dipyridylamine, No. 128, 0.10g., Al, Ag, Cu, S.S., Ti                                           | 357.7   | 260°C (500°F) | 48          | 8.2            | 77.0                          | 59.3          | N.D.          | 4.8                   | 0.3 g/                  |
| 0.20g., Al, Ag, Cu, S.S., Ti                                                                         | 359.5   | 260°C (500°F) | 48          | 8.5            | 173.0                         | 126.0         | N.D.          | 2.3                   | 0.3 g/                  |
|                   |         |               |             |                |                               |               |               |                       |                         |
| 2,2'-Dipyridylamine, No. 128, 0.10g. and Diphenyl selenide, No. 282PCB, 0.10g., Al, Ag, Cu, S.S., Ti | 357.8   | 260°C (500°F) | 48          | 5.9            | 95.0                          | 70.5          | N.D.          | 2.9                   | 0.2 g/                  |
|                   |         |               |             |                |                               |               |               |                       |                         |
| Diphenyl selenide, No. 282PCB 0.10 g., Al, Ag, Cu, S.S., Ti                                          | 357.9   | 260°C (500°F) | 48          | 7.5            | 60.0                          | 43.8          | N.D.          | 3.4                   | 0.2 g/                  |
| 0.20 g., Al, Ag, Cu, S.S., Ti                                                                        | 359.1   | 260°C (500°F) | 48          | 8.9            | 63.3                          | 48.3          | N.D.          | 2.3                   | 0.2 g/                  |

g/ 24 hours with air at 260°C and 12 hours with 95% N<sub>2</sub> - 5% O<sub>2</sub> gas mixture at 316°C.

b/ 260°C for 24 hours, raise the temperature to 316°C for 12 hours, after 36 hours drop the temperature back to 260°C for 12 hours with 95% N<sub>2</sub> - 5% O<sub>2</sub> gas mixture.

g/ Al 0.14 Ag 0.10 Cu 1.10 S.S. 0.08 Ti 0.14

d/ Al 0.08 Ag 0.06 Cu 0.44 S.S. 0.02 Ti-0.16

g/ Al 0.18 Ag 0.12 Cu 0.28 Cr-Mo 0.34 Ti 0.16

g/ Al 0.56 Ag 0.38 Cu 0.94 S.S. 0.38 Ti 0.10

g/ Al 0.24 Ag 0.22 Cu 1.46 S.S. 0.48 Ti 0.36

h/ Al 0.22 Ag 0.36 Cu 0.62 S.S. 0.02 Ti 0.16

i/ Al 0.20 Ag 0.28 Cu 1.00 S.S. 0.02 Ti 0.04

j/ Al 0.00 Ag 0.14 Cu 0.52 S.S. 0.00 Ti 0.08

k/ Al 0.24 Ag 0.32 Cu 1.08 S.S. 0.94 Ti 0.50

l/ Al 0.34 Ag 0.50 Cu 1.68 S.S. 0.78 Ti 0.00

m/ Al 0.34 Ag 0.72 Cu 4.80 S.S. 1.26 Ti 0.06

n/ Al 0.66 Ag 1.04 Cu 2.08 S.S. 1.68 Ti 0.00

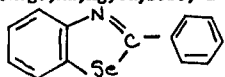
o/ Al 0.32 Ag 0.00 Cu 6.38 S.S. 1.80 Ti 0.18

1/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.

N.D. Not yet determined.

Table 10. Oxidations in N-Octadecyl-tri-n-Octyl Silane, MLO 56-578 (Cont'd).

| Additive, CCL No., Formula, Concentration, Metals Present <sup>1</sup> | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
|                                                                        |         |               |             |                | 54.5°C * (130°F)              | 100°C (212°F) | 195°C (383°F) |                       |                         |
| 2-Phenylbenzoselenazole, No. 300B, 0.20g., Al, Ag, Cu, S.S., Ti        | 359.2   | 260°C (500°F) | 48          | 7.8            | 61.9                          | 46.7          | N.D.          | 4.3                   | 0.1 <u>c/</u>           |
| 0.10g., Al, Ag, Cu, Cr-Mo, Ti                                          | 361.7   | <u>a/</u>     | 36          | 4.9            | 46.2                          | 34.0          | N.D.          | 3.8                   | 0.2 <u>d/</u>           |
| 0.20g., Al, Ag, Cu, S.S., Ti                                           | 360.5   | <u>a/</u>     | 36          | 7.4            | 46.5                          | 36.2          | N.D.          | 4.3                   | 0.1 <u>e/</u>           |
| 0.40g., Al, Ag, Cu, S.S., Ti                                           | 360.5   | <u>a/</u>     | 36          | 6.7            | 47.5                          | 37.2          | N.D.          | 6.3                   | 0.2 <u>f/</u>           |
| 0.40g., Al, Ag, Cu, Cr-Mo, Ti                                          | 360.7   | <u>a/</u>     | 36          | 7.6            | 53.9                          | 42.0          | N.D.          | 4.4                   | 0.3 <u>g/</u>           |
| 0.10g., Al, Ag, Cu, S.S., Ti                                           | 364.7   | <u>b/</u>     | 48          | 10.4           | 65.3                          | 52.0          | N.D.          | 2.6                   | 0.1 <u>h/</u>           |
| 0.20g., Al, Ag, Cu, S.S., Ti                                           | 420.9   | 260°C (500°F) | 48          | 5.0            | 33.2                          | 31.0          | 21.7          | 5.1                   | 0.3 <u>k/</u>           |



Di-(2-hydroxy-1-naphthyl) selenide, No. 307, 0.20g. Al, Ag, Cu, S.S., Ti

359.3 260°C (500°F)

48

6.3

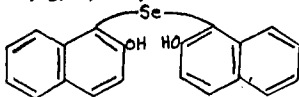
62.2

46.3

N.D.

2.6

0.1 i/



1,4,2-Benzoselenazin-3-one, No. 308, 0.20g., Al, Ag, Cu, S.S., Ti

359.4 260°C (500°F)

48

6.0

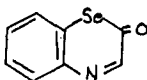
53.5

40.8

N.D.

2.4

0.3 j/



a/ 24 Hours with air at 260°C and 12 hours more with 95% N<sub>2</sub> - 5% O<sub>2</sub> at 316°C.

b/ 260°C for 24 hours, raise the temperature to 316°C for 12 hours, after 36 hours drop the temperature back to 260°C for 12 hours with 95% N<sub>2</sub> - 5% O<sub>2</sub> gas mixture.

Metal Effect, Weight Loss, mg/cm<sup>2</sup>

c/ Al 0.14 Ag 0.20 Cu 0.34 S.S. 0.16 Ti 0.00

k/ Al 0.56 Ag 0.52 Cu 1.50 S.S. 0.64 Ti 0.40

d/ Al 0.54 Ag 0.28 Cu 0.52 Cr-Mo 0.50 Ti 0.24

e/ Al 0.34 Ag 0.42 Cu 0.48 S.S. 0.42 Ti 0.20

f/ Al 0.54 Ag 0.60 Cu 0.58 S.S. 0.64 Ti 0.12

g/ Al 0.60 Ag 0.56 Cu 1.00 Cr-MO 7.12 Ti 0.18

h/ Al 0.48 Ag 0.40 Cu 1.54 S.S. 0.42 Ti 0.12

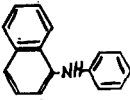
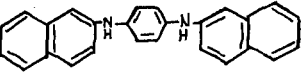
i/ Al 0.04 Ag 0.66 Cu 9.92 S.S. 0.98 Ti 0.22

j/ Al 0.10 Ag 1.56 Cu 9.14 S.S. 1.10 Ti 0.08

l/ Unless otherwise indicated the oxidations were performed with 25 ml of fluid with dry air passing at the rate of 1 l/hr.

N.D. Not yet determined.

TABLE 11  
Oxidations in Diphenyl Di-n-dodecyl Silane, MLO 56-280

| Additive, CCL No., Formula, Concentration, Metals Present                          | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|------------------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
|                                                                                    |         |               |             |                | 54.5°C (130°F)                | 100°C (212°F) | 195°C (383°F) |                       |                         |
| None, Al, Ag, Cu, S.S., Ti 1/                                                      | 356.1   | 260°C (500°F) | 24          | 10.5           | 107.0                         | 85.5          | N.D.          | 3.4                   | 0.1 a/                  |
| None, Al, Ag, Cu, S.S., Ti 1/                                                      | 356.2   | 260°C (500°F) | 48          | 15.1           | 865.0                         | 528.0         | N.D.          | 4.0                   | 0.3 b/                  |
| None, No Metals 2/                                                                 | 352.1   | 316°C (600°F) | 12          | 7.7            | 25.7                          | 24.6          | N.D.          | 2.7                   | 0.1                     |
| None, No Metals 2/                                                                 | 353.9   | 316°C (600°F) | 12          | 8.3            | 23.2                          | 22.4          | N.D.          | 1.5                   | 0.1                     |
| None, No Metals 2/                                                                 | 352.2   | 316°C (600°F) | 24          | 18.0           | 96.0                          | 88.4          | N.D.          | 3.0                   | 0.1                     |
| None, 1 Al Square 1/                                                               | 354.1   | 316°C (600°F) | 12          | 8.3            | 37.0                          | 31.0          | N.D.          | 1.7                   | 0.1 g/                  |
| None, 2 Al Squares 1/                                                              | 354.2   | 316°C (600°F) | 12          | 9.7            | 46.0                          | 38.0          | N.D.          | 2.4                   | 0.1 g/                  |
| None, Al, Ag, Cu, S.S., Ti 2/                                                      | 352.3   | 316°C (600°F) | 12          | 8.1            | 3.1                           | 7.8           | N.D.          | 1.9                   | 0.1 g/                  |
| None, Al, Ag, Cu, S.S., Ti 2/                                                      | 353.10  | 316°C (600°F) | 12          | 6.7            | -4.2                          | 0.8           | N.D.          | 1.3                   | 0.1 g/                  |
| None, Al, Ag, Cu, S.S., Ti 2/                                                      | 352.4   | 316°C (600°F) | 24          | 11.4           | 13.0                          | 16.7          | N.D.          | 1.1                   | 0.2 g/                  |
| Phenyl-alpha-naphthylamine, No. 61, 0.12 g., Al, Ag, Cu, S.S., Ti 2/               | 352.7   | 316°C (600°F) | 12          | 6.4            | 2.6                           | 6.3           | N.D.          | 1.4                   | 0.1 h/                  |
| 0.12 g., Al, Ag, Cu, S.S., Ti 2/                                                   | 352.8   | 316°C (600°F) | 24          | 10.8           | 13.6                          | 17.1          | N.D.          | 1.4                   | 0.2 i/                  |
|   |         |               |             |                |                               |               |               |                       |                         |
| N,N'-Di-2-naphthyl-p-phenylenediamine, NO. 260 0.10g., Al, Ag, Cu, S.S., Ti 1/     | 356.5   | 260°C (500°F) | 48          | 18.4           | N.M.                          |               |               | 2.3                   | 99.3 j/                 |
|  |         |               |             |                |                               |               |               |                       |                         |
| Acridine, No. 82 (recryst.) 0.08 g., Al, Ag, Cu, S.S., Ti 1/                       | 356.4   | 260°C (500°F) | 48          | 16.6           | N.M.                          |               |               | 1.1                   | 90.8 k/                 |
| 0.12 g., Al, Ag, Cu, S.S., Ti 2/                                                   | 352.5   | 316°C (600°F) | 12          | 7.5            | 9.2                           | 12.1          | N.D.          | 1.4                   | 0.1 l/                  |
| 0.12 g., Al, Ag, Cu, S.S., Ti 1/                                                   | 354.3   | 316°C (600°F) | 12          | 12.9           | 61.0                          | 57.0          | N.D.          | 1.6                   | 0.2 m/                  |
| 0.12 g., Al, Ag, Cu, S.S., Ti 1/                                                   | 354.5   | 316°C (600°F) | 12          | 16.5           | 96.9                          | 93.0          | N.D.          | 1.5                   | 0.1 n/                  |
| 0.12 g., Al, Ag, Cu, S.S., Ti 2/                                                   | 352.6   | 316°C (600°F) | 24          | 12.7           | 39.4                          | 36.7          | N.D.          | 1.7                   | 0.2 o/                  |
| 0.12 g., Al, Ag, Cu, S.S., Ti 1/                                                   | 354.4   | 316°C (600°F) | 24          | 21.0           | 330.0                         | 325.0         | N.D.          | 1.5                   | 0.2 p/                  |
| 0.12g., Al, Ag, Cu, S.S., Ti 1/                                                    | 354.6   | 316°C (600°F) | 24          | 25.9           | N.M.                          | 462.0         | N.D.          | 1.3                   | 0.2 q/                  |

1/ Gas Flow 1/hr - Air

2/ Gas Flow 1/hr - 95% N<sub>2</sub> - 5% O<sub>2</sub>

Metal Effect, Weight Loss, mg/cm<sup>2</sup>

a/ Al 0.16 Ag 0.28 Cu 1.00 S.S. 0.16 Ti 0.02

b/ Al 0.30 Ag 0.18 Cu 0.96 S.S. 0.24 Ti 0.04

c/ Al 0.16

d/ Al 0.18 Al 0.36

e/ Al 19.2 Ag 0.00 Cu 0.22 S.S. 0.08 Ti 0.04

f/ Al 15.1 Ag 0.12 Cu 0.20 S.S. 0.00 Ti 0.14

g/ Al 25.9 Ag 0.12 Cu 0.14 S.S. 0.18 Ti 0.00

h/ Al 19.4 Ag 0.22 Cu 0.30 S.S. 0.04 Ti 0.08

i/ Al 25.2 Ag 0.10 Cu 0.52 S.S. -0.06 Ti 0.00

j/ Al 0.10 Ag 1.22 Cu 1.64 S.S. 0.20 Ti 0.04

k/ Al 0.16 Ag 1.16 Cu 3.04 S.S. 0.30 Ti 0.06

l/ Al 19.1 Ag 0.00 Cu 0.36 S.S. 0.12 Ti 0.10

m/ Al 1.70 Ag 0.56 Cu 1.04 S.S. 0.48 Ti 0.08

n/ Al 0.18 Ag 0.32 Cu 0.82 S.S. 0.38 Ti 0.04

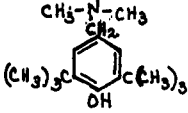
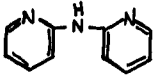
o/ Al 18.1 Ag 0.04 Cu 0.62 S.S. 0.22 Ti 0.10

p/ Al 0.28 Ag 0.34 Cu 1.24 S.S. 0.56 Ti 0.04

q/ Al 0.24 Ag 1.08 Cu 3.58 S.S. 0.82 Ti 0.14

N.D. Not yet determined.

Table 11. Oxidations in Diphenyl Di-n-dodecyl Silane, MLO 56-280 (Cont'd)

| Additive, CCL No., Formula, Concentration, Metals Present                                                 | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|-----------------------------------------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
|                                                                                                           |         |               |             |                | 54.5°C (130°F)                | 100°C (212°F) | 195°C (383°F) |                       |                         |
| 4-Hydroxy-3,5-di-tert.-butyl benzoyl dimethylamine, No. 371<br>0.12 g., Al, Ag, Cu, S.S., Ti 1/           | 356.3   | 260°C (500°F) | 48          | 12.7           | N.M.                          |               |               | 1.9                   | 0.5 a/                  |
| 0.12g. Al, Ag, Cu, S.S., Ti 2/                                                                            | 352.9   | 316°C (600°F) | 12          | 8.0            | 12.1                          | 14.0          | N.D.          | 1.5                   | 0.1 b/                  |
| 0.1g. Al, Ag, Cu, S.S., Ti 2/                                                                             | 352.10  | 316°C (600°F) | 24          | 10.1           | 11.4                          | 15.5          | N.D.          | 1.4                   | 0.1 g/                  |
|                          |         |               |             |                |                               |               |               |                       |                         |
| 2,2'-Dipyridylamine, No. 128<br>0.10g., Al, Ag, Cu, S.S., Ti 1/                                           | 357.5   | 260°C (500°F) | 48          | 11.4           | 164.0                         | 131.5         | N.D.          | 1.6                   | 7.4 d/                  |
|                          |         |               |             |                |                               |               |               |                       |                         |
| 2,2'-Diphenylamine, No. 128<br>0.10g. and Diphenylselenide, No. 282PCB, 0.10g.<br>Al, Ag, Cu, S.S., Ti 1/ | 357.6   | 260°C (500°F) | 48          | 8.2            | 76.0                          | 61.0          | N.D.          | 1.4                   | 4.9 g/                  |
|                          |         |               |             |                |                               |               |               |                       |                         |

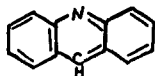
- 1/ Gas Flow 1/hr.-Air  
 2/ Gas Flow 1/hr. - 95% N<sub>2</sub> - 5% O<sub>2</sub>  
 Metal Effect, Weight Loss, mg/cm<sup>2</sup>  
 a/ Al 1.34 Ag 0.84 Cu 1.66 S.S. 0.28 Ti 0.04  
 b/ Al 17.3 Ag 0.10 Cu 51.9 S.S. 0.06 Ti 0.14  
 g/ Al 1.34 Ag 0.84 Cu 1.66 S.S. 0.28 Ti 0.04  
 d/ Al 0.40 Ag 1.52 Cu 5.60 S.S. 2.52 Ti 0.64  
 g/ Al 0.36 Ag 1.88 Cu 7.03 S.S. 3.24 Ti 0.78

TABLE 12

Oxidations in Silicone MLO 9840, XF258

Gas Flow: 1/1 Hr. Air

|                                                                 |        |               |    |     |       |       |      |     |         |
|-----------------------------------------------------------------|--------|---------------|----|-----|-------|-------|------|-----|---------|
| Acridine, No. 82<br>recryst. 1/ 0.12g.,<br>Al, Ag, Cu, S.S., Ti | 354.7  | 316°C (600°F) | 12 | 1.5 | 1.8   | 0.5   | N.D. | 1.6 | 0.1 a/  |
| recryst. 0.12 g.<br>Al, Ag, Cu, S.S., Ti                        | 354.8  | 316°C (600°F) | 24 | 3.2 | 9.8   | 6.8   | N.D. | 1.0 | 0.1 b/  |
| residue, 0.12 g.<br>Al, Ag, Cu, S.S., Ti                        | 354.9  | 316°C (600°F) | 12 | 3.1 | 25.8  | 23.0  | N.D. | 0.8 | 0.1 g/  |
| residue, 0.12 g.<br>Al, Ag, Cu, S.S., Ti                        | 354.10 | 316°C (600°F) | 24 | 5.9 | 127.0 | 115.5 | N.D. | 1.1 | 0.02 d/ |

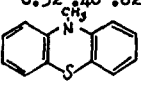
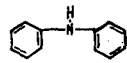


1/ The commercial sample was purified by recrystallization from alcohol. The first crop of crystals which appeared of good purity is labelled "recryst." The residue after removal of another crop of crystals and evaporation of solvent was labelled "residue".

Metal Effect, Weight Loss, mg/cm<sup>2</sup>  
 a/ Al 0.08 Ag 0.24 Cu 0.46 S.S. 0.12 Ti 0.14  
 b/ Al 0.04 Ag 0.14 Cu 0.78 S.S. 0.10 Ti 0.00  
 g/ Al 0.00 Ag 0.46 Cu 0.64 S.S. 0.00 Ti 0.04  
 d/ Al 0.04 Ag 0.22 Cu 0.48 S.S. 0.00 Ti 0.06  
 N.D. Not yet determined.

TABLE 13  
Oxidations in a Pentaerythritol Ester, MLO 55-584

Sample 25 ml., Air Flow 1 l./Hr.

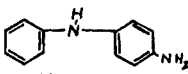
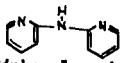
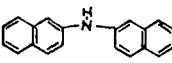
| Additive, CCL No., Formula, Concentration, Metals Present and Weight Loss, mg/cm <sup>2</sup>                                                                                                                             | Run No. | Temp. °C (°F) | Time, Hours | Weight Loss, % | Kinematic Viscosity Change, % |               |               | Neutralization Number | Iso-octane Insoluble, % |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------|-------------|----------------|-------------------------------|---------------|---------------|-----------------------|-------------------------|
|                                                                                                                                                                                                                           |         |               |             |                | 54.5°C (130°F)                | 100°C (212°F) | 195°C (383°F) |                       |                         |
| N-Methylphenothiazine, No. 5, $\frac{a}{0.27g. Al Ag Cu S.S. Ti}$<br>0.00 .30 1.08 .12 .02                                                                                                                                | 362.1   | 204°C (400°F) | 60          | 3.9            | 23.1                          | 17.6          | N.D.          | 3.2                   | 2.2                     |
| 5 0.27g. Al Ag Cu S.S. Ti<br>0.36 .46 .76 .12 .18                                                                                                                                                                         | 365.10  | 204°C (400°F) | 60          | 2.5            | 19.6                          | 14.5          | N.D.          | 3.7                   | 1.3                     |
| 5 0.27g. Al Ag Cu Cr-MO Ti<br>0.28 .20 .74 .12 .10                                                                                                                                                                        | 362.2   | 204°C (400°F) | 60          | 3.9            | 21.5                          | 15.0          | N.D.          | 3.1                   | 1.3                     |
| 5, 0.27g. Al Ag Cu Cr-MO Ti<br>0.32 .46 .82 .96 .24                                                                                                                                                                       | 363.8   | 204°C (400°F) | 60          | 2.6            | 17.7                          | 12.0          | N.D.          | 3.1                   | 2.0                     |
| <br>N-Methylphenothiazine, No. 5,<br>0.27g. and Vanadyl 2-ethyl<br>hexoate, No. 379, 0.02g.<br>Al Ag Cu S.S. Ti<br>0.14 .32 3.66 .14 .06 | 362.7   | 204°C (400°F) | 60          | 5.5            | 14.9                          | 10.2          | N.D.          | 37.7                  | 3.8                     |
| N-Methylphenothiazine, No. 5<br>0.27g. and Stannous naphthenate,<br>No. 373, 0.02g.<br>Al Ag Cu S.S. Ti<br>0.14 .24 .88 .18 .10                                                                                           | 362.6   | 204°C (400°F) | 60          | 5.3            | 21.6                          | 15.5          | N.D.          | 4.4                   | 2.0                     |
| N-Methylphenothiazine, No. 5,<br>0.27g. and Ferrocene, No. 374,<br>0.02g. Al Ag Cu S.S. Ti<br>0.00 .32 .98 .20 .08                                                                                                        | 362.8   | 204°C (400°F) | 60          | 5.2            | 29.6                          | 23.5          | N.D.          | 14.9                  | 4.2                     |
| 5 0.15g. and 374 0.05g.<br>Al Ag Cu S.S. Ti<br>0.42 .48 1.1 .26 .22                                                                                                                                                       | 365.9   | 204°C (400°F) | 60          | 3.7            | 18.8                          | 12.4          | N.D.          | 8.7                   | 1.8                     |
| Diphenylamine, No. 52, 0.22g.<br>Al Ag Cu S.S. Ti<br>0.02 -.04 .40 -.12 -.04<br>.00 .08 .04 .02 .00                                                                                                                       | 413.9   | 204°C (400°F) | 60          | 4.8            | 28.6                          | 19.4          | N.D.          | 4.1                   | 0.9                     |
| 52 0.22g. Al Ag Cu S.S. Ti<br>0.14 .04 .96 .22 .04<br>.02 .02 .06 .00 .00                                                                                                                                                 | 414.9   | 260°C (500°F) | 48          | 7.1            | N.M.                          | N.M.          | N.D.          | 7.1                   | N.F.                    |
| <br>p-Aminodiphenylamine, No. 360,<br>0.25g. Al Ag Cu S.S. Ti<br>0.26 .44 .38 .10 .22                                                  | 362.4   | 204°C (400°F) | 60          | 6.5            | 11.9                          | 7.9           | N.D.          | 3.3                   | 2.5                     |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.00 .66 .38 .10 .20                                                                                                                                                                       | 374.10  | 204°C (400°F) | 60          | 2.2            | 10.4                          | 7.5           | N.D.          | 2.2                   | 1.2                     |
| 360 0.24g. Al Ag Cu S.S. Ti<br>-0.26 -16-.14-.22 -.16<br>.26 .18 .24 .04 .04                                                                                                                                              | 413.8   | 204°C (400°F) | 60          | 6.1            | 9.9                           | 6.2           | N.D.          | 1.5                   | 1.1                     |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.26 .80 .82 .46 .24                                                                                                                                                                       | 375.10  | 232°C (450°F) | 48          | 5.5            | 18.0                          | 12.3          | N.D.          | 14.9                  | 2.8                     |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.32 .62 .58 .18 .04                                                                                                                                                                       | 381.8   | 260°C (500°F) | 24          | 5.8            | 15.2                          | 10.0          | N.D.          | 22.5                  | 2.8                     |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.02 .32 .50 .02 -.12                                                                                                                                                                      | 379.10  | 260°C (500°F) | 36          | 8.9            | 37.3                          | 28.9          | N.D.          | 25.2                  | 2.9                     |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.32 .62 .58 .18 .04                                                                                                                                                                       | 380.6   | 260°C (500°F) | 36          | 5.7            | 38.2                          | 21.7          | N.D.          | 22.0                  | 3.0                     |

N.D. Not Determined.

N.F. Not Filterable.

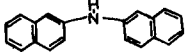
$\frac{a}{}$  At 500 F the phenothiazine type of additives in 1% concentration did not significantly retard the oxidation. In a 48 hour run the blank values for change in kinematic viscosity were over 200% and the neutralization numbers were above 25.

Table 13. Oxidations in a Pentaerythritol Ester, MLO 55-584 (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                                                                                                | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Air Flow 1 l/hr.<br>Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-----------------------------------------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                                                                                                                                                             |            |                     |                |                      | 54.5°C<br>(130°F)                                               | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| <b>p-Aminodiphenylamine, No. 360,</b><br>0.25g. Al Ag Cu S.S. Ti<br>-0.06 .32 .72 .00 .08                                                                                                                                   | 381.9      | 260°C<br>(500°F)    | 36             | 5.7                  | 22.6                                                            | 16.7             | N.D.             | 21.8                     | 3.6                           |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.26 .38 .48 .12 -.26                                                                                                                                                                        | 381.10     | 260°<br>(500°)      | 48             | 5.1                  | 15.8                                                            | 10.7             | N.D.             | 32.3                     | 3.3                           |
| 360 0.24g. Al Ag Cu S.S. Ti<br>-0.22-.26 -.10-.16 -.40<br>.02 .00 .14 .00 .00                                                                                                                                               | 414.8      | 260°<br>(500°)      | 48             | 6.7                  | 25.2                                                            | 17.2             | N.D.             | 21.9                     | 1.1                           |
| <br><b>Isopropoxydiphenylamine, No. 390,</b><br>0.25g. Al Ag Cu S.S. Ti<br>0.14 .24 .70 .06 .06                                            | 374.9      | 204°<br>(400°)      | 60             | 1.9                  | 18.5                                                            | 12.6             | N.D.             | 5.6                      | 0.9                           |
| 390 0.25g. Al Ag Cu S.S. Ti<br>0.00 .24 1.12 .20 .18                                                                                                                                                                        | 375.9      | 232°<br>(450°)      | 48             | 6.8                  | 29.1                                                            | 18.5             | N.D.             | 23.6                     | 2.9                           |
| 380 0.25g. Al Ag Cu S.S. Ti<br>0.10 .18 1.50 .10 .06                                                                                                                                                                        | 379.9      | 260°<br>(500°)      | 36             | 7.1                  | 93.0                                                            | 69.4             | N.D.             | 32.8                     | 5.9                           |
| <b>2,2'-Dipyridylamine, No. 128,</b><br>0.22g. Al Ag Cu S.S. Ti<br>-0.14.02 .86 .02 .04<br>.06.30 .12 .02 .02                                                                                                               | 413.10     | 204°<br>(400°)      | 60             | 3.7                  | 6.3                                                             | 4.5              | N.D.             | 1.0                      | 0.2                           |
| 128 0.25g. No Metals                                                                                                                                                                                                        | 367.5      | 260°<br>(500°)      | 48             | 7.8.                 | N.M.                                                            | N.M.             | N.D.             | 34.4                     | 0.7                           |
| 128 0.25g. Al Ag Ti<br>0.04 .06 -.12                                                                                                                                                                                        | 367.8      | 260°<br>(500°)      | 48             | 7.9                  | 69.8                                                            | 56.7             | N.D.             | 28.2                     | 0.8                           |
| 128 0.25g. Al Cu Ti<br>0.00 2.38 -.04                                                                                                                                                                                       | 367.7      | 260°<br>(500°)      | 48             | 6.7                  | 33.7                                                            | 25.9             | N.D.             | 28.1                     | 10.9                          |
| 128 0.25g. Al Ag Cu S.S. Ti<br>0.00 .08 .10 .64 -.22                                                                                                                                                                        | 367.6      | 260°<br>(500°)      | 48             | 8.1                  | 8.4                                                             | 4.8              | N.D.             | 24.0                     | 1.7                           |
| 128 0.22g. Al Ag Cu S.S. Ti<br>-0.04 .02 .86 .02 .04<br>.10 .16 .22 .16 .00                                                                                                                                                 | 414.10     | 260°<br>(500°)      | 48             | 7.4                  | 7.8                                                             | 4.3              | N.D.             | 7.4                      | 0.3                           |
| <br><b>N,N'-Diphenyl-p-phenylene-<br/>diamine, No. 186, 0.34g.</b><br>Al Ag Cu S.S. Ti<br>-0.34-.38-.14 -.04 -.04<br>.24 .36 .24 .22 .32 | 422.5      | 204°<br>(400°)      | 60             | 6.0                  | 16.3                                                            | 11.0             | N.D.             | 2.0                      | 1.3                           |
| <br><b>p-Aminodiphenyl, No. 367,</b><br>0.25g. Al Ag Cu S.S. Ti<br>0.16 .50 2.98 .10 .08                                                 | 374.2      | 204°<br>(400°)      | 60             | 0.5                  | 18.4                                                            | 10.7             | N.D.             | 23.5                     | 1.7                           |
| 367, 0.25g. Al Ag Cu S.S. Ti<br>0.06 .14 2.10 .24 -.02                                                                                                                                                                      | 375.2      | 232°<br>(450°)      | 48             | 6.9                  | 35.8                                                            | 20.3             | N.D.             | 28.7                     | 4.1                           |
| 367 0.25g. Al Ag Cu S.S. Ti<br>0.20 .32 1.60 .00 .04                                                                                                                                                                        | 379.2      | 260°<br>(500°)      | 36             | 8.7                  | 156.3                                                           | 108.2            | N.D.             | 24.1                     | 8.6                           |
| <b>D1-2-naphthylamine, No. 383,</b><br>0.25g. Al Ag Cu S.S. Ti<br>0.24 .30 1.24 .36 .14                                                                                                                                     | 374.3      | 204°<br>(400°)      | 60             | 1.1                  | 21.4                                                            | 14.9             | N.D.             | 12.7                     | 1.9                           |
| 383 0.30g. Al Ag Cu S.S. Ti<br>0.16 .38 .82 .02 .24                                                                                                                                                                         | 365.7      | 204°<br>(400°)      | 60             | 3.3                  | 25.6                                                            | 17.0             | N.D.             | 7.4                      | 2.4                           |
| 383 0.30g. Al Ag Cu Cr-Me Ti<br>0.20 .50.76 .08 .28                                                                                                                                                                         | 365.8      | 204°<br>(400°)      | 60             | 2.5                  | 24.8                                                            | 16.5             | N.D.             | 5.4                      | 2.3                           |
|                                                                                                                                           |            |                     |                |                      |                                                                 |                  |                  |                          |                               |

N.D. Not Determined.

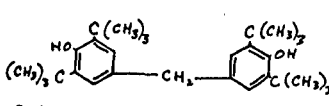
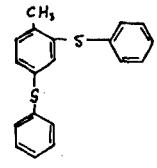
Table 13. Oxidations in a Pentaerythritol Ester, MLO 55-584 (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                      | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Kinematic Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|-----------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                   |            |                     |                |                      | 54.5°C<br>(130°F)             | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| Di-2-naphthylamine, No. 383,<br>0.25g. Al Ag Cu S.S. Ti<br>0.12 .30 1.32 .10 .00  | 375.3      | 232°<br>(450°)      | 48             | 6.0                  | 25.0                          | 14.7             | N.D.             | 33.1                     | 3.6                           |
| 383 0.25g. Al Ag Cu S.S. Ti<br>0.14 .42 1.78 .02 .06                              | 379.3      | 260°<br>(500°)      | 36             | 9.1                  | 75.4                          | 59.8             | N.D.             | 30.1                     | 5.2                           |
| 383 0.30g. No Metals                                                              | 367.3      | 260°<br>(500°)      | 48             | 5.8                  | 49.5                          | 35.3             | N.D.             | 24.3                     | 4.8                           |
| 383 0.30g. Al Ag Cu S.S. Ti<br>0.02 .14 1.32 .12 .20                              | 367.4      | 260°<br>(500°)      | 48             | 7.4                  | 27.8                          | 19.3             | N.D.             | 28.7                     | 2.8                           |
|  |            |                     |                |                      |                               |                  |                  |                          |                               |
| Age Rite Stalite, No. 389,<br>0.25g. Al Ag Cu S.S. Ti<br>0.22 .34 2.74 .16 .12    | 374.8      | 204°<br>(400°)      | 60             | 0.9                  | 24.4                          | 14.9             | N.D.             | 24.4                     | 0.3                           |
| 389 0.25g. Al Ag Cu S.S. Ti<br>0.28 .36 2.52 .06 .18                              | 375.8      | 232°<br>(450°)      | 48             | 6.1                  | 53.0                          | 36.1             | N.D.             | 30.3                     | 3.0                           |
| 389 0.25g. Al Ag Cu S.S. Ti<br>0.04 .14 1.76 .32 .00                              | 379.8      | 260°<br>(500°)      | 36             | 7.3                  | 50.4                          | 33.5             | N.D.             | 32.8                     | 3.2                           |
| Age Rite H.P., No. 388, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.20 .40 .50 .12 .10        | 374.7      | 204°<br>(400°)      | 60             | 0.6                  | 14.1                          | 8.9              | N.D.             | 1.5                      | 1.0                           |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.42 .74 1.34 .06 .14                             | 375.8      | 232°<br>(450°)      | 48             | 5.4                  | 22.4                          | 13.1             | N.D.             | 21.2                     | 3.3                           |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.18 .24 1.52 .18 .00                             | 379.7      | 260°<br>(500°)      | 36             | 8.1                  | 42.3                          | 32.0             | N.D.             | 32.9                     | 4.4                           |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.14 .44 .92 .04 .02                              | 380.7      | 260°<br>(500°)      | 36             | 3.7                  | 33.5                          | 24.0             | N.D.             | 28.9                     | 2.9                           |
| Age Rite Hipar, No. 387, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.20 .30 .66 .26 .20       | 374.6      | 204°<br>(400°)      | 60             | 0.0                  | 16.1                          | 11.5             | N.D.             | 2.2                      | 0.8                           |
| 387 0.25g. Al Ag Cu S.S. Ti<br>0.00 .30 1.22 .30 .40                              | 375.6      | 232°<br>(450°)      | 48             | 6.9                  | 20.5                          | 12.8             | N.D.             | 12.8                     | 2.9                           |
| 387 0.25g. Al Ag Cu S.S. Ti<br>0.02 .08 1.14 .10 .00                              | 379.6      | 260°<br>(500°)      | 36             | 8.9                  | 67.3                          | 54.2             | N.D.             | 25.5                     | 4.9                           |
| Age Rite Resin-D, No. 385, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.24 .50 1.22 .26 .26    | 374.4      | 204°<br>(400°)      | 60             | 1.5                  | 17.2                          | 11.3             | N.D.             | 6.9                      | 1.8                           |
| 385 0.25g. Al Ag Cu S.S. Ti<br>0.14 .22 .48 .18 .18                               | 375.4      | 232°<br>(450°)      | 48             | 5.0                  | 25.4                          | 15.4             | N.D.             | 31.9                     | 2.8                           |
| 385 0.25g. Al Ag Cu S.S. Ti<br>0.10 .50 .54 .18 -.06                              | 379.4      | 260°<br>(500°)      | 36             | 8.3                  | 29.6                          | 15.4             | N.D.             | 32.2                     | 3.4                           |
| Age Rite Resin, No. 386, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.14 .42 1.82 .34 .16      | 374.5      | 204°<br>(400°)      | 60             | 2.2                  | 69.0                          | 48.7             | N.D.             | 26.4                     | 6.0                           |
| 386 0.25g. Al Ag Cu S.S. Ti<br>0.12 .36 .74 .02 .18                               | 375.5      | 232°<br>(450°)      | 48             | 5.4                  | 67.5                          | 49.8             | N.D.             | 25.9                     | 6.5                           |
| 386 0.25g. Al Ag Cu S.S. Ti<br>0.10 .20 .60 .12 .02                               | 379.5      | 260°<br>(500°)      | 36             | 10.0                 | 221.5                         | 159.0            | N.D.             | 25.0                     | 9.7                           |

N.D. Not Determined.

WADC TR 53-293 Pt VIII

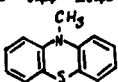
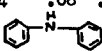
Table 13. Oxidations in a Pentaerythritol Ester, MLO 55-584 (Cont'd)

| Additive, CCL No., Formula,<br>Concentration, Metals Present                                                                                                                                | Run<br>No. | Temp.<br>°C<br>(°F) | Time,<br>Hours | Weight<br>Loss,<br>% | Sample 25 ml. Viscosity Change, % |                  |                  | Neutralization<br>Number | Iso-octane<br>Insoluble,<br>% |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------|----------------|----------------------|-----------------------------------|------------------|------------------|--------------------------|-------------------------------|
|                                                                                                                                                                                             |            |                     |                |                      | Kinematic<br>54.5°C *<br>(130°F)  | 100°C<br>(212°F) | 195°C<br>(383°F) |                          |                               |
| N-Aminoethylmorpholine, No. 117,<br>0.10g. and p-Aminodiphenylamine,<br>No. 360, 0.12g.<br>Al Ag Cu S.S. Ti<br>0.16 .58 .26 .12 .00                                                         | 391.9      | 204°<br>(400°)      | 60             | 5.9                  | 22.2                              | 16.2             | N.D.             | 5.1                      | N.F.                          |
| N-Aminoethylmorpholine, No. 117,<br>0.10g. and 2,2'-dipyridylamine,<br>No. 128, 0.11g.<br>Al Ag Cu S.S. Ti<br>0.10 .34 .28 .04 .08                                                          | 391.10     | 204°<br>(400°)      | 60             | 4.6                  | 7.2                               | 4.8              | N.D.             | 1.5                      | 0.4                           |
| N,N'-Diphenyl-p-phenylene-<br>diamine, No. 186, 0.17g. and<br>4,4'-bisthiopicolinamido<br>diphenyl, No. 401, 0.03g.<br>Al Ag Cu S.S. Ti<br>-0.10 -.04 -.18 -.06 -.14<br>.04 .20 .38 .20 .12 | 422.7      | 204°<br>(400°)      | 60             | 7.1                  | 14.8                              | 9.7              | N.D.             | 4.1                      | 1.2                           |
| 186 0.17g. and 401, 0.03g.<br>Al Ag Cu S.S. Ti<br>-0.28 -.22 -.06 -.06 -.08<br>.26 .34 .30 .08 .08                                                                                          | 422.8      | 204°<br>(400°)      | 60             | 6.1                  | 11.0                              | 7.7              | N.D.             | 3.0                      | 0.8                           |
| Vanadyl-2-ethyl hexoate,<br>No. 379, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.24 .20 1.48 .64 .02                                                                                                    | 362.3      | 204°<br>(400°)      | 60             | 3.5                  | 36.7                              | 25.7             | N.D.             | 72.9                     | 6.5                           |
| 4,4'-Methylene-bis-2,6-<br>ditertiary butyl phenol,<br>No. 370, 0.30g.<br>Al Ag Cu S.S. Ti<br>0.00 .10 1.52-.34 -.20                                                                        | 367.9      | 260°<br>(500°)      | 48             | 7.5                  | 71.3                              | 52.4             | N.D.             | 28.3                     | 11.2                          |
| <br>1,4,2-Benzoselenazin-3-one,<br>No. 308, 0.30g.<br>Al Ag Cu S.S. Ti<br>-0.14 2.92 11.7 .66 .00         | 367.10     | 260°<br>(500°)      | 48             | 5.4                  | 57.3                              | 42.6             | N.D.             | 28.6                     | 11.8                          |
| 2,4-Bis-(phenyl mercapto)<br>toluene, No. 372, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.22 .46 4.42 .18 .04                                                                                          | 362.5      | 204°<br>(400°)      | 60             | 4.7                  | 59.5                              | 39.9             | N.D.             | 22.1                     | 3.2                           |
|                                                                                                          |            |                     |                |                      |                                   |                  |                  |                          |                               |

N.D. Not Determined.  
N.F. Not Filterable.

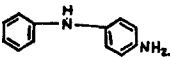
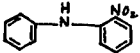
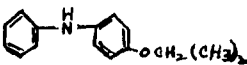
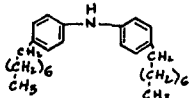
WADC TR 53-293 Pt VIII

TABLE 14  
Oxidations in Bis-(2-ethylhexyl) Sebacate

| Additive, CCL No., Concentration,<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup>                                              | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Weight<br>Loss,<br>% | Kinematic Viscosity |       | Neutralization<br>No. | Insoluble Percentage |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|---------------------------|----------------------|---------------------|-------|-----------------------|----------------------|--------------------------|
|                                                                                                                                         |            |                |                           |                      | Change, %           |       |                       | Isocetane<br>Wash    | Isocetane<br>Precipitate |
|                                                                                                                                         |            |                |                           |                      | 54.5°C              | 100°C |                       |                      |                          |
| N-Methylphenothiazine, No. 5,<br>0.26 g., No Metals                                                                                     | 393.2      | 60             | 204°<br>(400°)            | 1.6                  | 5.4                 | 3.9   | 4.2                   | 1.1                  | 1.5                      |
| 5, 0.27g.<br>Al Ag Cu S.S. Ti<br>0.44 .48 1.70 .24 .02                                                                                  | 363.1      | 60             | 204°<br>(400°)            | 2.8                  | 10.6                | 6.6   | 13.0                  | N.D.                 | 2.7                      |
| 5, 0.27g.<br>Al Ag Cu Cr-Mo. Ti<br>0.26 .44 1.48 .82 .28                                                                                | 363.2      | 60             | 204°<br>(400°)            | 4.7                  | 12.7                | 7.0   | 14.3                  | N.D.                 | 2.6                      |
|                                                        |            |                |                           |                      |                     |       |                       |                      |                          |
| N-Methylphenothiazine, No. 5,<br>0.20g., and Vanadyl-2-ethyl<br>hexoate, No. 379, 0.07g.<br>Al Ag Cu Cr-Mo Ti<br>0.48 .34 2.06 1.94 .20 | 363.6      | 60             | 204°<br>(400°)            | 7.0                  | 82.0                | 62.8  | 32.2                  | N.D.                 | 7.7                      |
| 5, 0.15 g. and Ferrocene,<br>No. 373, 0.07g.<br>Al Ag Cu S.S. Ti<br>0.00 .02 1.14 .08 .10                                               | 365.5      | 60             | 204°<br>(400°)            | 3.4                  | 16.9                | 10.0  | 24.1                  | N.D.                 | 1.3                      |
| 5, 0.20g., 373, 0.07g.<br>Al Ag Cu Cr-Mo Ti<br>0.30 .40 1.64 .32 .28                                                                    | 363.7      | 60             | 204°<br>(400°)            | 2.9                  | 10.0                | 5.6   | 10.4                  | N.D.                 | 2.7                      |
|                                                        |            |                |                           |                      |                     |       |                       |                      |                          |
| Diphenylamine, No. 52, 0.22g.<br>No Metals                                                                                              | 419.6      | 60             | 204°<br>(400°)            | 2.7                  | 33.5                | 7.7   | 15.0                  | 0.02                 | 1.7                      |
| 52, 0.22g.<br>Al Ag Cu S.S. Ti<br>-0.18 -.30 .20 .14 -.12<br>.26 .38 .42 .20 .22                                                        | 413.4      | 60             | 204°<br>(400°)            | 4.9                  | 18.9                | 12.4  | 14.6                  | 1.1                  | 1.8                      |
| 52, 0.44g.<br>Al Ag Cu S.S. Ti<br>-0.02 .10 .40 .12 .00<br>.16 .28 .40 .14 .16                                                          | 419.4      | 60             | 204°<br>(400°)            | 4.8                  | 20.4                | 13.8  | 8.2                   | 1.5                  | 3.4                      |
| 52, 0.22g.<br>Al Ag Cu S.S. Ti<br>0.08 .00 .68 .16 .06<br>.02 .02 .00 .00 .06                                                           | 414.4      | 48             | 260°<br>(500°)            | 8.0                  | 790.0               | 432.0 | 14.7                  | 14.0                 | 4.2                      |
| 52, 0.44g.<br>Al Ag Cu S.S. Ti<br>0.32 0.22 1.24 0.22 0.04<br>.04 .02 .06 .06 .04                                                       | 416.9      | 48             | 260°<br>(500°)            | 6.7                  | 33.4                | 25.3  | 16.3                  | N.F.                 | N.F.                     |
| Al Ag Cu S.S. Ti<br>0.32 .14 .58 .28 .16<br>.10 .04 .08 .02 .02                                                                         | 417.2 g/60 |                | 204°<br>(400°)            | 5.6                  | 23.4                | 14.7  | 15.0                  | 1.8                  | 2.5                      |
|                                                      |            |                |                           |                      |                     |       |                       |                      |                          |
| p-Aminodiphenylamine, No. 360<br>0.24g., Al Ag Cu S.S. Ti<br>0.20 .28 .26 .04 .02                                                       | 389.7      | 60             | 204°<br>(400°)            | 2.5                  | 16.3                | 10.7  | 14.1                  | 1.3                  | 1.0                      |
| 360 0.24g., Al Ag Cu S.S. Ti<br>0.16 .50 .22 .06 .12                                                                                    | 391.5      | 60             | 204°<br>(400°)            | 6.8                  | 19.5                | 13.3  | 14.4                  | 0.8                  | 1.1                      |
| 360 0.24g., Al Ag Cu S.S. Ti<br>-0.20 .04 .04 -.06 -.10<br>.22 .20 .14 .14 .08                                                          | 413.3      | 60             | 204°<br>(400°)            | 5.1                  | 16.1                | 10.5  | 10.5                  | 0.5                  | 1.0                      |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.34 .40 .46 .24 .08                                                                                    | 362.10     | 60             | 204°<br>(400°)            | 1.8                  | 9.6                 | 5.8   | 11.9                  | N.D.                 | 2.1                      |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.32 .56 .28 .24 .20                                                                                    | 363.3      | 60             | 204°<br>(400°)            | 4.4                  | 11.6                | 7.6   | 9.5                   | N.D.                 | 2.1                      |

N.D. Not Determined.  
N.F. Not Filterable.  
g/ Check Run on 413.4 to show metal effects.

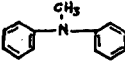
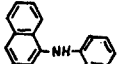
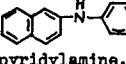
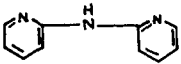
Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CCL No., Concentration,<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup> | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Weight<br>Loss,<br>% | Kinematic Viscosity<br>Change, %, 54.5°C | 25 ml Sample<br>Neutralization<br>No. | Air Flow 1 L/Hr.               |                                        |
|--------------------------------------------------------------------------------------------|------------|----------------|---------------------------|----------------------|------------------------------------------|---------------------------------------|--------------------------------|----------------------------------------|
|                                                                                            |            |                |                           |                      |                                          |                                       | Insoluble<br>Isocetane<br>Wash | Percentage<br>Isocetane<br>Precipitate |
|                                                                                            |            |                |                           |                      |                                          |                                       |                                |                                        |
| p-Aminodiphenylamine, No. 360,                                                             |            |                |                           |                      |                                          |                                       |                                |                                        |
| 0.25g. Al Ag Cu Cr-Mo Ti<br>0.30 .50 .46 .30 .26                                           | 363.4      | 60             | 204°<br>(400°)            | 2.7                  | 12.7                                     | 9.1                                   | 11.5                           | N.D. 2.2                               |
| 360, 0.25g. Al Ag Cu S.S. Ti<br>0.10 .24 .50 .26 .00                                       | 373.10     | 48             | 232°<br>(450°)            | 2.1                  | 10.9                                     | 6.1                                   | 21.6                           | N.D.                                   |
| 360, 0.24g. Al Ag Cu S.S. Ti<br>0.30 .52 .52 .24 .16                                       | 390.7      | 24             | 260°<br>(500°)            | 3.1                  | 10.1                                     | 5.9                                   | 18.6                           | 2.5 1.7                                |
| 360, 0.25g. Al Ag Cu S.S. Ti<br>0.16 1.12 .80 .58 .30                                      | 381.5      | 36             | 260°<br>(500°)            | 4.0                  | 9.0                                      | 5.5                                   | 16.3                           | N.D. 3.3                               |
| 360 0.25g. Al Ag Cu S.S. Ti<br>0.28 .94 1.08 1.02 .08                                      | 381.6      | 48             | 260°<br>(500°)            | 5.0                  | 12.1                                     | 7.4                                   | 16.4                           | N.D. 4.1                               |
| 360 0.25g. Al Ag Cu S.S. Ti<br>-0.06 .10 .56 .52 -.18<br>.22 .28 .20 .18 .16               | 414.3      | 48             | 260°<br>(500°)            | 6.0                  | 16.4                                     | 9.7                                   | 15.5                           | 3.8 0.9                                |
|           |            |                |                           |                      |                                          |                                       |                                |                                        |
| 2-Nitrodiphenylamine, No. 87,                                                              |            |                |                           |                      |                                          |                                       |                                |                                        |
| 0.25g. No Metals                                                                           | 394.1      | 60             | 204°<br>(400°)            | 2.2                  | 23.7                                     | 15.6                                  | 21.9                           | 0.2 2.0                                |
| 87, 0.25g. Al Ag Cu S.S. Ti<br>-0.26 .02 .22 -.12 -.08<br>.40 .38 .52 .18 .14              | 415.10     | 60             | 204°<br>(400°)            | 5.4                  | 14.3                                     | 9.4                                   | 15.3                           | 0.1 1.1                                |
| 87, 0.25g. Al Ag Cu S.S. Ti<br>-0.16 .12 .32 .16 .08<br>.10 .06 .14 .04 .00                | 417.1      | 60             | 204°<br>(400°)            | 5.4                  | 15.8                                     | 10.4                                  | 19.3                           | 0.2 1.0                                |
| 87, 0.50g. Al Ag Cu S.S. Ti<br>-0.28 -.32 -.02 -.20 -.10<br>.36 .36 .40 .30 .24            | 419.3      | 60             | 204°<br>(400°)            | 8.7                  | 18.8                                     | 11.1                                  | 16.7                           | 0.4 1.3                                |
| 87, 0.25g. Al Ag Cu S.S. Ti<br>0.16 .12 1.12 .46 -.32<br>.08 .06 .06 .10 .10               | 416.10     | 48             | 260°<br>(500°)            | 6.9                  | 24.0                                     | 18.5                                  | 18.3                           | N.F. N.F.                              |
|         |            |                |                           |                      |                                          |                                       |                                |                                        |
| p-Isopropoxydiphenylamine, No. 390, 0.25g.                                                 |            |                |                           |                      |                                          |                                       |                                |                                        |
| Al Ag Cu S.S. Ti<br>0.42 .44 .80 .24 .18                                                   | 372.9      | 60             | 204°<br>(400°)            | 6.2                  | 17.2                                     | 11.7                                  | 20.9                           | N.D. 2.0                               |
| 390, 0.25g. Al Ag Cu S.S. Ti<br>0.00 .32 2.08 .30 .00                                      | 373.9      | 48             | 232°<br>(450°)            | 2.4                  | 23.3                                     | 17.6                                  | 18.9                           | N.D. 3.5                               |
| 390, 0.25g. Al Ag Cu S.S. Ti<br>0.14 .08 .94 .02 .00                                       | 378.9      | 36             | 260°<br>(500°)            | 2.6                  | 81.5                                     | 66.2                                  | 20.9                           | N.D. 8.2                               |
|         |            |                |                           |                      |                                          |                                       |                                |                                        |
| p,p'-Diocetyldiphenylamine, No. 22,                                                        |            |                |                           |                      |                                          |                                       |                                |                                        |
| 0.49g. Al Ag Cu S.S. Ti<br>0.10 .16 2.24 .02 .14<br>.04 .00 .04 .04 .02                    | 415.8      | 60             | 204°<br>(400°)            | 4.7                  | 31.5                                     | 32.7                                  | 8.5                            | 0.04 5.7                               |
| 22, 0.49g. Al Ag Cu S.S. Ti<br>0.14 .06 2.92 .64 .10<br>.02 .08 .06 .02 .04                | 416.8      | 48             | 260°<br>(500°)            | 6.3                  | 54.5                                     | 39.8                                  | 15.4                           | 0.06 9.5                               |
| 22, 1.0g. Al Ag Cu S.S. Ti<br>0.64 .48 .14 .18 .42<br>.14 .04 .26 .18 .04                  | 417.3      | 48             | 260°<br>(500°)            | 4.8                  | 43.5                                     | 18.4                                  | 7.7                            | 0.05 0.6                               |
|         |            |                |                           |                      |                                          |                                       |                                |                                        |

N.D. Not Determined.

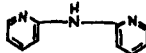
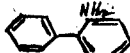
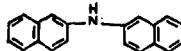
N.F. Not Filterable.

Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CGL No., Concentration<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup> | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Weight<br>Loss,<br>% | Kinematic Viscosity<br>Change, %, 100°C<br>54.5°C | 25 ml Sample Air Flow 1 l./hr. |           | Insoluble<br>Wash | Percentage<br>Isocetane<br>Precipitate |
|-------------------------------------------------------------------------------------------|------------|----------------|---------------------------|----------------------|---------------------------------------------------|--------------------------------|-----------|-------------------|----------------------------------------|
|                                                                                           |            |                |                           |                      |                                                   | Neutralization<br>No.          | Isocetane |                   |                                        |
| N-Methylphenylamine, No. 85,<br>0.23g., No Metals                                         | 394.3      | 60             | 204°<br>(400°)            | 2.5                  | 23.7                                              | 15.4                           | 16.0      | 0.10              | 5.4                                    |
| 89,0.24g. Al Ag Cu S.S. Ti<br>0.16 .14 -.04 -.24 -.16<br>.22 .26 .38 .22 .18              | 415.6      | 60             | 204°<br>(400°)            | 4.8                  | 21.6                                              | 13.3                           | 17.5      | 0.2               | 2.5                                    |
| 89,0.24g. Al Ag Cu S.S. Ti<br>-0.16 .14 .88 .34 .12<br>.02 .10 .06 .00 .04                | 416.6      | 48             | 260°<br>(500°)            | 7.4                  | 121.5                                             | 98.5                           | 17.0      | 0.3               | 9.4                                    |
|          |            |                |                           |                      |                                                   |                                |           |                   |                                        |
| Triphenylamine, No. 88, 0.31g.<br>No Metals                                               | 394.2      | 60             | 204°<br>(400°)            | 4.8                  | 62.2                                              | 39.6                           | 22.5      | 0.1               | 4.0                                    |
| 88,0.31g. Al Ag Cu S.S. Ti<br>0.06 .00 6.36 .04 .02<br>.22 .26 .38 .22 .18                | 415.7      | 60             | 204°<br>(400°)            | 4.3                  | 58.7                                              | 44.1                           | 12.0      | 0.1               | 0.3                                    |
| 88,0.31g. Al Ag Cu S.S. Ti<br>0.12 .02 .80 .22 .08<br>.02 .00 .02 .02 .00                 | 416.7      | 48             | 260°<br>(500°)            | 7.8                  | 48.0                                              | 23.4                           | 20.4      | 0.07              | 5.4                                    |
| (C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> N                                           |            |                |                           |                      |                                                   |                                |           |                   |                                        |
| Phenyl-alpha-naphthylamine,<br>No. 61, 0.28g., No Metals                                  | 393.7      | 60             | 204°<br>(400°)            | 1.1                  | 27.9                                              | 17.7                           | 18.8      | 0.3               | 2.5                                    |
| 61,0.28g. Al Ag Cu S.S. Ti<br>0.04 .02 .28 .00 .06<br>.04 .16 .20 .06 .04                 | 415.4      | 60             | 204°<br>(400°)            | 3.4                  | 25.3                                              | 16.2                           | 17.1      | 0.4               | 2.4                                    |
| 61,0.28g. Al Ag Cu S.S. Ti<br>0.20 .02 .72 .12 -.06<br>.18 .28 .16 .26 .26                | 416.4      | 48             | 260°<br>(500°)            | 6.3                  | 24.9                                              | 18.7                           | 14.8      | 0.3               | 14.4                                   |
|          |            |                |                           |                      |                                                   |                                |           |                   |                                        |
| N-Phenyl-2-naphthylamine, No. 140,<br>0.29g., No Metals                                   | 393.8      | 60             | 204°<br>(400°)            | 2.0                  | 31.5                                              | 19.1                           | 20.2      | 0.4               | 2.8                                    |
| 140,0.28g. Al Ag Cu S.S. Ti<br>-0.02 -.10 .16 -.10 -.10<br>.12 .16 .32 .14 .10            | 415.5      | 60             | 204°<br>(400°)            | 3.6                  | 22.4                                              | 15.5                           | 19.1      | 0.2               | 1.7                                    |
| 140,0.28g. Al Ag Cu S.S. Ti<br>0.04 .06 .10 -.16 .00<br>.16 .06 .42 .18 .12               | 417.7      | 60             | 204°<br>(400°)            | 3.5                  | 20.8                                              | 15.8                           | 11.9      | 0.2               | 1.6                                    |
| 140,0.28g. Al Ag Cu S.S. Ti<br>0.04-.12 .86 .16 .02<br>.26 .46 .26 .12 .20                | 416.5      | 48             | 260°<br>(500°)            | 7.5                  | 46.5                                              | 32.4                           | 14.9      | N.F.              | N.F.                                   |
|        |            |                |                           |                      |                                                   |                                |           |                   |                                        |
| 2,2'-Dipyridylamine, No. 128, 0.22g. 389.9s<br>No Metals                                  | 394.8s     | 60             | 204°<br>(400°)            | 4.1                  | 24.7                                              | 16.2                           | 18.9      | 0.09              | 0.9                                    |
| 128,0.22g. No Metals                                                                      | 394.8s     | 60             | 204°<br>(400°)            | 3.6                  | 27.0                                              | 16.2                           | 17.6      | 0.1               | 1.9                                    |
| 128,0.22g. Cu washer<br>0.88                                                              | 389.8s     | 60             | 204°<br>(400°)            | 2.8                  | 5.6                                               | 2.7                            | 17.0      | 2.6               | 0.3                                    |
| 128,0.22g. No Metals                                                                      | 399.7s     | 60             | 204°<br>(400°)            | 4.3                  | 28.9                                              | 18.9                           | 15.7      | 0.1               | 2.1                                    |
| 128,0.22g. Cu Washer<br>0.00                                                              | 401.5s     | 60             | 204°<br>(400°)            | 2.7                  | 8.7                                               | 5.8                            | 17.2      | 0.4               | 0.02                                   |
| 128,0.22g. Al Ag Cu S.S. Ti<br>-0.58-.50-.32-.42-.44<br>.60 .60 .50 .42 .34               | 413.5s     | 60             | 204°<br>(400°)            | 3.6                  | 11.0                                              | 6.7                            | 15.8      | 2.2               | 0.4                                    |
|        |            |                |                           |                      |                                                   |                                |           |                   |                                        |

N.F. Non Filterable.

Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

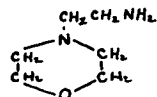
| Additive, CCL No., Concentration, Run<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup>            | No.    | Time<br>Hours | Temperature<br>°C<br>(°F) | Weight<br>Loss,<br>% | Kinematic Viscosity<br>Change, %, 54.5°C | Neutralization<br>No. | 25 ml Sample Air Flow 1 L/Hr. |                       |      |
|-----------------------------------------------------------------------------------------------------------|--------|---------------|---------------------------|----------------------|------------------------------------------|-----------------------|-------------------------------|-----------------------|------|
|                                                                                                           |        |               |                           |                      |                                          |                       | Insoluble Percentage          |                       |      |
|                                                                                                           |        |               |                           |                      |                                          |                       | Isocetane Wash                | Isocetane Precipitate |      |
| 2,2'-Dipyridylamine, No. 128,<br>(Cont'd) 0.25g. No Metals                                                | 386.5s | 24            | 260°<br>(500°)            | 3.7                  | 17.7                                     | 11.8                  | 15.7                          | 0.06                  | 4.6  |
| 128, 0.22g., No Metals                                                                                    | 390.9s | 24            | 260°<br>(500°)            | 6.2                  | 25.7                                     | 18.2                  | 18.8                          | 0.09                  | 0.9  |
| 128, 0.25g., Cu Washer<br>1.96                                                                            | 386.6s | 24            | 260°<br>(500°)            | 3.7                  | 18.4                                     | 13.5                  | 18.3                          | 2.6                   | 4.1  |
| 128, 0.22g., Cu Washer<br>1.10                                                                            | 390.8s | 24            | 260°<br>(500°)            | 4.1                  | 11.0                                     | 6.1                   | 19.0                          | 2.7                   | 0.7  |
| 128, 0.25g. Al Ag S.S. Ti<br>0.52 .72 1.40 .28                                                            | 386.4s | 24            | 260°<br>(500°)            | 3.4                  | 65.2                                     | 57.6                  | 19.8                          | 0.5                   | 4.3  |
| 128, 0.22g. Al Ag Cu S.S. Ti<br>0.34 1.14 3.70 1.70 .40<br>.08 .04 .04 .12 .02                            | 414.5  | 48            | 260°<br>(500°)            | 6.0                  | 15.4                                     | 10.6                  | 15.0                          | 5.1                   | 0.4  |
|                          |        |               |                           |                      |                                          |                       |                               |                       |      |
| N,N'-Diphenyl-p-phenylene-<br>diamine, No. 186, 0.33g.<br>Recryst. E.K. Blue Label<br>No Metals           | 407.5  | 60            | 204°<br>(400°)            | 1.2                  | 12.3                                     | 8.8                   | 9.4                           | 0.2                   | 0.9  |
| 186, 0.34g. No Metals                                                                                     | 419.9  | 60            | 204°<br>(400°)            | 1.7                  | 12.1                                     | 2.7                   | 5.9                           | 0.4                   | 1.5  |
| 186, 0.34g. Al Ag Cu S.S. Ti<br>-0.40-.32 .16 -.12 -.22<br>.22 .30 .36 .16 .22                            | 422.2  | 60            | 204°<br>(400°)            | 8.3                  | 29.2                                     | 20.3                  | 18.1                          | 0.7                   | 1.9  |
| 186, 0.34g. Al Ag Cu S.S. Ti<br>0.12 .16 .38 .24 .10<br>.18 .08 .16 .06 .00                               | 417.4  | 60            | 204°<br>(400°)            | 5.5                  | 9.4                                      | 8.5                   | 5.1                           | 0.1                   | 2.0  |
| 186, 0.34g. Al Ag Cu S.S. Ti<br>-0.40-.24-.20 .00 -.20<br>.32 .22 .20 .00 .26                             | 422.1  | 60            | 204°<br>(400°)            | 6.4                  | 8.8                                      | 6.2                   | 4.9                           | 0.7                   | 0.7  |
| 186, 0.34g. Al Ag Cu S.S. Ti<br>-0.62-.22-.06 .14 -.24<br>.84 1.02 1.02 .80 .54                           | 416.2  | 48            | 260°<br>(500°)            | 7.3                  | 19.5                                     | 14.1                  | 14.3                          | 1.5                   | 1.7  |
|                        |        |               |                           |                      |                                          |                       |                               |                       |      |
| p-Aminodiphenyl, No. 367, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.20 .28 1.42 .02 .04                             | 372.2  | 60            | 204°<br>(400°)            | 4.0                  | 14.1                                     | 8.5                   | 19.2                          | N.D.                  | 2.3  |
| 367, 0.25g. Al Ag Cu S.S. Ti<br>0.32 .64 2.66 .56 .34                                                     | 373.2  | 48            | 232°<br>(450°)            | 3.0                  | 24.4                                     | 17.8                  | 17.5                          | N.D.                  | 4.1  |
| 367, 0.25g. Al Ag Cu S.S. Ti<br>0.22 .38 1.20 .34 .18                                                     | 378.2  | 36            | 260°<br>(500°)            | 2.2                  | 30.7                                     | 19.7                  | 18.0                          | N.D.                  | 6.3  |
|                        |        |               |                           |                      |                                          |                       |                               |                       |      |
| Di-2-naphthylamine, No. 383,<br>0.34g. Al Ag Cu S.S. Ti<br>-0.04 -.16 .50 -.04 .00<br>.16 .12 .12 .04 .04 | 415.3  | 60            | 204°<br>(400°)            | 5.1                  | 25.8                                     | 16.7                  | 19.8                          | 0.4                   | 2.8  |
| 383, 0.34g. Al Ag Cu S.S. Ti<br>-0.38-.54 .10 -.20 -.48<br>.62 .80 .74 .46 .60                            | 416.3  | 48            | 260°<br>(500°)            | 7.1                  | 24.9                                     | 18.7                  | 16.7                          | N.F.                  | N.F. |
|                        |        |               |                           |                      |                                          |                       |                               |                       |      |
| Age Rite Stalite H, No. 389<br>0.25g. Al Ag Cu S.S. Ti<br>0.20 .34 4.42 .22 .20                           | 372.8  | 60            | 204°<br>(400°)            | 3.2                  | 29.0                                     | 19.1                  | 19.2                          | N.D.                  | 2.1  |
| 389, 0.25g. Al Ag Cu S.S. Ti<br>0.16 .20 1.42 .36 .06                                                     | 373.8  | 48            | 232°<br>(450°)            | 2.0                  | 32.8                                     | 21.7                  | 21.0                          | N.D.                  | 1.6  |
| 389, 0.25g. Al Ag Cu S.S. Ti<br>0.06 .24 .42 .22 .12                                                      | 378.8  | 36            | 260°<br>(500°)            | 3.1                  | 30.0                                     | 18.8                  | 21.3                          | N.D.                  | 1.5  |

N.D. Not Determined.

N.F. Not Filterable.

Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, GCL No., Concentration,<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup> | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Weight<br>Loss,<br>% | Kinematic Viscosity<br>Change, %, 54.5°C | 25 ml Sample Air Flow 1 L/Hr. |      | Neutralization<br>No. | Insoluble Percentage |                          |
|--------------------------------------------------------------------------------------------|------------|----------------|---------------------------|----------------------|------------------------------------------|-------------------------------|------|-----------------------|----------------------|--------------------------|
|                                                                                            |            |                |                           |                      |                                          | Viscosity<br>100°             |      |                       | Isocetane<br>Wash    | Isocetane<br>Precipitate |
| Age Rite H.P., No. 388, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.20 .38 1.10 .34 .20                | 372.7      | 60             | 204°C<br>(400°F)          | 2.5                  | 12.9                                     | 7.9                           | 16.0 | N.D.                  | 2.0                  |                          |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.04 .18 .72 .20 .06                                       | 373.7      | 48             | 232°<br>(450°)            | 2.8                  | 13.4                                     | 8.7                           | 16.7 | N.D.                  | 3.3                  |                          |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.16 .18 .74 .26 .10                                       | 378.7      | 36             | 260°<br>(500°)            | 1.6                  | 21.4                                     | 14.1                          | 15.8 | N.D.                  | 5.7                  |                          |
| 388, 0.25g. Al Ag Cu S.S. Ti<br>0.40 .36 1.32 .46 .20                                      | 380.4      | 36             | 260°<br>(500°)            | 4.8                  | 23.4                                     | 17.6                          | 18.3 | N.D.                  | 3.4                  |                          |
| Age Rite Hipar, No. 387, 0.25g.<br>Al Ag Cu S.S. Ti<br>0.08 .10 .42 .08 .00                | 372.6      | 60             | 204°<br>(400°)            | 3.1                  | 14.3                                     | 10.3                          | 15.4 | N.D.                  | 1.8                  |                          |
| 387, 0.25g. Al Ag Cu S.S. Ti<br>0.16 .44 .56 .24 .00                                       | 373.6      | 48             | 232°<br>(450°)            | 2.9                  | 13.0                                     | 8.2                           | 19.1 | N.D.                  | 3.2                  |                          |
| 387, 0.25g. Al Ag Cu S.S. Ti<br>0.32 .30 1.06 .42 .14                                      | 378.6      | 36             | 260°<br>(500°)            | 2.8                  | 22.4                                     | 15.6                          | 17.2 | N.D.                  | 5.8                  |                          |
| Age Rite Resin D., No. 385,<br>0.25g. Al Ag Cu S.S. Ti<br>0.28 .38 .68 .02 .00             | 372.4      | 60             | 204°<br>(400°)            | 4.2                  | 28.2                                     | 20.3                          | 20.4 | N.D.                  | 2.7                  |                          |
| 385, 0.25g. Al Ag Cu S.S. Ti<br>0.36 .46 .54 .26 .10                                       | 373.4      | 48             | 232°<br>(450°)            | 2.0                  | 24.4                                     | 18.8                          | 20.2 | N.D.                  | 3.5                  |                          |
| 385, 0.25g. Al Ag Cu S.S. Ti<br>0.14 .30 .40 .34 .04                                       | 378.4      | 36             | 260°<br>(500°)            | 2.6                  | 17.9                                     | 13.5                          | 19.4 | N.D.                  | 4.4                  |                          |
| Age Rite Resin, No. 386<br>0.25g. Al Ag Cu S.S. Ti<br>0.30 .30 1.76 .12 .00                | 372.5      | 60             | 204°<br>(400°)            | 11.2                 | N.M.                                     | N.M.                          | 22.4 | N.D.                  | 6.6                  |                          |
| 386, 0.25g. Al Ag Cu S.S. Ti<br>0.28 .32 .78 .16 .24                                       | 373.5      | 48             | 232°<br>(450°)            | 2.1                  | 56.5                                     | 42.5                          | 21.7 | N.D.                  | 4.5                  |                          |
| 386, 0.25g. Al Ag Cu S.S. Ti<br>0.20 .34 .44 .28 .02                                       | 378.5      | 36             | 260°<br>(500°)            | 2.1                  | 34.1                                     | 21.2                          | 18.1 | N.D.                  | 6.2                  |                          |
| N-Aminoethylmorpholine, No. 117<br>0.18g. No Metals                                        | 389.4      | 60             | 204°<br>(400°)            | 2.1                  | 33.4                                     | 23.2                          | 20.5 | 0.7                   | 1.4                  |                          |
| 117, 0.18g. Al Ag Cu S.S. Ti<br>0.30 .42 .48 .10 .06                                       | 389.5      | 60             | 204°<br>(400°)            | 3.0                  | 21.6                                     | 14.8                          | 19.1 | 2.7                   | 1.3                  |                          |
| 117, 0.28g. Al Ag Cu S.S. Ti<br>0.10 .46 .40 .14 .10                                       | 391.4      | 60             | 204°<br>(400°)            | 3.6                  | 20.7                                     | 14.7                          | 19.7 | 1.9                   | 1.1                  |                          |
| 117, 0.18g. No Metals                                                                      | 390.4      | 24             | 260°<br>(500°)            | 3.0                  | 22.0                                     | 15.9                          | 18.0 | 0.3                   | 3.6                  |                          |
| 117, 0.18g. Al Ag Cu S.S. Ti<br>CH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>            | 390.5      | 24             | 260°<br>(500°)            | 3.5                  | 16.3                                     | 10.9                          | 19.7 | N.F.                  | N.F.                 |                          |



N.D. Not Determined.

N.M. Too viscous for measurement.

N.F. Not Filterable.

Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

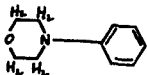
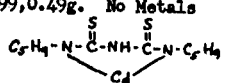
| Additive, CCL No., Concentration, Metals Present and Weight Loss, mg/cm <sup>2</sup>                                                                   | Run No. | Time, Hours | Temperature °C (°F) | Weight Loss, % | Kinematic Viscosity Change, % 54.5°C | Viscosity 100°C | 25 ml. Sample Air Flow 1 L/Hr. |                                     |                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------|---------------------|----------------|--------------------------------------|-----------------|--------------------------------|-------------------------------------|----------------------------------|
|                                                                                                                                                        |         |             |                     |                |                                      |                 | Neutralization No.             | Insoluble Percentage Isocetane Wash | Percentage Isocetane Precipitate |
| N-Phenylmorpholine, No. 141, 0.21g., No Metals                                                                                                         | 395.1   | 60          | 204° (400°)         | 2.5            | 31.6                                 | 21.8            | 19.8                           | 0.4                                 | 2.6                              |
| 141, 0.21g. Al Ag Cu S.S. Ti<br>0.20 .32 .88 .08 .12                                                                                                   | 389.6   | 60          | 204° (400°)         | 4.2            | 28.8                                 | 19.1            | 24.5                           | 1.8                                 | 1.9                              |
| 141, 0.21g. Al Ag Cu S.S. Ti<br>0.32 .32 .56 .28 .28                                                                                                   | 390.6   | 24          | 260° (500°)         | 3.7            | 20.1                                 | 14.1            | 18.1                           | 0.1                                 | 4.3                              |
|                                                                       |         |             |                     |                |                                      |                 |                                |                                     |                                  |
| Na Sul-BSN-Barium Sulfonate Neutral Salt in 50% Di-2-ethyl hexyl sebacate, No. 398, 0.60g. No Metals                                                   | 408.5   | 60          | 204° (400°)         | 7.0            | 33.8                                 | 22.7            | 34.2                           | 17.5                                | 1.2                              |
| 398, 0.60g. Cu                                                                                                                                         | 408.6   | 60          | 204° (400°)         | 8.5            | 547.0                                | 366.0           | 7.5                            | N.F.                                | 6.8                              |
| 100% Cadmium diamyl dithiocarbamate, No. 399, 0.17 No Metals                                                                                           | 410.8   | 60          | 204° (400°)         | 1.6            | 15.4                                 | 11.6            | 14.4                           | 0.01                                | 2.4                              |
| 399, 0.17g. Al Ag Cu S.S. Ti<br>0.22 .28 7.26 .16 .08                                                                                                  | 410.9   | 60          | 204° (400°)         | 5.0            | 10.7                                 | 7.4             | 15.9                           | 0.00                                | 2.0                              |
| 399, 0.49g. No Metals<br>                                              | 410.7   | 60          | 204° (400°)         | 1.8            | 12.5                                 | 8.5             | 12.3                           | 0.03                                | 2.0                              |
| 4,4'-bisthiopicolinamido diphenyl, No. 401, 0.27g. No Metals                                                                                           | 417.8   | 60          | 204° (400°)         | 3.1            | 14.8                                 | 9.4             | 11.9                           | 0.2                                 | 1.4                              |
| 401, 0.27g. No Metals                                                                                                                                  | 419.1   | 60          | 204° (400°)         | 4.0            | 18.3                                 | 12.6            | 14.2                           | 0.6                                 | 1.5                              |
| 401, 0.27g., 3 Cu Washers<br>1.12 0.06 1.04<br>.18 1.06 .28                                                                                            | 419.2   | 60          | 204° (400°)         | 5.1            | 20.9                                 | 14.4            | 20.2                           | 0.6                                 | 1.2                              |
| 401, 0.27g. 3 Ag<br>2.50 2.72 4.02<br>2.92 2.26 1.58                                                                                                   | 417.9   | 60          | 204° (400°)         | 5.3            | 18.8                                 | 12.1            | 13.6                           | 0.2                                 | 1.2                              |
| 401, 0.27g. Al Ag Cu S.S. Ti<br>-0.16 7.18 .50 .00 -.32<br>.16 1.18 .08 .14 .34                                                                        | 415.2   | 60          | 204° (400°)         | 5.3            | 32.8                                 | 21.4            | 23.6                           | 0.5                                 | 2.1                              |
| Phenothiazine, No. 293, 0.25g. and Na Sul BSN (Barium Sulfonate Neutral Salt 50% Dispersion) 0.01g. Al Ag Cu S.S. Ti<br>0.02-.06 .04 .00 .04           | 410.10  | 60          | 204° (400°)         | 3.9            | 18.2                                 | 12.1            | 16.4                           | 0.6                                 | 3.4                              |
| Phenothiazine, No. 293, 0.125g. and Cadmium Diamyl Dithiocarbamate, (100%), No. 399, 0.10g. No Metals                                                  | 410.3   | 60          | 204° (400°)         | 0.6            | 4.3                                  | 4.9             | 4.6                            | 0.6                                 | 1.5                              |
| 293 0.125g. and 399 0.05g. Al Ag Cu S.S. Ti<br>0.22 .12 1.96 .04 .00                                                                                   | 410.5   | 60          | 204° (400°)         | 5.5            | 16.8                                 | 11.2            | 20.4                           | 0.3                                 | 2.6                              |
| 293 0.25g. and 399 0.05g. Al Ag Cu S.S. Ti<br>0.10 .08 1.32 .04 .08                                                                                    | 410.6   | 60          | 204° (400°)         | 4.9            | 13.1                                 | 8.8             | 14.3                           | 0.2                                 | 2.8                              |
| Phenothiazine, No. 293, 0.25g. and 4,4'-bisthiopicolinamido diphenyl, No. 401, 0.01g. Al Ag Cu S.S. Ti<br>0.00 .04 .28-.08 -.14<br>.10 .26 .36 .08 .04 | 423.4   | 60          | 204° (400°)         | 3.1            | 13.9                                 | 8.8             | 12.6                           | 1.4                                 | 2.0                              |
| 293 0.25g. and 401 0.05g. Al Ag Cu S.S. Ti<br>0.06 .00 .34 .06 .02<br>.16 .10 .46 .08 .04                                                              | 417.6   | 60          | 204° (400°)         | 3.2            | 17.2                                 | 15.8            | 18.6                           | 1.7                                 | 1.9                              |

Table 14. Oxidations in Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CCL No., Concentration,<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup>                                                                                         | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | 25 ml Sample Air Flow 1 L/Hr. |                                               |       | Neutralization<br>No. | Insoluble Percentage |                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|---------------------------|-------------------------------|-----------------------------------------------|-------|-----------------------|----------------------|--------------------------|
|                                                                                                                                                                                    |            |                |                           | Weight<br>Loss,<br>%          | Kinematic<br>Viscosity<br>Change, %<br>54.5°C | 100°C |                       | Isocetane<br>Wash    | Isocetane<br>Precipitate |
|                                                                                                                                                                                    |            |                |                           |                               |                                               |       |                       |                      |                          |
| N,N'-Diphenyl-p-phenylenediamine,<br>No. 186, 0.17g. and 4,4'-bisthiopicolinamide diphenyl, No. 401,<br>0.01g.<br>Al Ag Cu S.S. Ti<br>0.14 .02 .54 .08 -.14<br>.08 .26 .52 .10 .04 | 423.2      | 60             | 204°<br>(400°)            | 3.8                           | 24.5                                          | 16.4  | 22.1                  | 1.9                  | 2.1                      |
| 186 0.17g. and 401 0.03g.<br>Al Ag Cu S.S. Ti<br>0.36-0.24-.04-.20 -.12<br>.24 .36 .24 .22 .32                                                                                     | 422.4      | 60             | 204°<br>(400°)            | 6.1                           | 14.9                                          | 9.7   | 12.5                  | 0.2                  | 0.8                      |
| 186 0.17g. and 401 0.03g.<br>Al Ag Cu S.S. Ti<br>0.06-.08 .30 .06 -.10<br>.02 .26 .42 .06 .00                                                                                      | 423.1      | 60             | 204°<br>(400°)            | 3.2                           | 21.3                                          | 14.8  | 12.1                  | 0.8                  | 2.1                      |
| 186 0.34g. and 401 0.01g.<br>Al Ag Cu S.S. Ti<br>0.06-.12 .04 .06 -.14<br>.04 .20 .20 .04 .02                                                                                      | 423.3      | 60             | 204°<br>(400°)            | 12.2                          | 8.3                                           | 5.3   | 5.1                   | 1.8                  | 2.5                      |
| 186 0.34g. and 401 0.03g.<br>Al Ag Cu S.S. Ti<br>-0.52-.34-.28 -.12 -.12<br>.32 .38 .50 .20 .12                                                                                    | 422.3      | 60             | 204°<br>(400°)            | 8.6                           | 8.1                                           | 4.7   | 4.3                   | 0.6                  | N.D.                     |
| 2-Phenylbenzoselenazole, No. 300B,<br>0.32g. and 4,4'-bisthiopicolinamido,<br>diphenyl, No. 401, 0.05g.<br>Al Ag Cu S.S. Ti<br>0.02 .30 1.50 .02 .04<br>.04 .42 .10 .02 .06        | 415.9      | 60             | 204°<br>(400°)            | 7.3                           | 15.4                                          | 9.7   | 12.1                  | N.F.                 | N.F.                     |
| 300B 0.32g. and 401 0.05g.<br>Al Ag Cu S.S. Ti<br>0.12 .22 1.22 .16 .06<br>.06 .08 .12 .00 .02                                                                                     | 417.10     | 60             | 204°<br>(400°)            | 8.4                           | 23.6                                          | 15.8  | 26.2                  | 11.8                 | 0.8                      |

TABLE 15  
Acid Behavior in an Oxidation of Bis-(2-ethylhexyl) Sebacate  
at 204°C (400°F)

| System                | Time,<br>Hours | Total<br>Neutralization<br>No. | Oil Insoluble<br>Neutralization<br>% | Oil Insoluble<br>Neutralization<br>No. | Oil Filtrate<br>Neutralization<br>No. | Isococtane Wash of<br>Oil Insoluble<br>Neutralization<br>% | Isococtane Wash of<br>Oil Insoluble<br>Neutralization<br>No. | Isococtane Precipitate<br>% Neutralization<br>% | Isococtane Precipitate<br>% Neutralization<br>No. | Oil from Isococtane Filtrate<br>Neutralization<br>No. |
|-----------------------|----------------|--------------------------------|--------------------------------------|----------------------------------------|---------------------------------------|------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| No Additive           | 24             | 14.9                           | 1.5                                  | 10.5                                   | 12.9                                  | 0.06                                                       | 47                                                           | 0.10                                            | 50                                                | 7.4                                                   |
| No Additive           | 48             | 18.9                           | 2.7                                  | 17.0                                   | 18.1                                  | 0.05                                                       | 64                                                           | 0.63                                            | 40                                                | 12.7                                                  |
| No Additive           | 60             | 24.8                           | 1.7                                  | 19.5                                   | 24.4                                  | 0.07                                                       | 48                                                           | 2.1                                             | 57                                                | 14.4                                                  |
| 0.5%<br>Phenothiazine | 24             | 2.0                            | 2.4                                  | 3.0                                    | 1.2                                   | 0.49                                                       | N.D.                                                         | 0.22                                            | 15                                                | 1.2                                                   |
| 0.5%<br>Phenothiazine | 48             | 2.7                            | 2.8                                  | 3.7                                    | 2.3                                   | 0.61                                                       | 3.2                                                          | 0.48                                            | 17                                                | 2.0                                                   |
| 0.5%<br>Phenothiazine | 60             | 5.9                            | 3.0                                  | 8.6                                    | 5.2                                   | 0.77                                                       | 4.7                                                          | 0.50                                            | 27                                                | 3.2                                                   |
| 1.0%<br>Phenothiazine | 24             | 2.1                            | 3.3                                  | 3.0                                    | 1.5                                   | 0.93                                                       | 2.8                                                          | 0.54                                            | 13                                                | 1.5                                                   |
| 1.0%<br>Phenothiazine | 48             | 3.1                            | 3.7                                  | 5.4                                    | 2.4                                   | 1.2                                                        | 2.7                                                          | 0.48                                            | 18                                                | 1.5                                                   |
| 1.0%<br>Phenothiazine | 60             | 3.7                            | 3.8                                  | 5.2                                    | 2.8                                   | 1.3                                                        | 2.9                                                          | 0.62                                            | 13                                                | 1.6                                                   |
| 2.0%<br>Phenothiazine | 24             | 2.3                            | 4.0                                  | 3.5                                    | 1.3                                   | 1.9                                                        | 3.2                                                          | 1.4                                             | 7.2                                               | 1.0                                                   |

TABLE 16

## Behavior of Insolubles in Oxidized Bis-(2-ethylhexyl) Sebacate

| Additive, CGL No., Concentration, Metals Present and Weight Less, mg/cm <sup>2</sup> | Run No. | Time, Hours | Temperature °C (°F) | Kinematic Viscosity Change, % | Oil   | Insoluble Percentage |       |                                                       |
|--------------------------------------------------------------------------------------|---------|-------------|---------------------|-------------------------------|-------|----------------------|-------|-------------------------------------------------------|
|                                                                                      |         |             |                     |                               |       | 54.5°C               | 100°C | Issectane Wash, Issectane Wash, Issectane Precipitate |
| None, No Metals                                                                      | 388.1   | 24          | 204°<br>(400°)      | 29.0                          | 15.0' | 1.22                 | 0.00  | 0.00 0.10                                             |
| None, Al Ag Cu S.S. Ti<br>0.02 0.10 .24 0.00 0.00                                    | 388.3   | 24          | 204°<br>(400°)      | 29.8                          | 18.2  | 1.62                 | 0.00  | 0.00 0.10                                             |
| None, No Metals                                                                      | 388.2   | 48          | 204°<br>(400°)      | 50.0                          | 30.0  | 1.65                 | 0.00  | 0.00 0.10                                             |
| None, No Metals                                                                      | 389.1   | 48          | 204°<br>(400°)      | 57.0                          | 37.4  | 1.15                 | 0.02  | 0.00 1.76                                             |
| None, Al Ag Cu S.S. Ti<br>0.04 .10 .20 .00 .02                                       | 388.4   | 48          | 204°<br>(400°)      | 47.2                          | 32.0  | 2.22                 | 0.04  | 0.00 2.66                                             |
| None, No Metals                                                                      | 389.2   | 60          | 204°<br>(400°)      | 58.4                          | 36.6  | 1.40                 | 0.03  | 0.00 2.73                                             |
| None, No Metals                                                                      | 391.1   | 60          | 204°<br>(400°)      | 60.6                          | 38.2  | 1.23                 | 0.06  | 0.05 N.D.                                             |
| None, Al Ag Cu S.S. Ti<br>0.12 .24 .98 .04 .04                                       | 391.2   | 60          | 204°<br>(400°)      | 68.5                          | 45.0  | 0.78                 | 0.06  | 0.04 4.23                                             |
| Phenothiazine, No. 293, 0.125g.<br>No Metal                                          | 408.1   | 60          | 204°<br>(400°)      | 7.3                           | 5.0   | 3.35                 | 0.58  | 0.48 0.47                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.00 .20 .44 .06 -.06                                | 388.6   | 48          | 204°<br>(400°)      | 10.9                          | 7.7   | 4.92                 | 1.76  | 1.42 1.37                                             |
| 293 0.25g., No Metals                                                                | 388.7   | 60          | 204°<br>(400°)      | 6.0                           | 3.9   | 3.61                 | 1.36  | 1.07 0.60                                             |
| 293 0.25g., No Metals                                                                | 388.5   | 48          | 204°<br>(400°)      | 4.9                           | 3.3   | 3.53                 | 1.16  | N.D. 0.43                                             |
| 293 0.25g., No Metals                                                                | 389.3   | 60          | 204°<br>(400°)      | 8.3                           | 3.2   | 4.93                 | 1.49  | 1.20 0.76                                             |
| 293 0.25g., No Metals                                                                | 399.10  | 60          | 204°<br>(400°)      | 5.1                           | 3.3   | 2.97                 | 1.28  | 1.03 0.57                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>-0.68-.76 .06-0.66-0.74                              | 408.3   | 60          | 204°<br>(400°)      | 13.6                          | 8.4   | 2.51                 | 0.33  | 0.23 1.11                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.10 .42 .66 .00 .06                                 | 391.3   | 60          | 204°<br>(400°)      | 18.0                          | 11.9  | 5.63                 | 2.08  | 1.56 1.23                                             |
| 293 0.25g., No Metals                                                                | 390.3   | 24          | 260°<br>(500°)      | 18.9                          | 12.5  | 12.7                 | 5.40  | 2.56 1.94                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.22 .74 .78 .22 .20                                 | 383.5   | 24          | 260°<br>(500°)      | 13.5                          | 8.8   | 6.38                 | 3.00  | 2.77 0.96                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.12 .46 .44 .04 .02                                 | 387.2   | 24          | 260°<br>(500°)      | 12.7                          | 8.5   | 6.40                 | 2.76  | 2.43 0.97                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.10 .42 .82 .02 .08                                 | 384.5   | 24          | 260°<br>(500°)      | 14.9                          | 9.4   | 6.60                 | 3.25  | 2.93 0.64                                             |
| 293 0.25g., Al Ag Cu S.S. Ti<br>0.24 .60 1.46 .18 .00                                | 385.5   | 48          | 260°<br>(500°)      | 33.8                          | 22.4  | 12.39                | 9.02  | 8.79 1.99                                             |
| P-Aminodiphenylamine, No. 360<br>0.23g., No Metals                                   | 394.5   | 60          | 204°<br>(400°)      | 19.0                          | 13.0  | 2.70                 | 1.02  | 0.87 1.04                                             |
| 360 0.23g., No Metals                                                                | 403.5   | 60          | 204°<br>(400°)      | 15.4                          | 11.2  | 3.06                 | 0.56  | 0.36 1.87                                             |
| 360 0.23g., Cu<br>-0.08                                                              | 403.6   | 60          | 204°<br>(400°)      | 14.1                          | 10.0  | 4.68                 | 1.01  | 0.72 2.50                                             |
| 360 0.24g., Al Ag Cu S.S. Ti<br>0.20 .28 .26 .04 .02                                 | 389.7   | 60          | 204°<br>(400°)      | 16.3                          | 10.7  | 3.42                 | 1.28  | 1.08 1.00                                             |
| 360 0.24g., Al Ag Cu S.S. Ti<br>0.16 .50 .22 .06 .12                                 | 391.5   | 60          | 204°<br>(400°)      | 19.5                          | 13.3  | 3.30                 | 0.88  | 0.74 1.11                                             |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.32 .56 .36 .16 .10                                 | 372.10  | 60          | 204°<br>(400°)      | 19.6                          | 13.6  | N.D.                 |       |                                                       |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.10 .24 .50 .26 .00                                 | 373.10  | 48          | 232°<br>(450°)      | 10.9                          | 6.1   | N.D.                 |       |                                                       |

N.D. Not Determined.

Table 16. Behavior of Insolubles in Oxidized Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CCL No., Concentration<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup>                                              | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Kinematic Viscosity |       | Insoluble Percentage |                   |                 |                          |
|----------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|---------------------------|---------------------|-------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                                                                        |            |                |                           | Change, %<br>54.5°C | 100°C | Oil                  | Isocetane<br>Wash | Acetone<br>Wash | Isocetane<br>Precipitate |
| <u>p-Aminodiphenylamine</u> , No. 360<br>0.24g., Al Ag Cu S.S. Ti<br>0.32 .32 .56 .28 .28                                              | 390.7      | 24             | 260°<br>(500°)            | 10.1                | 5.9   | 7.60                 | 2.53              | 2.23            | 1.68                     |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.12 1.02 .52 .22 -.04                                                                                 | 381.4      | 24             | 260°<br>(500°)            | 10.5                | 4.9   | N.D.                 |                   |                 | 3.30                     |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.26 .21 .52 .36 .12                                                                                   | 380.2      | 36             | 260°<br>(500°)            | 17.0                | 9.9   | N.D.                 |                   |                 | 2.91                     |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.24 1.10 .66 .70 .02                                                                                  | 378.10     | 36             | 260°<br>(500°)            | 7.7                 | 4.9   | N.D.                 |                   |                 | 4.48                     |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.16 1.12 .80 .58 .30                                                                                  | 381.5      | 36             | 260°<br>(500°)            | 9.0                 | 5.5   | N.D.                 |                   |                 | 3.12                     |
| 360 0.50g., Al Ag Cu S.S. Ti<br>0.36 1.20 1.14 .96 .26                                                                                 | 380.3      | 36             | 260°<br>(500°)            | 7.8                 | 4.6   | N.D.                 |                   |                 | 3.09                     |
| 360 0.50g., Al Ag Cu S.S. Ti<br>0.22 1.54 .86 .96 .10                                                                                  | 381.7      | 36             | 260°<br>(500°)            | 8.1                 | 4.2   | N.D.                 |                   |                 | 2.77                     |
| 360 0.25g., Al Ag Cu S.S. Ti<br>0.28 .94 1.08 1.02 .08                                                                                 | 381.6      | 48             | 260°<br>(500°)            | 12.1                | 7.4   | N.D.                 |                   |                 | 4.42                     |
| <u>Di-2-naphthylamine</u> , No. 383,<br>0.25g., Al Ag Cu S.S. Ti<br>0.14 .24 1.02 .18 .16                                              | 372.3      | 60             | 204°<br>(400°)            | 16.8                | 9.9   | N.D.                 |                   |                 | 2.93                     |
| 383 0.34g., No Metals                                                                                                                  | 395.10     | 60             | 204°<br>(400°)            | 28.4                | 18.8  | 2.40                 | 0.62              | 0.12            | 2.24                     |
| 383 0.34g., No Metals                                                                                                                  | 403.1      | 60             | 204°<br>(400°)            | 24.4                | 17.3  | 1.73                 | 1.20              | 0.00            | 2.99                     |
| 383 0.34g., Cu<br>0.58                                                                                                                 | 403.2      | 60             | 204°<br>(400°)            | 20.0                | 13.2  | 2.74                 | 0.47              | 0.25            | 3.54                     |
| 383 0.25g., Al Ag Cu S.S. Ti<br>0.22 .32 1.34 .46 .16                                                                                  | 373.3      | 48             | 232°<br>(450°)            | 21.1                | 14.2  | N.D.                 |                   |                 | 3.50                     |
| 383 0.25g., Al Ag Cu S.S. Ti<br>0.20 .64 1.28 .24 .02                                                                                  | 378.3      | 36             | 260°<br>(500°)            | 33.6                | 23.2  | N.D.                 |                   |                 | 7.50                     |
| <u>Phenethiazine</u> , No. 293, 0.12g.,<br><u>N-amineethylmorpholine</u> , No. 117,<br>0.12g. Al Ag Cu S.S. Ti<br>0.04 .58 .56 .24 .08 | 386.7      | 24             | 260°<br>(500°)            | 10.5                | 6.5   | 5.33                 | 2.60              | 2.38            | 0.57                     |
| 293 0.12g., 117 5 drops<br>Al Ag Cu S.S. Ti<br>0.22 .50 .30 .06                                                                        | 386.8      | 24             | 260°<br>(500°)            | 22.8                | 14.8  | 11.2                 | 2.66              | 2.31            | 0.79                     |
| 293 0.25g., 117 5 drops<br>Al Ag Cu S.S. Ti<br>0.30 .98 .80 .38 .16                                                                    | 383.6      | 24             | 260°<br>(500°)            | 7.2                 | 4.1   | 7.44                 | 4.11              | 3.66            | 0.48                     |
| 293 0.25g., 117 5 drops<br>Al Ag Cu S.S. Ti<br>0.10 .40 .38 .08 .00                                                                    | 384.6      | 24             | 260°<br>(500°)            | 4.1                 | 2.4   | 6.87                 | 3.58              | 2.68            | 0.35                     |
| 293 0.25g., 117 5 drops<br>Al Ag Cu S.S. Ti<br>0.22 1.08 1.22 .50 .44                                                                  | 385.6      | 48             | 260°<br>(500°)            | 10.2                | 6.5   | 5.40                 | 2.87              | 2.60            | 0.59                     |
| <u>Phenethiazine</u> , No. 293, 0.12g.,<br><u>N-Phenylmorpholine</u> , No. 141,<br>0.12 g. Al Ag Cu S.S. Ti<br>0.42 1.06 1.04 .60 .50  | 383.7      | 24             | 260°<br>(500°)            | 10.0                | 5.9   | 4.75                 | 2.38              | 2.87            | 0.76                     |
| 293 0.12g., 141 0.12g.<br>Al Ag Cu S.S. Ti<br>0.36 .60 .36 .24 .10                                                                     | 384.7      | 24             | 260°<br>(500°)            | 9.1                 | 5.1   | 4.36                 | 2.19              | 1.88            | 0.70                     |
| 293 0.12g., 141 0.12g.<br>Al Ag Cu S.S. Ti<br>0.26 .82 1.60 .64 .56                                                                    | 385.7      | 48             | 260°<br>(500°)            | 17.7                | 10.7  | 6.43                 | 2.49              | 2.20            | 1.49                     |

N.D. Not Determined.

Table 16. Behavior of Insolubles in Oxidized Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CCL No., Concentration,<br>Metals Present and Weight Loss,<br>mg/cm <sup>2</sup>                                                                                                                                                             | Run<br>No. | Time<br>Hours | Temperature<br>°C<br>(°F) | Kinematic Viscosity<br>Change, %, 54.5°C<br>100°C | Insoluble Percentage |                   |                 |                          |       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|---------------------------|---------------------------------------------------|----------------------|-------------------|-----------------|--------------------------|-------|
|                                                                                                                                                                                                                                                        |            |               |                           |                                                   | Oil                  | Issectane<br>Wash | Acetone<br>Wash | Issectane<br>Precipitate |       |
| <u>Phenethiazine, No. 293, 0.12g.</u><br><u>p-Aminediphenylamine, No. 360,</u><br><u>0.12g., Al Ag Cu S.S. Ti</u><br>0.38 .76 .68 .28 .04                                                                                                              | 382.4      | 24            | 260°<br>(500°)            | 11.4                                              | 5.2                  | 1.84              | 2.31            | 2.02                     | 2.37  |
| <u>Phenethiazine, No. 293, 0.10g.,</u><br><u>p-Aminodiphenylamine, No. 360,</u><br><u>0.10g., N-Aminethylmorpholine,</u><br><u>No. 117, 5 drops</u><br>Al Ag Cu S.S. Ti<br>0.02 .34 .08 .00 .02                                                        | 388.9      | 60            | 204°<br>(400°)            | 5.5                                               | 4.1                  | 3.16              | 0.89            | 0.69                     | 0.55  |
| 293 0.10g., 360 0.10g., 117<br>5 drops, No Metals                                                                                                                                                                                                      | 387.3      | 24            | 260°<br>(500°)            | 24.7                                              | 15.3                 | 10.06             | 3.46            | 2.98                     | 0.74  |
| 293 0.10g., 360 0.10g., 117<br>5 drops Al Ag Cu S.S. Ti<br>0.04 .66 .60 .16 .00                                                                                                                                                                        | 387.4      | 24            | 260°<br>(500°)            | 6.3                                               | 3.8                  | 7.53              | 0.38            | 2.75                     | 0.36  |
| <u>Phenethiazine, No. 293, 0.10g.,</u><br><u>p-Aminodiphenylamine, No. 360,</u><br><u>0.05g., 2,2'-Dipyridylamine,</u><br><u>No. 128, 0.05g., and N-amino-</u><br><u>ethylmorpholine, No. 117, 5 drops</u><br>Al Ag Cu S.S. Ti<br>0.04 .18 .06 .06 .18 | 388.10     | 60            | 204°<br>(400°)            | 5.8                                               | 3.9                  | 4.45              | 1.14            | 0.92                     | 0.71  |
| 293 0.10g., 360 0.05g., 128<br>0.05g., 117 5 drops<br>No Metals                                                                                                                                                                                        | 387.5      | 24            | 260°<br>(500°)            | 14.5                                              | 10.3                 | 6.04              | 2.76            | 2.46                     | 0.57  |
| 293 0.10, 360 0.05, 128 0.05,<br>117 5 drops<br>Al Ag Cu S.S. Ti<br>0.12 .64 .58 .30 .00                                                                                                                                                               | 387.6      | 24            | 260°<br>(500°)            | 5.0                                               | 2.7                  | 5.34              | 2.59            | 2.41                     | 0.35  |
| <u>Phenethiazine, No. 293, 0.05g.,</u><br><u>p-Aminodiphenylamine, No. 360,</u><br><u>0.05g., 2,2'-Dipyridylamine,</u><br><u>No. 128 0.05g., N-Phenylmorpholine,</u><br><u>No. 141 0.05g. Al Ag Cu S.S. Ti</u><br>0.00 .34 .38 .12-.06                 | 387.7      | 24            | 260°<br>(500°)            | 20.5                                              | 15.5                 | 11.12             | 3.85            | 3.03                     | 1.15  |
| 293 0.05g., 360 0.05g., 128 0.05g.,<br>141 0.05g., 117 5 drops<br>Al Ag Cu S.S. Ti<br>0.06 .36 .28 .04 .04                                                                                                                                             | 387.8      | 24            | 260°<br>(500°)            | 7.4                                               | 4.4                  | 7.58              | 3.30            | 3.00                     | 0.63  |
| <u>Phenethiazine, No. 293, 0.12g.</u><br><u>Di-2-naphthylamine, No. 383,</u><br><u>0.12g., Al Ag Cu S.S. Ti</u><br>0.06 .60 .80 .02 .24                                                                                                                | 382.3      | 24            | 260°<br>(500°)            | 20.6                                              | 14.5                 | 5.02              | 1.55            | 1.28                     | 3.38  |
| 293 0.06, 383 0.07, 360 0.12g.<br>Al Ag Cu S.S. Ti<br>0.12 184 .46 .36 .32                                                                                                                                                                             | 382.5      | 24            | 260°<br>(500°)            | 12.8                                              | 7.9                  | 5.97              | 2.44            | 2.12                     | 10.79 |
| <u>Phenethiazine, No. 293, 0.25g.,</u><br><u>Di-2-ethylhexyl hydrogen</u><br><u>phosphite, No. 101, 5 drops</u><br>Al Ag Cu S.S. Ti<br>0.04 .28 .74 -.08 .08                                                                                           | 382.8      | 24            | 260°<br>(500°)            | 58.0                                              | 45.0                 | Not Filterable    |                 |                          |       |
| <u>Phenethiazine, No. 293, 0.125g.,</u><br><u>Barium Sulfate Neutral Salt,</u><br><u>No. 398, 0.10g. Cu 1.28</u>                                                                                                                                       | 407.3      | 60            | 204°<br>(400°)            | 21.2                                              | 14.5                 | 4.47              | 1.22            | 0.81                     | 1.35  |
| 293 0.25g., 398 0.10g.<br>Cu 0.36                                                                                                                                                                                                                      | 407.4      | 60            | 204°<br>(400°)            | 13.5                                              | 10.0                 | 2.76              | 0.41            | 0.31                     | 1.32  |
| 293 0.25g., 398 0.10g.<br>Al Ag Cu S.S. Ti<br>-.64-.76 .22 -.68-.82                                                                                                                                                                                    | 408.4      | 60            | 204°<br>(400°)            | 12.8                                              | 8.8                  | 2.87              | 0.50            | 0.38                     | 1.02  |

Table 16. Behavior of Insolubles in Oxidized Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CCL No., Concentration, Metals Present and Weight Loss, mg/cm <sup>2</sup>                                                                                                                                                                                         | Run No. | Time Hours | Temperature °C (°F) | Kinematic Viscosity Change, % | 54.5°C | 100°C          | Insoluble Percentage |                |              |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------|---------------------|-------------------------------|--------|----------------|----------------------|----------------|--------------|-----------------------|
|                                                                                                                                                                                                                                                                              |         |            |                     |                               |        |                | Oil                  | Isocetane Wash | Acetone Wash | Isocetane Precipitate |
| Phenethiazine, No. 293, 0.25g.<br>Vanadyl-2-ethyl hexoate, No. 379<br>0.05g., Al Ag Cu S.S. Ti<br>0.08 .50 .72 .12 .02                                                                                                                                                       | 382.6   | 24         | 260°<br>(500°)      | 54.8                          | 39.6   | Not Filterable |                      |                |              | 2.29                  |
| Phenethiazine, No. 293, 0.20g.<br>Stannous naphthenate, No. 373,<br>0.05g., Al Ag Cu S.S. Ti<br>0.06 .86 .82 .38 .00                                                                                                                                                         | 382.7   | 24         | 260°<br>(500°)      | 14.1                          | 8.7    | 6.53           | 1.75                 | 1.56           | 1.97         |                       |
| Phenethiazine, No. 293, 0.06g.,<br>p-Aminediphenylamine, No. 360,<br>0.06g., Vanadyl-2-ethyl hexoate,<br>No. 379, 0.03g., Stannous<br>naphthenate, No. 373, 0.03 g.<br>Di-2-ethylhexyl hydrogen phosphite,<br>No. 101, 5 drops<br>Al Ag Cu S.S. Ti<br>0.20 1.04 1.72 .92 .46 | 382.10  | 24         | 260°<br>(500°)      | 13.1                          | 8.2    | 5.53           | 1.33                 | 1.16           | 1.70         |                       |
| p-Aminediphenylamine, No. 360,<br>0.12g., p-Amineethylmerpheline,<br>No. 117, 0.10g.<br>Al Ag Cu S.S. Ti<br>0.16 .42 .32 .12 .04                                                                                                                                             | 391.6   | 60         | 204°<br>(400°)      | 21.5                          | 15.0   | 3.17           | 1.10                 | 0.90           | 1.13         |                       |
| p-Aminediphenylamine, No. 360,<br>0.12g., Di-2-naphthylamine,<br>No. 383, 0.12g. No. 117 5 drops.<br>Al Ag Cu S.S. Ti<br>0.18 1.10 .94 .46 .14                                                                                                                               | 383.9   | 24         | 260°<br>(500°)      | 10.2                          | 4.0    | 6.87           | 3.14                 | 2.85           | 0.69         |                       |
| p-Aminediphenylamine, No. 360,<br>0.12g., p-Amineethylmerpheline,<br>No. 117, 5 drops, Di-2-naphthyl-<br>amine, No. 383, 0.12g.<br>Al Ag Cu S.S. Ti<br>0.06 .56 .40 .04 .02                                                                                                  | 384.9   | 24         | 260°<br>(500°)      | 11.1                          | 5.5    | 4.88           | 2.32                 | 2.09           | 0.74         |                       |
| 360 0.12g., 117 5 drops,<br>383 0.12g. Al Ag Cu S.S. Ti<br>0.26 1.34 .82 .52 .00                                                                                                                                                                                             | 385.9   | 48         | 260°<br>(500°)      | 12.8                          | 6.6    | 7.82           | 3.02                 | 2.76           | 0.92         |                       |
| p-Aminediphenylamine, No. 360,<br>0.05g., Di-2-naphthylamine,<br>No. 383, 0.05g., p-Amineethyl-<br>merpheline, No. 117, 5 drops,<br>2,2'-Dipyridylamine, No. 128,<br>0.05g., p-Phenylmerpheline, No. 141,<br>0.05g., Al Ag Cu S.S. Ti<br>0.10 .30 .36 .06 .00                | 387.9   | 24         | 260°<br>(500°)      | 13.6                          | 10.6   | 11.43          | 3.64                 | 3.18           | 0.71         |                       |
| N-Amineethylmerpheline, No. 117,<br>0.10g., 2,2'-Dipyridylamine, 0.11g.<br>No. 128, Cu 0.22                                                                                                                                                                                  | 391.8   | 60         | 204°<br>(400°)      | 20.4                          | 14.7   | 6.01           | 3.75                 | 3.12           | 0.82         |                       |
| 117 0.10g., 128 0.11g.<br>Al Ag Cu S.S. Ti<br>0.18 .48 .64 .14 .22                                                                                                                                                                                                           | 391.7   | 60         | 204°<br>(400°)      | 19.2                          | 12.7   | 4.62           | 2.52                 | 2.01           | 0.55         |                       |
| Di-2-naphthylamine, No. 383,<br>0.10g., N-Amineethylmerpheline,<br>No. 117, 5 drops, N-Phenyl-<br>merpheline, No. 141, 0.10g.<br>Al Ag Cu S.S. Ti<br>0.06 .68 .48 .10 .04                                                                                                    | 387.10  | 24         | 260°<br>(500°)      | 10.8                          | 7.0    | 8.75           | 3.18                 | 2.78           | 0.81         |                       |
| p-Aminediphenylamine, No. 360,<br>0.25g., Di-2-ethylhexyl hydrogen<br>phosphite, No. 101, 5 drops<br>Al Ag Cu S.S. Ti<br>0.30 .28 .66 .48 .06                                                                                                                                | 382.9   | 24         | 260°<br>(500°)      | 22.1                          | 13.0   | 8.12           | 2.92                 | 2.54           | 2.04         |                       |

Table 16. Behavior of Insolubles in Oxidized Bis-(2-ethylhexyl) Sebacate (Cont'd)

| Additive, CGL No., Concentration,<br>Metals Present and Weight Less<br>mg/cm <sup>2</sup>                                                                                                                                                                              | Run<br>No. | Time,<br>Hours | Temperature<br>°C<br>(°F) | Kinematic Viscosity |                 | Insoluble Percentage |                   |                 |                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|---------------------------|---------------------|-----------------|----------------------|-------------------|-----------------|--------------------------|
|                                                                                                                                                                                                                                                                        |            |                |                           | Change, %           | 54.5°C<br>100°C | Oil<br>Wash          | Issectane<br>Wash | Acetone<br>Wash | Issectane<br>Precipitate |
| <u>p-Aminodiphenylamine, No. 360,</u><br>0.12, <u>Di-2-ethylhexyl hydrogen</u><br><u>phosphite, No. 101, 5 drops,</u><br><u>Di-2-naphthylamine, 0.12g., No. 383.</u><br>Al Ag Cu S.S. Ti<br>0.32 .88 1.22 .72 .10                                                      | 381.8      | 24             | 260°<br>(500°)            | 12.6                | 7.0             | 4.72                 | 1.86              | 1.58            | 0.97                     |
| <u>p-Aminodiphenylamine, No. 360,</u><br>0.12g., <u>Di-2-ethylhexyl hydrogen</u><br><u>phosphite, No. 101, 5 drops,</u><br><u>Di-2-naphthylamine, 0.12g., No. 383.</u><br>Al Ag Cu S.S. Ti<br>0.02 .10 .84 .22 .00                                                     | 384.8      | 24             | 260°<br>(500°)            | 13.5                | 7.3             | 4.46                 | 1.89              | 1.64            | 0.88                     |
| 360 0.12g., 101 5 drops,<br>383 0.12g., Al Ag Cu S.S. Ti<br>Al Ag Cu S.S. Ti<br>0.00 .16 .64 .02 -.28                                                                                                                                                                  | 385.8      | 48             | 260°<br>(500°)            | 45.5                | 29.3            | 15.3                 | 3.40              | 2.51            | 3.45                     |
| <u>p-Aminodiphenylamine, No. 360,</u><br>0.10g., <u>Di-2-ethylhexyl hydrogen</u><br><u>phosphite, No. 101, 5 drops,</u><br><u>Di-2-naphthylamine, No. 383,</u><br>0.10g., <u>Stannous naphthenate,</u><br>No. 373, 0.05g.<br>Al Ag Cu S.S. Ti<br>0.44 .76 1.24 .82 .44 | 383.10     | 24             | 260°<br>(500°)            | 11.3                | 6.1             | 4.70                 | 1.67              | 0.98            | 0.92                     |
| 360 0.10g., 101, 5 drops,<br>383 0.10g., 373 0.05g.<br>Al Ag Cu S.S. Ti<br>0.38 .40 .76 .16 .00                                                                                                                                                                        | 384.10     | 24             | 260°<br>(500°)            | 15.7                | 9.4             | 4.77                 | 1.98              | 1.71            | 0.95                     |
| 360 0.10g., 101, 5 drops,<br>383, 0.10g., 373 0.05g.<br>Al Ag Cu S.S. Ti<br>0.08 .80 2.28 .64 .12                                                                                                                                                                      | 385.10     | 48             | 260°<br>(500°)            | 19.5                | 12.7            | 11.8                 | 2.14              | 1.81            | 1.46                     |

APPENDIX II. Code Numbers, Names, Index To Page Numbers and Source of Supply  
of Additives and Fluids

(Number in parenthesis refers to Part Number of WADC TR 53-293. The number following is the Page Number in the Part).

| CCL No. | Compound                                          | Index                                               | Source                                                |
|---------|---------------------------------------------------|-----------------------------------------------------|-------------------------------------------------------|
| 3       | Phenothiazine                                     | (VII) 36,52,59                                      | Eastman Kodak Co.                                     |
| 5       | N-Methylphenothiazine                             | (VII) 52,55,59<br>(VIII) 43,47                      | E. I. duPont de Nemours<br>and Co.<br>CCL Synthesized |
| 6a      | Thianthrene                                       | (VII) 37<br>(VIII) 18                               | E. I. duPont de Nemours<br>and Co.                    |
| 10B     | Phenazine                                         | (VII) 35                                            | E. I. duPont de Nemours<br>and Co.                    |
| 16      | N-Butyl-p-aminophenol                             | (VII) 60                                            | E. I. duPont de Nemours<br>and Co.                    |
| 17      | Disalicylalpropylenediamine                       | (VII) 30                                            | E. I. duPont de Nemours<br>and Co.                    |
| 18      | 2',2'-Methylene-bis-(4-methyl-6-<br>t-butylphenol | (VII) 38,53,56,59                                   | American Cyanamid Co.                                 |
| 20      | Propyl gallate                                    | (VII) 60                                            | Heyden Chemical Co.                                   |
| 22      | p,p'-Dioctyldiphenylamine                         | (VII) 27,28,42,43,<br><sup>51</sup><br>(VIII) 16,48 | B. F. Goodrich<br>Chemical Co.                        |
| 23      | 2,6-Di-t-butyl-4-methylphenol                     | (VII) 38                                            | Enjay Co., Inc.                                       |
| 44      | 2,5-Di- <u>tert</u> -butyl-hydroquinone           | (VII) 38,59                                         | Tennessee Eastman Co.                                 |
| 52      | Diphenylamine                                     | (VII) 27,49<br>(VIII) 43,47                         | Eastman Kodak Co.                                     |
| 53      | Carbazole                                         | (VII) 34                                            | The Matheson Co.                                      |
| 54      | Phenothioxine                                     | (VII) 37<br>(VIII) 16                               | The Matheson Co.                                      |
| 57      | Acridone                                          | (VII) 34                                            | The Matheson Co.                                      |
| 58      | Xanthone                                          | (VII) 37,38,47,50                                   | The Matheson Co.                                      |
| 61      | Phenyl- <u>alpha</u> -naphthylamine               | (VII) 27,43,49,55,61<br>(VIII) 17,39,41             | Shell Development Co.                                 |

| CCL No. | Compound                               | Index                                                                                   | Source                                                                             |
|---------|----------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| 82      | Acridine                               | (VII) 34,35,42,44,<br>46,49,52,55,65<br>(VIII) 21,24,26,27,30,<br>33,37,39,41,42,<br>49 | The Matheson Co.                                                                   |
| 87      | 2-Nitrodiphenylamine                   | (VII) 28<br>(VIII) 20,48                                                                | American Cyanamid Co.                                                              |
| 88      | Triphenylamine                         | (VII) 28,43<br>(VIII) 49                                                                | Eastman Kodak Co.                                                                  |
| 89      | N-Methylphenylamine                    | (VIII) 49                                                                               | Eastman Kodak Co.                                                                  |
| 97      | Quinizarin                             | (VII) 38                                                                                | Eastman Kodak Co.                                                                  |
| 105     | 2-Amino-3-methylpyridine               | (VII) 32                                                                                | Reilly Tar and<br>Chemical Co.                                                     |
| 106     | 2-Amino-4-methylpyridine               | (VII) 32                                                                                | Reilly Tar and<br>Chemical Co.                                                     |
| 108     | l-Cystine                              | (VIII) 18                                                                               | Eastman Kodak Co.                                                                  |
| 112     | Triethanolamine                        | (VII) 29                                                                                | Eastman Kodak Co.                                                                  |
| 117     | N-Aminoethylmorpholine                 | (VII) 29<br>(VIII) 26,27,51,58                                                          | Carbide and Carbon<br>Chemical Division<br>Union Carbide and<br>Carbon Corporation |
| 121     | N,N'-Di-(p-acetylamino-phenyl)<br>ures | (VII) 36                                                                                | CCL Synthesized                                                                    |
| 124     | Tetraethylthiuram disulfide            | (VIII) 19                                                                               | Monsanto Chemical Co.                                                              |
| 128     | 2,2'-Dipyridylamine                    | (VII) 32,33,34,42,<br>44,46,49,51,<br>55,58,61<br>(VIII) 17,24,26,31,<br>33,38,39,42    | Reilly Tar and<br>Chemical Co.                                                     |
| 132     | Phenyl sulfide                         | (VIII) 16                                                                               | Eastman Kodak Co.                                                                  |
| 133     | Phenyl sulfoxide                       | (VII) 37                                                                                | Eastman Kodak Co.                                                                  |
| 140     | N-Phenyl-2-naphthylamine               | (VII) 27<br>(VIII) 49                                                                   | Eastman Kodak Co.                                                                  |
| 141     | N-Phenylmorpholine                     | (VII) 30,45,49<br>(VIII) 31,34,52                                                       | Eastman Kodak Co.                                                                  |

| CCL No. | Compound                                    | Index                                            | Source                          |
|---------|---------------------------------------------|--------------------------------------------------|---------------------------------|
| 146     | p-Aminoacetamide                            | (VII) 30                                         | Eastman Kodak Co.               |
| 148     | 2,2'-Bibenzothiazole                        | (VII) 37                                         | CCL Synthesized                 |
| 155     | 2,2'-Dithiobis-(benzothiazole)              | (VIII) 19                                        | Monsanto Chemical Co.           |
| 156     | 4,4'-Thiobis(6-t-butyl-p-cresol)            | (VII) 60<br>(VIII) 19                            | Monsanto Chemical Co.           |
| 159     | N,N'-Diphenylthiourea                       | (VII) 36<br>(VIII) 20                            | Monsanto Chemical Co.           |
| 160     | Piperidinum-1-piperidine<br>carbodithioate  | (VIII) 20                                        | Monsanto Chemical Co.           |
| 161     | Diphenylguanidine                           | (VII) 36, 46, 49<br>(VIII) 24, 26, 27, 30,<br>33 | Monsanto Chemical Co.           |
| 163     | N-Cyclohexyl-2-benzo<br>thiazolesulfenamide | (VIII) 19                                        | Monsanto Chemical Co.           |
| 164     | 4,4'-Dithiodimorpholine                     | (VII) 37<br>(VIII) 20                            | Monsanto Chemical Co.           |
| 177     | Benzimidazole                               | (VII) 35                                         | Eastman Kodak Co.               |
| 182     | 5-Amino-1-naphthol                          | (VII) 29, 43                                     | Eastman Kodak Co.               |
| 186     | N,N'-Diphenyl-p-phenylene-<br>diamine       | (VII) 43<br>(VIII) 21, 44, 50, 53                | Eastman Kodak Co.               |
| 199     | 2-Amino-4-(p-diphenyl) thiazole             | (VIII) 20                                        | Eastman Kodak Co.               |
| 207     | 6-Amino-2-mercaptobenzothiazole             | (VIII) 19                                        | Eastman Kodak Co.               |
| 208     | 2-Methylmercaptobenzothiazole               | (VIII) 18                                        | Eastman Kodak Co.               |
| 211     | N-Ethyl-1-naphthylamine                     | (VII) 29                                         | Eastman Kodak Co.               |
| 212     | N-Methyl-1-naphthylamine                    | (VII) 29                                         | Eastman Kodak Co.               |
| 213     | 2-Methylbenzothiazole                       | (VIII) 17                                        | Eastman Kodak Co.               |
| 220     | N-Benzoyldiphenylamine                      | (VII) 29                                         | CCL Synthesized                 |
| 247     | Diphenyl-3-pyridyl phosphate                | (VII) 38, 54                                     | Southwest Research<br>Institute |
| 250     | 1,3-Di-p-butyl-2-thiourea                   | (VII) 36                                         | Eastman Kodak Co.               |
| 251     | p-Diphenylurea                              | (VII) 36                                         | Matheson, Coleman<br>and Bell   |

| CCL No.       | Compound                               | Index                                                        | Source                         |
|---------------|----------------------------------------|--------------------------------------------------------------|--------------------------------|
| 254           | 1,5-Diaminoanthraquinone               | (VII) 30                                                     | Matheson, Coleman and Bell     |
| 255           | 2,6-Diaminopyridine                    | (VII) 34                                                     | The Matheson Co.               |
| 256           | 2-Quinolinol                           | (VII) 32                                                     | Eastman Kodak Co.              |
| 257           | 8-Quinolinol                           | (VII) 32                                                     | Eastman Kodak Co.              |
| 260           | N,N'-Di-2-naphthyl-p-phenylene-diamine | (VII) 31,43,45,51,58<br>(VIII) 23,24,25,27,28,29,35,36,39,41 | Eastman Kodak Co.              |
| 261           | 1-Naphthylamine                        | (VII) 29,48                                                  | Eastman Kodak Co.              |
| 262           | 2-Naphthylamine                        | (VII) 29,49                                                  | Eastman Kodak Co.              |
| 264           | Chrysazin                              | (VII) 38                                                     | General Aniline and Film Corp. |
| 271           | Dilauryl selenide                      | (VIII) 17                                                    | California Research Corp.      |
| 282PCA<br>PCB | Phenyl selenide                        | (VII) 37,47,48,52,56<br>(VIII) 16,37,38,39                   | Eastman Kodak Co.              |
| 292           | 2,6-Ditertiary butyl-4-methyl-phenol   | (VII) 53,57,60                                               | Tennessee Eastman Co.          |
| 293           | Phenothiazine (Distilled)              | (VII) 36,52,55,59<br>(VIII) 21,52,54,56,57,58                | CCL Synthesized                |
| 296           | Phenoselenazine                        | (VII) 53,56                                                  | Peninsular ChemResearch, Inc.  |
| 299           | 2-Phenylnaptho(2,1) thiazole           | (VIII) 19                                                    | Peninsular ChemResearch, Inc.  |
| 300B          | 2-Phenylbenzoselenazole                | (VII) 37,47,48,53,56<br>(VIII) 17,24,26,27,37,38,40,54,55    | Peninsular ChemResearch, Inc.  |
| 303B          | o,o'-Dinitrodiphenyl diselenide        | (VIII) 19                                                    | Peninsular ChemResearch, Inc.  |
| 307           | Di-(2-hydroxy-1-naphthyl) selenide     | (VIII) 18,38,40                                              | Peninsular ChemResearch, Inc.  |
| 308           | 1,4,2-Benzoselenazin-3-one             | (VII) 53,56<br>(VIII) 38,40,46                               | Peninsular ChemResearch, Inc.  |
| 314           | 2,2'-Dibiphenyl diselenide             | (VIII) 16                                                    | Peninsular ChemResearch, Inc.  |
| 318           | N-Phenyldibenzylamine                  | (VII) 28                                                     | Eastman Organic Chemicals      |

| CGL No. | Compound                                                 | Index                             | Source                                           |
|---------|----------------------------------------------------------|-----------------------------------|--------------------------------------------------|
| 319     | Dilauryl diselenide                                      | (VII) 48                          | Peninsural ChemResearch,<br>Inc.                 |
| 320     | Benzyl sulfide                                           | (VIII) 18                         | Eastman Organic<br>Chemicals                     |
| 321     | Benzyl disulfide                                         | (VIII) 17                         | Eastman Organic<br>Chemicals                     |
| 322     | Phenyl disulfide                                         | (VIII) 19                         | Eastman Organic<br>Chemicals                     |
| 323     | Diphenyl diselenide                                      | (VII) 48<br>(VIII) 17             | Eastman Organic<br>Chemicals                     |
| 324     | Morpholine diselenide                                    | (VII) 37,53,56<br>(VIII) 17       | Monsanto Chemical Co.                            |
| 326     | Diphenylguanidine phthalate                              | (VII) 36                          | Monsanto Chemical Co.                            |
| 327     | Diphenylguanidine                                        | (VII) 36                          | Monsanto Chemical Co.                            |
| 330     | Zinc diethyldithiocarbamate                              | (VII) 47                          | Monsanto Chemical Co.                            |
| 332     | Thiocarbanilide                                          | (VII) 44,46<br>(VIII) 36          | Monsanto Chemical Co.                            |
| 340     | N,N'-Diphenylbenzidine                                   | (VII) 29,58                       | Eastman Organic<br>Chemicals                     |
| 341     | N-Phenylphthalimide                                      | (VII) 36,58                       | Eastman Organic<br>Chemicals                     |
| 342     | 1,5-Dihydroxyanthraquinone                               | (VII) 38,61                       | Eastman Organic<br>Chemicals                     |
| 343     | p-Hydroxy-p-methylacetanilide                            | (VII) 51,55,61                    | Eastman Organic<br>Chemicals                     |
| 344     | N,N'-Ethylenebisbenzamide                                | (VII) 58                          | Eastman Organic<br>Chemicals                     |
| 345     | 4,4'-Dihydroxybiphenyl                                   | (VII) 61                          | Eastman Organic<br>Chemicals                     |
| 348     | N,N'-Di-(p-methyl)-p-phenylene-<br>diamine               | (VII) 31,44                       | E. I. duPont de Nemours<br>and Co., Jackson Lab. |
| 349     | N-Phenyl-N'-(p-methylphenyl)-p-<br>phenylenediamine      | (VII) 31                          | E. I. duPont de Nemours<br>and Co., Jackson Lab. |
| 350     | N,N'-Di-(2-methyl-3-chlorophenyl)-<br>p-phenylenediamine | (VII) 32,46,50<br>(VIII) 29,32,36 | E. I. duPont de Nemours<br>and Co., Jackson Lab. |
| 351     | N,N'-Dicyclohexyl-p-phenylene-<br>diamine                | (VII) 31<br>(VIII) 25,27          | E. I. DuPont de Nemours<br>and Co., Jackson Lab. |

| CCL No. | Compound                                                  | Index                                                                             | Source                            |
|---------|-----------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------|
| 352     | N,N'-Diphenyl-1,4-benzoquinone-diamine                    | (VII) 32,44                                                                       | E. I. duPont deNemours and Co.    |
| 354     | Diphenyl-di-p-biphenylsilane                              | (VII) 38                                                                          | Wright Air Development Center     |
| 356     | Triphenyl-p-phenylsilane                                  | (VII) 39<br>(VIII) 31                                                             | Wright Air Development Center     |
| 359     | p-Nitrosodiphenylamine                                    | (VII) 28                                                                          | Hercules Powder Co.               |
| 360     | p-Aminodiphenylamine                                      | (VII) 28,43,45,49<br>(VIII) 26,27,31,32,<br>34,36,43,44,<br>47,48,55,56,<br>58,59 | Hercules Powder Co.               |
| 365     | Triphenylphosphite                                        | (VII) 38,47,50,54<br>65                                                           | Eastman Kodak Co.                 |
| 367     | o-Aminodiphenyl                                           | (VIII) 44,50                                                                      | Matheson, Coleman and Bell        |
| 369     | 2,6-Di- <u>tert</u> -butyl phenol                         | (VII) 53,56,60                                                                    | Wright Air Development Center     |
| 370     | 4,4'-Methylene-bis-2,6-ditertiary butyl phenol            | (VII) 47,53,56,59<br>(VIII) 21,46                                                 | Wright Air Development Center     |
| 371     | 4-Hydroxy-3,5-di- <u>tert</u> -butyl benzyl dimethylamine | (VII) 45,48,51,55,<br>58,59<br>(VIII) 18,39,42                                    | Wright Air Development Center     |
| 372     | 2,4-bis-(phenylmercapto) toluene                          | (VII) 52,56<br>(VIII) 20,31,34,46                                                 | Wright Air Development Center     |
| 373     | Stannous naphthenate                                      | (VII) 39,47,54,57,<br>60<br>(VIII) 36                                             | Thermit Corp. Research Laboratory |
| 374     | Ferrocene                                                 | (VII) 39,47,54,57,<br>60                                                          | Wright Air Development Center     |
| 375     | Morgan's Base (Dibenzoacridine)                           | (VII) 35<br>(VIII) 30,33                                                          | CCL Synthesized                   |
| 377     | Thianol                                                   | (VII) 60                                                                          | CCL Synthesized                   |
| 378     | Lithium salt of Thianol                                   | (VII) 60                                                                          | CCL Synthesized                   |
| 379     | Vanadyl-2-ethyl hexoate                                   | (VIII) 24,46                                                                      | Wright Air Development Center     |

| CCL No. | Compound                                                                                                                                        | Index                                    | Source                           |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|----------------------------------|
| 383     | Di-2-naphthylamine                                                                                                                              | (VIII) 24, 31, 34, 44,<br>45, 50, 56, 58 | American Cyanamid Co.            |
| 385     | Age Rite Resin D<br>(a polymer of trimethyldihydro-<br>quinoline)                                                                               | (VIII) 45, 51                            | B. F. Goodrich Co.               |
| 386     | Age Rite Resin<br>(a condensation product of aldol<br>and <u>alpha</u> -naphthylamine)                                                          | (VIII) 45, 51                            | B. F. Goodrich Co.               |
| 387     | Age Rite Hipar<br>(50% phenyl- <u>beta</u> -naphthylamine,<br>20% N,N'-diphenyl-p-phenylene-<br>diamine and 30% p-isopropoxy-<br>diphenylamine) | (VIII) 45, 51                            | B. F. Goodrich Co.               |
| 388     | Age Rite H.P.<br>(67% Phenyl- <u>beta</u> -naphthylamine,<br>33% N,N'-diphenyl-p-phenylene-<br>diamine)                                         | (VIII) 45, 51                            | B. F. Goodrich Co.               |
| 389     | Age Rite Stalite H<br>(Di-octylated-p-phenylene-<br>diamine)                                                                                    | (VIII) 45, 50                            | B.F. Goodrich Co.                |
| 390     | p-Isopropoxydiphenylamine                                                                                                                       | (VIII) 44, 48                            | B. F. Goodrich Co.               |
| 395     | Copper sebacate, 2,2'-Dipyridyl-<br>amine Complex                                                                                               | (VIII) 37                                | CCL Synthesized                  |
| 398     | Na Sul BSN-Barium Sulfate<br>(Neutral salt in 50% Di-(2-ethyl-<br>hexyl) sebacate)                                                              | (VIII) 52                                | R. T. Vanderbilt Co.,<br>Inc.    |
| 399     | Cadmium diamyl dithiocarbamate<br>(100%)                                                                                                        | (VIII) 20, 52                            | R. T. Vanderbilt Co.,<br>Inc.    |
| 401     | 4,4'-Bisthiopicolinamido diphenyl                                                                                                               | (VIII) 21, 52                            | Wright Air Development<br>Center |

# Fluids

| GCL No. | Fluid Medium                                                                                          | Index                       | Source                           |
|---------|-------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------------|
| 2       | Bis-(2-ethylhexyl) sebacate                                                                           | (VII) 59-61<br>(VIII) 47-59 | Rohm and Haas Co.<br>Plexol 201  |
| 170     | DC Silicone 550                                                                                       | (VII) 43-44                 | Dow Corning Corp.                |
| 298     | G.E. Silicone No. 81406<br>(MLO 53-446)                                                               | (VII) 45-47<br>(VIII) 35-36 | General Electric Co.             |
| 316     | Tris-( <i>o</i> -chlorophenyl) phosphate<br>(MLO 9522)                                                | (VII) 62                    | Southwest Research<br>Institute  |
| 336     | DC Silicone, XF258<br>(MLO 9840)                                                                      | (VII) 26-42<br>(VIII) 42    | Wright Air Development<br>Center |
| 337     | Phenyl- <i>o</i> -chlorophenyl phosphate (1:2)<br>(MLO 9579)                                          | (VII) 63                    | Wright Air Development<br>Center |
| 338     | Tris-(chlorophenyl) phosphate (1:1 ortho<br>meta) (MLO 9582)                                          | (VII) 62                    | Wright Air Development<br>Center |
| 339     | Pentaerythritol Ester, Hercules J-19<br>(MLO 55-584)                                                  | (VII) 51-54<br>(VIII) 43-46 | Wright Air Development<br>Center |
| 346     | Tris-( <i>m</i> -chlorophenyl) phosphate<br>(MLO 9533)                                                | (VII) 64-65                 | Wright Air Development<br>Center |
| 347     | Diphenyl- <i>o</i> -chlorophenyl phosphate<br>(MLO 9574)                                              | (VII) 63-64                 | Wright Air Development<br>Center |
| 357     | Tetrakis- <i>n</i> -dodecyl silane<br>(MLO 54-408D)                                                   | (VII) 48-50                 | Metal and Thermit Co.            |
| 366     | Bis-(1-methyl cyclohexylmethyl) sebacate<br>(MLO 55-796-1) First Batch<br>(MLO 55-796-2) Second Batch | (VII) 55<br>(VII) 55-57     | Wright Air Development<br>Center |
| 368     | Silane<br>(MLO 56-280)                                                                                | (VII) 50<br>(VIII) 41-42    | Wright Air Development<br>Center |
| 380     | Fluid F-60 (First Batch)                                                                              | (VIII) 22-24                | Wright Air Development<br>Center |
| 381     | <i>n</i> -Octadecyl-tri- <i>n</i> -octyl silane<br>(MLO 56-578)                                       | (VIII) 39-40                | Wright Air Development<br>Center |
| 382     | Di- <i>n</i> -dodecyl-di- <i>n</i> -octyl silane<br>(MLO 56-611)                                      | (VIII) 38                   | Wright Air Development<br>Center |
| 392     | Versilube F-50 Silicone                                                                               | (VIII) 28-32                | Wright Air Development<br>Center |

| CCL No. | Fluid Medium              | Index        | Source                           |
|---------|---------------------------|--------------|----------------------------------|
| 393     | Fluid F-60 (Second Batch) | (VIII) 25-27 | Dow Corning Corp.                |
| 400     | Mineral Oil, MLO 57-30    | (VIII) 16-21 | Wright Air Development<br>Center |
| 402     | Didodecyl dioctyl silane  | (VIII) 37    | Wright Air Development<br>Center |