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(54) **Power transmission fluids with enhanced lubricating properties**

(57) Automatic transmission fluids are described which contain a dialkyl thiadiazole and amine antioxidants, in an essentially phenolic-free and sulfurized fat-free base oil. The transmission fluids according to the present invention exhibit excellent compatibility and im-

proved antiwear, oxidation resistance, and torque capacity properties. In a preferred embodiment a combination of friction modifiers yields enhanced results.

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Description

CROSS REFERENCE TO RELATED APPLICATIONS

5 **[0001]** There are no related applications.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

10 **[0002]** This research was not sponsored by any entity of the Federal Government.

BACKGROUND OF THE INVENTION

1. Field of the Invention

15 **[0003]** This invention relates to oil-based automatic transmission fluid compositions having applicability across various automatic transmission equipment platforms, and improved oxidation resistance, anti-wear properties, and torque durability.

2. Description of the Prior Art

20 **[0004]** US Patent 5,578,236, to Ethyl Corporation discloses a power transmission fluid with enhanced performance characteristics. The power transmission fluid composition disclosed therein has, inter alia, an oil-soluble boron content of about 0.001 to about 0.1%, an oil soluble phosphorus content of about 0.005 to about 0.2%, and an oil soluble metal additive content of from 0 to about 100 ppm.

25 **[0005]** The composition of the '236 patent comprises at least about 50 weight % hydrotreated mineral oils in the range of about 55N to about 125N, about 5 to 40 wt% of hydrogenated poly alpha olefin oligomer having a viscosity of about 2 to about 6 cSt at 100 ° C, about 5 to about 20 wt % of an acrylic viscosity index improver, a seal swell agent, an ashless dispersant, an oil soluble friction modifier, and an inhibitor selected from foam, copper corrosion (including thiadiazoles), rust, and oxidation inhibitors. The finished composition has a Brookfield viscosity of 13,000 cP or less at - 40 ° C, an ASTM D-4683 viscosity of at least 2.6 mPa.s at 150 ° C, and a viscosity of at least 6.8 cSt at 100° C after 40 cycles in the FISST of ASTM D-5275. However, the compositions disclosed are preferably devoid of sulfurized components.

30 **[0006]** US Patent 5,441,656, also to Ethyl Corporation, discloses an automatic transmission fluid for overcoming shudder problems in continuous slip torque converter clutches in automatic transmissions. The automatic transmission fluid ("ATF") of the '656 patent includes, among other restrictions, a friction modifier content which contains an N-aliphatic hydrocarbyl substituted diethanolamine in which the N-aliphatic hydrocarbyl substituent having in the range of about 14 to about 40 carbon atoms, and an N-aliphatic hydrocarbyl substituted trimethylene diamine in which the N-aliphatic hydrocarbyl substituent is at least one straight chain aliphatic hydrocarbyl group having in the range of about 14 to about 20 carbon atoms. Conventional copper corrosion inhibitors (including thiadiazoles) and other optional (e. g. lubricity, dye, pour point depressant, etc.) components may be present.

35 **[0007]** U.S. Patent Nos. 5,344,579; 5,372,735; and 5,578,236 disclose automatic transmission fluid compositions which exhibit good anti-shudder properties.

40 **[0008]** Other U.S. Patents which disclose various automatic transmission fluids include 4,795,583; 4,855,074; 4,857,214; 5,089,156; 5,126,064; 5,164,103; 5,171,466; 5,198,133; 5,256,324; 5,360,562; 5,387,346; 5,387,352; 5,389,273; 5,439,606; 5,505,868; 5,652,201; 5,703,023; 5,817,605; 5,851,962; 5,891,786; and 5,972,851. Each of the above is incorporated by reference.

45 **[0009]** These references, however, fail to teach or suggest the combination of components of the present invention, including the combination of an amine antioxidant and an ashless dialkyl thiadiazole in an automatic transmission fluid (which is essentially free of sulfurized fats, and phenolic anti-oxidants).

50 **[0010]** Commercially, it is known to add various additive packages to automatic transmission fluid, including, among other things, extreme pressure agents, antiwear agents, antioxidant systems, corrosion inhibitor systems, metal de-activators, anti-rust agents, friction modifiers, dispersants, detergents, anti-foam agents, and viscosity index improvers. However, not all additives interact predictably or well with one another.

BRIEF SUMMARY OF THE INVENTION

55 **[0011]** The present invention relates to the improvement of across-the-board equipment compatibility of an automatic transmission fluid by the inclusion of an ashless dialkyl thiadiazole and at least one amine antioxidant into a base fluid

which is essentially free of sulfurized fats and phenolic antioxidants.

[0012] Other optional components, e.g. additional friction modifiers, non-phenolic antioxidants, dispersants, and viscosity index improvers, may also be included. The fully formulated transmission fluid composition provides performance for a multitude of transmission platforms, improved anti-wear properties, oxidation resistance, and torque capacity when incorporated into an automatic transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Figure 1 is a graphical representation of the GM band friction performance (mid-point dynamic torque) results of Examples 1 and 3 of the present invention.

Figure 2 is a graphical representation of the Ford clutch friction durability test (mid-point dynamic torque) results of Examples 1, 2, and 3 of the present invention.

Figure 3 is a graphical representation of the Ford Clutch Friction durability test (low-speed dynamic torque) results of Examples 1, 2, and 3 of the present invention.

Figure 4 is a graphical representation of the GM Cycling test results of Example 1 of the instant invention.

Figure 5 is a graphical representation of the GM oxidation test results reflecting total acid number increase of Example 1 of the present invention.

Figure 6 is a graphical representation of the GM oxidation test results reflecting viscosity increase of Example 1 of the present invention.

Figure 7 is a graphical representation of the ECCC friction durability test results (torque vs. speed) for Example 1 of the present invention.

Figure 8 is a graphical representation of the ECCC friction durability test results (hours to negative slope) for Example 1 of the present invention.

Figure 9 is a graphical representation of the ECCC friction durability test results (torque vs. speed) for Example 2 of the present invention.

Figure 10 is a graphical representation of the ECCC friction durability test results (hours to negative slope) for Example 2 of the present invention.

Figure 11 is a graphical representation of the ECCC friction durability test results (torque vs. speed) for Example 3 of the present invention.

Figure 12 is a graphical representation of the ECCC friction durability test results (hours to negative slope) for Example 3 of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Vehicles meeting the stringent demands of consumers today require durability and performance in all of the vehicular systems. One of the most important systems is the power transmission system ("transmission") which transmits the power generated by the automobile engine to the wheels. It being one of the most complex systems in the vehicle, it is also one of the most costly to diagnose, repair, or replace. The transmission usually includes, inter alia, a clutch with plates, a torque converter, and a plurality of gears to alter the power delivered to the wheels by changing the gear ratio. Such a transmission may also include a wet clutch.

[0015] Discriminating consumers primarily desire high performance, low maintenance (high mileage between servicing), and extended life expectancy. However, with the advent of new transmission technologies, old standards of performance which were previously met with approval are now becoming unacceptable.

[0016] For example, there is worldwide activity by the automobile manufacturers to develop automatic transmissions incorporating various electronically controlled converter clutch (ECCC) designs. These developments are being driven by the anticipated increase in Corporate Average Fuel Economy (CAFE) requirements in the U.S.A. The ECCC design allows increases in fuel economy to be gained.

[0017] The advent of ECCC transmissions as well as vehicles equipped with a continuously variable transmission (CVT) and advances in aerodynamic body design result in passenger cars with smaller transmissions which tend to operate with higher energy densities and higher operating temperatures. Such changes have challenged lubricant suppliers to formulate automatic transmission fluids with new and unique performance characteristics including higher torque capacity and friction durability.

[0018] As a result, many original equipment manufacturers (OEMs) are looking for automatic transmission fluids with frictional characteristics capable of meeting or exceeding the requirements of ECCC, CVT, and other designs while retaining sufficient anti-wear and friction durability performance.

[0019] A need exists for an effective way of overcoming the across-the-board fluid and transmission compatibility

problems with automatic transmissions, especially to meet the needs of after-market automatic transmission service suppliers.

[0020] This invention provides an automatic transmission fluid that exhibits good oxidative resistance, anti-wear performance, and torque capacity and helps to solve the problems of existing incompatibility.

[0021] This invention also provides an automatic transmission fluid capable of passing the Ford Friction Durability Test, Ford ECCC friction durability test, the GM Band Clutch test, and the FZG wear test with at least a stage 11 pass.

[0022] In one of its embodiments, a fluid according to the present invention contains an amine antioxidant and an ashless dialkyl thiadiazole in an essentially sulfur free and phenolic antioxidant free fluid.

[0023] In another embodiment, the fluids according to the present invention contain a mixture of amines and an ashless dialkyl thiadiazole, in a base fluid which is essentially free of sulfurized fats and phenolic antioxidants.

[0024] The dialkyl thiadiazoles according to the present invention include ashless dialkyl thiadiazoles.

[0025] The amine antioxidants according to the present invention include oil-soluble aromatic secondary amines, aromatic secondary monoamines, aromatic secondary polymixtures, and aromatic primary amines.

[0026] In one embodiment, the fluids of the present invention are used in formulating automatic transmission fluids which exhibit an 11 stage pass in the FZG test at 150° C, as set forth in ASTM D 5182-97, which is incorporated herein by reference.

[0027] In another embodiment of the present invention, a method of improving wear performance in automatic transmissions and a method of providing good stability is set forth.

[0028] Said methods comprise adding to, and operating in, an automatic transmission an automatic transmission fluid comprising (1) a major amount of a base oil and (2) a minor amount of an additive composition which comprises, as essential components at least Component (A) and Component (B) as described below, in a fluid which is essentially free of sulfurized fats and phenolic antioxidants.

[0029] Although the Components above and in the below list are described occasionally with reference to a function, that function may be one of other functions served by the same component and should not be construed as a mandatory limiting function.

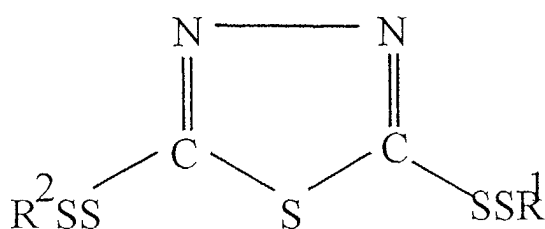
MANDATORY COMPONENTS

Component (A) Ashless Dialkyl Thiadiazole

[0030] The fluids of the present invention should include a dialkyl thiadiazole. Exemplary suitable compounds include bis-tert-dodecylthiothiadiazole; and 2,5-bis(hydrocarbylthio)-1,3,4-thiadiazole. One commercially available dialkyl thiadiazole is HiTEC® 4313 corrosion inhibitor, a product of Ethyl Corporation, Richmond, Virginia.

[0031] Each alkyl in such dialkyl thiadiazole is independently a hydrocarbyl group having from about 9 to about 18 carbon atoms.

[0032] Dialkyl thiadiazoles suitable for the practice of the instant invention are of the general formula (I):



wherein R¹ is a hydrocarbyl substituent having from 6 to 18 carbon atoms; R² is a hydrocarbyl substituent having from 6 to 18 carbon atoms; and may be the same as or different from R¹. Preferably, R¹ and R² are about 9-12 carbon atoms, and most preferably R¹ and R² are each 9 carbon atoms.

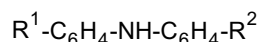
[0033] Mixtures of dialkyl thiadiazoles of formula (I) with monoalkyl thiadiazoles may also be used within the scope of the present invention. Such mono alkyl thiadiazoles occur when either substituent R¹ or R² is H. However, at least 0.05 weight percent of the fully formulated fluid composition should comprise the dialkyl thiadiazole, more preferably at least about 0.10 weight %. A presently preferred range is from about 0.05 weight % to about 1.00 weight %, more preferably about 0.10 to about 0.60 weight%, most preferably about 0.3wt%. The thiadiazoles according to the present invention may have antioxidants, corrosion inhibition, and extreme pressure properties.

Component (B) - Amine Antioxidants

[0034] Amine antioxidants, especially oil-soluble aromatic secondary amines can also be used in the compositions of the present invention. Aromatic secondary monoamines, aromatic secondary polymixtures, and aromatic primary amines may be used.

[0035] Suitable aromatic secondary monoamines include diphenylamine, alkyl diphenylamines containing 1 to 2 alkyl substituents each having up to about 16 carbon atoms, phenyl- α -naphthylamine, phenyl- γ -naphthylamine, alkyl- or aralkylsubstituted phenyl- α -naphthylamine containing one or two alkyl or aralkyl groups each having up to about 16 carbon atoms, alkyl- or aralkyl-substituted phenyl- β -naphthylamine containing one or two alkyl or aralkyl groups each having up to about 16 carbon atoms, alkylated p-phenylene diamines available from Goodyear under the tradename "Wingstay 100" and from Uniroyal, and similar compounds.

[0036] A preferred type of aromatic amine is an alkylated diphenylamine of the general formula



wherein R^1 is an alkyl group (preferably a branched alkyl group) having 8 to 12 carbon atoms (more preferably about 9 carbon atoms) and R^2 is a hydrogen atom or an alkyl group (preferably a branched alkyl group) having 8 to 12 carbon atoms (preferably about 9 carbon atoms). More preferably, R^1 and R^2 are the same.

[0037] The diphenylamine antioxidants according to the present invention include, for example, 4, 4' dinonylated diphenylamine, which is commercially available as NaugaLube® 438L, from Uniroyal Chemical Company.

[0038] In addition to containing the above mandatory components, the finished fluid or concentrate should be free of phenolic antioxidants and sulfur-containing additives, e.g. sulfurized fats.

[0039] In addition to the above mandatory components, the present invention may also optionally contain the following additional components:

Component (C) - Dispersant

[0040] Component (C) comprises at least one oil-soluble phosphorus or boron-containing ashless dispersant. The phosphorus or boron-containing ashless dispersants can be formed by phosphorylating or boronating an ashless dispersant having basic nitrogen and/or at least one hydroxyl group in the molecule, such as a succinimide dispersant, succinic ester dispersant, succinic ester-amide dispersant, Mannich base dispersant, hydrocarbyl polyamine dispersant, or polymeric polyamine dispersant.

[0041] The polyamine succinimides in which the succinic group contains a hydrocarbyl substituent containing at least 30 carbon atoms are described for example in U.S. Pat. Nos. 3,172,892; 3,202,678; 3,216,936; 3,219,666; 3,254,025; 3,272,746; and 4,234,435. The alkenyl succinimides may be formed by conventional methods such as by heating an alkenyl succinic anhydride, acid, acid-ester, acid halide, or lower alkyl ester with a polyamine containing at least one primary amino group. The alkenyl succinic anhydride may be made readily by heating a mixture of olefin and maleic anhydride to, for example, about 180-220 °C. The olefin is preferably a polymer or copolymer of a lower monoolefin such as ethylene, propylene, 1-butene, isobutene and the like and mixtures thereof. The more preferred source of alkenyl group is from polyisobutene having a gel permeation chromatography (GPC) number average molecular weight of up to 10,000 or higher, preferably in the range of about 500 to about 2,500, and most preferably in the range of about 800 to about 1,500.

[0042] As used herein the term "succinimide" is meant to encompass the completed reaction product from reaction between one or more polyamine reactants and a hydrocarbon-substituted succinic acid or anhydride (or like succinic acylating agent), and is intended to encompass compounds wherein the product may have amide, amidine, and/or salt linkages in addition to the imide linkage of the type that results from the reaction of a primary amino group and an anhydride moiety.

[0043] Alkenyl succinic acid esters and diesters of polyhydric alcohols containing 2-20 carbon atoms and 2-6 hydroxyl groups can be used in forming the phosphorus-containing ashless dispersants. Representative examples are described in U.S. Pat. Nos. 3,331,776; 3,381,022; and 3,522,179. The alkenyl succinic portion of these esters corresponds to the alkenyl succinic portion of the succinimides described above.

[0044] Suitable alkenyl succinic ester-amides for forming the phosphorylated ashless dispersant are described for example in U.S. Pat. Nos. 3,184,474; 3,576,743; 3,632,511; 3,804,763; 3,836,471; 3,862,981; 3,936,480; 3,948,800; 3,950,341; 3,957,854; 3,957,855; 3,991,098; 4,071,548; and 4,173,540.

[0045] Hydrocarbyl polyamine dispersants that can be phosphorylated are generally produced by reacting an aliphatic or alicyclic halide (or mixture thereof) containing an average of at least about 40 carbon atoms with one or more amines, preferably polyalkylene polyamines. Examples of such hydrocarbyl polyamine dispersants are described in

U.S. Pat. Nos. 3,275,554; 3,394,576; 3,438,757; 3,454,555; 3,565,804; 3,671,511; and 3,821,302.

[0046] In general, the hydrocarbyl-substituted polyamines are high molecular weight hydrocarbyl-N-substituted polyamines containing basic nitrogen in the molecule. The hydrocarbyl group typically has a number average molecular weight in the range of about 750-10,000 as determined by GPC, more usually in the range of about 1,000-5,000, and is derived from a suitable polyolefin. Preferred hydrocarbyl-substituted amines or polyamines are prepared from polyisobutenyl chlorides and polyamines having from 2 to about 12 amine nitrogen atoms and from 2 to about 40 carbon atoms.

[0047] Mannich polyamine dispersants which can be utilized in forming the phosphorylated ashless dispersant is a reaction product of an alkyl phenol, typically having a long chain alkyl substituent on the ring, with one or more aliphatic aldehydes containing from 1 to about 7 carbon atoms (especially formaldehyde and derivatives thereof), and polyamines (especially polyalkylene polyamines). Examples of Mannich condensation products, and methods for their production are described in U.S. Pat. Nos. 2,459,112; 2,962,442; 2,984,550; 3,036,003; 3,166,516; 3,236,770; 3,368,972; 3,413,347; 3,442,808; 3,448,047; 3,454,497; 3,459,661; 3,493,520; 3,539,633; 3,558,743; 3,586,629; 3,591,598; 3,600,372; 3,634,515; 3,649,229; 3,697,574; 3,703,536; 3,704,308; 3,725,277; 3,725,480; 3,726,882; 3,736,357; 3,751,365; 3,756,953; 3,793,202; 3,798,165; 3,798,247; 3,803,039; 3,872,019; 3,904,595; 3,957,746; 3,980,569; 3,985,802; 4,006,089; 4,011,380; 4,025,451; 4,058,468; 4,083,699; 4,090,854; 4,354,950; and 4,485,023.

[0048] The preferred hydrocarbon sources for preparation of the Mannich polyamine dispersants are those derived from substantially saturated petroleum fractions and olefin polymers, preferably polymers of mono-olefins having from 2 to about 6 carbon atoms. The hydrocarbon source generally contains at least about 40 and preferably at least about 50 carbon atoms to provide substantial oil solubility to the dispersant. The olefin polymers having a GPC number average molecular weight between about 600 and 5,000 are preferred for reasons of easy reactivity and low cost. However, polymers of higher molecular weight can also be used. Especially suitable hydrocarbon sources are isobutylene polymers.

[0049] The preferred Mannich base dispersants for this use are Mannich base ashless dispersants formed by condensing about one molar proportion of long chain hydrocarbon-substituted phenol with from about 1 to 2.5 moles of formaldehyde and from about 0.5 to 2 moles of polyalkylene polyamine.

[0050] Polymeric polyamine dispersants suitable for preparing phosphorylated ashless dispersants are polymers containing basic amine groups and oil solubilizing groups (for example, pendant alkyl groups having at least about 8 carbon atoms). Such materials are illustrated by interpolymers formed from various monomers such as decyl methacrylate, vinyl decyl ether or relatively high molecular weight olefins, with aminoalkyl acrylates and aminoalkyl acrylamides. Examples of polymeric polyamine dispersants are set forth in U.S. Pat. Nos. 3,329,658; 3,449,250; 3,493,520; 3,519,565; 3,666,730; 3,687,849; and 3,702,300.

[0051] The various types of ashless dispersants described above can be phosphorylated by procedures described in U.S. Pat. Nos. 3,184,411; 3,342,735; 3,403,102; 3,502,607; 3,511,780; 3,513,093; 3,513,093; 4,615,826; 4,648,980; 4,857,214 and 5,198,133.

[0052] In another preferred embodiment, the dispersants or the phosphorus-containing dispersants of the present invention are also boronated.

[0053] Methods that can be used for boronating (borating) the various types of ashless dispersants described above are described in U.S. Pat. Nos. 3,087,936; 3,254,025; 3,281,428; 3,282,955; 2,284,409; 2,284,410; 3,338,832; 3,344,069; 3,533,945; 3,658,836; 3,703,536; 3,718,663; 4,455,243; and 4,652,387.

[0054] Preferred procedures for phosphorylating and boronating ashless dispersants such as those referred to above are set forth in U.S. Pat. Nos. 4,857,214 and 5,198,133.

[0055] The amount of phosphorylated ashless dispersant on an "active ingredient basis" (i.e., excluding the weight of impurities, diluents and solvents typically associated therewith) is generally within the range of about 0.5 to about 7.5 weight percent (wt%), typically within the range of about 0.5 to 6.5 wt%, preferably within the range of about 0.5 to about 5.5 wt%, and most preferably within the range of about 1.0 to about 4.5 wt%.

[0056] In a preferred embodiment of the present invention, an ashless dispersant with an N/P ratio as set forth in US Patent 5,972,851, which is incorporated herein by reference. In this preferred embodiment, an optional component of the present invention is a dispersant having a nitrogen to phosphorus mass ratio between about 3:1 and about 10:1. The dispersant of the preferred embodiment can be prepared in at least two ways. In one method, an ashless dispersant is phosphorylated to such a degree that the nitrogen to phosphorus mass ratio between about 3:1 and about 10:1. In another embodiment, a phosphorylated dispersant and a non-phosphorylated dispersant are blended together such that the total nitrogen to phosphorus mass ratio of the dispersant is between about 3:1 and about 10:1.

[0057] Overall, the dispersant is preferably present in the final fluid in an amount of about 1.00% to about 15.00 % by weight, more preferably from about 1.00 weight % to about 8.00 weight %, more preferably about 3-6 wt %.

Component (D) - Additional Antioxidants

[0058] The compositions of the present invention may optionally but preferably include one or more phenolic-free anti-oxidants, for example, sulfurized olefins, oil-soluble copper compounds, phosphorus-containing antioxidants (e.g. organic phosphites), and mixtures thereof.

[0059] These additional non-phenolic antioxidants may be optionally included in the fully formulated final inventive lubricating composition at from about 0.00 to about 5.00 weight percent, more preferably from about 0.01 weight % to about 1.00 weight %.

Component (E) - Friction Modifiers

[0060] The compositions of the present invention may optionally but preferably contain one or more friction modifiers. These typically include such compounds as fatty amines or ethoxylated fatty amines, aliphatic fatty acid amides, aliphatic fatty alkanolamides, ethoxylated aliphatic ether amines, ethoxylated fatty acid amides, aliphatic carboxylic acids, glycerol esters, aliphatic carboxylic ester-amides, aliphatic phosphonates, aliphatic phosphates, aliphatic thiophosphonates, aliphatic thiophosphates, fatty imidazolines, fatty tertiary amines etc., wherein the aliphatic group usually contains above about eight carbon atoms so as to render the compound suitably oil soluble.

[0061] Suitable friction modifiers also include metal salts of fatty acids and alkylbenzene sulfonic acids. Preferred cations are zinc, magnesium, calcium, barium, and sodium and any alkaline, or alkaline earth metals may be used. The salts may be overbased by including an excess of cations per equivalent of amine. The excess cations are then treated with carbon dioxide to form the carbonate. The metal salts are prepared by reacting a suitable salt with the acid to form the salt, and where appropriate adding carbon dioxide to the reaction mixture to form the carbonate of any cation beyond that needed to form the salt. A preferred friction modifier is zinc oleate.

[0062] Also suitable are aliphatic substituted succinimides formed by reacting one or more aliphatic succinic acids or anhydrides with ammonia or other primary amines.

[0063] One preferred group of friction modifiers is comprised of the N-aliphatic hydrocarbyl-substituted diethanol amines in which the N-aliphatic hydrocarbyl-substituent is at least one straight chain aliphatic hydrocarbyl group free of acetylenic unsaturation and having in the range of about 14 to about 20 carbon atoms.

[0064] Some commercially available friction modifiers which are suitable in the practice of the invention are the Armeen® series of primary amines (12D, 16D, 18D, O, OD, OL, OLD, C, CD, S, SD, T, TD, HT, and HTD); secondary amines (2C, 2T, 2HT, 2-18); tertiary monoalkyl amines (DM12D, DM16D, DM18D, DMOD, DMCD, DMSD, DMTD, DMHTD); tertiary dialkyl amines (M2C, M2HT); tertiary trialkyl amines (3-12, 3-16); diamines, under the tradename Duomeen® (C, CD, T, TTM, OL, LT-4, S); triamines, under the tradename Triameen® T; tetramines, under the tradename Tetrameen® T; ethoxylated amines, under the tradename Ethomeen® (C-12, C-15, C-20, C-25, O-12, O-15, T-12, T-15, T-25, S-12, S-15, S-20, S-25, 18-12, 18-20, 18-25, 18-60); and ethoxylated diamines, under the tradename Ethoduomeen® (T-13, T-20, T-25). Especially preferred are Ethomeen® T-12, an ethoxylated tallow diamine, and Ethomeen® C-12, an ethoxylated cocoalkylamine. All from the above list are available from Akzo Nobel Chemical Company.

[0065] Also suitable for use as friction modifiers in the scope of the present invention are alkanolamides derived from C₁₂-C₁₈ fatty acids, e.g. cocoamide and tallowamide. Commercial examples of these alkanolamides include Schercomid SL-ML (lauramide diethanolamine), and Schercomid SOA-E, a C₁₈-amide, each available from Scher Chemicals, Inc, New Jersey. Schercomid SL-ML is especially preferred.

[0066] A particularly preferred friction modifier system is composed of a combination of at least one N-aliphatic hydrocarbyl-substituted diethanolamine and at least one N-aliphatic hydrocarbyl-substituted trimethylene diamine in which the N-aliphatic hydrocarbyl-substituent is at least one straight chain aliphatic hydrocarbyl group free of acetylenic unsaturation and having in the range of about 14 to about 20 carbon atoms. Further details concerning this friction modifier system are set forth in U.S. Pat. Nos. 5,372,735 and 5,441,656, incorporated herein by reference.

[0067] Another particularly preferred friction modifier system is based on the combination of (i) at least one di(hydroxyalkyl) aliphatic tertiary amine in which the hydroxyalkyl groups, being the same or different, each contain from 2 to about 4 carbon atoms, and in which the aliphatic group is an acyclic hydrocarbyl group containing from about 10 to about 25 carbon atoms, and (ii) at least one hydroxyalkyl aliphatic imidazoline in which the hydroxyalkyl group contains from 2 to about 4 carbon atoms, and in which the aliphatic group is an acyclic hydrocarbyl group containing from about 10 to about 25 carbon atoms. Further details concerning this friction modifier system are set forth in U.S. Pat. No. 5,344,579, incorporated herein by reference.

[0068] Component (i), the di(hydroxyalkyl) aliphatic tertiary amine, has a nitrogen atom to which are bonded two hydroxyalkyl groups and one non-cyclic aliphatic hydrocarbyl group having 10 to 25 carbon atoms, and preferably 13 to 19 carbon atoms. The hydroxyalkyl groups of these tertiary amines can be the same or different, but each contains from 2 to 4 carbon atoms. The hydroxyl groups can be in any position in the hydroxyalkyl groups, but preferably are

in the β -position. Preferably the two hydroxyalkyl groups in component (i) are the same, and most preferably are 2-hydroxyethyl groups. The aliphatic group of these tertiary amines can be straight or branched chain and it can be saturated or olefinically unsaturated and if unsaturated, it typically contains from one to three olefinic double bonds. Component (i) can have a single type of aliphatic group or it can comprise a mixture of compounds having different aliphatic groups in which the average number of carbon atoms falls within the foregoing range of from 10 to 25 carbon atoms.

[0069] Another set of friction modifiers which is suitable for practice within the scope of the present invention includes: 1) at least one dihydroxy alkyl aliphatic tertiary amine (e.g., alkyl C_{12} - C_{18} and cyclic hydrocarbyl); and 2) at least one aliphatic fatty alkanol amide in which the aliphatic group is an acyclic hydrocarbyl group containing from 12 to 18 carbon atoms. The aliphatic fatty alkanol is preferably a dihydroxy alkyl. Especially preferred is an aliphatic primary amine, an aliphatic secondary amine, or a mixture thereof, in which the aliphatic group contains from 12 to 18 carbon atoms.

[0070] From the foregoing it will be clear that component (i) can be a single compound or a mixture of compounds meeting the structural criteria described above.

[0071] The hydroxyalkyl aliphatic imidazolines, component (ii), suitable for use in the practice of this invention are characterized by having in the 1-position on the imidazoline ring a hydroxyalkyl group that contains from 2 to 4 carbon atoms, and by having in the adjacent 2-position on the ring a non-cyclic hydrocarbyl group containing 10 to 25 carbon atoms. While the hydroxyl group of the hydroxyalkyl group can be in any position thereof, it preferably is on the β -carbon atom, such as 2-hydroxyethyl, 2-hydroxypropyl or 2-hydroxybutyl. Typically the aliphatic group is a saturated or olefinically unsaturated hydrocarbyl group, and when olefinically unsaturated, the aliphatic group may contain one, two or three such double bonds. Component (ii) may be a single substantially pure compound or it may be a mixture of compounds in which the aliphatic group has an average of from 10 to 25 carbon atoms. Preferably the aliphatic group has 15 to 19 carbon atoms, or an average of 15 to 19 carbon atoms. Most preferably the aliphatic group has, or averages, 17 carbon atoms. The aliphatic group(s) may be straight or branched chain groups, with substantially straight chain groups being preferred. A particularly preferred compound is 1-hydroxyethyl-2-heptadecenyl imidazoline. A commercially available imidazoline based friction modifier essentially suitable for use as ii) in the invention is Unamine O, available from Lonza Chemicals.

[0072] It will thus be clear that component (ii) can be a single compound or a mixture of compounds meeting the structural criteria described above.

[0073] Generally speaking, the fully formulated final compositions of this invention will optionally contain up to about 1.25 wt% on an active ingredient basis, and preferably from about 0.005 to about 1.1 wt% on an active ingredient basis of one or more friction modifiers, most preferably about 0.005 - 1.00 wt %.

Component (F) - Detergent

[0074] Small amounts of certain metal-containing detergents, such as calcium sulfurized phenates, and calcium sulfonates can advantageously also be used. However, if an oil-soluble phenate or sulfonate is used it should be proportioned such that the finished fluid contains no more than about 300 ppm of metal, preferably no more than about 200 ppm of metal, and most preferably no more than about 150 ppm of metal. These sulfurized phenates are preferably neutral salts containing a stoichiometric amount of calcium, and in any event should have a total base number (TBN) of not more than about 200 or 300 mg KOH/gram, however, salts which are basic in nature will also be usable in the present invention.

[0075] An especially preferred detergent is a low-base calcium phenate such as OLOA 216 C, available from the Oronite Division of Chevron. OLOA 216 C is said to be a calcium hydroxide salt of a sulfurized alkylphenate having a nominal TBN of 150.

[0076] Another detergent useable in the invention is a neutral calcium sulfonate, such as HiTEC® 614, a neutral calcium sulfonate available from Ethyl Corporation, Richmond, Virginia.

[0077] In the overbased detergent area, such detergents which may be used in the present invention include OLOA 219 C, an overbased calcium phenate detergent available from Oronite. Also suitable are HiTEC® 611 and 609, overbased calcium sulfonate detergents available from Ethyl corporation.

[0078] In the final fluid, the detergent may be present in an amount of from 0.01-1.0% by weight, more preferably from about 0.03% to about 0.75 % by weight, and most preferably from about 0.05 to about 0.30 % by weight.

Component (G) - Anti-Rust

[0079] Various known anti-rust agents or additives are known for use in transmission fluids, and are suitable for use in the fluids according to the present invention. Especially preferred are alkyl polyoxyalkylene ethers, such as Mazawet® 77, C-8 acids such as Neofat® 8, oxyalkyl amines such as Tomah PA-14, 3-decyloxypropylamine, and polyoxypropylene-polyoxyethylene block copolymers such as Pluronic® L-81.

[0080] Mixtures of the above anti-rust agents are especially preferred. Anti-rust agents are preferably used in low

quantities, e.g less than about 0.02 wt %, preferably from about 0.01 to about 0.10 weight %.

Component (H) - Anti-Foam

[0081] Anti-foam agents may also be included in a fluid according to the present invention. Various agents are known for such use. Especially preferred are copolymers of ethyl acrylate and hexyl ethyl acrylate, such as PC-1244, available from Solutia. Also preferred are silicone fluids such as 4% DCF. Mixtures of anti-foam agents are especially preferred.

[0082] Given their high activity levels, anti foam agents are generally present in small amounts, from about 0.00 - 0.10 weight %, more preferably between about 0.02-0.07 wt %, most preferably about 0.05 wt %.

Component (I) - Diluent

[0083] If the additives are provided in an additive package concentrate, a suitable carrier diluent is added to ease blending, solubilizing, and transporting the additive package. The diluent oil needs to be compatible with the base oil and the additive package. Generally, the diluent is present in the concentrate in an amount of between 5-20%, although it can vary widely with application. Generally speaking, less diluent is preferable as it lowers transportation costs and treat rates.

Component (J) - Base Oil

[0084] If the inventive composition is to be prepared as a concentrate, then base oil may be omitted and an appropriate adjustment made in the weight % of each of the above optional and mandatory ingredients to prepare a suitable concentrate, taking care that solubility and compatibility is maintained. However, if a fully formulated fluid is to be prepared, then base oil is a mandatory component.

[0085] The base oils used in forming the automatic transmission fluids of this invention can be any suitable natural or synthetic oil having the necessary viscosity properties for this usage. Natural oils include animal oils and vegetable oils (e.g., castor oil, lard oil etc.), liquid petroleum oils and hydrotreated, severely hydrotreated, iso-dewaxed, solvent-treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic and mixed paraffinic-naphthenic types. Oils of lubricating viscosity derived from coal or shale are also useful base oils.

[0086] The synthetic lubricating oils suitable for use in this invention include one of any number of commonly used synthetic hydrocarbon oils, which include, but are not limited to, poly-alpha-olefins, synthetic esters, alkylated aromatics, alkylene oxide polymers, interpolymers, copolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification etc., esters of dicarboxylic acids and silicon-based oils. Thus, the base oil may be composed entirely of a natural oil such as mineral oil of suitable viscosity or it may be composed entirely of a synthetic oil such as a poly-alpha-olefin oligomer of suitable viscosity.

[0087] Likewise, the base oil may be a blend of natural and/or synthetic base oils provided that the blend has the requisite properties for use in the formation of an automatic transmission fluid. Ordinarily, the base oil should have a kinematic viscosity in the range of 3 to 8 centistokes (cSt) at 100 °C. Preferred automatic transmission fluids used in the practice of this invention can be formulated without a viscosity index improver so as to possess a kinematic viscosity of at least 3.0 cSt at 100°C and a Brookfield viscosity of no more than 20,000 cP at -40 °C, or formulated using a viscosity index improver so as to possess a kinematic viscosity of at least 6.8 cSt at 100 °C and a Brookfield viscosity of no more than 20,000 cP at -40 °C.

[0088] Suitable base stock oil includes, preferably, Group I, II, and III base oils, as are known to those of skill in the art. In certain instances, usually depending on the final use of the lubricant composition according to the present invention, Group I is preferred, and in other instances, Group II and III are preferred.

[0089] Group I base stocks contain less than 90% saturates (as determined by ASTM D 2007) and/or greater than 0.03 percent sulfur (as determined by ASTM D 2622, D 4294, D 4927, or D 3120) and have a viscosity index greater than or equal to 80 and less than 120 (as determined by ASTM D 2270).

[0090] Group II base stocks contain greater than or equal to 90 % saturates and less than or equal to 0.03 % sulfur and have a viscosity index greater than 80 and less than 120 using the above noted test methods. Group II + oils may also be used. These are oils which have a VI at the high end of the VI spectrum, e.g. about 120.

[0091] Group III base stocks contain greater than or equal to 90 percent saturates and less than or equal to 0.03 % sulfur and have a viscosity index greater than or equal to 120 using the tests noted above.

[0092] In another embodiment, the transmission fluid contains less than 5% poly-alpha-olefins (PAO) and is more preferably PAO free.

Component (K) - Viscosity Index Improver

[0093] The compositions of the present invention optionally, but preferably, contain a viscosity index improver (VII). Preferred VIIs include, but are not limited to, olefin copolymer VIIs, polyalkylmethacrylate VIIs and styrene-maleic ester VIIs. Of these, polyalkylmethacrylate VIIs are particularly preferred. The viscosity index improver is supplied in the form of a solution in an inert solvent, typically a mineral oil solvent, which usually is a severely refined mineral oil. The viscosity index improver solution as received often will have a boiling point above 200°C, and a specific gravity of less than 1 at 25 °C. Preferably, the viscosity index improver will have sufficient shear stability such that the finished composition possesses a kinematic viscosity of at least 5, and more preferably at least 6.8, cSt at 100 °C after 40 cycles in the FISST (Fuel Injector Shear Stability Test) of ASTM D-5275.

[0094] On an active ingredient basis (i.e., excluding the weight of inert diluent or solvent associated with the viscosity index improver as supplied), the finished fluid compositions of this invention will normally contain in the range of about 0 to about 15 wt% of the polymeric viscosity index improver. Small departures from this range may be resorted to as necessary or desirable in any given situation.

[0095] Suitable materials for use as component (K) include styrene-maleic ester VIIs such as LUBRIZOL® 3702, LUBRIZOL®3706 and LUBRIZOL®3715 available from The Lubrizol Corporation; polyalkylmethacrylate VIIs such as those available from RÖHM GmbH (Darmstadt, Germany) under the trade designations: VISCOPLEX® 5543, VISCOPLEX® 5548, VISCOPLEX® 5549, VISCOPLEX® 5550, VISCOPLEX® 5551 and VISCOPLEX® 5151, from Rohm & Haas Company (Philadelphia, Pennsylvania) under the trade designations ACRYLOID® 1277, ACRYLOID® 1265 and ACRYLOID® 1269, and from Ethyl Corporation (Richmond, Virginia) under the trade designation HiTEC® 5710 viscosity index improver; and olefin copolymer VIIs such as HiTEC® 5747 VII, HiTEC® 5751 VII, HiTEC® 5770 VII and HiTEC® 5772 VII available from Ethyl Corporation and SHELLVIS® 200 available from Shell Chemical Company. Mixtures of the foregoing products can also be used as well as dispersant and dispersant/antioxidant VIIs.

[0096] Preferably, the viscosity index improver will be provided as a hydrocarbon solution having a polymer content in the range of from about 25 to about 80 wt% and a nitrogen content in the range of about 0 to about 0.5 wt%. Such products preferably exhibit a permanent shear stability index (a PSSI value) using ASTM test method D-3945A of no higher than about 75, preferably 50 or less, and most preferably 35 or less.

[0097] Preferred is a dispersant polymethacrylate viscosity index improver such as HiTEC® 5738, or a non dispersant polymethacrylate viscosity index improver such as HiTEC®5739, both products of Ethyl Corporation, Richmond Virginia, or a mixture of dispersant and non-dispersant viscosity index improvers. Especially preferred is an ultra high shear stable dispersant polymethacrylate viscosity index improver such as HiTEC 5769, also a product of Ethyl Corporation, Richmond, Virginia.

[0098] Preferably, the VII shows a less than 5% shear loss in the 20 hour Tapered Roller Bearing test or KRL shear test. This is a published standard test entitled "Viscosity Shear Stability of Transmission Lubricants" and is described in CEC L-45-T93, available from CEC, 61 New Cavendish Street, London WIM 8AR, England. The same test is also published as DIN 51 350, part 6, and is available from Deutsches Institut für Normung, Burgerfenshase 6, 1000 Berlin 30, Germany. Both of these references are incorporated herein by reference.

[0099] Quantitatively, the viscosity index improver may be present in an amount of from 0-25% by weight, preferably from 0.2-20% by weight.

Component (L) - Dye

[0100] It is preferred to add a colorant to the fluid to give it a unique character which is detectable. Generally, azo class dyes are used, such as C.I. Solvent Red 24 or C.I. Solvent Red 164, as set forth in the "Colour Index" of the American Association of Textile Chemists and Colorists and the Society of Dyers and Colourists (U.K.) which is incorporated herein by reference. For automatic transmission fluids, Automate Red Dye is especially preferred. Dye is present in a very minimal amount, usually less than 400 ppm, preferably between about 200-300 ppm in the finished oil.

Component (M) - Seal Swell Agents

[0101] The automatic transmission fluids of the present invention may further include seal swell agents. Seal swell agents such as esters, adipates, sebacates, azealates, phthalates, sulfones, alcohols, alkylbenzenes, substituted sulfones, aromatics, or mineral oils cause swelling of elastomeric materials used as seals in engines and automatic transmissions.

[0102] Alcohol-type seal swell agents are generally low volatility linear alkyl alcohols, such as decyl alcohol, tridecyl alcohol and tetradecyl alcohol.

[0103] Alkylbenzenes useful as seal swell agents include dodecylbenzenes, tetradecylbenzenes, dinonyl-benzenes, di(2-ethylhexyl)benzene, and the like.

[0104] Substituted sulfolanes (e.g. those described in U.S. Pat. No. 4,029,588, incorporated herein by reference) are likewise useful as seal swell agents in compositions according to the present invention.

[0105] Mineral oils useful as seal swell agents in the present invention include low viscosity mineral oils with high naphthenic or aromatic content.

[0106] Aromatic seal swell agents include the commercially available Exxon Aromatic 200 ND seal swell agent.

[0107] Commercially available examples of mineral oil seal swell agents include Exxon® Necton®-37 (FN 1380) and Exxon® Mineral Seal Oil (FN 3200).

[0108] When used in the ATF of the present invention, a seal swell agent will typically comprise from about 1 to about 30 wt. %, preferably from about 1 to about 20 wt. %, most preferably from about 1 to about 10 wt. %, based on the total weight of ATF.

Component (N) - Additional Corrosion Inhibitors

[0109] The automatic transmission fluids of the present invention may further include additional corrosion inhibitors. Other suitable additional inhibitors of copper corrosion include ether amines, polyethoxylated compounds such as ethoxylated amines and ethoxylated alcohols, imidazolines, and the like.

[0110] Thiazoles, triazoles and thiadiazoles may also be used in the present invention. Examples include benzotriazole; tolyltriazole; octyltriazole; decyltriazole; dodecyltriazole; 2-mercaptobenzothiazole; 2,5-dimercapto-1,3,4-thiadiazole; 2-mercapto-5-hydrocarbylthio-1,3,4-thiadiazoles; and 2-mercapto-5-hydrocarbyldithio-1,3,4-thiadiazoles. The preferred compounds are the 1,3,4-thiadiazoles, especially the 2-hydrocarbyldithio-5-mercapto-1,3,4-dithiadiazoles, a number of which are available as articles of commerce. These may be present in an amount of from 0.00 to 0.50 weight percent, more preferably from about 0.01 to about 0.10 weight percent, based on the final formulation.

Component (O) - Anti Wear/ Extreme Pressure Additive

[0111] The automatic transmission fluids of the present invention may further include anti-wear/extreme pressure additives.

[0112] When the desired phosphorus content of the finished fluid is not completely supplied by use of a phosphorus-containing ashless dispersant (or a boron- and phosphorus-containing ashless dispersant), the remainder of the phosphorus content is preferably supplied by inclusion in the composition of one or more phosphorus-containing esters or acid-esters such as oil-soluble organic phosphites, oil-soluble organic acid phosphites, oil-soluble organic phosphates, oil-soluble organic acid phosphates, oil-soluble phosphoramidates. Examples include trihydrocarbyl phosphates, trihydrocarbyl phosphites, dihydrocarbyl phosphates, dihydrocarbyl phosphonates or dihydrocarbyl phosphites or mixtures thereof, monohydrocarbyl phosphates, monohydrocarbyl phosphites, and mixtures of any two or more of the foregoing. Oil-soluble amine salts of organic acid phosphates are a preferred category of auxiliary phosphorus-containing additives for use in the fluids of this invention. Sulfur-containing analogs of any of the foregoing compounds can also be used, but are less preferred. A suitable commercially-available auxiliary phosphorus additive is an amine phosphate antiwear/extreme pressure agent available from Ciba-Geigy Corporation as Irgalube® 349 or from R.T. Vanderbilt as Vanlube® 672.

[0113] Additional thiadiazoles may also be included to enhance extreme pressure performance.

[0114] The extreme pressure/anti wear additive is preferably present in the final fully-formulated fluid in an amount of from 0.00 to about 1.00 weight %, more preferably from about 0.10 to about 1.00 weight %.

[0115] In selecting any of the foregoing optional additives, it is important to ensure that the selected component(s) is/are soluble or stably dispersible in the additive package and finished ATF composition, are compatible with the other components of the composition, and do not interfere significantly with the performance properties of the composition, such as the friction, viscosity and/or shear stability properties, needed or at least desired in the overall finished composition.

[0116] In general, the ancillary additive components are employed in the oils in minor amounts sufficient to improve the performance characteristics and properties of the base fluid. The amounts will thus vary in accordance with such factors as the viscosity characteristics of the base fluid employed, the viscosity characteristics desired in the finished fluid, the service conditions for which the finished fluid is intended, and the performance characteristics desired in the finished fluid. However, generally speaking, the following concentrations (weight percent unless indicated otherwise) of the additional components (active ingredients) in the base fluids are illustrative:

Component	Typical Range	Preferred Range
C	1.00-10.00	1.00-8.00
D	0.00 - 5.00	0.01 -1.00

(continued)

Component	Typical Range	Preferred Range
E	≤ 1.25	0.005 - 1.10
F	0.01-1.00	0.03 - 0.75
G	≤ 0.02	0.01 - 0.10
H	≤ 0.10	0.02-0.07
I	≤ 25.00 (in the concentrate)	5.00 - 20.00 (in the concentrate)
J	Balance	Balance
K	0.00 - 25.00	2.00 - 20.00
L	0-400 ppm	200-300 ppm
M	1.00 - 30.00	5.00-15.00
N	0.00-0.50	0.01-0.10
O	0.00-1.00	0.10-1.00

[0117] It will be appreciated that the individual components employed can be separately blended into the base fluid or can be blended therein in various subcombinations, if desired. Ordinarily, the particular sequence of such blending steps is not critical. Moreover, such components can be blended in the form of separate solutions in a diluent. It is preferable, however, to blend the additive components used in the form of a concentrate, as this simplifies the blending operations, reduces the likelihood of blending errors, and takes advantage of the compatibility and solubility characteristics afforded by the overall concentrate.

[0118] Additive concentrates can thus be formulated to contain all of the additive components and if desired, some of the base oil component, in amounts proportioned to yield finished fluid blends consistent with the concentrations described above. In most cases, the additive concentrate will contain one or more diluents such as light mineral oils, to facilitate handling and blending of the concentrate. Thus concentrates containing up to about 50% by weight of one or more diluents or solvents can be used, provided the solvents are not present in amounts that interfere with the low and high temperature and flash point characteristics and the performance of the finished power transmission fluid composition. In this connection, the additive components utilized pursuant to this invention should be selected and proportioned such that an additive concentrate or package formulated from such components will have a flash point of 170 °C or above, and preferably a flash point of at least 180 °C, using the ASTM D-92 test procedure.

[0119] In the present invention, the finished fluid or concentrate should be essentially free of phenolic antioxidants and sulfurized fats.

EXAMPLES

[0120] Illustrative compositions suitable for use in the practice of this invention are presented in the following Examples, wherein all parts and percentages are by weight unless specified otherwise.

[0121] The fluids prepared in the Examples were then subjected to testing under commonly known tests, including:

The Ford Plate Clutch Friction Test, MERCON® V Specification Number WSP-M2C185-A (Section 3.8). The Ford test stresses friction durability by using a low volume of fluid, 305 ml's, and high test energy per cycle, 20,740 joules. Repeated dissipation of this much energy into this small volume of test fluid for 20,000 cycles is a strenuous evaluation of the fluid's ability to maintain constant frictional characteristics.

The GM Band Clutch Test. GM Band Clutch Test (GM performance specification: GM 6417 M, April 1997) run according to DEXRON® III procedures. Briefly, this test involves engaging the clutch at the rate of four cycles per minute for 100 hours (i.e., 24,000 cycles) at 135 degrees C. The DEXRON® III Band Clutch Test limit for the mid-point torque is 185-220 Nm.

The GM Dexron III Cycling Test (GM-6297-M), revised April 1993; corresponding to the Ford Mercon V Friction Durability Test (Dexron 5 Specification 3.9, Revised Jul 1, 1996 and October 1, 1998 which sets limits on shift times for 20,000 shift cycles. Shifting from 1st to 2nd gear, 0.30-0.75 seconds; from 2nd to 3rd gear 0.30 to 0.75 sec. The FZG wear test. The FZG test is conducted in the FZG gear rig test machine. This test, IP (Institute of Petroleum) 334/79, which is incorporated herein by reference, measures lubricity, and in the test, two steel spin gears are rotated together for a series of 75 minute stages. The relative torque between the gears is increased by a fixed amount after each stage and the gears are run together for a given period after which they are examined for wear or damage. The result of the test is quoted in terms of the final pass stage and the first fail stage. The test is technically equal to ASTM D 5182-97. This test can be conducted at selected temperatures, nominally 90 degrees

C and 150 degrees C.

The ECCC Friction Durability Test, as measured by the low speed SAE#2 friction rig. As is well known in the art, the friction durability of an ATF is assessed through the use of an SAE #2 friction test machine. In the low speed setup, a conventional SAE #2 machine is equipped with a 30 hp 3600 rpm motor with shaft extensions on both ends. The inertia end is flanged to a flywheel to provide the desired total energy for each dynamic engagement. Opposite the inertia end is the input shaft that extends into the clutch housing and is splined to adapt to the various drive hubs for different clutch designs. The clutch housing is supported on the shaft by bearings that allow rotation and transfer of torque independently of the input shaft itself. A second motor is used to drive the 0 - 7.5 rpm static breakaway drive. Frictional force is measured through a load cell at a given temperature, load, and sliding speed. The load is supplied by means of a pneumatic apply piston. A variable speed DC motor and a high torque speed reduced capable of providing 500 Nm at 1 rpm are employed. The arrangement is described more fully in "Prediction of Anti-Shudder Performance in ATFs in CSTCC-Equipped Vehicles Using the Low-Speed SAE #2 Machine", Srinivasan et al., presented at the Esslinger Conference in 1998, pp. 1657-1668, which is incorporated herein by reference.

Table 1 -

Composition of Examples					
Component*	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Description
A	0.300	0.300	0.300	0.300	Ashless Dialkyl Thiadiazole
B	0.500	0.500	0.500	0.500	Diphenyl Amine Antioxidant
E1	0.100	0.200	0.100	0.100	Friction Modifier - alkyl diethanolamine
E2	0.000	0.300	0.200	0.200	Friction Modifier - fatty acid diethanolamide
E3	0.200	0.00	0.00	0.00	Friction Modifier - Imidazoline
F	0.050	0.050	0.080	0.100	Detergent
C, G, H	4.150	4.150	4.020	4.020	Dispersant, Anti-Rust, Anti-foam
I, J, K	84.875	84.475	84.675	84.655	Diluent; Base Oil, Poly (meth) acrylate Viscosity Index Improver
L,M	10.025	10.025	10.025	10.025	Dye, Seal Swell
Total	100.000	100.000	100.000	100.000	

*All in weight % based on finished fluid

[0122] Results of the testing of these compositions are shown in Figures 1-12 which illustrate the cross-platform acceptability of an automatic transmission fluid according to the present invention.

[0123] Thus, one embodiment of the present invention comprises an automatic transmission fluid, containing (1) a major amount of a phenolic-free sulfurized fat-free base oil and (2) a minor amount of an additive comprising A) an ashless dialkyl thiadiazole, and (B) a amine antioxidant, which fluid satisfies the Ford Friction Durability Test, the GM Band Clutch test, and the FZG test.

[0124] It is clear, upon examination of the data presented, that the compositions of the present invention exhibit superior performance.

[0125] Turning to Figure 1, a graphical representation of the GM band friction performance (mid-point dynamic torque) results of Examples 1 and 3 of the present invention, it may be seen that Examples 1 and 3 (after an initial break in period) fall within the strict requirements of the GM Band Friction performance specifications for mid-point dynamic torque.

[0126] With reference to Figure 2, a graphical representation of the Ford clutch friction durability test (mid-point dynamic torque), it may clearly be seen that Examples 1, 2, and 3 of the present invention fall within the strict requirements of the Ford Clutch friction performance specifications for mid-point dynamic torque.

[0127] Similarly, Figure 3 illustrates the Ford Clutch Friction durability test (low-speed dynamic torque) results of Examples 1, 2 and 3 which show that the exemplary compositions according to the present invention fall within the strict limits of the test.

[0128] With reference now to Figure 4, an illustration of the GM Cycling test, it may be seen that the shift times for automatic transmissions fall within the parameters of the test, ensuring smoother shifts of an automatic transmission, for Example 1 of the instant invention.

[0129] Figure 5 illustrates the extraordinary resistance to oxidation of fluids according to the present invention. The GM oxidation test results reflecting total acid number increase of Example 1 of the present invention are well within the test limits, even after 600 hours. Thus, a fluid will have long life.

[0130] Figure 6 illustrates the lack of viscosity increase of the composition of Example 1 according to the present invention. Again, fluids according to the present invention will have long life.

[0131] Figures 7, 9, and 11 are graphical representations of the ECCC friction durability test results (torque vs. speed) for Examples 1, 2, and 3 (respectively) of the present invention. Excellent torque consistency is seen, especially for Examples 2 and 3, even after 115 hours, resulting in smoother shifts for the duration.

[0132] Figures 8, 10, and 12 are graphical representations of the ECCC friction durability test results (hours to negative slope) for Examples 1, 2, and 3 (respectively) of the present invention. As may be seen, especially for Examples 2 and 3, the friction durability of fluids according to the present invention are excellent.

[0133] Thus it is now possible, as evidenced by the data presented, to formulate power transmission fluids to which one capable cross-platform utilization and have excellent properties.

[0134] This invention is susceptible to considerable variation in its practice. Accordingly, this invention is not limited to the specific exemplifications set forth hereinabove. Rather, this invention is within the spirit and scope of the appended claims, including the equivalents thereof available as a matter of law.

[0135] The patentee does not intend to dedicate any disclosed embodiments to the public, and to the extent any disclosed modifications or alterations may not literally fall within the scope of the claims, they are considered to be part of the invention under the doctrine of equivalents.

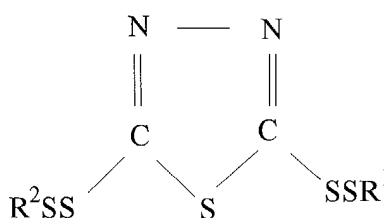
[0136] Typically, the ATF compositions of the invention contain less than 0.1 wt%, preferably less than 0.01 wt%, of sulfurized fats and phenolic antioxidants. More preferably, they are free of sulfurized fats and phenolic antioxidants.

Claims

1. An automatic transmission fluid which is substantially free of sulfurized fats and phenolic antioxidants and which comprises:

- (1) a major amount of a base oil; and
- (2) a minor amount of an additive comprising:
 - (A) an ashless dialkyl thiadiazole; and
 - (B) at least one amine antioxidant.

2. An automatic transmission fluid according to claim 1, wherein component (A) is a compound of the formula:



wherein:

R¹ and R² are the same or different and each represent a C₆₋₁₈ hydrocarbyl substituent.

3. An automatic transmission fluid according to claim 2, wherein R¹ and R² are the same or different and each represent a C₉₋₁₂ hydrocarbyl substituent.

4. An automatic transmission fluid according to claim 3, wherein R¹ and R² are the same, and each have 9 carbons.

5. An automatic transmission fluid according to any one of claims 1 to 4, which further comprises at least one aliphatic fatty alkanol amide.

6. An automatic transmission fluid according to any one of claims 1 to 5, which further comprises at least one aliphatic fatty diethanolamine.
- 5 7. An automatic transmission fluid according to any one of claims 1 to 6, wherein component (A) is present in an amount of from 0.05 to 0.75 weight percent, based on the weight of the transmission fluid.
8. An automatic transmission fluid according to claim 7, wherein component (A) is present in an amount of about 0.3 weight percent, based on the weight of the transmission fluid.
- 10 9. An automatic transmission fluid according to any one of claims 1 to 8, wherein component (B) is an n-alkyl (tallow) diethanolamine.
10. An automatic transmission fluid according to any one of claims 1 to 9, wherein component (B) is present in an amount of from 0.05 to 1.00 weight percent, based on the weight of the transmission fluid.
- 15 11. An automatic transmission fluid according to claim 10, wherein component (B) is present in an amount of from 0.10 to 0.50 weight percent, based on the weight of the transmission fluid.
- 20 12. An automatic transmission fluid according to any one of claims 1 to 11, wherein the fluid comprises at least one imidazoline friction modifier and/or at least one ethoxylated amine friction modifier.
13. An automatic transmission fluid according to any one of claims 1 to 12, which further comprises at least one inhibitor selected from foam inhibitors, corrosion inhibitors, rust inhibitors, and oxidation inhibitors.
- 25 14. An automatic transmission fluid according to any one of claims 1 to 13, which further comprises at least one viscosity index improver, detergent, dispersant, or friction modifier.
15. An automatic transmission fluid according to claim 14, wherein there is a mixture of viscosity index improvers present.
- 30 16. An automatic transmission fluid according to any one of claims 1 to 15, wherein there is at least one dispersant present, said dispersant having a total nitrogen to phosphorus mass ratio of from 3:1 to 10:1.
- 35 17. An automatic transmission fluid composition comprising:
 - (1) a major amount of a base oil and
 - (2) a minor amount of an additive composition comprising:
 - 40 (A) a dialkyl thiadiazole,
 - (B) an amine based antioxidant,
 - (C) a dispersant having a total nitrogen to phosphorus mass ratio of from 3:1 to 10:1; and
 - (E) a mixed friction modifier system containing:
 - 45 (i) an ethoxylated amine based friction modifier; and
 - (ii) an imidazoline based friction modifier.
18. An automatic transmission fluid according to claim 17, which is substantially free of sulfurized fats and phenolic antioxidants .
- 50 19. An automatic transmission fluid according to claim 18, further comprising at least one additive selected from seal swell agents, foam inhibitors, lubricity agents, and dyes.
20. A method of improving automatic transmission antiwear and extreme pressure performance, said method comprising adding to, and operating in, said automatic transmission an automatic transmission fluid according to any one of claims 1 to 19.
- 55 21. Use of an automatic transmission fluid according to any one of claims 1 to 19 in an automatic transmission.

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22. Use of an automatic transmission fluid according to any one of claims 1 to 19 for improving the antiwear performance of an automatic transmission.

5 **23.** Use of an automatic transmission fluid according to any one of claims 1 to 19 for improving the extreme pressure performance of an automatic transmission.

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Fig. 1- GM Band Friction Performance
Mid Point Dynamic Torque

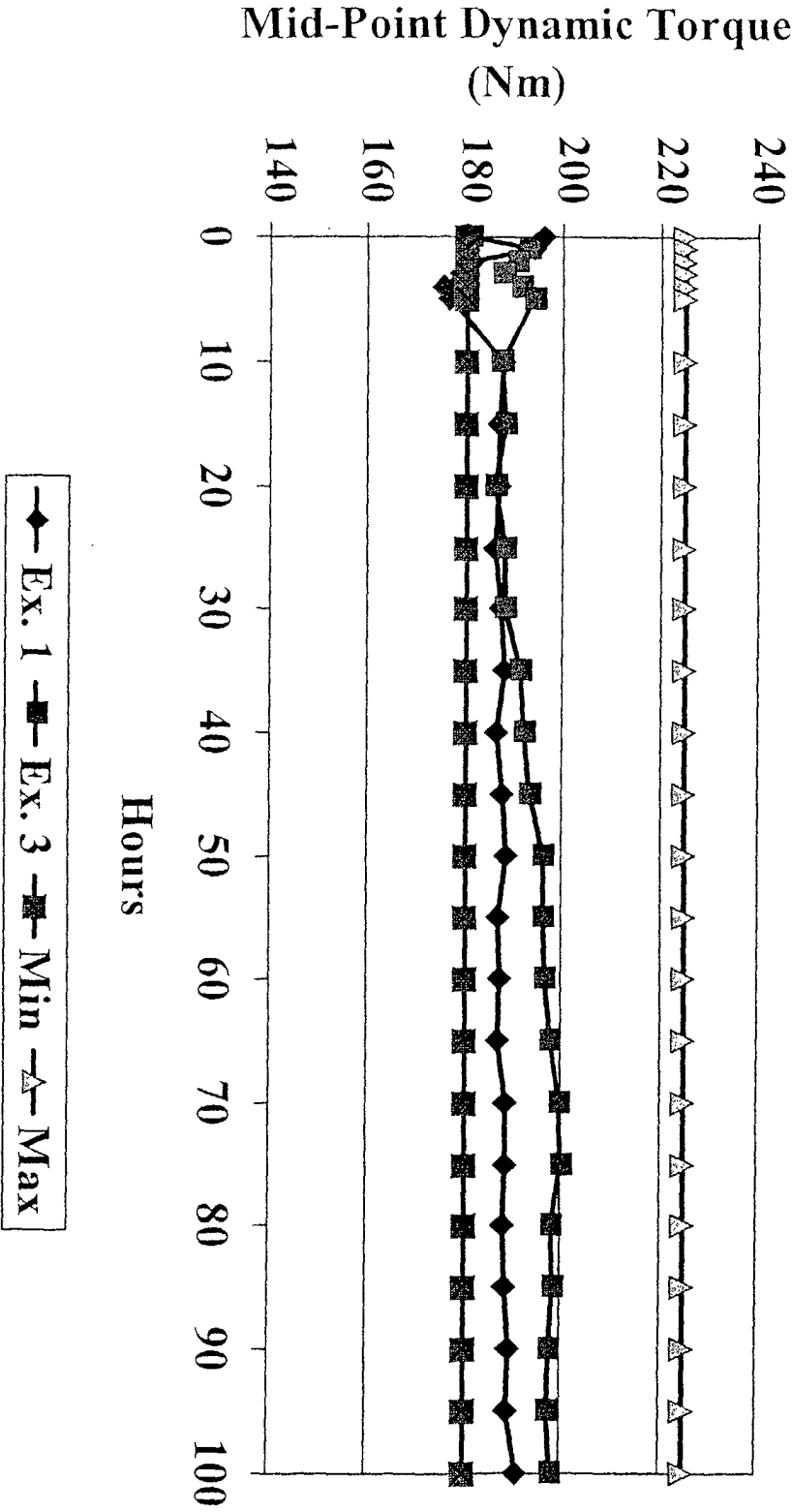


Fig. 2 - Ford Clutch Friction Durability Test
Mid-Point Dynamic Torque
20K Friction

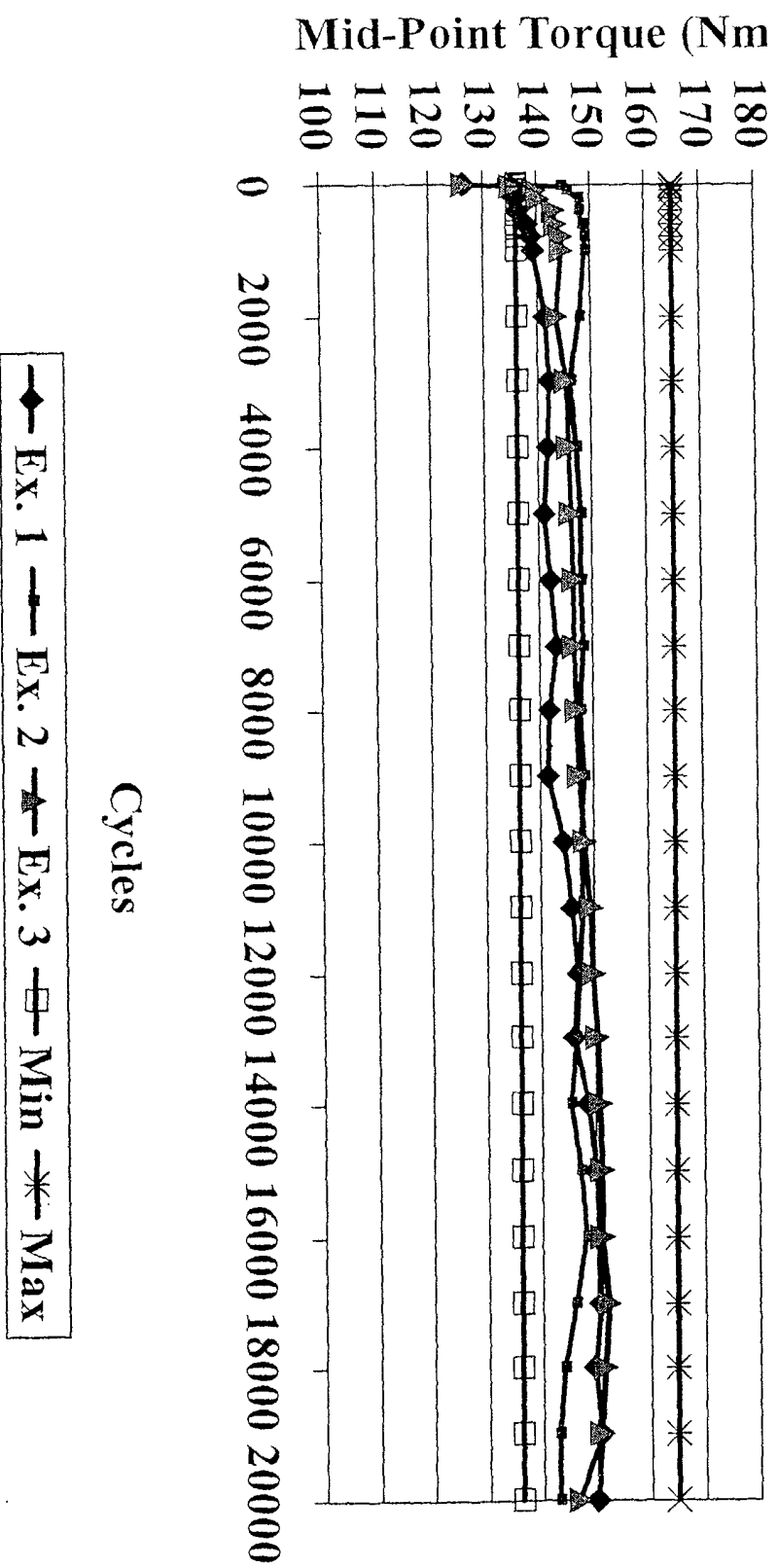


Fig. 3 - Ford Clutch Friction Durability Test
Low-Speed Dynamic Torque
20K Friction

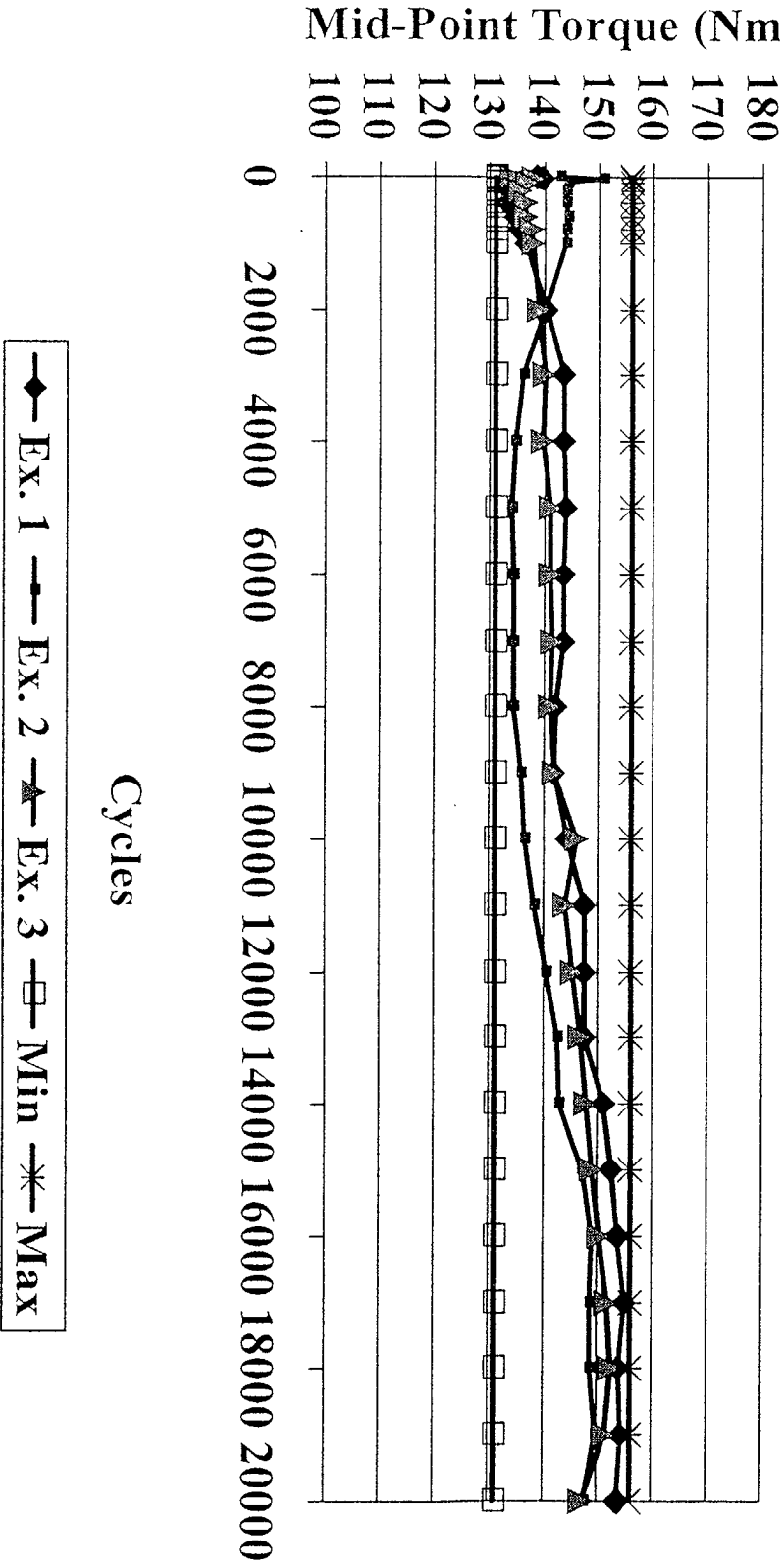
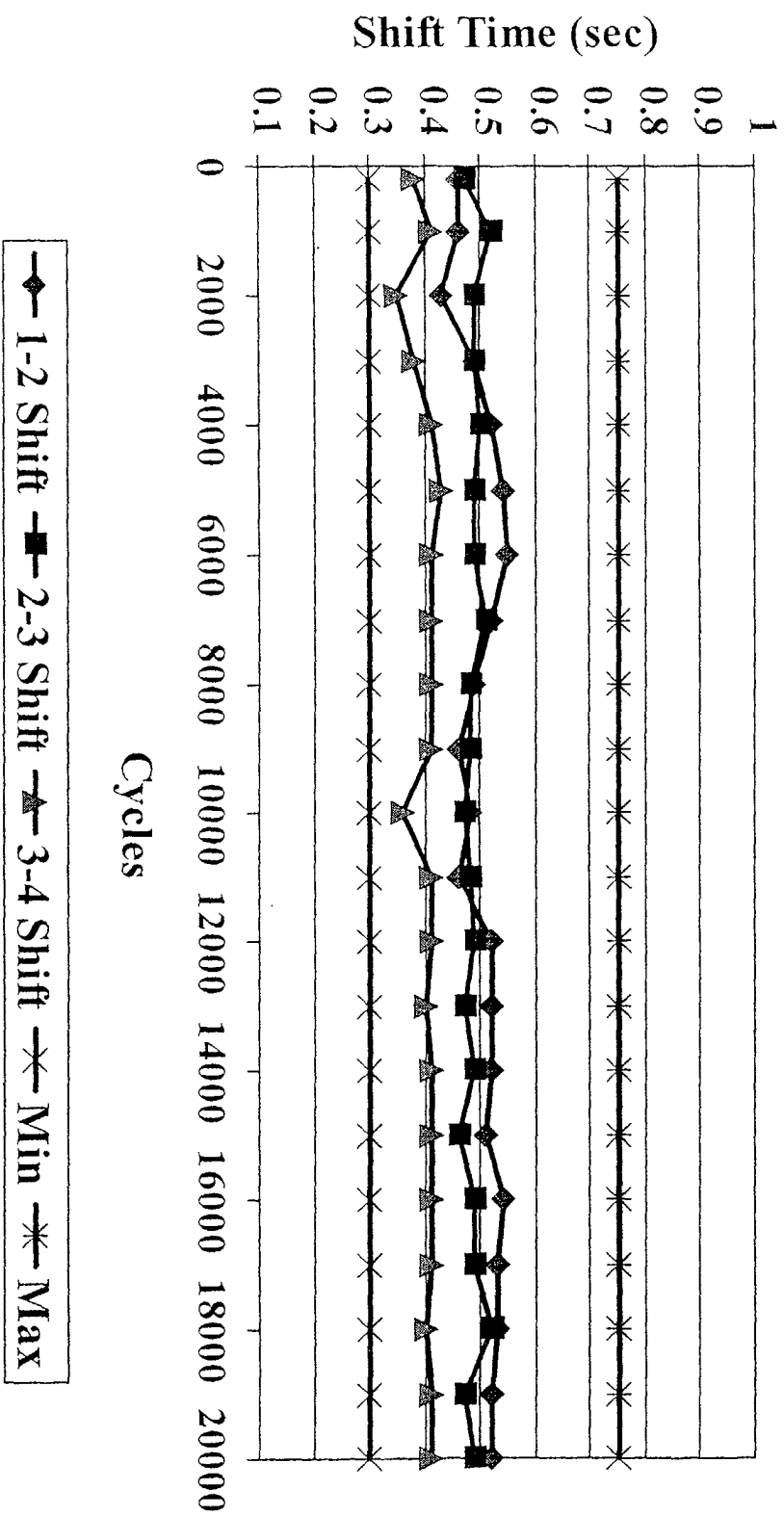


Fig. 4 - GM Cycling Test Ex. 1



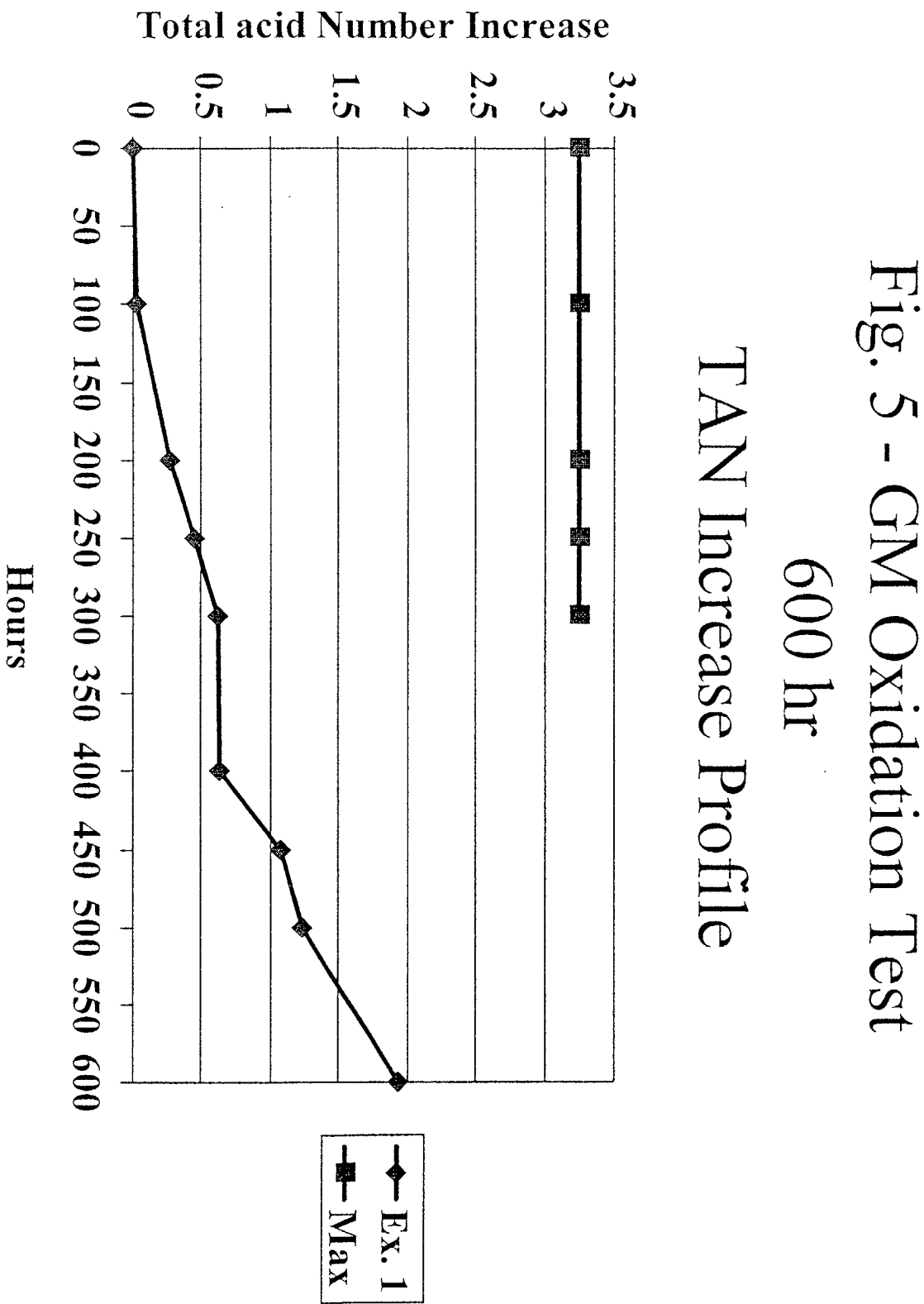


Fig. 6 - GM Oxidation Test
600 hr

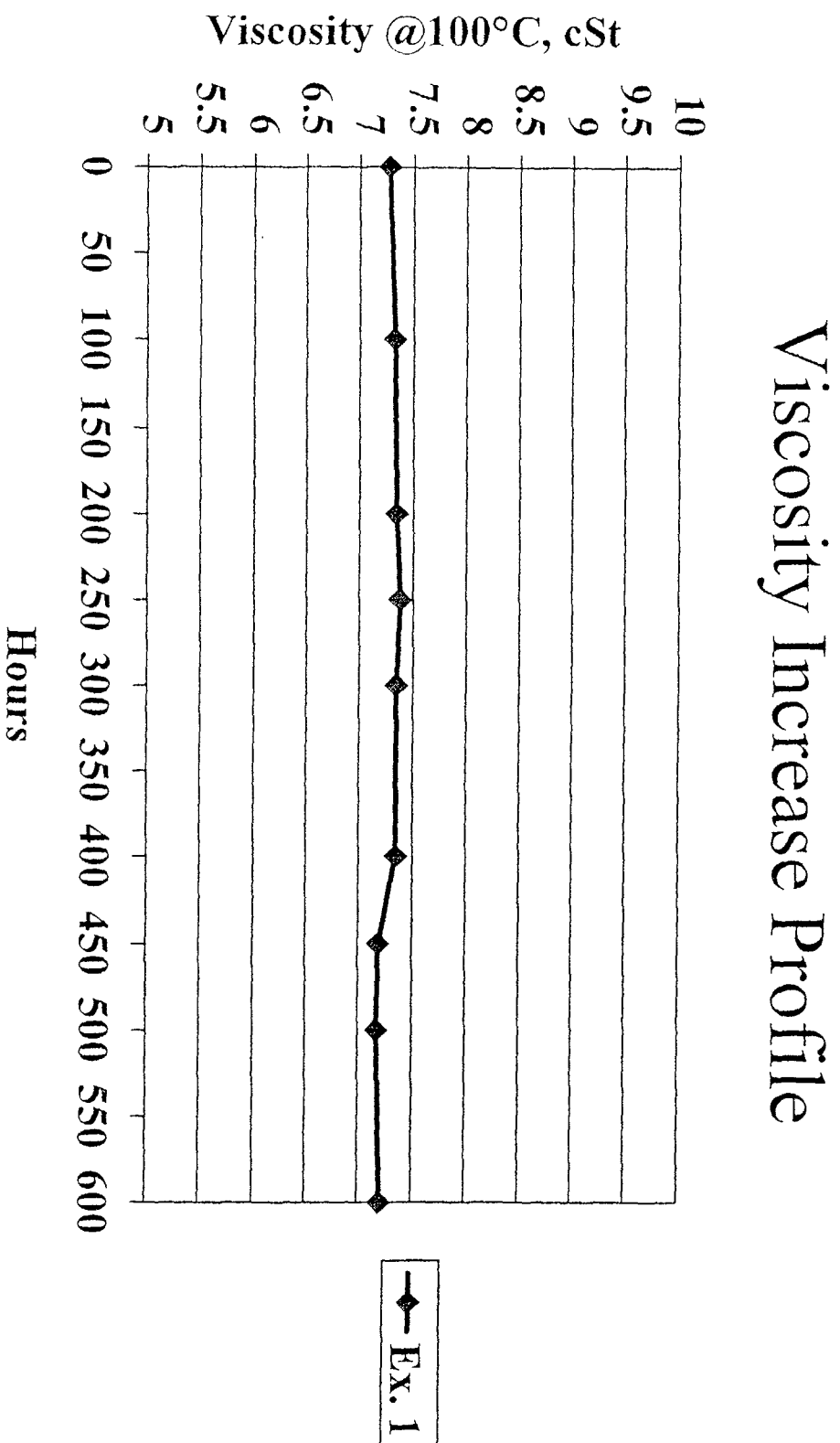


Fig. 7 - ECCC Friction Durability Test
Ex. 1

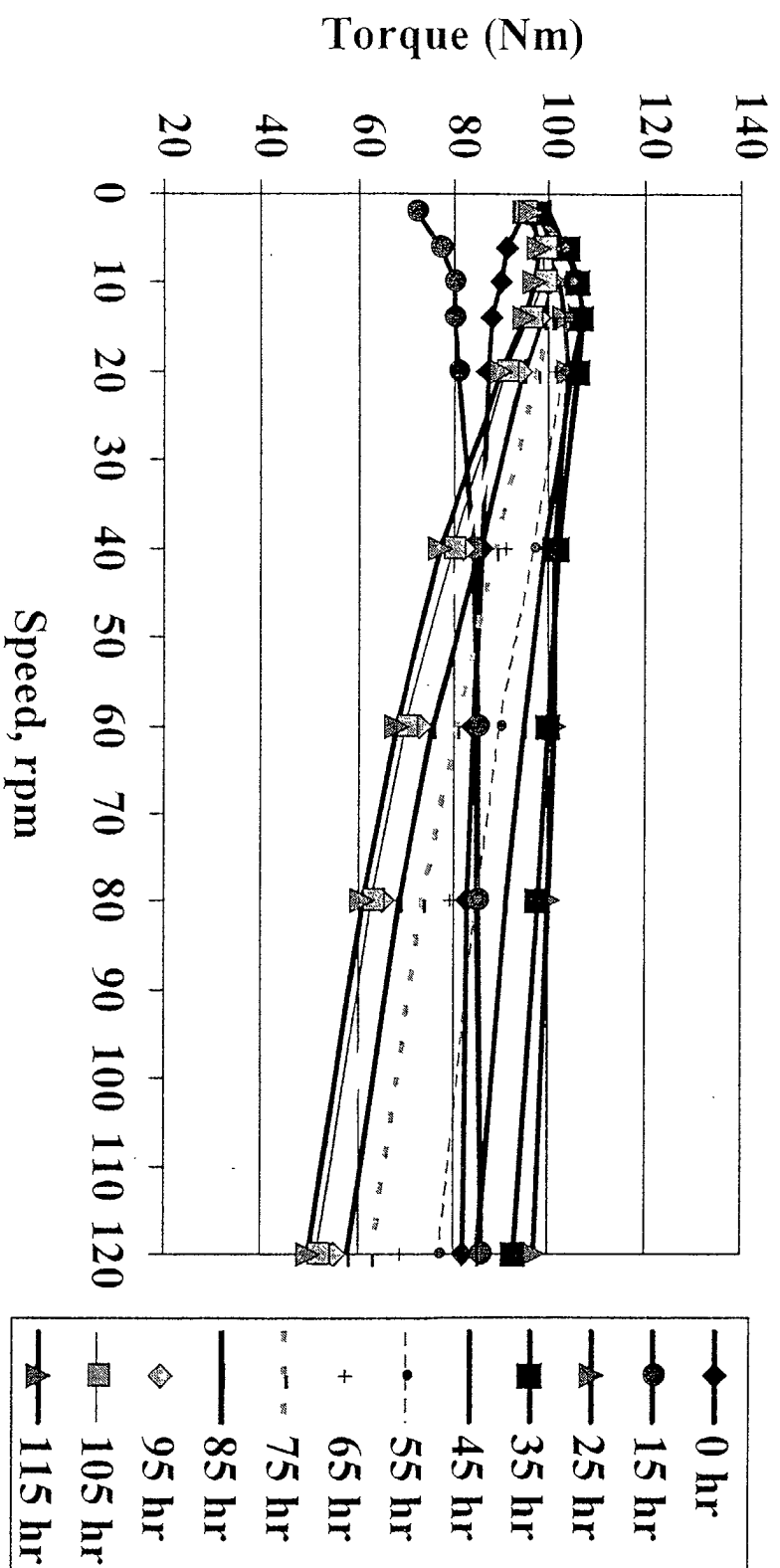


Fig. 8 - ECCC Friction Durability Test
Hours to Negative Slope; Ex. 1

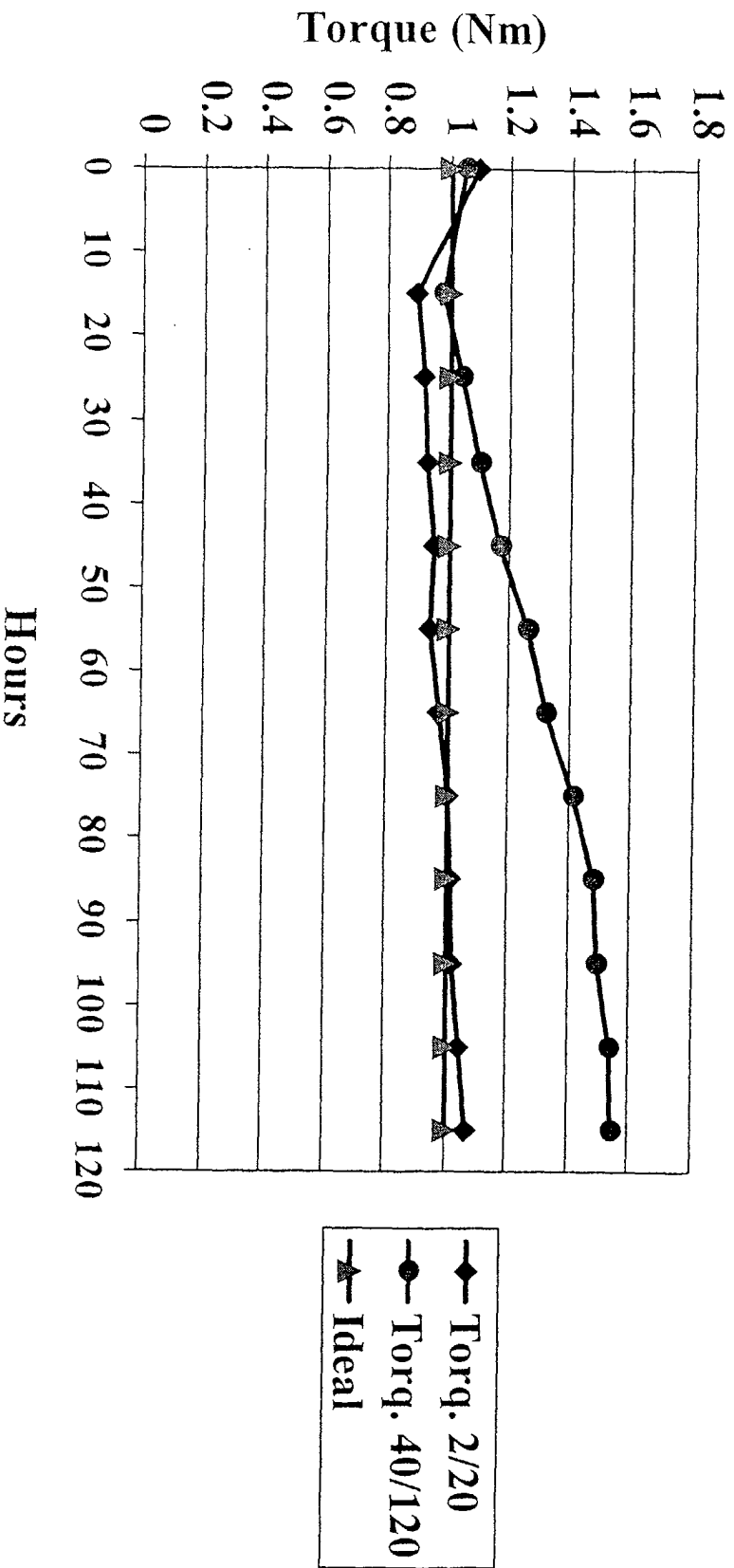


Fig. 9 - ECCC Friction Durability Test
Ex. 2

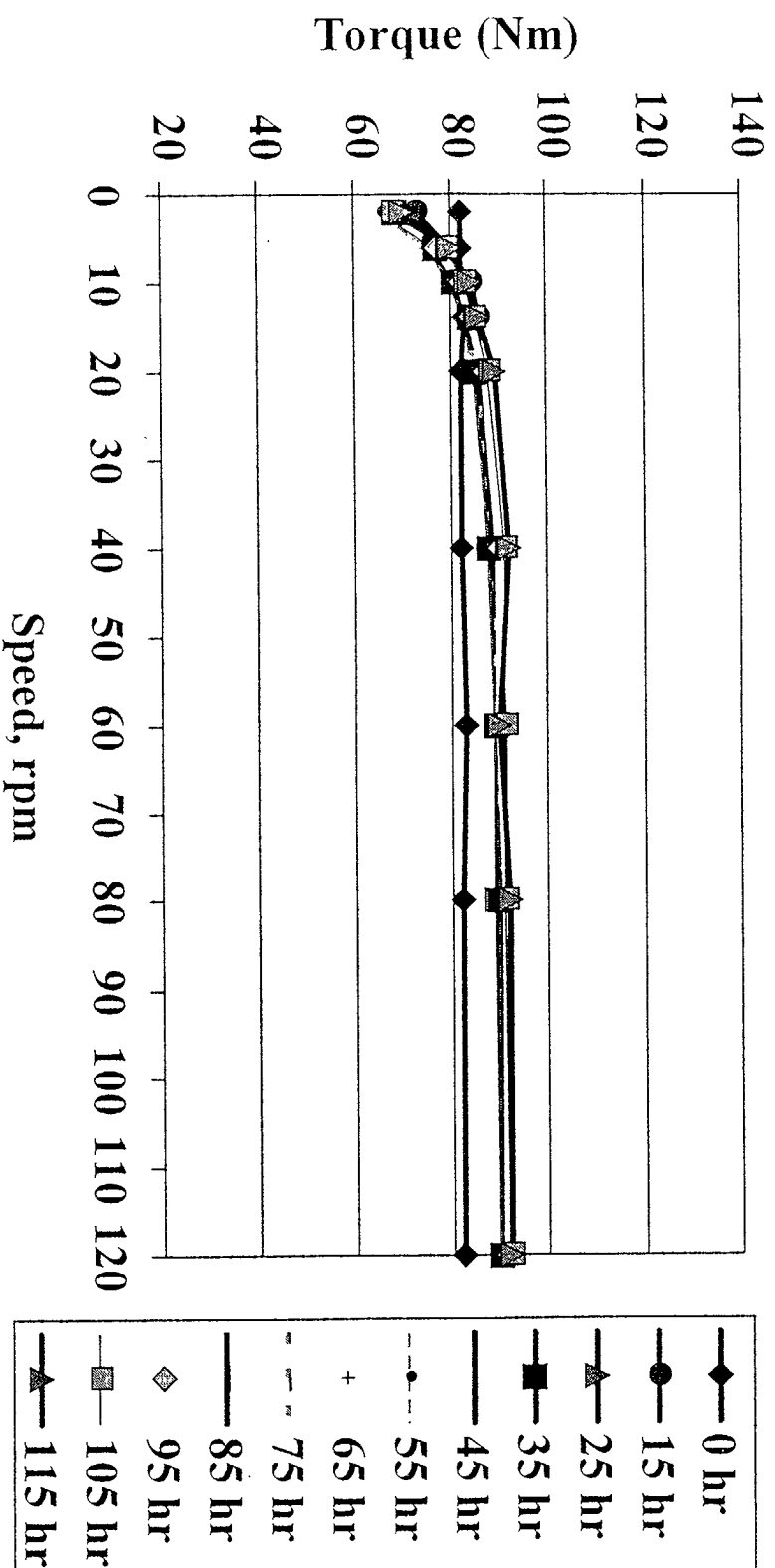


Fig. 10 - ECCC Friction Durability Test
Hours to Negative Slope; Ex. 2

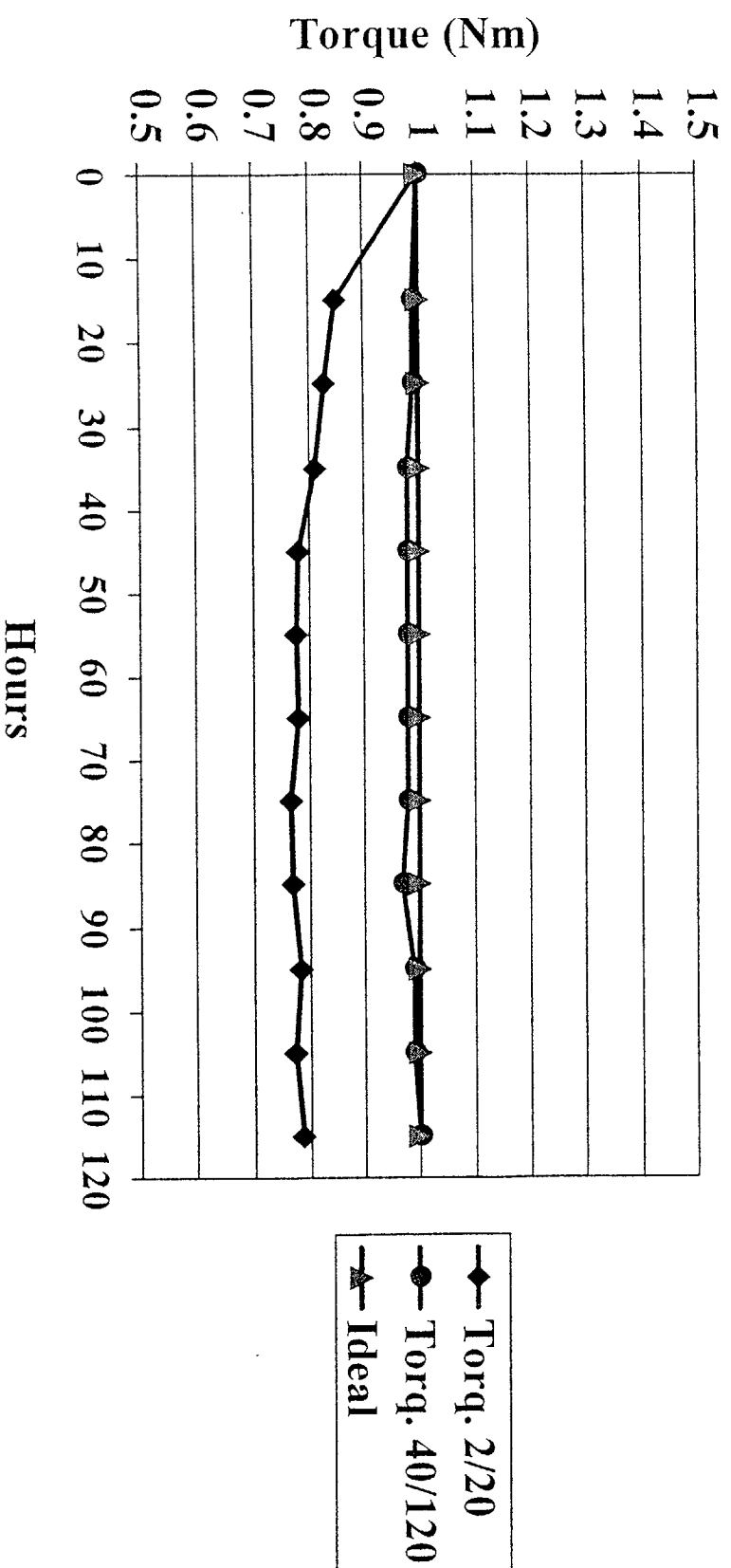


Fig. 11 - ECCC Friction Durability Test
Ex. 3

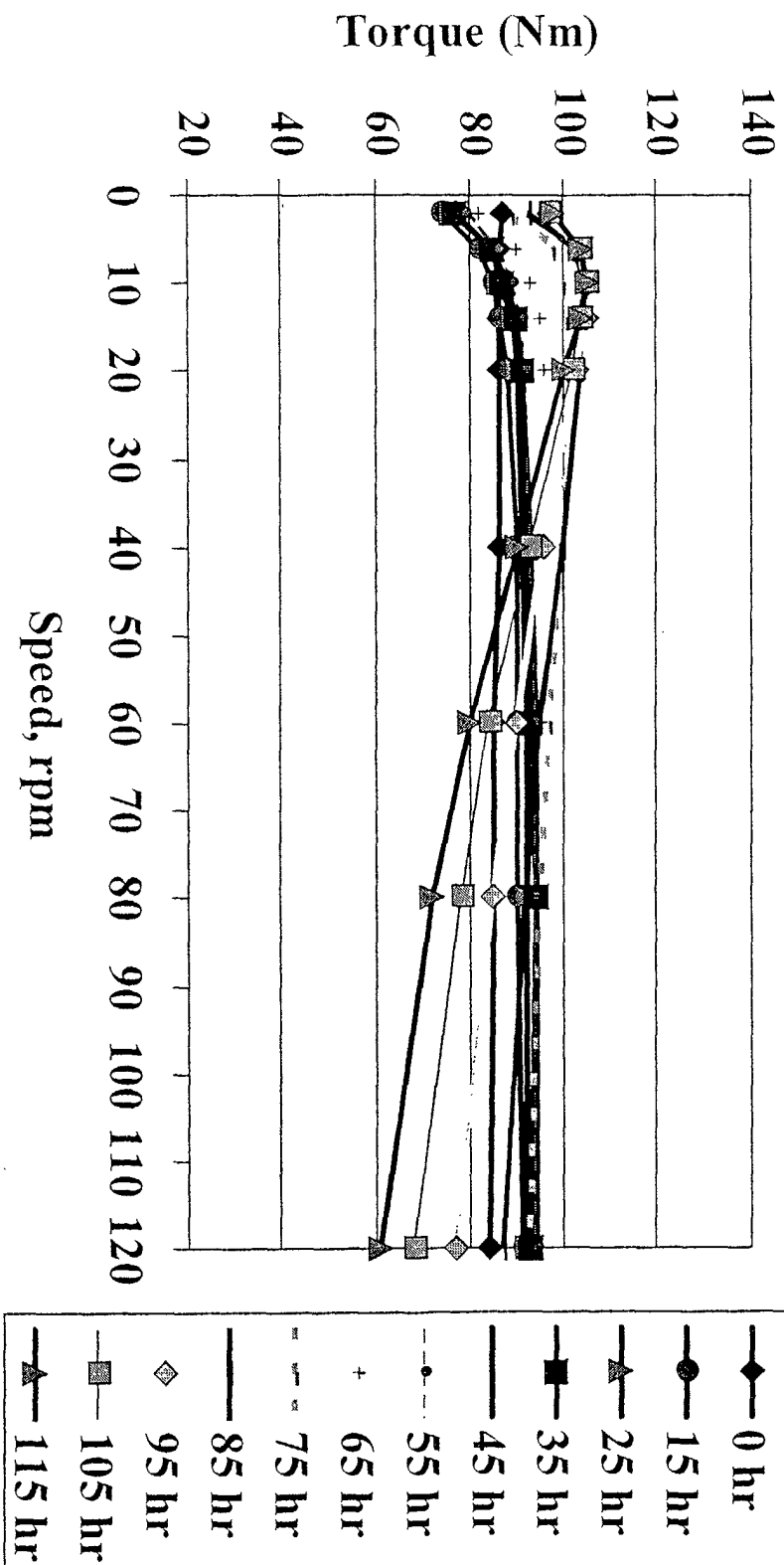


Fig. 12 - ECCC Friction Durability Test
Hours to Negative Slope, Ex. 3

