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CHEMICAL AND PHYSICAL PROPERTIES OF ASPHALT- RUBBER MIXTURES — PHASE III

VOLUME 2

Prepared by:
J.C. Rosner, Ph.D., P.E.
J.G. Chehovits, P.E.

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16. Abstract

This study had the objective of evaluating the effects of asphalt characteristics on physical properties of asphalt-rubber mixtures. Sixteen different asphalt-rubber mixtures formulated with 2 different asphalts and additions of extender oil (making a total of 4 different binders), and 2 types of granulated reclaimed rubber at 20 and 25 percent concentrations were studied.

Testing procedures utilized included absolute viscosity at 140F, Schweyer Rheometer and force-ductility at 39.2F, and viscosity during mixing by the Torque-Fork and Haake viscometer. All mixtures were produced in the Torque-Fork mixer at 375F using a 1 hour mixing duration. A total of 17 measured or calculated parameters are reported and discussed.

The study concluded that (1) asphalt characteristics significantly influence many physical properties of asphalt-rubber mixtures, and (2) generally, less viscous asphalts result in asphalt-rubber mixtures with lower viscosities, lower failure stresses, higher failure strains, and higher creep compliances. In several cases, interactions between component materials were noted.

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<u>LIST OF APPENDICES</u>

1.0 EXPERIMENT DESCRIPTION.

1.1 The objective of this experiment was to evaluate the effects of asphalt characteristics on physical properties of asphalt-rubber mixtures.

1.2 A laboratory investigation which considered two rubber types, two rubber concentrations, and four asphalt types was performed.

1.2.1 Granulated rubber utilized was produced from two different reclamation processes and materials as follows:

- Ambient grind tread peel crumb (TPO44)
- Ambient grind high natural rubber content devulcanized crumb (GT274).

1.2.2 Each of the two rubber types studied was incorporated into asphalt-rubber mixtures at two concentrations - 20 and 25 percent by weight of total mixture.

1.2.3 The four asphalt types studied were:

- AR4000 with 15 percent extender oil
- AR4000 with 6 percent extender oil
- AR4000 with 2 percent extender oil
- AR1000

1.2.4 Details of asphalts and rubbers studied are contained in the project Summary Report (1).

1.2.5 Asphalt-rubber mixtures were all prepared using a standard mixing procedure in the Arizona Torque-Fork. Details of the mixing procedure are contained in the project Summary Report (1).

1.3 Materials properties assessed in this study are:

- Absolute viscosity at 140F (60C)
- Apparent viscosity and shear rate sensitivity by the Schweyer Rheometer at 39.2F (4C)
- Stress, strain and creep compliance properties at 39.2F (4C) using Force-Ductility
- Viscosity during mixing at 375F (191C) using the Arizona Torque-Fork
- Viscosity during mixing at 375F (191C) using the Haake Rotational Viscometer.

1.3.1 Using the testing procedures described above, a total of 17 different parameters were evaluated, analyzed and reported. Details of testing procedures are contained in the project Summary Report (1).

2.0 EXPERIMENTAL DESIGN AND DATA ANALYSIS

2.1 The experiment was designed as a sequentially randomized three factor fixed factorial model with two replications per cell.

2.1.1 The experimental matrix is presented in Figure 1.

2.1.2 This experiment utilized portions of data reported in Volume I, "Effects of Rubber Type, Concentration, and Asphalt" of this project. Additional data generated for this experiment was randomized by rubber type. Within each rubber type, rubber concentration, asphalt cement, and replication were randomized.

2.1.3 The fixed factor model is:

$$Y_{ijkl} = \mu + R_i + Q_j + A_k + (RQ)_{ij} + (RA)_{ik} + (QA)_{jk} + (RQA)_{ijk} + \varepsilon_{(ijk)l}$$

where:

Y_{ijkl} = Response variable (viscosity, Schweyer constants, etc.) for the i^{th} level of rubber type, j^{th} level of rubber concentration, k^{th} level of asphalt type and l^{th} replication.

μ = Effect of overall mean.

R_i = Effect of rubber type.

Q_j = Effect of rubber concentration.

A_k = Effect of asphalt type.

$(RQ)_{ij}$, $(RA)_{ik}$, $(QA)_{jk}$ = Second order interactions.

$(RQA)_{ijk}$ = Third order interaction.

$\varepsilon_{(ijk)l}$ = Experimental error.

ASPHALT

CONCENTRATION

RUBBER

	GT 274		TP 044	
	20%	25%	20%	25%
AR4000 + 15% Cal.*	— —	— —	— —	— —
AR4000 + 6% Cal.	— —	— —	— —	— —
AR4000 + 2% Cal.	— —	— —	— —	— —
AR1000	— —	— —	— —	— —

* Note: Cal. = Califlux GP

Figure 1 Experimental Test Matrix

2.1.4 Degrees of freedom for the analysis are as follows:

Source	Degrees of Freedom
R_i	1
Q_j	1
A_k	3
$(RQ)_{ij}$	1
$(RA)_{ik}$	3
$(QA)_{jk}$	3
$(RQA)_{ijk}$	3
Error	16
Total	31

2.1.5 Prior to analysis, homogeneity of variance was tested by the Foster and Burr q-test (2). Appropriate data transformations were used when necessary to comply with variance homogeneity constraints required for analysis of variance.

2.2 Levels of Independent Variables

2.2.1 Rubber at two levels as follows:

- TP044
- GT274

2.2.2 Rubber quantities at two levels, 20 and 25 percent by weight of the asphalt-rubber mixture.

2.2.3 Asphalt at four levels:

- AR1000
- AR4000 + 2 percent Califlux by weight of asphalt cement
- AR4000 + 6 percent Califlux by weight of asphalt cement
- AR4000 +15 percent Califlux by weight of asphalt cement

2.3 Following ANOVA, significant effects were ranked using the Newman Keuls multiple range test (3).

3.0 RESULTS AND DISCUSSIONS.

3.1 Absolute Viscosity.

3.1.1 Measured vacuum capillary absolute viscosity results at 140F (60C) are tabulated in Appendix A in Table A-1. Each value tabulated in Table A-1 is the average of viscosity values obtained from several bulbs of one viscometer. Two viscosity tests were performed for each matrix cell replication.

3.1.2 The data which were statistically analyzed are tabulated in Appendix A in Table A-2. Each value tabulated in Table A-2 is the mean of the two measured values in Table A-1. Analyzed data are plotted in Appendix A, Figures A1 through A3.

3.1.3 The ANOVA summary for absolute viscosity is tabulated in Table A-3.

3.1.3.1 Concentration and asphalt were significant effects at the 0.01 level. Rubber type and all interactions were not significant at the 0.05 level.

3.1.4 Newman-Keuls ranking on data collapsed across rubber type shows that mixtures containing 25 percent rubber and AR4000 with 2 percent Califlux (147,178 poise average) have higher absolute viscosities than all other mixtures. All other mixtures were not significantly different (42,110 poise average).

3.2 Schweyer Rheometer Constant, G-tube.

3.2.1 Measured rheometer constants using the G-tube are tabulated in Appendix B in Table B-1.

3.2.2 The measured data did not require transformations to provide for variance homogeneity prior to analysis. Analyzed data are plotted in Appendix B, Figures B1 through B3.

3.2.3 The ANOVA summary for rheometer constant G-tube data is tabulated in Table B-2.

3.2.3.1 None of the main effects or interactions were significant at the 0.05 level.

3.2.4 Analysis indicates that shear suceptibility constants measured in the G-tube of asphalt-rubber mixtures tested were not influenced by component materials. Overall average value was 0.62 indicating that mixtures tested were pseudoplastic.

3.3 Schweyer Rheometer Constant, F-tube.

3.3.1 Measured rheometer constants using the F-tube are tabulated in Appendix C in Table C-1 and plotted in Figures C1 through C3.

3.3.2 Measured data did not require transformation to provide for variance homogeneity for analysis.

3.3.3 The ANOVA summary for rheometer constant, F-tube, is tabulated in Table C-2.

3.3.3.1 The rubber-asphalt interaction was significant at the 0.05 level but not at the 0.01. Other interactions and main effects were not significant at the 0.05 level.

3.3.4 Analysis indicates that shear susceptibility constants measured in the F-tube of asphalt-rubber mixtures tested were not influenced by component materials except for a rubber-asphalt interaction. Overall average value was 1.04 indicating that mixtures tested were very close to being Newtonian in behavior.

3.4 Schweyer Rheometer Apparent Viscosity ($\eta_{0.05}$) at 39.2F (4C), G-tube

3.4.1 Measured apparent viscosity data using the G-tube are tabulated in Appendix D in Table D-1 and plotted in Figures D1 through D3.

3.4.2 In order to satisfy variance homogeneity requirements, logarithmic transformations of the data were required prior to analysis. Log transformed data are tabulated in Appendix D in Table D-2 and plotted in Figures D4 through D6.

3.4.3 The ANOVA summary for apparent viscosity, G-tube is tabulated in Table D-3.

3.4.3.1 Asphalt was significant at the 0.01 level. All other main effects and interactions were not significant at the 0.05 level.

3.4.4 Newman-Keuls ranking of apparent viscosity in the G-tube data collapsed across rubber type and concentration shows that mixtures containing the AR1000 asphalt and the AR4000 with 2 and 6 percent Califlux were not different (62.0×10^6 Pa-s average) and had higher viscosities than mixtures containing AR4000 with 15 percent Califlux (11.8×10^6 Pa-s).

3.5 Schweyer Rheometer Apparent Viscosity ($\eta_{0.05}$) at 39.2F (4C), F-tube

3.5.1 Measured apparent viscosity data using the F-tube are tabulated in Appendix E in Table E-1 and plotted in Figures E1 through E3.

3.5.2 In order to satisfy variance homogeneity requirements, logarithmic transformations of the data were required prior to analysis. Log transformed data are tabulated in Appendix E in Table E-2 and plotted in Figures E4 through E6.

3.5.3 The ANOVA summary for apparent viscosity, F-tube is tabulated in Table E-3.

3.5.3.1 Rubber type and asphalt were significant effects at the 0.05 level. Concentration and all interactions were not significant at the 0.05 level.

3.5.4 Newman-Keuls ranking on apparent viscosity in the F-tube data collapsed across rubber concentration shows the following ranking:

GT274	TPO44
AR4000 + 2%C*	AR4000 + 6%C
AR4000 + 6%C	AR1000
AR1000	AR4000 + 2%C
AR4000 + 15%C	AR4000 +15%C

*Note: C = Califlux
= signifies no significant differences

For GT274 mixtures, apparent viscosities in the F-tube of AR4000 with 2 and 6 percent Califlux were not different (876 x 10^6 Pa-s average), of the AR4000 with 6 percent Califlux and the AR1000 were not different (240 x 10^6 Pa-s average), and of the AR1000 and the AR4000 with 15 percent Califlux were not different (67 x 10^6 Pa-s average).

For TPO44 mixtures containing the AR4000 with 2 and 6 percent Califlux and the AR1000, apparent viscosities in the F-tube were not different 1723 x 10^6 Pa-s average) and were greater than for the AR4000 with 15 percent Califlux (265 x 10^6 Pa-s).

3.6 Force-Ductility Load at Failure at 39.2F (4C)

3.6.1 Measured force ductility load at failure data are tabulated in Appendix F in Table F-1. Three measurements were obtained for each matrix cell replicate.

3.6.2 Analyzed load at failure data are tabulated in Table F-2 and plotted in Figures F1 through F3. Each entry in Table F-2 is the mean of three measurements from Table F-1.

3.6.3 The ANOVA summary for force ductility load at failure is tabulated in Table F-3.

3.6.3.1 All main effects, the rubber-concentration interaction, and the concentration-asphalt interaction were significant at the 0.01 level. Other interactions were not significant at the 0.05 level.

3.6.4 Newman-Keuls ranking shows that mixtures with both rubbers containing the AR4000 with 2 percent Califlux were not different and had the highest loads at failure (20.3 pound average). For each rubber type and concentration investigated, loads at failure are ranked from highest to lowest and are significantly different by asphalt in the following order from highest to lowest:

AR4000 + 2% Califlux
AR4000 + 6% Califlux
AR1000
AR4000 +15% Califlux

except that the 20 percent GT274 mixtures containing the AR4000 with 6 percent Califlux and the AR1000 are not different.

3.7 Force-Ductility Elongation at Failure at 39.2F (4C)

3.7.1 Measured force ductility elongation at failure data are tabulated in Appendix G in Table G-1. Three measurements were obtained for each matrix cell replicate.

3.7.2 Elongation at failure data which were analyzed are tabulated in Table G2 and plotted in Figures G1 through G3. Each entry in Table G-2 is the mean of two values from Table G-1.

3.7.3 The ANOVA summary for elongation at failure is tabulated in Table G-3.

3.7.3.1 All main effects and interactions were significant at the 0.01 level except for the rubber-asphalt interaction which was not significant at the 0.05 level.

3.7.4 Newman-Keuls ranking shows that the mixture of AR4000 with 15 percent Califlux and 20 percent GT274 rubber had the highest elongation at failure (623.2 mm). Elongations at failure of mixtures containing TPO44 rubber with all asphalts and at both rubber concentrations were not significantly different (209.6 mm average) but were lower than for all GT274 mixtures.

3.7.5 An asphalt-concentration interaction exists with GT274 rubber mixtures in that elongation at failure ranking orders are different at 20 and 25 percent rubber. Ranking orders from highest to lowest are as follows for GT274 mixtures:

20% GT274	25% GT274
AR4000 + 15% Califlux	AR1000
AR1000	AR4000 + 2% Califlux
AR4000 + 6% Califlux	AR4000 + 6% Califlux
AR4000 + 2% Califlux	AR4000 + 15% Califlux

*Note: signifies no significant difference

At 25 percent GT274, additions of Califlux from 2 to 15 percent to the AR4000 do not influence elongation at failure, while with 20 percent rubber, Califlux additions do influence results.

3.8 Force-Ductility Engineering Stress at Failure at 39.2F (4C)

3.8.1 Calculated engineering stress at failure data are tabulated in Appendix H in Table H-1. Three determinations were obtained for each matrix cell replication.

3.8.2 Engineering stress at failure data which were analyzed are tabulated in Table H-2 and plotted in Figures H1 through H3. Each entry in Table H-2 is the mean of three values in Table H-1.

3.8.3 The ANOVA summary for engineering stress at failure is tabulated in Table H-3.

3.8.3.1 Rubber-asphalt interaction and rubber-concentration-asphalt interaction were not significant at the 0.05 level. All main effects and other interactions were significant at the 0.01 level.

3.8.4 Newman-Keuls ranking shows that the mixture containing AR4000 with 2 percent Califlux and 25 percent TP044 rubber had the highest engineering stress at failure (138 psi) while the 20 percent GT274 mixture with AR4000 and 15 percent Califlux had the lowest (31.2 psi). For each rubber type and concentration investigated engineering stress at failure means are ranked from highest to lowest by asphalt in the following order:

AR4000 + 2% Califlux
AR4000 + 6% Califlux
AR1000
AR4000 + 15% Califlux

except that with GT274 mixtures, differences are not noted between the AR4000 with 6 percent Califlux and the AR1000 mixtures. With the 25 percent TP044 mixtures differences are not noted between mixtures containing the AR4000 with 2 and 6 percent Califlux.

3.9 Force-Ductility Engineering Strain at Failure at 39.2F (4C)

3.9.1 Calculated engineering strain at failure values are tabulated in Appendix I in Table I-1. Three determinations were obtained for each matrix cell replication.

3.9.2 Engineering strain at failure data which were analyzed are tabulated in Table I-2 and are plotted in Figures I1 through I3. Each entry in Table I-2 is the mean of three values from Table I-1.

3.9.3 The ANOVA summary for engineering strain at failure is tabulated in Table I-3.

3.9.3.1 All main effects and interactions were significant at the 0.01 level except for the rubber-asphalt interaction which was significant at the 0.05 level but not at 0.01.

3.9.4 Newman-Keuls ranking shows that the mixture of AR4000 with 15 percent Califlux and 20 percent GT274 rubber had the highest engineering strain at failure (10.47 mm/mm). Engineering strain at failure of mixtures containing TP044 rubber with all asphalts and at both rubber concentrations (4.01 mm/mm average) were lower than for all GT274 mixtures. An asphalt-concentration interaction exists with GT274 rubber in that mean engineering strain at failure ranking orders are different at 20 and 25 percent rubbers. The interaction is the same as discussed in Section 3.7.5 of this report.

3.10 Force-Ductility True Stress at Failure at 39.2F (4C)

3.10.1 Calculated force-ductility true stress at failure data are tabulated in Appendix J in Table J-1. Three determinations were obtained for each matrix cell replication.

3.10.2 Analyzed true stress at failure data are tabulated in Appendix J in Table J-2 and plotted in Figures J1 through J3. Each entry in Table J-2 is the mean of three values from Table J-1.

3.10.3 The ANOVA summary for true stress at failure data is tabulated in Table J-3.

3.10.3.1 All main effects and interactions were significant at the 0.01 level except for the rubber-concentration interaction which was significant at the 0.05 level, but not at 0.01 and the three-way interaction which was not significant at the 0.05 level.

3.10.4 Newman-Keuls ranking shows that AR4000 with 2 percent Califlux mixtures with 20 and 25 percent GT274 rubber had the highest true stress at failure (987 psi average) while the 20 percent TPO44 mixture with AR4000 and 15 percent Califlux had the lowest (258 psi). Mean ranking orders from highest to lowest for each rubber and concentration are:

GT274		TPO44	
20%	25%	20%	25%
AR4000 +2%C*	AR4000 +2%C	AR4000 +2%C	AR4000 +6%C
AR4000 +6%	AR1000	AR4000 +6%C	AR4000 +2%C
AR1000	AR4000 +6&C	AR1000	AR1000
AR4000 +15%C	AR1000 +15%C	AR4000 +15%C	AR4000 + 15%C

*Note: C = Califlux

= signifies no significant difference.

For each rubber type and concentration, AR4000 with 15 percent Califlux results in lowest true stress at failure while AR4000 + 2 percent Califlux results in the highest except for TPO44 at 25 percent for which AR4000 + 6 percent Califlux resulted in the highest true stress at failure. For the 25 percent TPO44 mixtures, differences are not noted between the AR4000 with 6 percent Califlux and the AR1000 mixtures.

3.11 Force-Ductility True Strain at Failure at 39.2F (4C)

3.11.1 True strain at failure data are tabulated in Appendix K in Table K-1. Three determinations were obtained for each matrix cell replication.

3.11.2 Analyzed true strain at failure data are tabulated in Appendix K in Table K-2 and plotted in Figures K1 through K3. Each entry in Table K-2 is the mean of three values from Table K-1.

3.11.3 The ANOVA summary for true strain at failure is tabulated in Table K-3.

3.11.3.1 All main effects and interactions were significant at the 0.01 level except for the rubber-concentration interaction which was significant at the 0.05 level but not at the 0.01 and the rubber-asphalt interaction which was not significant at the 0.05 level.

3.11.4 Newman-Keuls ranking shows that the 20 percent GT274 mixture containing AR4000 with 15 percent Califlux had the highest true strain at failure (2.44 mm/mm) while the 25 percent TPO44 mixture containing AR4000 with 2 percent Califlux had the lowest (1.51 mm/mm). Mixtures containing TPO44 rubber with all asphalts and both concentrations had lower true strains at failure than all GT274 mixtures. An asphalt-concentration interaction exists for GT274 rubber in that mean true strain at failure ranking orders are different at 20 and 25 percent rubbber. The interaction is the same as discussed in Section 3.7.5 of this report.

3.12 Force-Ductility Engineering Creep Compliance at Failure at 39.2F (4C)

3.12.1 Engineering creep compliance data are tabulated in Appendix L in Table L-1. Three determinations were made for each matrix cell replication.

3.12.2 Engineering creep compliance at failure data which were analyzed are tabulated in Table L-2 and plotted in Figures L1 through L3. Each entry in Table L-2 is the mean of three values from Table L-1.

3.12.3 The ANOVA summary for engineering creep compliance at failure is tabulated in Table L-3.

3.12.3.1 All main effects and interactions were significant at the 0.01 level.

3.12.4 Newman-Keuls ranking shows that the 20 percent GT274 mixture containing AR4000 with 15 percent Califlux had the highest engineering creep compliance at failure (0.3389 psi^{-1}) while the 25 percent TPO44 mixtures containing the AR1000 and the AR4000 with 2 and 6 percent Califlux had the lowest (0.0307 psi^{-1} average). For each rubber and concentration investigated, engineering creep compliance at failure means are ranked from highest to lowest by asphalt in the following order:

AR4000 + 15% Califlux
AR1000
AR4000 + 6% Califlux
AR4000 + 2% Califlux

With GT274 mixtures at 20 percent, results differ significantly for each asphalt, while at 25 percent, AR4000 with 2 and 6 percent Califlux give the same results. With TPO44 mixtures at 20 percent, AR4000 with 6 percent Califlux and AR1000 give results which are not different while at 25 percent, AR1000, and AR4000 with 2 and 6 percent Califlux give results which are not different.

3.13 Force-Ductility True Creep Compliance at Failure at 39.2F (4C)

3.13.1 Calculated true creep compliance data are tabulated in Appendix M in Table M-1. Three determinations were made for each matrix cell replication.

3.13.2 Analyzed true creep compliance data are tabulated in Table M-2 and plotted in Figures M1 through M3. Each entry in Table M-2 is the mean of three values in Table M-1 times 100. Data were multiplied by 100 for analysis to reduce error due to truncation of very small numbers during calculations.

3.13.3 The ANOVA summary for true creep compliance at failure is tabulated in Table M-3.

3.13.3.1 Except for rubber type, all main effects and two-way interactions were significant at the 0.01 level. Rubber and the three-way interaction were not significant at the 0.05 level.

3.13.4 Newman-Keuls ranking on data collapsed across rubber type shows that at each rubber concentration, mixtures containing the AR4000 with 15 percent Califlux had higher true creep compliance at failure than mixtures containing the other asphalts (0.006825 psi^{-1} average at 20 percent rubber and 0.001886 psi^{-1} at 25 percent rubber). At 25 percent rubber, mixtures containing the AR4000 with 6 and 2 percent Califlux and the AR1000 had engineering creep compliance at failure values which were not different (0.002658 psi^{-1} average). At 20 percent rubber, true creep compliance at failure for AR1000 mixtures (0.003863 psi^{-1} average) were higher than those of the AR4000 with 2 and 6 percent Califlux which were the same (0.002825 psi^{-1} average).

3.14 Force-Ductility Maximum True Creep Compliance at 39.2F (4C)

3.14.1 Maximum true creep compliance data are tabulated in Appendix N in Table N-1. Three determinations were made for each matrix cell replication.

3.14.2 Analyzed maximum true creep compliance data are tabulated in Appendix N in Table N-2 and plotted in Figures N1 through N12. Each entry in Table N-2 is the mean of three values in Table N-1.

3.14.3 The ANOVA summary for maximum true creep compliance data is tabulated in Table N-3.

3.14.3.1 All main effects and interactions were significant at the 0.01 level except for the three-way interaction which was not significant at the 0.05 level.

3.14.4 Newman-Keuls ranking shows that the 20 percent GT274 mixture containing the AR4000 with 15 percent Califlux had the highest maximum true creep compliance (0.0161 psi^{-1}), while mixtures containing 20 and 25 percent TPO44 rubber and AR4000 with 2 percent Califlux which were not different had the lowest (0.00356 psi^{-1} average). For each rubber type and concentration, mean maximum true creep compliance values are ranked from highest to lowest by asphalt type as follows:

AR4000 + 15% Califlux
AR1000
AR4000 + 6% Califlux
AR4000 + 2% Califlux

Within each rubber and concentration grouping, mixtures with different asphalts are significantly different from each other.

3.15 Force-Ductility Time to Maximum True Creep Compliance

3.15.1 Time to maximum true creep compliance data are tabulated in Appendix O in Table O-1. Three determinations were made for each matrix cell replication.

3.15.2 Analyzed time to maximum true creep compliance data are tabulated in Appendix N in Table O-2 and plotted in Figures O1 through O12. Each entry in Table O-2 is the mean of three values in Table O-1.

3.15.3 The ANOVA summary for time to maximum true creep compliance data is tabulated in Table O-3.

3.15.3.1 All main effects and the rubber-asphalt interaction were significant at the 0.01 level. Other interactions were not significant at the 0.05 level.

3.15.4 Newman-Keuls ranking shows that the 20 percent GT274 mixtures containing AR4000 with 2 and 6 percent Califlux were not different and had the longest time to maximum true creep compliance (12.9 minute average), while the 25 percent TPO44 mixture with AR1000 had the shortest (7.15

minutes). Ranking for each rubber and rubber concentration from longest to shortest by asphalt type is:

GT274				TPO44			
20%		25%		20%		25%	
AR4000	+6%C*	AR4000	+2%C	AR4000	+15%C	AR4000	+6%C
AR4000	+2%	AR4000	+6%C	AR4000	+2%C	AR4000	+2%C
AR1000		AR1000		AR4000	+6%C	AR4000	+15%C
AR4000	+15%C	AR4000	+15%C	AR1000		AR1000	

*Note: C = Califlux
= signifies no significant difference

3.16 Arizona Torque-Fork Viscosity During Mixing at 375F (191C).

3.16.1 Measured mixing viscosity data at 15 minutes and 1 hour by the Torque-Fork are tabulated in Appendix P in Table P-1 and plotted in Figures P1 and P2. Since measurements were not replicated, statistical analysis could not be performed.

3.16.2 Differences in viscosity due to asphalt type are noted in Figures P1 and P2 for each rubber type and concentration investigated. For GT274 mixtures, at both 20 and 25 percent rubber, AR1000 and AR4000 with 2 percent Califlux give higher mixing viscosities as measured by the Torque-Fork than the AR4000 with 6 or 15 percent Califlux. For 20 percent TPO44 mixtures, AR1000 gave the lowest mixing viscosity while at 25 percent rubber, AR1000 resulted in the highest mixing viscosity which may indicate a concentration-asphalt interaction.

3.17 Haake Viscosity During Mixing at 375F (191C).

3.17.1 Measured mixing viscosity data at 15 minutes and 1 hour by the Haake viscometer are tabulated in Appendix Q in Table Q-1 and plotted in Figures Q1 and Q2. Since measurements were not replicated statistical analysis could not be performed.

3.17.2 Differences in viscosity due to asphalt type are noted in Figures Q1 and Q2 for each rubber type and concentration investigated. Greater differences due to asphalt are noted with GT274 rubber than with TPO44 rubber.

4.0 CONCLUSIONS

4.1 A summary of three-way ANOVA results is tabulated in Table 1. This table indicates independent variables and interactions which were found to significantly affect test parameters studied. From Table 1 it is noted that except for shear susceptibility constants obtained from the Schweyer Rheometer, different asphalt cements resulted in asphalt-rubber mixtures with significantly different physical properties.

4.2 With many of the parameters investigated only slight or no differences were noted with results obtained from the AR1000 and the AR4000 with 6 percent Califlux.

4.3 Apparent viscosity as measured by the Schweyer Rheometer is less for asphalt-rubber mixtures containing the AR4000 with 15 percent Califlux than for the other asphalts.

4.4 In the force-ductility test, load and stress at failure are highest for the stiffest asphalt (AR4000 with 2 percent Califlux) and lowest for the least viscous asphalt (AR4000 with 15 percent Califlux) for all but one mixture.

4.5 In the force-ductility test, elongation or strain at failure for TP044 mixtures is not influenced by asphalt as much as for GT274 mixtures. An asphalt-concentration interaction exists for GT274 mixtures in that at 20 percent rubber, less viscous asphalts result in higher failure strains or elongations, while, at 25 percent rubber, the least viscous asphalt (AR4000 with 15 percent Califlux) resulted in the lowest failure strain and elongation.

4.6 Creep compliance as determined in the force-ductility test was highest for the asphalt-rubber mixtures containing the least viscous asphalt (AR4000 with 15 percent Califlux) and lowest for the stiffest (AR4000 with 2 percent Califlux).

4.7 Viscosities during mixing at 375F as measured by the Torque-Fork or Haake viscometer are generally lower for the lower viscosity asphalts but several interactions between asphalt, rubber type, and rubber concentration appear to exist.

Table 1

Summary of Three-Way ANOVA Results
at the 0.05 Level of Significance

TEST PARAMETER \ EFFECT	R	Q	A	RQ	RA	QA	RQA
ABSOLUTE VISCOSITY (140F)	-*	Y	Y	-	-	-	-
SCHWEYER RHEOMETER (39.2F)							
Constant(C), G-tube	-	-	-	-	-	-	-
Constant(C), F-tube	-	-	-	-	Y	-	-
App. Viscosity, G-tube	-	-	Y	-	-	-	-
App. Viscosity, F-tube	Y	-	Y	-	-	-	-
FORCE DUCTILITY (39.2F)							
Load at Failure	Y	Y	Y	Y	-	Y	-
Elongation at Failure	Y	Y	Y	Y	-	Y	Y
Eng. Stress at Failure	Y	Y	Y	Y	-	Y	-
Eng. Strain at Failure	Y	Y	Y	Y	Y	Y	Y
True Stress at Failure	Y	Y	Y	Y	Y	Y	-
True Strain at Failure	Y	Y	Y	Y	-	Y	Y
Eng. Creep Compliance	Y	Y	Y	Y	Y	Y	Y
True Creep Compliance	-	Y	Y	Y	Y	Y	-
Max.True Creep Compliance	Y	Y	Y	Y	Y	Y	-
Time to Max.T.Creep Compl.	Y	Y	Y	-	Y	-	-

*Note: Y = Significant at the 0.05 level
- = Not significant at the 0.05 level

References

1. Rosner, J. C. and Chehovits, J. G., "Chemical and Physical Properties of Asphalt-Rubber, Phase III - Summary Report, April, 1982.

2. Burr, I. W., Applied Statistical Methods, Academic Press, Inc., New York, 1974.

APPENDIX A

VACUUM CAPILLARY ABSOLUTE VISCOSITY AT 140F (60C)

TABLE A-1
Absolute Viscosity (140F), Poise

a. Measured Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	14135	49157	19157	30373
	14406	56133	19247	13536
	14119	49854	14547	32957
	15066	48818	12947	47655
AR4000 + 6% Extender Oil	23491	59886	24086	39160
	25446	67721	19544	55868
	25926	64117	23020	83741
	23691	62883	24823	51601
AR4000 + 2% Extender Oil	57678	148695	99636	122329
	59360	139532	21892	92521
	58363	149752	37639	160806
	63662	148516	38442	215266
AR1000	30421	96104	23766	18262
	35608	112326	26401	20545
	42063	85615	7805	110166
	23686	27257	9084	125270

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	14431.5	50990.5	16474.5	31130.3
	S	460.24	3555.09	3061.80	16581.83
	CV	3.18	6.97	18.58	53.26
AR4000 + 6% Extender Oil	$\overline{X}$	24638.5	63651.3	22868.3	57592.5
	S	1183.41	3807.81	2565.59	21666.37
	CV	4.80	5.98	11.21	37.62
AR4000 + 2% Extender Oil	$\overline{X}$	59765.8	146623.8	49402.3	147730.5
	S	2908.22	4966.92	37783.58	59654.07
	CV	4.86	3.38	76.48	40.38
AR1000	$\overline{X}$	39244.5	80325.5	16764	68560.8
	S	8931.22	41343.53	9037.66	52005.89
	CV	27.10	51.4	53.91	75.85

TABLE A-2

Absolute Viscosity (140F), Poise

a. Analyzed Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	14271	52645	19202	21955
	14593	49336	13747	40306
AR4000 + 6% Extender Oil	24469	63804	21815	47514
	24809	63500	23922	67671
AR4000 + 2% Extender Oil	58519	144114	60764	107425
	61013	149134	38041	188036
AR1000	33015	104215	25084	19404
	32875	56436	8445	117718

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\bar{X}$	14432.0	50990.5	16474.5	31130.5
	S	285.29	2931.77	4833.13	16258.99
	CV	1.98	5.75	29.34	52.23
AR4000 + 6% Extender Oil	$\bar{X}$	24639.0	63652.0	22868.5	57592.5
	S	301.24	269.34	1866.80	17859.10
	CV	1.22	.42	8.16	31.01
AR4000 + 2% Extender Oil	$\bar{X}$	59766.0	146624.0	49402.5	147730.5
	S	2209.68	4447.72	20132.58	71421.35
	CV	3.70	3.03	40.75	48.35
AR1000	$\bar{X}$	32945.0	80325.5	16764.5	68561.0
	S	124.04	42332.19	14742.15	87106.20
	CV	.38	52.70	87.94	127.05

TABLE A-3

ANOVA Summary, Absolute Viscosity (140F)

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	493757456	493757456	.79	4.49	8.53
Q	1	20942294988	20942294988	33.41	4.49	8.53
A	3	24102248214	8034082738	12.82	3.24	5.29
RQ	1	13275416	13275416	.02	4.49	8.53
RA	3	128936183	42978727	.07	3.24	5.29
QA	3	5152706063	1717568687	2.74	3.24	5.29
RQA	3	311313075	103771025	.17	3.24	5.29
Error	16	10029880674	626867542			
TOTAL	31	61174412073				

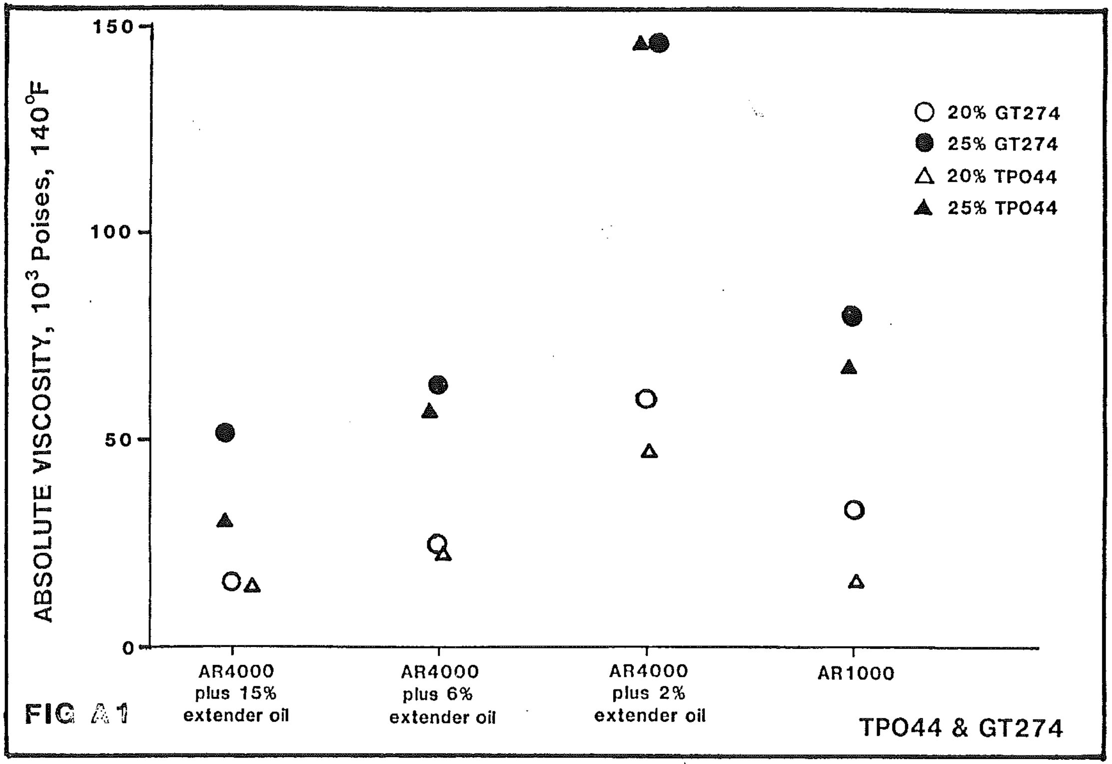


FIG A1

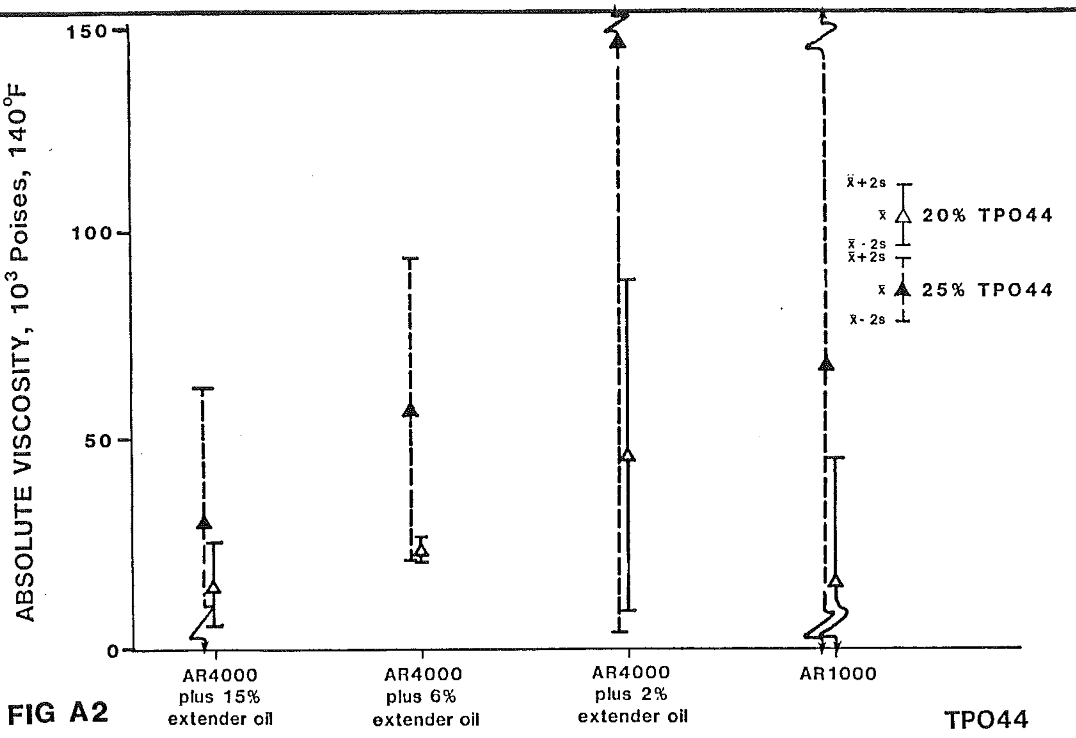

ABSOLUTE VISCOSITY, 10³ Poises, 140°F
150
100
50
0
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
TPO44

FIG A2

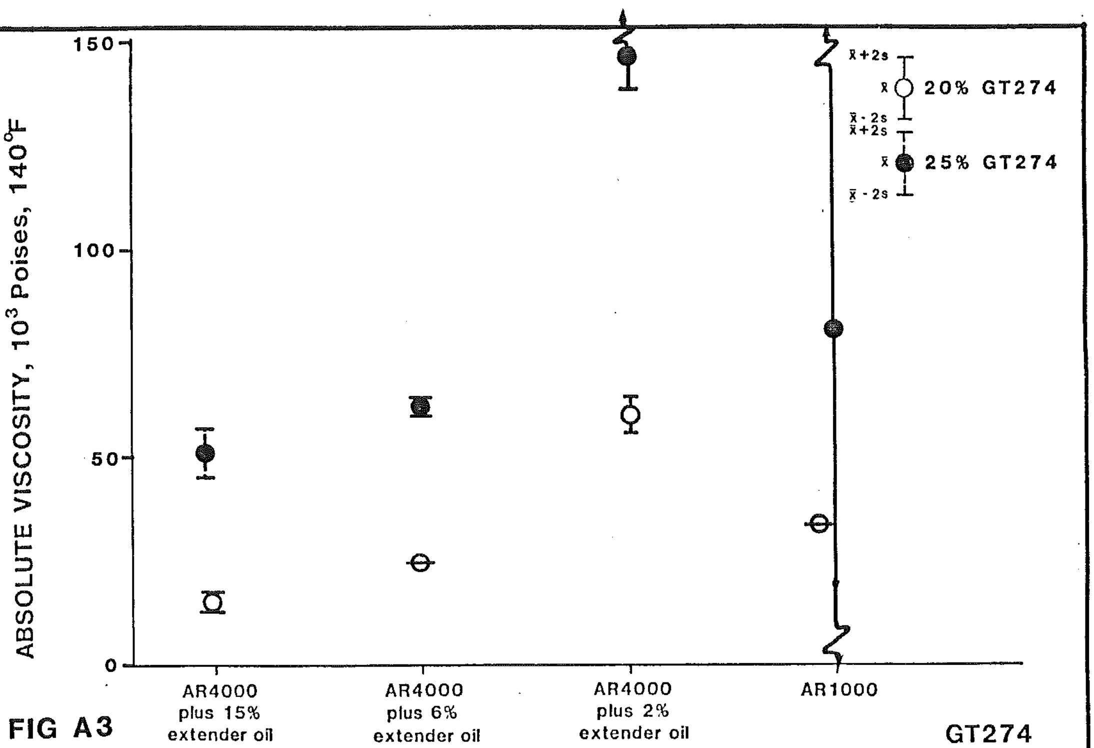

ABSOLUTE VISCOSITY, 10³ Poises, 140°F
150
100
50
0
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
GT274

FIG A3

APPENDIX B

SCHWEYER RHEOMETER CONSTANT

(C), G-TUBE

TABLE B-1

Schweyer Rheometer Constant (C), G-tube

a. Measured and Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.37	1.2	.57	.43
	.52	.49	.66	.57
AR4000 + 6% Ext. Oil	.47	.46	.78	.76
	.56	.49	.70	.76
AR4000 + 2% Ext. Oil	.44	.48	.52	.54
	.41	.46	.91	.61
AR1000	.57	.43	.74	1.5
	.61	.71	.29	.74

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	.45	.85	.62	.50
+ 15%	S	.133	.629	.080	.124
Extender Oil	CV	29.87	74.44	12.97	24.81
AR4000	$\overline{X}$	.52	.48	.74	.76
+ 6%	S	.080	.027	.071	0
Extender Oil	CV	15.48	5.60	9.58	0
AR4000	$\overline{X}$	.43	.47	.72	.58
+ 2%	S	.027	.018	.346	.062
Extender Oil	CV	6.25	3.77	48.33	10.79
AR1000	$\overline{X}$	.59	.57	.52	1.12
	S	.035	.248	.399	.673
	CV	6.01	43.52	77.42	60.12

TABLE B-2

ANOVA Summary, Schweyer Rheometer Constant (C), G-tube

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.1815031	.1815031	3.66	4.49	8.53
Q	1	.0712531	.0712531	1.44	4.49	8.53
A	3	.0957344	.0319110	.64	3.24	5.29
RQ	1	.0000281	.0000281	.00057	4.49	8.53
RA	3	.1546844	.0515600	1.04	3.24	5.29
QA	3	.1451844	.0483948	.98	3.24	5.29
RQA	3	.3468094	.1156031	2.33	3.24	5.29
Error	16	.7940500	.0496281			
TOTAL	31	1.7892469				

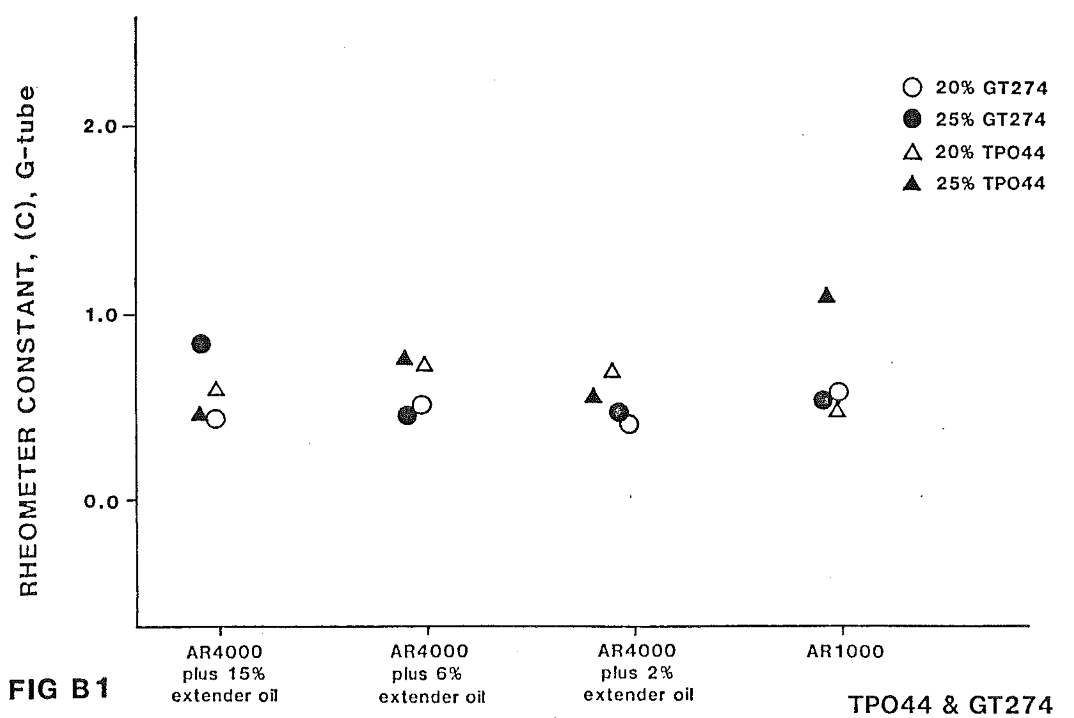


FIG B1

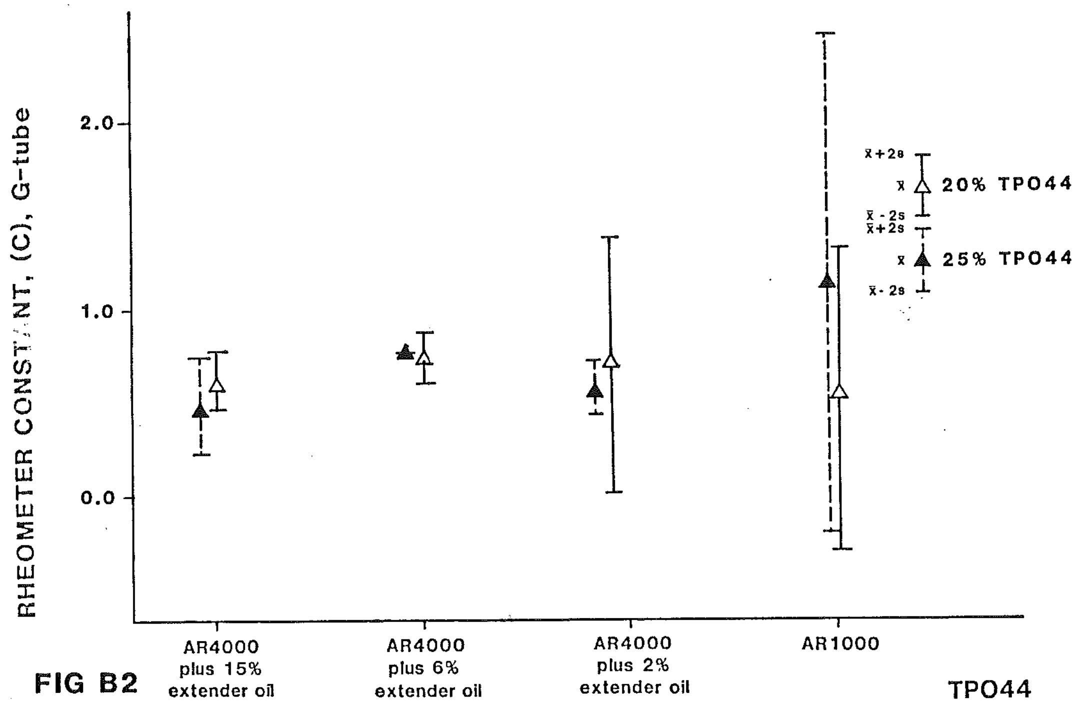

RHEOMETER CONSTANT, (C), G-tube
2.0
1.0
0.0
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG B2

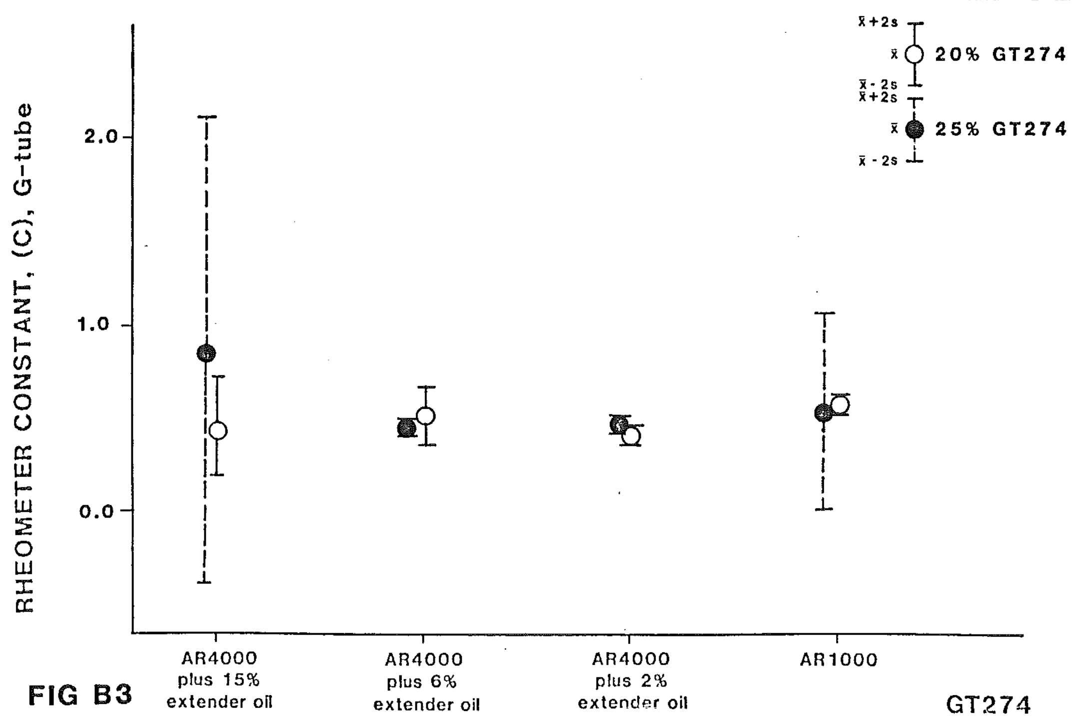

RHEOMETER CONSTANT, (C), G-tube
2.0
1.0
0.0
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG B3

APPENDIX C

SCHWEYER RHEOMETER CONSTANT

(C), F-TUBE

TABLE C-1

Schweyer Rheometer Constant (C), F-tube

a. Measured and Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.59	.75	1.3	1.4
	1.1	.81	1.4	1.4
AR4000 + 6% Ext. Oil	1.3	1.1	.84	.86
	1.1	1.2	1.8	.94
AR4000 + 2% Ext. Oil	.90	1.1	.68	1.1
	1.7	1.5	.59	.70
AR1000	1.1	.75	.13	1.1
	.92	.82	.98	.98

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	.85	.78	1.35	1.40
	S	.452	.053	.089	0
	CV	53.47	6.82	6.56	0
AR4000 + 6% Extender Oil	$\overline{X}$	1.20	1.15	1.32	.90
	S	.177	.089	.851	.071
	CV	14.77	7.70	64.44	7.88
AR4000 + 2% Extender Oil	$\overline{X}$	1.30	1.30	.73	.90
	S	.709	.354	.239	.354
	CV	54.52	27.26	33.00	39.38
AR1000	$\overline{X}$	1.01	.79	.56	1.04
	S	.159	.062	.753	.106
	CV	15.79	7.90	35.69	10.22

TABLE C-2

ANOVA Summary, Schweyer Rheometer Constant (C), F-tube

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.0091125	.0091125	.10	4.49	8.53
Q	1	.0002000	.0002000	.002	4.49	8.53
A	3	.4003125	.1334375	1.43	3.24	5.29
RQ	1	.0648000	.0648000	.69	4.49	8.53
RA	3	1.2192625	.4064208	4.34	3.24	5.29
QA	3	.1792750	.0597583	.64	3.24	5.29
RQA	3	.2974250	.0991417	1.06	3.24	5.29
Error	16	1.4970000	.0935625			
TOTAL	31	3.6673875				

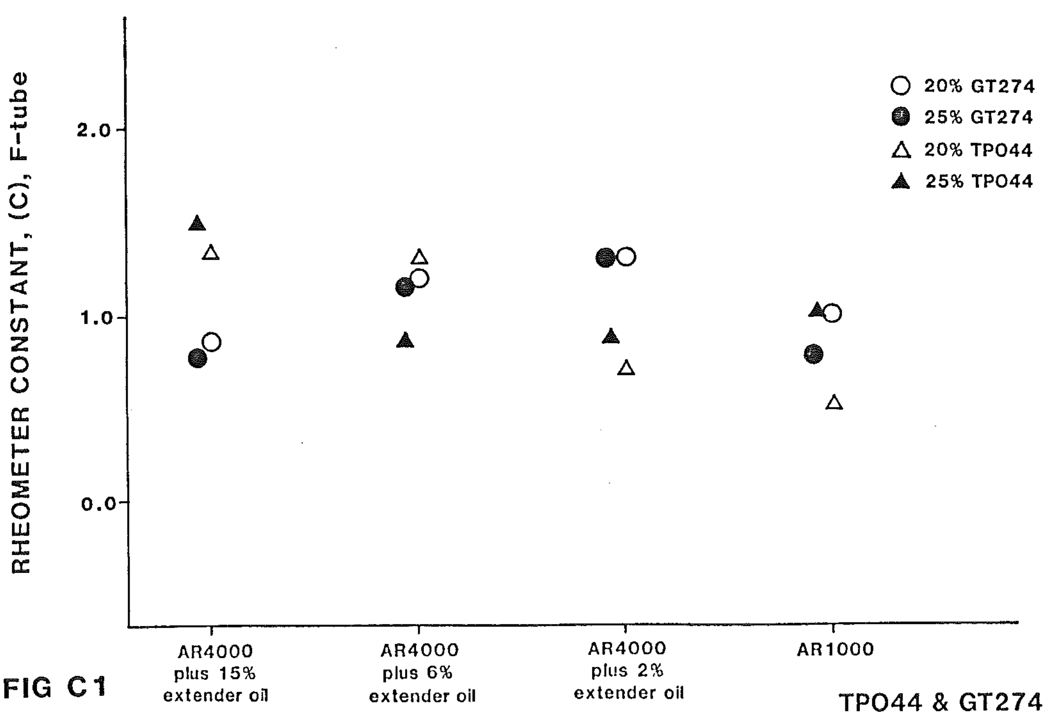
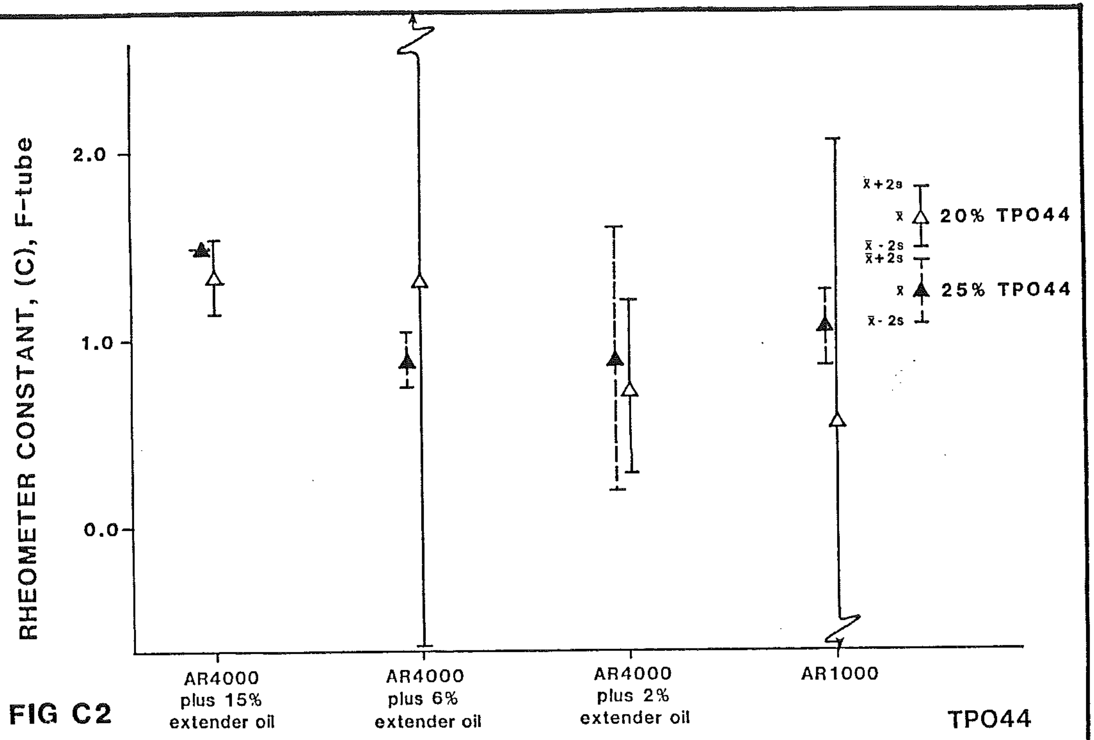
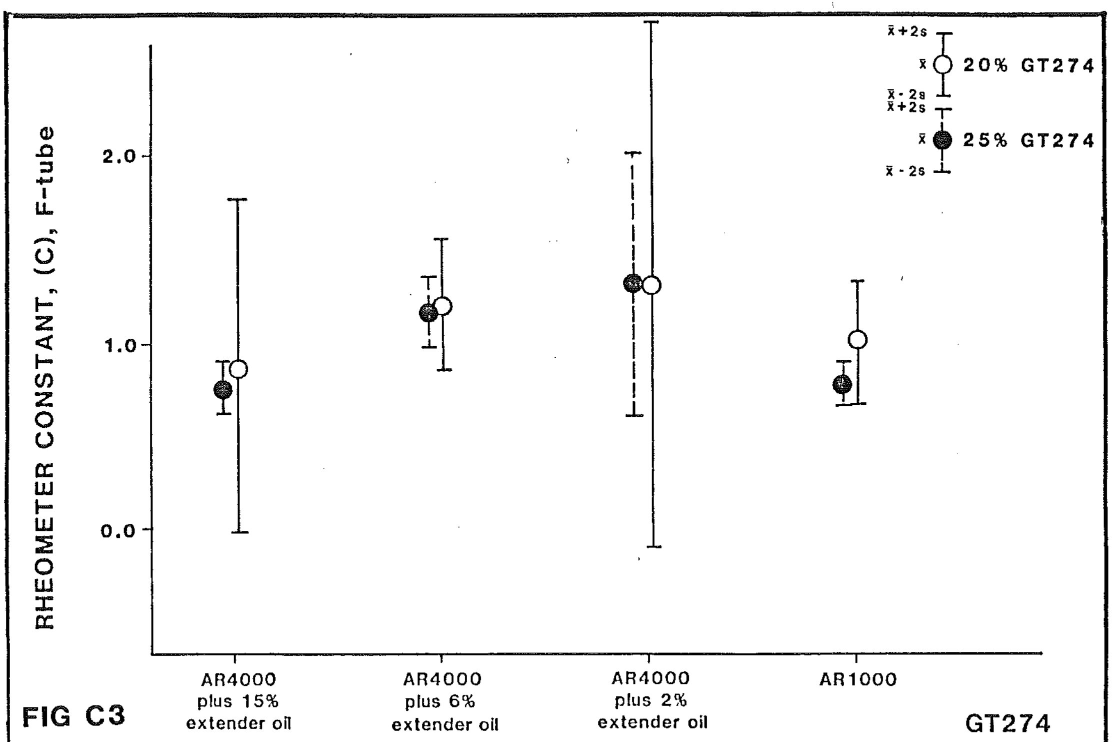


FIG C1



RHEOMETER CONSTANT, (C), F-tube
2.0
1.0
0.0
x̄+2s
x̄
20% TPO44
x̄-2s
x̄+2s
x̄
25% TPO44
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG C2



RHEOMETER CONSTANT, (C), F-tube
2.0
1.0
0.0
x̄+2s
x̄
20% GT274
x̄-2s
x̄+2s
x̄
25% GT274
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG C3

APPENDIX D

VISCOSITY ($\eta_{0.05}$) BY SCHWEYER

RHEOMETER AT 39.2F (4C), G-TUBE

TABLE D-1

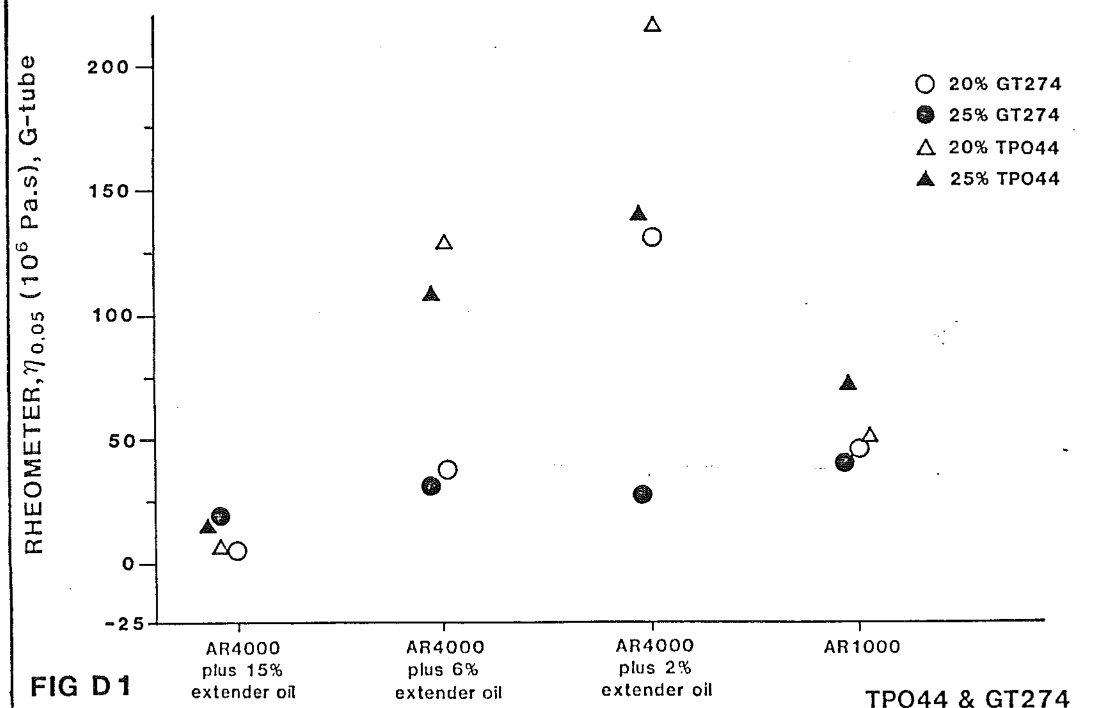
Schweyer Rheometer Apparent Viscosity, $\eta_{0.05}$, 10^6 Pa-s, G-tube

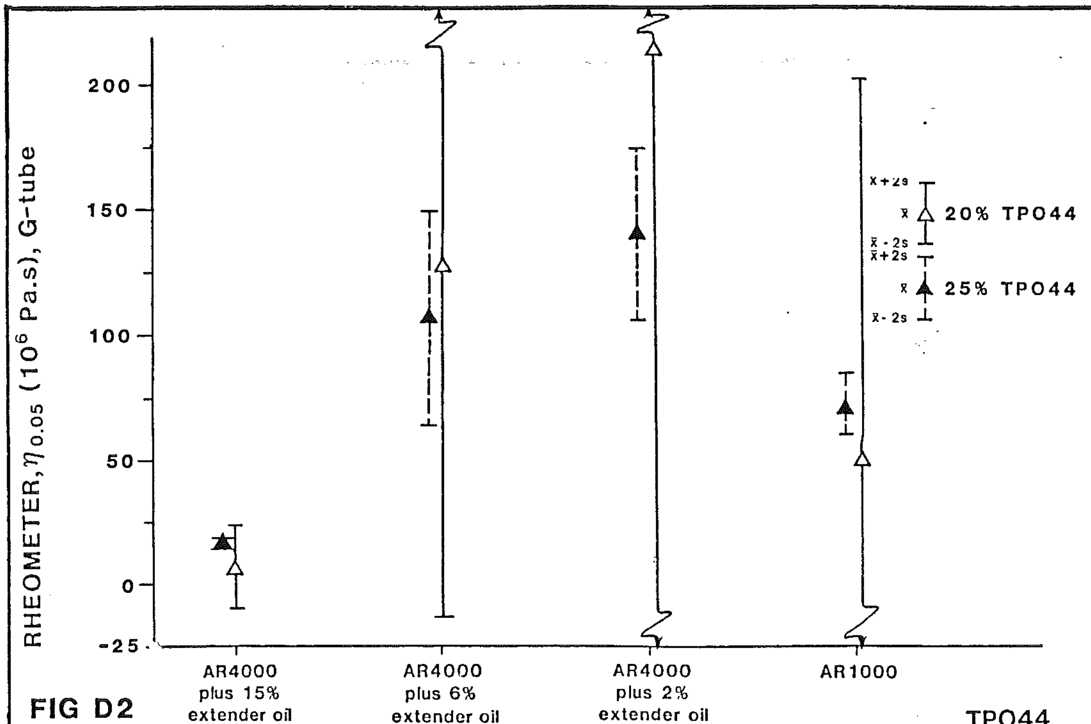
a. Measured Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	3.1	28	12	15
	8.8	6.9	24	17
AR4000 + 6% Ext. Oil	27	17	170	95
	47	44	89	120
AR4000 + 2% Ext. Oil	140	34	24	130
	120	21	410	150
AR1000	30	35	95	76
	60	42	8.8	69

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	5.95	17.5	7.2	16.0
+ 15%	S	5.05	18.69	8.51	1.77
Extender Oil	CV	84.88	107.13	118.13	11.08
AR4000	$\overline{X}$	37.0	30.5	129.5	107.5
+ 6%	S	17.72	23.92	71.77	22.15
Extender Oil	CV	47.89	78.43	55.42	20.60
AR4000	$\overline{X}$	130.0	27.5	217.0	140.0
+ 2%	S	17.72	11.52	342.00	17.72
Extender Oil	CV	13.63	41.88	157.60	12.66
AR1000	$\overline{X}$	45.0	38.5	51.9	72.5
	S	26.58	6.20	76.37	6.20
	CV	59.07	16.11	147.15	8.55


RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), G-tube
200
150
100
50
0
-25
20% GT274
25% GT274
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44 & GT274
FIG D1


RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), G-tube
200
150
100
50
0
-25
$\bar{x}+2s$
$\bar{x}$
20% TPO44
$\bar{x}-2s$
$\bar{x}+2s$
$\bar{x}$
25% TPO44
$\bar{x}-2s$
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44
FIG D2

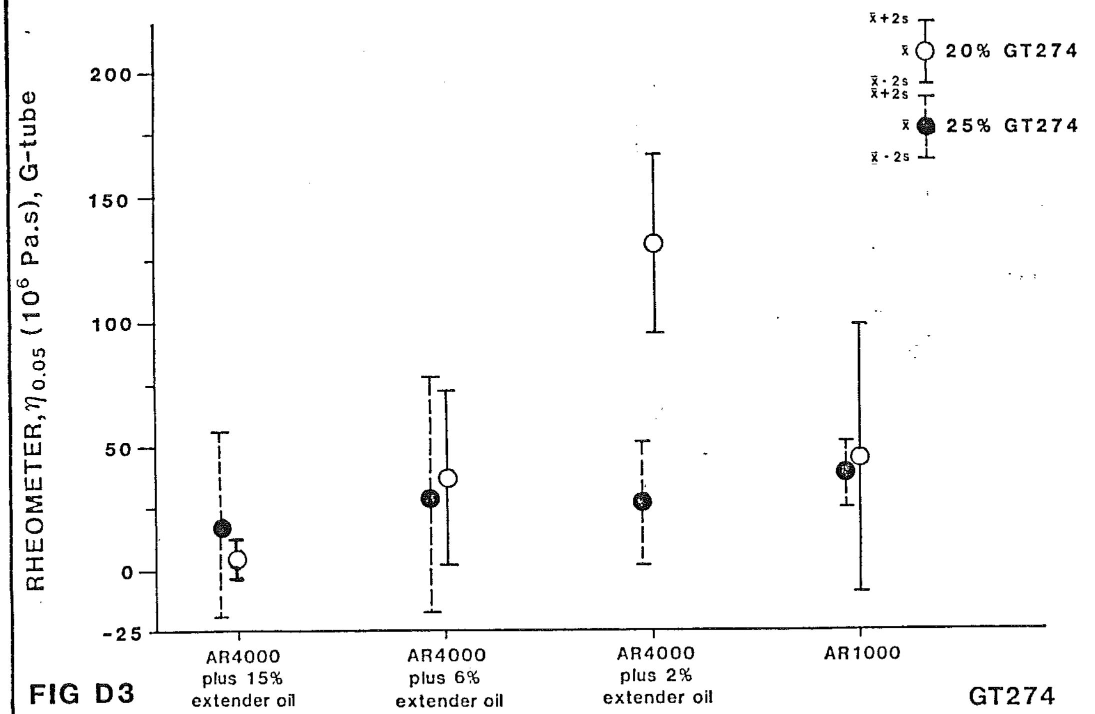

x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), G-tube
200
150
100
50
0
-25
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG D3

TABLE D-2

Schweyer Rheometer, Log Apparent Viscosity, $\eta_{0.05}$, 10^6 Pa-s, G-tube

a. Analyzed Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	.49136	1.44716	1.07918	1.17609
	.94448	.838849	1.38021	1.23045
AR4000 + 6% Extender Oil	1.4314	1.23045	2.23045	1.97772
	1.6721	1.64345	1.94939	2.07918
AR4000 + 2% Extender Oil	2.1461	1.53148	1.38021	2.11394
	2.0792	1.32222	2.61278	2.17609
AR1000	1.4771	1.54407	1.97772	1.88081
	1.7782	1.62325	.944483	1.83885

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	.17792	1.14300	.72970	1.20327
	S	.40147	.53896	.61929	.04816
	CV	55.92	47.15	84.87	4.00
AR4000 + 6% Extender Oil	$\overline{X}$	1.55173	1.43695	2.08992	2.02845
	S	.21329	.36592	.24902	.08989
	CV	13.75	25.47	11.92	4.43
AR4000 + 2% Extender Oil	$\overline{X}$	2.11265	1.42685	1.99650	2.14502
	S	.05931	.18540	1.09205	.05506
	CV	2.81	12.99	54.70	2.57
AR1000	$\overline{X}$	1.62764	1.58366	1.46110	1.85983
	S	.26671	.070155	.91545	.03718
	CV	16.39	4.43	62.65	2.00

TABLE D-3

ANOVA Summary, Schweyer Rheometer, Log Apparent Viscosity, G-tube

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.4576231	.4576231	3.55	4.49	8.53
Q	1	.0364338	.0364338	.28	4.49	8.53
A	3	4.4456033	1.4818677	11.50	3.24	5.29
RQ	1	.2376465	.2376465	1.85	4.49	8.53
RA	3	.3702865	.1234288	.96	3.24	5.29
QA	3	.5901563	.1967188	1.53	3.24	5.29
RQA	3	.2109931	.0703310	.55	3.24	5.29
Error	16	2.0611420	.1288214			
TOTAL	31	8.4098845				

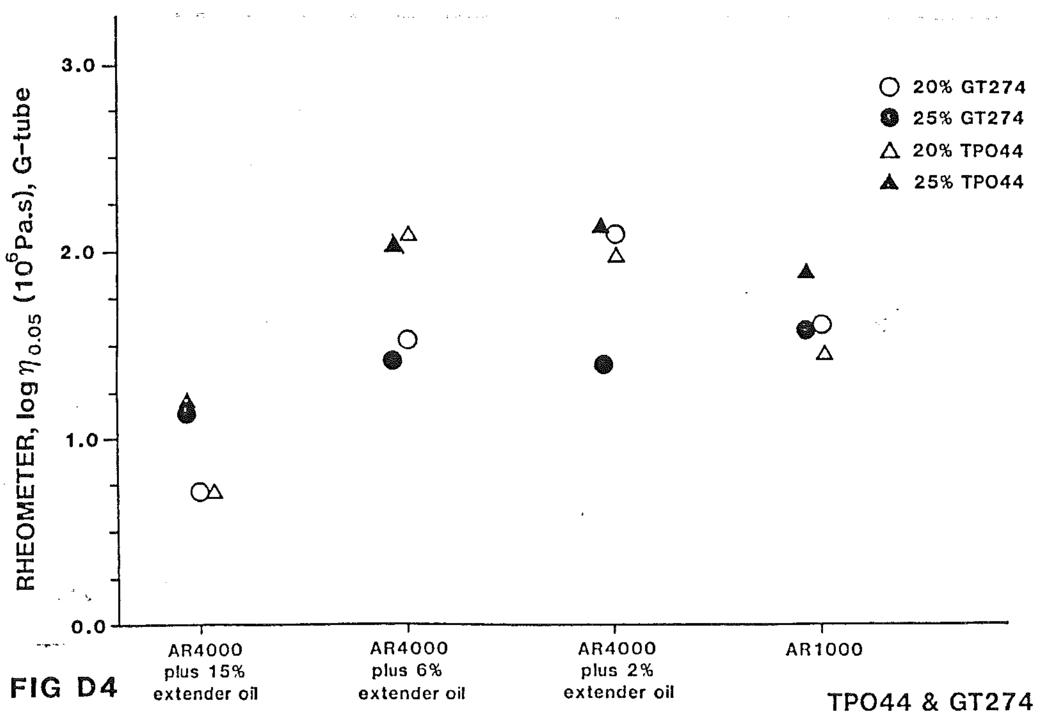


FIG D4

TPO44 & GT274

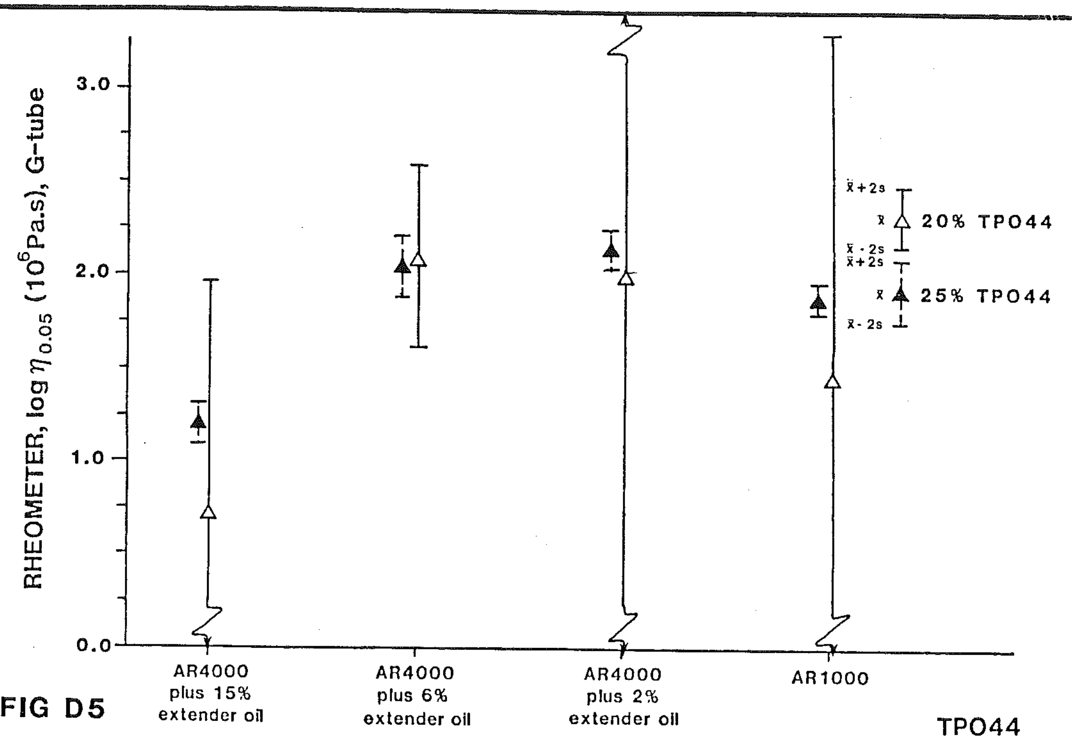

RHEOMETER, log $\eta_{0.05}$ (10^6Pa.s), G-tube
3.0
2.0
1.0
0.0
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG D5

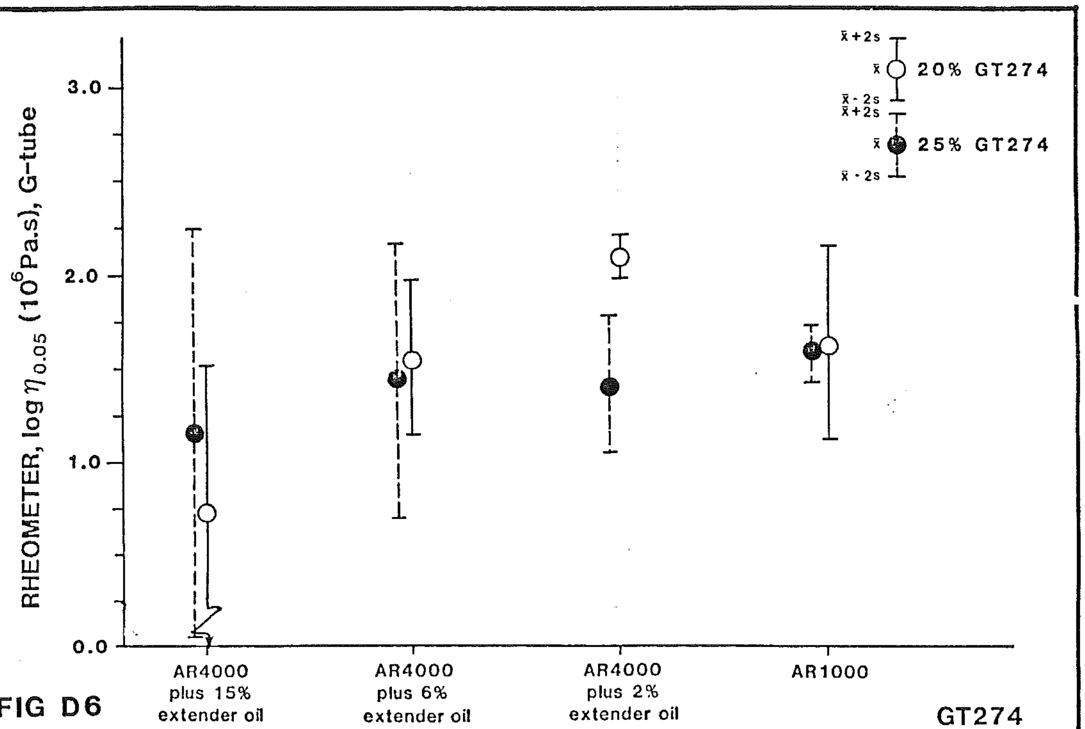

RHEOMETER, log $\eta_{0.05}$ (10^6Pa.s), G-tube
3.0
2.0
1.0
0.0
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG D6

APPENDIX E

VISCOSITY ($\eta_{0.05}$) BY SCHWEYER RHEOMETER

AT 39.2F (4C), F-TUBE

TABLE E-1

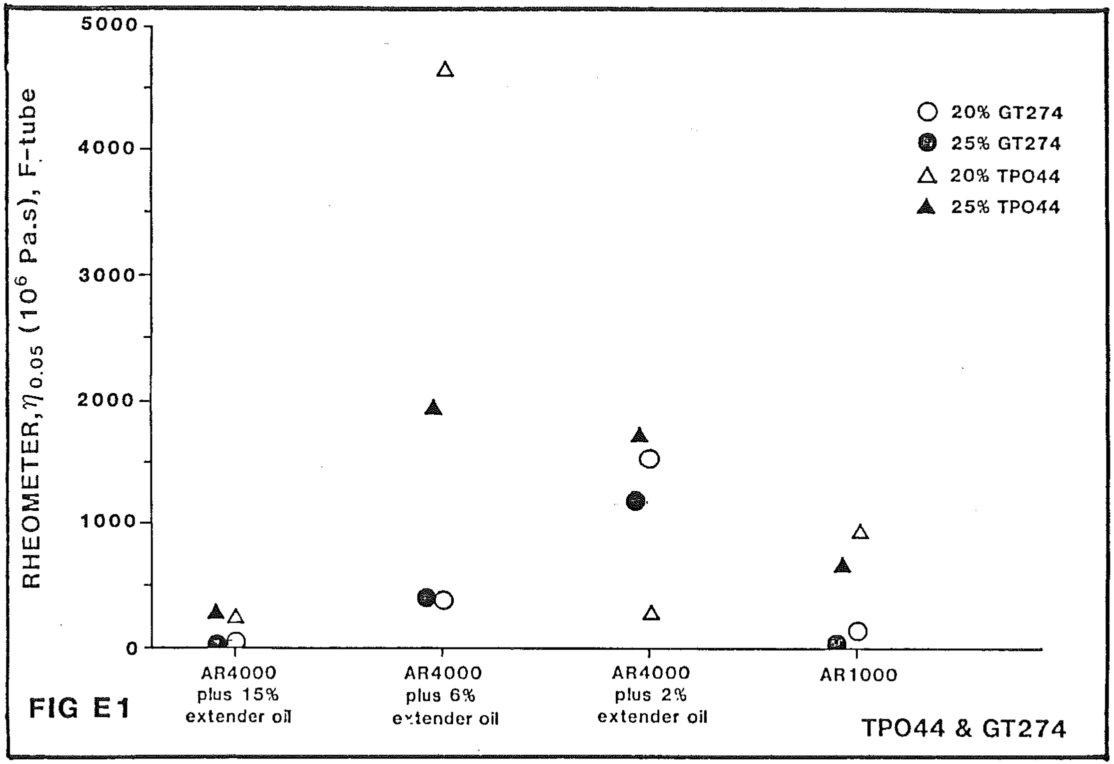
Schweyer Rheometer, Apparent Viscosity, $\eta_{0.05}$, 10^6 Pa-s, F-tube

a. Measured Data

	GT274 20%	GT274 25%	TP044 20%	TP044 25%
AR4000 + 15% Ext. Oil	19	27	190	200
	65	41	330	340
AR4000 + 6% Ext. Oil	370	230	330	430
	410	530	9000	3500
AR4000 + 2% Ext. Oil	370	400	290	3200
	2700	2000	280	310
AR1000	160	55	1500	910
	97	69	420	510

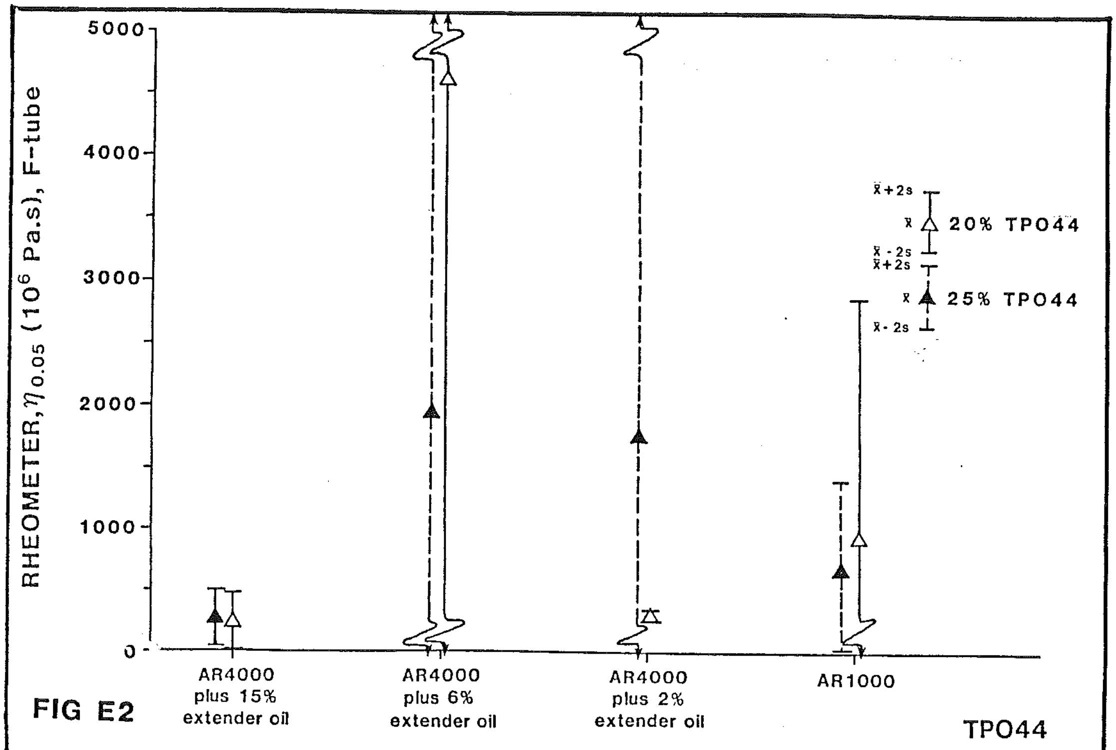
b. Summary

		GT274 20%	GT274 25%	TP044 20%	TP044 25%
AR4000 + 15% Extender Oil	$\overline{X}$	42	34	260	270
	S	40.76	12.40	124.04	124.04
	CV	97.04	36.48	47.71	45.94
AR4000 + 6% Extender Oil	$\overline{X}$	390	380	4665	1965
	S	35.44	265.80	7681.62	2720.02
	CV	9.09	69.95	164.66	138.42
AR4000 + 2% Extender Oil	$\overline{X}$	1535	1200	285	1755
	S	2064.38	1417.60	8.86	2560.54
	CV	134.49	118.13	3.11	145.90
AR1000	$\overline{X}$	128.5	62	960	710
	S	55.82	12.40	956.88	354.40
	CV	43.44	20.01	99.68	49.92



RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), F-tube
5000
4000
3000
2000
1000
0
20% GT274
25% GT274
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44 & GT274

FIG E1



RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), F-tube
5000
4000
3000
2000
1000
0
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
20% TPO44
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG E2

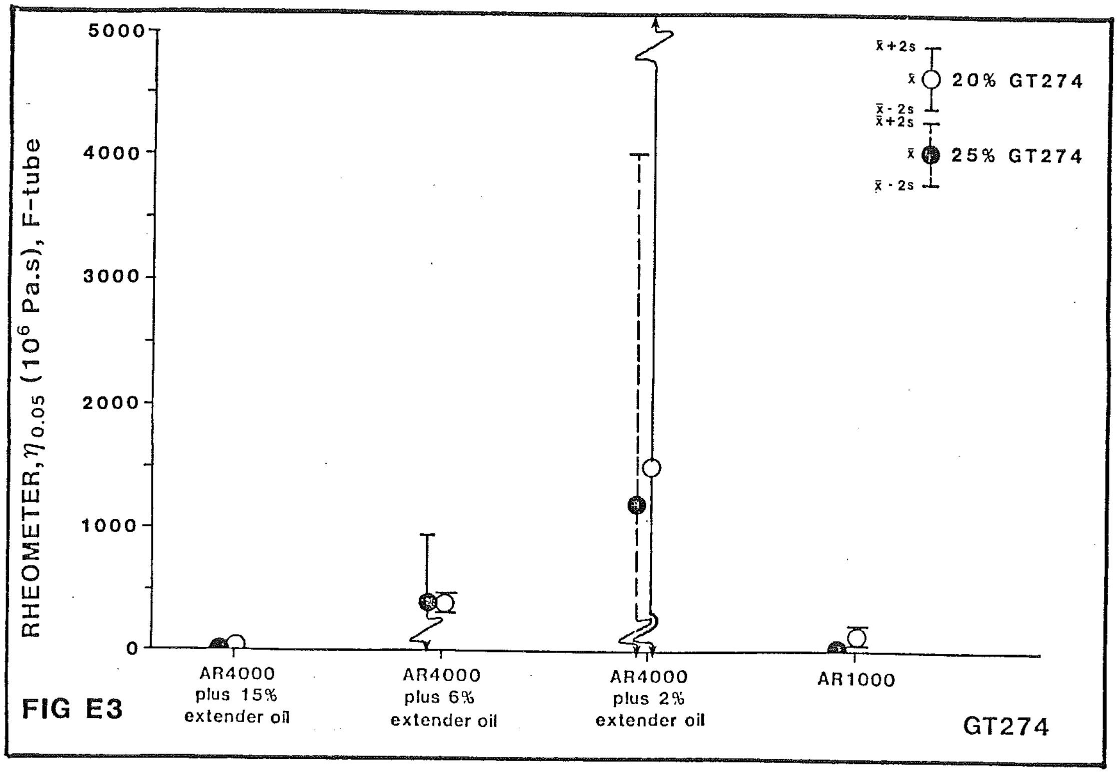

5000
4000
3000
2000
1000
0
RHEOMETER, $\eta_{0.05}$ (10^6 Pa.s), F-tube
$\bar{x}+2s$
$\bar{x}$ 20% GT274
$\bar{x}-2s$
$\bar{x}+2s$
$\bar{x}$ 25% GT274
$\bar{x}-2s$
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274
FIG E3

TABLE E-2

Schweyer Rheometer, Log Apparent Viscosity, $\eta_{0.05}$, 10^6 Pa-s, F-tube

a. Analyzed Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	1.27875	1.43136	2.27875	2.30103
	1.81291	1.61278	2.51851	2.53148
AR4000 + 6% Extender Oil	2.56820	2.36173	2.51851	2.63347
	2.61278	2.72428	3.95424	3.54407
AR4000 + 2% Extender Oil	2.56820	2.60206	2.46240	3.50515
	3.43136	3.30103	2.44716	2.49136
AR1000	2.20412	1.74036	3.17609	2.95904
	1.98677	1.83885	2.62325	2.70757

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	1.5	1.5	2.4	2.4
	S	.47	.16	.21	.20
	CV	30.62	10.56	8.85	8.45
AR4000 + 6% Extender Oil	$\overline{X}$	2.6	2.5	3.2	3.1
	S	.04	.32	1.27	.81
	CV	1.52	12.63	39.30	26.12
AR4000 + 2% Extender Oil	$\overline{X}$	3.0	3.0	2.5	3.0
	S	.76	.62	.01	.90
	CV	25.49	20.99	.55	29.96
AR1000	$\overline{X}$	2.1	1.8	2.9	2.8
	S	.19	.08	.49	.22
	CV	9.19	4.88	16.89	7.86

TABLE E-3

ANOVA Summary, Schweyer Rheometer, Log Apparent Viscosity, F-tube

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	2.2986574	2.2987	11.98	4.49	8.53
Q	1	.0007642	.0008	.004	4.49	8.53
A	3	4.3476362	1.4492	7.55	3.24	5.29
RQ	1	.0745849	.0746	.39	4.49	8.53
RA	3	1.7688956	.5896	3.07	3.24	5.29
QA	3	.2101843	.0701	.38	3.24	5.29
RQA	3	.1350180	.0450	.25	3.24	5.29
Error	16	3.0700961	.1919			
TOTAL	31	11.9058367				

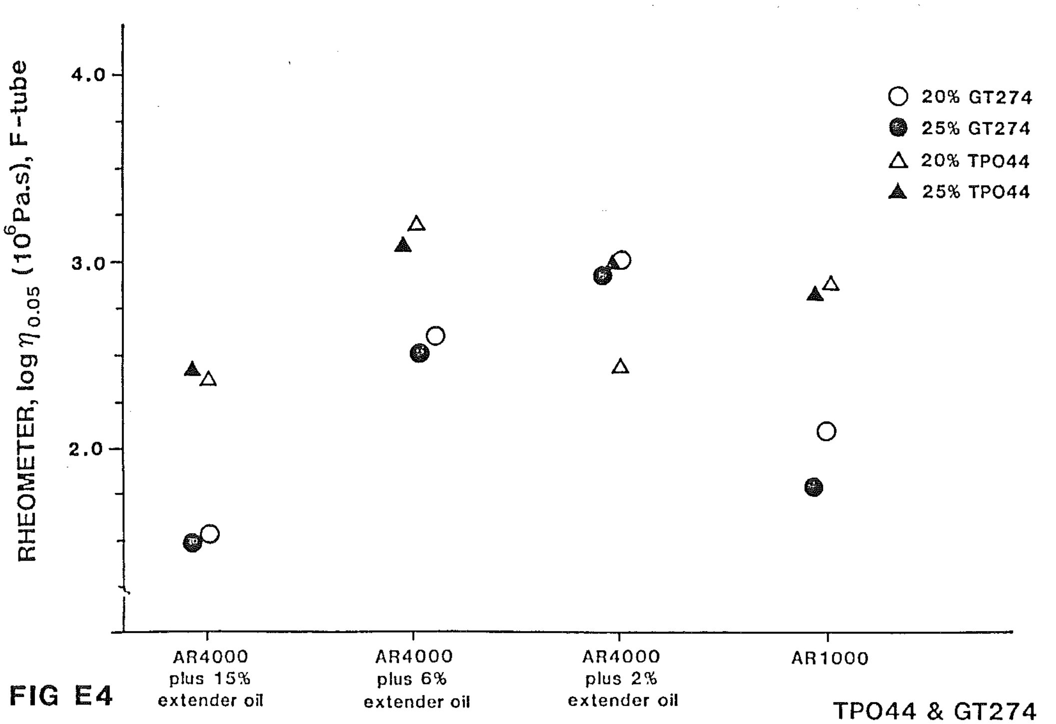


FIG E4

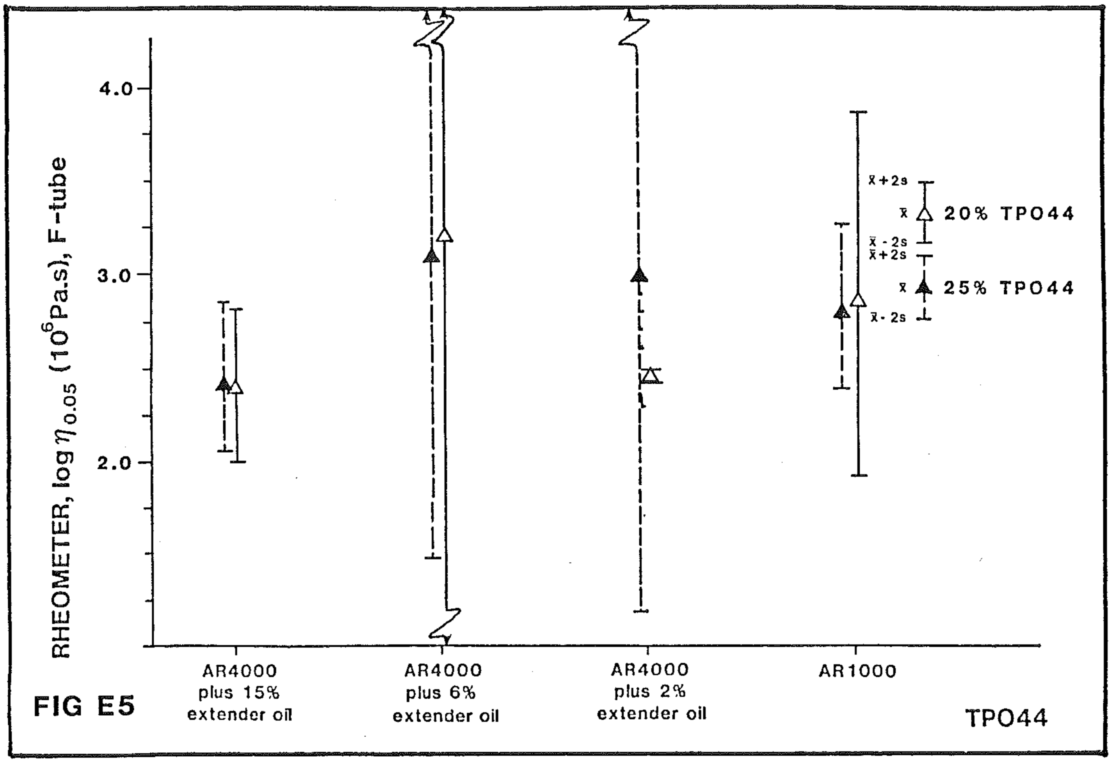

RHEOMETER, log $\eta_{0.05}$ (10^6Pa.s), F-tube
4.0
3.0
2.0
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG E5

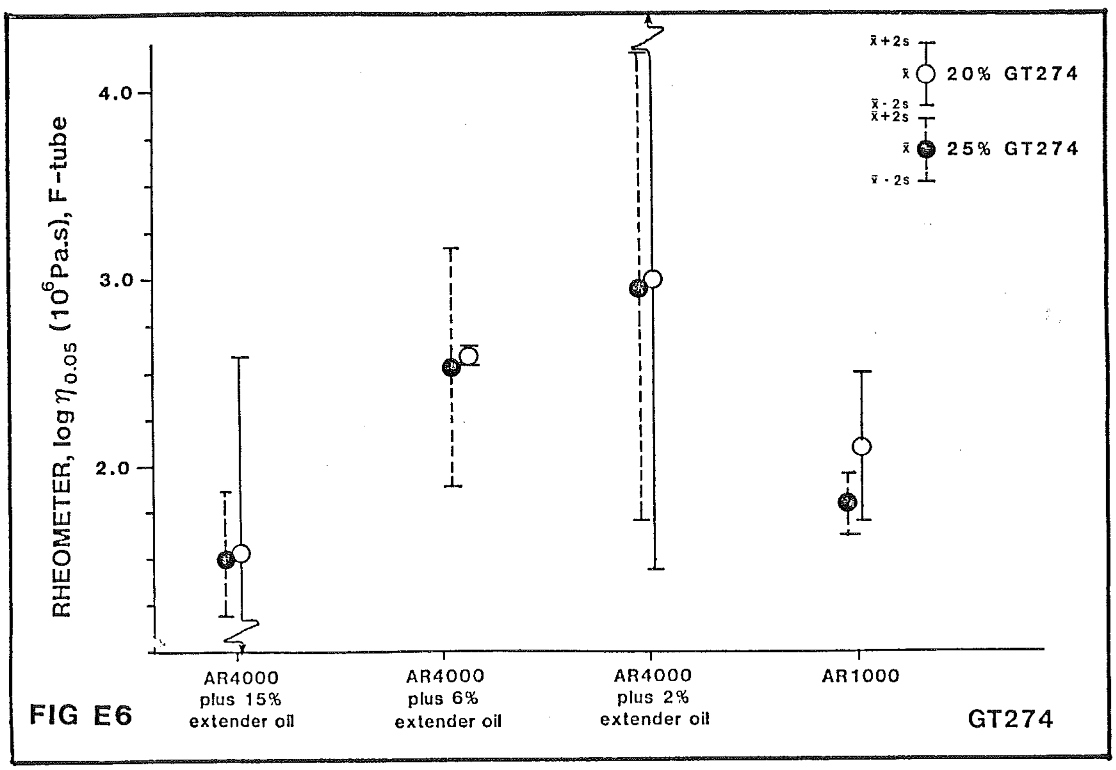

RHEOMETER, log $\eta_{0.05}$ (10^6Pa.s), F-tube
4.0
3.0
2.0
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG E6

APPENDIX F

FORCE-DUCTILITY LOAD AT FAILURE AT 39.2F (4C)

TABLE F-1

Load at Failure, pounds

a. Measured Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	5.32	7.14	7.28	11.07
	4.69	8.14	7.17	13.33
	5.24	6.71	7.41	12.23
	4.54	7.95	7.34	12.61
	5.45	8.01	7.15	12.93
	4.73	7.04	6.64	12.31
AR4000 + 6% Ext. Oil	11.58	13.92	14.11	20.19
	11.96	15.27	15.89	19.49
	12.85	16.34	15.48	20.62
	10.80	14.63	15.11	22.99
	11.50	15.10	14.19	20.54
	10.97	13.87	15.03	20.51
AR4000 + 2% Ext. Oil	18.1	18.17	23.04	23.71
	18.98	18.93	21.62	23.47
	19.0	19.22	18.79	21.29
	19.94	19.30	21.64	23.20
	19.41	19.41	20.89	22.13
	18.25	18.98	19.89	18.87
AR1000	11.1	12.66	9.27	17.18
	10.6	12.58	13.28	18.68
	10.8	13.90	10.12	20.24
	10.0	13.7	13.79	16.21
	10.27	14.0	12.74	16.37
	10.94	12.7	12.10	14.19

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	5.00	7.50	7.17	12.41
+ 15%	S	.385	.606	.276	.774
Extender Oil	CV	7.72	8.08	3.85	6.23
AR4000	$\overline{X}$	11.61	14.86	14.97	20.72
+ 6%	S	.740	.931	.704	1.186
Extender Oil	CV	6.37	6.27	4.70	5.72
AR4000	$\overline{X}$	18.95	19.00	20.98	22.11
+ 2%	S	.697	.447	1.489	1.831
Extender Oil	CV	3.68	2.35	7.10	8.28
AR1000	$\overline{X}$	10.62	13.26	11.88	17.15
	S	.418	.676	1.806	2.104
	CV	3.93	5.10	15.20	12.27

TABLE F-2

Load at Failure, pounds

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	5.083	7.33	7.287	12.21
	4.907	7.667	7.043	12.617
AR4000 + 6% Ext. Oil	12.13	15.177	15.16	20.100
	11.09	14.533	14.777	21.347
AR4000 + 2% Ext. Oil	18.693	18.773	21.150	22.823
	19.203	19.230	20.807	21.40
AR1000	10.833	13.047	10.890	18.700
	10.403	13.467	12.877	15.590

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	5.00	7.50	7.17	12.41
	S	.156	.299	.216	.361
	CV	3.12	3.98	3.02	2.90
AR4000 + 6% Extender Oil	$\overline{X}$	11.61	14.86	14.97	20.72
	S	.921	.571	.339	1.105
	CV	7.94	3.84	2.27	5.33
AR4000 + 2% Extender Oil	$\overline{X}$	18.95	19.00	20.98	22.11
	S	.452	.405	.304	1.261
	CV	2.38	2.13	1.45	5.70
AR1000	$\overline{X}$	10.62	13.26	11.88	17.15
	S	.381	.372	1.760	2.755
	CV	3.59	2.81	14.81	16.07

TABLE F-3

ANOVA Summary, Load at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	88.48490	88.4849	140.45	4.49	8.53
Q	1	83.45674	83.4567	132.47	4.49	8.53
A	3	621.33565	207.1119	328.74	3.24	5.29
RQ	1	10.02848	10.0285	15.92	4.49	8.53
RA	3	5.67412	1.8913	3.002	3.24	5.29
QA	3	19.00285	6.3343	10.05	3.24	5.29
RQA	3	.91049	.6300	.48	3.24	5.29
Error	16	10.08043				
TOTAL	31	838.97368				

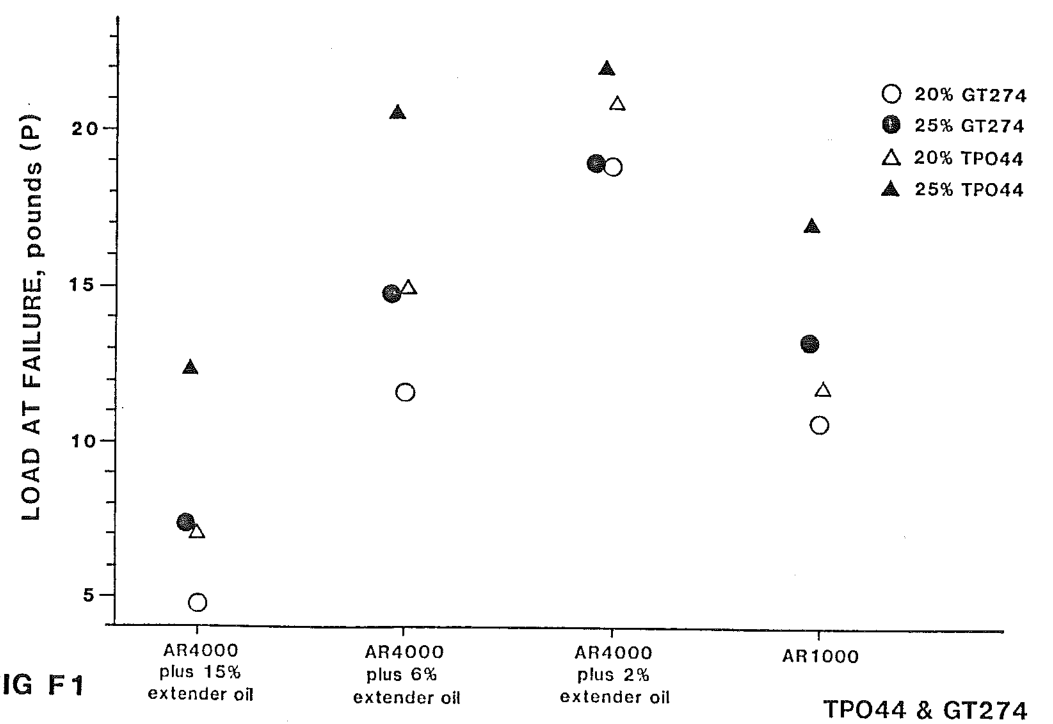


FIG F1

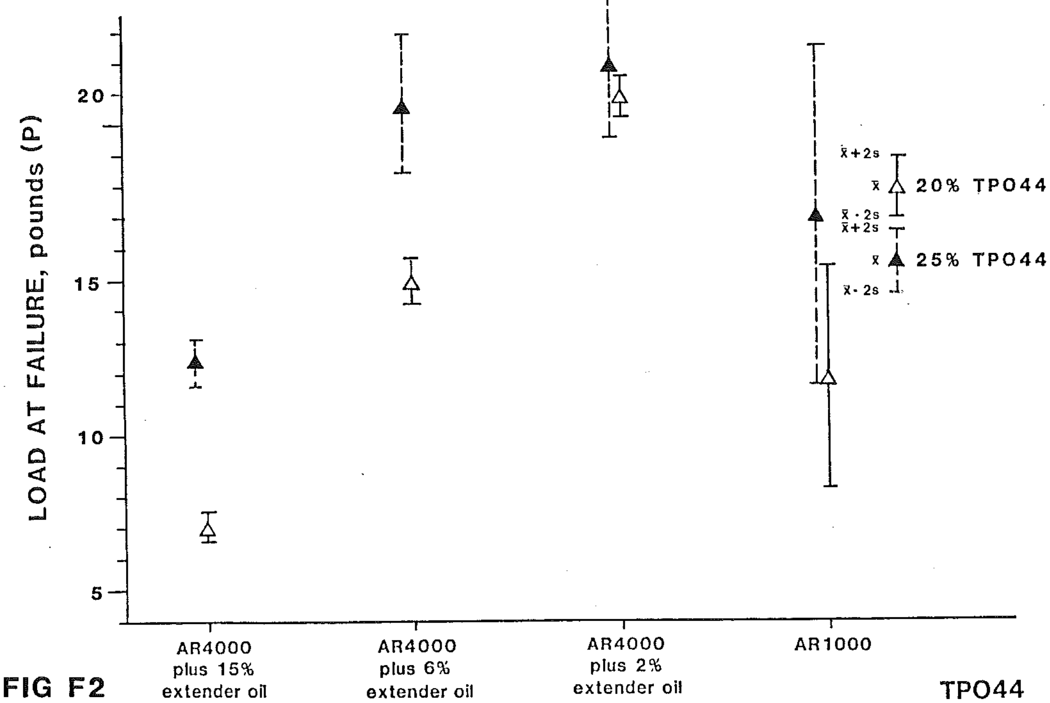

LOAD AT FAILURE, pounds (P)
20
15
10
5
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG F2

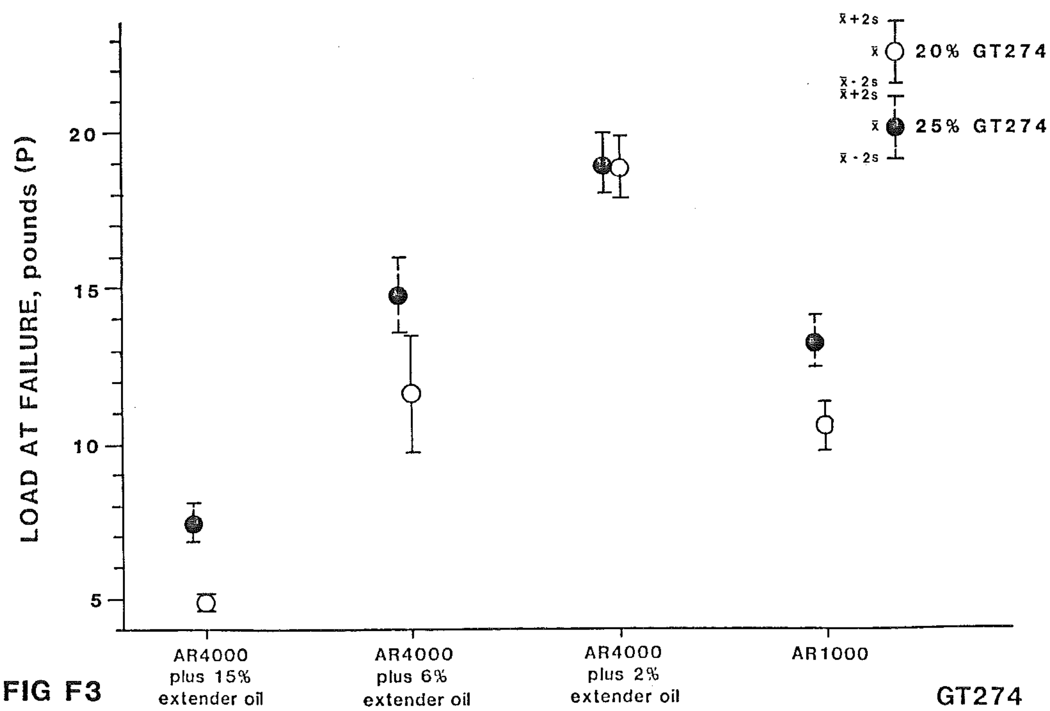

LOAD AT FAILURE, pounds (P)
20
15
10
5
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG F3

APPENDIX G

FORCE DUCTILITY ELONGATION AT FAILURE AT 39.2F(4C)

TABLE G-1

Elongation at Failure; mm

a. Measured Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	484	248	231	198
	545	332	201	205
	522	369	293	196
	574	429	202	186
	455	374	235	201
	559	308	275	229
AR4000 + 6% Ext. Oil	423	302	232	207
	441	360	173	201
	414	331	190	180
	405	365	208	239
	433	382	238	195
	426	382	220	190
AR4000 + 2% Ext. Oil	387	358	201	178
	378	351	193	203
	388	376	205	175
	357	367	202	174
	392	397	189	192
	412	346	210	244
AR1000	499	451	253	181
	452	421	235	183
	462	445	240	184
	409	425	280	189
	394	406	209	202
	463	406	239	174

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	523	343	240	203
	S	45.88	62.29	37.69	14.46
	CV	8.77	18.14	15.74	7.14
AR4000 + 6% Extender Oil	$\overline{X}$	424	354	210	202
	S	12.93	31.49	25.06	20.36
	CV	3.05	8.90	11.93	10.08
AR4000 + 2% Extender Oil	$\overline{X}$	386	366	200	194
	S	18.00	18.71	7.75	26.84
	CV	4.67	5.12	3.87	13.81
AR1000	$\overline{X}$	447	426	243	186
	S	38.63	19.03	23.30	9.44
	CV	8.65	4.47	9.60	5.09

TABLE G-2

Elongation at Failure; mm

a. Analyzed Data

	GT274 20%	GT274 25%	TP044 20%	TP044 25%
AR4000 + 15% Extender Oil	517.0	316.3	241.7	199.7
	529.3	370.3	237.3	205.3
AR4000 + 6% Extender Oil	426.0	331.0	198.3	196.0
	421.3	376.3	222.0	208.0
AR4000 + 2% Extender Oil	384.3	361.7	199.7	185.3
	387.0	370.0	200.3	203.3
AR1000	471.0	439.0	242.7	182.7
	422.0	412.3	242.7	188.3

b. Summary

		GT274 20%	GT274 25%	TP044 20%	TP044 25%
AR4000 + 15% Extender Oil	$\overline{X}$	523.2	343.3	239.5	202.5
	S	10.9	47.84	3.90	4.96
	CV	2.08	13.94	1.63	2.45
AR4000 + 6% Extender Oil	$\overline{X}$	423.7	353.7	210.2	202.0
	S	4.16	40.1	21.00	10.63
	CV	.98	11.35	9.99	5.26
AR4000 + 2% Extender Oil	$\overline{X}$	385.7	365.9	200.0	194.3
	S	2.39	7.35	.53	15.95
	CV	.62	2.01	.27	8.21
AR1000	$\overline{X}$	446.5	425.7	242.7	185.5
	S	43.41	23.66	0	4.96
	CV	9.72	5.56	0	2.67

TABLE G-3

ANOVA Summary, Elongation at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	316251.045	316251.045	1067.95	4.49	8.53
Q	1	19870.211	19870.211	67.10	4.49	8.53
A	3	9835.576	3278.525	11.07	3.24	5.29
RQ	1	4167.845	4167.845	14.07	4.49	8.53
RA	3	2773.182	924.394	3.12	3.24	5.29
QA	3	10099.026	3366.342	11.37	3.24	5.29
RQA	3	8729.432	2909.811	9.83	3.24	5.29
Error	16	4738.080	296.130			
TOTAL	31	376464.398				

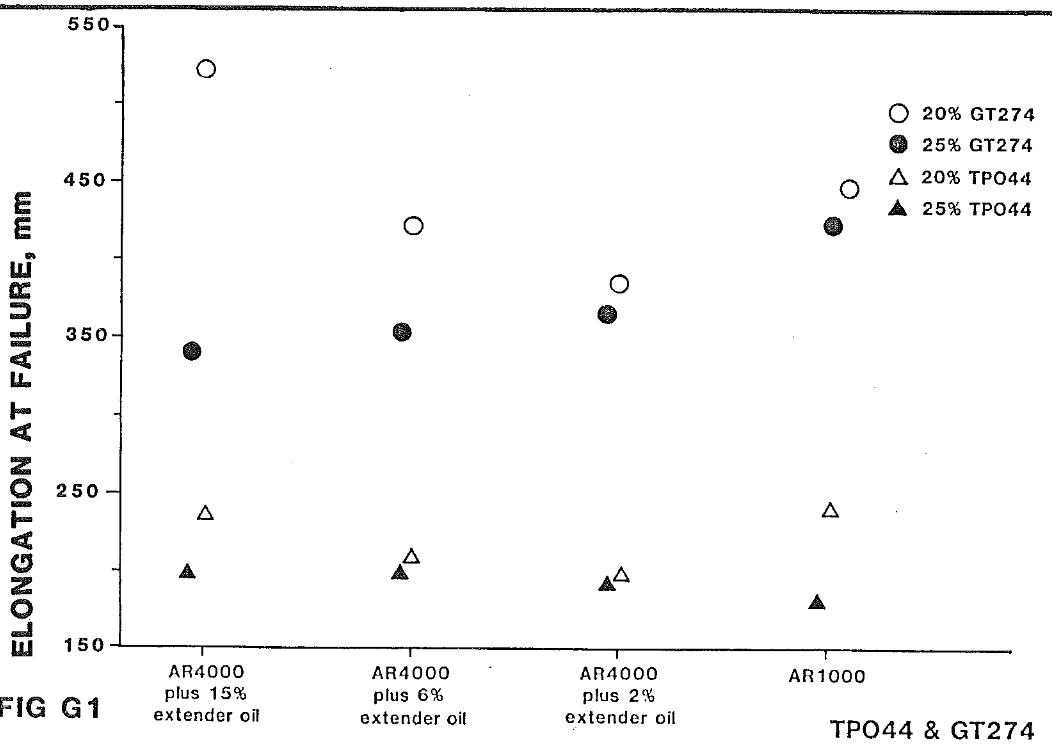
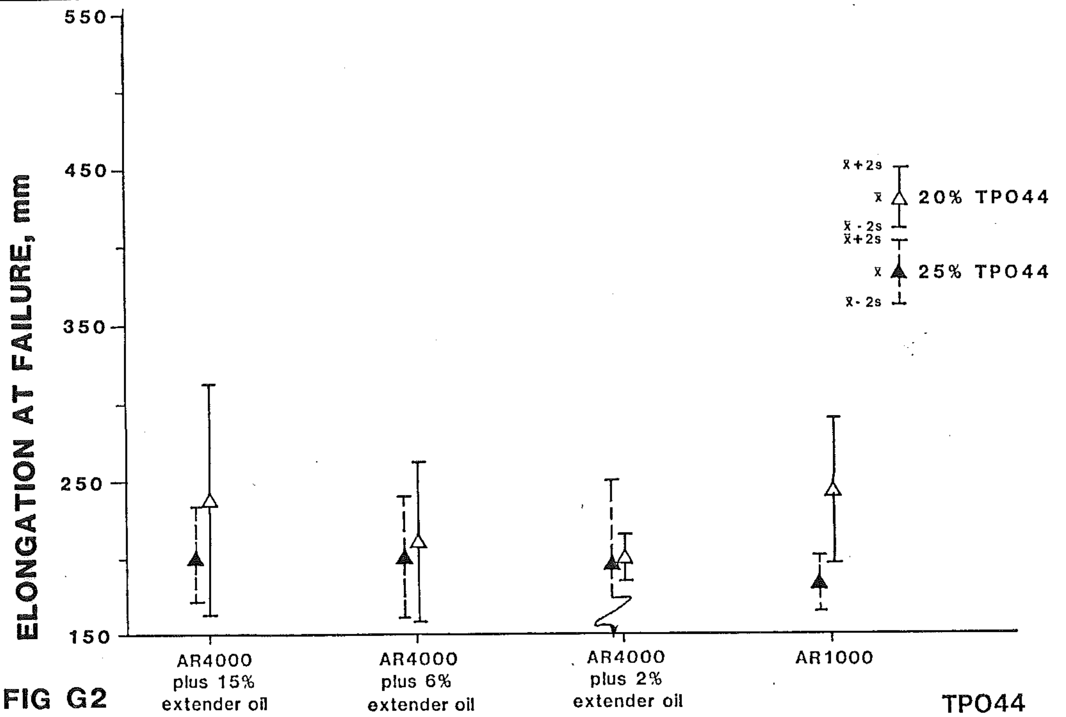
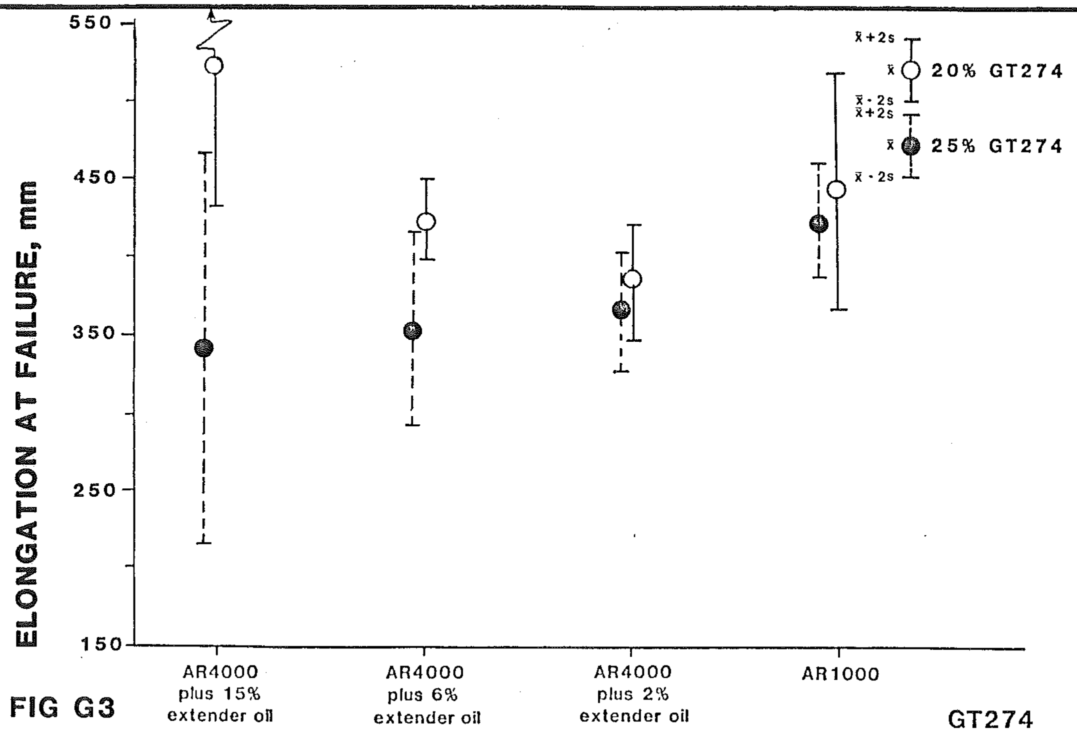


FIG G1



ELONGATION AT FAILURE, mm
550
450
350
250
150
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG G2



ELONGATION AT FAILURE, mm
550
450
350
250
150
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG G3

APPENDIX H

FORCE-DUCTILITY ENGINEERING STRESS AT FAILURE AT 39.2F (4C)

TABLE H-1

Engineering Stress at Failure, psi

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	33.2	44.7	45.5	69.2
	29.4	50.9	44.8	83.3
	32.7	42.0	46.4	76.4
	28.4	49.7	45.8	78.8
	34.1	50.0	44.7	80.8
	29.5	44.0	41.5	76.9
AR4000 + 6% Ext. Oil	72.4	87.0	88.2	126.2
	74.8	95.4	99.3	121.8
	80.3	102.2	96.8	128.9
	67.5	87.7	94.4	143.7
	71.9	94.1	88.7	128.4
	68.5	86.7	93.9	128.2
AR4000 + 2% Ext. Oil	113.4	113.6	144.0	148.2
	118.6	118.3	135.1	146.7
	118.5	120.1	117.4	133.1
	124.7	120.6	135.3	145.0
	121.3	121.3	130.6	138.3
	114.1	118.6	124.3	118.0
AR1000	69.2	79.1	57.9	107.4
	66.2	78.6	83.0	116.8
	67.5	86.9	63.2	126.5
	62.5	85.8	86.2	101.3
	64.2	87.5	79.6	102.3
	68.2	79.1	75.6	88.7

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	31.217	46.883	44.783	77.566
	S	2.39	3.76	1.73	4.83
	CV	7.67	8.02	3.86	6.23
AR4000 + 6% Extender Oil	$\overline{X}$	72.567	92.183	93.550	129.533
	S	4.64	6.19	4.40	7.42
	CV	6.39	6.71	4.70	5.73
AR4000 + 2% Extender Oil	$\overline{X}$	118.433	118.750	131.117	138.217
	S	4.28	2.77	9.32	11.42
	CV	3.61	2.34	7.11	8.27
AR1000	$\overline{X}$	66.3	82.833	74.250	107.167
	S	2.54	4.31	11.31	13.16
	CV	3.83	5.20	15.23	12.28

TABLE H-2

Engineering Stress at Failure, psi

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	31.77	45.87	45.57	76.30
	30.67	47.90	44.00	78.83
AR4000 + 6% Ext. Oil	75.83	94.87	94.77	125.63
	69.30	89.50	92.33	133.43
AR4000 + 2% Ext. Oil	116.83	117.33	132.17	142.47
	120.03	120.17	130.07	133.77
AR1000	67.63	81.53	68.03	116.90
	64.97	84.13	80.47	97.43

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\bar{X}$	31.22	46.89	44.79	77.57
	S	.975	1.799	1.391	2.242
	CV	3.12	3.84	3.11	2.89
AR4000 + 6% Extender Oil	$\bar{X}$	72.57	92.19	93.55	129.53
	S	5.786	4.758	2.162	6.911
	CV	7.97	5.16	2.31	5.34
AR4000 + 2% Extender Oil	$\bar{X}$	118.43	118.75	131.12	138.12
	S	2.835	2.516	1.861	7.708
	CV	2.39	2.12	1.42	5.58
AR1000	$\bar{X}$	66.30	82.83	74.25	107.17
	S	2.357	2.304	11.022	17.250
	CV	3.55	2.78	14.84	16.10

TABLE H-3

ANOVA Summary, Engineering Stress at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	3482.7858	3482.7858	139.57	4.49	8.53
Q	1	3232.4820	3232.4820	129.54	4.49	8.53
A	3	24240.5694	8080.1898	323.80	3.24	5.29
RQ	1	399.5965	399.5965	16.01	4.49	8.53
RA	3	232.3011	77.4437	3.10	3.24	5.29
QA	3	735.8522	245.2841	9.83	3.24	5.29
RQA	3	37.2353	12.4118	.50	3.24	5.29
Error	16	399.2719	24.9545			
TOTAL	31	32760.0941				

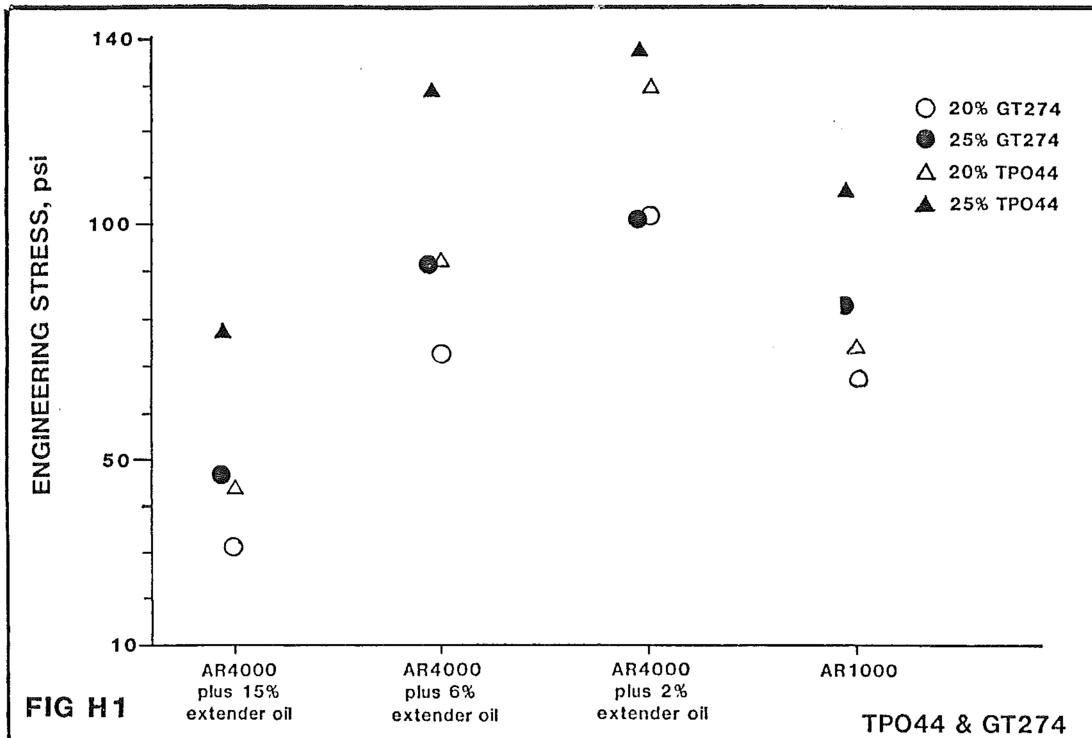
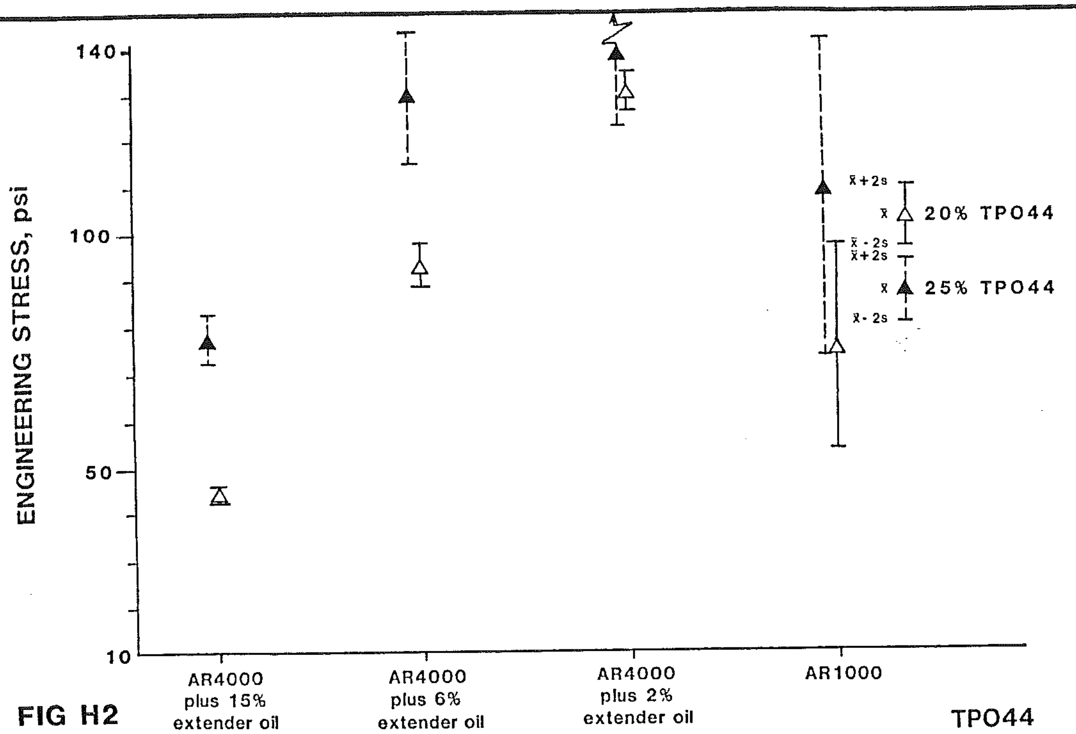
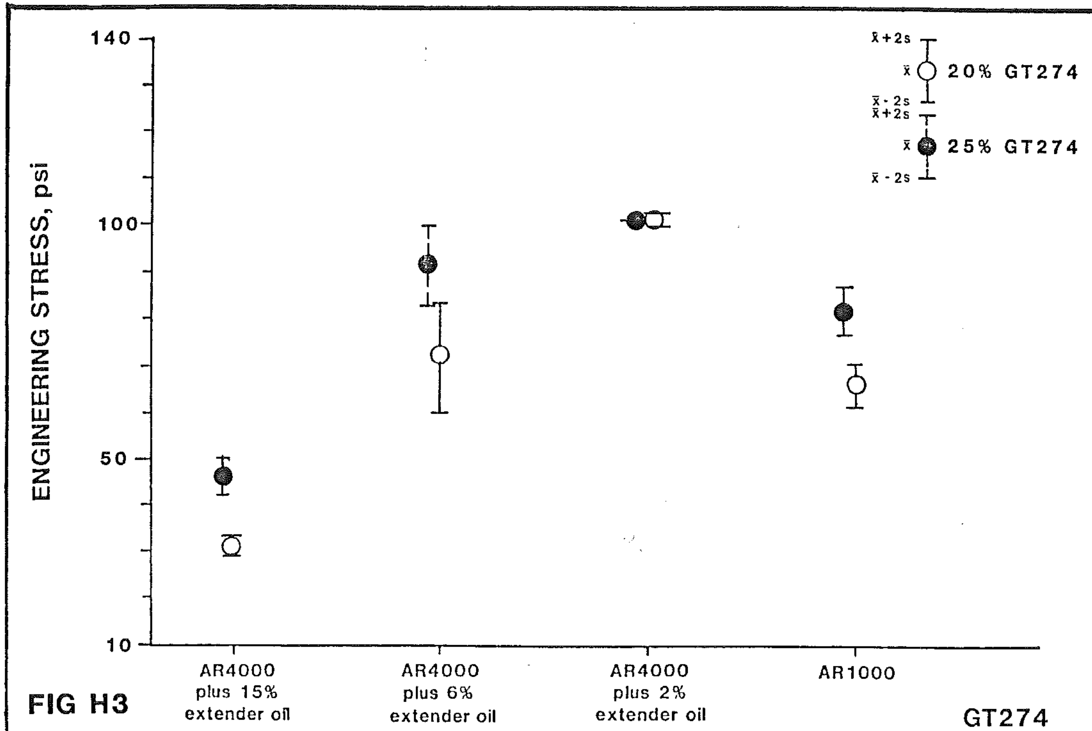


FIG H1



ENGINEERING STRESS, psi
140
100
50
10
x̄+2s
x̄
20% TPO44
x̄-2s
x̄+2s
x̄
25% TPO44
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG H2



ENGINEERING STRESS, psi
140
100
50
10
x̄+2s
x̄
20% GT274
x̄-2s
x̄+2s
x̄
25% GT274
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG H3

APPENDIX I

FORCE-DUCTILITY ENGINEERING STRAIN AT FAILURE AT 39.2F (4C)

TABLE I-1

Engineering Strain at Failure mm/mm

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	9.68	5.17	4.53	3.96
	10.90	6.64	4.02	4.10
	10.24	7.53	5.86	4.00
	11.48	8.58	4.04	3.88
	9.10	7.63	4.80	4.10
	11.41	6.29	5.39	4.58
AR4000 + 6% Ext. Oil	8.46	6.16	4.73	4.14
	9.00	7.35	3.04	4.02
	8.28	6.49	3.80	3.60
	8.27	7.30	4.16	4.88
	8.84	7.49	4.76	3.90
	8.52	7.21	4.40	3.96
AR4000 + 2% Ext. Oil	7.76	7.16	3.94	3.42
	7.41	6.75	3.86	3.90
	7.30	7.09	3.94	3.24
	7.29	7.06	3.81	3.55
	7.54	7.49	3.57	3.52
	8.24	6.78	3.89	3.54
AR1000	9.42	8.67	4.87	3.35
	8.86	8.25	4.43	3.62
	9.24	8.24	4.53	4.69
	8.18	8.02	4.96	3.50
	8.38	7.81	4.75	3.81
	9.08	7.96	4.38	3.35

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	10.468	6.973	4.773	4.103
+ 15%	S	.96	1.20	.74	.25
Extender Oil	CV	9.20	17.15	15.47	6.05
AR4000	$\overline{X}$	8.562	7.000	4.148	4.083
+ 6%	S	.30	.54	.65	.43
Extender Oil	CV	3.49	7.73	15.72	10.53
AR4000	$\overline{X}$	7.590	7.055	3.835	3.528
+ 2%	S	.36	.27	.14	.22
Extender Oil	CV	4.79	3.86	3.62	6.13
AR1000	$\overline{X}$	8.860	8.158	4.653	3.720
	S	.49	.30	.24	.51
	CV	5.53	3.70	5.18	13.61

TABLE I-2

Engineering Strain at Failure mm/mm

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	10.273	6.447	4.803	4.02
	10.663	7.500	4.743	4.187
AR4000 + 6% Ext. Oil	8.58	6.667	3.857	3.92
	8.543	7.333	4.44	4.247
AR4000 + 2% Ext. Oil	7.490	7.000	3.913	3.520
	7.690	7.110	3.757	3.537
AR1000	9.173	8.387	4.610	3.067
	8.547	7.930	4.697	3.553

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	10.47	6.97	4.77	4.10
+ 15%	S	.346	.933	.053	.148
Extender Oil	CV	3.30	13.38	1.11	3.61
AR4000	$\overline{X}$	8.56	7.00	4.15	4.08
+ 6%	S	.033	.590	.517	.290
Extender Oil	CV	38	8.43	12.45	7.09
AR4000	$\overline{X}$	7.59	7.06	3.48	3.53
+ 2%	S	.177	.097	.500	.015
Extender Oil	CV	2.33	1.38	14.38	.43
	$\overline{X}$	8.86	8.16	4.65	3.31
AR1000	S	.555	.405	.077	.431
	CV	6.26	4.96	1.66	13.01

TABLE I-3

ANOVA Summary, Engineering Strain at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	129.8546701	129.8547	1338.12	4.49	8.53
Q	1	9.4112911	9.4113	96.98	4.49	8.53
A	3	5.0212808	1.6738	17.25	3.24	5.29
RQ	1	1.9090580	1.9091	19.67	4.49	8.53
RA	3	1.1923611	.3975	4.10	3.24	5.29
QA	3	3.0259816	1.0087	10.39	3.24	5.29
RQA	3	3.4331988	1.1444	11.79	3.24	5.29
Error	16	1.5526780	.0970			
TOTAL	31	155.4005195				

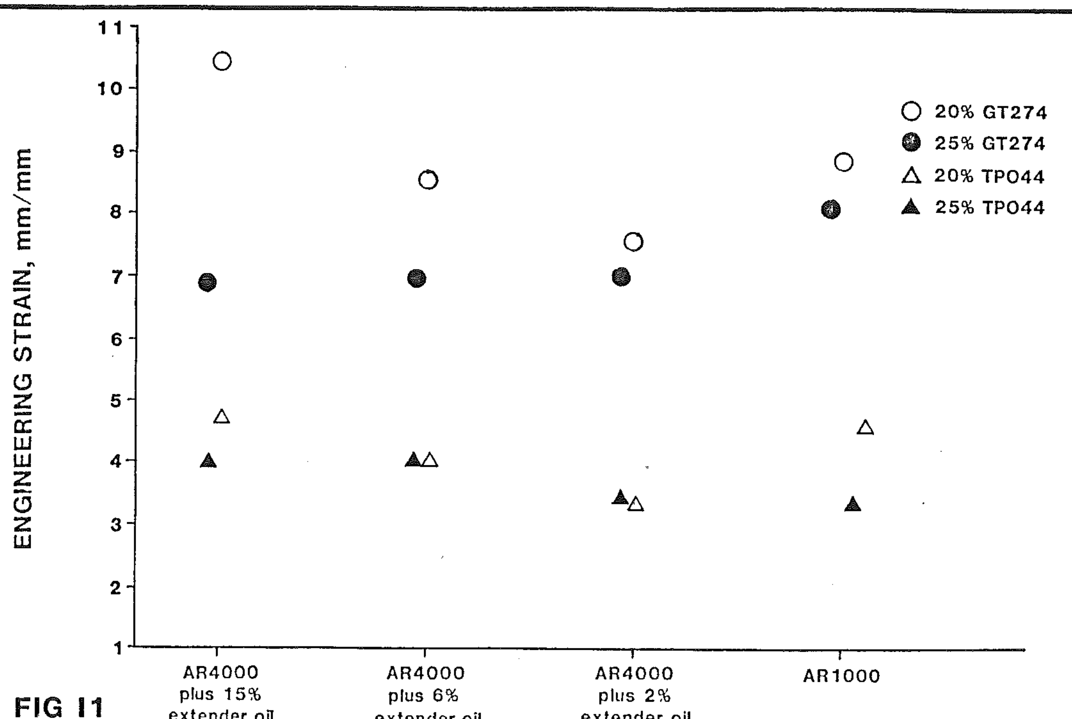


FIG 11

TPO44 & GT274

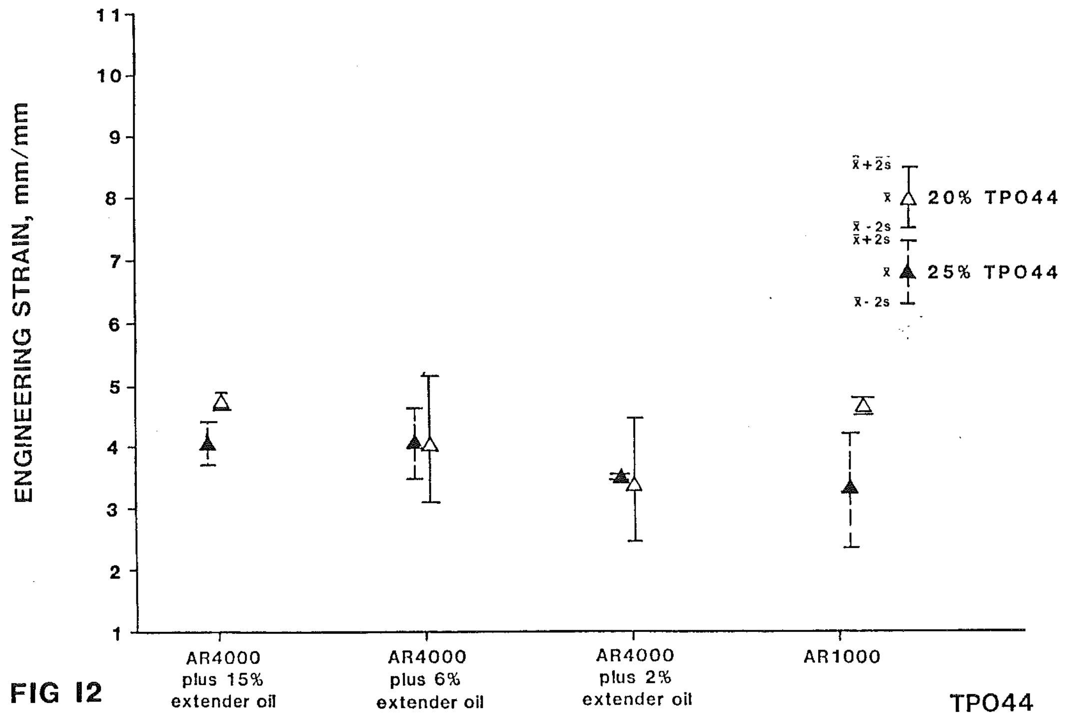

ENGINEERING STRAIN, mm/mm
11
10
9
8
7
6
5
4
3
2
1
x̄+2s
x̄
20% TPO44
x̄ - 2s
x̄+2s
x̄
25% TPO44
x̄ - 2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG 12

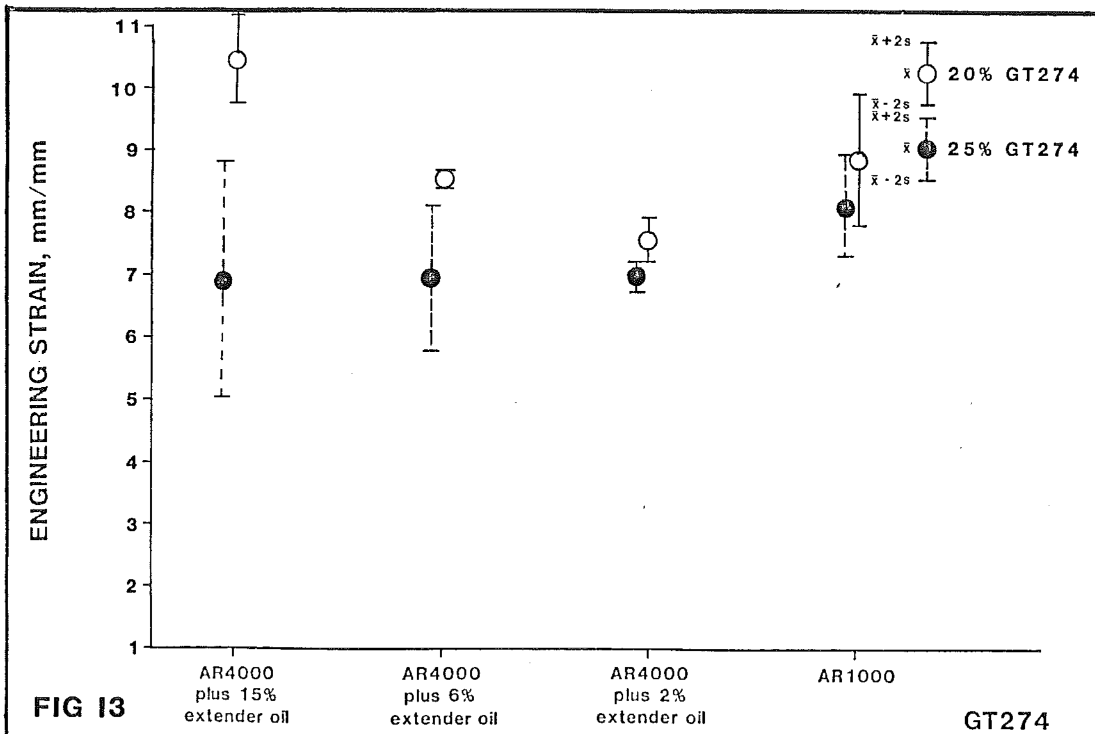

ENGINEERING STRAIN, mm/mm
11
10
9
8
7
6
5
4
3
2
1
x̄+2s
x̄
20% GT274
x̄ - 2s
x̄+2s
x̄
25% GT274
x̄ - 2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG 13

APPENDIX J

FORCE-DUCTILITY TRUE STRESS AT FAILURE AT 39.2F (4C)

TABLE J-1
True Stress at Failure, psi

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	355.0	275.5	251.6	343.3
	349.6	388.8	225.1	425.0
	367.8	358.0	318.0	382.2
	354.0	476.2	231.1	384.1
	344.2	432.0	258.9	412.3
	366.6	320.6	265.1	429.3
AR4000 + 6% Ext. Oil	684.9	623.4	505.8	648.6
	747.5	796.5	400.7	611.5
	745.2	765.1	464.5	592.8
	625.7	727.9	487.2	844.4
	707.2	798.8	510.9	629.1
	652.5	711.5	507.1	635.7
AR4000 + 2% Ext. Oil	993.5	926.8	711.5	655.5
	997.8	916.7	656.6	719.3
	983.4	972.4	580.5	564.3
	1033.0	972.1	650.8	659.7
	1035.8	1030.6	596.1	625.0
	1054.1	923.4	607.9	535.3
AR1000	720.8	765.4	339.9	466.6
	652.7	727.6	451.0	539.8
	691.7	802.6	349.2	720.2
	573.6	774.2	513.7	455.9
	602.1	770.9	457.5	492.3
	689.0	709.0	406.5	385.5

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	356.20	375.18	258.30	396.03
+ 15%	S	9.34	73.25	33.16	32.63
Extender Oil	CV	2.62	19.52	12.84	8.24
AR4000	$\overline{X}$	693.83	737.22	479.37	660.35
+ 6%	S	49.25	66.03	42.27	92.25
Extender Oil	CV	7.10	8.96	8.82	13.97
AR4000	$\overline{X}$	1016.27	957.00	633.90	626.52
+ 2%	S	28.40	43.70	48.54	67.44
Extender Oil	CV	2.79	4.57	7.66	10.76
AR1000	$\overline{X}$	654.98	758.28	419.63	509.95
	S	57.03	34.05	67.46	114.68
	CV	8.71	4.49	16.08	22.49

TABLE J-2

True Stress at Failure, psi

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	357.47	340.77	264.9	383.50
	354.93	409.60	251.7	408.57
AR4000 + 6% Ext. Oil	725.87	728.33	457.00	617.63
	661.8	746.07	501.73	703.07
AR4000 + 2% Ext. Oil	991.57	938.63	649.53	643.30
	1040.97	975.37	618.27	606.67
AR1000	688.40	765.20	380.03	575.53
	621.57	751.37	459.23	444.57

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	356.2	375.2	258.3	396.0
	S	2.25	60.98	11.70	22.21
	CV	.63	16.25	4.53	5.61
AR4000 + 6% Extender Oil	$\overline{X}$	693.8	737.2	479.4	660.4
	S	56.77	15.72	39.63	75.70
	CV	8.18	2.13	8.27	11.46
AR4000 + 2% Extender Oil	$\overline{X}$	1016.3	957.0	633.9	625.0
	S	43.77	32.55	27.70	32.52
	CV	4.31	3.40	4.37	5.20
AR1000	$\overline{X}$	655.0	758.3	419.6	510.1
	S	59.21	12.25	70.17	116.03
	CV	9.04	1.62	16.72	22.75

TABLE J-3

ANOVA Summary, True Stress at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	318525.7020	318525.7020	183.73	4.49	8.53
Q	1	35997.8112	35997.8112	20.76	4.49	8.53
A	3	906525.5157	302175.1719	174.30	3.24	5.29
RQ	1	13112.2818	13112.2818	7.56	4.49	8.53
RA	3	101715.4257	33905.1419	19.56	3.24	5.29
QA	3	27686.7597	9228.9199	5.32	3.24	5.29
RQA	3	8773.1549	2924.3850	1.69	3.24	5.29
Error	16	27739.0745	1733.6922			
TOTAL	31	1440075.7256				

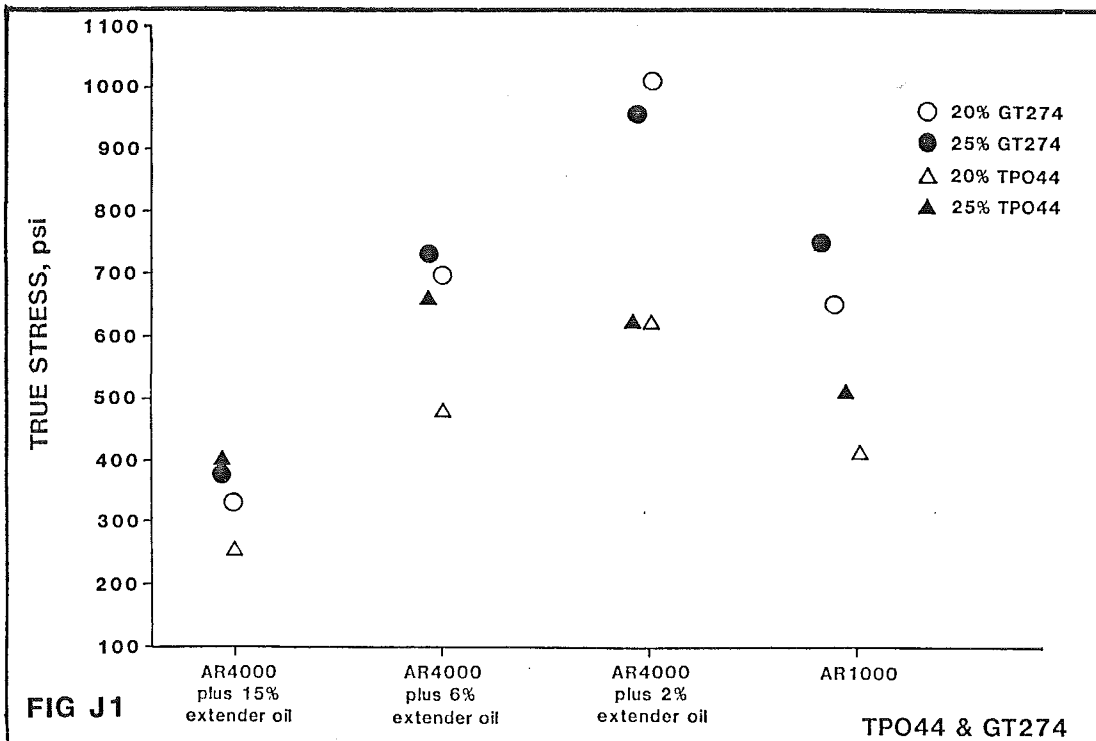
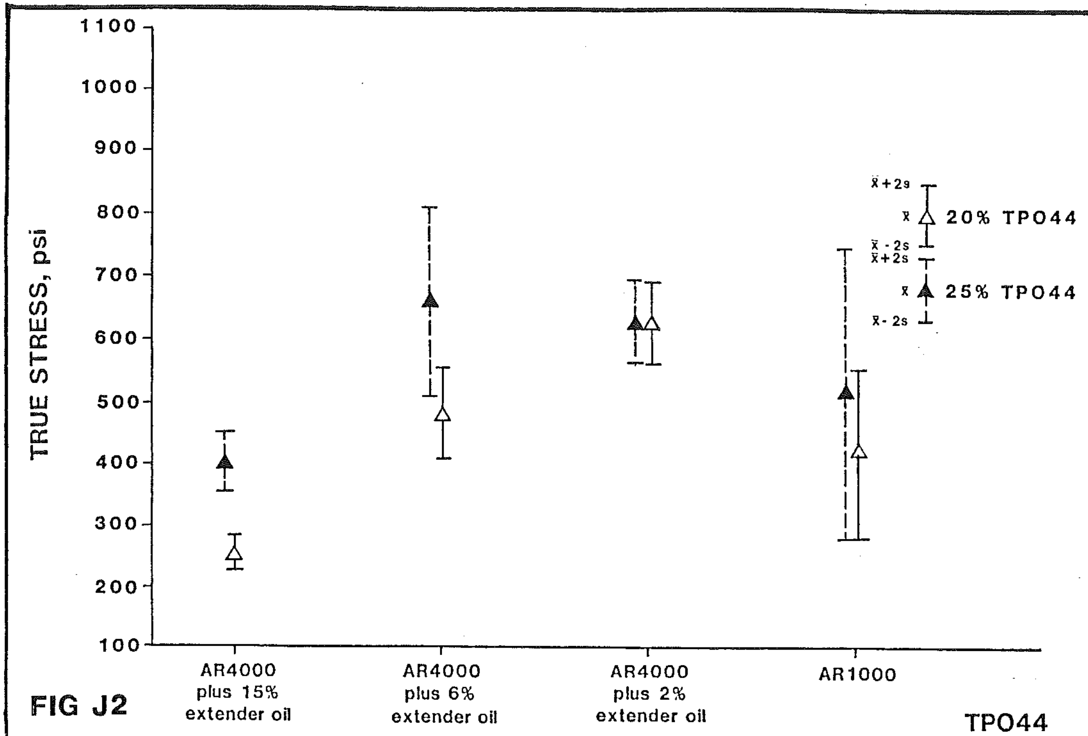
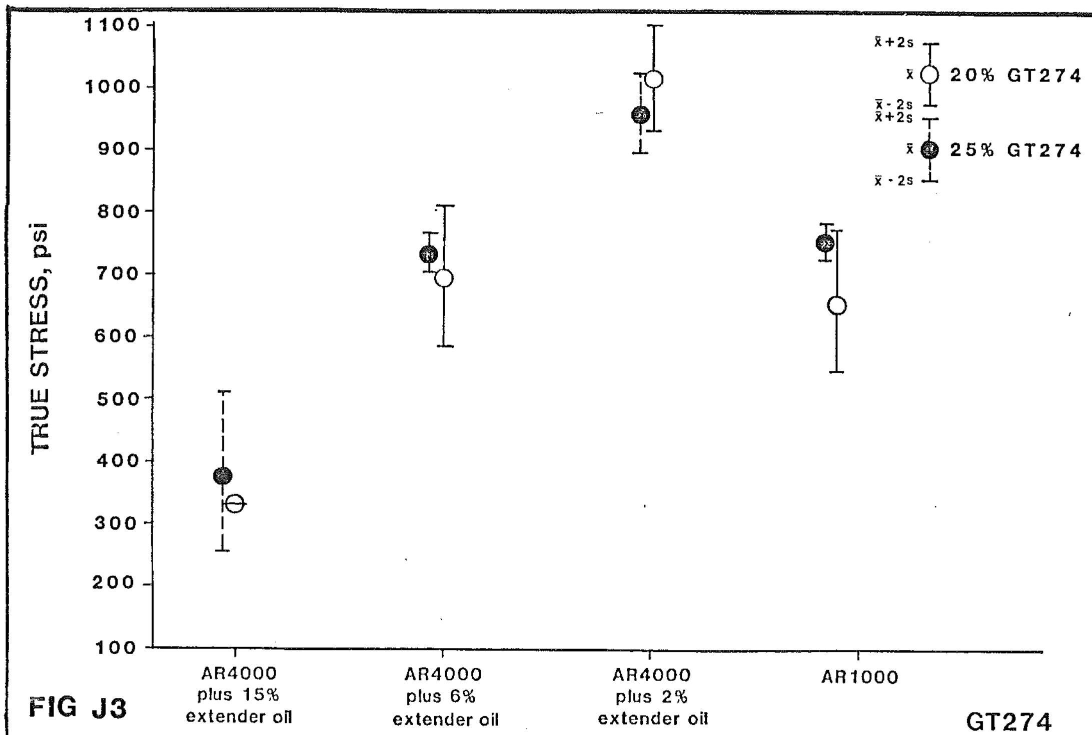


FIG J1



1100
1000
900
800
700
600
500
400
300
200
100
TRUE STRESS, psi
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG J2



1100
1000
900
800
700
600
500
400
300
200
100
TRUE STRESS, psi
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG J3

APPENDIX K

FORCE-DUCTILITY TRUE STRAIN AT FAILURE AT 39.2F (4C)

TABLE K-1

True Strain at Failure

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	2.37	1.82	1.71	1.60
	2.48	2.03	1.61	1.63
	2.42	2.14	1.93	1.61
	2.52	2.26	1.62	1.58
	2.31	2.16	1.76	1.63
	2.52	1.99	1.86	1.72
AR4000 + 6% Ext. Oil	2.25	1.97	1.75	1.64
	2.30	2.12	1.40	1.61
	2.23	2.01	1.57	1.53
	2.23	2.12	1.64	1.77
	2.29	2.14	1.75	1.59
	2.25	2.11	1.69	1.60
AR4000 + 2% Ext. Oil	2.17	2.10	1.60	1.49
	2.13	2.05	1.58	1.59
	2.12	2.09	1.60	1.44
	2.11	2.09	1.57	1.51
	2.14	2.14	1.52	1.51
	2.22	2.05	1.59	1.51
AR1000	2.34	2.27	1.77	1.47
	2.39	2.23	1.69	1.53
	2.33	2.22	1.71	1.74
	2.22	2.20	1.79	1.50
	2.24	2.18	1.75	1.57
	2.31	2.19	1.68	1.47

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	2.437	2.067	1.748	1.628
	S	.085	.155	.129	.049
	CV	3.51	7.48	7.36	3.00
AR4000 + 6% Extender Oil	$\overline{X}$	2.258	2.078	1.633	1.623
	S	.030	.070	.133	.080
	CV	1.33	3.38	8.17	4.95
AR4000 + 2% Extender Oil	$\overline{X}$	2.148	2.087	1.577	1.508
	S	.041	.034	.030	.048
	CV	1.89	1.62	1.91	3.20
AR1000	$\overline{X}$	2.305	2.215	1.732	1.547
	S	.064	.033	.045	.102
	CV	2.78	1.48	2.59	6.60

TABLE K-2

True Strain at Failure

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	2.423	1.997	1.750	1.613
	2.450	2.137	1.747	1.643
AR4000 + 6% Ext. Oil	2.260	2.033	1.573	1.593
	2.257	2.123	1.693	1.653
AR4000 + 2% Ext. Oil	2.140	2.080	1.593	1.507
	2.157	2.093	1.560	1.51
AR1000	2.353	2.240	1.723	1.580
	2.257	2.190	1.740	1.513

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	2.44	2.07	1.75	1.63
	S	.024	.124	.003	.027
	CV	.98	6.00	.15	1.63
AR4000 + 6% Extender Oil	$\overline{X}$	2.26	2.08	1.63	1.62
	S	.003	.080	.106	.053
	CV	.12	3.84	6.51	3.28
AR4000 + 2% Extender Oil	$\overline{X}$	2.15	2.09	1.58	1.51
	S	.015	.012	.029	.003
	CV	.70	.55	1.85	.18
AR1000	$\overline{X}$	2.31	2.22	1.73	1.55
	S	.085	.044	.015	.059
	CV	3.69	2.00	.87	3.84

TABLE K-3

ANOVA Summary, True Strain at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	2.6444250	2.64442	1293.97	4.49	8.53
Q	1	.1472888	.14729	72.07	4.49	8.53
A	3	.0934938	.03116	15.25	3.24	5.29
RQ	1	.0126803	.01268	6.21	4.49	8.53
RA	3	.0069116	.00230	1.13	3.24	5.29
QA	3	.0371688	.01239	6.06	3.24	5.29
RQA	3	.0373858	.01246	6.10	3.24	5.29
Error	16	.0326985	.00204			
TOTAL	31	3.0120527				

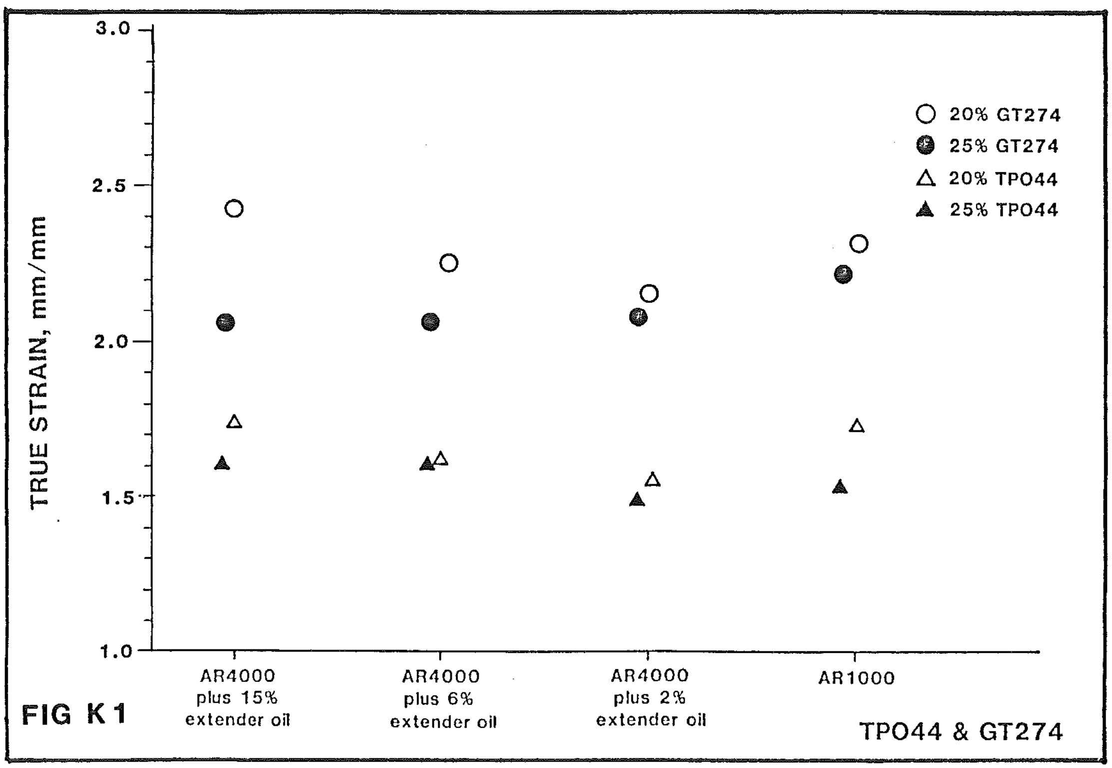


FIG K1

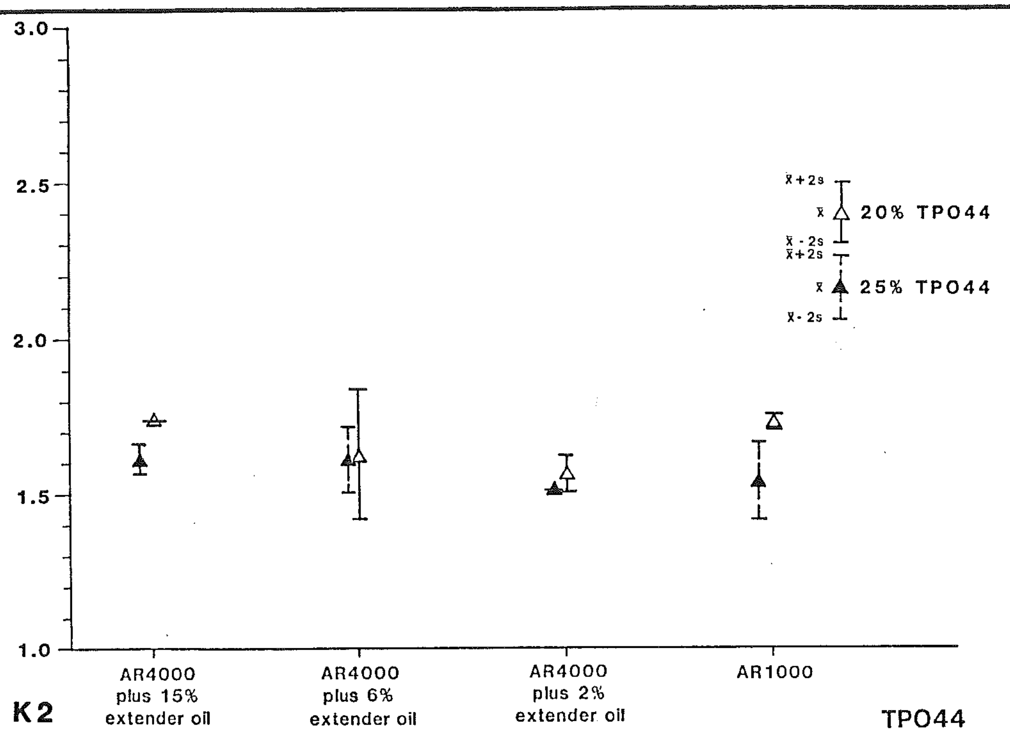

3.0
2.5
2.0
1.5
1.0
TRUE STRAIN, mm/mm
x̄+2s
x̄
x̄-2s
20% TPO44
25% TPO44
AR4000
plus 15%
extender oil
AR4000
plus 6%
extender oil
AR4000
plus 2%
extender oil
AR1000
TPO44

FIG K2

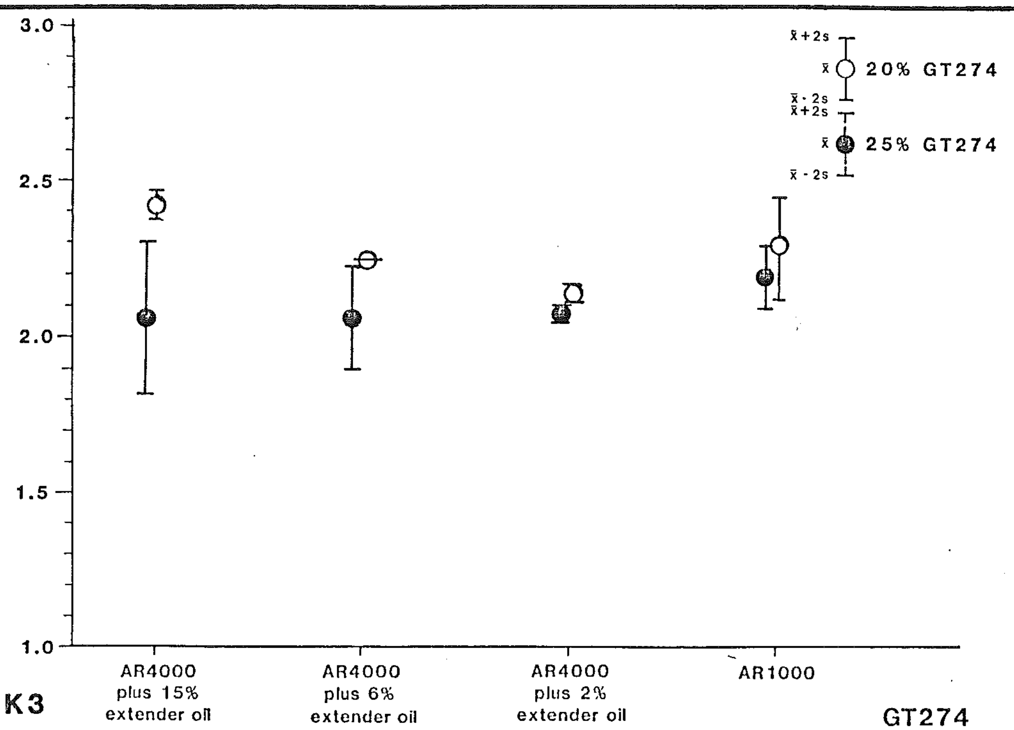

3.0
2.5
2.0
1.5
1.0
TRUE STRAIN, mm/mm
x̄+2s
x̄
x̄-2s
20% GT274
25% GT274
AR4000
plus 15%
extender oil
AR4000
plus 6%
extender oil
AR4000
plus 2%
extender oil
AR1000
GT274

FIG K3

APPENDIX L

FORCE-DUCTILITY ENGINEERING

CREEP COMPLIANCE AT 39.2F (4C)

TABLE L-1

Engineering Creep Compliance at Failure, psi^{-1}

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.291	.116	.00995	.0572
	.371	.130	.0897	.0492
	.313	.179	.1260	.0523
	.405	.173	.0881	.0492
	.267	.1525	.1070	.0508
	.386	.1429	.1300	.0595
AR4000 + 6% Ext. Oil	.117	.0708	.0537	.0328
	.120	.0770	.0306	.0330
	.103	.0635	.0393	.0279
	.122	.0832	.0441	.0340
	.123	.0796	.0537	.0304
	.124	.0831	.0469	.0309
AR4000 + 2% Ext. Oil	.068	.0630	.0274	.0231
	.063	.0571	.0286	.0266
	.062	.0591	.0336	.0244
	.0584	.0585	.0282	.0245
	.0621	.0618	.0273	.0254
	.0722	.0572	.0313	.0300
AR1000	.136	.110	.0840	.0312
	.134	.105	.0534	.0310
	.137	.0949	.0717	.0371
	.131	.093	.0576	.0346
	.131	.089	.0596	.0373
	.133	.101	.0579	.0377

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	.3388	.1489	.1067	.0530
+ 15%	S	.05613	.02439	.01790	.00434
Extender Oil	CV	16.57	16.38	16.77	8.18
AR4000	$\overline{X}$	.1182	.0763	.0447	.0315
+ 6%	S	.00783	.00774	.00889	.00222
Extender Oil	CV	6.63	10.15	19.88	7.06
AR4000	$\overline{X}$	.0643	.0595	.0294	.0256
+ 2%	S	.00495	.00244	.00252	.00242
Extender Oil	CV	7.71	4.10	8.57	9.43
	$\overline{X}$	.1337	.0988	.0640	.0348
AR1000	S	.00250	.00792	.01157	.00308
	CV	1.87	8.01	18.07	8.84

TABLE L-2

Engineering Creep Compliance at Failure, psi^{-1}

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.325	.1416	.1051	.0529
	.3527	.1561	.1084	.0532
AR4000 + 6% Ext. Oil	.1133	.0704	.0412	.0312
	.123	.0820	.0482	.0318
AR4000 + 2% Ext. Oil	.06433	.05973	.02987	.02470
	.06423	.05917	.02893	.02663
AR1000	.13567	.10330	.06970	.03310
	.13167	.09433	.05837	.03653

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\bar{X}$	.3389	.1489	.1068	.0531
	S	.02454	.01285	.00292	.00027
	CV	7.24	8.63	2.74	.50
AR4000 + 6% Extender Oil	$\bar{X}$	.1182	.0762	.0447	.0315
	S	.00859	.01028	.00620	.00053
	CV	7.27	13.49	13.87	1.69
AR4000 + 2% Extender Oil	$\bar{X}$	.0643	.0595	.0294	.0257
	S	.00009	.00050	.00083	.00171
	CV	.14	.83	2.83	6.66
AR1000	$\bar{X}$	.1337	.0988	.0640	.0348
	S	.00354	.00795	.01003	.00304
	CV	2.65	8.04	15.68	8.73

TABLE L-3

ANOVA Summary, Engineering Creep Compliance at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.0525447	.05255	1115.01	4.49	8.53
Q	1	.0172506	.01725	366.06	4.49	8.53
A	3	.0621398	.02071	439.54	3.24	5.29
RQ	1	.0036885	.003688	78.27	4.49	8.53
RA	3	.0194808	.00649	137.80	3.24	5.29
QA	3	.0160545	.00535	113.56	3.24	5.29
RQA	3	.0060301	.002010	42.65	3.24	5.29
Error	16	.0007540	.00005			
TOTAL	31	.1779430				

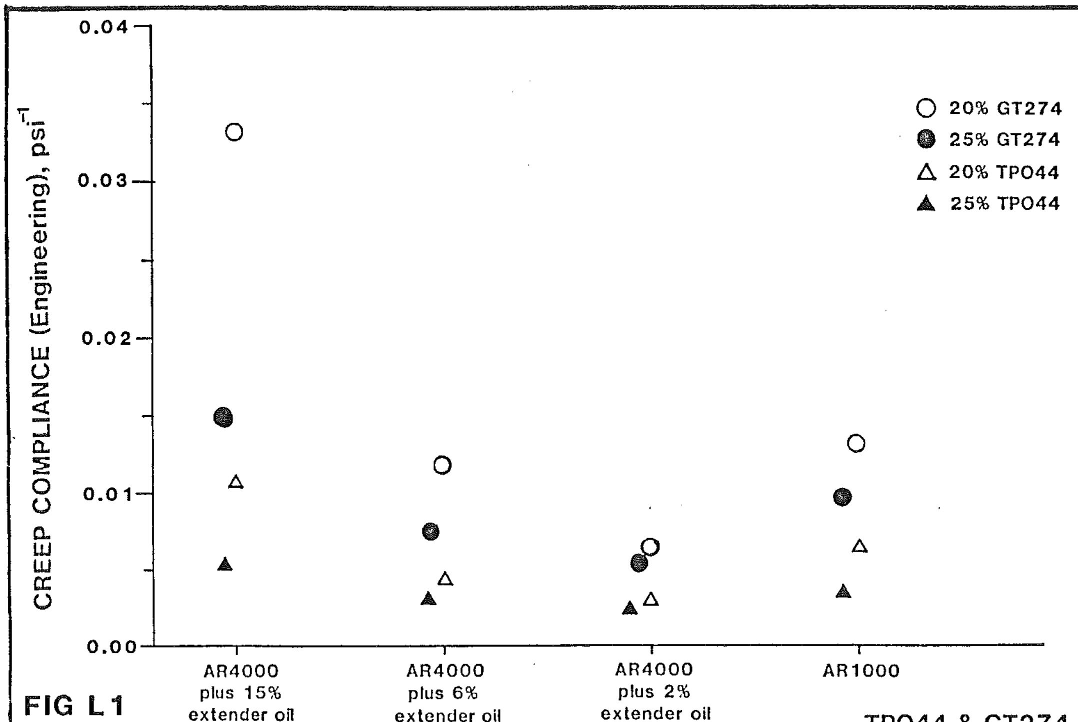
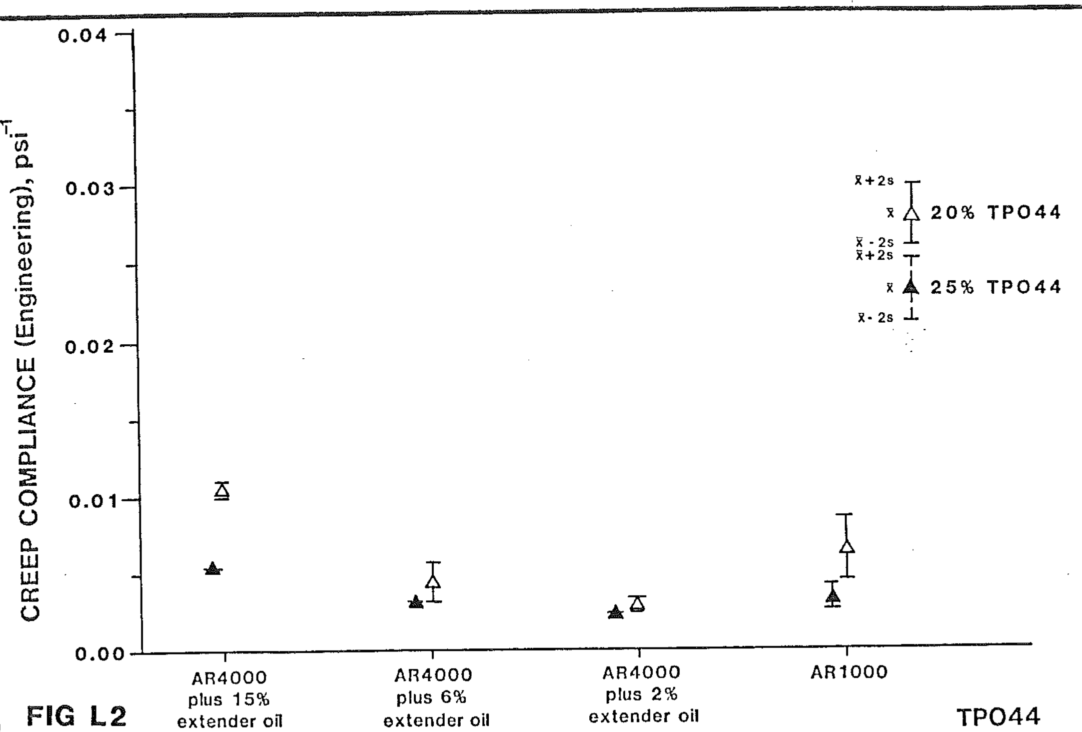


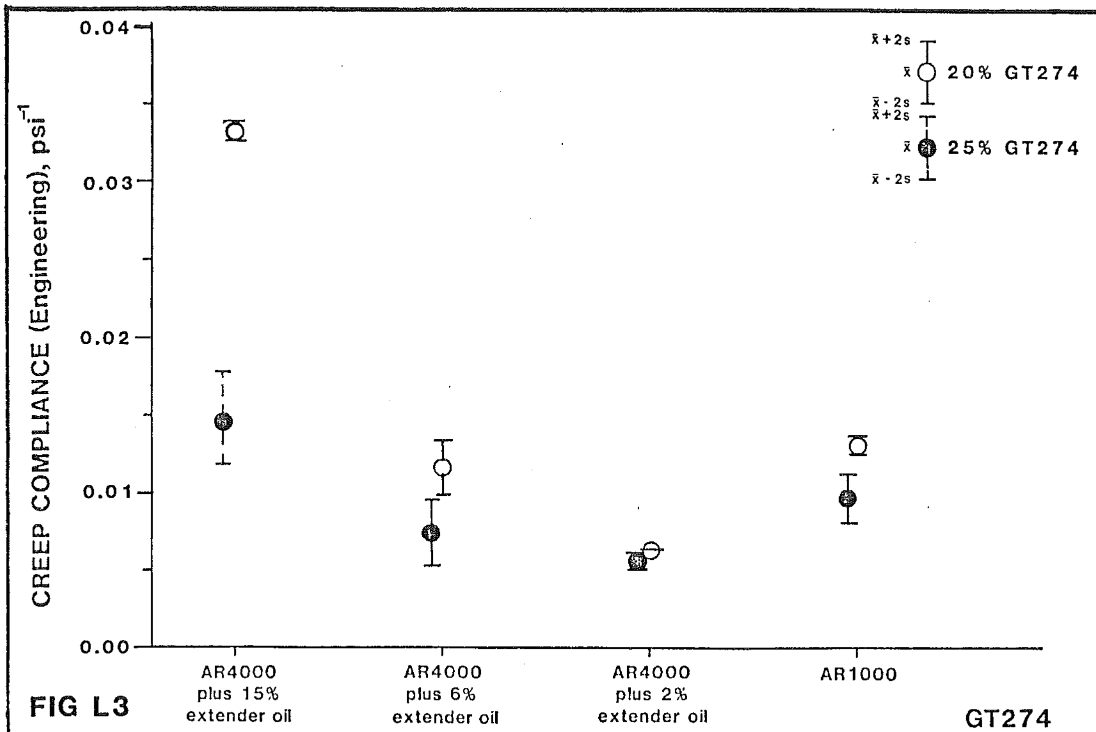
FIG L1

TPO44 & GT274



CREEP COMPLIANCE (Engineering), psi^{-1}
0.04
0.03
0.02
0.01
0.00
x̄+2s
x̄
x̄ - 2s
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG L2



CREEP COMPLIANCE (Engineering), psi^{-1}
0.04
0.03
0.02
0.01
0.00
x̄+2s
x̄
x̄ - 2s
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG L3

APPENDIX M

FORCE-DUCTILITY TRUE CREEP COMPLIANCE AT FAILURE AT 39.2F (4C)

TABLE M-1

True Creep Compliance at Failure, psi^{-1}

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.00667	.00660	.00680	.00467
	.00708	.00523	.00717	.00383
	.00658	.00599	.00606	.00421
	.00713	.00474	.00700	.0041
	.00672	.00499	.00679	.0040
	.00687	.0062	.00700	.0040
AR4000 + 6% Ext. Oil	.00328	.00316	.0035	.0025
	.00308	.00266	.0035	.0026
	.00299	.00260	.0034	.0026
	.00356	.00291	.00337	.0021
	.00323	.00268	.00343	.0025
	.00345	.00296	.00333	.0025
AR4000 + 2% Ext. Oil	.00218	.00227	.0022	.00227
	.00213	.00223	.0024	.00221
	.00215	.00215	.0028	.00256
	.00205	.00215	.00241	.0023
	.00207	.00208	.00255	.0024
	.00211	.00222	.00261	.0028
AR1000	.00325	.00296	.00521	.00315
	.00351	.00306	.00375	.00284
	.00336	.00277	.00490	.00241
	.00387	.00284	.00348	.00330
	.00372	.00282	.00382	.00319
	.00335	.00309	.00414	.00381

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000	$\overline{X}$	.00684	.00563	.00680	.00414
+ 15%	S	.00023	.0007	.00039	.00029
Extender Oil	CV	3.29	13.20	5.75	7.03
AR4000	$\overline{X}$	.00326	.00283	.00342	.00246
+ 6%	S	.00022	.0002	.00007	.00019
Extender Oil	CV	6.61	7.69	2.02	7.55
AR4000	$\overline{X}$	.00212	.00218	.00250	.00242
+ 2%	S	.00005	.00007	.00021	.00022
Extender Oil	CV	2.31	3.17	8.26	9.14
AR1000	$\overline{X}$	.00351	.00292	.00421	.00312
	S	.00024	.00013	.00069	.00047
	CV	6.85	4.56	16.35	15.03

TABLE M-2

True Creep Compliance at Failure, psi^{-1}

a. Analyzed Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	.678 .691	.594 .531	.668 .693	.424 .403
AR4000 + 6% Extender Oil	.312 .341	.281 .285	.347 .338	.257 .237
AR4000 + 2% Extender Oil	.215 .208	.222 .215	.247 .252	.235 .250
AR1000	.337 .365	.293 .292	.462 .381	.280 .343

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	.6845	.5625	.6805	.4135
	S	.0115	.0558	.0222	.0186
	CV	1.68	9.92	3.25	4.50
AR4000 + 6% Extender Oil	$\overline{X}$	.3265	.2830	.3425	.2470
	S	.0257	.0035	.0079	.0177
	CV	7.87	1.25	2.33	7.17
AR4000 + 2% Extender Oil	$\overline{X}$	.2115	.2185	.2495	.2425
	S	.0062	.0062	.0044	.0132
	CV	2.93	2.84	1.78	5.48
AR1000	$\overline{X}$	.3510	.2925	.4215	.3115
	S	.0248	.0009	.0718	.0558
	CV	7.07	.303	17.03	17.92

TABLE M-3

ANOVA Summary, True Creep Compliance at Failure

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.0000578	.0000578	.10	4.49	8.53
Q	1	.0606390	.0606390	106.59	4.49	8.53
A	3	.5703488	.1901163	334.18	3.24	5.29
RQ	1	.0086133	.0086133	15.14	4.49	8.53
RA	3	.0177738	.0059246	10.41	3.24	5.29
QA	3	.0388781	.0129594	22.78	3.24	5.29
RQA	3	.0046753	.0015584	2.74	3.24	5.29
Error	16	.0091025	.0005689			
TOTAL	31	.7100887				

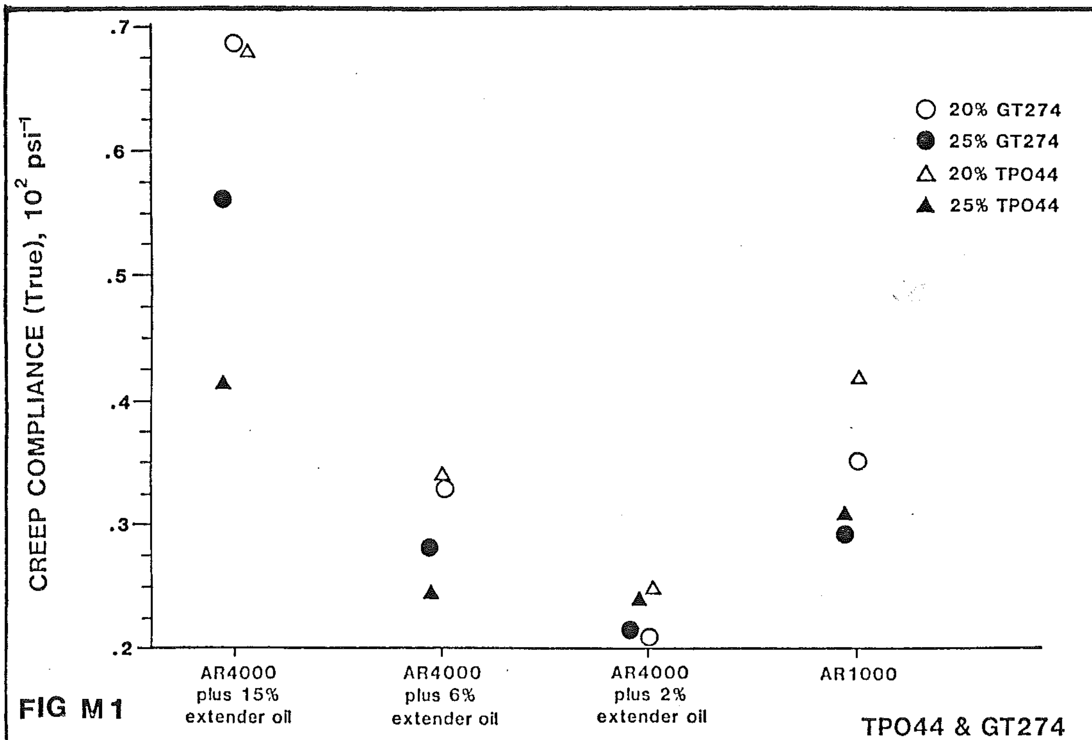
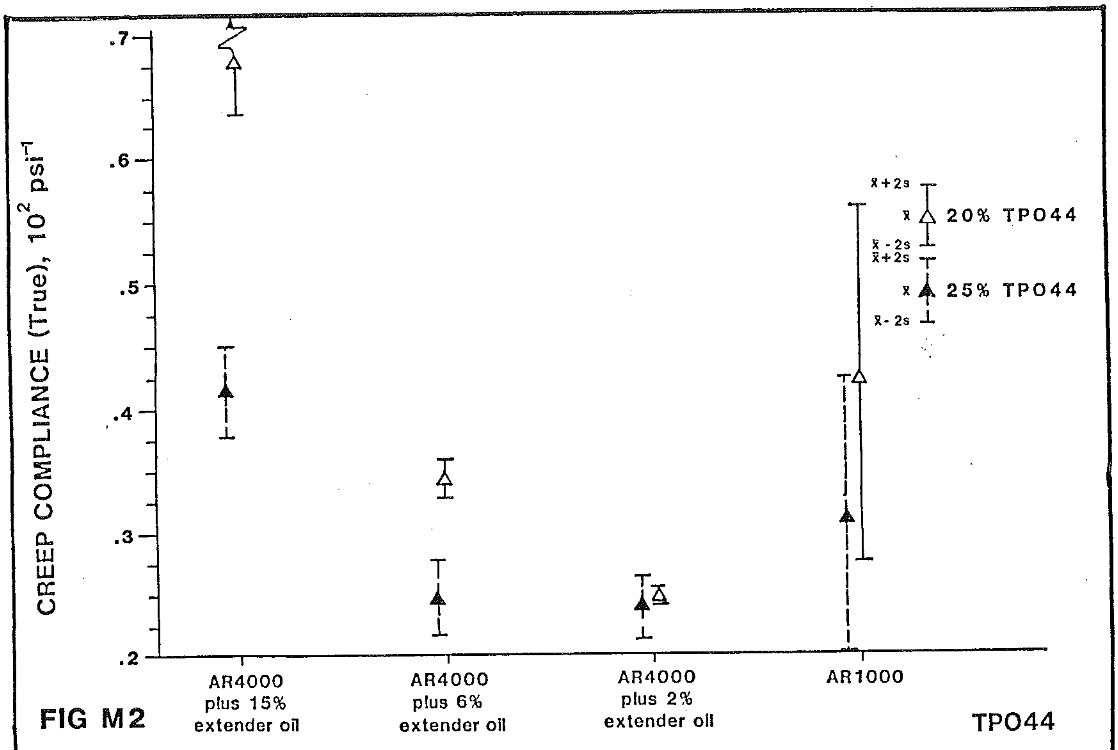
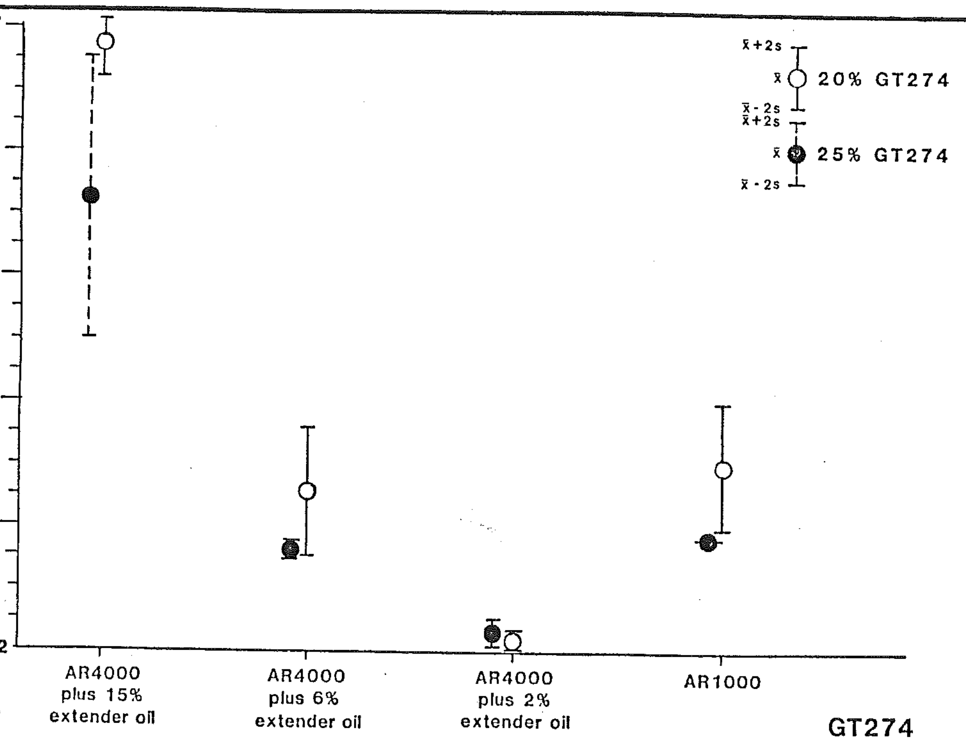


FIG M1



CREEP COMPLIANCE (True), 10^2 psi^{-1}
.7
.6
.5
.4
.3
.2
x̄+2s
x̄
20% TPO44
x̄-2s
x̄+2s
x̄
25% TPO44
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG M2



CREEP COMPLIANCE (True), 10^2 psi^{-1}
.7
.6
.5
.4
.3
.2
x̄+2s
x̄
20% GT274
x̄-2s
x̄+2s
x̄
25% GT274
x̄-2s
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG M3

APPENDIX N

FORCE-DUCTILITY MAXIMUM TRUE CREEP

COMPLIANCE AT 39.2F (4C)

TABLE N-1

Maximum True Creep Compliance, psi^{-1}

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.0164	.0136	.00944	.00726
	.0162	.0132	.00940	.00659
	.0156	.0167	.00895	.00711
	.0167	.0140	.00949	.0075
	.0155	.0136	.00918	.0065
	.0161	.01457	.00963	.0072
AR4000 + 6% Ext. Oil	.00752	.00787	.0054	.0043
	.00747	.00753	.0047	.0044
	.00717	.0069	.0049	.0042
	.00794	.00834	.00493	.0044
	.00835	.00755	.00514	.0046
	.00849	.00816	.00503	.0046
AR4000 + 2% Ext. Oil	.00512	.00694	.0033	.00336
	.00509	.00659	.0034	.00348
	.00493	.00649	.0037	.00376
	.00435	.00688	.00343	.0037
	.00452	.00657	.00338	.0035
	.00508	.00680	.00346	.0043
AR1000	.00931	.00938	.00744	.00621
	.00981	.00977	.00562	.00538
	.00939	.00838	.00678	.00496
	.00990	.00948	.00565	.00604
	.00903	.00875	.00583	.00598
	.00924	.00968	.00615	.00642

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\bar{X}$	.01608	.01423	.00935	.00703
	S	.00046	.00013	.00024	.00040
	CV	2.87	8.92	2.61	5.63
AR4000 + 6% Extender Oil	$\bar{X}$	.00782	.00772	.00502	.00442
	S	.00053	.00052	.00024	.00016
	CV	6.71	6.70	4.75	3.63
AR4000 + 2% Extender Oil	$\bar{X}$	.00485	.00671	.00345	.00368
	S	.00033	.00019	.00014	.00034
	CV	6.83	2.77	3.95	9.13
AR1000	$\bar{X}$	.00945	.00924	.00625	.00583
	S	.00034	.00055	.00073	.00055
	CV	3.59	5.99	11.64	9.45

TABLE N-2

Maximum True Creep Compliance, psi^{-1}

a. Analyzed Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	.01606 .01610	.01450 .01406	.00926 .00943	.00699 .00707
AR4000 + 6% Ext. Oil	.00739 .00826	.00743 .00802	.00500 .00503	.00430 .00453
AR4000 + 2% Ext. Oil	.00505 .00465	.00667 .00675	.00347 .00342	.00353 .00383
AR1000	.00950 .00939	.00918 .00930	.00661 .00588	.00552 .00615

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	.01608	.01428	.00935	.00703
	S	.00004	.00039	.00015	.00007
	CV	.22	2.73	1.61	1.01
AR4000 + 6% Extender Oil	$\overline{X}$	.00783	.00773	.00502	.00442
	S	.00077	.00052	.00003	.00020
	CV	9.85	6.77	.53	4.62
AR4000 + 2% Extender Oil	$\overline{X}$	.00485	.00671	.00345	.00368
	S	.00035	.00007	.00004	.00027
	CV	7.31	1.06	1.29	7.22
AR1000	$\overline{X}$	.00945	.00924	.00625	.00584
	S	.00010	.00011	.00065	.00056
	CV	1.03	1.15	10.36	9.57

TABLE N-3

ANOVA Summary, Maximum True Creep Compliance

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	.0001213	.0001213	1492.92	4.49	8.53
Q	1	.0000014	.0000014	17.23	4.49	8.53
A	3	.0002168	.0000723	889.44	3.24	5.29
RQ	1	.0000010	.0000010	12.31	4.49	8.53
RA	3	.0000269	.0000090	110.36	3.24	5.29
QA	3	.0000097	.0000032	39.75	3.24	5.29
RQA	3	.0000006	.0000002	2.46	3.24	5.29
Error	16	.0000013	.00000008			
TOTAL	31	.0003789				

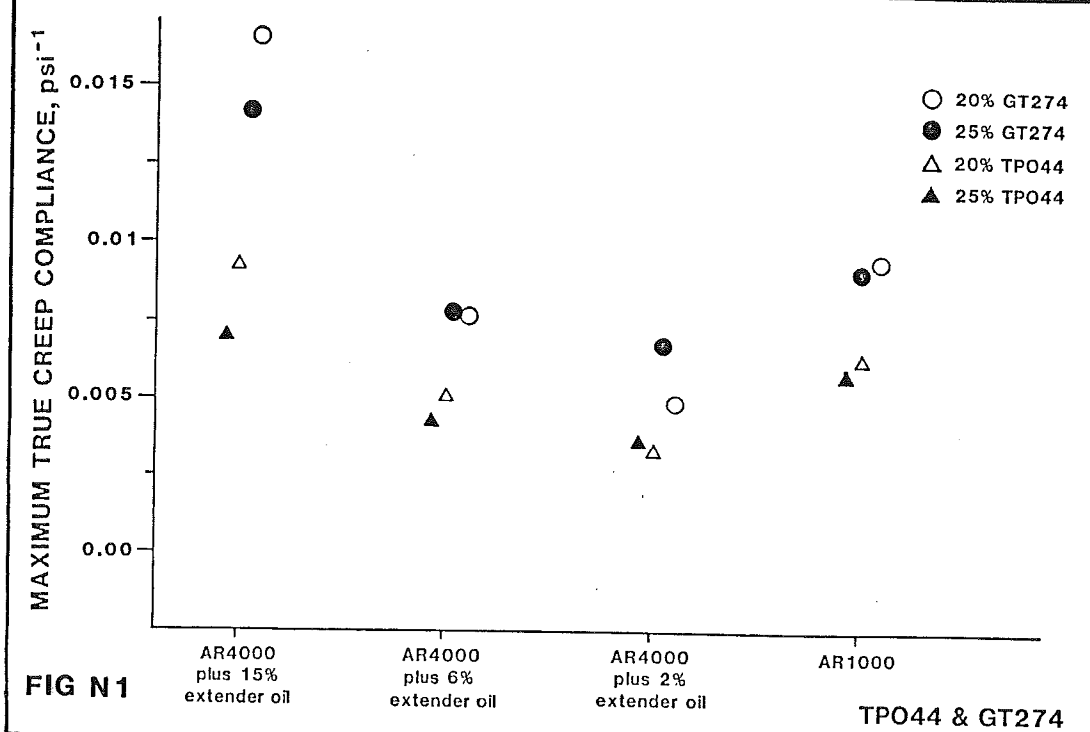


FIG N1

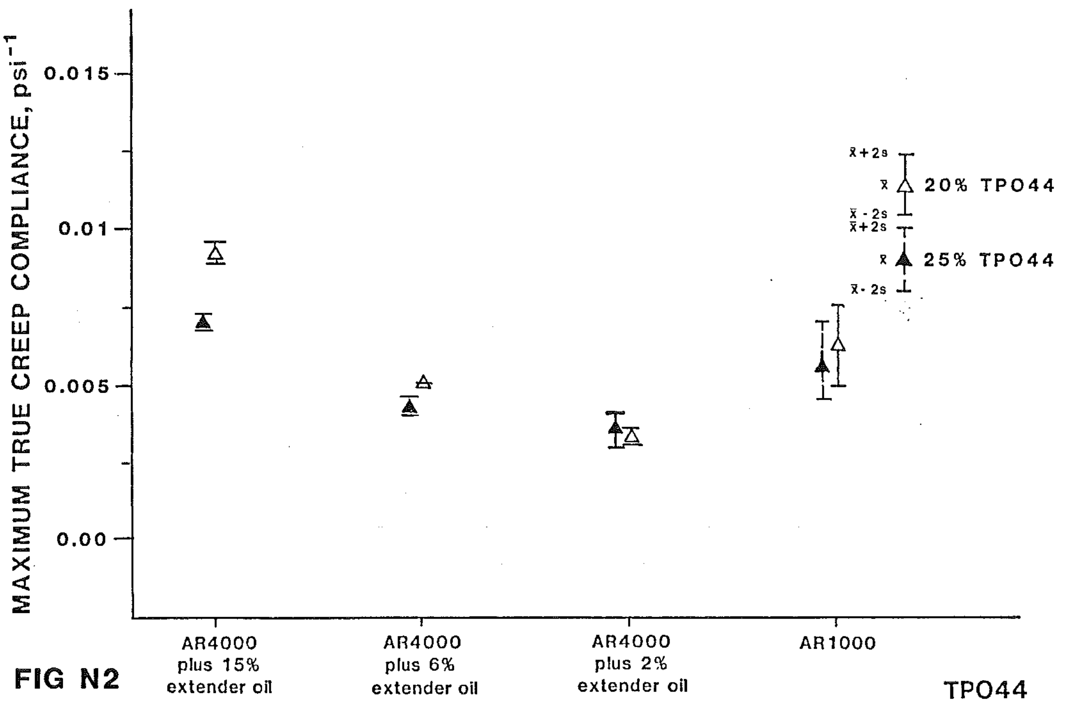

MAXIMUM TRUE CREEP COMPLIANCE, psi^{-1}
0.015
0.01
0.005
0.00
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
20% TPO44
25% TPO44
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
TPO44

FIG N2

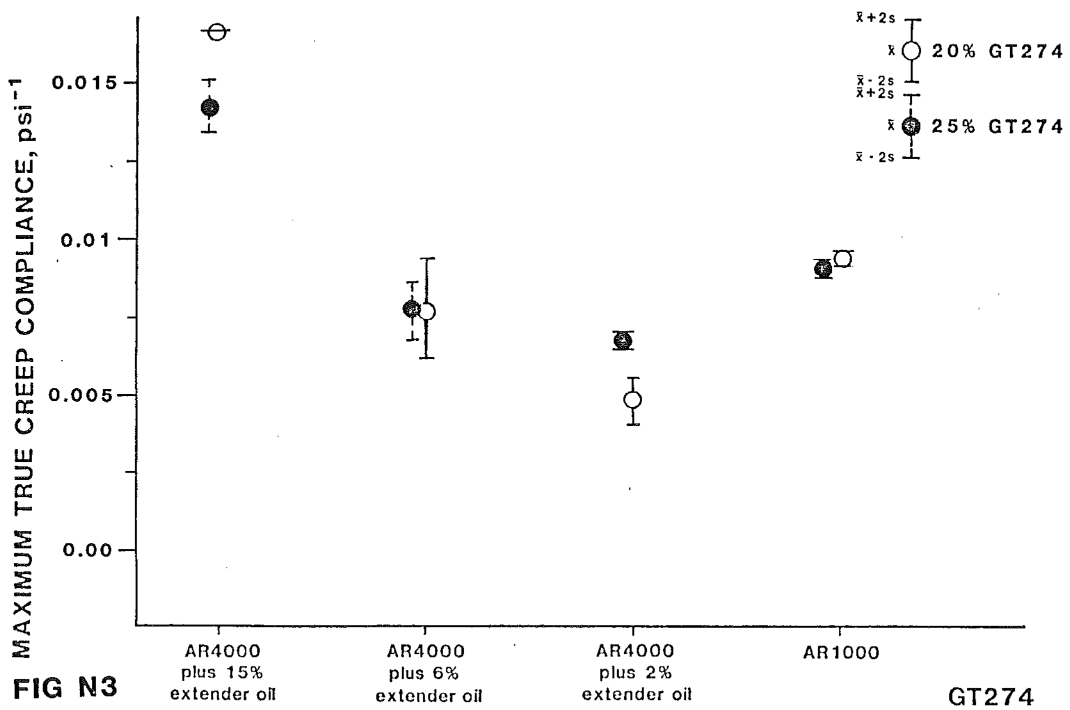

MAXIMUM TRUE CREEP COMPLIANCE, psi^{-1}
0.015
0.01
0.005
0.00
$\bar{x}+2s$
$\bar{x}$
$\bar{x}-2s$
20% GT274
25% GT274
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
GT274

FIG N3

APPENDIX O

FORCE DUCTILITY TIME TO MAXIMUM TRUE CREEP COMPLIANCE AT 39.2F(4C)

TABLE O-1

Time to Maximum True Creep Compliance, minutes

a. Calculated Data

	GT274		TP044	
	20%	25%	20%	25%
AR4000 + 15% Ext. Oil	11	10	11	8
	11	10	11	9
	11	8	11	8
	11	10	11	7
	12	9	10	9
	11	9	11	8
AR4000 + 6% Ext. Oil	14	11	9	9
	13	11	11	9
	13	11	10	10
	13	10	10	10
	12	11	11	9
	13	10	12	9
AR4000 + 2% Ext. Oil	12	11	10	9
	13	11	10	9
	13	11	11	9
	13	11	11	9
	13	11	11	9
	13	11	11	10
AR1000	12	10	9	7
	12	9	9	8
	12	9	9	7
	11	10	9	7
	12	11	10	7
	11	10	9	7

b. Summary

		GT274		TP044	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\overline{X}$	11.2	9.3	10.8	8.2
	S	.41	.82	.41	.75
	CV	3.66	8.75	3.77	9.22
AR4000 + 6% Extender Oil	$\overline{X}$	13.0	10.7	10.5	9.3
	S	.63	.52	1.05	.52
	CV	4.87	4.84	9.99	5.53
AR4000 + 2% Extender Oil	$\overline{X}$	12.8	11.0	10.7	9.2
	S	.41	0	.52	.41
	CV	3.18	0	4.84	4.45
AR1000	$\overline{X}$	11.7	9.8	9.2	7.2
	S	.52	.75	.41	.41
	CV	4.43	7.66	4.45	5.70

TABLE O-2

Time to Maximum True Creep Compliance, minutes

a. Analyzed Data

	GT274		TPO44	
	20%	25%	20%	25%
AR4000 + 15% Extender Oil	11.0	9.3	11.0	8.3
	11.3	9.3	10.7	8.0
AR4000 + 15% Extender Oil	13.3	11.0	10.0	9.3
	12.7	10.3	11.0	9.3
AR4000 +15% Extender Oil	12.7	11.0	10.3	9.0
	13.0	11.0	11.0	9.3
AR4000 +15% Extender Oil	12.0	9.3	9.0	7.3
	11.3	10.3	9.3	7.0

b. Summary

		GT274		TPO44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	$\bar{X}$	11.15	9.30	10.85	8.15
	S	.266	0	.266	.266
	CV	2.38	0	2.45	3.26
AR4000 + 6% Extender Oil	$\bar{X}$	13.00	10.65	10.50	9.30
	S	.532	.620	.886	0
	CV	4.09	5.82	8.44	0
AR4000 + 2% Extender Oil	$\bar{X}$	12.85	11.00	10.65	9.15
	S	.266	0	.620	.266
	CV	2.07	0	5.82	2.90
AR1000	$\bar{X}$	11.65	9.80	9.15	7.15
	S	.620	.886	.266	.266
	CV	5.32	9.04	2.90	3.72

TABLE O-3

ANOVA Summary, Time to Maximum True Creep Compliance

ANOVA

SOURCE	df	SS	MS	F	F.05	F.01
R	1	26.28125	26.28125	188.57	4.49	8.53
Q	1	29.26125	29.26125	209.95	4.49	8.53
A	3	12.98375	4.32792	31.05	3.24	5.29
RQ	1	.03125	.03125	.22	4.49	8.53
RA	3	3.64375	1.12458	8.72	3.24	5.29
QA	3	.41375	.13792	.99	3.24	5.29
RQA	3	1.06375	.35458	2.54	3.24	5.29
Error	16	2.23000	.13938			
TOTAL	31	75.90875				

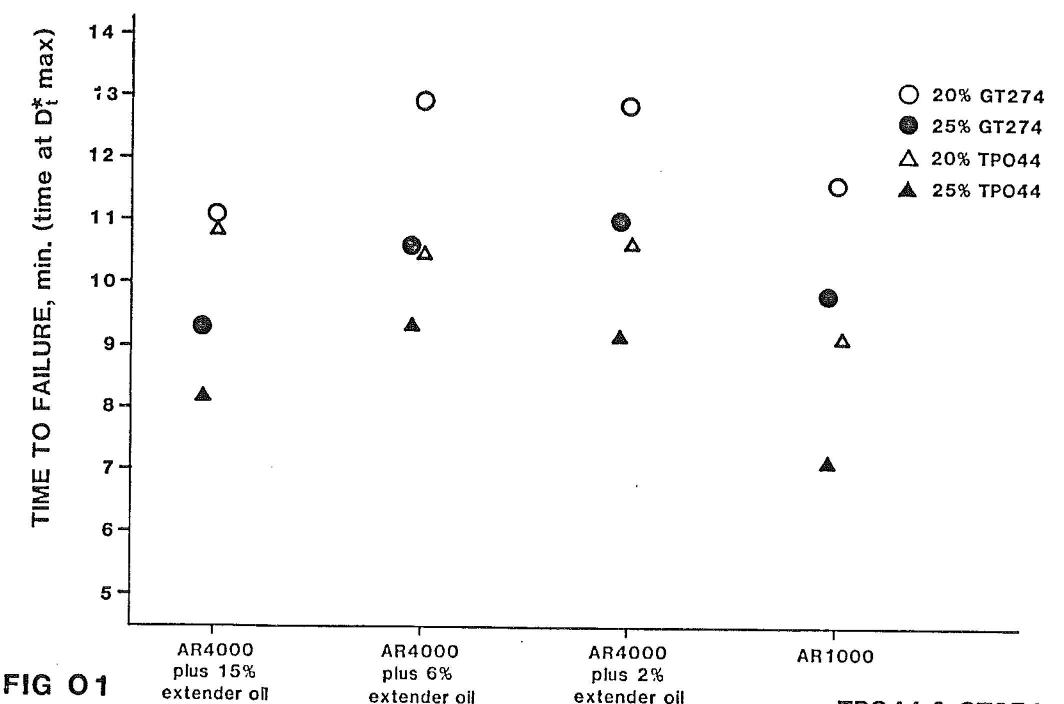


FIG O1

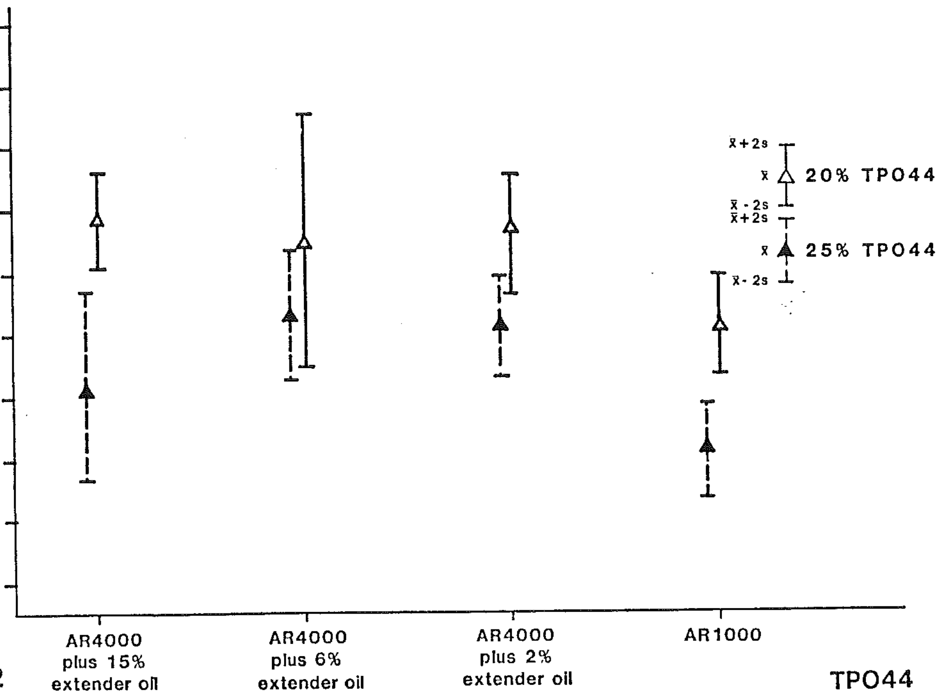

TIME TO FAILURE, min. (time at D_t^* max)
14
13
12
11
10
9
8
7
6
5
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
x̄+2s
x̄
20% TPO44
x̄-2s
x̄+2s
x̄
25% TPO44
x̄-2s
TPO44

FIG 02

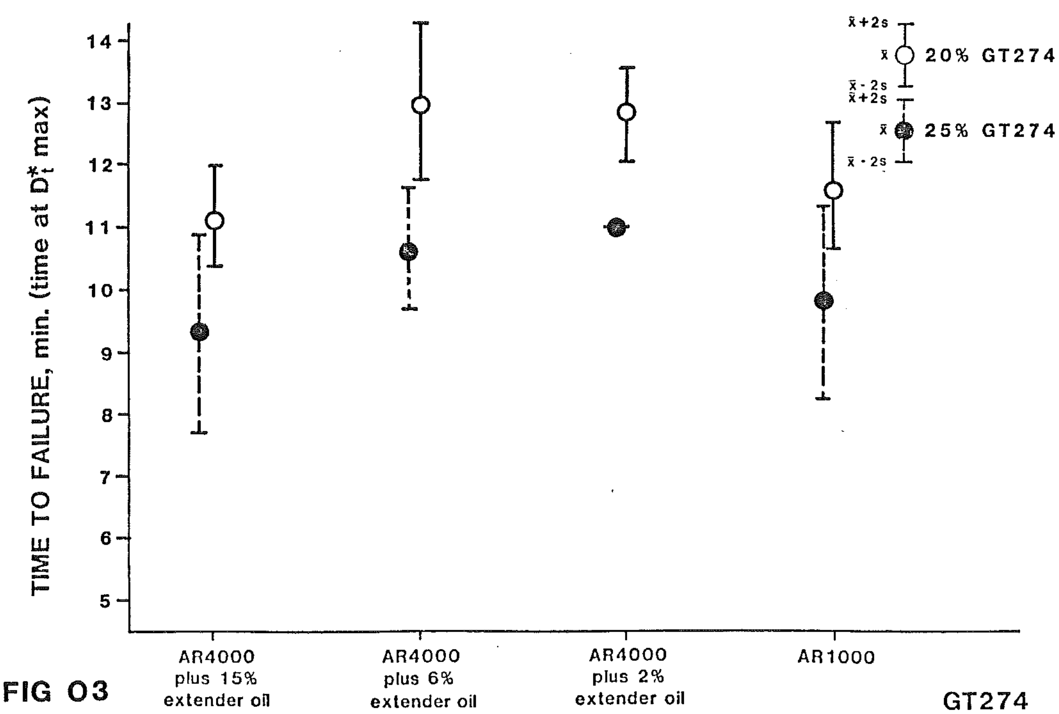

TIME TO FAILURE, min. (time at D_t^* max)
14
13
12
11
10
9
8
7
6
5
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
x̄+2s
x̄
20% GT274
x̄-2s
x̄+2s
x̄
25% GT274
x̄-2s
GT274

FIG 03

APPENDIX P

TORQUE-FORK VISCOSITY DURING MIXING AT 375F (191C) AND 500 RPM, POISES

TABLE P-1

Torque-Fork Viscosity During Mixing at 375F (191C) and 500 RPM, Poises

		GT274		TPQ44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	15 min.	17.5	43.4	13.0	22.4
	1 hr.	22.4	56.1	18.7	38.9
AR4000 + 6% Extender Oil	15 min.	18.7	38.9	14.1	19.9
	1 hr.	22.4	49.7	18.7	33.1
AR4000 + 2% Extender Oil	15 min.	27.6	60.3	15.8	23.6
	1 min.	37.4	91.7	19.9	35.2
AR1000	15 min.	28.9	61.1	9.9	33.1
	1 hr.	34.5	81.4	13.5	39.0

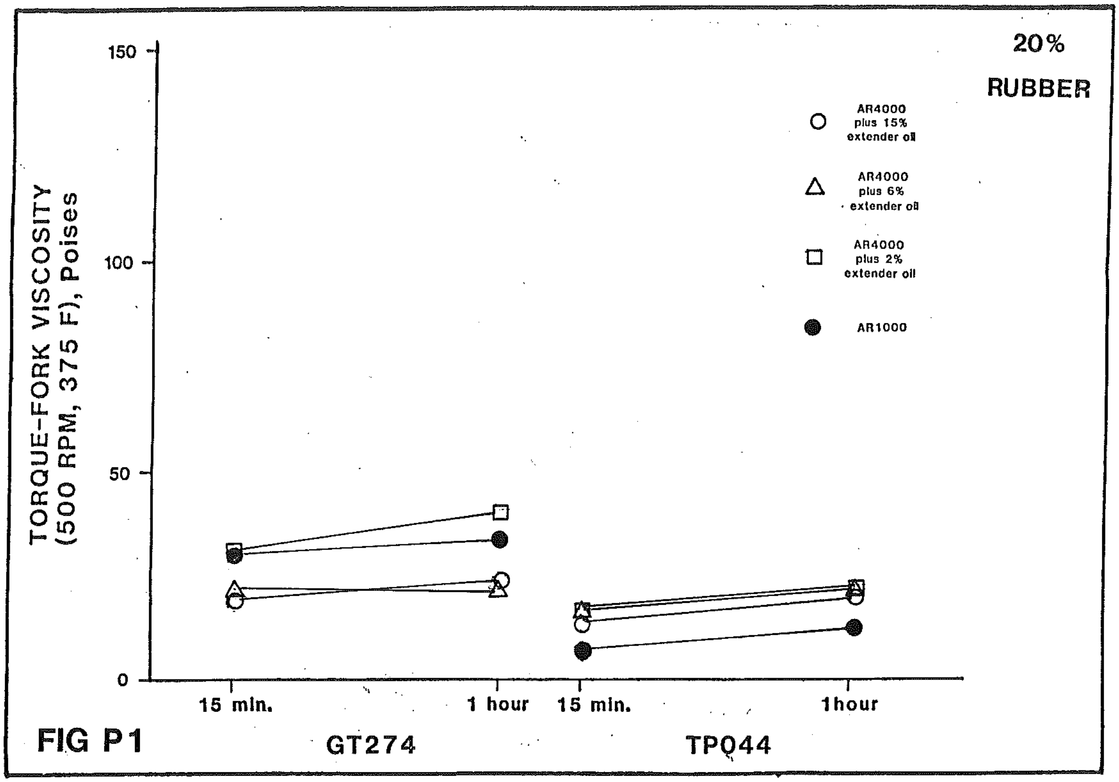

20%
RUBBER
TORQUE-FORK VISCOSITY
(500 RPM, 375 F), Poises
150
100
50
0
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
15 min.
1 hour
15 min.
1hour
GT274
TPQ44

FIG P1

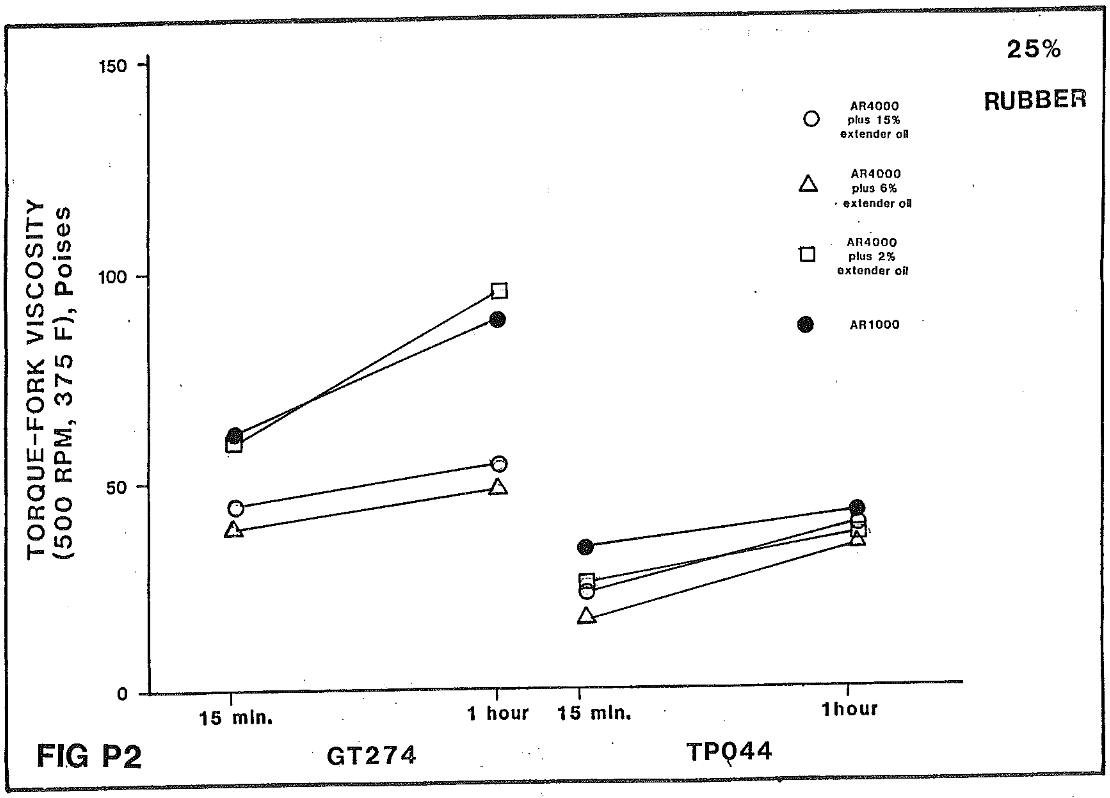

25%
RUBBER
TORQUE-FORK VISCOSITY
(500 RPM, 375 F), Poises
150
100
50
0
AR4000 plus 15% extender oil
AR4000 plus 6% extender oil
AR4000 plus 2% extender oil
AR1000
15 min.
1 hour
15 min.
1hour
GT274
TPQ44

FIG P2

APPENDIX Q

HAAKE VISCOSITY DURING MIXING AT 375F (191C), POISES

TABLE Q-1

Haake Viscosity During Mixing at 375F (191C), Poises

		GT274		TPQ44	
		20%	25%	20%	25%
AR4000 + 15% Extender Oil	15 min.	30	120	8	18
	1 hr.	47	180	14	36
AR4000 + 6% Extender Oil	15 min.	32	110	8	19
	1 hr.	45	140	15	80
AR4000 + 2% Extender Oil	15 min.	65	100	12	28
	1 min.	125	225	18	38
AR1000	15 min.	75	100	3.8	22
	1 hr.	90	240	7.5	70

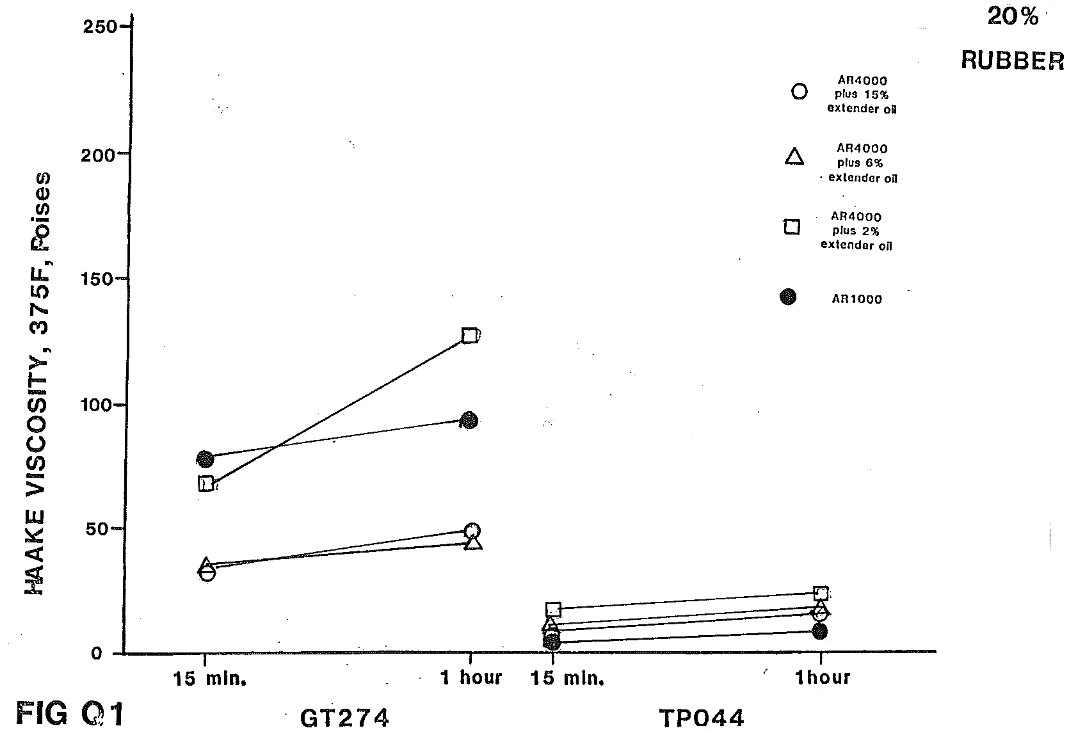

20%
RUBBER
AR4000
plus 15%
extender oil
AR4000
plus 6%
extender oil
AR4000
plus 2%
extender oil
AR1000
HAAKE VISCOSITY, 375F, Poises
250
200
150
100
50
0
15 min.
1 hour
15 min.
1hour
GT274
TP044

FIG Q1

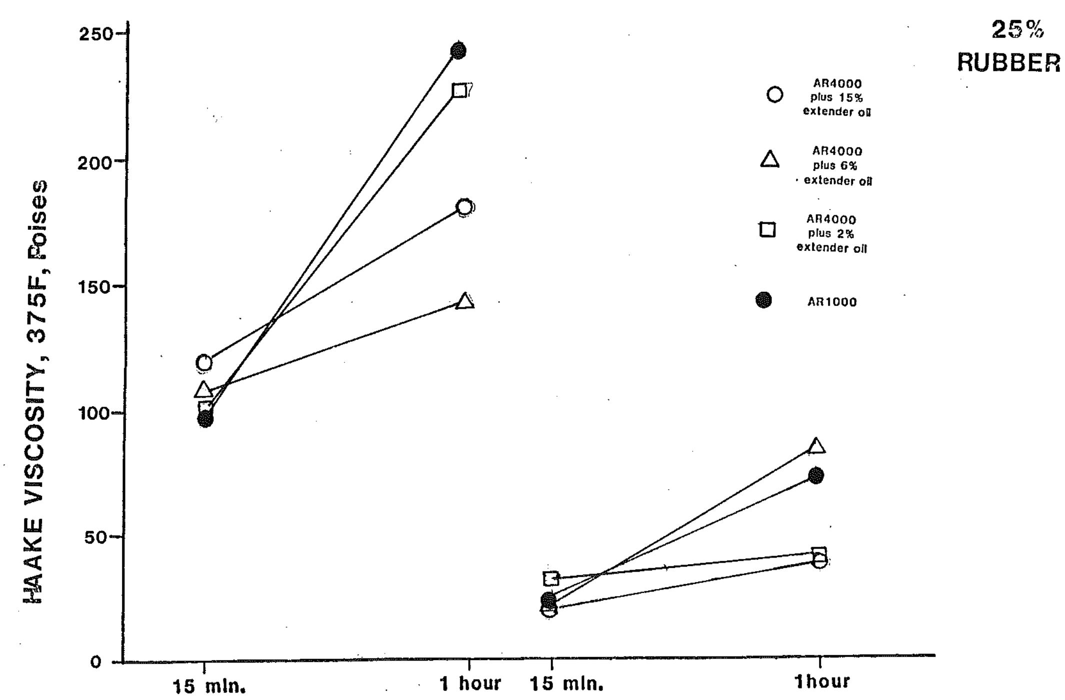

25%
RUBBER
AR4000
plus 15%
extender oil
AR4000
plus 6%
extender oil
AR4000
plus 2%
extender oil
AR1000
HAAKE VISCOSITY, 375F, Poises
250
200
150
100
50
0
15 min.
1 hour
15 min.
1hour
GT274
TP044

FIG Q2